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Annotated Bibliography of the Hard Clam (*Mercenaria mercenaria*)

J. L. McHugh, Marjorie W. Sumner, Paul J. Flagg,
Douglas W. Lipton, and William J. Behrens

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U.S. DEPARTMENT OF COMMERCE
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728. Vertical sections of semimonthly mean temperature on the San Francisco-Honolulu route: From expendable bathythermograph observations, June 1966-December 1974. By J. F. T. Saur, L. E. Eber, D. R. McLain, and C. E. Dorman. January 1979, iii + 35 p., 4 figs., 1 table.

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732. Assessment of the Northwest Atlantic mackerel, *Scomber scombrus,* stock. By Emory D. Anderson. April 1979, iv + 13 p., 9 figs., 15 tables.

733. Possible management procedures for increasing production of sockeye salmon smolts in the Naknek River system, Bristol Bay, Alaska. By Robert J. Ellis and William J. McNeil. April 1979, iii + 9 p., 4 figs., 11 tables.

734. Escape of king crab, *Paralithodes camtschatica,* from derelict pots. By William L. High and Donald D. Worlund. May 1979, iii + 11 p., 5 figs., 6 tables.

735. History of the fishery and summary statistics of the sockeye salmon, *Oncorhynchus nerka,* runs to the Chignik Lakes, Alaska, 1888-1956. By Michael L. Dahlberg. August 1979, iv + 16 p., 15 figs., 11 tables.

736. A historical and descriptive account of Pacific coast anadromous salmonid rearing facilities and a summary of their releases by region, 1960-76. By Roy J. Wahle and Robert Z. Smith. September 1979, iv + 40 p., 15 figs., 25 tables.

737. Movements of pelagic dolphins (*Stenella* spp.) in the eastern tropical Pacific as indicated by results of tagging, with summary of tagging operations, 1969-76. By W. F. Perrin, W. E. Evans, and D. B. Holts. September 1979, iii + 14 p., 9 figs., 8 tables.

738. Environmental baselines in Long Island Sound, 1972-73. By R. N. Reid, A. B. Frame, and A. F. Draxler. December 1979, iv + 31 p., 40 figs., 6 tables.

739. Bottom-water temperature trends in the Middle Atlantic Bight during spring and autumn, 1964-76. By Clarence W. Davis. December 1972, iii + 13 p., 10 figs., 9 tables.

740. Food of fifteen northwest Atlantic gadiform fishes. By Richard W. Langton and Ray E. Bowman. February 1980, iv + 23 p., 3 figs., 11 tables.

741. Distribution of gammaridean Amphipoda (Crustacea) in the Middle Atlantic Bight region. By John J. Dickinson, Roland L. Wigley, Richard D. Brodeur, and Susan Brown-Leger. October 1980, vi + 46 p., 26 figs., 52 tables.

742. Water structure at Ocean Weather Station V, northwestern Pacific Ocean, 1966-71. By D. M. Husby and G. R. Seckel. October 1980, 18 figs., 4 tables.

743. Average density index for walleye pollock, *Theragra chalcogramma,* in the Bering Sea. By Loh-Lee Low and Ikuo Ikeda. November 1980, iii + 11 p., 3 figs., 9 tables.

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CONTENTS

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J. L. McHUGH, MARJORIE W. SUMNER, PAUL J. FLAGG, DOUGLAS W. LIPTON, and WILLIAM J. BEHRENS[3]

INTRODUCTION

Work on this bibliography began about the beginning of September 1974, when an undergraduate student, Douglas Lipton, started work on a summary of the life history of *Mercenaria mercenaria* as a tutorial research project. Serious work began in November 1975, when financial support was received from the New York Sea Grant Institute. At the time, we believed that we might find a few hundred major references to *M. mercenaria* in the literature, and were not prepared for a literature that exceeds 2,200 titles. We now know why authors of bibliographies often include the adjective "partial" in their titles. Although we combed the literature assiduously, we are certain that we have missed references. We also have not been able to locate some citations.

The search began by reviewing some obvious sources, such as Proceedings of the National Shellfisheries Association, Biological Bulletin, major fishery journals, and the like. We decided at the beginning to write new abstracts in almost all cases, because many authors do not know how to write an informative abstract, or have too many constraints placed on them by editors. After writing the abstract, we checked the literature cited for references that clearly referred to hard clam, or which appeared to be pertinent even if the species name did not appear in the title. These were located and abstracted, and the process was repeated. At this stage we are finding virtually no new citations, except those in current issues of journals.

This process itself was partially self-defeating, because we found that when specific reference to hard clam was not contained in the title, the paper sometimes was pertinent, sometimes not. We felt, however, that a certain amount of oversearching was necessary for completeness. Worse still was the practice of some journals, including many of importance, of not including titles in literature references, which made the search doubly difficult. We question whether the time and space saved by omitting the title is a good idea.

Another set of problems that bothered us considerably was caused by carelessness. Every possible error that could be imagined was met. We found misspelled author's names, wrong names, names of joint authors missing, names of joint authors added, wrong dates, incorrect titles, wrong journal names, wrong volume and issue numbers, and wrong pagination. Total absence of error was not expected, but such errors were too frequent to be ascribed to chance. Many authors obviously do not take literature citations very seriously, record references by a form of shorthand, and do not check carefully afterward. This raises doubts about the scientific accuracy and quality of many papers. The most distressing thing, however, was the enormous amount of time wasted by the authors of this bibliography, and by librarians locally and across the country, trying to verify and locate inaccurate references. Some we never found, and are not sure that they exist.

We are not certain that we have eliminated errors of this kind, but hope they are at a minimum. We have tried to maintain a high level of accuracy, but there are many opportunities to commit slips even in the best of circumstances.

To save time in preparation we have chosen to omit diacritical marks. This will be obvious when papers are in French, not so obvious elsewhere. We hope that this will not cause undue trouble.

There are several underlying themes in the clam literature. Of prime importance are papers describing life history and ecology of the hard clam, that is, describing its role in nature and how it copes with the many threats to continued existence. Other papers use the hard clam as a convenient tool in pharmacology or deal with its antiviral or anticancer properties. Still others are concerned with special powers of particular organs such as "catch muscle" and what makes it work, or the crystalline style and its role in the organism. We hope the fairly complete index will be helpful in segregating and recombining these diverse themes in various ways. It is planned to make this even more useful by preparing separately two additional documents, a technical review of the knowledge accumulated, and a more popular account intended for enforcement officers, hatchery workers, and the industry generally.

About 80 papers are listed in the index only by title. Most of these contained nothing on *Mercenaria*, but this could not be detected by reading the titles. About 20 of these could not be located and therefore we could not tell whether *Mercenaria* was mentioned or not. After entry 850, all titles were annotated.

Bibliographies are out of date before they are printed, because papers keep coming out. Probably the most important omission at this time is the paper by Michael Castagna and John N. Kraeuter, entitled "Manual for growing the hard clam *Mercenaria*," published in 1981 as Special Report in Applied Marine Science and Ocean Engineering No. 249 by the Virginia Institute of Marine Science, Gloucester Point, Va. We hope this bibliography will help by saving time in hunting for past literature, some of which is difficult to find.

We hired Donna Terrett to type the bibliography and the index. This was fortunate, because she had uninterrupted time to spend on it full time and took an interest in the work and its accuracy, which added much to the appearance of the finished product. Whatever faults remain are solely the responsibility of the senior author.

Paul Flagg spent the summer 1977 preparing a partial index to the bibliography.

[1]The studies on which this paper is based were supported by grants from the New York Sea Grant Institute.

[2]Contribution No. 299 of the Marine Sciences Research Center of the State University of New York, Stony Brook, N.Y.

[3]Marine Sciences Research Center, State University of New York, Stony Brook, NY 11794.

William Behrens also worked with us for a while and wrote a few abstracts.

I also want to thank the staff of the several libraries at Stony Brook, not only the main library, but also its branches in the Division of Biological Research and Department of Earth and Space Sciences, and the Health Sciences Library. Their help in locating many publications, and in obtaining many through interlibrary loan, was invaluable.

Finally, I owe a great debt of gratitude to Marjorie W. Sumner, who carried most of the load of searching the literature. She spent many hours in the various parts of the SUNY Stony Brook library and in some other libraries, hunting down elusive titles, and her knowledge of these libraries and their people was of inestimable value.

1
Abbott, R. T. 1954.

American Seashells. D. Van Nostrand Co., Inc., N.J., 541 p.

It is assumed that more recent books on the same subject by this author, abstracted elsewhere in this bibliography, contain the same, or more up-to-date information on the species of *Mercenaria* (=Venus). - J.L.M.

2
Abbott, R. Tucker. 1970.

How to know the American marine shells. A Signet Book, New American Library, Times Mirror, N.Y. Revised ed. W-6528, 222 p.

The hard-shelled clam *Mercenaria* goes through a male phase in which functional sperm is produced when the clam is only a few months old. Later about half of the population turns female. Under adverse environmental conditions more females than males are present. This is a survival mechanism. A figure is given showing hinge ligament, anterior and posterior muscle scars, pallial line and sinus, lunule, and cardinal teeth. There are many local names, including quahaug, hard-shelled clam, littleneck, and cherrystone. Classification is: Kingdom Animalia, Subkingdom Invertebrata, Phylum Mollusca, Class Pelecypoda, Order Eulamellibranchia, Suborder Heterodonta, Family Veneridae, Genus *Mercenaria*, Species *mercenaria* Linne. Distribution Canada to Florida. Very common. Used in chowders and on half shell. External morphology described. The form *notata* Say from the same region has external, brown, zigzag mottlings. *M. campechiensis* ranges from Va. to Tex. It is very similar but much more obese, lacks smooth central area on outside of valves, and lunule is usually as wide as long. In vicinity of St. Petersburg, Fla. is a malformed race with sharp, elevated ridge inside each valve, passing from umbo obliquely backward to pallial sinus. Southern quahog is common but not extensively used commercially. A useful glossary is included. - J.L.M.

3
Abbott, R. Tucker. 1972.

Kingdom of the seashell. Crown Publishers, Inc., New York (2nd printing, 1975), 256 p.

A beautifully illustrated, popular account of conchology. References to *Mercenaria mercenaria* include an account of the preparation and uses of shell money or wampum. Black wampum came from purple parts of shell. Beads usually were 1/3 inch diameter, 1/8 inch long, and drilled for stringing. White wampum was usually made from *Busycon* shells. Wampum was used as currency soon after white men came, by Indians and colonists. A 6-foot strand was worth about 5 shillings. In the early 1700s it could be used as fare on the Brooklyn ferry. A wampum factory run by white men operated in northern New Jersey for a few years. Wampum was finally outlawed as currency early in the 1800s when counterfeits flooded the market. In the form of long, wide belts, wampum was used to record treaties, and other important transactions between Indian nations. Presumably the record was preserved by patterns woven with white and colored beads. A brief account of the hard clam industry and life history of the species is included. All mollusks probably produce pearls occasionally. The pearl of a porcellaneous, dull, white shell like hard clam will have color and luster similar to the shell itself. Hard clam pearls often are purple or shaded with purple. Antiviral and antitumor properties of mercenene and paolins from clams and abalone are mentioned. - J.L.M.

4
Abdulappa, M. K., and J. S. S. Lakshminarayana. 1968.

Pathogenesis of helminths in the Mollusca and their relation to water quality. In Proc. Symp. Mollusca, Pt. III. Mar. Biol. Assn. India, Mandapam Camp: 758-779.

This review paper covers other subjects not suggested in the title, such as bacterial and viral contamination of mollusks and indicators of pollution.

Reference to *Venus mercenaria* comes from a paper abstracted elsewhere in this bibliography. - J.L.M.

5
Abelson, Philip H. 1957.

Organic constituents of fossils. In Treatise on Marine Ecology and Paleoecology, Vol. 2. Mem. Geol. Soc. Am. 67: 87-92.

A Recent shell, from Cape May, N.J. and a fossil shell from the Calvert formation, both *Mercenaria mercenaria*, compared fairly closely. The recent form contained an assemblage of amino acids typical of a structural protein. The fossil shell contained fewer amino acids, which may be presumed to be more stable than the moieties which have disappeared. - J.L.M.

6
Ackman, R. G., and M. G. Cormier. 1967.

α-Tocopherol in some Atlantic fish and shellfish with particular reference to live-holding without food. J. Fish. Res. Bd. Canada 24(2): 357-373.

Lipid and α-tocopherol content of *Venus mercenaria* were determined 1 to 4 weeks after collection. Percent lipid ranged from 0.5 to 0.65 and was lower than in most other bivalves. α-tocopherol content after 1 week was 11.6 μg/g in medium-sized clams and 4.9 μg/g in large clams; after 2 wks 9.2 μg/g in small clams; and after 4 wks zero in large clams. α-tocopherol content of the lipid fraction after 1 wk was 1700 μg/g in medium-sized clams and 1000 μg/g in large clams; after 2 wks 1430 μg/g in small clams; and after 4 wks zero. It is possible that the larger part of the α-tocopherol orginally present is derived from plant cells which pass through the gut. If it is a cellular-level lipid, rapid utilization or elimination of α-tocopherol could be explained, as there would be none in depot fat reserves. - J.L.M.

7
Ackman, R. G., and H. J. Hingley. 1968.

The occurrence and retention of dimethyl-β-propiothetin in some filter-feeding organisms. J. Fish. Res. Bd. Canada 25(2): 267-284.

Although mature oysters, scallops, and a pteropod had high levels of DMPT, and mussels intermediate levels, the amounts found in *Mercenaria mercenaria* from Prince Edward Island were insignificant. A basic difference in food assimilation between quahaug and the other species could be the reason, perhaps by preliminary filtration of certain sizes of phytoplankton. DMPT is a precursor of dimethyl sulphide (DMS), which is responsible for undesirable odors in some fishes. Many phytoplankton species contain DMPT, which thus might be expected to be found in tissues of filter feeders. - J.L.M.

8
Ackman, R. G., S. Epstein, and M. Kelleher. 1974.

A comparison of lipids and fatty acids of the ocean quahaug, *Arctica islandica*, from Nova Scotia and New Brunswick. J. Fish. Res. Bd. Canada 31(11): 1803-1811.

This paper came to our attention through the key word quahaug. The purpose of the study was to compare fatty acid composition of ocean quahaug from different areas to see if they reflected differences in local food sources which might explain alleged flavor problems. - J.L.M.

9
Ackman, R. G., S. N. Hooper, and P. J. Ke. 1971.

The distribution of saturated and isoprenoid fatty acids in the lipids of three species of molluscs, *Littorina littorea*, *Crassostrea virginica*, and *Venus mercenaria*. Comp. Biochem. Physiol. 39B(3): 579-587.

All 3 species were found to contain isoprenoid, iso, anteiso, and normal odd-numbered fatty acids qualitatively similar to those in higher forms of aquatic life. Branched-chain and normal odd-numbered fatty acids tended to be associated quantitatively with trends in neighboring normal even-numbered fatty acids, specifically with myristic, palmitic, and stearic acids. - modified authors' abstract - J.L.M.

10
Agarwal, R. A., and Michael J. Greenberg. 1968.

Some properties of cardioexcitors from the ganglia of freshwater clams. Proc. 24th Internatl. Congr. Physiol. Sci. 7:4 (abstract 10).

Aqueous extracts of ganglia of 3 freshwater clam species were tested for their effects on isolated hearts of the same species and of *Mercenaria mercenaria*. Some fractions had excitatory effects on all hearts, others had quite different effects on freshwater clam and *Mercenaria* hearts. The observations suggested that neural secretions, other than the usual transmitters, may have a role in long-term maintenance of rhythmical muscular activity. - J.L.M.

11
Agarwal, R. A., and Michael J. Greenberg. 1969.

A comparative study of cardioactive agents from bivalve tissue. Comp. Biochem. Physiol. 31(6) : 835-850.

Bivalve ganglia and heart tissues contain substances that affect cardiac rhythmicity. These substances can be separated from common molluscan neurohumors (5-HT, ACh, and catecholamines) by gel filtration, and can be distinguished from these transmitters by their pharmacological properties. Of unidentified substances, only Peak C had a consistent and strong effect on isolated hearts of bivalves. Peak C can be recognized by the difference in characteristic responses elicited from hearts of *Mercenaria* and *Amblema*. *M. mercenaria*, as a kind of standard mollusk, was used for ganglion extracts to compare with freshwater bivalves, and *Mercenaria* hearts were used for bioassay. Peak C was present in all tissues examined, but its concentration was highest in ganglia. It was concluded that Peak C is a substance of nervous origin, and that its role in the animal is, at least in part, to maintain long-term rhythmicity in active hearts. - J.L.M.

12
Agarwal, R. A., P. J. B. Ligon, and Michael J. Greenberg. 1972.

The distribution of cardioactive agents among molluscan species and tissues. Comp. Gen. Pharmacol. 3(11): 249-260.

Five cardioactive substances, in addition to acetylcholine (ACh) and 5-hydroxytryptamine (5HT), have been separated from ganglion and non-nervous tissue extracts of members of the 4 major molluscan classes, including *Mercenaria mercenaria*. The as yet unidentified active substances were named peaks A, B, B°, C, and D. Nervous tissues always had more of the active substances than non-nervous tissues. All ganglion extracts contained peaks A, B°, ACh, and C. Peaks B and D, and 5HT were missing from only one species each. No catecholamine peak resembling that of *Mercenaria* was found in any extract tested. Each active fraction was identified mainly by its elution volume and by its effects on *M. mercenaria* heart and other assay hearts. Responses of isolated *Mercenaria* hearts to peaks A, B, C, D, and 5HT were similar, in that amplitude, frequency, and at high doses, tone were increased. Peak D response became distinct only after 5HT excitation of *Mercenaria* heart was blocked by UML. Responses of *Mercenaria* ventricles to dopamine and B° were similar in their effects on tone, amplitude, and frequency of heartbeat. All substances had highest activities in ganglion extracts. Degree of localization varied: peak C was strongly restricted to nervous tissue; activity of peak A was most evenly distributed. The powerful pharmacological agents peaks C and B° were widely distributed in molluscan ganglia. Peak B° activity was noted for the first time in these studies. Peaks C and B° were partially purified. Peak C activity is produced by a small, positively charged molecule which is not a polypeptide. B° resembles a catecholamine in fluorescent characteristics, but is not adrenaline, noradrenaline, or dopamine. (Abstracter's note: dopa is 3,4-dihydroxyphenylalanine, UML is methysergide, and Dopamine is 3-hydroxytyramine.) - modified authors' abstract - J.L.M.

13
Ahmed, Muzammil, and Albert K. Sparks. 1968.

Chromosomes of oysters, clams and mussels. Proc. Natl. Shellf. Assn. 58: 10.

14
Aiello, Edward. 1970.

Nervous and chemical stimulation of gill cilia in bivalve molluscs. Physiol. Zool. 43(1): 60-70.

Mercenaria mercenaria was among 13 species examined. Five of 5 nerve-gill preparations tested responded to electrical stimulation of the branchial nerve. The cilioexcitatory effect was shown by rapid appearance of metachronal waves on previously quiescent filaments. Serotonin also stimulated ciliary activity. The lowest concentration that stimulated *M. mercenaria* was about 0.02 μg/ml. The effect of nerve stimulation by electrical impulse was blocked by 20 μg/ml of BOL (bromolysergic acid diethylamide). BOL significantly reduced the frequency of beating induced by some concentrations of serotonin (5-hydroxytryptamine). It was concluded that cilioexcitatory fibers are present in branchial nerves of *M. mercenaria* and that serotonin (5-HT) is the excitatory agent. It increased the rate of beating cilia and caused quiescent cilia to begin beating. - J.L.M.

15
Albert, Phil. 1978.

Insight: or how the DEM classifies shellfish areas. Upstream, Save the Bay, Inc., Dept. Envir. Mgmt. 2(1): 4.

Criteria used in Narragansett Bay closures are: 1) distance of an area from the source of pollution; 2) volume of sewage in an area; 3) dilution of the sewage by clean water; and 4) median most probable number (MPN) of coliform bacteria not to exceed 70 per 100 ml. Elevated coliform levels are not caused by increased rainfall. Highest rainfall in 4 yrs produced the lowest coliform count at station 11A. DEM's first priority is to clean up the Bay. Closure lines will continue as long as the severe effects of pollution remain. - J.L.M.

16
Allbee, Roger. 1973.

To take food from the sea. New York Sea Grant Adv. Serv., in cooperation with U.S. Dept. Commer. and Dept. Agric., Sea Grant Pub. 73-001, 16 p.

At one time clams were actively harvested only when oysters were out of season. Today hard clam, *Mercenaria mercenaria*, accounts for 13 million pounds of the total 22 million pounds reported fishery landings (1972). In 1880 production was mainly at Port Washington, Little Neck, Whitestone, Centerport, and Islip. In 1969 Great South Bay produced over 83% of total N.Y. hard clam landings. In 1972, 4501 independent baymen had commercial permits to harvest clams from Great South Bay. - J.L.M.

17
Allee, W. C. 1923.

Studies in marine ecology: I. The distribution of common littoral invertebrates of the Woods Hole region. Biol. Bull. 44(4): 167-191.

Venus mercenaria was fairly abundant in muddy and sandy bottom, sparse among rocks and rockweed, gravel and eelgrass. No evidence was found that long continued collecting by invertebrate classes or the supply department of the Marine Biological Laboratory at Woods Hole, Mass. had affected the abundance of animals in the area over a nine-year period. - J.L.M.

18
Allee, W. C. 1923.

Studies in marine ecology. II. An annotated catalogue of the distribution of common invertebrates of the Woods Hole littoral. Ms deposited in the following libraries: U.S. Fish Comm., Washington, D.C.; Mar. Biol. Lab., Woods Hole; Mus. Comp. Zool., Harvard; U.S. Natl. Mus.; Scripps Inst. Ocean., La Jolla, Calif.; and Mount Desert Isl. Biol. Lab.

Listed for reference. - J.L.M.

19
Allee, W. C. 1923.

Studies in marine ecology. III. Some physical factors related to the distribution of littoral invertebrates. Biol. Bull. 44: 205-253.

Venus mercenaria was found in muddy sand association, eelgrass and muck association, marginal muck association between the edge of the eelgrass and low tide, and in the intertidal *Mya* association in the lower part of the flats where buried rocks lie within a few inches of the surface. - J.L.M.

20
Allee, W. C. 1923.

Studies in marine ecology. IV. The effect of temperature in limiting geographical range of invertebrates of the Woods Hole littoral. Ecology 4(4): 341-354.

21
Allee, W. C. 1934.

Concerning the organization of marine coastal communities. Ecol. Monogr. 4(4): 541-554.

A series of communities on level bottom, attributed to C. G. Joh. Petersen (1918) included *Venus* community with *Echinocardium*; open sandy coasts of the Kattegat and in the North Sea, 10-11 m; and the deep *Venus* community, sporadically in the Kattegat in sand. Judging from their habitat tolerances the *Macoma* community should be found at the *Venus* stations, but in fact are found only where the "*Venus* community" are lacking. *Mytilus* of the *Macoma* group lives on buoys in the *Venus* territory of the Kattegat, but the constituents limited to the bottom cannot be found there. It must be that *Echinocardium* and *Ophioglypha* and the plaice fishes exclude them. "*Venus* animals" cannot reach up on the buoys in the Kattegat to destroy young *Mytilus*. Distribution of the *Macoma* community is understandable only in the light of biological factors which bring about competition with the "*Venus* community". - J.L.M.

22
Allen, E. J., and R. A. Todd. 1900

The fauna of the Salcombe estuary. Sears. Found., J. Mar. Res. 6: 151-217.

23
Allen, J. A. 1962.

Preliminary experiments on the feeding and excretion of bivalves using *Phaeodactylum* labelled with ^{32}P. J. Mar. Biol. Assn. U.K. 42(3): 609-623.

The *Venus* species used in these experiments was *striatula*, not *mercenaria*. Results of filtration experiments were similar to those reported by Rice and Smith (1958) and Jorgensen (1960) for other species. *V. striatula* produced very little pseudofaeces. Most material excreted in the first 3 days is green-brown and composed of *Phaeodactylum* which probably has never entered cells of the digestive diverticula but has immediately been rejected by sorting mechanisms of the stomach. Material excreted later is browner and probably composed of material that has been extruded from cells of digestive tubules and returned to the stomach. There is a steady loss of ^{32}P into solution during the first week. Of the body tissues of the clam, the digestive diverticula had the highest count of ^{32}P per mg dry tissue. This

probably also is the main storage organ of P. The ^{32}P is about 9 times as concentrated in the digestive gland of *Venus* as in *Mya*. Concentrations in other tissues are about the same in both species. The second highest concentration was found in kidney, and it was probable that this organ was responsible for loss of ^{32}P to the surrounding medium. Smallest concentrations were found in muscle and shell. Up to 94% of the ^{32}P present in *Phaeodactylum* was assimilated. There was no marked transfer to gonads. - J.L.M.

24
Allen, J. A. 1963.

Ecology and functional morphology of molluscs. Oceanogr. Mar. Biol. Ann. Rev. 1: 253-288.

Many species do not spawn until a certain temperature is reached, such as *Venus* (Ansell 1961). This review article undoubtedly covers many aspects of ecology and functional morphology of *Mercenaria (Venus) mercenaria*, but this was the only specific reference found. Sections cover habit and habitat, breeding, embryology and development, growth, shellfish cultivation, genetics and variation, and geographical distribution and population studies. There is an extensive bibliography. - J.L.M.

25
Allen, J. A. 1970.

Experiments on the uptake of radioactive phosphorus by bivalves and its subsequent distribution within the body. Comp. Biochem. Physiol. 36(1): 131-141.

Using suspension of *Phaeodactylum* labelled with P_{32}, maximum filtration rates of 40 ml/hr for *Venus striatula* 21 to 28 mm in total length were recorded. - J.L.M. and M.W.S.

26
Allen, J. Frances. 1954.

The influence of bottom sediments on the distribution of five species of bivalves in the Little Annemessex River, Chesapeake Bay. Nautilus 68(2): 56-65.

M. mercenaria was abundant only in sandy bottoms, not mud. - J.L.M.

27
Allen, Kenneth. 1961.

Amino acids in the Mollusca. Am. Zool. 1(2): 253-261.

The sulfonic amino acid taurine was found only in marine mollusks, not freshwater or terrestrial forms. Marine species examined included *Venus mercenaria* (Simpson et al. 1959). The technique was paper chromatography. This review paper concluded that amino acid metabolism in mollusks is poorly known. In marine mollusks the only subject studied to any extent has been the role of amino acids in osmoregulation, in which taurine plays an important role. - J.L.M.

28
Aller, H. D. 1912.

Notes on distribution of the more common bivalves of Beaufort, N.C. Stud. Biol. Lab. Johns Hopkins Univ. 28: 76.

According to Jacot (1921), abstracted elsewhere in this bibliography, Aller recorded *Venus mercenaria* from this area. - J.L.M.

29
Amende, Lynn M., and Sidney K. Pierce, Jr. 1978.

Hypotaurine: the identity of an unknown ninhydrin-positive compound coeluting with urea in amino acid extracts of bivalve tissue. Comp. Biochem. Physiol. 59B(3): 257-261.

30
American Public Health Association, Inc. 1970.

Recommended procedures for the examination of sea water and shellfish. 4th ed. Am. Pub. Health Assn., New York, viii + 105 p.

Contains detailed procedures on *Mercenaria mercenaria* and other species. - J.L.M.

31
Anderson, J. D., and C. L. Prosser. 1953.

Osmoregulating capacity in populations occurring in different salinities. Biol. Bull. 105(2): 369 (abstract).

Quahogs from Great Pond, Falmouth, Mass. collected at low tide had 0.44 N NaCl blood osmoconcentration where water osmoconcentration was 0.40 N NaCl, and 0.33 N NaCl where water was 0.20. Quahogs adjusted their blood to external concentration when they were pumping water, but failed to pump below about 50% seawater. From dilute regions quahogs tended to pump at lower concentrations than from concentrated water. - J.L.M.

32
Anderson, J. W., J. M. Neff, B. A. Cox, H. E. Tatem, and G. M. Hightower. 1974.

Characteristics of dispersions and water-soluble extracts of crude and refined oils and their toxicity to estuarine crustaceans and fish. Marine Biol. 27: 75-88.

33
Anderson, Robert S. 1977.

Biochemistry and physiology of invertebrate macrophages *in vitro*. In Comparative Pathobiology. Vol. 3. Invertebrate immune responses. Lee A. Bulla, Jr. and Thomas C. Cheng (eds.). Plenum Press, New York, p. 1-20.

No increment in O_2 utilization was seen in *Mercenaria* (Cheng 1975). Particle ingestion stimulated glycogen and glucose catabolism and lactate production in *Mercenaria* hemocytes. - J.L.M.

34
Anderson, William D., Willis J. Keith, F. Holland Mills, Michael E. Bailey, and John L. Steinmeyer. 1978.

A comprehensive survey of South Carolina's hard clam resources. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978, Abstracts, (page not numbered).

In 4 yrs of survey 35,922 yd^2 bottom samples were taken with hydraulic patent tongs. Estimated area of clam bottoms was 6,809 acres. Highest densities, and 70% of clams sampled, were in a mixture of shell and sand. Sampling in the Santee River estuary in 1973 and 1974 located high densities of hard clam which have led to a continuing commercial fishery. Seven permits are issued annually to hydraulic escalator harvesters. Ex-vessel revenue in the hard clam industry of the State has exceeded annual average production since 1974-75 sixfold. - J.L.M.

35
Anderson, William D., Willis J. Keith, F. Holland Mills, Michael E. Bailey, and John L. Steinmeyer. 1978.

A survey of South Carolina's hard clam resources. S. C. Wildlife and Marine Resources Department, Marine Resources Center, Tech. Rept. 32, vi + 17 p. + 15 p. appendix III.

An estimated 6,809 acres (2,756 ha), roughly 1% of S.C.'s marsh-estuarine area of 746,445 acres contain clams in various densities. Most are northern clams, *Mercenaria mercenaria*, and in substantially smaller numbers the southern clam, *M. campechiensis*, and their reciprocal hybrids are found sympatrically throughout S.C.'s coastal waters. Clams are usually found in small feeder creeks and protected areas not exposed to wave action or strong currents. Except for the Santee Delta, commercial quantities are scarce in

open estuarine areas. *Mercenaria mercenaria* is also found in conjunction with oysters or other environmentally favorable areas that are protected by overlying shells. Predation of juveniles by blue crabs, stone crab, and other xanthid crabs appears to be a major inhibitor to proliferation in areas with no overlying protection. About 15% (1,035 acres) of the State's estimated clam bottoms are closed by fecal coliform pollution. Public clam bottoms (1,418 acres) make up 21% of the estimated total. The remaining acreage is leased for commercial shellfish production. The Santee River estuary clam population is apparently adapted to low salinities. Highest concentrations are in areas of shell and sand substrate and less severe wave action. The fishery is expected to be maintained by managing fishing effort and rotating harvest areas. However, the proposed Cooper River rediversion project may cause commercial extinction of the clam fishery from major changes in the estuarine salinity regime. The report is illustrated with excellent figures, including one that shows that about 50% of all clams sampled were at about 2 meters depth, with less than 10% at depths greater than 5 meters, and that over half of clams sampled were littlenecks. - J.L.M.

36
Anderson, William D., Willis J. Keith, F. Holland Mills, Michael E. Bailey, and John L. Steinmeyer. 1979.

A comprehensive survey of South Carolina's hard clam resources. Proc. Natl. Shellf. Assn. 69: 201 (abstract).

Hydraulic patent tongs were used to inventory South Carolina's hard clam standing crop. In the 4 yr survey (1973-1977) 35,922 yd^2 (30,031 m^2) samples were taken. An estimated 6,809 acres (2,756 ha) of clam bottoms were found. Highest clam densities and 78% of total clams sampled were found in a mixture of shell and sand substrate. Initial survey results in fall 1973 and early 1974 discovered high density populations in the Santee River estuary. Seven permits are issued annually and harvesting is managed by the Division of Marine Resources. Since the 1974-75 clam season, South Carolina's hard clam ex-vessel revenue has exceeded the pre-survey annual average production by six times. - J.L.M.

37
Andrews, Jay D. 1955.

Notes on fungus parasites of bivalve mollusks in Chesapeake Bay. Proc. Natl. Shellf. Assn. 45: 157-163.

In Aug 1953 the meat of a dead hard clam was found infected with a fungus similar to *Dermocystidium marinum*, a fungus that causes mortality in American oyster. - J.L.M.

38
Andrews, J. D. 1956.

Annotated checklist of mollusks of Chesapeake Bay. Unpub. ms., 10 p.

We assume that this manuscript contains reference to *Mercenaria mercenaria*. - J.L.M.

39
Andrews, J. D. 1966.

Problems in shellfish production. Proc. Natl. Shellf. Assn. 57: 9-10.

40
Andrews, J. D. 1970.

Climatic and ecological settings for growing shellfish. In Proc. Conf. on Artificial Propag. of Commercially Valuable Shellfish - Oysters. Coll. Mar. Stud., Univ. Del., Newark, p. 97-107.

On the mid-Atlantic coast of N. America the environment of estuarine shellfishes is rigorous. Temps range from 0° to 30°C and salinities vary by 10°/oo to 15°/oo annually and up to 5°/oo in a tidal cycle. These regular changes are augmented by droughts, flash floods, and hurricanes. Drastic changes in temp and salinity of coastal waters are produced by effects of continental climates. *Mercenaria mercenaria* is one of the most important bivalves of the area. It has evolved into 2 species in the northern and southern parts of its range. Among other east coast species *M. mercenaria* has been introduced on the west coast. Successful introduction was possible because this clam tolerated cold waters. Hard clam requires salinities no less than about half that of seawater (about 18°/₀₀), hence is confined to the lower part of Chesapeake Bay. Hard clams less than 1 inch long are scarce because the lower Bay is an area of high predation, mostly by blue crabs. Shelly oyster beds provide best habitats for survival, and most hard clams are harvested in such places. Commercial catch in Chesapeake Bay is mostly clams over 10 yrs old. In the Long Island, N.Y. area, recruitment is regular and young clams grow well. In Chesapeake Bay regularity and intensity of hard clam spatfall is not well understood. One-inch clams planted in sandy bottoms suffered heavy mortality from predation. In mesh-lined trays survival was excellent. Planting hard clams on shelled beds has been advocated to increase survival. Oysters and soft clams tolerate lower salinities, hence are less vulnerable to predation. The Maryland hydraulic escalator clam harvester could be used to bring buried shell to the surface. Most nursery operations appear to get good survival of young clams, but growth is less than in nature. Hard clams are considered prime at sizes small enough for harvesting before growth has become excessively slow. Estuaries and lagoons of the Atlantic coast have extremely wide variations of environmental factors seasonally, thus it seems unlikely that large natural areas can be protected from such variations for efficient mariculture. Modification of environments for rearing early stages seems well within reach. Because natural environments are seldom "right" for long, full advantage should be taken of opportunities to manipulate shellfishes into the best habitats according to season and objective. - J.L.M.

41
Andrews, Jay D. 1970.

The mollusc fisheries of Chesapeake Bay (USA). In Proc. Symposium on Mollusca, Pt. III (India): 847-856.

Hard clam, *Mercenaria mercenaria*, supports 1 of 3 major mollusk fisheries in the Bay. Most hard clams are taken on the seaside of the eastern shore of Md. and Va., e.g., the ocean side of the peninsula that forms the eastern boundary of Chesapeake Bay. Within the Bay the species is limited to lower Bay areas in salinities above 15°/₀₀. In the Bay most of the catch is made with power-operated patent tongs in water 20 feet deep or more. In the Maryland sector of Chincoteague Bay on the seaside of the Eastern Shore hydraulic soft clam dredges are used, and in Virginia more primitive methods still persist: hand tongs, bull rakes, and treading. The prime market is for steamers (for clam bakes) and raw clams to be served on the half shell. Larger clams are used in chowders and soups. Clams are harvested all year, but seasonal variations in demand have led to a complicated system of storage by intensive protected plantings to hold for favorable prices. Only a small part of the east coast clam harvest comes from the Chesapeake area (16% in 1966). Reproduction, predation, and disease are the major biological problems of the Chesapeake shellfish industry. All three species are prolific, but losses are large in the early stages. Summer-breeding oyster and hard clam are less successful in reproduction than the fall-breeding soft clam. Hard clam has a longer spawning season, at minimum temperature of about 20°C. Size of breeding population has not been clearly related to spawning success. Two experimental hard clam hatcheries are operating on the seaside of the eastern shore of Va. Nursery areas or protection are needed to allow clams to grow to predator-resistant size. Bivalve spat are subject to heavy predation, especially in the first week after setting. In lower Chesapeake Bay 2 snails (*Urosalpinx cinerea* and *Eupleura caudata*), blue crab (*Callinectes sapidus*), 4 xanthid crabs, and the flatworm *Stylochus ellipticus* are considered serious predators. Sea stars (*Asterias*), conchs (*Busycon*), and moon snails (*Polynices*) are less abundant and less important as predators. Skates and rays undoubtedly take some bivalves. In the York River small *M. mercenaria* are always difficult to find. On bottoms worked commercially clams smaller than one inch are scarce. Blue crabs quickly dig and crack concentrated plantings of small clams, but protected clams show very low death rates from disease and other causes. *Mercenaria* grows very slowly after the first 2 or 3 years. Old clams are common in commercial catches. Tray-held hard clams had very low mortalities when protected from predation for 10 years. Clams in natural populations are scattered, in contrast to oysters on planted grounds, and disease-caused mortalities have not been evident. Diseases of hard clam have not been studied in Chesapeake Bay. - J.L.M.

42
Andrews, Jean. 1971.

Sea Shells of the Texas coast. Univ. Texas Press, Austin, 285 p.

Southern quahog, *Mercenaria campechiensis* (Gmelin, 1790). Length 3 to 6 in. Dirty gray to whitish; interior white, rarely with purple blotches; porcellaneous. Valves equal; ovate trigonal; inequilateral; inflated. Sculpture of numerous concentric growth lines; near the beaks they are farther apart; shell very heavy. Lunule as wide as long; 3 cardinals in each valve; left middle cardinal split. Two muscle scars are connected by a pallial line with small, angular sinus. No periostracum visible. *M. campechiensis* has not been used commercially as has *M. mercenaria*. Habitat: offshore; common. Chesapeake Bay to Florida, Texas, and Cuba; Miocene to Recent. *Mercenaria campechiensis texana* (Dall, 1902). Length 3 to 5 in. Dirty white, often with brown zigzag marks; interior white, occasionally marked with purple. Surface sculpture with irregular large concentric growth lines; central area of each valve glossy and smooth in older clams; very heavy and porcellaneous. Lunule 3/4 as wide as long; 3 cardinal teeth in each valve; left middle cardinal split. Two muscle scars are connected by a pallial line with small angular sinus; margin faintly crenulate. Lives in bays, in open bays and inlet-influenced areas. Fairly common. Range: northern Gulf of Mexico to Tampico, Mexico. Pleistocene to Recent. *Mercenaria mercenaria* is not listed as present. - J.L.M.

43
Andrews, Wallace H., Cecile D. Diggs, and Clyde R. Wilson. 1975.

Evaluation of a medium for the rapid recovery of *Escherichia coli* from shellfish. Appl. Microbiol. 29(1): 130-131.

A medium which shortens the time necessary to identify and enumerate *E. coli* in estuarine waters was evaluated for use in recovery of *E. coli* from *Mercenaria mercenaria* and *Crassostrea virginica*. Productivity of *E. coli* by this medium was comparable to that of the lengthier Am. Pub. Health Assn. method and false positives were reduced substantially. - modified author's abstract. - J.L.M.

44
Andrews, W. H., C. D. Diggs, J. J. Miescier, C. R. Wilson, W. N. Adams, S. A. Furfari, and J. F. Musselman. 1976.

Validity of members of the total coliform and fecal coliform groups for indicating the presence of *Salmonella* in the quahaug, *Mercenaria mercenaria*. J. Milk Food Technol. 39(5): 322-324.

No samples of *Mercenaria mercenaria* taken from waters classified as safe for shellfish harvesting, over a period of 24 months, contained *Salmonella*. Criteria for safe waters were: 1) no more than 70 MPN total coliforms/100 ml water; or 2) no more than 14 MPN fecal coliforms/100 ml water. *Salmonella* also was not detected in quahog samples meeting the wholesale market quality standard of 230 fecal coliforms/100 g shellfish, as specified by the National Shellfish Sanitation Program. Fecal coliform MPN of quahog meats increased more closely with increase in total and fecal coliform MPN of the waters than did total coliform MPN of meats. Five *Salmonella* serotypes, including *S. paratyphi* B., were found singly and in combination in a small number of quahog samples from waters in which total coliform MPN/100 ml was over 200, and in which fecal coliform MPN/100 ml was over 14. - J.L.M.

45
Anonymous. 1935.

Canarsie clams and typhoid fever. N.Y. City Dept. Health, Quart. Bull. 3: 87-89.

Not until 1915 could any considerable number of cases of typhoid fever in New York City be traced to infected shellfish, despite careful investigation. For the next 10 years no group of cases could be attributed to shellfish. Then in 1924-25 an outbreak of over 625 cases was traced to infected shellfish from the shores of Long Island. This was part of a much more extensive epidemic which reached as far as Chicago, and led to strict regulatory measures. From 1924 to 1935 the number of cases of typhoid fever in New York City dropped irregularly from 1,687 to something over 300 per year. Those attributable to shellfish ranged from 22.7% in 1924 to a low of 2.3% in 1932, with rises in incidence in 1933 and 1935. Although Canarsie Beach was posted with warning signs, extensive publicity had been given to the danger, and the Beach was patrolled, surreptitious digging of clams (presumably hard clam) persisted. The Department of Health was removing clams from the area, breaking them up, and dumping them at sea. - J.L.M.

46
Anonymous. 1936.

Surveying sewage pollution in shell fish producing waters. Eng. News-Record, July 9, 1936: 49-50.

As a result of considerable experimental and field work the U.S. Public Health Service arrived at the conclusion that generally not more than 50% of the 1 cc tubes in an area should show the presence of *B. coli* if that area is to be used to take shellfish for market. *B. coli* was found high in the far western end of Raritan Bay, and in that portion to the north and northwest of Sandy Hook Point. Except for isolated cases, results in the rest of the Bay were satisfactory. An additional area adjacent to Sandy Hook Point was ordered closed. After proper action by New Jersey, New York City opened markets to products coming from approved sources. - J.L.M.

47
Anonymous. 1936.

Temperature and hibernation of hard-shell clams. U.S. Fish Wildl. Serv., Bull. 252: 4.

A brief progress report on studies completed by V. L. Loosanoff on *Venus mercenaria* in tanks in which water was renewed with every tidal excursion. Clams were immobilized by imbedding one valve in concrete and shell movements were recorded. Temps varied from 0 to 28°C, thus covering the entire natural range for the area. Critical hibernation temp lay between 5° and 6°C. At 0°C clams remained closed 100% of the time; at 1 to 2.9° closed 100% (29 clams); from 3 to 4.9° shells of 30 clams were open 6.5% of the time; and as soon as 5 to 5.9° was reached shell activity increased markedly, clams remaining open 35 to 40% of the time. Clams at 8° were open 65% of the time; 10 to 11°C 75 to 85%; and from 12 to 28°C 80 to 90% of the time. Undoubtedly growth and fattening of clams, and development of sexual products, are dependent upon the length of time valves are open, hence the clam can feed. - J.L.M.

48
Anonymous. 1941.

High court rejects *B. coli* as indicating unsafe water. Water Works Engineering 94: 516-517, 527.

49
Anonymous. 1944.

Culture of hard clams. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Leafl. 72, 2 p.

This paper was cited as authored by Loosanoff, but his name appears only in the list of publications appended. *Venus mercenaria* was most abundant from Massachusetts to Virginia, but was found from Maine to Florida, and supported considerable fisheries also in North Carolina and Florida. They live from the intertidal zone to a depth of over 50 ft. Some may spawn at 3 or 4 months of age, but most spawn at one year. Spawning begins when water temp reaches about 73°F. Spawning season is longer in the south. Growth is affected by currents, depth, salinity and temp, and bottom materials. Hard clams can feed only when covered with water. Natural beds are found between 10°/oo and 28°/oo salinity, and can tolerate normal fluctuation in salinity. Growth is most rapid in warmer waters, hence faster south than north. In northern waters growth is only from May to mid-November. A hard clam farm can yield up to 600 bu of 2 1/2-inch clams/acre/yr. Location of the farm should be based on good water circulation, relatively firm bottom, and be below low tide level (at least 3 ft of water at low tide). Water should be free of pollution, and well protected from wind and rough water. A nearby source of seed is important. Preparation of the ground for planting should include removal of thick grass, stones, and other debris, and destruction of cockles, conch, and sea stars. Clams are not active at low temp. Therefore, planting should be done in warmer seasons, to avoid exposure to attack by predators. If water circulation is good, up to 25 seed clams can be planted/ft^2 of bottom. Some control of seaweeds and predators may be necessary at times before harvesting. - J.L.M.

50
Anonymous. 1954.

Paleobiochemistry. Geophysical Laboratory, Carnegie Inst. of Washington, 1954: 97-101.

Analysis of a recent clam shell from Cape May, N.J. showed that although amino acids were not laid down uniformly throughout the shell, they were present in all portions. Shells of fossils from one locality, including *Mercenaria mercenaria*, showed qualitative and quantitative differences in amino acid content. - J.L.M. and M.W.S.

51
Anonymous. 1957.

Exploratory fishing for hard clams and finfish in the northeastern Gulf of Mexico. Comm. Fish. Rev. 19(11): 20-21.

Hard clams (presumably *Mercenaria campechiensis*) were taken in small numbers at all stations off the Florida coast between Cape St. George and Gasparilla Island in the 3 to 5 fathom depth range. Best results were off Pass-a-grille and Venice (300 clams, approximately 1 bu/30 min tow). Seventy percent were 2 in long (littlenecks), 30% 3 to 4 in (cherrystones and chowders). Yield was about 1 gal meats/bu. They were judged to equal the northern species (*M. mercenaria*) in taste, texture, and size, but keeping quality was poor. - J.L.M.

52
Anonymous. 1957.

Shellfish and sardinelike fish potential explored in eastern Gulf of Mexico (M/V *Silver Bay* Cruise 2). Comm. Fish. Rev. 19(9): 31.

53
Anonymous. 1958.

Gulf of Mexico explored for hard clams and scallops (M/V *Silver Bay* Cruise 10). Comm. Fish. Rev. 20(9): 41-43.

Tows for hard clam were made between Cape Romano, Fla. and Anclote Keys. *Venus* sp. was taken in all tows. Best catches were off Pass-a-grille Beach, Venice, and Marco Island in depths from 16 to 22 ft (from a few clams to 1.5 bu/15 min tow). Clams were 2 to 4 1/2 in, 75% about 3 in. Yield was about one gal meats/bu. Clams were held in a wooden tank in circulating seawater for 15 days with negligible loss. Forty-six tows between Cape San Blas and Horn Island in 20 ft of water caught no clams. - J.L.M.

54
Anonymous. 1958.

The commercial shellfishes of Long Island. In Report of the New York State Joint Legislative Committee on Revision of the Conservation Law 1957-1958, Legislative Doc. (1958) 11: 45-63.

(Abstracter's note: in addition to hard clam this document deals with other molluscan species, and includes a section on nets used by commercial fishermen and another on recommended legislation. Only specific references to hard clam are included in this abstract.) Hard clam is normally found in lower part of estuary, and infrequently in upper estuary or ocean. Larval period may vary from 7 to 30 days depending on temperature. Tidal flushing would remove fewer from the estuary when larval life is short. Short larval period also may reduce predation and increase survival. Between larval life and permanent setting clams may swim or crawl. Growth rate and maximum size is related to food supply. Overcrowding reduces growth. Hard clam can utilize dense concentrations of phytoplankton that inhibit feeding of oysters. Hard clam in relict populations in Gulf of St. Lawrence grow less than half as fast as those at Cape Cod. Sand favors faster growth of hard clam than does mud. Hard clam lives at or near low tide mark and down to depths of several fathoms. Throughout life clams retain some powers of locomotion. If disrupted they can reestablish in the substrate. Small clams can do this within minutes, larger ones in a few hours. Hard clams have been found high up on beaches after storms. Predation on small clams may be high because young predators are more abundant than adults. Newly set clams suffer high mortality from this cause even when adults are scarce. Hard clam matures in its second year and can produce 2 million eggs at 2 1/2 inches long. Numbers of eggs increase with size of female with no decline in quality. Hard clam may live much longer than 12 years. There is no direct evidence that exploitation affects propagation adversely. There is no evidence that power dredging affects a hard clam fishery differently than bullraking. The proposed law that prohibits taking of hard clam less than one-inch thick is a conservation measure because in certified waters of N.Y. there is no surplus of young clams for planting on leased grounds. There is presently no simple, inexpensive method of populating barren areas with young clams, although some hard clam farms are in operation. The future does not appear bright for profitable commercial farming of hard clam. - J.L.M.

55
Anonymous. 1960.

Proceedings at preliminary conference called by Governor Christopher DelSesto of the State of Rhode Island with advisors in regard to oil pollution of Narragansett Bay by "The Thirtle"; also as to the effect on marine life in the Bay. Sept. 8, 1960, State House, Providence, R.I., 29 p. (stenographic record).

The only substantive reference to *Mercenaria mercenaria* is a statement by Prof. Steacy D. Hicks of the University of Rhode Island that after 25 washings of crude oil with water, the water is still toxic to marine life, and will depress filtering rate of clams and quahaugs. - J.L.M.

56
Anonymous. 1960.

Hard clams found in commercial quantities off North Carolina coast. Comm. Fish. Rev. 22(2): 42-43.

Preliminary test fishing with a 14-tooth Fall River clam dredge from 10 mi west of Beaufort Inlet to Cape Lookout, N.C. took *Mercenaria* sp. From about 4 mi west of the Inlet to Cape Lookout an extensive commercial bed was found. Catch rates varied from 0 to 6 1/2 bu/30 min drag. Simulated commercial fishing took 45 bu of 3 to 4 in clams in 6 hrs. South and southwest of Cape Lookout Bight clams were taken up to 5 bu/hr. Seven stations south of Drum Inlet yielded large quantities of dead shells but no live clams. Clams were 2 to 5 in long, but mostly over 3 in. Yields were about 1 gal meats/bu. - J.L.M.

57
Anonymous. 1960.

Savannah River-Cape Hatteras offshore areas surveyed for fish and shellfish resources. Comm. Fish. Rev. 22(10): 42-43.

In 29 drags with a 14-tooth Fall River dredge scattered individual live *Venus mercenaria* were taken with dead shells in the vicinity of Bogue Inlet and Cape Fear, N.C. No live clams were found off Cape Romain. - J.L.M.

58
Anonymous. 1961.

Fish and shellfish resources off coasts of North and South Carolina and Georgia surveyed. Comm. Fish. Rev. 23(2): 26.

Clam dredging off Cape Romain to St. Catherine Sound with a 14-tooth Fall River dredge in 4 to 8 fath took a few live *Venus mercenaria* 3-5 in long. No clam beds were found. Large quantities of dead shells were taken at some stations. - J.L.M.

59
Anonymous. 1961.

Survey of fish and shellfish resources off Georgia and Florida (M/V Silver Bay Cruise 28). Comm. Fish. Rev. 23(4): 31-33.

The cruise covered the area between Fort Pierce, Fla. and Brunswick, Ga., but hard clam (*Venus* sp.) dredging was done only between Eau Gallie and Jacksonville Beach. Hard clams were scarce. A few were taken in Cape Canaveral Cove and 300 dead shells were brought up off Matanzas. - J.L.M.

60
Anonymous. 1961.

Fish and shellfish resources off North Carolina coast surveyed. Comm. Fish. Rev. 23(5): 24-26.

Catches of medium-size hard clams, 2 1/2 to 4 1/2 in, off the Cape Fear River ranged up to 44 clams/15 min tow. One live clam and dead shells were taken north of Cape Lookout Shoals. In 4 to 6 fath north of Cape Hatteras only dead shells were taken. - J.L.M.

61
Anonymous. 1963.

Seasonal distribution of royal-red shrimp and hard clams surveyed in Gulf of Mexico (R/V Oregon Cruise 83). Comm. Fish. Rev. 25(2): 31-32.

Off the southwest coast of Florida dredging was done in depths of 3 to 5 fathoms. Most clams were taken off St. Petersburg (20 to 185 hard clams 3 to 5 in long/30 min tow). Heavy beds of pen shells (*Atrina rigida*) hampered sampling effectiveness. - J.L.M.

62
Anonymous. 1970.

A study of the effects of a commercial hydraulic clam dredge on benthic communities in estuarine areas - Florida. Fla. Mar. Res. Lab., Fed. Aid Progr. Rept. (completion) 2-53-R, June 21, 1967 - June 30, 1970, 55 p.

It is assumed that this is essentially the same as a published report by Godcharles (1971), with the same title, issued as no. 64 in the Marine Research Lab. Technical Series. This is abstracted elsewhere in this bibliography under the author's name. - J.L.M. and M.W.S.

63
Anonymous. 1970.

Cultures marines. Essais d'acclimatation du clam, *Venus mercenaria*, en milieu lagunaire Mediterraneen. Science et Peche, Bull. Inst. Peches Marit. 193: 1-13.

Describes work conducted from May 1964 to May 1969 under support from CNEXO. Grand Etang de Thau was the principal site of experiments. Work ceased in May 1969 because experimental clams were stolen in the experimental area and considerable losses were suffered elsewhere through pollution. Difficulties encountered were: problems of obtaining young clams, of finding a favorable environment relatively easy of access, and various intrusions in the experimental areas. None was considered insurmountable, however. The experience suggested that the following requirements should be met: 1) an experimental area of sufficient dimensions and with water deep enough to diminish the probability of poaching; 2) examine the possibility of operating in deep water in terms of setting; 3) authorize use of an experimental basin like that at Bouziges, but larger and free from pollution, and where renewal of water will be easier; and 4) ensure surveillance and permanent control by a qualified person. - J.L.M.

64
Anonymous. 1970.

Crabs are serious predators of clams. Comm. Fish. Rev. 32(4): 18.

Rock crabs, *Cancer irroratus*, and mud crabs, *Neopanope texana*, are serious clam predators. Rock crabs, as numerous as 4 per sq m, can destroy as many as 25 10 mm long clams/hr; mud crabs up to 20 per sq m, can destroy up to 14 small clams (5 mm long) in 1 hr. Thus these two species of crab could almost destroy a good commercial set of clams. - J.L.M.

65
Anonymous. 1971.

Maine Coastal Resources Renewal. Part 1. The Aquaculture component. State Planning Off., Augusta, 46 p.

Aquaculture activities in Maine concerned with hard clam, *Mercenaria mercenaria*, were: laboratory culture by the Dept. of Sea and Shore Fisheries at Wiscasset; and survey of commercially important plants and animals by the Darling Research Center of the Univ. of Maine, also at Wiscasset. Hard clam prospers on shallow bottoms with little tidal scouring but good water movement; is usually found between tides and on shallow gravel, sand, or muddy bottoms. It is cultured by removing seed clams from exposed coastal areas and redistributing them to reduce density and prevent winter exposure. Hard clam is easy to propagate artificially. Can be dredged. Potential exists in selected areas of Casco Bay. To improve yields it is being cultured successfully in commercial laboratories. It cannot tolerate tidal scouring. It is susceptible to predators and pollution, and to disease when cultured intensively. Tradition is a major factor in creating markets. Strong demand for clams in New England makes the area consume 1/2 of the national production of clams, but recent pollution of many flats has forced the region to import 80% of its clam consumption. Hard clam production in Maine has fallen from a peak of 590,000 lbs in 1949 to a yearly average of less than 3,000 lbs in the last decade. The report considers potential and problems, including legal and social aspects. (Abstracter's note: its scientific stature is suspect because specie is used several times where species is meant. Review by a competent biologist would have been advisable.) .- J.L.M.

66
Anonymous. 1971.

Ocean quahog becomes more important as surf and bay clams dwindle. Comm. Fish. Rev. 33(4): 17-19.

"Once thought inexhaustible, resources of hard clams, *Mercenaria mercenaria*, ... are dwindling rapidly; at the same time, demand is increasing constantly." Narragansett Bay once was the best setting ground for hard clam in the world. Blount Seafood Corp., Warren, N.H., once derived 76% of their production from the Bay. Now they handle only a few thousand bushels of hard clam, and process ocean quahog, *Arctica islandica*, almost exclusively. - J.L.M.

67
Anonymous. 1972.

Economic potential of clam operation. Va. Inst. Mar. Sci., manuscript rept., 17 p. (apparently unpublished).

(Abstracter's note: the copy received through interlibrary loan did not identify author, date, or agency.) Cost and return estimates were based on culture of clam larvae and juveniles in a hatchery system, assuming the operation would be in an area where clam culture techniques would work. Hatchery costs were based on actual costs of construction in 1969 and 1970, and equipment costs 1969-71. It is assumed, although the paper does not so state, that the clam was *Mercenaria mercenaria*. Estimated clam production of about 34.5 million clams was based on actual experience in the 1st half of 1972. It was concluded that the method used would provide some profit potential, provided that unforeseen problems did not arise. Costs of $29.9 million over a 10-yr period were estimated to produce average annual profits of about $30,879 per yr. A similar economic survey of bay scallop culture concluded that a modest profit would be realized. - J.L.M.

68
Anonymous. 1972.

Clams from polluted areas show measurable signs of stress. Maritimes, Grad. School of Oceanogr., Univ. R. I., p. 15-16.

Stress from hydrocarbons and other organic compounds dumped into the Providence River causes the meat to be darker, development of a ridge on the inside edge of the shell, where the mantle retracts from the edge, and sometimes a mud-blister infestation which makes the inner surface of the shell around the hinge look as if it has a thin smearing of brownish mud. The clam may also have small pinhead-sized discolorations on the surface of the inner shell. This mud-blister infestation is caused by a parasitic worm not normally found in clams. The clam usually lives beneath the surface but may come to the top when exposed to an irritant. Clams from polluted areas have a smaller average size than clams from clean areas. (Abstracter's note: this might be because no harvesting is allowed.) Kidneys of clams from polluted areas are plugged with a black substance that is a residue of organic compounds. In a normal clam the ratio by weight of taurine to glycine is two to one. In clams from the Providence River, however, the ratio is about five to one. Other reactions to stress are lower amounts of carbohydrates and slightly altered fatty acid patterns. Clams from the polluted area may die in 6 to 8 yrs. Healthy clams may live 12 yrs. When the clams are kept in a clean environment for a year, most symptoms remain. Some hydrocarbons are absorbed by bacteria, leaving a complex of organic materials to be filtered by the clams. These are the irritants that start the syndrome. One way to help the industry might be to leave the clams in the River to provide a spawning stock. Much of the larvae will be carried down to clean areas of the Bay. - J.L.M.

69
Anonymous. 1973.

Partial report of aquacultural studies conducted by the Maine Department of Marine Resources (formerly Department of Sea and Shore Fisheries) based on a five-year grant by Maine Yankee Atomic Power Company. Me. Dept. Mar. Resour., Augusta, 243 p.

The report contains some information on *Mercenaria mercenaria.* In Maine the species is near the limit of its temp range, and it varies widely in abundance for this reason. It is stated that correlation between sea temp and abundance is 0.79 ($F_{0.99}$=0.47), and that the optimum average annual water temp is about 9.3°C. Quahogs grew best in early summer in condenser cooling water discharge, and least in ambient seawater. In summer, growth was best in condenser water maintained below 23°C by mixing with ambient water. - J.L.M.

70
Anonymous. 1973.

Engineering and technology. 8A. Aquaculture Marine Research 1973. NOAA: 621-637.

71
Anonymous. 1973.

Investigation of the impact of a major flood on the fisheries resources and environments of the Chesapeake Bay. VIMS Completion Report.

Hard clam populations suffered the least damage of all shellfishes. Mortality in natural populations was 5% or less, although clams being held for depuration suffered mortalities ranging up to 100% depending on conditions on the depurating beds. Losses to individual firms were as high as $25,000. - M.C.

72
Anonymous. 1974.

The Fish Farming Market. Frost and Sullivan, Inc., 106 Fulton St., New York, N.Y. 10038, 197 p.

According to Vondruska, John (1976). Aquacultural economics bibliography. NOAA Tech. Rept. NMFS SSRF-703, p. 81, this publication contains information on clams (species not given). - J.L.M.

73
Anonymous. 1974.

The case for shucking off clams. The Consumer Newsletter Moneysworth 5(2).

This brief article in a somewhat sensational manner discussed the dangers of eating raw or steamed clams or oysters. Although not specifically mentioned by name, the article apparently encompasses both *Mercenaria* and *Mya.* - M.C.

74
Anonymous. 1975.

Shellfish "farm": California hatchery provides clam, oyster seed for worldwide market. Comm. Fish Farmer and Aquacult. News 1(6): 20-24.

International Shellfish Enterprises, Inc., of Moss Landing, Calif. produces seed of 3 oyster species and 2 clams, including *Mercenaria mercenaria.* Plans were to ship 10 million clam seed and 15 million oyster seed to points in the U.S., Europe and the Far East in 1975. - J.L.M.

75
Anonymous. 1975.

No title. Abstract in National Fisherman, June 1975: 3-B.

Increased yields and easier harvesting are claimed for a new method developed at the New York Ocean Science Laboratory. Seed clams are enclosed in continuous bags of "Vexar" plastic netting made by DuPont Co. Mollusks are fed through a metal tube sleeved with the flexible netting. Mesh size is about 1/2-inch square. As the predetermined quantity of seed clams is fed they bag themselves by pulling the required amount of netting off the outside of the tube. - J.L.M.

76
Anonymous. 1976.

Growing your own clams and oysters. Univ. N. C. Sea Grant Program Newsletter, July 1976: 1, 5.

Advisory agents are reluctant to advise people to plunge into oyster and clam farming, since economic feasibility is still being tested. Clams like shallow water with relatively high salinity, strong tidal currents, and plenty of food. It must be in an area that can be observed and protected from vandals. A pen must be built to keep out predators. Seed clams are then put in the pen, then it is a matter of watching for holes in the wire, removing crabs, raking off seaweed, and waiting 16 to 18 months for the clams to grow to market size. The major question for viable culture is to have enough survival to pay for pens and the lease, plus enough for a reasonable profit. Clam rearing appears feasible provided the area is good for growth. - J.L.M.

77
Anonymous. 1976.

Report on shellfish purification points up need for more research. Comm. Fish Farmer 2(6): 40-41.

Listed also under Furfari, S. A. Abstract no. 460. - J.L.M.

78
Anonymous. 1976.

Bringing clams to the backyard in Buxton. Univ. N. C. Sea Grant Program Newsletter, July 1976: 2.

Describes a project to raise clams *(Mercenaria mercenaria)*. A pen was built of treated wood pilings and vinyl coated wire. It was divided into 7 sections. Clams of various sizes were placed in each, 1/8 inch, 1/4 inch, 3/8 inch, and 5/8 inch. A lease for 5 acres has also been applied for. No results are given. - J.L.M.

79
Anonymous. 1977.

Clam pearls are a rare but delightful find. Marine Resource Bull. 9(1), Va. Inst. Mar. Sci., Sea Grant Adv. Serv.: 3.

Mercenaria mercenaria infrequently produces a pearl which is slightly softer than the oyster pearl, but more varied in size, shape, and color. Such pearls sell for about $35, usually to be set in jewelry. Some clam dealers are said to hoard the pearls and shuckers have been known to hide them in their mouths when they find them at work. Hard clam pearls are 1/4 inch or smaller. They may be round or oval, but usually are slightly flattened balls. Color ranges from white or rose to deep purple. Cooking destroys gem quality. A pearl is formed when a parasite or other foreign substance enters the mollusk. The clam tries to isolate the material with its shell-forming substance. Not enough clam pearls are found to support a commercial industry. - J.L.M.

80
Anonymous. 1977.

South Carolina survey locates subtidal clams. Mar. Fish. Rev. 39(11): 38-39.

The species is not identified, but it is almost certainly *Mercenaria mercenaria*. An extensive survey, started in 1973 and 80% complete by the time of this report, had located concentrations of clams in several areas of the S. C. coast. Most clam resources of the State are in the intertidal zone. The largest concentrations below low tide are in the Santee estuary, and a hydraulic escalator dredge fishery has operated there since 1974. It was not anticipated that the intertidal clam fishery could be expanded significantly. - J.L.M.

81
Anonymous. 1977.

The effects of tropical storm Agnes on the Chesapeake Bay estuarine system. Summary report. In The Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System. Chesapeake Research Consortium, Inc. Johns Hopkins Univ. Press, Baltimore, CRC Pub. 54: 1-29.

The effects of the tropical storm on hard clam, *Mercenaria mercenaria*; blue crab; and finfishes was minor and temporary. Soft shell clams and oysters suffered heavy mortalities. Hard clams survived the fresh waters of Agnes with one prominent exception. Clams relocated from the James River to the York River to undergo a 3-week cleansing period suffered almost 50% mortality. A combination of stress and low salinity apparently was responsible. Direct loss was estimated at $42,410. - J.L.M.

82
Anonymous. 1978.

Louisiana holds promise as big clam producer. Natl. Fisherman Yearbook 58 (13): 182.

Describes the potential of the State for clam production. In the first 3 months of 1977 over 7,000 bushels were harvested experimentally. - J.L.M.

83
Ansell, A. D. 1961.

Reproduction, growth and mortality of *Venus striatula* (da Costa) in Kames Bay, Millport. J. Mar. Biol. Assn. U.K. 41(1): 191-215.

The population studied was made up mostly of clams from a very successful spawning in 1955, which increased the population a hundred-fold. Gonads were ripe in late April to early May, when water temp had reached about 9°C. First spawning was on 20 May in 1957. Spawning was somewhat later in 1958. Clams spawned at intervals through the season and spawning was never complete. Ovogenesis continued through winter, spermatogenesis began shortly after the spawning season was over. Sex ratio was approximately equal, and no hermaphrodites were found. In the laboratory, epidemic spawning occurred, stimulated about equally by either sex. No spawning occurred in the laboratory at temps below 11°C, but observations in nature suggested that it may occur at about 9°C. Eggs were fertilized in the laboratory. Some larvae may set at a length of 190 μ, but most at

200-220 μ. A few remained planktonic until 280 μ. At 5°C larvae failed to grow. At temps from 10°C to 22.5°C larvae behaved normally. Mortality was low at these temps but high at 5° and 26°C. Growth rates increased with temp increase from 5° to 16°C. Maximum growth rate appeared to be at about 18°C and growth was retarded above 20°C. In nature, spat grew to 0.1 to 0.3 mm before the first winter, then growth slowed or stopped. Noticeable growth was restricted to May-Aug inclusive, and reached a max in July. More or less well-defined rings on the shell are formed annually, and can be used to estimate age. The 1955 set grew faster than clams born earlier despite the larger population. About 15% of the clams in their first year of life were bored by *Natica alderi*, 5% in their 2nd, and 1-2% in their third year. An additional 25% of the population died from unknown causes. Experiments showed that mortality was not a function of population density between 300 clams/m^2 and 10,000/m^2. Clams of the 1955 set grew from a mean of about 9 mm on 23 Oct 1956 to 17.9 mm on 18 Feb 1959. - J.L.M.

84
Ansell, Alan D. 1961.

The functional morphology of the British species of Veneracea (Eulamellibranchia). J. Mar. Biol. Assn. U.K. 41(2): 489-517.

Venus casina, V. ovata, and *V. fasciata* were taken off the British coast (exact location not cited) in stony or coarse gravel bottom. *V. striatula* was obtained from Kames Bay and Hunterston Sands, Ayrshire. Some species of *Venus* have short, fused siphons, which may be regarded as primitive in the Veneracea. The genus contains shallow-burrowing forms. The ability to move horizontally as well as ventrally in a soft substrate is retained. *Venus (= Mercenaria) mercenaria* is not mentioned. (Abstracter's note: Hillman (1963) says this paper also contains information on a 4th fold in the mantle of other *Venus* species.) - J.L.M. and M.W.S.

85
Ansell, Alan D. 1962.

Observations on burrowing in the Veneridae (Eulamellibranchia). Biol. Bull. 123(3): 521-530.

Recordings were made of time sequence of movements of *Mercenaria mercenaria* and 4 other bivalve species. All observations were on animals burrowing in clean sand. The sequence is essentially as follows: 1) valves separate; 2) foot is protruded, pointed with a probing motion; back and forth searching motion continues until foot fully extended; tip of foot may extend to a length equal to that of the whole animal; degree of vertical penetration may vary considerably, depending partly on type of substrate; 3) heel of foot is protruded vertically; 4) heel expands laterally and posteriorly so that an anchor is formed; if substrate is firm enough, foot maintains this position and shell moves; 5) valves open slightly; 6) siphonal apertures close, and adductor muscles contract, reducing volume of mantle cavity; excess water is forced out in a stream from anterior end just below adductor muscle; presumably the pallial curtain (velum) maintains a seal around foot and remainder of mantle edge during the operation; almost immediately anterior pedal retractors contract and posterior retractors relax, causing anterior end of shell to dip and posterior end to rise; it is probable that contraction of anterior retractors is confined to that part near its insertion into the shell; final movement takes place as shell moves forward and down; foot remains in position of anchorage and more distal portion of anterior retractors acts to draw body forward; at same time elements of posterior retractors running downward and forward to base of foot contract, assisting movement. At all times during the whole of the digging period tips of siphons maintain contact with surface of substrate. If contact is lost by disturbance or some other cause the sequence of movements is broken. After completion of downward movement siphonal apertures reopen. A short time later, if shell is completely buried, apertures close again and siphons are slightly withdrawn then "stretched." Apertures then reopen. Relaxation of retractor muscles and changes in shape of foot associated with anchorage are brought about by action of intrinsic musculature of foot and visceral mass against a hydroskeleton provided by blood filling the large sinuses. Downward movement is associated with forward movement, so that the animal moves obliquely downward. Forward movement is caused by asymmetry of foot as it protrudes, the posterior end being anchored more or less immediately below posterior margin of shell by the heel, while anterior end of foot is thrust forward some distance. If downward component of movement is prevented, as on a hard substrate, the clam moves horizontally. In both cases the shell makes a rocking movement. Essentially the same actions are responsible for horizontal movements of postlarval clams on hard substrates. Variations in time sequence of digging activities come largely from variation in time required for foot to obtain anchorage in the early stages. Thus, early sequences take longer than later ones. This period ends when hinge margin is level with surface of substrate. Then time intervals between movements drop substantially, then slowly and gradually increase until the sequence is complete. Total depths (to uppermost surface of shell) reached by hard clams at completion of burrowing ranged from 1.4 to 9.2 cm for 84 separate trials. Gradual increase in time sequence, after movements related to initial anchorage, may arise from a gradual increase in resistance as the clam moves deeper. On the other hand, increasing time interval could be an expression of tiring. It has been suggested that cessation of burrowing is caused by fatigue, but this is not likely, because clams will burrow repeatedly if removed from the substratum immediately on completion of a sequence. Because tips of siphons maintain contact with surface of substrate and extension of siphons follows each downward movement, cessation of burrowing may be a response to stimuli originating from siphons. Stretch receptors and other proprioceptors may be acting. - J.L.M.

86

Ansell, Alan D. 1962.

The functional morphology of the larva, and the post-larval development of *Venus striatula* (DaCosta). J. Mar. Biol. Assn. U.K. 42(2): 419-443.

Within the Veneracea the Family Veneridae forms a group of closely related suspension-feeding bivalves, which have retained the ability to move horizontally and vertically close to the surface in relatively soft substrata. The Veneridae have evolved along unspecialized lines, and the slow rate of metamorphosis to the adult form is associated with lack of special adaptations. *Venus (=Mercenaria) mercenaria* is not mentioned. - J.L.M. and M.W.S.

87

Ansell, Alan D. 1962.

An approach to sea farming. New Scientist 14(288): 408-409.

Rate of increase of phytoplankton is controlled mainly by light intensity and ambient temp. Nutrient levels in the sea usually are low, and dense phytoplankton populations occur only rarely. Concrete 1,000 liter (220 gal) tanks were built on the grounds of a generating station at Poole, Dorset, England. Scrubbed flue gas was added as necessary to renew CO_2. N and P fertilizers were added as sodium hydrogen phosphate and ammonium sulphate. A "pure" plant crop was ensured by inoculation at time of fertilization with sufficient algal cells to swamp competitors. The alga *Phaeodactylum* was used because it tolerates extreme conditions and competes successfully with all naturally occurring species that appeared in tanks. Artificial light usually was not necessary because satisfactory growth was obtained almost all year, except early in January. Even when water temp fell to 1°C growth continued, although more slowly. The final crop at low temp may equal that obtained in summer. Although this was batch culture, continued growth could be obtained by harvesting frequently. Yields of up to 7.5 g dry organic matter/tank/day in March and 16.5 g/tank/day in May-Aug were obtained. Average composition of *Phaeodactylum* was 47% protein, 20% fat, and 6% carbohydrate, with 27% ash. Calculated food value, about 4,000 calories/g, compared favorably with many other plant crops and high proportion of protein to dry weight was important. Under the most favorable conditions 80% of the phosphate added may be returned, and a similar yield of nitrogen.

Infection by *Monas* may seriously reduce a culture in a short time, but when a *Phaeodactylum* culture is fast-growing, *Monas* is not a problem. Harvesting and direct use of the phytoplankton crop presents problems, but feeding the culture to *Mercenaria (Venus) mercenaria*, which can filter up to 2 liters of water/hr, and is high priced, may solve the problem. - J.L.M.

88
Ansell, Alan D. 1963.

Seafood from industrial waste. Sea Frontiers 9(3): 178-185.

In England, CO_2 from flue gas of an electric generating plant, water, simple inorganic salts, and sunlight were being used to grow cultures of *Phaeodactylum tricornutum* as food for *Venus mercenaria* in laboratory experiments. Most efficient use of phytoplankton was obtained when it was added to the water in low concentrations. Questions still needed to be answered before full-scale pilot plant operations would be feasible. - J.L.M.

89
Ansell, A. D. 1963.

The biology of *Venus mercenaria* in British waters, and in relation to generating station effluents. Ann. Rept. Challenger Soc. 3(15): 38 (abstract).

V. mercenaria is distributed throughout Southampton Water in southern England and has been recorded from Portsmouth Harbor and the Newtown estuary, Isle of Wight. Centers of maximum population density are Netley, Marchwood, and Millbrook Point. Annual growth in length and weight is greatest in warm water from Poole generating station. Clams there begin growth earlier in the season and continue later. Differences in salinity or substrate type did not appear to affect growth. In warm effluents clams came into condition earlier in the season and reached spawning potential earlier. The peak was maintained slightly longer than at other sites, but spawning potential fell off in July, remaining high elsewhere. In British waters *V. mercenaria* behaves like an animal near the northern limit of its range. Effects of warm effluents change this response to one typical of more southerly areas. Great potential advantages were seen in controlled use of warm effluents. - J.L.M.

90
Ansell, Alan D. 1963.

Venus mercenaria (L) in Southampton Water. Ecology 44(2): 396-397.

Venus mercenaria had been known to occur in Southampton Water, the estuary of the River Test in southern England. It also is found in the Solent, the strait between Southampton Water and the Isle of Wight, and in Portsmouth Harbour to the east. It is well established in the area, growth is rapid in some places, and the species produces a spatfall in some years. The detailed distribution is described. Clams placed in a laboratory tank, from an ambient natural temp of 16°C to 18.6°C, spawned. Clams have spawned in the laboratory at temps between 17.8 and 26.9°C with and without stimulation by sperm suspension. Clams which spawned at 17.8°C had never been in temps higher than 18°C and had been exposed to a rise of only 2°C before spawning. This is lower than ever before reported and suggests that the species has become acclimated to local temps, which rarely exceed 22°C. Fertilized eggs have developed into straight-hinge veliger larvae within 48 hrs at 19° to 21°C and have been brought to setting, typically in 13 days after fertilization. Clams have been estimated from shell rings to be 5+, 9+, and 12+ yrs old, suggesting setting in 1955, 1951, and 1948. Age distribution varies somewhat with locality. Size-frequency distributions are given for three areas. The origins of these clams are obscure. Experimental introductions have been made in Great Britain, but none is known in the Southampton area. It is suggested that accidental introductions via the galleys of transatlantic vessels is most likely. The time of introduction is not known, except that it was prior to 1948. Successful establishment and spreading may have been assisted by warm water from many industrial sites in the area. - J.L.M.

91
Ansell, Alan D. 1964.

Some parameters of growth of mature *Venus mercenaria* L. J. Cons. 29(2): 214-220.

Most of the data reported in this paper were based on hard clams from the area of the outfall of Marchwood generating station in Southampton Water in southern England. Relationship between length and total weight was determined separately for adults and for laboratory-reared juveniles: adults, log W = 2.8838 log L - 3.2869; juveniles, log W = 3.1422 log L - 3.6185. For wet and dry flesh weight it was assumed that regression lines for all W/L relationships should be parallel, and in the form log W = 2.8838 log L - X, where X was calculated for upper and lower limits of possible values from X = - 3.2869 (for total weight) using upper and lower of other weights as percentages of total weight. When wet flesh W was 8% of total W, log F_w = 2.8838 log L - 4.3838; at 25% of total W, log F_w = 2.8838 log L - 3.8890. Dry flesh weight varied between 1.5% and 5.5% of total weight, and the appropriate equations were: log F_d = 2.8838 log L - 4.5465; and log F_d = 2.8838 log L - 5.1108. Exact relationships depended largely on state of gonads, which affected wet and dry flesh weights. Percentage wet flesh weight increased progressively with increase in size of clam from Jan to Mar 1962, but from June onwards percentage wet flesh weight was more or less the same for clams of all sizes. The same variations applied to dry flesh weights. Limits of total body nitrogen in relation to length were: log N = 2.8838 log L - 5.6434, and log N = 2.8838 log L - 6.1108; limits of total carbohydrate were log C = 2.8838 log L - 5.0917, and log C = 2.8838 log L - 5.9647. Relationships between length and total volume, and length and shell cavity volume, respectively were: log V_t = 3.0497 log L - 3.7867, and log V_{sc} = 3.1653 log L - 4.2652. The wide variation found demonstrates the dangers of using such transformations unless the "condition" of the animals is well known, in preparing the regression line and in the actual experiments. Where only length is known for a given group of clams, the only accurate transformations are to total weight, total volume, and shell cavity volume. Position of the regression line within limits given here depends on "condition", slope depends on relative condition of animals of different sizes. - J.L.M.

92
Ansell, Alan D. 1964.

The clam and industry in Britain. Sea Frontiers 10(1): 48-55.

Venus mercenaria has become naturalized after accidental introduction in some European areas, notably in Southampton Water, England. Although the clam is localized within the single estuarine system it has become the dominant bivalve on many shores. History of the species in England began with several accidental and deliberate introductions in the 19th century. Live specimens were recovered from the estuary of the Humber in 1864 and clams were taken at intervals until 1907. It is unlikely that it bred there, and the colony was supported only by continued introductions from the U.S. In 1869 clams were imported and planted at Reculver in Kent and at the mouth of the Mersey. These clams did not survive. In 1883 another attempt to introduce hard clams near Liverpool, this time in waters of lower salinity, also failed. Other attempts in northern waters of Britain, although clams survived for a while, did not develop breeding stocks. In the early 1860s similar introductions were made in French waters. These clams did not reproduce. Some 50 yrs later, however, successful introduction was made at Charente-Maritime, which now supports the only hard clam fishery in Europe. The colony in Southampton Water may have originated from clams accidentally introduced with American oysters, or as some have suggested, larvae may have drifted across from Brittany. The most likely explanation is that clams may have been discarded from the galley of a transatlantic liner, for which Southampton is a major port. There is some evidence that the original introduction occurred prior to 1936 and that the population remained at a low level for a time. Southampton Water is moderately polluted, and the pollution-tolerant hard clam may have thus been able to occupy the niche vacated by the less tolerant soft clam. At Marchwood, near where the Test River enters Southampton Water, an electric generating station has raised water temperatures by discharging saline cooling water. This may have enhanced the environment for successful clam spawning. The season of growth may have been extended by as much as a month and the rate of growth in the growing season was about doubled. No evidence of increased mortality was found. Greatest effects were noted in things like growth and condition, which are important in commercial shellfish growing. The author suggests that these favorable conditions could be used to advantage, combining them with hatchery culture and predator control. - J.L.M.

93
Ansell, A. D. 1964.

Experiments in mollusc husbandry. Fish. News Internatl. 3(3): 216-219.

Laboratory experiments were conducted on *Venus mercenaria* fed with cultures of *Phaeodactylum tricornutum*. The diatom was chosen because it is tolerant to different and changing conditions, hence is relatively easy to culture. As hard clams grow, rate of transport of water increases, so that a large clam may pump up to 6 liters of water/hr. Below about 6°C most clams are inactive, but above 9°C most are active. Rate of water movement increases with temp within tolerance range of the animal. In winter, between Sept and March or April, lack of food and low temps restrict clam activity. Condition may remain fairly steady or fall slightly, and carbohydrate reserves are used up gradually. When plankton is abundant in spring response of clams varies with temp. Thus, if temp is too low, growth and condition do not improve even if food supply is abundant. In warm water from a power plant the period of growth is extended, growth is faster, and condition and reproductive activity are affected favorably. By manipulating water temp and augmenting food supply clams can be brought to marketable size in half the time required under traditional methods. Possibilities for such intensive culture, using warm water from power stations should be studied on a larger scale. Seed can be produced in hatcheries. - J.L.M.

94
Ansell, Alan D. 1967.

Egg production of *Mercenaria mercenaria*. Limnol. Oceanogr. 12(1): 172-176.

Hard clams from Southampton Water, England, were induced to spawn in the laboratory. In two experiments the range of eggs spawned per female was 0.38×10^6-18.83×10^6 and 0.58×10^6-29.93×10^6, respectively, and the average number of eggs per female was 7.11×10^6 and 9.28×10^6. Shell cavity volume of female clams was weakly correlated with number of eggs produced, but number of times a female spawned was not related to number of eggs produced. In the first experiment the clams were mostly smaller than those used by Davis and Chanley (1956). The results were consistent if the relationship between shell cavity volume and egg production is extrapolated. In the 2nd experiment clam sizes were similar to those of Davis and Chanley but number of eggs was still significantly lower. In Southampton Water gametogenesis does not occur directly after spawning, but in the following spring. Clams collected in January still must undergo main period of gonad proliferation before spawning. Davis and Chanley's clams were from Long Island Sound where gonad proliferation resumes following spawning and continues until December. For these reasons, clams from Long Island Sound would be expected to produce more eggs than clams from Southampton Water collected in winter. - D.L.

95
Ansell, Alan D. 1968.

Defensive adaptations to predation in the mollusca. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 487-512.

This review paper states that *Venus (Mercenaria) mercenaria* avoids predation by burrowing. The reference paper is abstracted elsewhere in this bibliography. *V. ovata* and *V. rhomboides* can leap out of the substrate. - J.L.M.

96
Ansell, A. D. 1968.

The rate of growth of the hard clam *Mercenaria mercenaria* (L) throughout the geographical range. J. Cons. 31: 364-409.

Published data on growth of hard clam throughout its geographical range are reviewed and data transformed for comparative purposes. Local variation in annual growth is extreme and is more or less the same throughout the continuous range of the species. Growth occurred only in summer in the northern part of the range, and throughout the year in the southern part. Optimum temperature for growth was 20°C and no growth occurred below 9°C or above 31°C. The relationship of growth and temperature appeared similar throughout the species geographical range. Deviations from the growth-temperature relationship were interpreted as the effect of other factors such as food availability on growth. Data for growth of *Mercenaria campechiensis* and *M. mercenaria* X *M. campechiensis* hybrids are presented. Growth in these clams increases with increasing temperature in the range 10-30°C. - D.L.

97
Ansell, Alan D. 1969.

Thermal releases and shellfish culture: Possibilities and limitations. Chesapeake Sci. 10(3-4): 256-257.

Development of intensive shellfish cultivation requires 1) a reliable source of seed, 2) systematic optimum conditions of culture for maximum yield, and 3) application of techniques like selective breeding to improve the stock. Use of waste heat may contribute to requirement 2. Warm water can be used to provide an extended, or even continuous, growing period. Observations on *Mercenaria mercenaria* at Poole, Dorset, and nearby control areas has shown that for most of the year growth was limited by factors other than temp, the most important of which was availability of suitable planktonic food. The main effect of increased temp was to allow the animal to utilize more effectively peaks of plankton biomass which occur at times when normally clam activity was reduced. Thus, while irrigation by warm water simulated conditions typical of areas farther south, the water mass as a whole was not similarly affected, and the seasonal cycle of phytoplankton biomass characteristic of inshore boreal waters remained a limiting factor. Excess food was present only for short periods, and at times food supply was insufficient to serve maintenance needs of clams at higher temp. From Oct to Feb clams did not grow even at temps over 10°C, and body weight fell. Optimum temp for shell growth was 20°C but condition increased at lower temps, with optimum about 14°C. Thus, at optimum temp for shell growth, meat yield may be decreased. Full potentiality of warm-water culture may be achieved only with supplemental feeding, e.g., thermal and nutrient enrichment are necessary. Growing and fattening may require separate stages of culture. More rapid glycogen accumulation might be obtained by controlled use of non-living food. Limitations of power plant operation must be considered: water supply may be discontinuous and temp may vary. Annual temp range may be extended to include higher summer temps but retaining normal winter temps. Diurnal temp fluctuation may be greater and abrupt temp changes more frequent than in nature. Thus, the species used must have high temp tolerance. Another constraint is use of chemicals to prevent fouling in the power plant. Other incidental additions, such as heavy metals and radionuclides, must be expected. - J.L.M.

98
Ansell, Alan D. 1977.

The adenosine triphosphate content of some marine bivalve molluscs. J. Exper. Mar. Biol. Ecol. 28(3): 269-283.

Total ATP (adenosine triphosphate) content of representatives of 23 bivalve families varied from 1.26 to 0.26% of dry tissue weight. Four members of family Veneridae were examined, but not *Mercenaria mercenaria*. ATP content of these 4 varied from 0.18 to 0.82% of dry tissue. Highest values were in muscle tissues. High maintained levels of ATP were associated with ability of species to use energy rapidly for short periods, such as in escape responses. Thus, some families have consistently more than average, and some consistently less than average ATP values. - J.L.M.

99
Ansell, Alan D., and K. F. Lander. 1967.

Studies on the hard-shell clam, *Venus mercenaria*, in British waters. III. Further observations on the seasonal biochemical cycle and on spawning. J. Appl. Ecol. 4(2): 425-435.

Clams were collected along the downstream bank of the outfall channel of a power station in Southampton Water in the same area used in earlier studies. From Jan 1963 to Oct 1964 percentage wet and dry flesh weight followed an upward trend, with peaks in early June and Aug in 1963 and a peak in May in 1964. Trend in wet weight over nearly 2 yrs was from about 13% to about 17%. Trend in dry weight was from about 2.2% to about 3.6%. Spawning potentiality peaked in early June, in Aug and in Oct in 1963, and in May in 1964. These trends were accompanied by a downward trend in water content of flesh. Spawning invariably led to a rise in water content. Studies in 1961 and 1962 showed differences in cycle of condition changes between small and large clams. No significant size difference was seen in 1963-64. The autumn peak is more likely to produce a set of young clams. Total N content reached a minimum between Nov and Feb and peaked in May or June. Total N fell after spring spawning and rose to a second peak prior to autumn spawning. In 1962 changes in carbohydrate and protein occurred together, leading to the conclusion that this was related to development of gonad and spawning, and that storage of reserve carbohydrate was not very important. But in 1963 total carbohydrate rose rapidly in spring, but although N fell at spawning, carbohydrate remained high until Nov. In 1964 carbohydrate did not rise appreciably until July. Ash content of flesh showed no significant cycles. The population studied is not characteristic of the whole clam population in Southampton Water because cooling water of the plant keeps water temp higher. In other areas, away from influence of warm water, wet and dry flesh rise to a peak in July-Aug, then fall. There is apparently no spring spawning. Increases in organic production associated with growth accounted for 64% of total production in 1962, 51.9% in 1963, 69.6% in 1964. Losses from spawning were 1 g in 1962 and 1.4 g in 1963. Thus, total organic material released as spawn was 26.5% in 1962 and 25.9% in 1963. By the end of summer there is a net gain in stored reserves, accounted for by an increase in total carbohydrate content. In winter part of this reserve is utilized. As carbohydrate is used up, water content rises, so the change is not reflected in wet weight percentage. On a dry weight basis gonad production is between 40 and 60% of total organic production each year. About 16% of total production may be used in winter, when metabolic rate may fall to 5% of summer rate. Where natural populations of clams are sparse, only intermittent spawning occurs, probably because not enough sex products are produced to stimulate all clams to spawn. Spring spawning in the area of the power plant does not produce recruitment for the clam population as a whole because temp outside the warmed area is too low. Years when successful sets have occurred have been years of hot, dry summers. Water temp may act directly by determining whether eggs and larvae can survive and grow. Low rainfall reduces flushing and aids retention of larvae until setting. The good setting years 1955 and 1959 were anomalous in seasonal pattern of zooplankton production and possibly also in phytoplankton abundance. Zooplankton production was low in fall, hence grazing of phytoplankton was reduced. Reduction in competition may favor survival of clam larvae. - J.L.M.

100
Ansell, Alan D., and F. A. Loosmore. 1963.

Preliminary observations on the relationship between growth, spawning and condition in experimental colonies of *Venus mercenaria* L. J. Cons. 28(1): 285-294.

Despite the commercial importance of *Venus (Mercenaria) mercenaria* in the U.S. few studies have been made of ecology and growth of adults. Major works, abstracted elsewhere in this bibliography, are identified. Observation of natural and experimental populations of hard clam in Southampton Water and Poole Harbour in southern England showed that spawning and growth were related to condition of clams in each population. In *V. mercenaria*, unlike oysters, little storage of food reserves occurs, and development of gonadial material takes place as and when sufficient food is available. This has an effect on commercial fisheries, because hard clams reach peak condition (which is a measure of the state of the gonad) immediately before and during the spawning season. Environmental factors appear to affect condition, growth and spawning similarly, so that in areas where growth is early, fattening and ripening of gonad will occur early also. Animals from a population with condition index less than about 12 (mean wet weight of flesh as a percentage of total wet weight of animal in shell) were unlikely to spawn even when subjected to spawning stimuli, although work in the U.S. and in England has shown that spawning can be induced in winter when condition index is lower than 12. It would be interesting to know whether the induction process produces a short rise in condition index, or changes the physiological state of gonad development only. - J.L.M.

101
Ansell, A. D., and E. R. Trueman. 1967.

Burrowing in *Mercenaria mercenaria* (L.) (Bivalvia, Veneridae). J. Exper. Biol. 46: 105-115.

Studies were made with new techniques based on measures of impedance, hydrostatic pressure and displacement, which offered minimum disturbance to normal activities. Digging cycle includes extension of foot, closure of siphons, adduction of shell valves, and retraction of foot, in that order. Digging period includes many digging cycles, which bring the clam to its final position in the substrate. Closure of siphons and apposition of mantle margins temporarily seals the mantle cavity to form a pressure chamber. Adduction dilates distal portion of foot, aiding anchorage, and ejection of water from mantle cavity loosens sand. Downward movement is by passive dropping of the heavy shell into the fluid cavity formed at adduction, and by active movement caused by contraction of retractor muscles pulling the shell downwards toward the anchored foot. Strength of pedal retraction is 5-6 g in a clam of 21 g in water. When shell is completely covered by sand the opening movement of the ligament is too small to open valves completely, and pressures generated by withdrawal of foot and siphons in a secondary phase of siphonal movements supplement action of the ligament. Burrowing movements of *Mercenaria* are compared with those of 5 other bivalves. Greatest contrast was with *Ensis*. *Mercenaria* is protected from predators by the heavy shell. Its response to disturbance, which involves stimulation of siphons, is to withdraw siphons and close shell. Burrowing occurs normally only after gross disturbance when clam has been exposed on the surface of the substrate, or in response to continued unfavorable conditions in the overlying water. Penetration is made with foot extended ventrally, by antero-posterior rocking caused by successive contraction of the almost equally sized anterior and posterior pedal retractor muscles. (Abstracter's note: maximum depth to which *Mercenaria* may burrow is not stated, but according to the illustrations this appears to be only about 1/5th to 1/6th the height of the shell from ligament to valve edge.) - modified authors' summary - J.L.M.

102
Ansell, A. D., F. A. Loosmore, and K. F. Lander. 1964.

Studies on the hard-shell clam, *Venus mercenaria*, in British waters. II. Seasonal cycle in condition and biochemical composition. J. Appl. Ecol. 1(1): 83-95.

Total weight of each clam was determined after washing in fresh water and air-drying. Wet flesh weight was measured after a standard draining period of about 48 hrs. Usually, air-dried shells also were weighed. Ash content of flesh was determined after ignition at 800°C. For chemical determinations one or more meats were homogenized. Lipid was determined by Soxhlet extraction with carbon tetrachloride or petroleum ether. Total N of flesh was done after Kjeldahl digestion of 2 g of meat. Carbohydrate was determined as glucose. Clams were taken from shore along the outfall channel of a power station in Southampton Water. A few came from experimental sites elsewhere. Condition was expressed as ratio of wet flesh weight to total weight in percent. Condition was lowest, about 11%, in Feb. Values rose through Mar to May inclusive, parallel with the rise in spawning potentiality. Condition index reached a peak of 15.5% in early June, as did spawning potentiality, then both values fell as spawning began. In late July these values rose again, then fell to the end of Sept. Condition index remained fairly steady during Sept to Nov inclusive, then fell to a minimum in late winter. Dry flesh weight expressed as a percentage of total weight showed a similar seasonal cycle, from a minimum of 2 to a maximum of 3%. Condition may vary from year to year. Large clams showed a different seasonal cycle than small animals. In winter, condition was correlated positively with size. In spring, condition of smaller clams increased relatively more rapidly, so that by early June all clams had same average condition factor. Differences in condition between 1961 and 1962 appeared to be related to spawning potentiality, suggesting that 1962 was a "good" spawning year, 1961 less favorable. No extensive spatfall was noted in 1961. Biochemical analysis on clams collected on 3 April 1962 gave the following results: small clams (2.5 to 4.5 cm shell length) - moisture 82.1%; protein (=Nx6.25) 11.1% wet, 62% dry; lipid 0.3% wet, 1.7% dry; carbohydrate 3.3% wet, 18.4% dry; ash 1.6% wet, 8.9% dry. Large clams 5.75-9.5 cm): moisture 81.1%; protein 11% wet, 58.2% dry; lipid 0.5% wet, 2.6% dry; carbohydrate 4.2% wet, 22.2% dry; ash 2% wet, 10.6% dry. Lipid showed little significant seasonal variation. Percent protein fell steadily from maximum in Feb to minimum from June to Sept inclusive. Carbohydrate in small clams rose from minimum in March to maximum in July; in large clams carbohydrate fluctuated but showed no significant seasonal trend. Analysis of adductor muscle, mantle, siphons, visceral mass, digestive gland, and foot showed little significant seasonal change in most, with possible exception of foot, mantle, and siphons, in which carbohydrate fell steadily from Jan-Feb to May-June and protein rose. Lipid content of digestive gland was high compared to that of other organs, which agrees with its suggested function in part as a site for fat storage. Gonad had much higher carbohydrate than any other organ. Changes in carbohydrate composition of small clams therefore must be caused by proliferation of gonad, arising from consequent increase in ratio of gonad weight to meat weight. In other areas preliminary analyses showed clams to have higher condition indices. It was suggested that in sparse populations gametes are too sparse in the water to stimulate mass spawning, thus spawning rarely occurs and loss of condition is slight. Some conclusions could be drawn from the study about organic production represented by gonad development and the contribution of this to total production from all growth processes. During 1962, a 4 cm clam of 2.4 g initial wet meat weight added about 2 g organic wet material by growth. In this period gonad material of about 3 g wet meat was developed, of which about 2.6 g was released in spawning. Total increment retained was therefore about 2.4 g wet flesh. About 52% of total organic production was released as spawn. Contribution to organic production by gonad development and spawning also can be estimated from changes in carbohydrate/protein ratio. The estimate corresponded closely with that derived from wet flesh weight. Male and female gonads when ripe may make up to 50% of total body weight. There is apparently no antagonism between gonad development and body and shell growth. - J.L.M.

103
Ansell, Alan D., J. Coughlan, K. F. Lander, and F. A. Loosmore. 1964.

Studies on the mass culture of *Phaeodactylum*. IV. Production and nutrient utilization in outdoor mass culture. Limnol. Oceanogr. 9(3): 334-342.

104
Ansell, A. D., K. F. Lander, J. Coughlan, and F. A. Loosmore. 1964.

Studies on the hard-shell clam, *Venus mercenaria*, in British waters. I. Growth and reproduction in natural and experimental colonies. J. Appl. Ecol. 1(1): 63-82.

An accidentally introduced, successfully reproducing colony of *Venus mercenaria* in Southampton Water is compared with experimentally introduced colonies in Poole Harbour and elsewhere. Temp is a major factor affecting growth rate. Where animals are exposed to warm water from cooling water outfalls of electric generating stations the season of growth is extended and the instantaneous rate of growth increased. Exposure to warmed water also produces an earlier build-up of spawning potentiality, and results in a greater production of eggs. *V. mercenaria* in British waters behaves like an animal near the northernmost limit of its range. The effect of exposure to warmer waters of a generating station is similar to a shift southwards in geographic range. This could be used to develop intensive culture. - J.L.M.

105
Arcisz, W., and L. A. Sandholzer. 1947.

A technological study of the ocean quahog fishery. Comm. Fish. Rev. 9(6): 1-21.

This is a comprehensive account of status of knowledge of *Arctica islandica* in the mid-1940s, including classification, anatomy, geographic distribution, existing commercial fisheries, fishing methods, processing, food quality, and bacteriological condition. It was located through the key word *quahog*. *Mercenaria mercenaria* is not mentioned.

106
Arcisz, William, Elsie Wattie, and James L. Dallas. 1953.

Seasonal variations of coliforms and enterococci in a closed shellfish area. Natl. Shellf. Assn., Convention Addresses 1951: 1-11.

Eel Pond, an arm of the sea with a narrow entrance, lies in the center of Woods Hole, Mass. It is moderately polluted year-round, but pollution increases markedly from June to Aug, with influx of summer visitors. Surface water samples were taken at 6 stations at least once a month from Aug 1948 through July 1950. At one station samples of 6 or more *Venus mercenaria* were taken for bacteriological examination. Coliform MPN/100 ml varied from 208 to 10,500 average monthly values. In general they were highest in summer, lowest in winter, following trend of water temp. A secondary peak in April was attributed to temporary increases in population, as summer residents visited to inspect and prepare their homes. Average monthly counts of enterococci varied from 1.0 to 119.0 MPN/100 ml, highest in Apr, lowest in Oct. Coliform counts in quahogs were lower in winter, higher in summer, than in the water. From Dec through Apr, coliform counts in clams were considerably below the 2,400 MPN/100 ml Public Health Service tentative coliform standard for shellfish other than oysters, while the overlying water was in the grossly polluted range. Enterococcus values were about the same in clams and water from Dec through Mar, then rose and remained much higher from Apr through Nov. At the station near the entrance to the Pond from which clam samples were taken, coliform and enterococci counts were higher than at other stations. Salinities ranged from 27°/°° to 32°/°°. Water pollution was correlated directly with size of human population. But even in winter, when the population is at a minimum, water quality does not decrease sufficiently to permit harvesting or marketing of shellfish. - J.L.M.

107
Armstrong, Lee R. 1965.

Burrowing limitations in Pelecypoda. Veliger 7(3): 195-200.

Experiments were made on 10 clam species (*Mercenaria* not included) to determine how clams, once in position and covered with sand, could elevate themselves back toward the surface. It was demonstrated that clams do not elevate voluntarily in their burrows. Directional movements were rotational and downward only. All species studied, including *Protothaca staminea* and *Saxidomus nuttalli*, which are similar in external morphology to *Mercenaria*, were less dense than the medium in which they live, so that, when agitated, they were buoyed upward. Clams subject to wave action can regain normal posture as long as they are not buried with siphons down. (Abstracter's note: It would be interesting to repeat these experiments with *Mercenaria mercenaria*.) - J.L.M.

108
Arnold, Augusta Foote. 1901.

The Sea-Beach at Ebb-Tide. Dover Pubs. Inc., New York (reprinted 1968), xii+490 p.

Hard clam ranges from Cape Cod to Florida in shallow, muddy bays and estuaries or sandy open deeper bays or open ocean. Harvest is extensive from Cape Cod to Cape May with rakes. Greatest length is about 3" and height 2 1/2". The species increases in size and bulk toward the south, sometimes reaching 5 lbs and 6" diameter. The shell is distinguished by prominent umbones directed forward, heart-shaped lunule, external ligament, concentric sculpturing of growth lines, pure white interior sometimes with violet zones around muscle scars and margin, three stout cardinal teeth, fine crenulation inside ventral margin, and sharp-angled pallial sinus. - J.L.M.

109
Askew, C. G. 1972.

The growth of oysters *Ostrea edulis* and *Crassostrea gigas* in Emsworth Harbour. Aquaculture 1: 237-259.

Hard clams held in separate trays at each site became smothered with silt and suffered almost total mortality. Thus no results on *Mercenaria mercenaria* were included. - J.L.M.

110
Atkins, Daphne. 1936.

On the ciliary mechanisms and interrelationships of lamellibranchs. I. Some new observations on sorting mechanisms. Quart. J. Micr. Sci. 79(314): 181-308.

The lamellibranchs studied, in which *Venus* or *Mercenaria* were not included, agree in having a sorting mechanism on the gills, composed of adjoining tracts of frontal cilia beating in opposite directions on the same gill filament or leaflet. The arrangement was somewhat different in different groups. Tracts of fine frontal cilia, beating continuously, convey particles intended for consumption, while tracts of coarse cilia, fully active only when stimulated, transport material intended to be rejected. Although these tracts function to sort food, their chief value may be to remove from gills mud or sand which appears in the water periodically. When coarse cilia of rejection tracts are fully active, i.e., when much material is dropped on the gill, they sweep everything in the direction in which they are beating, especially if the particles have become connected by mucus, overcoming by their greater strength the action of the fine cilia of the food tracts. The paper is clearly illustrated with many drawings. - J.L.M.

111
Atkins, Daphne. 1937.

On the ciliary mechanisms and interrelationships of lamellibranchs. II. Sorting devices on the gills. Quart. J. Micr. Sci. 79(315): 339-373.

Several species of *Venus* are mentioned, but *Venus (Mercenaria) mercenaria* is not included. The paper is clearly illustrated and will be useful as a guide to ciliary mechanisms in related species. - J.L.M.

112
Atkins, Daphne. 1937.

On the ciliary mechanisms and interrelationships of lamellibranchs. III. Types of lamellibranch gills and their food currents. Quart. J. Micr. Sci. 79(315): 375-421.

Seven main types of lamellibranch gill and their food currents have been described and compared. Reference to *Venus (Mercenaria) mercenaria* is through the work of Kellogg (1915), which is abstracted elsewhere in this bibliography. Atkins says that Kellogg found frontal currents directed ventrally on all gill lamellae of *V. mercenaria*, passing to the free edge on all demibranchs. - J.L.M.

113
Atkins, Daphne. 1937.

On the ciliary mechanisms and interrelationships of lamellibranchs. IV. Cuticular fusion, with special reference to the fourth aperture in certain lamellibranchs. Quart. J. Micr. Sci. 79(315): 423-445.

114
Atkins, Daphne 1938.

On the ciliary mechanisms and interrelationships of lamellibranchs. VII. Latero-frontal cilia of the gill filaments and their phylogenetic value. Quart. J. Micr. Sci. 80: 345-436.

Several species of *Venus* are mentioned, but not *Venus (Mercenaria) mercenaria*. This paper and the others in the series provide a detailed description of ciliary mechanisms and structure of related species, illustrated with elegant drawings. - J.L.M.

115
Atkins, Daphne. 1943.

On the ciliary mechanisms and interrelationships of lamellibranch bivalves. VIII. Notes on gill musculature in the microciliobranchia. Quart. J. Micr. Sci. 84: 188-255.

116
Atlantic States Marine Fisheries Commission. 1958.

16th Annual Report, 79 p.

Records the request of the North Atlantic Section of the Commission to the U.S. Fish and Wildlife Service to make a census of the hard clam population of Nantucket Sound. This report also gives progress reports on clam investigations and contains lists of publications of clam investigations personnel from 1947 to 1957, and clam research project reports from 1948 to 1957. All publications of the Commission should be consulted for references to studies of *Mercenaria (Venus) mercenaria*. - J.L.M.

117
Atwater, W. O. 1892.

The chemical composition and nutritive values of food-fishes and aquatic invertebrates. In Misc. Doc. 274, House of Reps. 1st Sess., 51st Congress 1889-90. Pt. XVI. Rept. Comm. Fish and Fisheries for 1888: 679-868.

Two samples of *Venus mercenaria* were examined, from Little Neck, N.Y. (whole clams in the shell) and Islip, N.Y. (canned). The following analyses are reported (whole clams first, canned clams in parentheses): number of clams 20(25); total weight 1,907.5 g (409.5); average weight 95.4 g (16.4); whole specimens, flesh 16.8% (50.55), liquids 14.91% (49.45). Total edible portion 31.71% (100%), shell and other refuse 67.5% (0), loss in preparation 0.79% (0), water-free substance of flesh 3.66% (12.35), of liquids 0.73% (4.69), of edible portion 4.39% (17.04). Flesh contained water 78.24% (75.56), water-free substance 21.76% (24.44); liquids contained water 95.12% (90.52), water-free substance 4.88% (9.48); total edible portion contained water 86.18% (82.96), water-free substance 13.82% (17.04). Proximate analysis gave for water-free substance in flesh N 8.52 (10.93), protein calculated as Nx6.25=53.25 (68.31), fat 3.39 (5.20), and crude ash 10.19 (9.53); in liquids N 2.96 (6.88), protein 18.50 (43.00), fat 0.34 (2.73), ash 64.97 (34.43); in total edible portion N 7.60 (9.81), protein 47.49 (61.32), fat 2.88 (4.52), ash 19.28 (16.38). For fresh substance similar analyses gave for flesh: water 78.24 (75.56), N 1.86 (2.67), protein 11.59 (16.70), fat 0.74 (1.27), ash 2.22 (2.33); for liquids: water 95.12 (90.52), N 0.14 (0.65), protein 0.90 (4.07), fat 0.02 (0.26), ash 3.17 (3.26); for total edible portion: water 86.18 (82.96), water-free substance 13.82 (17.04), N 1.05 (1.67), protein 6.52 (10.45), fat 0.40 (0.77), ash 2.68 (2.79), and extractives 4.24 (3.03). - J.L.M.

118
Atwater, W. O. 1892.

The chemical composition and nutritive values of food fishes and aquatic invertebrates. U.S. Comm. Fish., Rept. 16, 679 p.

Data cited by Vinogradov 1953. - J.L.M.

119
Atwood, Roger P., James D. Cherry, and Jerome O. Klein. 1964.

Clams and viruses: Studies with Coxsackie B5 virus. Unpublished studies. Communicable Disease Center, Hepatitis Surveillance Rept., U.S. Pub. Health Serv., Atlanta, Ga., p. 26-27.

Experiments on *Mercenaria mercenaria* were made to measure rate of clearance of virus from seawater and clam tissues. Distribution of virus in clam gills was roughly the same as in whole clams. Distribution of virus in seawater and in whole clam with time was roughly similar. Titer of virus in clam tissues increased in the 1st one or two days, but remained well below initial water titers. Titer in clams declined after 2nd day but somewhat more slowly than in seawater, so that after 6th day the amount of recoverable virus in clams exceeded that of seawater. Incomplete studies with polio virus Type I and clams also showed no higher titer in clam tissue than in water samples. It was concluded that, although low titer in virus may persist in clams somewhat beyond its extinction point in seawater, there appears to be no true concentration or multiplication of virus in clam tissue. - J.L.M.

120
Avolizi, R. J., and M. A. Nuwayhid. 1974.

Effects of crude oil and dispersants on bivalves. Mar. Pollut. Bull. 5(10): 149-153.

Experiments were done on *Brachidontes variabilis* and *Donax trunculus*. *Mercenaria mercenaria* is not mentioned. Light Arabian crude was most toxic to *Donax*, Corexit most toxic to the mussel. Oil also depressed significantly the respiration of *Brachidontes* at sublethal concentrations. - J.L.M.

121
Ayres, P. A. 1975.

The quantitative bacteriology of some commercial bivalve shellfish entering British markets. J. Hyg. Camb. 74(3): 431-440.

Samples were obtained from producers or wholesalers. Only six samples of hard clams were treated, from a producer or wholesaler on the east coast. No specific comments are given on these samples. The relation between the numbers of non-specific bacteria growing at 20° and 37° appears to be a useful measure for assessing the likelihood that raw shellfish are a public health risk. - J.L.M.

122
Baab, Judith S., Gerald L. Hamm, Kenneth C. Haines, Arthur Chu, and Oswald A. Roels. 1973.

Shellfish mariculture in an artificial upwelling system. Proc. Nat. Shellfish. Assn. 63: 63-67.

A mariculture system was established in St. Croix using "artificial upwelling" to obtain deep water rich in nutrients. *Mercenaria mercenaria* were grown in sediment and wire trays. Diatoms were *Bellerochea*, *Chaetoceros*, and *Thalassiosira*. After 60 days clams in trays had about a 9% increase in weight while clams in sediment showed about a 14% increase. Clams in tanks cleaned every three weeks filtered cells with greater efficiency than clams in tanks cleaned every one or every two weeks. After 29 days, clams in the tank cleaned every three weeks had 9.5% increase in weight; clams in tanks cleaned every two weeks had 5.2% weight increase; and clams in tanks cleaned every week a 4.8% increase. F_1 hybrids (male *M. mercenaria* X female *M. campechiensis*) grew 5 times as fast as pure *M. mercenaria*. - D.L.

123
Bader, Richard G. 1954.

The role of organic matter in determining the distribution of pelecypods in marine sediments. J. Mar. Res. 13(1): 32-47.

Studies at Mt. Desert Island, Me. demonstrated that water depth and median diameter and sorting of sediments are grossly related to density of pelecypod populations. Finer and poorly sorted sediments of the deeper water have the widest range of pelecypod densities. Organic content of sediments and its decomposition apparently control pelecypod densities. As organic content (food supply) increases, pelecypod populations increase until bacterial decomposition of organic material becomes the major limiting factor, then the population decreases. No specific mention of *Mercenaria mercenaria*. - J.L.M. and M.W.S.

124
Bagg, James Francis, Jr. 1975.

A study of proposed alternate Long Island Sound bridge sites and their projected impacts on the natural environment. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N.Y, x + 258 p.

Section III. Shellfish. Discusses the commercial and recreational importance of the major shellfishes and points out where the major centers of abundance are. The effects on hard clam are questionable. Recommendations are given that would minimize the effects on hard clam. - J.L.M.

125
Baiardi, J., L. Curtis, J. Hurst, E. Premuzic, J. Wourms, E. T. Premuzic, et al. 1974.

Occurrence of growth controlling agents in marine organisms. Species distribution and preliminary chemical data. Paper to be presented at the 4th Food-Drugs from the Sea Conference, Univ. Puerto Rico, Mayaguez, 17-21 Nov. 1974. New York Ocean Science Lab. (NYOSL), Montauk, N.Y. (typed from abstract), 2 p.

Experimental data from NYOSL have shown a lack of specificity of anti-tumor activity in various marine invertebrates. A possible growth control role of components of crude and partially purified extracts is suggested. A low molecular weight fraction which showed strong absorbance at 280 nm was obtained. Extracts from 6 species, including *Mercenaria mercenaria*, yielded a fraction which inhibited rate of production of red blood cells in mouse hemopoietic system for inhibition or stimulation of erythrocyte production. Active fractions contained similar and chemically related components; were non-species specific; had wide phylogenetic occurrence (in a ctenophore, sea star, tunicate, lobster, cod, and hard clam); and were capable of acting on growth of normal cells. - J.L.M.

126
Bailey, K. 1948.

Tropomyosin: a new asymmetric protein component of the muscle fibril. Biochem. J. 43: 271-279.

127
Bailey, K. 1956.

Invertebrate tropomyosin. Biochem. J., Proc. 64: 9.

Adductor muscles of many lamellibranchs contain components which give characteristic X-ray diffraction and electronoptical patterns quite distinct from those of mammalian skeletal muscle. Fibrils responsible for this pattern are especially abundant in slow, smooth parts of adductor muscles. The work described here was done on *Pinna* and oyster adductors. The protein is a tropomyosin. It is even more asymmetric than rabbit myosin. - J.L.M.

128
Bailey, Kenneth. 1957.

Invertebrate tropomyosin. Biochim. Biophys. Acta 24: 612-619.

Tropomyosin was prepared from *Pinna* and *Octopus* muscle. The only mention of *Venus mercenaria* was by reference to a paper by Kominz et al. (1957), abstracted elsewhere in this bibliography and from a personal communication from Dr. K. Laki. - J.L.M.

129
Baldwin, John, and Anne M. Opie. 1978.

On the role of octopine dehydrogenase in the adductor muscles of bivalve molluscs. Comp. Biochem. Physiol. 61B(1): 85-92.

High activity of octopine dehydrogenase in adductor muscles of bivalve molluscs is associated with a dependence on anaerobic glycolysis during swimming. Studies were done on *Pecten alba*. *Mercenaria mercenaria* was not studied. - J.L.M.

130
Ball, Eric G., and Bettina Meyerhof. 1940.

On the occurrence of iron-porphyrin compounds and succinic dehydrogenase in marine organisms possessing the copper blood pigment hemocyanin. J. Biol. Chem. 134(2): 483-493.

Seven species, including *Venus mercenaria*, were investigated. Although hemocyanin has been reported in hard clam tissue, its presence is doubtful. Body fluid has a faint bluish color suggestive of hemocyanin, but its presence was not confirmed. Heart and adductor muscles contain iron-porphyrin compounds. Cytochrome spectra have been detected only in heart tissue, and this tissue also contains appreciable amounts of succinic dehydrogenase. Heart muscle also contains myoglobin, and adductor muscles a hemochromogen which resembles myoglobin. Presence of succinic dehydrogenase in adductor muscle is doubtful. - J.L.M.

131
Baptist, John P. 1955.

Burrowing ability of juvenile clams. U.S. Dept. Interior, Fish Wildl. Serv., Spec. Sci. Rept. — Fish. 140, 13 p.

The paper deals with *Mya arenaria*. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S. and J.L.M.

132
Baptist, J. P., D. A. Wolfe, and D. R. Colby. 1976.

Effects of chronic gamma radiation on the growth and survival of juvenile clams *(Mercenaria mercenaria)* and scallops *(Argopecten irradians)*. Health Physics 30(1): 79-83.

Lots of 30 clams each (mean length 10.8 mm) were exposed to 5 intensities of gamma radiation for periods up to 14 months. Exposure rates ranged downward from 37 rads/hr to a level slightly higher than background radiation. Adverse effects on growth and survival occurred only at the highest exposure rate. Growth slowed and then stopped at 12 weeks, but this probably was caused by inadequate food. Survival was 100% up to the 4th month, then the group exposed to highest rate began to show some mortality. - J.L.M.

133
Bardach, John E., John H. Ryther, and William O. McLarney. 1972.

Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms. Wiley-Interscience, New York, 868 p.

Chapter 37: 743-756. Culture of clams and cockles. - Clam culture is second only to oyster culture in antiquity among aquatic invertebrates, but it has never been as widespread or highly developed, perhaps because clams are abundant and easy to harvest in nature. Clam culture in Japan is described. North American oyster culture is quite primitive as compared with Japan, but the U.S. has taken the lead in clam culture. *Mercenaria mercenaria* is by far the most popular. The basic hatchery procedure is the "Milford method", with which, by controlling water temp, it is possible to spawn hard clams any day of the year. Quahogs are more tolerant of varying temp than oysters but not as tolerant of low salinity. Swimming larvae can withstand salinities as low as 15°/°° but successful hatching of eggs and development to straight-hinge stage requires at least 22°/°°. Optimal salinity for development of quahog eggs in Long Island Sound is 27°/°°. Larvae are similarly plastic with respect to pH, but a pH range of 7-8.5 is required for normal development. Larvae develop normally at temps from 18 to 30°C, but optimum is near the upper limit. At 30°C setting may occur 7 days after hatching, at 24°C 10 days may be required. Dissolved O_2 concentration does not seem to be too critical, but well-oxygenated water should be provided. Pumping and respiratory rates are directly related to O_2 demand. The lower the O_2 the harder the clam must pump, which reduces the energy available for growth. At Milford, quahogs fed *Scenedesmus obliquus* in dried form grew nearly as well as those fed live food. At 10°C hard clam larvae will ingest, but not digest and assimilate, algae. At 15°C algae with thin cell walls only would be digested. At 25°C quahog larvae can digest most algae. Seed clams sometimes are planted in the natural environment as small as 3 mm long, but it is preferable to hold them until at least 12.5 mm to reduce predation. At present the center of the quahog industry in the U.S. is N.Y., where growth to marketable size takes 5 to 8 yrs. The industry may shift to the south to take advantage of faster growth. The world's first commercial clam hatchery was established in Va. Hybridization of *M. mercenaria* with its southern counterpart *M. campechiensis* has potential for quahog culture in the south. Southern quahog grows faster but does not keep as well. Hybrids appear to be intermediate in keeping quality out of water. Seed clams from Milford, Conn. transplanted to Alligator Harbor, Fla. reached marketable size in 2 yrs. Somewhat larger seed (33-44 mm) were market size in 8-10 months. In Fla. salinity must be at least 25°/°° and bottom firm. If water is too shallow, high summer temp may cause mortality at low tide. Density of planting was important. Seed stocked at 750/m^2 grew 0.6 to 0.7 mm/month, but at 100 to 500/m^2 growth was uniformly good, 1.4 to 1.7 mm/month. Fences were necessary to exclude predators. Without protection none survived more than a few months. Principal predator was blue crab, *Callinectes sapidus*. Mortality in fenced plots averaged 10%. The only other important predator was *Busycon contrarium*. In Va. predation has been controlled by preparing beds with crushed oyster shell, crushed stone or pea gravel. At Milford quahog larvae grew best in 5 ppm lindane. The authors express hope that this chemical will not be adopted unthinkingly by clam growers. Fences used to exclude predators reduced water circulation, and a layer of soft sediment, presumably generated by clams, developed. This layer did not appear to be detrimental, but it was noted that siltation can cause 100% mortality under certain circumstances. Expense of keeping seed in the hatchery until it is resistant to enemies is recognized as an economic constraint. In Fla. quahogs were grown from less than 5 mm long to 10-15 mm at concentrations up to 5,000/m^2 in sand-filled, mesh-covered boxes. This may be too expensive for commercial application. Quahog seed from Milford have been shipped to other places along the Atlantic and Gulf of Mexico coasts, and to Japan, Europe, and the U.K. In Ireland these were planted on bottoms where the favorite cockle will not grow. At Poole Harbor, Dorset, England, hard clams have been cultured using waste heat, sewage, and flue gas, as a means of reducing pollution and producing food. Clams grew more rapidly at all stages and spawned earlier and more prolifically. In N. America and Europe, where clams are a luxury food, clam culture may be economically feasible. Genetic studies should be continued. A method for growing clams of uniform size also is needed. - J.L.M.

134 Barker, Richard M. 1964.

Microtextural variation in pelecypod shells. Malacologia 2(1): 69-83.

Studies were based on small numbers of 4 bivalve species, including lots of 15 *Mercenaria mercenaria* from localities from Prince Edward Island, Canada to Florida. Dendritic crystallization of $CaCO_3$ plays an essential role in producing great textural variation. Growth layers fall into 5 cyclic groupings. One first-order layer contains 2 second order layers, 24 third order, about 365 fourth order, and about 1,460 fifth order layers. These consist of 3 ultra-fine elemental layers: 1) cryptocrystalline $CaCO_3$; 2) opaque or semi-opaque conchiolin; and 3) conchiolin dispersed in a micro-crystalline aggregate of aragonite. A 5th order layer is a simple alternation of conchiolin with one of the carbonate elements. The 4th order layer is about 30 μ thick and has exactly 8 elemental layers. The 3rd order layer has an average thickness of about 0.5 mm and is created by a cyclic variation in thickness of the 4th order layer with a period of 15 layers. The 3rd order layer also has a dark phase of relatively thick composite and conchiolin layers alternating with a light phase in which the cryptocrystalline layers are almost as thick as the others. The 2nd order layer has a normal phase in which numbers of conchiolin and composite elements exceed those of cryptocrystalline $CaCO_3$, and a carbonate phase in which cryptocrystalline $CaCO_3$ elements are more numerous. This layer is about 6.5 mm thick, and the normal phase makes up about 6 mm of it. The 1st order layer has an average thickness of about 13 mm and is characterized by thickening and thinning of its 2 component layers. If these layers reflect environmental periodicities, the 1st order layer represents annual change of temp and salinity, the 2nd order equinoctial tides and storms, the 3rd the fortnightly tidal cycle, the 4th day and night, and the 5th order layer the daily tidal rhythm. These growth layers are superimposed upon 2 main layers parallel to shell surfaces: 1) an outer main layer in which crystals are small and growth layers thick; 2) inner or middle main layer in which crystals are large and growth layers thin. Microscopic measurements show that crystal size is related inversely to salinity and thickness of growth layers directly to temp. There was no microscopic evidence of complete cessation of growth, although summer layers may be ten times as thick as winter layers. Mathematical evaluation by more rigorous and extensive analyses are recommended. Conclusions should be tested by laboratory experiments and further ecological studies. - J.L.M.

135

Barnes, R.S.K. 1973

The intertidal lamellibranchs of Southampton Water with particular reference to *Cerastoderma edule* and *C. glaucum*. Proc. Malacol. Soc. London 40(5): 413-433.

Of some 80 invertebrate species recorded from intertidal areas of Southampton Water (U.K.) over a 2 to 3 yr period, only 8, including *Mercenaria mercenaria* (an introduced species) were at all frequent. Hard clam had replaced *Mya arenaria*, a native species, which had recently declined drastically in numbers. *M. mercenaria* supports a commercial fishery in the area. Size groups of about 60 mm shell height are selected out, cleansed by holding temporarily in clean seawater, and sold. Distribution is not natural, for stocks have been introduced on beaches in attempts to establish new breeding centers. The species has maintained itself in its new environment, and all sizes up to about 120 mm shell height were present. Because medium-sized clams are used commercially, small and large clams predominate on most beaches. Hard clams were present at all collecting stations, but were abundant only at three, particularly at Cracknore Hard. The general lamellibranch fauna of the area conformed to the sandy-mud variety of the *Macoma balthica* community, made aberrant by presence of considerable numbers of hard clam. - J.L.M.

136

Barry, M. M., and P. P. Yevich. 1972.

Incidence of gonadal cancer in the quahog *Mercenaria mercenaria*. Oncology 26(1): 87-96.

Of 316 female *M. mercenaria* from Narragansett Bay, R.I. 12 had ovarian neoplasms, including one which had neoplastic cellular invasion of the red gland, heart, and genital pores. Of 223 males, 2 had testicular neoplasms devoid of invasive properties. Morphological and nuclear cytological characteristics of tumors were identical and of germ cell origin. Neoplastic tissues in both sexes had many characteristics of mammalian germ cell tumors, but the classical lymphocytic infiltration of connective tissue stroma and arrangement of vesicular cells into lobules or strands were absent. Quahaugs do not have a lymphocyte comparable to that of higher vertebrates, thus absence of lymphocytic infiltration is to be expected. - J.L.M.

137

Bates, Hans A., and Henry Rapoport. 1975.

A chemical assay for saxitoxin, the paralytic shellfish poison. J. Agric. Food Chem. 23(2): 237-239.

The chemical assay for saxitoxin has been successfully applied to a number of shellfish samples. As a procedural test, the nontoxic Atlantic clam, *Mercenaria mercenaria*, was subjected to the chemical assay. As expected, no saxitoxin was detected. When the ground clam meat was treated with amounts of saxitoxin down to 0.004 μg/g the recovery was complete according to chemical assay. - J.L.M.

138

Battle, Helen I. 1932.

Rhythmical sexual maturity and spawning of certain bivalve mollusks. Contrib. Can. Biol. Fish., N.S. 20 (Ser. A, Gen. 17): 257-276.

Reports observations on *Mytilus edulis*, *Macoma baltica* (sic), *Mya arenaria*, and *Yoldia sapotilla*. *Venus (Mercenaria) mercenaria* is not mentioned. - J.L.M.

139

Bauer, Beverly A., and R. R. Eitenmiller. 1974.

Muscle arylamidase activity of several marine species. J. Fish. Res. Bd. Canada 31(4): 445-449.

Arylamidases are enzymes that can hydrolyze amino acid-β-naphthylamides. They are inhibited by puromyocin and can be differentiated from other exopeptidases by this property. This study was part of a larger study of enzymes involved in proteolytic breakdown of muscles of marine animals. Quahog clam (presumably *Mercenaria mercenaria*, although scientific names were not given) was among the 3 fishes and 3 invertebrates examined. Optimum pH for activity was between 7.0 and 7.5, using alanyl-β-napthylamide as substrate. Maximum activity of the clam was shown with leucyl-β-naphthylamide. Puromycin inhibited the arylamidase. Apparently only one arylamidase was present in clam muscle. - J.L.M.

140

Bauer, F. Robert. 1978.

R.I. shellfishermen organize, gain new allies in battle to save Narragansett Bay clamming. Natl. Fisherman 59(2): 20.

By banding together and forming a Shellfishermens Association local operators have been able to put political pressure on local and state elected officials and kill a proposed bill that would allow building of depuration plants to clean polluted clams. The shellfishermen argued that such plants would remove the incentive to clean up the bay. The fishermen also believed that pressure should be put on the City of Providence to modernize the sewage system so that the upper Bay would not have to be closed down every time it rains more than an inch. Even the old-time hand rakers are seeing the value of joining together. - J.L.M.

141

Baughman, J. L. 1948.

An annotated bibliography of oysters with pertinent material on mussels and other shellfish and an appendix on pollution. Texas A. and M. Research Found., College Station, Tex., 794 p.

Abstracts are listed in alphabetical order by author. Some are extensively summarized. Usefulness of the bibliography is enhanced by a rather detailed subject and author index. References to *Mercenaria (Venus) mercenaria* are abstracted elsewhere in this bibliography. - J.L.M.

142

Bayne, B. 1975.

Reproduction in bivalve molluscs under environmental stress. In Physiological Ecology of Estuarine Organisms. F. John Vernberg (ed). Univ. S.C. Press, Columbia, S.C., 259-277.

This is essentially a review paper, although some original data are included. Some data are from unpublished work of others. It is not clear from the context whether any new data of the author are included. Ambient temp and food levels synchronize different stages in bivalve gametogenic cycles. Changes in either variable have limits, beyond which gametogenesis fails or does not occur. Within these limits, animals show considerable tolerance, even under conditions of stress at which they have to utilize their own tissue reserves to meet basal energy requirements. Under such stresses fecundity is reduced and vitality of gametes and vigor of larvae are impaired. This may be at least partially caused by reduced synthesis of neutral lipid in developing ova. References to *Mercenaria mercenaria* are limited to citations of work of other authors, abstracted elsewhere in this bibliography. - J.L.M.

143
Bayne, B. L. 1976.

Aspects of reproduction in bivalve molluscs. In Estuarine Processes. Vol. 1. Uses, Stresses, and Adaptation to the Estuary. Martin Wiley (ed.). Academic Press, New York, p. 432-448.

Mercenaria mercenaria, among other mollusks, has a swimming larva that feeds on suspended particulate matter. About 52% of the energy available for production, once the demands of maintenance have been met, is eventually utilized in gametogenesis. This value probably increases with age. It is consistent with a planktotrophic "strategy" characterized by high fecundity and high metabolic cost. *Mercenaria mercenaria* in a mixed estuary usually spawned at or just after low tide, which coincided with maximum water temperature caused by heat brought down the estuary during ebb tide. Discussion of energy (=nutrient) reserves, other seasonal physiological changes, and relationships between adult condition and larval vigor do not refer specifically to hard clam, but the following processes apply generally: use of energy resources for reproduction takes the form of storage and utilization of glycogen, coupled with an annual gametogenic cycle that probably is synchronized with a variety of environmental factors. Details vary between species, but all involved accumulation of energy when food is abundant, for use in maintenance and gametogenesis. A mutual control of the storage cycle between glycogen synthesis in the adult and lipid synthesis in the developing oocyte may exist, based on neurosecretory hormones and blood glucose levels. Physiological factors buffer gametogenic events from environmental disturbance, although not always with 100% efficiency. Included are acclimation of metabolic rate with changes in temperature, and a switch mechanism that lets gametogenesis proceed to completion once sufficient nutrient reserve has accumulated, even with short-term environmental deterioration. Despite the buffering effects, stress on the adult affects fecundity and vigor of larvae. Successful embryogenesis depends on lipid reserves in the egg to bring the larva to the feeding stage. Lipids also seem to play a role in larval growth. - J.L.M.

144
Bayne, B. L. (ed.). 1976.

Marine Mussels: Their ecology and physiology. Internatl. Biol. Progr. 10, Cambridge Univ. Press, xvii + 506 p.

This useful book, as its title implies, deals primarily with mussels, but other bivalves, including *Mercenaria (Venus) mercenaria*, have been considered when appropriate to avoid superficial discussion of certain subjects. All references to *M. mercenaria* are from published papers abstracted elsewhere in this bibliography. - J.L.M.

145
Bear, Richard S., and Cecily Cannan Selby. 1956.

The structure of paramyosin fibrils according to X-ray diffraction. J. Biophys. and Biochem. Cytol. 2(1): 55-69.

Various molluscan sources have been used, but that preferred for extraction of paramyosin is the "white" portion of the adductor muscle of *Venus mercenaria*, because the protein is so highly concentrated there. The small-angle pattern then is overlaid only weakly with actin diffraction. The wide-angle diffraction of paramyosin probably is of α-type, and supercoiled α-helices must be involved. Cables of this type, about 1,400 A long, may extend over 2 cells. Other considerations suggest that the cable units may be aggregated into supercables essentially forming rather solid rods of about 100 A diameter. An alternative interpretation of the small-angle diffraction would conclude that large particles are arranged helically, with minimum helix diam about 150 A. The simplest particle connection would have 5 particles in 2 coil turns along 720 A of fibril or helix axis. This view is distinctly different from the suggested arrangement of "rods" in net-like layers. The authors prefer the net-of-rods model over the particulate-helix model and give technical reasons for the preference. - J.L.M.

146
Becker, Dean Scott. 1978.

Evaluation of a hard clam spawner transplant site using a dye tracer technique. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N.Y., ix + 63 p.

The hard clam, *Mercenaria mercenaria*, spawner transplant site of the Town of Islip, N.Y. was evaluated with a water-soluble fluorescent dye tracer for 18 days. Dye was measured with a fluorometer from a small boat. The pattern of dispersion suggested that the site is in an undesirable location for maximizing the set of larvae within town waters. An alternative site was recommended, and ways in which Islip can maximize setting densities within Town waters from planted spawners were suggested. - J.L.M.

147
Beedham, G. E. 1958.

Observations on the mantle of the Lamellibranchia. Quart. J. Microsc. Sci. 99(2): 181-197.

148
Behrens, William John. 1978.

Heavy metals in transplanted hard clams, *Mercenaria mercenaria*, in Great South Bay, New York. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N.Y., x + 51 p.

Heavy metals are not considered in setting standards for hard clams in waters closed to harvesting. Yet hard clam is known to concentrate heavy metals from water and food. Digestive glands and kidney of hard clam contain the highest concentrations, and eating the whole organism enhances ingestion as compared with eating only muscle. The study was undertaken to determine if levels of Cu, Pb, Cr, Cd, Ni, and Zn are higher in clams from an area closed to shellfishing, and if so are they depurated under current transplant practices. Clams were taken in Awixa Creek, marked, and transplanted to the middle of the Bay. Variations in metal levels of clams from different areas of the Bay were significant and may be caused by variations in availability of metals or differences in biology of clams. Transplanted clams were depurated of bacteria over a short period of time, but heavy metals remained at their original levels or increased. The only metal that increased after transplanting was Ni. - J.L.M.

149
Behrens, W. J., and I. W. Duedall. 1979.

Heavy metals in transplanted hard clams, *Mercenaria mercenaria*, in Great South Bay, New York. In Abstr. of Papers submitted for the 42nd Ann. Meeting, Am. Soc. Limnol. Oceanogr., Mar. Sci. Research Ctr., State Univ. of N.Y., Stony Brook, N.Y., June 18-21, 1979.

An area of Great South Bay closed to shellfishing had elevated levels of heavy metals in hard clams and sediments. Clams were transplanted from this area into the central portion of the Bay, which is open to shellfishing. No depuration of Cd, Cr, Cu, Ni, Pb, or Zn was noted over 50 days, but significant increases in total body content of Cd, Ni, and Pb occurred. Cd and Pb levels were not elevated above natural levels found in the transplant area, but Ni levels were approximately 56% higher. Transplanting may therefore introduce hard clams with significantly higher levels of Ni into the harvestable resource. Cu, Pb, and Ni levels in natural populations of hard clam decreased from May to July, then increased through September, reflecting seasonal trends associated with biological processes of the organisms and environmental factors. - J.L.M.

150
Belding, David L. 1909.

A report upon the mollusk fisheries of Massachusetts. Boston, Wright & Potter Printing Co., 243 p.

Declines in the quahaug industry were noted in Chatham, Buzzards Bay, and the Fall River district, among others. Causes were increased demand, overfishing, and water pollution. Other factors, such as climatic change, may have played a part. Shellfisheries in Mass. are in a chaotic state, legally and economically. Existing laws do more harm than good, and are direct obstacles to improvement. Protection of the resource is a paramount problem. All shellfish laws should be revised. Numerous examples of inequity and irrationality are given. Two matters were stressed for immediate attention: 1) shipping out of Massachusetts many thousands of bushels of quahaugs to New York, where they were planted (under 1 1/2-in legal size) and harvested a year later at yields of at least 5 bu for each bu planted; and 2) lack of enforcement of the 1 1/2-inch quahaug law. All the problems of the clam industry are summed up as "abuse of nature". Conclusions and recommendations of this study were: the shellfisheries have declined, causes were overfishing and unwise laws, the remedy is not to check demand (as has been attempted) but to increase production by utilizing vast barren flats, that present chaotic laws make this impossible, that there is need of reform or shellfisheries will disappear, and that the first step is to remove these laws to permit application of proper cultural methods. The section on the quahaug industry (p. 36-80) contains a detailed discussion, by areas, of the history and present status of the industry in Mass. It was concluded that quahaug farming is practical and possible. Rates of growth vary widely depending on water currents. Fastest growth recorded was from 1 1/2 to 2 1/2 inches in a year and average growth between 1/2 and 3/4 inch per year, a yield of 3-5 bu/yr for each bu planted. (Abstracter's note: this report was obtained from the Univ. of Mass. Library. It is well worth reading because the problems more than 65 years ago were so similar to those of today. We have not progressed very much.) - J.L.M.

151
Belding, David L. 1911.

The life history and growth of the quahaug *(Venus mercenaria)*. Comm. Fish Game, Mass., Ann. Rept. 1910: 18-128.

Interlibrary loan supplied the following on request for the title given above: A report upon the quahaug and oyster fisheries of Massachusetts, including the life history, growth and cultivation of the quahaug *(Venus mercenaria)*, and observations on the set of oyster spat in Wellfleet Bay. Commonwealth of Mass., Wright & Potter Printing Co., State Printers, Boston, 1912, 134 p. + 69 plates. Pages 2 to 41 inclusive contain a paper entitled: The life history and growth of the quahaug *(Venus mercenaria)*. If the other paper exists it must be essentially the same, because the work reported here was conducted from 1906 to 1909. It is described as a final report on the best methods of increasing the natural supply, as determined by a study of the life history, habits, and artificial propagation of this mollusk, following a preliminary report published in the report on the mollusk fisheries for 1909. The section on quahaug culture follows the life history report (pages 41 to 112 inclusive). These reports include great detail, which can be digested only by reading the entire document. - J.L.M.

152
Belding, David L. 1912.

A report upon the quahaug and oyster fisheries of Massachusetts, including the life history, growth and cultivation of the quahaug *(Venus mercenaria)*, and observations on the set of the oyster spat in Wellfleet Bay. Boston, Wright & Potter Printing Co., 134 p., 69 figs. Reissued in 1964 as Mass. Div. Mar. Fish., Contr. 12, 134 p.

The aim of this paper was to complete the 1909 investigation by a final report on best methods to increase the natural supply of quahaug, as determined by a study of life history, habits, and artificial propagation.

The quahaug, *Venus mercenaria*, is placed with soft clam *(Mya)* and sea clam *(Mactra)* in the class Lamellibranchia of the order Eulamellibranchia because the edges of the mantle are united by one or two sutures, there are two adductor muscles, and gill filaments are united at regular intervals by vascular junctions. The scientific name is supposed to have arisen from use of the shell as "black wampum" by Indians, "black" because the more purple the greater the value. Hard clam is a truly American species, found from Gulf of St. Lawrence to Gulf of Mexico. A few have been found on the Pacific coast, where they were transplanted accidentally with oysters. Attempts are being made to develop an industry in Louisiana, but demand is small. In Mass. few are found north of Plymouth. Evidence from Indian shell heaps suggest that quahaug once was more widely distributed in the area. It is suggested that declining water temperatures in Massachusetts Bay have been responsible for the change. Beds in New England and New York have been overfished. Principal commercial fisheries in Mass. are in the Buzzards Bay villages, and at Wellfleet, Eastham, Orleans, Edgartown, and Nantucket. It is found on sandy and muddy flats just below low water and sometimes between the tide lines, down to more than 50 ft, in exposed areas on the north side of Cape Cod, and in sheltered bays and inlets on the southern coast of the State. A detailed description is given of internal and external anatomy and of egg, spermatozoon, and spawning. Temperature affects hard clams in 3 principal ways: by regulating food supply and hence growth, by controlling geographic distribution, and by influencing various stages of development. In laboratory, some lots of hard clam spawned 3 different times during season. In Wellfleet lab. quahaugs extruded spawn from 23 June to 29 July. Season lasts less than a month for any particular batch. Temperature is the controlling factor in spawning. The average quahaug spawns when 2 years old, in its 3rd summer, at 1 1/4 to 1 1/2 inches long. At Wellfleet lab. only clams in the 2 1/2- to 3 3/4-inch category spawned, however. Littlenecks under 2 1/2 inches and blunts did not throw eggs or sperm. Attachment, setting, and movements are discussed in some detail. Slight breaks in the shell are not always fatal. The clam repairs the break from the inside. An abstract cannot do justice to this comprehensive work, which goes into many aspects of the biology of hard clam, the decline of the industry in Massachusetts, and possibilities for aquaculture. It is liberally illustrated with drawings, graphs, and photographs. - J.L.M.

153
Belding, David L. 1916.

A report upon the clam fishery. Mass. Comm. Fish Game, 50th Ann. Rept. for the year 1915, Doc. 25: 93-239.

The report deals in great detail with soft clam, *Mya arenaria*, and only occasional mention is made of *Mercenaria (Venus) mercenaria*. Young *V. mercenaria* crawl by a pulling movement of the foot. The small clam opens its valves, stretches out the foot, and applies the distal end to a suitable resting place. The 2 retractor muscles of the foot are relaxed. As the foot is extended, the shell is drawn down slightly toward the tip of the foot by contraction of the anterior retractor. Thus the foot is drawn into the shell, which advances the shell as far as the distal end of the foot, covering a distance equal to the length of the extruded foot. Growth of any mollusk is proportional directly to weight of shell. A quahaug of 25 mm increases in volume by 527% in a year. - J.L.M.

154
Belding, D. L. 1931.

The quahaug fishery of Massachusetts. Mass. Dept. Conserv., Div. Fish Game, Mar. Fish. Serv. 2, 41 p.

This comprehensive paper, prepared for information of consumers and fishermen, would require an abstract almost as long to do it justice. This abstract is primarily a digest of the one-page resume of main facts, and a short version of the 68-item table of contents. Length of life uncertain, at least 20-25 yrs; max. size in Mass. over 5 1/4 inches long; at legal size (2 in) is about 2 1/2 yrs old; sexually mature in second year, about 1 1/2 inches long;

spawns 15 June to 15 Aug; eggs 1/325 inch diam; average number of eggs at 2 1/2 inches about 2 million; larva swims for 10-12 days at 72°F before setting; attaches at about 12 days old by byssus, which is retained until about 1/2 inch long; burrows freely throughout life; withstands salinity of 1.015 to 1.022 (about 22.8°/₀₀ to 34°/₀₀ at 72°F); will repair most injuries to shell; edible portion 17.85% of total live weight. An acre of ground, with a moderate average of 20 quahogs 2 1/2 inches long per sq ft, contains 860,000 quahogs or 1,500 bu, which at spawning may release 800 billion eggs. Major headings in table of contents are: NATURAL HISTORY (p. 5-29), Anatomy, Early life history, Habits, Growth Rate, Conditions affecting growth, Growth tables; THE QUAHOG FISHERY (p. 29-41), Fishing grounds, Industrial practices, Laws, and Quahog culture. This is one of the most comprehensive accounts in existence. It applies only to Massachusetts, and some of the facts stated may have been amended by later studies. - J.L.M.

155

Bender, Norman K. 1976.

The institutional structure of New York State's clam industry. Sea Grant Adv. Serv., Cornell Univ., 15 p.

Ownership of underwater land and shellfish resources in New York State traces back to royal grants and patents dated as early as 1666. These patents gave the responsibility to regulate underwater shellfish lands to local boards of trustees (town trustees). The concept still holds that local towns can regulate the harvest of their shellfish resources in conformity with New York State Fish and Wildlife Law. Only the towns of North Hempstead and Riverhead do not have their own shellfish regulations, and their shellfish resources are regulated entirely according to State law. New York State requires commercial clam diggers to purchase a shellfish diggers permit, but recreational clammers do not need a State license. Most towns, however, require licenses for commercial and recreational diggers. Types of license, limitations which they impose, and fees are listed in a table. The State of New York prohibits dredges, scrapes, and mechanical dredges operated by motor driven boats on public grounds. Tongs, rakes, and treading are permitted, but some limitations are placed on these methods also. Gear regulations differ slightly from town to town. There are also some differences in maximum commercial catch per day. Public health regulations are carried out by the State. Enforcement is by conservation officers of the State Dept. of Environmental Conservation, State Police, and by Nassau and Suffolk County Marine Police officers and town bay constables. There are large variations in public aquacultural practices in New York. A State or Town agency may transplant spawner clams from one area to another in an attempt to increase chances of obtaining a good set. Clams are also transplanted from closed to open waters for depuration, under State surveillance. Some towns have invested considerable sums of money in these activities, especially Islip, but it is too early to evaluate the degree of success of such programs. Various fishermen's organizations also take an interest in various aspects of government programs.-J.L.M.

156

Bennett, Miriam F. 1954.

The rhythmic activity of the quahog, *Venus mercenaria*, and its modification by light. Biol. Bull. 107(2): 174-191.

Continuous kymograph recordings were made of opening and closing of valves of *Venus mercenaria* from Virginia and from Massachusetts, Feb to Dec 1953. Experiments were conducted in Illinois. Clams were held at temps varying from 20° to 22°C. Activity showed a persisting diurnal rhythm with maxima in afternoon and minima in early morning. A persistent tidal rhythm also was noted, in which minimal activity corresponded with low tide in the area of collection. An observed lunar cycle corresponded with the summation of diurnal and tidal cycles. A group of clams held in darkness in daytime and 100 foot-candles at night shifted their cycles as compared to controls so that phases of diurnal rhythm were 1 hr earlier, phases of tidal cycle about 20 hrs earlier, and phases of long-cycle rhythm 25 days ahead. The study produced no evidence whether rhythms and shifts were endogenous or exogenous. It is suggested that such rhythms, rather than water temp, may provide the stimulus for spawning of hard clam. Greater activity in daytime may be favorable for feeding, when plankton organisms are closer to the bottom. - modified author's summary - J.L.M.

157
Berg, Gerald. 1967.

Transmission of Viruses by the Water Route. Interscience Publishers Div., John Wiley & Sons, New York, xviii+484 p.

From introduction and discussion to section entitled *Survival of Viruses in Water and Waste Water*: 369-470. - Viruses can be found miles from sewage outfalls. Shellfishes concentrate viruses, especially during periods of high activity. Thousands of plaque-forming units of virus can be concentrated in each shellfish experimentally, but few infective units of virus have been detected in oysters from beds close to sewage outfalls. Apparently viruses of human origin neither infect, nor adsorb strongly to, shellfish tissue, and are easily detected there. Infectious hepatitis is sometimes associated with consumption of raw shellfishes. Unless the agent responsible for this disease is concentrated by shellfishes to a greater extent than other viruses studied, the infective dose for man of the infectious hepatitis agent would appear to be small. Shellfishes apparently can be freed of viruses by depuration. Disappearance of virus particles from clams is a mechanical rinsing effect, not inactivation. This is suggested by persistence of virus in clams in winter and disappearance as water temp rises. It is also compatible with the observation that viruses cannot be detected in cells of clams. Reliable data are not available on fate of viruses in water. Their numbers are reduced over a period of time, but mechanism of removal is obscure. Ultraviolet radiation near the water surface, adsorption and sedimentation, and bacterial antagonism have been considered. Shellfish-associated infectious hepatitis was first recognized in 1955 in Sweden from oysters stored wet, according to James W. Mosley. First recognized outbreaks in the United States were from consumption of raw clams from New Jersey and raw oysters in the South. Later, a small epidemic was traced to privately harvested clams from Connecticut. In 1964 raw clams caused 2 epidemics, one in New Jersey and the greater Philadelphia area, one in Connecticut. Other cases of infectious hepatitis have been associated with consumption of raw shellfishes. Clams seem to be much more of a problem than oysters. Alfred Perlmutter suggested that the difference between oyster and hard clam might be associated with the custom of not eating oysters in the "R" months. There is no evidence that shellfish tissue supports multiplication of human viruses. - J.L.M.

158
Berry, William B. N., and Richard M. Barker. 1975.

Growth increments in fossil and modern bivalves. In Growth Rhythms and the History of the Earth's Rotation. G. D. Rosenberg and S. K. Runcorn (eds.). John Wiley & Sons, London, p. 9-25.

Species in the family Veneridae have the most conspicuous clusters of fine growth increments that suggest fortnightly tidal phenomena. These include *Venus* and *Mercenaria*. Other references to *Mercenaria mercenaria* are by citation of papers abstracted elsewhere in this bibliography. - J.L.M.

159
Bevelander, Gerrit. 1952.

Calcification in molluscs. III. Intake and deposition of Ca^{45} and P^{32} in relation to shell formation. Biol. Bull. 102(1): 9-15.

Several marine and freshwater mollusks, including *Venus* (presumably *Venus mercenaria*) were used in these experiments. The results and conclusions obviously apply generally to all. Elaboration of mollusk shell consists of formation of a protein membrane, the periostracum, and concomitant or subsequent mineralization of this membrane. It is highly probable that this protein complex may be involved actively in formation or growth of mineral crystals. Marine and freshwater mollusks take up labeled Ca and P from water. Labeled Ca is concentrated on the periphery of the mantle and also is incorporated into crystals of $CaCO_3$ in the newly formed shell. Labeled PO_4 was localized on the inner margin of the mantle in the region of the mucus glands. It was also incorporated in the periostracum surrounding the crystals. Phosphatase and phosphate present in the mantle are concerned with a phosphorylating process; the significance of this to mineralization is not clear. - J.L.M.

160
Bevelander, Gerrit, and Paul Benzer. 1948.

Calcification in marine molluscs. Biol. Bull. 94(3): 176-183.

Several species were used as experimental animals, including *Venus mercenaria*. Aside from the comment that *Venus* and *Codokia* were better suited to histological and histochemical studies than the other species because they lack heavy pigmentation in mantle tissues; and some photos of sections of *Venus* mantle showing general topography, elaboration of conchin, distribution of mucus, and distribution of alkaline phosphatase, there is no other specific reference to hard clam. Presumably the conclusions apply generally to this species. Calcification of shell occurs by formation of an organic matrix upon which minute granules of calcium phosphate are deposited. Crystal growth occurs in seawater in presence of mantle epithelium and in contact with it. The enzyme alkaline phosphatase appears to be concerned with calcification. Modification of certain constituents of seawater produces a shell partially or completely lacking in mineral content. - modified author's summary - J.L.M.

161
Bevelander, Gerrit, and I. Krimsky. 1949.

Calcification in marine molluscs. II. Some aspects of phosphate metabolism. Bermuda Biol. Sta. Ann. Rept. 1949, 3 p.

Mercenaria (Venus) mercenaria is not mentioned. Several mollusk species were placed in aquaria of normal seawater into which radiophosphate (P^{32}) had been introduced. Later analyses showed phosphate present in liver, kidney, gonads, and other tissues. It was concluded that phosphate is readily obtained via the digestive tract, and that phosphate is quickly seized upon and stored in parts of the organism where it can be used later in metabolism. Heavy deposits of phosphate were observed on the visceral surface of the mantle in those areas occupied by mucous glands. Phosphate is not an integral part of the mineral component of mature shell, but organic matrix contains considerable amounts. Alkaline phosphatase was extracted from mantle tissues of several molluscan species. Phosphatase also could be extracted from the innermost layer of conchin which lies adjacent to the shell. It appears that this enzyme acts extracellularly. Phosphatase is in some manner associated intimately with growth and metabolism of those substances which take part in shell formation. *In vitro*, phosphatase in mantle tissues is capable of hydrolysing mucus in this region. Phosphorylation is apparently one of the first of a series of events in calcification of mollusk shell. - J.L.M.

162
Bevelander, G., and H. Nakahara. 1969.

An electron microscope study of the formation of the nacreous layer in the shell of certain bivalve molluscs. Calcif. Tiss. Res. 3: 84-92.

163
Bidwell, Milton H. 1940.

A review of bacteriological shellfish scoring. Natl. Shellf. Assn., Convention Addresses, 9 p., not numbered.

Coliform organisms seem to serve as a fair measure of pollution in seawaters. Coliform scores reported as M.P.N. have in general the same relative significance. The relative intensity of coliform in shellfish and seawater is in increasing order of seawater, oysters, hard clams, and soft clams. Seasonal variation fails to greatly affect hard clams. - J.L.M.

164
Biggs, Robert B. 1968.

Environmental effects of overboard spoil disposal. J. San. Eng. Div. 94 (SA3), Proc. Am. Soc. Civil Eng., Paper 5979, June: 477-487.

165
Bird, Samuel O. 1970.

Shallow-marine and estuarine benthic molluscan communities from area of Beaufort, North Carolina. Am. Assn. Petrol. Geol., Bull. 54(9): 1651-1676.

Mercenaria mercenaria was taken at most stations, and was found in open ocean as well as the estuary. Salinity range was 0-35°/₀₀; substrate M-Mu (not further identified); optimum environment estuarine, salinity 26-28°/₀₀, F-VF. Hard clam did not dominate any community. - J.L.M.

166
Bissell, G. E. 1972.

Review of the east coast quahaug fishery (Guidelines for development). Western Consultants, West Vancouver, B.C., 93 p.

Cited in Ackman et al. 1974, abstracted elsewhere in this bibliography. - J.L.M.

167
Blake, J. W. 1960.

Oxygen consumption of bivalve prey and their attractiveness to the gastropod, *Urosalpinx cinerea*. Limnol. Oceanogr. 5: 273-280.

Experimental animals were *Crassostrea virginica* and *Modiolus demissus*. *Mercenaria mercenaria* not mentioned. - J.L.M.

168
Blogoslawski, Walter J. 1979.

Water quality in shellfish culture. Proc. Natl. Shellf. Assn. 69: 137-141.

Water must conform to the requirements of the species being raised with regard to water temperature, salinity, available nutrients, pH, dissolved oxygen, and metabolic wastes. It must also be free of pathogenic microbes and chemical contamination. A mariculture facility permits control and enhancement of culture water through screening and examination of intake waters, disinfection methods, and use of thermal and nutrient additives. - J.L.M.

169
Bluepoints Company Inc. (no date).

An easy way of opening clams. Privately printed, 1 p.

Shows with drawings how to open a clam. - J.L.M.

170
Blumer, M., G. Souza, and J. Sass. 1970.

Hydrocarbon pollution of edible shellfish by an oil spill. Mar. Biol. 5: 195-202.

Except for modification caused by solubility effects hydrocarbon concentration in sediments was small after 4 months. *Crassostrea virginica* and *Aequipecten irradians* contained the same oil pollutant, while uncontaminated scallops contained different hydrocarbons in lesser amounts. No mention was made of *Mercenaria mercenaria*. - J.L.M. and M.W.S.

171
Boadle-Biber, Margaret C., and Robert H. Roth. 1972.

Factors modifying the synthesis of dopamine from tyrosine in pedal ganglia of *Mercenaria mercenaria* (Mollusca). Comp. Gen. Pharmacol. 3(9): 61-74.

The catecholamine, dopamine (DA), is present in the 3 ganglia of hard clam, but pedal ganglion is by far the richest source (236±16 ng), which is about 200 μg/g wet weight. Visceral and cerebral ganglia contained 76±3 and 37±5 ng DA, respectively. The 5-hydroxytryptamine (5HT) content of the 3 ganglia was 101, 116, and 107 ng, respectively. Endogenous noradrenaline (NA) was not found. Enzymatic capacity for making DA from tyrosine was present in pedal ganglia of *M. mercenaria*, but 3,4-dihydroxyphenylalanine (dopa) was not found. 5HT was also formed from tryptophan in pedal ganglia. Incubation of pedal ganglia in KCl-rich seawater accelerated synthesis of DA from tyrosine 2- to 3-fold compared to controls. Specific activity of DA isolated from K^+-stimulated ganglia also was increased. Acceleration of DA synthesis appeared to take place at the tyrosine hydroxylation step. Synthesis of DA from tyrosine in pedal ganglia was inhibited up to 60% by 10^{-4} M DA in the medium. - modified authors' abstract - J.L.M.

172
Bockrath, Joseph, and Diana Wheeler. 1975.

Closed-cycle mariculture in Maryland, Virginia, and Delaware: An examination of the adaptability of existing fishery laws to new technology. William and Mary Law Rev. 17(1): 85-107.

Delaware has fortuitously drafted fishery laws that will readily accommodate closed-cycle mollusk mariculture. The fate of artificial shellfish cultivation, however, may depend upon the almost unlimited discretion of the Secretary of the Department of Natural Resources and Environmental Control to regulate the shellfish industry. In Maryland and Virginia the head of the comparable agency does not hold such power, and the degree to which closed-cycle mariculture fits into the framework of shellfishery laws is directly dependent on the wording and the intent of the statutes. Application of the statutes of these two states is sufficiently uncertain to discourage the development of a new industry. If Maryland and Virginia wish to encourage closed-cycle mariculture development, adoption of entirely new statutes will be necessary. - J.L.M.

173
Boehm, Paul D., and James G. Quinn. 1976.

The effect of dissolved organic matter in sea water on the uptake of mixed individual hydrocarbons and number 2 fuel oil by a marine filter-feeding bivalve (*Mercenaria mercenaria*). Estuarine Coastal Mar. Sci. 4: 93-105.

Hard clams were exposed in the laboratory to an n-alkane, hexadecane, an aromatic hydrocarbon, phenanthrene, and no. 2 fuel oil in seawater. In one series of exposures naturally occurring surfactant dissolved organic matter (DOM) was removed from natural seawater with activated charcoal, in another it was not. Removal of DOM from the media gave a statistically significant increase in uptake of hexadecane, no change in uptake of phenanthrene, and a sevenfold increase in quantity of no. 2 fuel oil taken up. When DOM is present it takes up saturated hydrocarbons and they are thus taken up less readily by clams. When DOM is removed these hydrocarbons are retained more readily by clam gills because their physical state in seawater is changed. - modified authors' abstract - J.L.M.

174
Boehm, P. D., and J. G. Quinn. 1977.

The persistence of chronically accumulated hydrocarbons in the hard shell clam *Mercenaria mercenaria*. Mar. Biol. 44(3): 227-233.

Hard clams from the chronically polluted environment of the Providence River, R.I. were held in a flowing seawater system in the laboratory for 120 days for depuration. Initial temp was 20.5°C, maximum 22.5°C, and final temp after 120 days 11.5°C. Hydrocarbon content of meats at beginning of the experiment was 41.9 µg/g wet weight, at the end 29.3 µg/g. This loss of only about 30% in 120 days was interpreted as demonstrating that hard clams are only slowly depurated of petroleum hydrocarbons. Persistence of contamination is related to duration of exposure and chemical composition of source hydrocarbons. - J.L.M.

175
Boesch, D. F. 1973.

Classification and community structure of macrobenthos in the Hampton Roads area, Virginia. Mar. Biol. 21: 226-244.

Mercenaria mercenaria was collected but not discussed. - J.L.M.

176
Boesch, Donald F., Carl H. Hershner, and Jerome H. Milgram. 1974.

Oil spills and the marine environment. Ballinger Pub. Co., Cambridge, Mass., xv + 114 p.

Contains a few references to *Mercenaria mercenaria*. Pertinent papers are abstracted elsewhere in this bibliography. - J.L.M.

177
Bonnet, James C., Virginia D. Sidwell, and Elizabeth G. Zook. 1974.

Chemical and nutritive values of several fresh and canned finfish, crustaceans, and mollusks. Part II. Fatty acid composition. Mar. Fish. Rev. 36(2): 8-9.

Fat content of fresh and canned *Mercenaria mercenaria* was 0.38 ±0.02, range 0.24-0.47, in 8 analyses. - J.L.M.

178
Boroughs, Howard, Walter A. Chipman, and Theodore R. Rice. 1957.

Laboratory experiments on the uptake, accumulation, and loss of radionuclides by marine organisms. In The Effects of Atomic Radiation on Oceanography and Fisheries. NAS-NRC Pub. 551, Washington, D.C., p. 80-87.

At the second trophic level, crustaceans and molluscan shellfishes, including *Mercenaria (Venus) mercenaria*, were studied. All accumulated strontium rapidly from seawater. Soft parts of hard clam, at the end of 20 days, had accumulated cesium^{137} by a factor of six over the concentration in surrounding seawater and the concentration had not yet reached a steady state. - J.L.M.

179
Boschetti, Mario M. 1964.

Status of shellfish depuration in Massachusetts. In Proc. 5th Natl. Shellf. Sanitation Workshop, U.S. Dept. Health, Educ., and Welfare, Appendix G: 93-96.

Sixty five percent show some reduction of coliform density, 35% show no reduction or an increase. Fifty percent of the samples show at least a 30% reduction. Twenty-five percent of samples show at least 64% reduction. Species treated was *Mya arenaria*. Other depuration plants were treating *Mercenaria mercenaria* for a short time with limited success. - J.L.M.

180
Boss, K. J., and A. S. Merrill. 1965.

Degree of host specificity in two species of *Odostomia* (Pyramidellidae: Gastropoda). Proc. Malacol. Soc. London 36: 349-355.

181
Bousfield, E. L. 1960.

Canadian Atlantic Sea Shells. Canadian Dept. Northern Affairs and National Resources, National Museum of Canada, v+72 p.

Venus (Mercenaria) mercenaria: northern quahog, hard shell clam, littleneck, cherrystone; 2 1/2 to 4 1/2 inches. SW Gulf of St. Lawrence: Miramichi Bay to Cape Breton Island; rare elsewhere but recorded at the head of St. Mary Bay, Digby Co., N.S. and Tidal Cove, Passamaquoddy Bay, N.B; abundant from New England states to Gulf of Mexico. Fairly common on mud bottom in warm shallow bays and estuaries. Shell thick, heavy, moderately inflated; exterior dull white with numerous concentric growth lines, strongly raised in young specimens. Lunule large, moderately sunk. Interior white, posterior border and muscle scar purple; lower margin finely crenulate. Each valve with 3 cardinal teeth but no laterals. Pallial sinus shallow, triangular. - J.L.M.

182
Bowden, J. 1958.

The structure and innervation of lamellibranch muscle. Internatl. Rev. Cytol. 7: 295-335.

A few species, including *Venus (Mercenaria)*, have pink muscles as in smooth and double-obliquely striated parts of *Venus* adductor muscles. Contracted fibers from different adductor muscles showed characteristic lattices, on the basis of which Marceau (1909), abstracted elsewhere in this bibliography, classified them into 3 groups. Group 2 had fewer fibrils than group 1 and a more obvious and open lattice. These were in slow parts of adductors of most genera, including *Venus*. This is a review paper, in which specific references to *Venus* were cited from papers abstracted elsewhere in this bibliography. - J.L.M. and M.W.S.

183
Boyden, C. R. 1974.

Trace element content and body size in molluscs. Nature (Lond.) 251 (5473): 311-314.

Cd, Cu, Fe, Ni, Pb, and Zn were measured in 6 molluscan species, including *Mercenaria mercenaria*, from Southampton Water, England. Precise relationships between trace element content and dry body weight depended on element and species. Three general relationships were identified: 1) element content related to about 0.75 power of body wt -- this was true for Cd, Cu, and Fe in *M. mercenaria*; 2) element content directly related to body wt -- true for Ni, Pb, and Zn in hard clam; and 3) element content directly related to square of body wt -- true only for the limpet *Patella vulgata*. However, although total trace element content was directly related to body wt in all species examined, concentration per unit wt of tissue usually was greatest in small animals, e.g., the regression was negative, or at best zero. - J.L.M.

184
Boyden, C. R. 1977.

Effect of size upon metal content of shellfish. J. Mar. Biol. Assn. U.K. 57(3): 675-714.

A single population of *Mercenaria mercenaria* from Southampton Water in southern England was sampled in January 1974. Dry tissue weight varied from about 0.15 g to about 8 g. For Cd, Cu, and Fe regression of metal content on dry tissue weight had slopes less than 1.00. For Ni, Pb, and Zn slopes were close to 1.00 (1.01 to 1.05). Ni and Pb concentrations were low. Other species examined were oysters, mussel, *Venerupis*, scallops, and several gastropods. - J.L.M.

185
Brand, Larry. 1976.

Distribution of potential food resources for shellfish in Bournes Pond. In Marine Resources Development and Management. A Report on the Woods Hole Oceanographic Institution Sea Grant Program for July 1975-June 1976. NOAA Sea Grant 04-6-158-44016. Dean F. Bumpus (coordinator): 23-24.

Studies were underway on growth of *Mercenaria mercenaria* and other bivalves in relation to amounts of particulate organic matter and phytoplankton in the natural environment. Water circulation is a very important factor determining distribution of food. - J.L.M.

186
Brand, T. von. 1946.

Anaerobiosis in Invertebrates. Biodynamica, Normandy, Mo. Monogr. 4, 328 p.

Most contents of this book were reprinted from Biodynamica 92 (1944) and 100 and 105 (1945). References to *Venus (Mercenaria) mercenaria* are citations from papers by Dugal and Mitchell, abstracted elsewhere in this bibliography. It is mentioned that oxygen consumption by *V. mercenaria* stopped only when valves were closed artificially. *Venus* continued to consume oxygen when valves were closed by the clam itself. - J.L.M.

187
Breese, W. P. 1975 (1976?).

Out-bay culture of bivalve molluscs. Proc. Natl. Shellf. Assn. 65: 76-77.

(Abstracter's note: here is an example in which the editor or the printer, or both, have confused the issue. The title page of the volume is dated June 1975, the running head says volume 65-1976. Date of publication remains obscure.) The paper deals entirely with oysters *(Crassostrea gigas)*, so the title is misleading. The proposal is described as hardly more than an idea at present, supported only by a single uncontrolled experiment. The suggested technique probably could apply to most commercial bivalves, including *Mercenaria mercenaria*. Essentially it contemplates culture in tanks or ponds with controls on water flow, retention time, depth, and opportunity to treat the water if necessary. Unresolved problems are stocking rate, water flow per unit biomass, and exchange rate or retention time. The next step is to develop a ration. In a pilot exercise in a 17x30 ft tank with water 4 ft deep small *C. gigas* spat grew from about 2 mm to 36 mm, and larger spat from about 9 to 55 mm from 13 June 1974 to 30 May 1975. Because incoming water probably did not contain enough food to support this growth it was assumed that significant phytoplankton production took place in the tank. No cost estimates are included. - J.L.M.

188
Brett, Charles Everett. 1963.

Relationships between marine invertebrate infauna distribution and sediment type distribution in Bogue Sound, North Carolina. U.S. Atom. Energy Comm., Div. Research, Final Rept. Contract No. AT(40-1)2593, Oak Ridge, Tenn., 202 p. Dissert. Abstr. 24(1964): 3288.

A marsh island lagoon, containing a large standing crop of *Mercenaria mercenaria*, had bottom sediments characteristic of that environment. Nine other environments in the area had their own environmental characteristics and infaunal assemblages. If radioactive materials were to be introduced into the Bogue Sound area, the greatest concentration by uptake in bottom sediments probably would occur where commercial shellfishes are most concentrated, because shellfishes tend to be abundant in finer grained sediments, which by virtue of their higher content of clay and organic matter tend to take up more radioactive material. Fine bottom sediments also have least tendency to redistribute, thus concentrate radioisotopes more than coarser sediments which are redistributed periodically by current and wave action. - J.L.M.

189
Bricelj, Vera Monica. 1979.

Fecundity and related aspects of hard clam (*Mercenaria mercenaria*) reproduction in Great South Bay, New York. A thesis presented to the Graduate School in partial fulfillment of the requirements for the degree of Master of Science in Marine Environmental Sciences, State University of New York at Stony Brook, xi + 98 p.

In artificial spawning an optimum gamete ratio of approximately 1.8×10^5 sperm/100 eggs was determined. Unfertilized spawned ova ranged from 50 to 97 μm and were characterized by a bimodal size-frequency distribution. Clams from Long Island Sound had somewhat smaller ova than those from Great South Bay. Although individual fecundity varied widely among individuals, correlation between length and fecundity of clams from Great South Bay was significant. Fifteen to 25% of the variation in fecundity was attributed to the difference in size of clams. No significant differences in fecundity, size of eggs, or larval survival were detected between clams from two diverse Bay habitats. Laboratory spawning tends to underestimate natural fecundity. Sex ratio was approximately 50:50. The smallest clam to spawn was a sublegal female 33.1 mm in length. Seed clams were capable of producing viable spawn, but fecundities were extremely low. It can be concluded that a continuing shift to smaller sizes as a result of heavy harvesting could significantly reduce total egg production and setting in the Bay. There is no evidence to support a decline in egg production with increasing age. Large cherrystones or chowders may be used alternatively in spawner transplant programs, since no significant difference in fecundity was found between the two size groups. Littlenecks contribute the largest amount of eggs to total population fecundity because they are dominant in numbers in the Bay. It can be roughly estimated that only one out of approximately 29 million eggs survives to become a legal-sized clam. The maximum number of eggs produced by a large cherrystone is about 8 times that of a seed clam. The minimum legal size should be reexamined, or regulatory efforts be directed to preserve larger clams in some uncertified areas. - J.L.M.

190
Bricelj, V. M., and R. E. Malouf. 1980.

Aspects of reproduction of hard clams, *Mercenaria mercenaria*, in Great South Bay, New York. Natl. Shellf. Assn., Abstracts, Technical Session: 16 (abstract).

Optimum gamete ratio of approximately 1.8×10^5 sperm/100 eggs was determined. Unfertilized spawned ova ranged from 50 to 97 μm and were characterized by a bimodal size-frequency distribution. Egg production among individuals was highly variable, but correlation between size (length) and egg production was significant; 15 to 25% of the variation in fecundity was attributable to the difference in size of clams. Maximum egg production recorded for a single female over the spawning season was 16.8 million eggs. No significant differences in fecundity, size of eggs, or larval survival were detected between clams from two diverse bay habitats. Laboratory spawning tends to underestimate natural fecundities. Sexes were approximately equal. The smallest clam to spawn was a sublegal female 33.1 mm long. Seed clams produced viable spawn but had extremely low fecundities. - J.L.M.

191
Brown, Carolyn. 1974.

A pigment-producing pseudomonad which discolors culture containers of embryos of a bivalve mollusk. Chesapeake Sci. 15(1): 17-21.

A recurring pink discoloration at the bottom of polyethylene buckets containing hard clam, *Mercenaria mercenaria*, embryos was produced by a red-pigmented pseudomonad. Discoloration was not a problem, but number of bacterial cells was of concern. Below 10^3 cells/ml of culture of clam embryos the bacterium was not detrimental to clams, but at higher concentrations embryonic development decreased or clams died. Chloramphenicol and neomycin were effective controls and they did not have adverse effects on clam embryos. - modified author's abstract. - J.L.M.

192
Brown, Frank A., Jr. 1958.

Studies of the timing mechanisms of daily, tidal, and lunar periodicities in organisms. In Perspectives in Marine Biology. A. A. Buzzati-Traverso (ed.). Univ. Calif. Press, Berkeley, p. 269-282.

This review chapter cites work on a variety of plant and animal species, including *Venus*, also called quahog, therefore *Venus (Mercenaria) mercenaria*. Graphs of solar and lunar cycles, and responses to barometric pressure changes, are given. Oxygen consumption of *Venus* rises with falling pressure. In discussion, V. L. Loosanoff commented that he would like an explanation of why such clearly demonstrated rhythms in experimental animals, kept under rather unfavorable conditions such as small quantities of water, cannot be easily or at all detected in clams such as *Venus mercenaria* under natural or almost natural conditions. No reply was recorded. - J.L.M.

193
Brown, F. A., Jr., H. M. Webb, and M. F. Bennett. 1955.

27-Day cycles of activity in oysters and quahogs. Anat. Rec. 122(3): 463.

Opening of shells was recorded continuously for 45 days in one test and 75 days in another. Clams were in containers of seawater at 10°C in the first period. Distilled water was added periodically to maintain salinity. In the 2nd period clams were held at room temp and seawater was changed every 3 or 4 days. Analysis showed clear cycles of lunar-day and solar-day frequencies. A very striking 27-day cycle was present. In the lunar-day cycle very conspicuous patterns of major and minor periods of activity recurred 3 days earlier in each succeeding synodic month. Another analysis of the data in which all cycles of primary solar and lunar frequencies were randomized also showed the 27-day cycle. - J.L.M.

194
Brown, Frank A., Jr., H. Marguerite Webb, and Miriam F. Bennett. 1955.

Proof for an endogenous component in persistent solar and lunar rhythmicity in organisms. Proc. Nat. Acad. Sci. 41: 93-100.

The paper deals with fiddler crab, *Uca pugnax*. *Mercenaria mercenaria* is not mentioned. Crabs were transported 51° westward, from Woods Hole, Mass. to Berkeley, Calif. within 24 hrs. Thus it was possible to measure the approximate degree of precision of the capacity of crabs to maintain daily and lunar cycles of color change while no concurrent physical cycle of the same length could be affecting them. Compared with controls kept at Woods Hole the Berkeley crabs shifted their cycles to slightly later in the day, about 22 min forward. There was no tendency for animals in Calif. to drift away from Woods Hole controls. - J.L.M.

195
Brown, Frank A., H. Marguerite Webb, and Erwin J. Macey. 1957.

Lag-lead correlations of barometric pressure and biological activity. Biol. Bull. 113(1): 112-119.

Using statistical correlation techniques, the authors claim to have found statistically significant correlations between biological activity and barometric pressure changes in a variety of animals and plants, in which the organisms were actually leading barometric pressure changes by more than a day. The correlation for *Venus (Mercenaria)* was -0.446 ± 0.096 2 days in advance. Specific experiments with potato tissue and fiddler crabs are cited in confirmation. (Abstracter's note: results for *Venus* were obtained from statistical analysis of data taken from the literature. Different time displacements were tried and the highest value of r was selected. Conclusions drawn from such manipulation are suspect. In the absence of direct experimental evidence, such conclusions are not warranted.) - J.L.M.

196
Brown, F. A., Jr., M. F. Bennett, H. M. Webb, and C. L. Ralph. 1955.

A correlation between barometric pressure changes and oyster and quahog activity. Anat. Rec. 122(3): 462-463.

Forms of mean daily cycles of barometric pressure and mean daily cycles of opening and closing of shells in constant light and temp were compared for 7 two-week periods. General forms for the 2 cycles were quite striking, but forms of cycles for certain portions of the day were often inverted relative to the same portions for other 2-week periods. Activity cycles, often having forms paralleling pressure changes, were out of phase with pressure changes by 1 to 3 hrs, suggesting a correlation between rate and direction of pressure change and amount of clam activity. An hourly correlation for all data between minutes open/hr and concurrent rate and direction of pressure change showed increased activity in proportion to rate of pressure fall and decreased activity in proportion to rate of rise. It was suggested that the character of the response related to any given barometric pressure was determined in some way by an endogenous rhythmic process. (Abstracter's note: It apparently is the policy of Anat. Rec. not to include illustrations. This note would have been easier to understand if graphs had been included.) - J.L.M.

197
Brown, Frank A., Jr., M. F. Bennett, H. M. Webb, and C. L. Ralph. 1956.

Persistent daily, monthly and 27-day cycles of activity in the oyster and quahog. J. Exp. Zool. 131(2): 235-262.

Venus mercenaria used in experiments were collected at West Falmouth, Mass. and held in the laboratory under continuous illumination of about 1 ft.c. Experiments were carried out from 17 June to 30 Aug. 1954, at room temp, which varied between 21 and 27°C. No overt rhythm of opening and closing was observed, but statistical rhythms were detected. A low degree of opening was seen about 6 am and a relatively high degree through the rest of the day, with a tendency for maxima in late morning and late afternoon or early evening. Daily cycles of opening and closing appeared to be correlated with barometric pressure changes. The characteristic pattern was repeated at 27-day intervals, and it was postulated that this was in some way related to the 27-day cycle of rotation of the sun on its axis. - from authors' summary - J.L.M.

198
Brown, F. A., Jr., H. M. Webb, M. F. Bennett, and M. I. Sandeen. 1955.

Evidence for an exogenous contribution to persistent diurnal and lunar rhythmicity under so-called constant conditions. Biol. Bull. 109(2): 238-254.

199
Brown, Robert S., and Carole J. O'Toole. 1978.

Histochemical analyses of pigment accumulations in *Mercenaria mercenaria* L. and *Mya arenaria* L. Proc. Natl. Shellf. Assn. 68: 75-76 (abstract).

Histopathologic analysis of *Mercenaria* collected from Massachusetts, Rhode Island, and New Jersey demonstrated accumulation of pigments of 3 types: 1) irregular, 2-20 µm diam, orange-brown staining bodies, present extracellularly in alimentary tract epithelium and gonadal connective tissue, and intracellularly in renal epithelium; 2) spherical 7-12 µm diam eosinophilic concretions, present intracellularly in renal epithelium; and 3) 30-200 µm diam melanotic casts present in renal tubular lumens. Only type 1 pigment was found in *Mya*. This pigment had morphological characteristics of lipofuscins (brown staining bodies of oxidized lipids) found in vertebrates. All 3 pigment types had histochemical characteristics of lipofuscins. Accumulation of these pigments appears to be a normal physiological process although abnormally large accumulations were noted in clams from certain environments. - J.L.M.

200
Brunet, R., and A. Jullien. 1936.

Des characteristiques architecturales du coeur chez deux Lamellibranches marins: *Ostrea edulis* et *Venus gallina*. Compt. Rend. Acad. Sci. Paris 202: 1945.

Presented by title only. - J.L.M.

201
Bryan, G. W., A. Preston, and W. L. Templeton. 1966.

Accumulation of radionuclides by aquatic organisms of economic importance in the United Kingdom. In Disposal of Radioactive Wastes into the Seas, Oceans and Surface Waters. Internatl. Atomic Energy Ag., Vienna, p. 623-637.

202
Buck, John D., Patricia M. Bubucis, and Theodore J. Combs. 1977.

Occurrence of human-associated yeasts in bivalve shellfish from Long Island Sound. Applied and Environmental Microbiology 33(2): 370-378.

Potentially pathogenic yeasts, especially *Candida parapsilosis*, *C. Tropicalis*, and *Torulopsis glabrata*, were found in *Mercenaria mercenaria* from Long Island Sound. Some inconsistency and seasonal variation was noted. *C. albicans* densities were greatest during colder months in more heavily polluted waters. Quahog meat contained the greatest numbers of isolates but not necessarily the most species. - J.L.M.

203
Buckley, George D. 1974.

Ecological aspects of some molluscan species of Pleasant Bay, Orleans, Massachusetts. Bull. Am. Malacol. Un. 40: 13.

Mercenaria mercenaria is one of the major species harvested from the area. Horseshoe crab, *Limulus polyphemus*, has been accused wrongly of being a major shellfish predator. It preys only occasionally on young *Mercenaria* and *Mya*. *Polinices* and *Lunatia* are more serious predators and *Urosalpinx cinerea* is even more abundant and predacious. The Bay is largely undeveloped and unpolluted. The environment is unique, with vast protected salt marshes and uniform environment except for seasonal temp fluctuations. Given proper study and management the yield of living resources could be greatly increased. It would be advisable to declare the Bay a natural resource area under Coastal Zone Management regulations, to permit commercial and recreational development on and near the water. - J.L.M.

204
Buckner, Stuart C. 1978.

An approach to the management of a hard clam resource. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978, Abstracts: page not numbered.

A comprehensive shellfish management program in the Town of Islip, N.Y. includes research on harvest, catch per unit of effort, and a hard clam population survey. Annual stocking programs include hard clam transplants, spawner transplants, and mariculture. No data are given. - J.L.M.

205
Buckner, Stuart C. 1979.

Shellfish management in the Town of Islip. In Proc. Symp. Mariculture in N.Y. State. N.Y. Sea Grant Inst. and Cornell Univ. NYSGI-RP-79-01: 13-18.

Surveys show that the average density of hard clams is 67 bu per acre in open waters, 122 bu/acre in closed waters. For 1976 it was estimated that 524,000 bu were harvested commercially, and 21,000 bu by residents. Transplants from closed to open waters are an important part of the program. At least one area each year is located along the north shore of the Bay to provide a winter ground. Clams are spread thinly to avoid a "bonanza" type harvest. Spawner transplants are also made, to enhance productivity. The Town also has a mariculture program using aggregate, baffles, and predator netting. Human interference is the chief problem with this program. The Town is also considering construction of a shellfish hatchery. - J.L.M.

206
Buckner, Stuart C. 1979.

An approach to the management of a hard clam resource. Proc. Natl. Shellf. Assn. 69: 193 (abstract).

Specific research projects discussed include a yearly analysis of harvest and catch per unit of effort, and a hard clam population survey. As a result a number of stocking programs including hard clam transplants, spawner transplants, and a mariculture project are carried out. - J.L.M.

207
Budington, R. A. 1904.

Nervous regulation of the heart of *Venus mercenaria*. Biol. Bull. 6: 311-312.

Normal rate and character of heart beat varies widely among individual quahogs. Partially exhausted hearts show extreme irregularities. Electrical stimulation of visceral ganglion arrests beat; stimulation of cerebral ganglion has no effect. Stimulation of nerves passing from visceral ganglion to heart gives results comparable to those obtained by stimulation of vagus in vertebrates, e.g., long after-effects of strong stimulation, and typical escape from weak stimulation. No evidence of acceleration was ever present. No group of animals below lamellibranch mollusks has a definitely localized cardiac organ. Therefore, it appears that cardiac muscle, wherever found, does not function entirely independently of inhibitory influences of the central nervous system. - J.L.M.

208
Buelow, Ralph W., Daniel A. Hunt, Philip S. Kelley, and Pearce M. Klazer. 1966.

Indian River Bay shellfish growing area study. A report of a cooperative study of pollution sources, hydrography, and water quality in the western section of Indian River Bay, Delaware, conducted 13 September to 26 September 1965. U.S. Dept. H.E.W., Pub. Health Serv., Bu. State Serv., Div. Envir. Engr. Food Prot., Shellf. Sanit. Br., NE Research Ctr., Narragansett, R.I., iii + 40 p., appendix.

Contains information on hydrographic conditions and water quality. *Mercenaria mercenaria* is not mentioned. - J.L.M.

209
Bullis, Harvey R., Jr., and John R. Thompson. 1965.

Collections by the exploratory fishing vessels *Oregon*, *Silver Bay*, *Combat*, and *Pelican* made during 1956-1960 in the southwest North Atlantic. U.S. Fish Wildl. Serv., Spec. Sci. Rept.—Fish. 510, iii+130 p.

Observations represent over 100 cruises and over 6,000 fishing stations. *Mercenaria mercenaria* was not taken, but *M. campechiensis* was found in 51 locations. - J.L.M. and M.W.S.

210
Bumpus, F. Merlin, and Irvine H. Page. 1955.

Serotonin and its methylated derivatives in human urine. J. Biol. Chem. 212(1): 111-116.

Pharmacological assays were done with *Venus mercenaria* heart. The heart was 5- to 10-fold "more sensitive" to bufotenine (N, N-dimethylserotonin) and twice as sensitive to the N-methyl derivative as to serotonin, 5-hydroxytryptamine (5-HT) itself. On arterial pressure of anaesthetized dogs the order of activity of the 3 compounds was just the reverse. - J.L.M.

211
Burbanck, W. D., Madelene E. Pierce, and G. C. Whiteley, Jr. 1956.

A study of the bottom fauna of Rand's Harbor, Massachusetts: An application of the ecotone concept. Ecol. Monogr. 26(3): 213-243.

An ecotone is conceived as a tension area always formed when two or more communities are in contact, a zone of great biotic and physical-chemical instability. In the area studied hard clams were free of predation by carnivorous snails, which did not penetrate the harbor, they were harvested on a small scale and irregularly by fishermen. Thus, only general statements could be made about fluctuations in numbers. In summer of 1950 *Venus* was only about one fifth as abundant as in 1949. The most severe decline was in the shallow muddy north arm where fishermen seldom operate but blue crabs (*Callinectes sapidus*) were most numerous. In summer 1949 these crabs were abundant in Rand's Harbor and in similar estuaries in the Woods Hole area. It was suggested that crab predation rather than overharvesting was responsible for the decline in clam abundance. In summer most *Venus* had already begun their migration from the channel. Only about one-fourth were in the muddy channel, one half on the gravelly slope, and one quarter at low tide. Substrate inhabited was all combinations of mud, peat, gravel, and sand. Hard clam has a wide range of tolerance for fresh water, which may account for its presence at all tide levels. The Harbor is a man-made estuary about 30 yrs old. Greatest depth is not over 25 ft at high tide. Fresh water flows into both arms. Summer temp was 20 to 23°C, pH 7.0 to 7.6, salinity 27 to 30°/°°. Intensive sampling was done in 4 summers from 1946 to 1950. *Venus mercenaria* was one of the most abundant organisms. - J.L.M.

212
Burnett, Allison L. 1955.

A demonstration of the efficacy of muscular force in the opening of clams by the starfish, *Asterias forbesi*. Biol. Bull. 109(3): 355 (abstract).

A gape of 1 to 2 mm is sufficient for a sea star to insert its stomach between valves of a quahog. Pull required to produce a small gape was recorded by inserting the hook of a spring scale in a notch in the shell of a 2-in quahog. Both adductor muscles were then severed and strong rubber bands, sufficient to withstand a pull greater than that required to open the intact clam, were wrapped around the valves. A sea star of 6-in radius opened the valves a distance of 2 mm within 5 min and held this opening for 3 min. Alternate opening and closing was repeated over a feeding period of 1 1/2 hrs. After about 30 min valves were held open as long as 10 min. The stomach of the sea star does not appear to be damaged when the valves of the clam close. - J.L.M.

213
Burnett, Allison L. 1960.

The mechanism employed by the starfish, *Asterias forbesi* to gain access to the interior of the bivalve, *Venus mercenaria*. Ecology 41(3): 583-584.

Much research has been done on the subject, some investigators believing that the clam is opened by sheer force, others claiming that a toxic secretion is given off. In the 1950s several studies demonstrated that no toxic substance is secreted between the valves, and that the sea star can apply forces of 3,000 to 5,500 g with its tube feet. No author previously had given a complete account of the feeding process. Eight 2-1/2 in clams were bound with heavy cord so that it was impossible to open the valves. All were attacked, and sea stars remained humped over the clams for 8 to 48 hrs. Clams appeared unharmed: hearts were beating regularly, and adductor muscles intact. Carmine particles introduced into the water failed to enter the valves. In another group of clams a 1 mm^2 hole was made at the edge of the valves, which were tied shut. Sea stars were able to insert their stomachs through the notch and digest the clam. Thus, this experiment had no value in testing presence of a toxin. The experiment was repeated, covering the opening with fine bolting cloth. After 2 hrs most clams suffered partial digestion of the mantle, but the rest of the clam was intact. Clams survived, with regular heart beats, for as long as 5 hrs, but eventually were completely digested. There was no evidence of a toxin.

Sea stars need only to open valves slightly to begin digestion. To test whether opening is possible solely by force a small notch was filed in the mid-ventral edges of several clams and the hook of a spring balance was inserted. A force of 7 to 10 lbs (3,000 to 4,500 g) was sufficient to cause a gape of 2 mm. Adductor muscles were then severed and rubber bands strong enough to withstand a greater force were wrapped around the valves. Sea stars were able to overcome the resistance of the strong rubber. After 5 min valves were open about 2 mm and remained open for 3 min then snapped closed, presumably on the everted stomach of the sea star. Soon the valves were opened again for about 5 min. This process of opening and closing continued for about 1/2 hr, then the sea star gave up. This proves that a sea star can open a clam by force alone, and that a toxic substance is not necessary. When valves are open 1 mm or less, enzymes of the sea star stomach digest the living clam, causing adductor muscles to fail after a relatively short time. Apparently the stomach of the sea star is not necessarily damaged if the clam closes while this process is going on. - J.L.M.

214
Burrell, Victor G., Jr. 1977.

Mortalities of oysters and hard clams associated with heavy runoff in the Santee River system, South Carolina in the spring of 1975. Proc. Natl. Shellf. Assn. 67: 35-43.

Although *Mercenaria mercenaria* normally does not tolerate salinities below 10 to 13°/°°, conditions under which oysters can survive, hard clams survived two periods of low salinity with less than 5% mortality, whereas 32% to 66% of oysters died. Changes in ionic concentration were measured by conductivity determinations on shell cavity liquor. At lowest salinities, conductivity of clam liquor was considerably higher than ambient salinity. Oysters showed a greater range of conductivity, but also maintained higher conductivity than surrounding water during heavy runoff. Low concentrations of dissolved O_2 and presence of H_2S, associated in some places with high runoff, did not appear to be implicated. Lower clam mortality probably was related to their ability to remain closed longer than oysters. - J.L.M.

215
Burson, S. L., Jr., M. J. Fahrenbach, L. H. Frommhagen, B. A. Riccardi, R. A. Brown, J. A. Brockman, H. V. Lewry, and E. L. R. Stockstad. 1956.

Isolation and purification of mactins, heparin-like anticoagulants from Mollusca. J. Am. Chem. Soc. 78(22): 5874-5878.

Experimental animals were surf clam and ocean quahog. *Mercenaria mercenaria* is not mentioned. - J.L.M.

216
Butler, Philip A. 1951.

Experimental planting of hard clam, *Venus*. U.S. Fish Wildl. Serv., Br. Fish. Biol., Ann. Rept.

217
Butler, Philip A. (ed.). 1959.

Annotated bibliography of unpublished estuarine research in the Gulf of Mexico 1925-1959. Gulf States Mar. Fish. Comm., New Orleans, La., 51 p.

Contains listings of some general survey papers which may refer to hard clam. No. 2066 is the only specific reference to *Mercenaria*. The title is listed elsewhere in this bibliography. - J.L.M.

218
Butler, Philip A. 1959.

Growth of New England hard clams in Florida. Proc. Natl. Shellf. Assn. 49, August 1958: ii.

Listed by title only. M.W.S. and J.L.M.

219
Butler, Philip A. 1960.

Annotated bibliography of unpublished estuarine research in the Gulf of Mexico. Supplement 1: individual pages to be inserted in original edition. Gulf States Mar. Fish. Comm., New Orleans.

Contains listing of some general survey reports which may refer to hard clam, e.g., nos. 5128 and 5132. - J.L.M.

220
Butler, Philip A. 1961.

Effects of pesticides on commercial fisheries. Proc. Gulf Caribb. Fish. Inst., 13th Ann. Sess.: 168-171.

It is of special concern that marine bottom forms like clams may be unusually susceptible to chemical pesticides. The first evidence of toxicity is a decrease in growth rate. This provides a fortunate index of sublethal effects. Young oysters have been used to evaluate the effects of pesticides. - J.L.M.

221
Butler, Philip A. 1964.

Commercial fisheries investigations. In Pesticide-Wildlife Studies, 1963. U.S. Fish Wildl. Serv. Circ. 199, p. 5-28.

Mercenaria mercenaria exposed in the laboratory to a concentration of 1.0 ppb DDT stored pesticide in clam tissues at levels from 3 to 9 ppm. Clams maintained in clean seawater and analysed at intervals contained residues of 3.5 ppm at the beginning of the experiment, 0.88 ppm after 10 days, and 0.161 ppm after 20 days. - J.L.M.

222
Butler, Philip A. 1965.

Reaction of estuarine mollusks to environmental factors. Biological Problems in Water Pollution (Third Seminar-1962). U.S. Dept. Health, Educ. Welfare, Public Health Serv. Pub. No. 999-WP-25:92-104. Reprinted, presumably verbatim, from Biological Problems in Water Pollution, Third Seminar -- 1962.

Clams transplanted from Rhode Island to Florida when they were approximately 1/2" in diameter doubled in size in winter when they would have been in hibernation in Rhode Island. Artificially propagated clams (1/4") from Milford, Conn. were suspended in trays on opposite sides of an island in Florida. Both lots were of equal size. One group yielded 24% greater volumes of meat than clams on the opposite side, yet both sides of the island appeared biologically and physically similar, to the author. Hybrid seed clams of reciprocal crosses of *M. mercenaria* x *M. campechiensis*, were suspended in midwater next to pure *M. mercenaria*. After over four years, pure strain clams were 50% longer and had nearly double the meat yields of hybrids. There was some question whether this was a hybrid cross. Nevertheless, it showed that the complete background of clams must be known. - D.L.

223
Butler, P. 1965.

Commercial fishery investigations. In The effects of pesticides on fish and wildlife. U.S. Dept. Interior, Fish Wildl. Serv. Circ. 226, p. 65-77.

224
Butler, Philip A. 1966.

Pesticides in the marine environment. In Pesticides in the Environment and their Effects on Wildlife. J. Appl. Ecol. 3 (Suppl.): 253-259.

After exposure for 7 days to 1.0 µg DDT/liter in flowing seawater *Mercenaria mercenaria* had accumulated 6 ppm DDT. This was considerably less than residues in one species of mussel and 4 oyster species treated similarly. After 15 days flushing hard clams retained residues of 0.5 ppm; the other species had higher residues. Rates of uptake and retention were unpredictable and did not appear to be related directly to water-pumping activity. On the east coast of the United States American oyster is the best assay organism for DDT effects. If oysters are not present *Mercenaria* or some other species may be substituted. - J.L.M.

225
Butler, Philip A. 1966.

Fixation of DDT in estuaries. Trans. 31st N. Am. Wildl. Nat. Res. Conf.: 184.

226
Butler, Philip A. 1966.

The problem of pesticides in estuaries. Trans. Am. Fish. Soc. 95(4)(suppl.), Spec. Pub. 3: 110-115.

227
Butler, Philip A. 1969.

Monitoring pesticide pollution. BioScience 19(10): 889-891.

Mercenaria mercenaria was least efficient in storing pesticide residues of all mollusks evaluated. - J.L.M.

228
Butler, P. A. 1971.

Influence of pesticides on marine ecosystems. Proc. Royal Soc. London B177: 321-329.

Mercenaria mercenaria accumulated various amounts of tissue residue after 5-day exposure to aldrin, DDT, dieldrin, endrin, heptachlor, lindane, and methoxychlor. *Mya arenaria* accumulated substantially greater amounts of all pesticides. After flushing for 7 and 15 days residues were reduced, but the amount of reduction varied between compounds. Residues of some compounds were reduced more effectively by *Mya* than by *Mercenaria*. For meaningful assay it is obvious that capabilities of the assay animal must be known. In general, however, accumulation in *Mercenaria* was slower and flushing was also slower than by soft clam. One lesson learned from the National Estuarine Monitoring Program in the U.S. was the importance of a continuing series of samples collected at regular intervals, and adequate control of sampling. At the monitoring station in Conscience Bay, N.Y., where mussels were the assay animal, residues of DDT remained fairly constant at 0.5 to 1.0 ppm in 1967 and the first half of 1968, then unaccountably dropped to zero and remained there. It was found that technicians doing the sampling had switched to hard clam, which is ineffective in storing polychlorinated hydrocarbon pesticides. A 5-year study of pesticide residues in estuarine mollusks in the U.S. demonstrated that residues were not high enough to be a human health hazard. Laboratory experiments suggested that chronic pollution with low levels of pesticides may have more widespread and permanent effects on estuarine biota than episodic events, the effects of which usually are local. - J.L.M.

229 Butler, Philip A. 1973.

Organochlorine residues in estuarine mollusks, 1965-1972 - National pesticide monitoring program. Pt. I. General summary and conclusions. In Residues in Fish, Wildlife, and Estuaries. Pestic. Monitor. J. 6(4): 238-246.

Mercenaria mercenaria was not regarded as a satisfactory species to monitor accumulation and retention of organochloride compounds because under similar laboratory conditions hard clams accumulated residues half as large as American oyster and flushed these compounds much more quickly. Hard clam was examined in Del. and N.Y. Residues were low as compared with carnivores such as fish-eating birds. Metabolites of DDT were the only residues detected in many analyses of filter-feeding mollusks. In most areas a pronounced decline in number of samples containing high residues of DDT was noted over the period, but in N.Y. more samples had residues in excess of 10 ppb in 1971 than earlier. Organochloride residues are flushed rapidly from molluscan tissues when water supply is not contaminated. - J.L.M.

Pt. II. Residue data - Individual states. Sect. C: Delaware: 263-267.

Samples were examined from 9 stations each month from Oct 1966 to Aug 1969. At stations 1-2, in upper Delaware Bay, only *Modiolus demissus* was examined; at stations 3-5, from Bowers Beach to Broadkill River, only *Crassostrea virginica*; at stations 6 to 8, Cape Henlopen and Rehoboth Bay, only *Mercenaria mercenaria*; and at station 9, in Indian River Bay, only *M. demissus*. Residues in oysters and clams showed no upward or downward trend in 3 yrs. In ribbed mussels residues declined markedly in the final year at the 3 stations. The relative inefficiency of hard clam in storing organochloride residues made it appear that Rehoboth Bay was free from this type of pollution, which it probably was not. Residues of DDE, TDE, DDT, and Dieldrin are reported for each month. - J.L.M.

Pt. II. Sect. J: New York: 303-315.

M. mercenaria was collected at 4 different sites to monitor organochloride pollution from March 1966 to June 1972. Other bivalves were sampled at other sites. In Conscience Bay, Long Island, when hard clam was substituted for blue mussel, DDT pollution apparently disappeared, but this was a consequence of the inefficiency of hard clam in storing such residues. PCBs were present in some samples in 1972, but were not identified or measured. Details of analyses are given by month for DDE, TDE, DDT, and Dieldrin. - J.L.M.

230

Byrne, C. J., and J. A. Calder. 1977.

Effect of the water-soluble fractions of crude, refined and waste oils on the embryonic and larval stages of the quahog clam, *Mercenaria* sp. Mar. Biol. 40(3): 225-231.

Embryonic and larval stages of hybrids of *M. mercenaria* and *M. campechiensis* were exposed to water-soluble fractions of 6 oils to note effects on survival and growth. Kuwait crude oil was least toxic on initial exposure to 2nd cleavage stage eggs and 2-day-old straight-hinge larvae. Median lethal concentration (LC_{50}) values in excess of 10 ppm were reached only after continuous exposure to water-soluble fraction (WSF) for up to 6 days. However, at 10 days, Kuwait was slightly more toxic than Southern Louisiana crude oil. At that stage both oils had LC_{50} near 2 ppm. Florida Jay crude oil was much more toxic, having an LC_{50} value less than 1 ppm at 48 hr and less than 0.2 ppm at 10 days. Refined oils, No. 2 fuel oil, and Bunker "C", had LC_{50} values of 0.10 ppm or less at all exposure times. Surviving larvae often grew more slowly than controls. - modified authors' abstract - J.L.M.

231
Cabelli, Victor J., and W. Paul Heffernan. 1968.

Seasonal factors relevant to fecal coliform levels in *Mercenaria mercenaria.* Proc. Natl. Shellf. Assn. 58: 1 (abstract).

Where water temp falls below 10°C for considerable periods very few coliform organisms can be recovered from *Mercenaria mercenaria* even in heavily polluted waters. This could be because low temp has a greater effect on uptake as compared with elimination, or that organisms die within the clam. Experiments were described which demonstrated a more marked inhibition of uptake as compared to elimination of *E. coli* at temps of 10°C and lower, and turbidities greater than 10 Jackson turbidity units. Seasonal changes also were found to affect uptake and elimination of coliform organisms by hard clam. - from authors' abstract - J.L.M.

232
Cabelli, V. J., and W. P. Heffernan. 1970.

Accumulation of *Escherichia coli* by the northern quahaug. Appl. Microbiol. 19(2): 239-244.

Concentration of coliform bacteria in *Mercenaria mercenaria* is a function of coliform content of surrounding water. In time an equilibrium level is reached at which intake and removal are equal. Digestive gland concentrates *Escherichia coli* by more than an order of magnitude over that of the surrounding water. Siphons contain more than ambient concentration. Gills, mantle, and shell liquor contain very low residues. - J.L.M.

233
Cabelli, Victor J., and W. Paul Heffernan. 1971.

Seasonal factors relevant to coliform levels in the northern quahaug. Proc. Natl. Shellf. Assn. 61: 95-101.

Few coliform organisms can be recovered from northern quahaug, *Mercenaria mercenaria,* when water temperature falls below 10°C for considerable periods of time, even though they are growing in heavily polluted waters. This could be due to a more marked effect of low temperatures on microbial uptake as contrasted to elimination, resulting in a gradual decrease in coliform levels in the animals. A second possibility is death of the organisms within the animal. The effect of seasonal changes on presence of fecal coliforms in animals from a polluted area is documented. The greater inhibitory action by temperatures of 10°C and lower and by turbidities above 10 Jackson Turbidity Units on uptake as compared to elimination of *Escherichia coli* by quahaug is demonstrated. Data on effect of temperature and turbidity changes on experimental uptake and elimination of *E. coli* by the animal are presented. Possible bases for these differences are discussed. - authors' abstract - D.L.

234
Cahn, A. R. 1951.

Clam culture in Japan. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Leafl. 399, 103 p.

Mercenaria (Venus) mercenaria is not included. However, the paper contains much useful information on life histories, ecology, reproduction, predators, culture methods, harvesting of wild crops, toxic effects of many clam species. Species and fishing gears are illustrated. Tables of production since 1909 are included. - J.L.M.

235
Cake, Edwin W., Jr. 1977.

Larval cestode parasites of edible mollusks of the northeastern Gulf of Mexico. Gulf Research Repts. 6(1): 1-8.

Larval cestodes of the genus *Tylocephalum* have been found in *Venus (Mercenaria) mercenaria texana* and *M. campechiensis* from the eastern Gulf of Mexico. These are not known to be infective to humans who eat clams raw, and experimental evidence obtained in this study suggests that these larvae are destroyed by human digestive acids and enzymes. Heavy infestations of larval cestodes may cause physiological stress in the host, which reduces the quality of meats. 101 larval cestodes were found in 6 *M. campechiensis* from 5 stations, in 69 *M. campechiensis* from 9 stations; and 477 larval cestodes in 3 *M. m. texana*, of 4 from 2 stations. - J.L.M.

236
Calabrese, Anthony. 1972.

How some pollutants affect embryos and larvae of American oyster and hard-shell clam. Mar. Fish. Rev. 34(11-12): 66-77.

Clam embryos and larvae were exposed to a range in pH from 6.0-9.5. Embryos developed normally in the pH range 7.0-8.75. At pH 9.0 development was reduced, and there was no development at pH 9.25-9.5. The pH range for normal larval survival was 6.25-8.75. The pH range for normal larval growth was 6.75-8.5. Larval growth was most rapid at pH 7.5-8.0. Heavy siltation or any pollution that changes the pH of waters could cause failure of clam recruitment. - D.L.

237
Calabrese, Anthony, and Harry C. Davis. 1966.

The pH tolerance of embryos and larvae of *Mercenaria mercenaria* and *Crassostrea virginica*. Biol. Bull. 131(3): 427-436.

Embryos and larvae of hard clams were reared in seawater with pH adjusted from 6.00 to 9.50. The pH range for normal embryonic development was 7.00-8.75. The lower pH limit for survival of clam larvae was 6.25. Survival in the pH range 6.25-8.75 was 68%. The pH range for normal growth for clam larvae was 6.75-8.50. Growth dropped rapidly at pH below 6.75. The optimum pH for larval growth was 7.50-8.00. Any siltation or pollution that would cause pH to fall below 7.00 or rise above 9.00 could cause failure of hard clam recruitment. - D.L.

238
Calabrese, A., and H. C. Davis. 1970.

Tolerances and requirements of embryos and larvae of bivalve molluscs. Helgolander wiss. Meeresunters. 20: 553-564.

This review paper contains no original data. The papers cited are abstracted elsewhere in this volume, thus a brief abstract is sufficient. The authors prefer to induce spawning rather than to strip. This eliminates broken tissue and immature eggs. Clams are placed in dishes filled with seawater and temp is raised in a water bath. If 28°C does not induce spawning, stripped sperm are added. Fertilized eggs are poured through a screen to remove faeces and other debris. Food for larvae must usually be less than 10 µ in diam. It must be digestible, and contain the necessary carbohydrates, fats, proteins, and vitamins. Naked flagellates are better than those with cell walls. Some algae which produce toxic metabolites must be avoided. If bacteria grow in algal cultures, even good food organisms may become toxic. Some bacteria produce toxic metabolites, others do not. Growth of hard clam larvae was much better when fed mixed naked algae than with *Chlorella*. Hard clam is less tolerant of low salinity than other bivalves. Below 22°/°° most embryos fail to develop to straight-hinge stage. Larvae, however, can survive and grow reasonably well at 17.5°/°° or even 15°/°°. Growth of clam larvae is much less affected by temp than are oyster larvae. Larvae tolerate a considerably wider range of pH than embryos. For successful recruitment of hard clams pH should not fall below 7.00, and reproduction is not successful when pH is appreciably above 9.00. Larvae can survive severe physical disturbance, such as vigorous disturbance prior to taking quantitative samples. But they can be killed by low concentrations of certain toxicants and in the laboratory are subject to disease. Larvae grow more rapidly in certain insecticides and other toxins, but others have marked adverse effects on growth, and at higher concentrations kill. If larvae are growing normally but mortality is high, disease is suspected. If growth is poor and mortality is high, toxins are suspected. Some materials toxic to bivalves are listed. Hard clam larvae can use *Chlorella* at 25 to 30°C, but not at 15°C, but they can grow at 15°C if fed naked flagellates. Salinity tolerance varies with temp and with stage of larval development. It has been assumed that tolerance to any factor will increase with age, but this is not invariably true. - J.L.M.

239

Calabrese, Anthony, and David A. Nelson. 1974.

Inhibition of embryonic development of the hard clam, *Mercenaria mercenaria*, by heavy metals. Bull. Environm. Contam. Toxicol. 11(1): 92-97.

Experiments were conducted in synthetic seawater in which background concentrations were: Hg 0.00003, Ag 0.003, Zn 0.029, Ni 0.0065, and Pb 0.007. Tests were terminated after 42-48 hrs. Clam embryos were much more sensitive than oyster embryos to Pb and Ni, somewhat more sensitive to Zn, as sensitive to Hg, and less sensitive to Ag. Hg (as $HgCl_2$) was 100% lethal to clams at 0.0075 ppm and Ag (as $AgNO_3$) at 0.045 ppm. LC_{50} values for Hg and Ag were 0.0048 ppm and 0.021 ppm, respectively. Zn (as $ZnCl_2$) and Ni (as $NiCl_2.6H_2O$) were 100% lethal to clams at 0.25 and 0.60 ppm, respectively, and LC_{50} were 0.166 and 0.31 ppm. Pb (as $Pb(NO_3)_2$) was least toxic of metals tested, lethal at 1.2 ppm. Results might have been different in natural seawater, which contains ligands which might increase or decrease toxic levels. Natural seawater was not used because it might be variable in trace metal content, and in dissolved organic or particulate matter. - J.L.M.

240

Calabrese, Anthony, Frederick P. Thurberg, and Edith Gould. 1977.

Effects of cadmium, mercury, and silver on marine animals. Mar. Fish. Rev. 39(4): 5-11.

Embryos and larvae of *Mercenaria mercenaria* were exposed to Hg and Ag. Levels that caused 50% mortality in 48 hr (LC_{50}) were respectively 4.8 and 21.0 ppb for embryos and 14.7 and 32.4 ppb for larvae. Clam embryos and larvae were as sensitive to Hg as oyster embryos and larvae, but less sensitive to Ag. Sublethal effects of Ag on adult hard clam were tested at various salinities for 96 hr. Respiration was significantly higher than controls after exposure to Ag levels as low as 100 ppb. This sensitivity varied with salinity, and certain Ag-salinity combinations were lethal. In long-term exposures (30-90 days) to 10 ppb Ag, oxygen consumption rates were also elevated. Clams placed in "clean" water for 30 days after 30 days in Ag-contaminated water still had elevated respiration. The most obvious generalization was that order and degree of metal toxicity vary, not only with salinity and metal salt form, but also with life stage and species. Early life stages of mollusks appear to be more sensitive to Hg and Ag than to Cd. Juveniles and adults take up more Hg and Ag in their tissues than Cd. In older animals, however, Cd produces more severe effects than Hg or Ag. Two general and basic effects of sublethal metal challenge were observed: 1) induction of enzymes that are either directly attacked or involved in mobilization of energy (glycolysis) or in production of metabolites for biosynthesis (pentose shunt). Chronic demand for enzyme production is costly in metabolic energy; and 2) loss of ligand sensitivity, by which enzyme reaction rates are regulated, which is perhaps the more serious effect. - J.L.M.

241
Calabrese, A., R. S. Collier, D. A. Nelson, and J. R. MacInnes. 1973.

The toxicity of heavy metals to embryos of the American oyster *Crassostrea virginica*. Mar. Biol. 18(3): 162-166.

This paper was cited, without title, in a 1973 paper as in press. As the title shows: The toxicity of heavy metals to embryos of the American oyster *Crassostrea virginica*, hard clam is not mentioned. - J.L.M. and M.W.S.

242
Calabrese, A., J. R. MacInnes, D. A. Nelson, and J. E. Miller. 1977.

Survival and growth of bivalve larvae under heavy-metal stress. Mar. Biol. 41(2): 179-184.

The order of toxicity for *Mercenaria mercenaria* larvae was Hg (greatest), Cu, Ag, Zn, and Ni (least). Growth of hard clam larvae, except in Ni-treated water, was not reduced at LC_5 values, but was reduced markedly at LC_{50} values. - modified authors' abstract. - J.L.M.

243
Campbell, Robert. 1955.

Hard clam conservation in Rhode Island. 5th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Fish Wildl. Serv.: 32.

Approximately 32,704 bu were transplanted in summer 1954. - J.L.M.

244
Campbell, Robert. 1964.

A report on the economically important shellfish resources of Raritan Bay. U.S. Dept. H.E.W., Pub. Health Serv., Northeast Shellf. Research Center, Narragansett, R.I. (processed), 11 p. (incl. title page and abstr.), 7 figs.

Studies of shellfish resources in Raritan Bay, which is about equally shared by New York and New Jersey, were stimulated by an outbreak of infectious hepatitis traced to hard clams taken from the Bay in 1960. *Mercenaria mercenaria* is the important commercial species, but *Mya arenaria* was more abundant than had been expected. By 1960, almost 90% of the original shellfish grounds had been unavailable for clamming because the waters were polluted by sewage. The hepatitis outbreak led to closing of the entire Bay on 1 May 1960. Samples were taken with a 1/2 yd construction type clamshell bucket operated from a hydraulic winch. Surface area sampled was about 5 ft^2 to a maximum depth of 18 inches. This was satisfactory except where rocks were encountered. Shallow areas were sampled with hand tongs. Hard clams were distributed more evenly north of the boundary between state waters (New York) than in New Jersey, where distribution was spotty. New York waters were more heavily populated, with 1.05 clams/ft^2 as compared with 0.47/ft^2 in New Jersey. In New York large clams were 3 times as abundant as littlenecks, in New Jersey the ratio was closer to 1:1. Large clams were of average size 250 clams/bu, littlenecks were 850/bu. Estimated populations were subject to error because size ranges varied and area of bottom was not measured precisely. Standing crop estimates for N.Y. were 291,200 bu of littlenecks and 3,153,000 bu of large clams. Confidence limits (95%) were rather large: total bushels in N.Y. 3,444,110 bu $\pm$ 667,520. Point estimates for N.J. were: littlenecks 353,000 bu, large 1,040,000 bu, total 1,393,000 bu. The figures are charts showing area, station pattern, and distribution by clam sizes, including sublegals (46 mm or less). The calculated sampling area was about 50,000 acres. - J.L.M.

245
Campbell, Robert. 1967.

A report on the shellfish resources of Raritan Bay, New Jersey. In Proc. Conf. on Pollution of Raritan Bay and Adjacent Interstate Waters, 3rd Sess., Fed. Water Poll. Control Adm., N.Y., App. A: 653-681.

This report describes distribution of 2 clam species, *Mercenaria mercenaria* and *Mya arenaria*. Prior to this study adequate information on hard clam distribution and abundance was available only for N.J. waters. Information on clams in N.Y. parts of the Bay came from hearsay and assumptions. Samples were taken with a clamshell bucket which covered a bottom area of about 5 ft^2 and dug to a maximum depth of 18 in. In shallower areas samples were taken with hand tongs. Size groups of clams were: "sub-legals" 15 to 46 mm long; "necks" 47-66 mm; and "large" over 66 mm. Charts illustrate distribution and density of the three size groups. The boundary between the 2 states runs roughly east and west, with N.Y. waters to the north. In general, distribution of hard clams was more even on the New York side, spottier south of the line. The N.Y. sector was far more widely covered with hard clams. General distribution patterns, particularly of "sub-legals", were irregular and were attributed to variations in setting and other factors. Average density of hard clams was 1.05 clams/ft^2 in N.Y., 0.47 in N.J. In N.Y. large sizes were 3 times as abundant as necks, in N.J. the two were about equal in abundance. The sub-legal group was least abundant of the 3 categories in both states. Total population estimates were made by assuming that "large" size represented 250 clams/bu, "neck" size 850/bu. Total standing crop estimates were: necks - N.Y. 291,200 bu, N.J. 353,000 bu; large - N.Y. 3,153,000 bu, N.J. 1,040,000 bu. - J.L.M.

246
Canario, Manuel T., Jr. 1964.

Rhode Island depuration study. In Proc. 5th Natl. Shellf. Sanitation Workshop, U.S. Dept. Health, Educ., and Welfare, Appendix I: 99-100.

Since 1955, when a peak production of 5,020,000 pounds were harvested, there has been a gradual decline in amount harvested and in number of diggers, in Rhode Island. Two major areas are closed to shellfish harvesting by pollution. It was estimated that 500,000 bu of quahaugs are in the Providence River area, and 400,000 bushels in Mt. Hope Bay. Some difficulties were encountered with depuration, but it is believed that such purification as is going to take place will occur in the first 24 hrs. The ultraviolet system of water recirculation is a practical method of purifying hard clam. - J.L.M.

247
Canzonier, Walter J. 1969.

Recent studies of hard clam activity and depuration. Proc. Natl. Shellf. Assn. 59:1 (abstract).

Hard clams were exposed to phage particles in running seawater for 7-18 days at levels of 5-9 particles per mℓ. Pooled samples showed clams concentrated particles 10-20 times seawater levels. Some individuals assayed at 50 times the concentration of the sea water. At higher levels (10^3-10^4 particles/mℓ) titre in clams did not exceed titre in seawater. Clams exposed for 24 hours exhibited no differences in patterns or rates of depuration compared with clams exposed longer. Clams exposed to 90-140 particles/mℓ of clam tissue rid themselves of 90% of their viral load, but 10-80% of clams sampled remained positive up to 12 days after depuration began. Experiments using *E. coli* as pollutant had depuration in 12-24 hours. Possibly some viral particles are sequestered and protected outside lumen by adsorption or migration between cells or by phagocytosis by clam leucocytes. - D.L.

248
Canzonier, Walter J. 1971.

Measurement of the oxygen requirements of a large population of *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. (1970) 61:2 (abstract).

Oxygen consumption of a population of 100 clams was measured continuously in a closed perfusion system. In a series of seven experiments consumption ranged from 4.1-9.5 mg/clam/hr with a mean of 5.7. These values agree closely with those obtained by others using individual clams (3.6-10 mg/clam/hr). From observations of continuously monitored clam activity and pumping observed in individuals, 65% oxygen saturation was the threshold below which clams would be excessively inhibited. Using these values it is possible to calculate minimum volumes of seawater required for operation of large-scale aquarium systems (e.g., depuration plants). Assuming a relatively high activity level of 70%, values determined ranged from 220-280 litres (58-73 gal) per bushel (200 clams) per hour at 17°C. - modified author's abstract - D.L.

249
Canzonier, Walter J. 1971.

Accumulation and elimination of coliphage S-13 by the hard clam, *Mercenaria mercenaria*. Appl. Microbiol. 21(6): 1024-1031.

Clams were exposed to low levels of S-13 (5 phage particles/mℓ, max 7 particles/mℓ) in running sea water for several days. *Escherichia coli* uptake and elimination also were monitored. Titers in clam tissues reached 2 to more than 1,000 times levels of exposure. On exposure to virus-free running water, clams polluted to relatively low levels (100 plaque-forming units/mℓ) eliminated most bacterial contaminants in 24 to 48 hr. Viral contaminants, however, persisted for days to weeks, even under ideal conditions for clam activity, provided that temp remained below inactivation threshold for virus. Most accumulated virus appeared to be sequestered in digestive gland. Retention of viral particles may occur even with low environmental levels of virus. These are not easily dislodged, and their elimination is independent of clam activity. Heavily contaminated clams eliminate most viral particles rapidly, giving the impression of extremely effective depuration. Viruses can persist in clams depurated to acceptable coliform levels. If small numbers of viral pathogens that remain in tissues are potentially infective, their stability under conditions of depuration and handling is extremely important. A monitoring system more critical than the coliform standard now in use is needed. - J.L.M.

250
Captiva, Francis J. 1960.

Equipment note no. 6.--Chain bridles and accumulators increase effectiveness of "Fall River" clam dredges in deep water. Comm. Fish. Rev. 22(12): 20-22.

Exploratory fishing located hard clams (*Venus* sp.) offshore of N.C. but several types of dredge were unsuccessful for commercial fishing because bottom was soft mud, sea conditions were adverse, or water was too deep. A 14-tooth Fall River dredge was modified to change the angle of attack and allow greater control. To reduce tendency to skip, a length of chain was inserted between chain bridle and towing warp. With this modification, commercial-size catches of 6 bu clams/30 min drag were taken consistently, whereas previous catches were only 1 to 2 bu/30 min. - J.L.M.

251
Carazzi, Davide. 1893.

Revisione del genere *Polydora* Bosc e cenni su du specie che vivono sulle ostriche. Mitth. Zool. Sta. Neaple 2(1-2): 4-45.

According to Sewell Hopkins (in Baughman 1948), Carazzi found *Polydora armata* tunneling in shells of *Venus* at Naples. - J.L.M.

252
Cardot, Jean. 1965.

Biochemical researches on the inactivation of 5-hydroxytryptamine in the heart of molluscs, *Helix pomantia, Buccinum undatum, Venus mercenaria,* and *Mya arenaria.* In Societe de Biologie de Lyon, 17 Mai 1965. (Lyon Society of Biology, 17 May 1965.) Compt. Rend. Seances Soc. Biol. (Paris) 159(7): 1612-1614.

253
Carlson, A. J. 1904.

The rhythm produced in the resting heart of molluscs by the stimulation of the cardio-accelerator nerves. Am. J. Physiol. 12(1): 55-66.

Issue 1, in which this paper appeared, was issued 1 Sept. 1904. Volume XII, Ginn and Co., Boston, was dated 1905. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S. and J.L.M.

254
Carlson, A. J. 1905.

Comparative physiology of the invertebrate heart. II. The function of the cardiac nerves in molluscs. Am. J. Physiol. 13(V): 396-426.

Studies made on several species, including *Venus mercenaria*, demonstrated the presence of cardio-inhibitory nerves, and apparently these nerves only. Stimulation of visceral ganglion failed to obtain cardio-accelerator effects. Auricles and ventricle are supplied with inhibitory nerves from visceral ganglion and the cardio-inhibitory mechanism can be excited reflexly by stimulation of siphonal nerves. - J.L.M.

255
Carlson, A. J. 1905.

Comparative physiology of the invertebrate heart. I. The innervation of the heart. Biol. Bull. 8(3): 123-160, 8 pls.

Details are given for a number of lamellibranchs, other mollusks, and members of other phyla. Cardiac nerves of *Venus* and some other species were not worked out in detail. The heart of *Venus* and others is innervated from visceral ganglion or cerebrovisceral commissures as in *Mya* and *Tapes.* This is evidently the plan of reno-cardiac innervation in all lamellibranchs. Cell bodies of cardiac nerves are probably situated in visceral ganglion or ganglia. When nerves come from cerebro-visceral commissures instead of from the ganglion directly it is because fibers follow the course of commissures for some distance before turning laterally to enter kidney and heart. The exact course through renal organs and heart itself has not yet been worked out. Physiological experiments on *Venus*, to be reported in a later paper, are mentioned. - J.L.M.

256
Carlson, A. J. 1905.

Comparative physiology of the invertebrate heart. III. Physiology of the cardiac nerves in molluscs (continued). Am. J. Physiol. 14(1): 16-53.

It is concluded that, with the exception of *Mytilus*, for which results were inconclusive, auricles and ventricle of lamellibranchs are supplied with inhibitory nerves from visceral ganglion or ganglia. These nerves enter the heart at the base of the auricles. - J.L.M.

257
Carlson, A. J. 1906.

Note sur les nerfs du coeur des invertébrés. Compt. Rend. Soc. Biol. Paris 60: 283.

From a comparative study of physiology of nerves of hearts of principal groups of mollusks and arthropods, pteropods excepted, the author concluded that invertebrates possess, probably without exception, excitor or inhibitor nerves, and usually both. This contradicts the earlier view that the heart of many mollusks is entirely free of nervous tissue. - J.L.M.

258
Carlson, A. J. 1906.

Comparative physiology of the invertebrate heart. V. The heart rhythm under normal and experimental conditions. Am. J. Physiol. 16(1): 47-66.

259
Carlson, A. J. 1906.

Comparative physiology of the invertebrate heart. VI. The excitability of the heart during the different phases of the heart beat. Am. J. Physiol. 16(1): 67-84.

260
Carlson, A. J. 1906.

Comparative physiology of the invertebrate heart. VII. The relation between the intensity of the stimulus and the magnitude of the contraction. Am. J. Physiol. 16(1): 85-99.

261
Carlson, A. J. 1906.

Comparative physiology of the invertebrate heart. VIII. The inhibitory effects of the single induced shock. Am. J. Physiol. 16(1): 100-109.

262
Carlson, A. J. 1922.

A note on the action of curare, atropine, and nicotine on the invertebrate heart. J. Gen. Physiol. 4(5): 559-568.

The primary action of curare and nicotine in mollusks is on the central nervous system and peripheral ganglia and not on motor nerve endings in muscle. Action on nerve centers is a primary stimulation followed by temporary or permanent paralysis depending on strength of dose. Atropine did not paralyze motor nerve endings in muscle in any mollusk studied. Solutions of curare, atropine, and nicotine of sufficient concentration to affect the heart appreciably have a primary stimulating action. The author concludes that the primary action is on ganglion cells of the heart and not on muscle. Continued action of solutions of the 3 alkaloids on heart of mollusks abolishes the influence of inhibitory nerves on the heart. In *Venus*, curare may act for 20 to 30 min before action of inhibitory nerves is abolished. *Venus* (species not given) was one of 22 mollusks studied, but no details are given other than the single mention cited above. - J.L.M.

263
Carlson, Gary P. 1972.

Detoxification of foreign organic compounds by the quahaug, *Mercenaria mercenaria*. Comp. Biochem. Physiol. 43B: 295-302.

Hard clam hepatopancreas was unable to metabolize the insecticide EPN, O-demethylate p-nitroanisole, N-demethylate aminopyrine, or oxidize hexobarbital. Quahaug hepatopancreas was able to reduce p-nitrobenzoic acid to p-aminobenzoic acid. The reaction was maximal at 35-45°C and pH 6.0, was stimulated by flavins, and inhibited by potassium cyanide but not by SKF-525A or carbon monoxide. Nitroreductase activity was found to a lesser extent in mantle, gill, foot, and gonadal tissue. - Modified auth. abstr. - J.L.M.

264
Carpenter, Horace F. 1889.

The shell-bearing mollusca of Rhode Island. Nautilus 3: 69-71.

In the synonymy of *Astarte castanea* Say appear the names *Venus castanea* Say and *V. sulcata* Mont., Maton and Rackett. This paper by Carpenter is very confusing, because it appeared in bits and pieces in many issues of Nautilus. This is the only reference to *Venus* or *Mercenaria* found in two attempts through interlibrary loan. Obviously much more material exists. Search terminated. - J.L.M.

265
Carpenter, Horace F. 1901.

The shell-bearing mollusca of Rhode Island. Nautilus 15(8): 92-96.

It is noted that the earlier portion of the paper appeared in vols. III and IV of Nautilus. This section contains the genera *Yoldia, Arca, Mytilus,* and *Modiolus.* See note under Carpenter (1889). - J.L.M.

266
Carpenter, J. S. 1967.

History of scallop and clam explorations in the Gulf of Mexico. Comm. Fish. Rev. 29(1): 47-53.

What is probably the largest bed of *Mercenaria campechiensis* off the U.S. coast extends from the Ten Thousand Islands area to St. Petersburg, off the west coast of Florida. This area of about 200 mi^2 now produces clams. The shoreline slopes very gradually and water depth is less than 12 ft in many places 4 to 5 mi offshore. The commercial fishery began in the late 1880s. From 1889 to 1915 boats from Key West made occasional trips to the Thousand Islands area. Landings in Key West varied from 10,000 to 25,000 clams a year. From 1913 to 1947 clams were taken in the Ten Thousand Islands area with a conveyor-belt dredge. Clams were shucked and used for canned chowder, minced clams, and clam juice. Operations stopped in 1947 because clams were scarce. Clams also have been found from Charlotte Harbor to lower Tampa Bay and Clearwater, but most beds are small. Small fisheries operated in some of these areas for a while. Commercial harvesting off Florida through 1960 fell to less than 20,000 lbs annually. After a temporary upsurge in the early 1960s catches fell off again. BCF clam explorations used modified "Fall River" dredges. Of 221 stations fished with clam gear, hard clams were found at 110 between St. Petersburg (about 28° N Lat) and Cape Romano (about 26° N). Best catches were made in 3 to 4 fath in the Pas-a-Grille and Venice areas in summers 1957 and 1958. In July 1958 hard clams were caught in 47 scallop-dredge drags between Cape Romano and Anclote Keys. The beds were still extensive and clams were about an inch larger than in 1957. Clam beds were located in the San Carlos and Cape Romano areas, but they were not extensive and catches were small. In December 1962 clam populations had decreased in all 4 areas. BCF vessels have found commercial concentrations of clams only in Florida waters of the Gulf of Mexico. It has been reported that small hard clam populations also exist off Mississippi and Louisiana. Exploratory fishing has found clams in only 2 drags off Galveston, Tex., 1 off Chandeleur Island, La., and a small bed in shoal water inside Horn Island, Miss. It was concluded that the future of the clam industry in the Gulf of Mexico is promising. - J.L.M.

267
Carr, H. Arnold. 1976.

Culturing and transplanting hatchery-spawned quahogs. Proc. Natl. Shellf. Assn. 65: 1 (abstract).

Between May and Oct 1973, 5.5 million quahogs, average length 2.0 mm, were suspended in trays (presumably in Buzzards Bay, Mass.). By Nov mean survival was 52% and mean size of clams delivered in May and June was 6.4 mm. Through the winter of 1973-74, with freezing water temp and ice, survival was 99%. Other hatchery-reared clams 8 to 20 mm long were transplanted to natural bottom. Recovery and survival of shell stock planted at water temp 6°C was greater than at 20°C. (Abstracter's note: it is presumed, although the context is not clear, that the final sentence describes the planting described in the sentence that precedes it.) - J.L.M.

268
Carr, H. Arnold. 1978.

Culture of hatchery-spawned *Mercenaria mercenaria* in Massachusetts. Proc. Natl. Shellf. Assn. 68: 76 (abstract).

In 1976, 12 towns bought hatchery clams between 5 and 14 mm. Growth varied with system design, density of clams, and substrate type. In winter survival was 80-90% in rafts and highly variable in pens in intertidal and shallow subtidal areas. Success of most transplants into natural, unprotected bottom appeared to be related to number of green crabs seen in the transplant site. Theoretical yields are high, but actual benefit to a town management program remains to be proven. - J.L.M.

269
Carr, Margie, Alex Nicholas, and Joseph A. Piscitelli. 1972.

An investigation of the anti-carcinogenic agent, mercenene. Part 4. The effect of several fractions of mercenene on the growth of Krebs-2 carcinoma. Proc. Pa. Acad. Sci. 46: 18 (abstract).

Carcinoma was injected intraperitoneally into the abdominal cavity of mice, allowed to grow for 2 days, then certain mice were subjected each day for 2 days to intraperitoneal injection of a specific fraction of mercenene (crude aqueous extract of *Mercenaria mercenaria*). On days 6 and 7 several mice from experimental and control groups were killed and numbers of cells in peritoneal cavities and volume of peritoneal fluid in each mouse were measured. Different fractions of mercenene (prepared by treatment with ammonium sulphate) varied in their inhibitory action. - J.L.M.

270
Carriker, Melbourne R. 1949.

Preliminary observations of the predation of commercial shellfish by conchs. Proc. Natl. Shellf. Assn. (1949): 86-92.

Laboratory studies showed that quahog-like bivalves were most resistant to predation by *Busycon carica* and *B. canaliculatus*, yet quahogs were readily opened and consumed. The findings of Colton (1908) were confirmed. The conch mounts the clam and holds it "in the hollow of its foot" so that the bills of the clam lie directly under the outer lip of the conch shell. By slow and strong contraction of the columellar muscle the conch brings the margin of its own shell to bear on the slight depression between the junction of the two quahog valves and presses against the edge of the valve farthest from it. This chips away a portion of the quahog valve. The process is repeated until the opening is large enough for the conch to wedge its shell margin between the clam valves. Periodically the conch examines progress by feeling with lobe-like projections on the rim of the anterior portion of the foot. Considerable wear on the conch shell takes place during attack, and this apparently is repaired during resting periods when the conch buries in the bottom. In some cases a conch will work away at a clam for several days without penetrating, and then may desert the clam. In one series of observations 52% of the sites of attack were posterior over the clam siphons, 27% over the midventral region, and 21% over the anterior portion opposite the siphon. Selection of site may be influenced by flow from the excurrent siphon. Sometimes the operculum of the conch also may be wedged between the quahog valves. There was no evidence that the conch may pour a secretion into the prey to kill it. Circumstantial evidence denied the possibility, because attacked but unopened clams with holes in the shell were active weeks later. In 23 days in an aquarium 69 mussels, 17 quahogs 0.8 to 2 inches long, 3 soft clams, and 1 razor clam were consumed. Mussels were attacked more readily than quahogs. In one experiment a conch consumed one quahog every 5 days. (Abstracter's note: publication date probably later than 1949.) - J.L.M.

271
Carriker, Melbourne R. 1950.

Predation of clams and oysters by conchs. Atl. Fisherman, Feb. 1950: 18, 37.

This article consists of extracts from an earlier paper, not identified, by the author. Some original data are included, but most information was taken from the literature. Conchs showed a decided tendency to prey upon thinner shelled mollusks, like mussels, first. Quahogs offer the greatest resistance to predation. The method of predation on quahogs is described from Colton (1908), abstracted elsewhere in this bibliography. A conch will work on a hard clam for as long as 7 days in an aquarium without penetrating, then may desert the clam. The predator only occasionally returns after deserting an individual clam. Out of 37 quahogs placed with one large conch in an aquarium, 15 were opened and 10 were attacked but not opened. Only twice did a conch return after the first attack failed. Selection of site of attack may be influenced by flow from the excurrent siphon of the prey. - J.L.M.

272
Carriker, Melbourne Romaine. 1950.

Killing and preservation of bivalve larvae in fluids. Nautilus 64(1): 14-17.

Retention of larvae in fluids rather than in slide preparations has many advantages. Among preservative fluids tried were 1% formalin, 4% formalin, and mercuric chloride. Best results were obtained with 1% formalin. Formula for the preservative was: formalin 10 cc, commercial sugar 100 g, filtered bay water (20 to 30°/oo) to make 1,000 cc, alkalized to approximately pH 10 with sodium bicarbonate. Solution pH should be held above 7. - J.L.M.

273
Carriker, Melbourne Romaine. 1951.

Observations on the penetration of tightly closing bivalves by *Busycon* and other predators. Ecology 32(1): 73-83.

In an aquarium conchs creep one centimeter in 6 to 12 sec, attracted by water pumped out by clams. Even deeply buried quahogs are attacked. Although *Venus*-like bivalves resist predation more than other pelecypods, they are readily penetrated and consumed. *Busycon* holds the clam in the hollow of its foot so that the ventral edges of the valves lie directly under the outer lip of the conch shell. By slowly and strongly contracting the columellar muscle the conch brings the margin of its own shell into the slight depression between the clam valves. Pressing against the edge of the valve farthest from it the conch chips off a piece. Relaxing and contracting, the conch makes an opening large enough to allow it to wedge its shell margin between the two valves. Sometimes the conch is unable to make an opening, merely smoothing off the edges of the clam shell. Hence the conch eventually deserts the clam. Of 37 clams placed with one large conch in one experiment 15 were opened and 10 were attacked but not opened. The operculum of the conch also has been seen wedged between clam valves in nature. Although it has been reported that conchs may pour a secretion between the valves which kills the clam there is no evidence to support this. Penetration and consumption of the clam is purely mechanical. The soft parts are consumed by rasping and swallowing. In the laboratory 6 conchs opened and consumed 17 *Venus mercenaria* in 23 days as well as 69 mussels, 3 soft clams, and one razor clam. Quahogs were 2-5 cm long. In another laboratory experiment consumption of quahogs 2 to 7.5 cm long buried in sand was nearly 1 clam per week. In an experimental site in Little Egg Harbor, N.J. conchs were present at a density of 1 per 100 ft^2. In a 47-day experiment, in which caged bivalves of various species were exposed to oyster drills, moon snails and conchs, quahogs were penetrated only in the absence of thinner shelled prey. Oyster drills and moon snails grew much faster when they fed on mixed bivalves than on hard clam alone. In the field *Busycon* consumed 0.35 hard clams per week in summer, in aquaria 0.86 clams per week in winter. In the field *Polinices* consumed 0.15 hard clams per week in summer. The higher rate in aquaria is explained by the absence of alternate foods. Field experiments showed that 91 conchs (the density found on a 75 by 125 ft area of bottom) could consume 700 quahogs from May through September. Although conchs and other predators prefer other prey, conch is the most serious enemy of large quahogs. In field experiments a small blue crab entered a cage of *Busycon* and mixed bivalves, molted, and could not escape. It opened and consumed 4 quahogs. This and other unpublished cage studies confirm the damage that can be done to hard clam and other bivalves by blue crabs. In one experiment a 12 cm caged blue crab consumed 6 quahogs 3 to 4 cm long in a week. Each predator leaves its signature on the empty valves. Photographs are included to show the relatively straight-sided hole made by *Urosalpinx*, sharply beveled hole of *Polinices*, smooth chipping by *Busycon*, and jagged chipping by *Callinectes*. Blue crab is probably a more serious enemy of hard clams than *Busycon*. (Abstracter's note: probably the most serious enemy of adult quahogs.) - J.L.M.

274
Carriker, M. R. 1951.

Ecological observations on the distribution of oyster larvae in New Jersey estuaries. Ecol. Monogr. 21: 19-38.

Bottoms of estuaries along the Atlantic coast of N.J., especially in the southern 2/3 of the State, where estuarine development is extensive, are inhabited by *Crassostrea virginica* and *Venus mercenaria*. In warmer parts of the year bivalve larvae dominate the plankton and identification is difficult. Biologists in N.J. are certain that they can identify larvae of *Mercenaria* and 7 other species. - J.L.M. and M.W.S.

275
Carriker, M. R. 1952.

Some recent investigations on native bivalve larvae in New Jersey estuaries. Proc. Natl. Shellf. Assn. (1950): 69-74.

Studies were carried out in Little Egg Har., N.J., the last 3 summers. The Harbor is 4 mi wide, 10 mi long with average depth at mean low water 4-7 ft in the largest part, only one prime inlet, and a deep, narrow channel. Tidal range in spring is about 3 ft. Salinity is usually uniform in the entire southern 2/3 and changes during the tidal cycle only about 1°/∘∘ except near the negligible influence of small tidal creeks. Temp also is relatively uniform. Current velocities are 130 cm/sec in the inlet, about 12 cm/sec in the middle. A large concentration of hard clams in the southeast portion of the Harbor was sampled at least from 10 June to 4 Sept. At straight-hinge stage larvae were approximately 1 day old. They grew from about 98 μ to 200 μ in about 7 days, but with considerable variation, reaching setting stage in 5 to more than 10 days. Growth of large swarms was fairly uniform up to 140 μ. This took about 4 days. Then the size range expanded. Greatest concentration seen was about 2,500 early stage larvae/100 liters in July. Oldest stages were so scarce that it was necessary to pump 500 to 1,000 liters of water to find them. Rarely were more than 5 ready-to-set larvae found/100 liters. Setting occurred over most of summer and in relatively small concentrations. The phenomenal sets of local folklore were not encountered. Larvae of extensive spawnings were found throughout the Harbor and at all tidal stages. Larvae from smaller spawnings remained localized. In daytime maximum larval concentrations usually were about 1 m below the surface. This concentration moved slightly toward the surface during maximum current velocity. At night larvae were more widely distributed through the water column and the stratum of maximum concentration also descended. - J.L.M.

276
Carriker, Melbourne R. 1954.

Preliminary studies on the field culture, behavior, and trapping of the larvae of the hard clam, *Venus (=Mercenaria) mercenaria* L. Proc. Natl. Shellf. Assn. 1952: 70-73.

N.J. annual catch of 5 million lbs of hard clam is taken from a wild crop. If availability of seed could be enhanced, enemies controlled, nutritional and other environmental factors improved, and faster growing, meatier clams bred, crops could be increased many-fold. Studies were made in Little Egg Harbor, N.J. Larvae were obtained by artificial spawning. Various types of substrate were provided. Behavior of larvae changed markedly with age. Swimming stages or *veligers* (about 98 to 166 μ long) were rather uniformly distributed in the water. Older swimming stages had a foot, which was extended as they attempted to contact the substrate. This searching behavior helped to locate favorable setting surfaces. At times they suddenly extended the *velum* and swam off to another site, where the process was repeated. Searching continued for several days. *Pedoveliger* (166 to 218 μ) is suggested as a name for this stage. During searching a byssus gland in the foot developed rapidly and the clam began weak byssal attachment. Soon the velum was lost and alternate crawling and attachment occurred. Detachment from the byssal thread was rapid and complete. Setting is synonymous with byssal attachment. *Crawler* is proposed for this stage. In time the byssal gland becomes functionless and the *juvenile* maintains position with its foot alone. Larvae seem to prefer attachment to a solid surface covered with a thin layer of sediment, then remain suspended in the sediment above. Densest sets were consistently over surfaces coated with thin accumulations of detritus. In clean microdishes clams consistently tried to dig into the glass with the foot. When fine sediment was added they moved vigorously until covered, then ceased locomotion and attached. In absence of suitable sources of contact stimulation crawlers aggregated in grape-like clusters and gained contact with each other. Crawlers in the open reacted strongly to cool light, moving actively as soon as illuminated. Earlier field observations had suggested that larvae select setting sites by differential water currents created by depressions in the substrate, obstacles in path of flow, or variations in bottom topography such as submerged banks of channels. Young set are highly vulnerable to predators. Several types of trap were devised to take advantage of this knowledge. The bottle-top trap was the most successful. A narrow-mouth one-gallon glass bottle 6 inches in diam was cut to remove the bottom about 1/3-way down from the neck. A large paraffined nail in a one-hole rubber stopper was inserted in the neck, and also an 8-inch piece of dowelling. Two or 3 shells were placed around the dowelling. Plastic screening with openings 1 mm^2 was wrapped over the dowelling and the bottle top and secured. Traps were housed in a special frame which permitted placement in shallow water. (Abstracter's note: the description was confusing and difficult to understand; an illustration would have been helpful.) In August, 5 traps caught 483 hard clam seed. Success was attributed to a relatively still pocket of water under a baffle, accumulation of fine layers of sediment, and elimination of larger predators by the screen. The steep upper sides of the bottle may aid in retaining crawlers within the trap, and shallowly sloping lower contours and cultch provide zones at the "shores" of the accumulating pool of sediment, thin enough to attract crawlers. - J.L.M.

277
Carriker, M. R. 1955.

Ecological studies on the hard clam and the oyster in the Gardiners Bay area, April - September 1954.

Research sponsored by J. and J. W. Elsworth Co. and M. C. Gale. Unpublished sequel to the 1954 report.

278
Carriker, Melbourne R. 1956.

Biology and propagation of young hard clams, *Mercenaria mercenaria*. J. Elisha Mitchell Sci. Soc. 72(1): 57-60.

Hard clam embryos developed into shelled, free-swimming veligers with a velum in 24 hours after fertilization. In about 7 days the veligers developed a foot and became pedoveligers. Pedoveligers exhibited searching behavior. Soon a byssal gland formed and the velum was lost. Young clams alternated between byssal attachment and crawling for the next few weeks. When clams grew to 7 mm the byssal gland became functionless and the foot was used for maintaining position. Shortly after pedoveliger settled, mantle edges fused and formed siphons which allow clam to burrow. Clams were spawned artificially and larvae cultured in field laboratories. Larvae were fed *Chlorella* and extracts of cereal pablum. The pedoveliger stage was reached in 10-14 days. Only occasional cultures reached the byssal stage. Hydrography of Home Pond was studied for its use for large-scale hard clam culture. It was suggested the inlet to the pond be closed at the onset of spawning season to prevent larvae being flushed out of the pond. Clams were subject to excessive predation by mud, green, and blue crabs. Larger clams are less vulnerable to predation than smaller ones. Screening was found to be partly effective in protecting young clams from predation. - D.L.

279
Carriker, M. R. 1957.

Preliminary study of newly hatched oyster drills, *Urosalphynx cinerea*. J. Elisha Mitchell Soc. 73: 328-351.

Newly hatched drills reacted positively to external metabolites of newly set *Venus mercenaria*. Clams were located readily by drills. A drill 1.5 mm high perforated a *Venus* 0.6 mm long in 45 min, and removed the flesh in another 45 min. In a day, one young drill consumed 1 to 19 young *Venus*. Young drills can crawl through superficial layers of sediment; thus, young clams cannot escape predation by burrowing shallowly. In the natural environment buffer-food species probably reduce this predation rate. - J.L.M.

280
Carriker, Melbourne Romaine. 1959.

The role of physical and biological factors in the culture of *Crassostrea* and *Mercenaria* in a salt-water pond. Ecol. Monogr. 29(3): 219-266.

Densest populations of *Venus mercenaria* lived in the vicinity of the inlet, where continuous recruitment of young took place. An unusual population of old *Venus* with maximum lengths of 5.5 inches was discovered in the head of the pond. *Venus* and oysters, especially at the head of the pond, retained conspicuous stores of glycogen throughout summer, indicating excellent food conditions, which may be associated with high fertility of sediments and minimal exchange in the upper portions. *Venus* grew fastest in the vicinity of the inlet. Most spawning of *Venus* occurred in late spring, slight spawning in summer, with a moderate peak in August. Most larvae settling within the pond entered from the bay as veligers. *Venus* larvae set most abundantly in the inlet, decreasing up the axis of the pond. Newly set *Venus* are well adapted to survival in the unstable bottom conditions of an inlet. *Callinectes sapidus* and xanthid mud crabs were the most conspicuous predators. Unprotected young *Venus* were almost completely destroyed by crabs in portions of the pond away from the inlet. As *Venus* grew larger they became less vulnerable. Unstable sediments and swift currents in the inlet provided protection. Over 80% survival of young *Venus* was obtained in enclosures in contrast to negligible survival in the open, except in the inlet, where about 40% of *Venus* survived. Larvae could be retained within the pond by closing the inlet temporarily just before spawning and during the larval period. It should be reopened as soon as spawning is complete. - J.L.M.

281

Carriker, M. R. 1961.

Interrelation of functional morphology, behavior, and autecology in early stages of the bivalve *Mercenaria mercenaria*. J. Elisha Mitchell Sci. Soc. 77(2): 168-241.

Clam larvae were obtained by inducing spawning in the laboratory. In 6 years, of 2,890 clams used, 12% spawned. Most spawning occurred in early summer and was more difficult to induce as the season advanced. Spawning could be delayed by keeping clams at low temperatures. The most vigorous and rapidly growing larvae, with least mortality, were progeny of fully spawning, vigorous females, who discharge their ova rapidly. Reared larvae survived gradual temperature fluctuations ranging from 13°-30°C. Larvae were fed cultures of *Chlorella* and *Nannochloris* with mixed microorganisms and pablum extract. Larvae grew best in seawater hauled from the bay, next best in seawater pumped into the lab, then heat-treated seawater, and grew worst in charcoal treated seawater. The minimum time for larvae to reach setting size was 8 days. Several early stages of hard clam are described by differences in structural features and behavior: Non-shelled planktonic stage, straight-hinged veliger, umboned veliger, prodissoconch I, prodissoconch II, pediveliger, byssal plantigrade, and juvenile plantigrade. Prodissoconch stages have smooth shells. The curvature of the primary and secondary shell ridges, formed in the byssal plantigrade, anchor the clam in sediment, but offer a minimum of resistance to locomotion through sediment. Pediveligers and newly set plantigrades locomote by ciliary action on the foot, but change to muscular crawling so the clam can burrow or emerge from sediment. During plantigrade stage, before loss of the velum, the byssus gland becomes functional and remains functional until the clam is about 9 mm. Clams attach quicker when buried in sediment, than on an open surface. The byssal thread can be dislodged to move to another site. The time between dislodgement and reattachment ranged from a few minutes to several hours in the lab. During plantigrade stage, mantle edges fuse, dividing gap between valves into exhalant and combination pedal and inhalant openings. A valvular membrane forms at the rim of the exhalant opening which controls and directs the exhalant current. An exhalant siphon with terminal tentacles forms at the base of the valvular membrane. The inhalant siphon develops as an extension of the mantle edge. Most of valvular membrane is reabsorbed with time. Tips of the two siphons are pointed away from each other. Tentacles form protective grids over siphons which exclude larger sedimentary grains from entering when the plantigrade is buried deep in sediment. Clams can emerge from a depth of sediment at least five times their shell length. In the lab, trochophore and early straight-hinged veligers concentrate in surface water layers of culture jars and swim strongly. Later stage veligers were distributed evenly in water column and remained suspended throughout planktonic life if they were healthy, sick veligers remained on the bottom. Lower Little Egg Harbor, New Jersey, retains relatively homogeneous seawater in which a large number of larvae remain for at least the veliger stage. For the period 1929-1951, estimates of annual yield to clammers ranged from 40 to 160 million clams. Distribution of veligers was studied in the bay. The largest and densest swarms appeared during July, but the size of the spawning varied from summer to summer. Of the 67 spawnings observed, 73% occurred during a period of two or three days of rising median daily temperature, the rest during periods of falling median temperatures. Overall average median daily spawning temperature was 25.7°C with a range of 22°-30°C. Spawning occurred more frequently, and produced higher density swarms of veligers, during neap tides than spring tides. Higher temperatures during neap tides probably triggered spawning. Time of spawning was probably around ebb tide when temperatures are maximum. Survival of veligers was about 2.6% during periods of little rainfall and median to low tidal amplitudes (minimal flushing and exchange). During periods of high rainfall and spring tides, even large veliger swarms disappeared from the water. Veligers grew to a setting size of about 200 microns in eight days from fertilization in Little Egg Harbor where median daily temperatures ranged from 20.4°-26.2°C and salinities from 30.4-31.4°/°°. Horizontal distribution of veligers was uneven but widespread. Maximum concentrations of larvae (up to 57,200/100 liters) were found in the lower part of the bay's central basin. Lower densities of larvae near the inlet were partly due to dilution from tidal exchange. Vertical distribution of larvae was determined by taking a vertical series of 97 plankton samples. Veligers remained suspended throughout planktonic life. During daylight veligers concentrated in the middle strata, away from bottom dwelling predators, and were more broadly distributed during darkness. Light and turbulence may stimulate larvae to rise vertically. Early stage larvae tend to remain in the original swarm produced by mass spawning of adults, but late stage larvae are dispersed by hydrographic mixing processes. Byssal plantigrade behavior was studied in the lab. They are strongly thigmokinetic and attach the byssus most frequently to hard surfaces covered with fine sediment containing much organic matter. They are negatively photokinetic, preferring dim light. No rheotactic response occurred in current velocities to 2.5 cm/sec. Hard clam sets occurred widely, though irregularly, in Little Egg Harbor. Distribution of new sets did not exactly coincide with that of adults. Maximum concentrations of plantigrades ($125/m^2$) were attached to shells coated with mud. Dense concentrations were found in sediment around objects projecting from the bottom possibly because: they may be stimulated to set beneath areas of differential turbulence, they may crawl or swim to areas of turbulence after setting elsewhere, or these baffle areas may provide microhabitats which provide protection from predators. A small device was designed to simulate desirable setting habitats for clams to determine the relative intensity of setting in the area. Number of clams set in the samplers was compared to veligers in the water before setting. Enemies of early stages of the hard clam included: *Siropidium*, *Condylostoma*, xanthid mud crabs, *Callinectes*, *Carcinides*, *Limulus*, *Urosalpinx*, *Eupleura*, *Polinices*, *Molgula*, *Sphaeroides*, ducks and geese, and possibly *Busycon* and *Asterias*. - D.L.

282
Carriker, Melbourne Romaine. 1961.

Comparative functional morphology of boring mechanisms in gastropods. Am. Zoologist 1: 263-266.

Fig. 1 shows representative gastropod bore holes in several mollusk species, including hole by *Natica severa* in shell of *Mercenaria mercenaria* and hole in shell edge of *M. mercenaria* made by *Murex fulvescens*. - J.L.M.

283
Carriker, M. R. 1967.

Ecology of estuarine benthic invertebrates: A perspective. In Estuaries. G. H. Lauff (ed.). Am. Assn. Adv. Sci., Pub. 83, Washington, D.C.: 442-487.

This comprehensive review paper contains some specific references to *Mercenaria mercenaria* from published works of the author and others. It contains no original data. Papers cited are abstracted elsewhere in this volume. - J.L.M.

284
Carriker, Melbourne R. 1979.

Molluscan bivalve larvae: Past, present, and future. In Estuarine Research: Past, Present, and Future: A Symposium. Melbourne R. Carriker (ed.). Atlantic Estuarine Research Society, p. 23-28.

Initial work on factors influencing setting by *Mercenaria mercenaria* was carried out by Keck et al. (1974), abstracted elsewhere in this bibliography. - J.L.M.

285
Carriker, M. R., et al. 1954.

Prel. report of biological studies on the hard clam *V. mercenaria* and the oyster *C. virginica* in salt ponds on Gardiner's Island, L.I., directed toward the utilization of these ponds in the culture of these shellfish, August 1952 to April 1954 (with sp. section on oyster drills). Research sponsored by J. and J. W. Elsworth Co. and M. C. Gale, unpublished.

286
Carson, Rachel L. 1943.

Food from the sea: Fish and shellfish of New England. U.S. Dept. Interior, Fish Wildl. Serv., Conserv. Bull. 33, 74 p.

In New England only *Mya arenaria*, soft clam, is a "true" clam. *Venus (Mercenaria) mercenaria*, hard clam, is called by the old Indian name "quahaug". Hard clam accounts for about 25% of New England clam production. The species is much more abundant south of Cape Cod. Shallow water below the low tide mark, to considerably deeper water, is predominantly the home of hard clams in New England. Farther south *Venus* lives only in shallow water. It has short siphons and usually buries only deep enough to cover the shell. Hard clams are harvested by long-handled rakes, tongs, or dredges. Early life history of hard clam is similar to that of soft clam, which is described in some detail. Essential features are larval life, during which survival is affected by temp changes. At metamorphosis, the young clam loses its swimming organ and sinks to the bottom, developing a muscular foot, a siphon, and gills. The young clam anchors itself to a firm surface by a single byssus thread, but at slack water may cast off this attachment and creep about. This alternate attachment and movement over the bottom may last for some time. During this period young are vulnerable to small predators. Before the shell is 1/4 inch long the young clam begins to dig into the bottom. This process also alternates with surface crawling. Byssus threads may be reformed until the clam is at least 1/2 inch long to anchor the young clam in its burrow temporarily. After final descent, threads are no longer produced, and the clam does not leave its burrow voluntarily. - J.L.M.

287
Carson, Rachel L. 1945.

Fish and shellfish of the Middle Atlantic coast. Conserv. Bull. 38, U.S. Dept. Interior, 32 p.

The hard clam or quahog is the most abundant clam on the Middle Atlantic coast. New York and New Jersey yield 2 to 3 million pounds each, Virginia slightly less productive, and small quantities taken in Delaware, Maryland, and North Carolina. Most is sold fresh, the rest canned. Hard clams live in coastal waters from almost high tide to more than 50 feet deep. Deeper clams are taken by dredging or with tongs (New York fishing is entirely by tongs), while clams near the tidal zone are dug with rakes or by hand. Hard clams are well adapted to cultivation and grow within a wide depth range and the fishery could be greatly developed by extensive farming. In practice cultivation has been neglected and pollution has been tolerated, and only a fraction of the potential value of the clam resource is realized. - J.L.M.

288
Carter, Melvin W. 1961.

Biological uptake of radioactive nuclides by clams. Dissert. Abstr. 21(8) Pt. 3: 2665.

Ruthenium was taken in by *Venus mercenaria* in relatively low levels but subsequently released to the environment. Radioactivity levels in tissues decreased even when ruthenium was maintained in the water. An aversion reaction was suspected. Cerium and promethium accumulated rapidly in soft tissues and shell cavity fluid, more slowly in shell. In fresh, undosed seawater soft tissues retained cerium or promethium in amounts greater than 63% for over 14 days. Accumulation was attributed to a substitution mechanism. Accumulation of cobalt 60 by soft tissues was suggestive of vitamin B_{12} incorporation. After 2 weeks in undosed seawater soft tissues retained about 65% of associated cobalt 60. Accumulation by shell was continuous for 17 days, probably by adsorption or ion exchange. Cultures of *Platymonas* spiked with cobalt 60 and prometheum 147 and fed to clams produced results similar to those using the radioactive elements themselves, but accumulation in soft tissues appeared to be more rapid and effective with *Platymonas*. Accumulation of cobalt alone, without *Platymonas*, although slower, eventually reached higher levels in clam tissues. Accumulation of promethium by shell, soft tissues, and old shell, at 4 days, was related to environmental levels of radionuclide. Cerium was most restrictive of radionuclides tested in its public health implications. Maximum safe daily intake of contaminated clam tissue by humans was less than 2 g. *Venus mercenaria* would be useful as an indicator of radioactive contamination of the environment for many types of nuclear waste. - J.L.M.

289
Carver, John A., Jr. 1966.

Some critical problems of the shellfish industry. Proc. Natl. Shellf. Assoc. 56: 9-12.

A general dissertation on shellfish production, stressing that technological inefficiency is not a good tool and that the Department of the Interior recognizes its responsibilities to help industry, including pollution control and abatement. - J.L.M.

290
Casey, James F. 1971.

A Maryland oceanside survey - Present and future. Comm. Fish. News, Md. Fish Wildl. Admin. 4(1): 3.

Describes use of a small, shallow-draft, escalator dredge to evaluate brood stocks and potentially harvestable zones for *Mercenaria mercenaria* and other fisheries. Studies included evaluation of setting areas and setting materials, and evaluation of effects of dredging and filling on the resource. Fishery resources of the seaside of Maryland were still undeveloped. - J.L.M.

291
Casey, James F. 1972.

Experimental seed clam planting in Maryland's oceanside bays begun. Comm. Fish. News, Md. Dept. Natural Resour. 5(6): 4.

On the oceanside of Maryland the hard clam industry concentrated on chowder and cherrystone sizes, but development of the surf clam fishery captured much of the market. Hard clam harvesters consequently shifted their effort to smaller clams, which also brought higher prices. Concern about the capacity of the quahog resource to withstand this drain on smaller clams led the Maryland Department of Natural Resources to plant large quantities of seed clams. The source of these 1/3-inch clams is not mentioned. Plans were underway to extend this planting program in 1973. Success of the experimental program was to be monitored. - J.L.M.

292
Casey, James F. 1973.

Hard clam seed planting program initiated in oceanside bays. Comm. Fish. News, Md. Dept. Natural Resour. 6(5): 3.

About one million hard clams, measuring from 4 to 15 mm, obtained from a hatchery in N.C., were being planted on old oyster shell beds, where chances for survival were best. Test plantings were made on shallow bottoms where sampling would be easy. One experimental planting was in the Assateague National Park area, where surveillance could be carried out. Three to four million clams were to be planted in 1974. - J.L.M.

293
Casey, James F. 1978.

DNR continues hard clam repletion program. Comm. Fish. News, Md. Dept. Nat. Resour. 11(1): 3.

In 1977 Maryland planted 1,232,000 hard clams in coastal bays, mostly (70%) on existing beds in Chincoteague Bay, which included small amounts in recreational clamming areas near Assateague Island. The remaining 30% were scattered throughout Isle of Wight and Assawoman Bays in shallow and deep waters. The cost was given as $15,776,000. (Abstracter's note: cost was corrected in the March issue, vol. 11, no. 3, to $15,776.) Sizes and sources of clams were not given. The project will monitor clam populations, growth, and predation. - J.L.M.

294
Castagna, Michael. 1970.

Field experiments testing the use of aggregate covers to protect juvenile clams. Proc. Natl. Shellf. Assn. (1969) 60: 2 (abstract).

Juvenile clams ranging in height from 0.6 to over 20 mm were placed in a series of field experiments to test aggregates as protective covers. The aggregates used were crushed rock (2-3 cm crushed gabbra), pea gravel (1-3 cm stream gravels), crushed oyster shell, or whole oyster shell. The survival rate was compared to unprotected areas. Survival of over 80% was accomplished in protected plots, while survival in control plots was usually between 15 and 35%. Crabs were the major predators of juvenile clams in the test area. - D.L.

295
Castagna, Mike. 1972.

Economic potential of clam operation and economic survey of scallop operation. Va. Inst. Mar. Sci., prelim. rept. (unpub.), 16 p.

This is a detailed listing of all costs relating to a clam operation in Virginia. The species is not named, but presumably it is *Mercenaria mercenaria.* Certain assumptions must be made if the figures are to be accepted. Seawater must be of suitable quality. Planting area also must have suitable seawater and physical properties adequate for growth. This requires a test brood and salinity samples in certain periods when water is suspect. Bottom sampling should be done to find out if wild clams are in the area and if there is sufficient diversity of age groups to show growth rates. Clam production was based on figures from Jan to June 1972. The 40 percent survival figure used for each step is lower than average. If this method is used in a pretested area, assuming no unseen disaster strikes during the first 10 years when loans are paid off, it appears that growing clams has some potential. - J.L.M.

296
Castagna, Michael. 1978.

Need and use of low technology aquaculture. Rept. Conf. on Marine Resources of the Coastal Plains States, 8-9 Dec 1977, Williamsburg, Va. Coastal Plains Center for Marine Devel. Serv.: 59-60.

The trend in culture of bivalve mollusks has been toward more technical and sophisticated methods, which may be too costly for profit. A bivalve culture system usually consists of 7 units: 1) a conditioning or holding unit for ripening or holding spawning stocks - this can be eliminated and the spawning season increased by bringing spawners in from other areas; 2) a spawning unit - a simple water bath is adequate; 3) a larval culture unit - use filtered centrifuged seawater warmed in a greenhouse and control temp with fans; 4) a postlarval culture unit - use ambient seawater with minimum filtering, no food added, and no temp control; 5) juvenile nursery unit - do in the field, with protection as necessary; 6) a finishing unit - may require thinning, or planting of rafted clams on natural bottom - some harvesting may be possible at this stage; and 7) an algal food culture unit - this is where greatest savings are possible by using selectively filtered or centrifuged seawater instead of unicellular algal culture and storing in gently aerated tanks in a solarium - after 24 to 72 hrs the bloom can be used to feed larvae. This is best until major and less costly advances are made in highly technical systems. - J.L.M.

297
Castagna, Michael, and Paul Chanley. 1966.

Salinity tolerance limits of some species of pelecypods from Virginia. Proc. Natl. Shellf. Assn. 56: 1 (abstract).

Species are not named. Most pelecypods studied were more euryhaline than their natural distribution would indicate. - J.L.M.

298
Castagna, M., and P. Chanley. 1973.

Salinity tolerance of some marine bivalves from inshore and estuarine environments in Virginia waters on the western mid-Atlantic coast. Malacologia 12(1): 47-96.

Although temp usually is considered the most important ecological factor influencing distribution of animals, salinity is usually the more obvious factor in estuaries. Hard clam is abundant at moderately high salinities from the Gulf of St. Lawrence to Fla. In Va. it is found in a variety of substrata intertidally and subtidally at salinities above 10°/°°. Other authors have reported that the salinity range is 12.5 to 46°/°°. Growth of adults is slow or zero below 17.5°/°° to 19°/°°. Larvae appear to require slightly higher salinity than juveniles or adults. Metamorphosis did not occur below 17.5°/°° to 20°/°°. Larval growth improved with increasing salinity from 15°/°° to 27.5°/°°. Eggs developed normally from 20°/°° to 35°/°° and the optimum was about 27.5°/°°. It was concluded that the approximate minimum salinity at which adult *Mercenaria mercenaria* survive is 12.5°/°°, and larvae 15°/°°. - J.L.M.

299
Castagna, Michael, and John N. Kraeuter. 1976.

A mariculture system for growing the hard clam, *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 66: 100 (abstract).

The Glancy-Wells (centrifuged, incubated seawater) solarium method is used for growing algal food. Clams are spawned with temperature stimulation and stripped sperm. Larvae are grown in clarified incubated seawater until set. Juveniles are immediately transferred to flowing seawater tables and held until 2 mm hinge to lip. Then they are planted in a nursery area on an intertidal flat at 300/ft^2, protected from predators by a crushed stone aggregate cover, and prevented from washing away by 2 ft high plastic screen baffles. Where rays are a problem, a plastic screen fence is built. Cost of growing clams is about 1.5¢ each. Survival over winter was about 88%. The system is simple, uses little energy, and is relatively inexpensive. - J.L.M.

300
Castagna, M., and J. N. Kraeuter. 1976.

The aggregate protection method of culturing the hard clam, *Mercenaria mercenaria*. 10th European Symposium on Marine Biology, Ostend, Belgium. Vol. I: 33 (abstract).

A low technology method utilizing hatchery-raised seed clams and field grow-out techniques is presented. This technique is economically feasible and can be taught to most individuals within a week. The Wells-Glancy method (centrifuged, incubated seawater) of raising food is used. Larvae set in 8-10 days and are supplied with natural seawater until they reach 2 mm. They are then placed in nursery plots, protected from predation by a layer of gravel or aggregate. Movement is prevented by a system of baffles. Field survival of a test group of 600,000 clams approached 80%. Costs of raising the clams for the first year are included, but not stated in the abstract. - - J.L.M.

301
Castagna, Michael, and John N. Kraeuter. 1977.

Mercenaria culture using stone aggregate for predator protection. Proc. Natl. Shellf. Assn. 67: 1-6.

The most serious problems in field maintenance of seed clams are predation and loss by current and wave action. Larvae were raised by standard hatchery techniques, which are described in some detail. Clams were held after setting for about 6 weeks or until they grew to 2 mm. They were then placed on plots covered with 4 cm of 1- to 3-cm chips of crushed stone aggregate. Protection against current and wave action was provided by baffles of steel rod and plastic screen, also described. Larger predators, mostly blue crabs and rays, were held out with a net 2 m high. Annual production of hatchery seed ranged from 12 to 55 million newly set clams. Survival to field size was 15% to 20%. Littleneck size was reached in 22 to 28 months. Cost for 600,000 clams planted in the field was 1.5¢/clam, including estimated interest on a loan to provide hatchery, labor, utilities, and all supplies. Other costs would be maintenance of field plots for 2 yrs, about 1/2¢/clam, and harvesting, about 0.2¢/clam. Current market value of prime-sized littleneck clams was about 5¢/clam. Survival was in excess of 75%. Economical commercial operation would be possible with 40% survival. Further reductions in costs are possible. - J.L.M.

302
Castagna, Michael A., Lawrence W. Mason, and Fred C. Biggs. 1970.

Hard clam culture method developed at VIMS. Aggregates on bottom protect seed clams from predators. Va. Inst. Marine Sci., Mar. Resour. Adv. Ser. 4, 3 p.

Predators destroy almost all unprotected clams smaller than one inch. Blue crab is the major predator in Virginia, but other crabs, boring snails, bottom-dwelling fishes, and waterfowl also are responsible. Quahog requires waters of moderately high salinity, where these predators abound. This often prevents successful natural reproduction. Methods of protection have included planting clams in screened trays or boxes, within fenced enclosures, under sheets of netting or hardware cloth, in saltwater ponds or tanks, and intertidally. These techniques are unreliable, expensive, and cause silting and slow growth. The new method spreads shell, gravel, or other materials called aggregates over the bottom before planting. Preparation of bottom is simple, there is no maintenance, and increased yields should soon pay for initial cost of aggregate. The technique promises to encourage operation of clam hatcheries. Tests with *Mercenaria mercenaria* showed that 80% to 90% or more of seed clams survived through seasons in which blue crabs and other predators were most active. Survival of unprotected controls was about 16% and never more than 30%. Clams as small as 1/25 to 1/5 inch survived well in some plantings, but those larger than match-head size did best. Smaller clams were too active and would leave the protection of the aggregate. Tests were to be continued. - J.L.M.

303
Castagna, Michael A., Lawrence W. Mason, and Fred C. Biggs. 1971.

Hard clam culture method developed at VIMS. Comm. Fish. News, Fish. Wildl. Admin. Md. 4(1): 2,4.

This is essentially the same article published in 1970 in VIMS Marine Resources Advisory Series No. 4, and abstracted above. Recommendations were: 1) select aggregates that are cheap and plentiful in the area; 2) particles should be heavy enough to sink and remain on bottom, and small enough to pack well; 3) coarse materials should be spread to a thickness of 1 to 3 inches if coarse, 1 to 2 inches if fine; 4) scatter seed clams evenly over the aggregate at 25 to 50 clams/ft^2; and 5) plant when clams are active, e.g., when water temp is 48°F or higher, and plant at slack tide. - J.L.M.

304
Cerame-Vivas, M. J., and I. E. Gray. 1966.

The distributional pattern of benthic invertebrates of the continental shelf off North Carolina. Ecology 47(2): 260-270.

In winter, bottom temperatures between the inner and outer shelf commonly differ by 10 to 12°C. Area A, inshore, is the coldest of 3 areas or distinct biotic provinces, influenced by the Virginian coastal current which brings cold water from Cape Cod to Cape Hatteras. Area C, under the warm Florida current which flows over the outer shelf, has a relatively mild oceanic climate, even in winter. In summer, the contrast between these 2 areas is not as great. Conditions in area B, intermediate between A and C, were more complicated. Of 54 species taken in area A, 44% were found only in A. Of 114 in area B, 44% were in B only; and of 115 from area C 63% were from C only. *Mercenaria mercenaria* was taken only in area B. (Abstracter's note: considering the area of the continental shelf in which *Mercenaria* was taken, and the latitude, it is possible that the species was *Mercenaria campechiensis*.) - J.L.M. and M.W.S.

305
Cevoli, Kathy. 1978.

Our ailing sewer systems: Victims of an "age of neglect." Upstream, Save the Bay, Inc., Dept. Envir. Mgmt. 2(1): 1-3.

Shellfish harvesting areas must be closed. - J.L.M.

306
Chanley, P. E. 1955.

Possible causes of growth variations in clam larvae. Proc. Natl. Shellf. Assn. 45: 84-94.

This paper reports results of preliminary studies. Conclusions are tentative and subject to revision later. Significantly different rates of growth were found between larvae from one female crossed with 2 different males, and 2 females crossed with the same male. The tentative conclusion was that differences were inherited. Significant differences in mean lengths of larvae 2 days old were not correlated with later differences in growth rate. The tentative conclusion was that early differences are caused by physiological differences in eggs. Range of length of larvae from a single pair of parents increased as larvae grew larger and older. It was concluded that sibling larvae have widely different growth rates which are inherited. (Abstracter's note: variations in growth rates, of course, are to be expected. The increase in range with age may be more apparent than real. It is relative range rather than absolute ranges that should be compared.) Ability of sperm to fertilize eggs decreases as time between discharge of sperm and fertilization increases. Eggs remain receptive for longer. - modified author's summary - J.L.M.

307
Chanley, Paul E. 1958.

Survival of some juvenile bivalves in water of low salinity. Proc. Natl. Shellf. Assn. 48: 52-65.

Venus mercenaria in the 1st experiment were 10 to 21.5 mm long. At salinity 22.5°/oo and 27°/oo, over 90% dug in and fed during the 1st day. At 17.5°/oo to 20°/oo it took 7 days for 90% to dig in and feed. At 15°/oo none opened until the 7th day, and it took 19 days for over 90% to dig in and feed. At 10°/oo or lower there was little digging or feeding and all clams eventually died. However, at 10°/oo the first death was on the 28th day and only 10% had died in 32 days. Two clams survived until the 82nd and 90th days. At 5°/oo the first death was on the 18th day; all were dead on the 54th day. Even in fresh water clams lasted 22 days before the 1st death; all were dead by the 45th day. Clams were transferred direct from 27°/oo to each of the experimental salinities in 3 separate trays. When 10% had died one tray of that lot was returned to 27°/oo. When 50% had died the second tray was returned to 27°/oo. After 10% mortality in 10°/oo, 5°/oo, and 0°/oo, 14%, 4%, and 22% died when returned to 27°/oo. After 50% mortality in the same reduced salinities, 71%, 50%, and 40% respectively died when returned to 27°/oo. At the end of this experiment 25 clams which had survived 15°/oo for 75 days were held at 12.5°/oo for 49 days without a death. Another 25 clams were transferred directly from 27°/oo and held with only 3 deaths for 100 days, but survivors did not feed normally. Conditioning juvenile quahogs at intermediate salinities did not allow them to survive at lower minimal salinities. Smaller clams, 1.8 to 3.6 mm long, reacted to low salinities more rapidly than larger sizes. Clams of similar sizes (10 to 21.5 mm) from Narragansett Bay reacted to lower salinities in about the same way as Milford, Conn. clams, but at 10°/oo and lower Narragansett clams did not survive as well. Growth was reduced progressively with reduction in salinity and at 15°/oo it was negligible. Apparently juvenile hard clams can survive in salinities slightly lower than those at which they can grow. Temp was not controlled in these experiments, but varied from 15.3 to 21.9°C. Temps were uniform for all clams within an experiment. - J.L.M.

308
Chanley, Paul E. 1961.

Inheritance of shell markings and growth in the hard clam, *Venus mercenaria*. Proc. Natl. Shellf. Assn. 50: 163-169.

Inheritance of *Venus mercenaria (Mercenaria mercenaria) notata* shell markings was followed through two generations. Offspring from three crosses of unmarked "white" clams were unmarked, while three crosses of white clams with clams having the "notata" marking, produced about half unmarked offspring and about half marked with the reddish-brown zigzag lines, typical of *notata* subspecies. When two clams with *notata* shell markings were crossed, about one-fourth of the offspring were unmarked and about half were marked with zigzag lines. The remaining one-fourth were almost solidly reddish-brown, with a light band from the umbo around the lunule, and two other light bands from the umbo to the margin of the shell, dividing it roughly into thirds. This marking is considered typical of clams homozygous for the color factor. The zigzag lines, which are commonly used to identify the *notata* subspecies, are considered the phenotypic markings of heterozygous clams. Offspring from fast-growing sibling clams were 60% larger, after 15 months, than offspring from clams randomly selected from wild stock. This suggests that only a few generations would be required to develop fast-growing races of clams. - author's abstract. - D.L.

309
Chanley, Paul. 1968.

Larval development in the Class Bivalvia. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 475-481.

Mercenaria mercenaria is not mentioned, but the discussion applies in general to that species. - J.L.M.

310
Chanley, Paul. 1975.

Laboratory cultivation of assorted bivalve mollusks. In Culture of Marine Invertebrate Animals. Walter L. Smith and Matoira H. Chanley (eds.). Plenum Press, New York, p. 297-318.

This is largely a summary of contributions of many workers, with a bibliography. The synopsis is arranged under the following headings: water supply and treatment; collecting and culturing larvae and adults; obtaining reproduction by direct development, incubation of larvae, stripping and spawning, and conditioning; culturing free-living larvae, including care of eggs and larvae; diseases and other problems, including bacterial pathogens, protozoan predators, and fungus diseases; competitors and predators; and setting. *Mercenaria mercenaria* develops gametes in fall in Connecticut and can be spawned in the laboratory from late December into the normal spawning period, which begins in June. On Long Island, in Virginia, and in North Carolina gametogenesis does not begin until spring and laboratory spawning cannot be induced outside the natural season without special conditioning. The author estimates that *M. mercenaria* will have mature gametes from May through October, northern specimens from January through July. Hard clam is relatively easy to spawn, and will grow on a variety of foods, some non-algal. Papers from which information on *M. mercenaria* was taken are abstracted elsewhere in this bibliography. - J.L.M.

311
Chanley, Paul, and J. D. Andrews. 1971.

Aids for identification of bivalve larvae of Virginia. Malacologia 11(1): 45-119.

Mercenaria mercenaria is compared with other larvae in a plate that shows stages at about 100, 115, 130, 145, 160, and 175 μ. The known spawning period in Va. is May to Oct. The species is abundant in salinities above 15°/∘∘. Length-height relationship at various sizes is compared with that of other species. Straight-hinge larvae have a total length of 100-155 μ and a hinge-line length of 70-80 μ. At 140-235 μ the umbo is broadly rounded. A key to straight-hinge and umbonate larvae is given. The following description is included: dimensions - total length 100-235 μ, height 10-30 μ less, usually 20-25 μ less than length, but frequently only 15 μ less near metamorphosis, depth usually 60-65 μ less than length, hinge line 70-80 μ, metamorphosis from 175 to 235 μ, but usually 210-225 μ. Shape - broadly rounded umbos developing at about 150 μ, anterior end slightly more pointed than posterior, ends of nearly equal length, anterior shoulder longer than posterior. Hinge - one small anterior tooth in each valve, large posterior ligament. Other characters - color not distinctive, conspicuous apical flagellum, no eyespot. Distribution - adults abundant where salinity above 15°/∘∘, spawning primarily in June and July but continuing until November. Comparison to other species - the long hinge line with resulting late umbo development is usually distinctive, early larvae have proportionately greater height than mytilids, mytilid umbos are not broadly rounded. A useful glossary is included. - J.L.M.

312
Chanley, P. E., and R. F. Normandy. 1962.

Studies of preserved food for larvae of bivalve mollusks. Proc. Natl. Shellf. Assn. 51, August 1960: iii.

Listed by title only. Name of junior author misspelled, should be Normandin. - J.L.M.

313
Chanley, Paul, and Robert F. Normandin. 1967.

Use of artificial foods for larvae of the hard clam, *Mercenaria mercenaria* (L.). Proc. Natl. Shellf. Assn. 57: 31-37.

Artificial foods, consisting of nutrient solutions and suspensions of finely ground dried, fresh, and frozen materials in seawater were presented to hard clam larvae. Experimental foods were evaluated by comparing larval growth and survival to that in unfed cultures and in cultures receiving live unicellular algae. Nutrient solutions were unsatisfactory foods. Some dried foods were satisfactory though larvae receiving them tended to metamorphose at larger sizes than larvae receiving live unicellular algae. Finely ground fresh or frozen preparations, especially sea lettuce, *Ulva lactuca*, were the most satisfactory artificial foods. Clams were reared through pelagic stages to a maximum length of 450 microns on this diet without excessive mortality, but a major disadvantage of all particulate artificial foods was the clumping of food particles and a resulting accumulation of detritus in older cultures. - D.L.

314
Charest, Margaret. 1978.

Great South Bay is major supplier to hard clam lovers of America. Natl. Fisherman 58(9): 4B-5B.

Describes types of gear and vessels, market grades of clam, transplants, problems of winter clamming, and effects of pollution. - J.L.M.

315
Charles, G. H. 1966.

Sense organs (less Cephalopods). In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.). Academic Press, New York, Vol. II: 455-521.

Contains references to *Mercenaria (Venus) mercenaria* abstracted elsewhere in this bibliography. - J.L.M.

316
Check, Ronald M., and Manuel T. Canario, Jr. 1972.

Residues of chlorinated hydrocarbon pesticides in the northern quahog (hard-shell clam), *Mercenaria mercenaria* - 1968 and 1969. Pestic. Monit. J. 6(3): 229-230.

Samples were collected in most months from Sept 1968 to Sept 1969 at 5 locations in Narragansett Bay, R.I. and one in nearby Mount Hope Bay. Dieldrin was present in all 56 samples and *p, p'* - DDD in 3. Absence of DDE and DDT in amounts greater than 0.02 ppm was an unexpected result. Average levels were 0.04 ppm for dieldrin and 0.026 ppm for *p, p'* DDD. Residues of dieldrin and DDD were higher in samples from upper reaches of Narragansett Bay. - J.L.M.

317
Chekenian, Jane. 1973.

All about clams. LI, Newsday's Magazine for Long Island, 22 July 1973: 11-16.

Popular account of hard clam industry on Long Island, New York, including early history, clam distribution, kinds of clamming gear, and brief descriptions of razor clam, skimmer or surf clam, and dangers of water pollution. Includes an interview with Jeffrey Zegel, one of the more successful full-time diggers on Great South Bay. - J.L.M.

318
Cheng, Thomas C. 1965.

Parasitological problems associated with food protection. J. Envir. Health 28(3): 208-214.

Parasites in food can be transmitted to man, can cause chemical changes in food which are detrimental to man, or can be of concern because their effects have not been studied adequately. This paper reviews knowledge of these 3 categories. Trematodes, nematodes, and other parasitic organisms are known to be present in *Mercenaria mercenaria*, other mollusks, and fishes. Infection of man is particularly probable when seafood is eaten raw, as hard clams are, partially cooked, as with clams steamed open, or smoked. Much remains to be learned about transmission of parasites by marine organisms. More data are needed. References to *M. mercenaria* cite papers abstracted elsewhere in this bibliography. - J.L.M.

319
Cheng, Thomas C. 1966.

Perivascular leucocytosis and other types of cellular reactions in the oyster *Crassostrea virginica* experimentally infected with the nematode *Angiostrongylus cantonensis*. J. Invert. Pathol. 8(1): 52-58.

Conspicuous leucocytic response was observed in oysters 10 to 14 days after infection. Intraluminal nematode larvae attracted extraluminal leucocytes after 10th day. The leucocyte-attracting substance was believed to be nematode molting fluid. Infection occurred only when first-stage larvae of nematodes were ingested and penetrated alimentary wall successfully. Larvae can be transported by Leydig tissues of oyster in blood vessels. *Mercenaria mercenaria* was mentioned by reference to a paper by Cheng and Burton (1965) abstracted elsewhere in this bibliography. - J.L.M.

320
Cheng, Thomas C. 1967.

Marine molluscs as hosts for symbiosis, with a review of known parasites of commercially important species. In Advances in Marine Biology, Vol. 5. F. S. Russell (ed.). Academic Press, London, xiii+424 p.

Some references to *Mercenaria mercenaria* in this book are cited from other works, abstracted elsewhere in this bibliography. Only uncited statements are included here. The bird schistosome *Austrobilharzia variglandis* is found along the Atlantic coast of the United States in *Nassarius obsoletus*, which shares mud flats with *Mya arenaria* and *Mercenaria mercenaria*. People digging clams in such areas may contract "clam diggers itch" or "swimmers itch" from cercarial attack, which produces dermatitis on exposed skin. Large numbers of *Himasthla quissetensis* cysts have been found in *M. mercenaria* from Connecticut, and the trematode is suspected, although it was not proven, of causing severe gastrointestinal disturbances in humans. *H. muehlensi* also has been suspected. *Malacobdella mercenaria*, a nemertinean, which is identical with *M. grossa*, has been found in *M. mercenaria* from Europe and North America, and also in *M. campechiensis*. The only known parasites of *Mercenaria mercenaria* at the time of writing were those already mentioned; *Odostomia bisutularis* and *O. Seminuda*, both induced experimentally; and the copepods *Mytilicola porrecta*, *Myocheres major*, and *Ostrincola gracilis*. (Abstracter's note: Much of this book is devoted to detailed discussions of parasites of commercially important marine mollusks, which include frequent references to such common American bivalves as *Crassostrea virginica*, *Mya arenaria*, and *Mytilus edulis*. It must be concluded either that *Mercenaria mercenaria* is remarkably free of parasites, or that the species has not been investigated extensively by parasitologists.) - J.L.M.

321
Cheng, Thomas C. 1970.

Parasites transmittable through waste water to estuarine invertebrates of economic importance and their public health significance. J. Parasitol. 56 (4 Sec II Pt. 1): 54-55.

Mercenaria mercenaria and *Crassostrea virginica* from the east coast of the U.S. can serve as experimental intermediate hosts for *Angiostrongylus cantonensis*, the nematode causative agent of a type of human meningoencephalitis in parts of Asia and the South Pacific, although much less effectively than certain other mollusks. It is conceivable that in nature the availability of first-stage larvae of *A. cantonensis* to susceptible estuarine pelecypods could be via freshwater runoff contaminated with feces of infected rats. Brackish-water predatory crabs also can serve as paratenic hosts of this nematode. The question needs further study. - J.L.M.

322

Cheng, Thomas C. 1975.

Functional morphology and biochemistry of molluscan phagocytes. In Pathobiology of Invertebrate Vectors of Disease. Lee A. Bulla and Thomas C. Cheng (eds.). Ann. N.Y. Acad. Sci. 266(Pt.V): 343-379.

The chapter presents results of research designed to answer such questions as: 1) are there different types of phagocytic cell in mollusks? 2) is one type of cell more important than others? 3) is phagocytic activity in mollusks influenced by ambient factors? 4) how are microorganisms taken into phagocytes? 5) what hydrolytic enzymes occur in phagocytes, and what are the optimum conditions for them to function? 6) what is the fate of bacteria that become degraded intracellularly? 7) do the intracellular enzymes function only within cells? and 8) what are the energy requirements of molluscan phagocytes? Conclusions relative only to *Mercenaria mercenaria* are reported in this abstract. Much of the work is described in other papers abstracted elsewhere in this bibliography. *Mercenaria mercenaria* once was believed to have 3 cell types: granulocytes, fibrocytes, and hyalinocytes. Granulocytes are similar to those of *Crassostrea virginica*, with large numbers of cytoplasmic granules, restricted primarily to the endoplasm. When permitted to spread against a solid substrate these cells produce thin filopodia, each with a supporting riblike structure which originates in the endoplasm. Cytoplasmic granules of *M. mercenaria* granulocytes are denser in appearance, and elongate vermiform granules also are present in most cells. Fibrocytes of *M. mercenaria* are similar to what had been designated as secondary fibrocytes of *C. virginica*, and are now believed to be degranulated granulocytes. Hyalinocytes of *M. mercenaria* include less cytoplasm than granulocytes, are less mobile, and are essentially without cytoplasmic granules, but contain vacuoles, vermiform bodies (possibly mitochondria), and a few refractile bodies in the cytoplasm. Studies with the transmission electron microscope suggest that cells of *M. mercenaria* originally defined as fibrocytes may be considered as cells at the end of the physiological cycle relative to phagocytosis and intracellular degradation. Cytoplasmic granules of *M. mercenaria* are membrane delimited and include a homogeneously electron-dense material. Some granules are elongate and vermiform. The functions of these organelles are not known. In addition to dense granules, *M. mercenaria* granulocytes include mitochondria, membrane-bound electron-lucid vesicles, lysosome-like bodies, glycogen granules, Golgi apparati, smooth and rough endoplasmic reticulum, and lipid droplets in their cytoplasm. Some cells have a centrosome. Hyalinocytes of *M. mercenaria* lack large electron-dense cytoplasmic granules, but a few smaller electron-opaque membrane-bound vesicles occur in the cytoplasm. Also contained are electron-lucid vesicles of varying sizes, liquid droplets, glycogen granules, and rough endoplasmic reticulum. Centrosomes and Golgi apparati have not been observed in hyalinocytes. The numbers of bacteria per unit area of each cell type exposed to certain bacterial species was greatest for granulocytes, which was interpreted to mean that molluscan granulocytes are the most important cells in phagocytosis. The only ambient factor that has been studied with respect to phagocytic activity is temp. Phagocytic activity is enhanced at higher temperatures. Bacteria are engulfed by a granulocyte in 2 ways, by filopodia and by endocytosis. In addition to phagocytosis of particulate nonself material, pinocytosis of soluble molecules has been reported. Lysozyme, acid and alkaline phosphatases, β-glucuronidase, and lipase occur in serum and cells of *M. mercenaria*. Bacteria are not totally composed of carbohydrates. Noncarbohydrate constituents are not passed from primary to secondary phagosomes, but are expelled from primary phagosomes to the exterior of the phagocyte. Large liquid droplets have been found within a spent phagocyte of *M. mercenaria*. Carbohydrate constituents of phagocytized bacteria are eventually converted into glycogen, which is discharged from cells into serum. It is likely that this carbohydrate, after hydrolysis to glucose, can be distributed by hemolymph to body tissues and utilized for energy production. Phagocytosis appears to serve 2 functions, eliminating certain nonself materials and providing a nutrient source. It is concluded that phagocytosis was originally a nutrient-acquiring process, and the function of defense was acquired later in evolution. The overall process of phagocytosis in mollusks is expensive in energy utilization. It has been concluded that glycolysis is the energy-providing pathway. The myeloperoxidase-hydrogen peroxide-halide antimicrobial system of mammalian phagocytes does not occur in hard clam. - J.L.M.

323
Cheng, Thomas C. 1976.

Identification of proliferative lesions in mollusks. Mar. Fish. Rev. 38(10): 5-6.

Identification of neoplasms in mollusks should not be based solely on gross and conventional histopathological observations, which have led to erroneous conclusions. Internal defense mechanisms of mollusks are primarily cellular. Encapsulation of foreign material may lead to destruction and resorption of nonself material, which then is no longer discernible, but an islet of cells that formed the original capsule remains. Such cells have been commonly misinterpreted as neoplastic, in the opinion of the author. A brief review of recent research includes references to *Mercenaria mercenaria* abstracted elsewhere in this bibliography. - J.L.M.

324
Cheng, Thomas C. 1976.

Beta-glucuronidase in the serum and hemolymph cells of *Mercenaria mercenaria* and *Crassostrea virginica* (Mollusca: Pelecypoda). J. Invert. Pathol. 27(1): 125-128.

Beta-glucuronidase, among other lysosomal enzymes, occurs in cells and serum of the hemolymph of American oyster and hard clam. It was of interest to determine the optimal pH of this enzyme as a basis for regulation of pH in depuration tanks. Tests showed that optimum pH of the enzyme in serum and in cells was 4.5, which is identical to that of mammalian β-glucuronidase. The exact physiological role of the enzyme in *M. mercenaria* is not known, but it probably serves to hydrolyse steroid glucosiduronic acids and acid mucopolysaccharides, which are known constituents of bacterial walls. Thus, this hydrolytic enzyme possibly plays a role in degrading susceptible bacteria that enter hard clams. It is possible also that activities in hemolymph cells are somehow correlated with their division, because there may be a correlation between cell proliferation and the level of β-glucuronidase. Levels of β-glucuronidase activity are higher in hemolymph cells than in serum of hard clam and oyster. This contradicts an earlier finding that activity was higher in serum than in cells. This may have been caused by release of enzyme from cells into serum during handling. - J.L.M.

325
Cheng, Thomas C. 1976.

Aspects of substrate utilization and energy requirement during molluscan phagocytosis. J. Invert. Pathol. 27(2): 263-268.

Unlike mammalian phagocytes, hemolymph cells of *Mercenaria mercenaria* showed no increase in oxygen consumption when phagocytosing *Bacillus megaterium* actively. Glycolysis is the energy-providing mechanism, as suggested by utilization of glycogen and glucose, which are reduced in whole hemolymph and in the serum fraction of hemolymph that had been exposed to *B. megaterium*, and by production of lactate, which increases in whole hemolymph and in serum and cells of hemolymph which had been exposed to *B. megaterium*. This conclusion is strengthened by the fact that KCN does not inhibit phagocytosis. H_2O_2 was absent in actively phagocytosing *M. mercenaria* cells. From this it was concluded that the myeloperoxidase-H_2O_2-halide antimicrobial system which occurs in mammalian cells is absent in *M. mercenaria*. The antimicrobial system in *M. mercenaria* appears to be limited to lysosomal enzymes, which degrade susceptible microorganisms extracellularly and intracellularly. - J.L.M.

326
Cheng, Thomas C., and Richard W. Burton. 1965.

The American oyster and clam as experimental intermediate hosts of *Angiostrongylus cantonensis*. J. Parasitol. 51(2): 296.

A. cantonensis, the metastrongylid rat lungworm, is an etiologic agent in human eosinophilic meninogoencephalitis in the Pacific area. Infection of the host usually is established by ingestion of molluscan intermediate hosts containing 3rd-stage larvae. *A. cantonensis* has not been reported from North America, but it was considered to be of public health importance to determine if North American edible mollusks could serve as potential vehicles for infection. Six days after infection, young quahogs 2.5 to 3 cm long contained viable 2nd-stage nematode larvae in process of molting, and 3rd-stage larvae. Young white rats were infected successfully with these 3rd-stage larvae. It would be important to determine if animals which customarily defecate in the vicinity of shellfish beds can serve as definitive hosts of *A. cantonensis*. - J.L.M.

327
Cheng, Thomas C., and David A. Foley. 1975.

Hemolymph cells of the bivalve mollusc *Mercenaria mercenaria:* An electron microscopical study. J. Invert. Pathol. 26(3): 341-351.

Hemolymph cells of *M. mercenaria* were studied with a transmission electron microscope. Three morphological cell types were recognized: granulocytes, hyalinocytes, and fibrocytes. Their fine structural characteristics were described. So-called fibrocytes probably are granulocytes at the terminal phase of their physiologic cycle relative to degradation of phagocytized foreign materials, because they included large aggregates of glycogen granules in their cytoplasm and contained primary phagosomes enclosing partially degraded exogenous material and digestive lamellae. Cytoplasmic granules of hard clam granulocytes are delimited by a unit membrane and include a homogeneously electron-dense material. *Crassostrea virginica* cytoplasmic granules in granulocytes have a complex wall. Lipidlike droplets are reported for the first time in granulocytes and hyalinocytes of *M. mercenaria*. - modified authors' abstract - J.L.M.

328
Cheng, Thomas C., and Erik Rifkin. 1970.

Cellular reactions in marine molluscs in response to helminth parasitism. In A symposium on Diseases of Fishes and Shellfishes. Stanislas F. Snieszko (ed.). Am. Fish. Soc., Washington, D.C. Spec. Pub. 5: 443-496.

Lipase activity, and presence of a dehydrogenase and cholinesterase have been reported in leucocytes of *Mercenaria mercenaria*. When cercariae of the trematode *Himasthla quissetensis* were introduced experimentally into *M. mercenaria*, each metacercaria secreted a non-cellular inner cyst wall around itself, stimulated by some component in hemolymph of the clam. An outer cyst wall of host leucocytes and either myofibers or connective tissue fibers, also was formed. When cercariae were induced to encyst *in vitro* in whole blood of *M. mercenaria*, leucocytes were attracted to form an envelope around the inner wall, but when cercariae did not encyst this reaction did not occur. Chemotaxis must be the mechanism that attracts leucocytes to the parasite-secreted wall, but the chemical nature of the attractant is not known. These observations on hard clam were cited from other papers abstracted elsewhere in this bibliography. The paper also contains a section on pearl formation or "nacrezation", which is of general interest to students of mollusks, although hard clam is not mentioned specifically. - J.L.M.

329
Cheng, T. C., and G. E. Rodrick. 1975.

Release of lysosomal enzymes from hemolymph cells of *Mercenaria mercenaria*. Trans. Am. Micr. Soc. 94(3): 435 (abstract).

Lysozyme is released from hemolymph cells of *M. mercenaria* into the serum during phagocytosis. The amount of enzyme released increases as phagocytic challenge is increased, but reaches a maximum. Release of lysozyme is concurrent with phagocytosis, and not a delayed event. Lack of release of lactate dehydrogenase, a nonlysosomal enzyme, suggests that cell damage is not necessary for enzyme release. β-glucuronidase is also released from phagocytizing hemolymph cells. Acid and alkaline phosphatases also are released, but do not occur in appreciable amounts in serum. These results support the concept that release of lysosomal enzymes may play an important role in internal defense by mollusks against invading microorganisms and perhaps also against other nonself materials. - J.L.M.

330
Cheng, Thomas C., and Gary E. Rodrick. 1975.

Lysosomal and other enzymes in the hemolymph of *Crassostrea virginica* and *Mercenaria mercenaria*. Comp. Biochem. Physiol. 52(3B): 443-447.

Activities of lysozyme, acid and alkaline phosphatases, β-glucuronidase, amylase, lipase, glutamic-oxalacetic transaminase, and glutamic-pyruvic transaminase were assayed in whole hemolymph, 4,000 g pellets, and supernatants of *Mercenaria mercenaria*. All enzymes except amylase were present in whole hemolymph and fractions. Amylase was found in *Crassostrea virginica*, probably from the crystalline style. Lysosomal enzymes in molluscan serum probably had been released from certain hemolymph cells. They may play a role in destroying certain invading organisms. - modified authors' abstract - J.L.M.

331
Cheng, Thomas C., Ann Cali, and David A. Foley. 1974.

Cellular reactions in marine pelecypods as a factor influencing endosymbioses. In Symbiosis in the Sea. Winona B. Vernberg (ed.). Univ. S.C. Press, Columbia, p. 61-91.

Hemolymph cells of *Mercenaria mercenaria* are much more uniform in size (20-30 μ greatest diam) than those of *Crassostrea virginica*. Two types have been recognized on basis of structure: granulocytes, in which granules are limited to the endoplasm in the spread condition but uniformly distributed through the cytoplasm in freshly drawn cells; and fibrocytes, very similar to those of *C. virginica*, as described by Foley and Cheng (1972) in a paper abstracted elsewhere in this bibliography. The granulocyte is the phagocytic cell. Some evidence was obtained that bacteria were somehow altered chemically after they were phagocytized. Granulocytes of *M. mercenaria*, like those of *C. virginica*, are extremely efficient in recognizing "self" from "nonself", and foreign materials small enough to be phagocytized are readily arrested by this mechanism. Most organisms phagocytized are eliminated or degraded within the granulocyte, but some apparently survive. Microbial and other small symbionts do occur in mollusks. For example, *Minchinia nelsoni* is intercellular, and unless it becomes altered in some way, is recognized as "self" and is sustained within the body of the mollusk. The only known successful intracellular symbionts of marine mollusks are certain telosporean protozoa-like *Nematopsis*, a haplosporean, and microsporidians, which occur within phagocytes, or within cells of the gills, digestive tract or nephridium. The nephridium is a primary site for deposition of foreign materials introduced into the bodies of certain mollusks, and it could be reasoned that protozoan parasites found in the nephridium have been carried there by phagocytes. - J.L.M.

332
Cheng, Thomas C., Carl N. Shuster, Jr., and Alan H. Anderson. 1966.

A comparative study of the susceptibility and response of eight species of marine pelecypods to the trematode *Himasthla quissetensis*. Trans. Am. Micr. Soc. 85(2): 284-295.

Experiments were conducted on 10 hard clams raised from laboratory-fertilized eggs. A small hole was drilled in the left valve of each and 150 cercariae were introduced. The hole was sealed with paraffin and the animals held in seawater for 32 to 34 hrs. Soft tissues then were serially cross-sectioned after fixation, staining and embedding in paraffin. Two *Mercenaria mercenaria* had one metacercariae in the stomach. Other metacercariae of the trematode were in the process of penetrating stomach epithelium. Three quahaugs had encysted metacercariae in the heart, each encapsulated within an inner cyst wall. A number of leucocytes had adhered to the outer surface of the inner wall of the cysts, forming an outer wall. Unencysted metacercariae also were found in the space between palps and gills. No host leucocytes were seen in their vicinity. Penetration through external body surfaces probably is the primary method of infection. Observations of *M. mercenaria* showed that metacercariae also can be carried by ciliary activity of gills and be ingested with food organisms, then penetrating stomach wall. Where the post-cercarial form had penetrated the stomach wall of the clam, leucocytes were present, but not in appreciably greater numbers than usually found at this site. - J.L.M.

333
Cheng, Thomas C., Carl N. Shuster, Jr., and Alan H. Anderson. 1966.

Effects of plasma and tissue extracts of marine pelecypods on the cercaria of *Himasthla quissetensis*. Exper. Parasitol. 19(1): 9-14.

Plasma of 7 species of marine pelecypod, including *Mercenaria mercenaria*, stimulated cercarial encystment, but rapidity of encystation varied with type of serum. The stimulatory component of sera was heat labile. All tissue extracts killed cercariae, and time of death varied with type of extract. Longevity of treated cercariae was much less than that of those held in seawater. - modified authors' abstract - J.L.M.

334
Cheng, Thomas C., Amar S. Thakur, and Erik Rifkin. 1968.

Phagocytosis as an internal defense mechanism in the Mollusca: with an experimental study of the role of leucocytes in the removal of ink particles in *Littorina scabra* Linn. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 546-563.

Comments on lipase activity in leucocytes, and dehydrogenase and cholinesterase in amoebocytes of *Mercenaria mercenaria* are given in more detail elsewhere in this bibliography, in abstracts of papers in which original data appeared. - J.L.M.

335
Cheng, Thomas C., Gary E. Rodrick, David A. Foley, and Sherry A. Koehler. 1975.

Release of lysozyme from hemolymph cells of *Mercenaria mercenaria* during phagocytosis. J. Invert. Pathol. 25(2): 261-265.

Quahaugs studied came from N.J. waters. Lysozyme activity was detected in serum and cells of hemolymph of *M. mercenaria* which had been exposed to *Bacillus megaterium* and in clams which had not been exposed to bacteria. It is now known that lysozyme is released from hemolymph cells of hard clam into serum during phagocytosis. This release is concurrent with phagocytosis of bacteria and not a delayed effect. Release is not the result of destruction of the plasma membrane of hemolymph cells. What has been commonly called "degranulation" in molluscan granulocytes, i.e., explosive discharge of contents of cytoplasmic granules through cell surfaces, is in fact a morphological reflection of release of enzymes into the medium. Degranulation does not involve damage to the plasma membrane of granulocytes. The function of lysozyme in serum of *M. mercenaria* and other mollusks remains uncertain. Degranulation of granulocytes of *M. mercenaria* in vitro has been observed in absence of bacteria, but the process is increased when bacteria are present. Thus, it is assumed that release of enzymes from hemolymph cells is a normal process, which is enhanced during phagocytosis. - J.L.M.

336
Chesapeake Biological Laboratory. 1953.

The commercial fisheries of Maryland. Md. Board Nat. Res., Dept. Research Educ., Educ. Ser. 30, 45 p.

Hard clam grows in commercial abundance above the Virginia line in Chesapeake Bay only in a very limited area off Crisfield. It is restricted to saltier waters. In coastal bays on the ocean side, Chincoteague, Sinepuxent, and Isle of Wight, hard clams abound. - J.L.M.

337
Chestnut, Alphonse F. 1951.

The oyster and other mollusks in North Carolina. In Survey of Marine Fisheries of North Carolina, by Harden F. Taylor and a staff of associates. Univ. N.C. Press, Chapel Hill, p. 141-190.

Twelve species of *Venus* along the southeastern coast, eight of which are reported from waters of N.C. Species *mercenaria* the only one of commercial importance. Literature is meager. Little has been published since pioneer works of Kellogg and Belding in first 2 decades of 20th century. Sexes separate, but clams can change sex. Nearly all develop first as males, approximately 50% become female the 2nd year. Soon after spawning ceases in fall, sex products develop, often reaching maturity by midwinter. Cold water prevents spawning until next spring. Ovaries and testes usually white, but take on reddish or yellow tint with age. Spawning believed directly correlated with temperature, but other factors may operate. Spawns in Mass. from mid-June to mid-August, commencing at 76° to 77°F., in Long Island Sound at about 73°, beginning earlier and continuing longer. Some clammers believe they spawn year-round in N.C. Young hard clams may spawn at an age of three or four months, but most spawn after they reach their first year. Others have concluded that clams must be two years old before spawning. One observer stated that littlenecks and large chowders, although they may contain sex products, do not spawn. Sex cells are extruded into the mantle cavity and pass out through the excurrent siphon. Within 36 hours a shelled veliger larva is formed. Free swimming ceases 6 to 12 days later. The clam attaches to some surface with a byssus thread secreted by a gland in the foot. The primary purpose of attachment appears to be protective, to prevent involuntary transport by waves or currents. Soon the young clam burrows into the bottom. At all stages, to the adult, hard clams retain considerable powers of locomotion. The well-developed foot is used to burrow, crawl for short distances, or to turn over. Lateral movement is limited, however, and the average distance travelled in 38 days was 2 inches, and a maximum of 6 inches, from the place where clams were first bedded. Hard clams rarely burrow to a depth greater than the length of the shell. Burrowing depth appears to be related to periods of feeding, water temperature, and tides. Some investigators have emphasized the importance of currents to hard clam, assuming that the stronger the current the greater the food supply. Currents also provide oxygen and carry away metabolic products. Bottom microorganisms, as well as plankton, are an important part of the food supply. Hard clams live as well in the intertidal zone as they do at 50 feet, but are usually found on flats in relatively shallow waters a few feet below low tide. An equal mixture of mud and sand is considered to be the best bottom type, but clams grow in a variety of bottoms, ranging from sand to gravel to rocks. Organic acids in the bottom can erode the shell and retard growth. Natural clam beds can be found at salinities from 10 to 28°/°°, and clams can tolerate wide fluctuations of salinity for short periods. A hurricane in 1933 ruined oyster beds in some N.C. waters. Soon after, hard clams became very abundant in areas where they had never existed in commercial quantities. It was concluded that increased salinity, provided by new inlets cut through the outer banks by the storm, was the cause. Hard clams grow slowly. In New England they reach less than a quarter inch long by winter of the year of birth. It takes about 4 1/2 years to reach 3 inches long. Investigators disagree on the best environment for growth, one claiming that clams grow most rapidly in the intertidal zone, another saying that growth is better below low tide, for the feeding period can be longer. Maximum rate of growth is at 14 mm long. Crowding causes competition for food and space, and under such conditions clams may be forced out of the bottom and exposed to enemies. In colder waters shell growth ceases in winter. Shell growth commences when water temperature reaches about 49°F (9°C) and ceases when temperature drops to 41-45°F (5-7°C). Young are more vulnerable to predation than adults. Principal enemies of young are sea stars, crabs, snails, and fishes; adults are attacked by sea stars, moon snails, and conch. Clam culture has not been well developed. Expected yield from a planting of 20 seed clams per square foot would be about 1,200 bu of 2 1/2-inch clams per acre. The clam industry and its history in North Carolina is described briefly. Four grades are recognized: littleneck, cherrystone, large, and chowder. Harvesting is almost entirely by rakes and treading. Clam producing areas are waters within the influence of the outer banks inlets. Production varied widely, from a maximum of about 1.3 million pounds of meats in 1941 (170,000 US bu) to a low of 78,000 pounds in 1887. About the turn of the century clams were bought at 40¢ per bu and processed at Ocracoke as clam juice, chowder, and whole clams. Many cans were labelled quahaugs from Islip, N.Y. Clamming in N.C., up to 1948 at least, was an alternative occupation when other fishing activities were slow. Weather and the hard labor involved were constraints. Hard clam has certain advantages over oyster in the market. The tradition of the R months does not apply, and quality of meats does not vary as widely seasonally as with oyster. Most clams have been marketed through brokers, or shipped to Baltimore. Prices in New York in March 1949 were: littleneck $6.50-7.50, cherrystone $5.00-5.50, large $4.50, chowder $2.50-3.00 per New York basket. More scientific study is needed on which to base recommendations for clam farming and management of the industry. - J.L.M.

338
Chestnut, A. F. 1952.

Growth rates and movements of hard clams, *Venus mercenaria*. Proc. Gulf Carib. Fish. Inst., 4th Ann. Sess.: 49-59.

Hard clams (2.7-10.1 cm in length) were marked and planted in the lower intertidal of the north and south shores of Bogue Sound, North Carolina. Clams planted in the mud bottom of the south shore did not grow significantly. Clams planted in the hard sand of the north shore grew on the average from 13 to 219 mm. Growth occurred in every month of the year, was greatest in April and May, declined through the summer, increased in October, and then declined with the lower winter temps. Planted clams migrated in all directions, but predominantly toward the shoreline. Distance traveled ranged from 3 to 83 inches in a year. - D.L.

339
Chestnut, A. F. 1953.

Studies of the North Carolina clam industry. Natl. Shellf. Assn., Convention Addresses 1951: 85-88.

Records of clam production in N.C. go back to 1880. The catch was unusually high as early as 1902. A plant was established at Ocracoke in 1898 by J. H. Doxsee from Islip, N.Y. He packed clam chowder, whole clams, and clam juice. The product was labeled as quahaugs from Islip, N.Y. The plant later moved to Sealevel, N.C. and finally to Marco, Fla. Production fluctuated considerably from 1880 to 1950, but never reached the record high of the turn of the century. At the time of writing the industry was concentrated in Core Sound. Most of the catch was *Venus mercenaria*, and the variety *V. mercenaria notata*. Some *V. campechiensis* also are found in the catch. Gears are rakes, tongs, and dredges. The dredging method is described in detail. Weather often limits operations. Most clams in the dredge catch are chowder size. From June 1949 to Jan 1951 the price increased from 1¢ to 2¢ per lb. Clammers did not grade clams by size. Dealers sorted into chowders, cherrystones, and littlenecks. Since about 1940 clams were shipped as frozen, shucked clams for chowder. Some smaller clams were shipped to the midwest in the shell. Recently, increased quantities had been shipped in mixed sizes, in the shell, to Va., Md., and farther north. Up to the early 1950s there had been no attempts at cultivation in N.C. A few dealers were holding clams on leased ground for favorable markets. Potential for growth of the industry appeared good. - J.L.M.

340
Chestnut, A. F., and H. S. Davis. 1975.

Synopsis of marine fisheries of North Carolina. Part I: Statistical information, 1880-1973. Univ. N.C. Sea Grant Program, UNC-5G-75-12: 425.

Landings and landed value of *Mercenaria mercenaria* are given for each year since 1880 that data are available. Tables include, inter alia, year of record catch, year of lowest catch, year of record value, landings by months for some years, numbers of persons in the industry, numbers of vessels and boats, numbers of units of gear, catches by gear, catch by counties and by district. - J.L.M.

341
Chestnut, A. F., W. E. Fahy, and H. J. Porter. 1957.

Growth of young *Venus mercenaria*, *Venus campechiensis*, and their hybrids. Proc. Natl. Shellf. Assn. 47: 50-56.

Hybrids of *Mercenaria mercenaria* and *M. campechiensis* grew more rapidly than the northern species in N.C. waters. The southern species did not survive N.C. winter, which suggests lack of resistance to cold. Native *M. campechiensis* grow in the intertidal zone in N.C., but southern quahogs used in this study were progeny of Fla. clams. The growing period in N.C. for *M. mercenaria* was much longer than the growth period reported by Gustafson (1954) in Maine (abstracted elsewhere in this bibliography). - J.L.M.

342
Chiba, Kenji, and Yasuo Oshima. 1957.

Effect of suspending particles on the pumping and feeding of marine bivalves, especially of Japanese neck-clam. Bull. Jpn. Soc. Sci. Fish. 23(7&8): 348-353.

Mercenaria meretrix was studied, among 3 other bivalves. The paper is in Japanese, but it has an English abstract and data in tables are in English. Suspensions of bentonite, talc, shale, diatomaceous earth, kaolin, charcoal powder, soluble starch, and 2 phytoplankton species were used. Rate of pumping was reduced by high concentrations of bentonite. In *M. meretrix lusoria*, amount of feeding increased with growing concentration of particles up to the time of discharge of pseudofeces, and pseudofeces increased further, but true feces did not increase in higher concentrations. - J.L.M.

343
Chipman, Walter A. 1959.

The use of radioisotopes in studies of the foods and feeding activities of marine animals. Pubbl. Staz. Zool. Napoli, Vol. XXXI Suppl.: 154-175.

Venus mercenaria is mentioned, but details are not given. - J.L.M.

344
Chipman, Walter A. 1960.

Accumulation of radioactive pollutants by marine organisms and its relation to fisheries. In Trans. 2nd Seminar on Biological Problems in Water Pollution, 20-24 Apr 1959. C. M. Tarzwell (ed.). U.S. Dept. HEW, Pub. Health Serv., Robt. A. Taft Sanitary Eng. Center, Cincinnati, p. 8-14.

Mercenaria mercenaria is not mentioned except in tables 1 and 2, which list important fisheries of the Atlantic coast of the United States by landed value and weight. Hard clam in 1956 was 7th by value and 19th by weight of meats. Being filter feeders, molluscan shellfishes are able to concentrate particles, including radioactive particles, from large volumes of water. These accumulate in filtering mechanisms, on body surfaces, and within the digestive tract, so that high radioactivity may be present, even though the radionuclides responsible are poorly absorbed and not concentrated within tissues. The entire soft tissues of oysters and clams are utilized, whereas only certain parts of most other seafoods are eaten. Thus, shellfishes may be most hazardous to humans in contaminated areas. - J.L.M.

345
Chipman, Walter A., and P. S. Galtsoff. 1949.

Effects of oil mixed with carbonized sand on aquatic animals. U.S. Fish Wildl. Spec. Sci. Rep.--Fish. 1, 66 p., including illustr.

There was no significant difference between clams in controls and in water contaminated with various types of oil. *Venus mercenaria* was the clam used. - J.L.M.

346
Chipman, Walter A., Theodore R. Rice, and Thomas J. Price. 1958.

Uptake and accumulation of radioactive zinc by marine plankton, fish, and shellfish. Fish. Bull. 58(135): 279-292.

Venus (Mercenaria) mercenaria and other bivalve mollusks concentrate large amounts of trace metals like Zn. Radioactive Zn added to the water was taken up rapidly in great amounts. Considerable accumulation of nuclide took place in gills and hepatopancreas. *Nitzschia closterium* took up large amounts of Zn^{65} and transferred it to marine animals. Less Zn was found in hard clam than in oyster, but more than in bay scallop. - J.L.M.

347
Christensen, Aage Moller. 1957.

The feeding behavior of the seastar *Evasterias troschelii* Stimson. Limnol. Oceanogr. 2(3): 180-197.

Experiments were done with *Protothaca staminea*. (Abstracter's note: *P. staminea* is sufficiently similar to *Mercenaria mercenaria* so that the results probably are applicable also.) Seastars were able to open a clam against known resistances in excess of 5,000 grams. If prevented from applying force seastars still will succeed in feeding on clams, but digestion is prolonged because it is difficult to insert all lobes of the stomach into the prey. - J.L.M.

348
Christensen, Darryl J., C. Austin Farley, and Frederick G. Kern. 1974.

Epizootic neoplasms in the clam *Macoma balthica* (L.) from Chesapeake Bay. J. Natl. Cancer Inst. 52(6): 1739-1749.

Mercenaria mercenaria is mentioned in discussion, by reference to a paper by Yevich (misspelled Yevitch) and Berry (sic), 1969, abstracted elsewhere in this bibliography. These authors are said to have described a tumor of germ cell origin in hard clam, which was thought comparable to granulosa cell carcinoma in man. Christensen et al. comment that this sort of comparison is questionable, because granulosa cell tumors have been distinguished from germ cell neoplasms on the basis of mesenchymal origin, and presence of highly specialized endocrine tissues such as granulosa cells has not been established in mollusks. - J.L.M.

349
Ciuchta, Henry P., and David E. Mann, Jr. 1961.

Effects of *dl*-, *l*-, and *d*-ephedrine on levarterenol tachyphylaxis in the isolated heart of *Venus mercenaria*. J. Pharm. Sci. 50(8): 648-651.

Acute tolerance, or tachyphylaxis, is a phenomenon in which successive equal doses of a pharmacologic agent cause diminished responses when administered at frequent intervals. Experiments on isolated hard clam hearts showed that tachyphylaxis induced by levarterenol was blocked most effectively by *l*-ephedrine, intermediately by *dl*-ephedrine, and least by *d*-ephedrine. Levarterenol and epinephrine appear to act at the same receptor site; thus it is suggested that ephedrine could block levarterenol responses by acting on the same receptor sites. Positive intropic responses at higher doses of ephedrine isomers showed that both agents may act at the same site. Ephedrine may block inhibitory cardiac sites on which levarterenol acts, thus allowing levarterenol to stimulate. - J.L.M.

350

Clark, George R., II. 1968.

Mollusk shell: daily growth lines. Science 161(3843): 800-802.

Ridges forming the concentric sculpture on shells of laboratory grown *Pecten diegensis* show daily periodicity. Missing growth lines account for all scatter in the data, so the maximum, not the average, line count is most representative. - J.L.M.

351

Clark, George R., II. 1974.

Growth lines in invertebrate skeletons. Ann. Rev. Earth Planetary Sci., 2 Ann. Reviews, Inc., Palo Alto, Calif., p. 77-99.

This review paper cites several references to *Mercenaria mercenaria* abstracted elsewhere in this bibliography. It reviews growth lines as records of the environment, and practical applications of growth line records. Included is a summary of periodic events, such as tides, temp variations, spawning, and influence of declination and latitude of sun and moon on environmental variables. - J.L.M.

352

Clark, John R. 1969.

Thermal pollution and aquatic life. Sci. Am. 220(3): 18-27.

Effects of rising temp on spawning of oysters and clams (species not identified) is particularly dramatic. They spawn within a few hours after water temp rises to the critical level. - J.L.M. and M.W.S.

353

Clark, J. R. 1970.

Living resources. In Proc. Symp. Water Poll. Greater N.Y. Area. Gordon & Breach, N.Y., p. 101-106.

354

Clarke, Arthur H. 1971.

Littorina littorea, native or introduced? The Biologist 53(3): 160-162.

It seems likely that by the 17th and 18th centuries a warm-stenothermal physiological race of *L. littorea* was distributed in a way similar to that of other warm-stenothermal species, like *Mercenaria mercenaria*, among others, in eastern Canada, in the vicinity of Northumberland Strait and a few semi-enclosed bays along the Nova Scotia coast. - J.L.M.

355

Clarke, John R. 1978.

The response of an intertidal bivalve heart to hypo-osmotic and ionic stress at high pressure. Comp. Biochem. Physiol. 61A(1): 35-42.

Research was done on *Modiolus demissus*. *Mercenaria mercenaria* is not mentioned. - J.L.M.

356
Claus, G. 1971.

Life and pollution in Great South Bay. Underwater Nat. 7(1): 11-16.

Per acre fertilizer usage on Long Island, N.Y. is about 50 times national average. Most phosphates in these fertilizers are carried into bays and coastal waters. Unnecessarily large amounts of highly toxic weed killers and pesticides also are used, and these also are carried into the Bay. One result of increased pollution has been decline of the shellfish industry in New York. The famous Bluepoint oyster began to be affected in the early 1940s, and concerned communities enlisted help of scientists from the Woods Hole Oceanographic Institution. Scientists discovered that in warm weather the water turned a murky green from blooms of a unicellular green alga termed "small form". Mass mortalities of shellfish coincided with blooms. The organism was identified as *Nannochloris atomus*, which frequently exceeded a million cells per ml of water. It was concluded that shellfish mortality had three causes: 1) blooms suppressed growth of bivalves and their normal food organisms, often leading to starvation; 2) being very small, algae clogged ciliary tracts of bivalves, also interfering with feeding; and 3) the alga had direct toxic effects on shellfishes. High phosphate values were found in Bay waters. The source was identified as the extensive duck farms on the eastern part of Long Island. Wastes from duck farms were carried by streams into Moriches Bay and thence to Great South Bay. A hurricane in 1934 closed Moriches Inlet, the only opening from Moriches Bay to the sea. This increased the flow of phosphate-loaded wastes into Great South Bay. Flushing rate of the Great South Bay system was estimated to be 48 days, allowing plenty of time for blooms to develop in warm weather. Bacteriological studies showed that the common fecal organism *E. coli* was present in large numbers in Bay waters. Its presence was attributed to duck farm effluents. Shellfishes from many beds in the Bay also had high numbers of coliform bacteria, and this led to closure of many shellfish beds. Duck farm operators now are required to treat their effluents. Moriches Inlet was reopened, and the channel in the Bay was dredged to decrease flushing time. Problems also exist with growing numbers of pleasure boats using the Bay. More recent studies in the late 1960s showed that flushing time was much less than calculated earlier, about 12 days. Duck farm wastes do not have high coliform counts when they enter Moriches Bay. Smallest numbers of coliform organisms were often found in streams and canals along the north shore of Great South Bay and highest numbers near Fire Island Inlet. It was concluded that the counterclockwise circulation carried water from the north shore toward the Inlet and that coliform organisms multiplied during transit, originating from cesspools and untreated sewage on the north shore. At the time of writing it was concluded that harmful effects of domestic and industrial sewage were not at levels dangerous to biota, and indeed could be improving the food supply for bivalves. The bottom of Moriches Bay and streams carrying duck farm wastes was covered with large numbers of hard clams. In 1967 the Town of Riverhead transplanted 1,800 bu of clams to clean waters, intending to reharvest when clams had cleansed themselves. But clam diggers got to the supply first, and in face of this economic loss the Town terminated the program. Clams transplanted as an experiment into the polluted East River did not die, as expected, but grew over a period of several months. Sediments in Great South Bay contain high amounts of organic materials. In summer this sometimes leads to oxygen depletion and production of H_2S, methane, and other toxins. Eelgrass and algae produce oxygen, which counters these threats to bivalves, but the system is in delicate balance, and could be jeopardized by disappearance of eelgrass or other environmental variations, natural or man-made. Solutions proposed are a combined sewer system that can handle land runoff as well as sewage, mandatory waste holding and treatment facilities for all vessels, and elimination of cesspools. The author was pessimistic that this will come about. Great South Bay will turn into an anaerobic bog within 100 yrs if present sedimentation rates continue. Even if recommended measures are carried out, the Bay will come to the same end in about 300 yrs. This raises questions about the economic benefits of spending the $1 billion estimated as necessary to provide relief. - J.L.M.

357
Clem, J. David. 1971.

Sanitary shellfish: Keeping a step ahead. Fed. Drug. Adm. Pap. 5(5): 15-17.

Activities of Federal and State governments and shellfish industry to produce non-contaminated shellfish since the typhoid fever epidemic of 1924-25 are reviewed. In judging the adequacy of classification of shellfish grounds from which mollusks can be safely harvested for market, the State control agency must consider the most unfavorable pollution and worst hydrographic conditions. Safe or approved areas are separated from obviously polluted areas by buffer zones. Mechanical breakdowns, natural disasters, and human error must be allowed for. Two closed areas have been designated in sewage sludge dump sites in the inner part of New York Bight and off Delaware Bay, with a radius of 6 mi from the point of dumping. These areas are patrolled by the Coast Guard. A compilation of commercial shellfish growing areas in the U.S. in 1966 showed that of about 10 million acres of shellfish grounds 2 million were closed by pollution. The Shellfish Sanitation Program Manual of Operations requires resurveys every 10 yrs, or more frequently if circumstances warrant. A resurvey may be made necessary by passage of a hurricane over an area. These activities relate to all commercial shellfish species, including hard clam. - J.L.M.

358
Clench, William J. 1939.

Mollusks that "muscle in". New England Nat. 3: 12-13.

A popular account of the methods by which *Busycon* opens a bivalve, such as *Venus (Mercenaria) campechiensis*. The whelk usually envelops a clam with its foot and opens the valves by suction. The method observed was that in which the whelk inserted the edge of its own shell between the valves of the clam and broke away small parts until a hole was made large enough to insert the proboscis, to feed on soft parts of the clam with its radula. The whelk shell also was damaged. Relatively few whelk shells were found, however, which had suffered such damage. Some parasitic snails have developed a strong tooth or spine at the edge of the opercular opening to aid the opening process. - J.L.M.

359
Clench, William J. 1948.

A remarkable malformed specimen of *Venus campechiensis* Gmelin. Revista Soc. Malacol. 6(1): 10.

A right valve only was found on the beach at Sanibel Island, Fla. Three photographs show that the valve was coiled like a gastropod, the axis of the coil almost in a single plane. The left valve must have been much smaller, probably only large enough to close the "aperture". - J.L.M.

360
Cobb, William Robert. 1972.

Penetration of calcium carbonate substrata by *Cliona celata*, a marine burrowing sponge. Diss. Abstr. Int. B. Sci. Eng. 32(9): 5531-B-5532-B (Ph.D. thesis, Univ. R.I., 1971, 175 p.).

A special type of *Cliona* cell, with capacity to etch, removes small calcareous chips from the substratum. Dissolution of shell was confined to a narrow zone of contact between cell edge and substratum. Penetration was effected by a rounding-up of the cell edge, formation of a curvilinear etching around the circumference of each etching cell, undercutting of the substratum, enclosure of a chip by the cell, and release of the chip at the site of penetration. Circular etchings, crevice-like undercuts, cup-shaped pits, and angular multifaceted chips were the microscopic patterns and products. General appearance of each was the same in Iceland spar, or in shells of bivalves including *Mercenaria mercenaria*. The etching agent released by penetrating cells dissolved organic and crystalline components of bivalve shells. Burrowing and massive forms of *Cliona celata* began penetration by a variety of asexual methods. - J.L.M.

361
Coe, W. R. 1943.

Biology of the nemerteans of the Atlantic coast of North America. Trans. Conn. Acad. Arts Sci. 35: 129-328.

According to Ropes & Merrill (1967) Coe found *Malacobdella grossa* in *Mercenaria mercenaria* from the Atlantic coast of North America, and in *Venus (Mercenaria) mercenaria* from the European coast. - J.L.M.

362
Coe, W. R. 1948.

Nutrition, environmental conditions, and growth of marine bivalve molluscs. J. Mar. Res. 7: 586-601.

363
Coe, W. R. 1951.

Geographical distribution of the nemerteans of the northern coast of the Gulf of Mexico as compared with those of the southern coast of Florida, with description of three new species. J. Wash. Acad. Sci. 41: 328-331.

Includes commensals in *Mercenaria mercenaria*. - J.L.M.

364
Coe, Wesley R. 1956.

Fluctuations in populations of littoral marine invertebrates. J. Mar. Res. 15: 212-232.

Major species discussed are pismo clam, oysters, sea stars (starfish), *Donax*, mussels, and dinoflagellates. Catastrophic changes, introductions of foreign species, commercial production records, and population cycles are discussed. The only reference to quahog is a statement that *Venus mercenaria* was introduced from the Atlantic to the Pacific, without mention of dates or places. - J.L.M.

365
Coffey, Burton T. 1972.

Aquaculture sustains L. I. Sound fishery. Natl. Fisherman 52(10): A12, A26.

The article deals in general terms with shellfish culture programs of Frank M. Flower and Sons, Inc., of Bayville, Long Island, N.Y. on Oyster Bay. The hatchery can produce up to 20 million clams and oysters in one day. Year-round production was the goal. - J.L.M.

366
Coffin, Gareth W., and Walter R. Welch. 1964.

A technique for separating small mollusks from bottom sediments. Proc. Natl. Shellf. Assn. 53: 175-180.

Clams less than 5 mm long are difficult to separate from sediments with which they are collected. Flotation or screening, or combinations of the two, have been used. Methods developed by various workers are described. A new technique, combining the advantages of screening, elutriating, and decanting, was developed. Equipment and 5 stages in the operation are described. Methods were varied as necessary to save time by taking advantage of knowledge of life history of clams and nature of sediments. The method was developed for studies of *Mya arenaria*, but it has worked well with several other bivalves, including *Mercenaria mercenaria*. - J.L.M.

367
Cohen, Carolyn, and Andrew G. Szent-Gyorgyi. 1957.

Optical rotation and helical polypeptide chain configuration in α-proteins. J. Am. Chem. Soc. 79: 248.

368
Cohen, Carolyn, Andrew G. Szent-Gyorgyi, and John Kendrick-Jones. 1971.

Paramyosin and the filaments of molluscan "catch" muscles. I. Paramyosin: Structure and Assembly. J. Mol. Biol. 56(2): 223-237.

Paramyosin is an α-protein found in many muscles of mollusks and other invertebrates. It is present in especially large amounts in "catch" muscles of mollusks. White adductor muscle of *Mercenaria mercenaria* had a molecular length of 1,257±35 Angstrom units (A), and in the polar (PI) form a light band 532 A wide (scaled to 725 A) and a dark band 193 A wide. Red adductor muscle had a molecular length of 1,255 A, a light band of 530 A, and a dark band of 195 A. Band patterns can be accounted for by arrays of molecules which do not have end-to-end bonding. In stained preparations precipitated with divalent cations the dark regions are interpreted as "gap" areas where stain can penetrate the paracrystal; the light areas are overlap areas where stain is largely excluded. Thus, the molecule length is 725 A plus the length of the overlap zone. The paper is illustrated with striking electron micrographs which confirm interpretation of negative staining patterns. Marked corrugation at the edge of fibers corresponded to light regions where stain was excluded. - J.L.M.

369
Cole, H. A. 1937.

Experiments in the breeding of oysters *(Ostrea edulis)* in tanks, with special reference to the food of the larva and spat. Minist. Agric. Fish., Fish. Invest., Lond. Ser. II, 15(4): 1-25.

Although this paper does not mention *Mercenaria mercenaria* or *Venus* species, it contains some important conclusions which may have implications for rearing and setting of clam larvae. The general conclusion was that physical conditions cannot be limiting factors in growth and setting of oyster larvae. Growth and setting occurred in unusually cold and sunless seasons, and in exceptionally bright and sunny seasons, at all water temps between 15° and 22°C, at pH of 8.0 to 8.85, at salinities between 30 and 34.5°/°°, in turbid or clear water, enriched or not, and in stagnant or flowing water. The nature and quantity of food organisms appeared to be factors limiting breeding, larval life, and spatfall. - J.L.M.

370
Cole, H. A., and B. T. Hepper. 1954.

The use of neutral red solution for the comparative study of filtration rates of Lamellibranchs. J. Cons. 20(1): 197-203.

Mytilus edulis was the experimental animal. *Mercenaria mercenaria* is not mentioned. - J.L.M.

371
Cole, Richard W. 1977.

No title. (A draft survey of hard clam resources of Rehoboth and Indian River Bays, Del.) - see letter dated 15 Apr 77.

PRIVILEGED DOCUMENT

Commercial landings in Del have been declining since 1965. Commercial and recreational landings of hard clam make it the third most important shellfish resource in the State. Nine full-time and about 30 part-time commercial clammers work the 2 bays. Commercial harvesters usually work waters deeper than 5 ft, recreational clammers seldom beyond 5 ft. The survey was done in response to repeated pressures to increase catch limits for commercial and recreational harvesting and to lease additional bottom for power dredging. Sampling of 1 m areas was done with a small hand-held venturi dredge by SCUBA divers. Depth of sampling was 12 in. Total samples were 338. Total clams taken were 528 in Indian River Bay and 404 in Rehoboth Bay. Clams per standard sample ranged from 0 to 21. Five principal sediment types were recognized: black, silty, organic-rich mud; sand; mixtures of silty mud and sand; mixtures of silty mud, sand, and oyster shells; and gravel. Shell and sandy mud contained significantly higher clam densities than other substrates. Most clams were larger than 3 in, which was interpreted as an indication of a declining population, yet abundance per unit area in Rehoboth Bay was higher than in a 1968 survey, and in Indian River Bay about the same. It was suggested, however, that sampling was more efficient in 1976. It was estimated that 67,412 recreational clammers used the 2 bays from 1 Apr to 31 Oct 1976. Based on age estimates the dominant size classes taken in 1976 were the same year classes that dominated the 1968 survey. It was concluded that recruitment has been poor in the interim. No relationship between water depth and clam abundance was seen. It was recommended that a 675-acre tract in the shell area of Rehoboth Bay be set aside and managed by the State as a dredging area. A daily catch limit of 2,500 clams also was recommended. Dredging should not begin until after the spawning season. No new leasing should be permitted. - J.L.M.

372
Cole, W. H. 1940.

The composition of fluids and sera of some marine animals and of the sea water in which they live. J. Gen. Physiol. 23: 575-584.

Mantle fluid of *Venus mercenaria* from Me. had pH 7.90, $-\Delta°$ 1.760, Na/Cl 0.856, K/Cl 0.0144, Ca/Cl 0.0185, Mg/Cl 0.0486, and SO_4/Cl 0.0496; from Delaware Bay: pH 7.65, $-\Delta°$ 1.369, Na/Cl 0.799, K/Cl 0.0182, Ca/Cl 0.0298, Mg/Cl 0.0799, SO4/Cl 0.0515. Blood of *V. mercenaria* from Delaware Bay had pH 7.68, $-\Delta°$ 1.386, Na/Cl 0.826, K/Cl 0.0184, Ca/Cl 0.0302, Mg/Cl 0.0778, and SO_4/Cl 0.0508. Seawater from the two localities had pH 8.10 and 8.01, respectively, $-\Delta°$ 1.759 and 1.336, Na/Cl 0.861-0.931 and 0.878, K/Cl 0.0173-0.0188 and 0.0232, Ca/Cl 0.0195-0.0197 and 0.0169, Mg/Cl 0.0687-0.0140 and 0.0984, SO_4/Cl 0.0516-0.0629 and 0.0514, respectively. Animals examined fell into 4 groups according to composition of body fluid compared to that of external medium. *Venus* and some echinoderms fell in a group with ionic ratios of 1.0 ± 0.1, except for the unexplained low ratio of 0.74 for Mg in mantle fluid of *Venus*. *Venus* collected from brackish water had significant differences from those living in seawater. All fluids were hypertonic to the external medium, even the mantle fluid, in material from Delaware Bay. Composition of mantle fluid and blood of *Venus* was identical within the experimental error, each containing more calcium than Bay water. Living conditions for hard clam are less favorable in Delaware Bay than in pure seawater, and it is likely that increased Ca content is caused by solution of $CaCO_3$ from valves. pH of all fluids was below that of seawater. Increased osmotic pressure of sera of animals in brackish water was caused by unequal accumulation of Na, K, Ca, and Cl ions. SO_4 and Mg ionic ratios did not change. - J.L.M.

373
Collins, J. W., and Hugh M. Smith. 1892.

A statistical report on the fisheries of the Gulf states. Bull. U.S. Fish Comm. for 1891, Vol. XI (1893): 93-184.

No mollusks other than American oyster had yet attained economic importance, although in Florida *Venus mercenaria* was taken in small quantities. In 1890 Fla. reported 7,330 lbs of hard clams landed, with a landed value of $747. This was 733 bu of clams. The same figures were reported for 1889. By counties, estimates were the same in both years: 1,330 lbs in Monroe County; 1,330 in Lee; 1,340 in Hillsboro; and 3,330 in Levy; all on the west coast. Gear used was not specified. - J.L.M.

374
Colton, Harold Sellers. 1908.

How *Fulgur* and *Sycotypus* eat oysters, mussels and clams. Proc. Acad. Nat. Sci. Phila. 60: 3-10, 5 pls.

The conchs *Fulgur* and *Sycotypus* are hardy and live well in captivity. *Fulgur* probably attacks any lamellibranch, *Sycotypus* attacks any except *Venus*. Quahogs are eaten in from 7 hrs to 3 days. The radula is not used to bore holes. Shells of oysters are opened by wedging the conch shell between the valves. The radula is used to tear out flesh. Quahaugs probably are eaten in the same way. Some conch shells are injured in the process. Meals are infrequent, and the conch buries in sand between feedings. Conchs may not be as serious a pest as oystermen believe. Illustrations of the feeding method are included. With oysters *Fulgur* crawls on top and waits until the oyster opens its valves, the process is then very rapid. Hard clams never open their valves voluntarily, and the snail uses the edge of its shell to chip away pieces from the edge of the clam shell. When the opening is 3 mm or more the proboscis is then inserted, or the snail inserts the edge of its shell into the gap and pries the clam open by contracting its columellar muscle. - J.L.M.

375
Committee on Merchant Marine and Fisheries. 1963

Molluscan shellfish. Hearings before the Subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchant Marine and Fisheries, House of Representatives, 88th Congress, First Session. Serial No. 88-13. U.S. Govt. Printing Office, Washington, D.C., v+229 p.

A comprehensive hearing on the many problems of the shellfish industry of the United States. Witnesses were drawn from all sections of the country, and included government experts as well as representatives of industry. Hard clam is mentioned many times in the testimony and the questioning of witnesses. - J.L.M.

376
Connell, L. R., Jr., and R. E. Loveland. 1980.

Growth rates and fouling in sediment-free raft culturing of juvenile hard clams, *Mercenaria mercenaria*, L. Natl. Shellf. Assn., Abstracts, Technical Sessions: 15 (abstract).

Juvenile clams, collected from natural *Mercenaria* intertidal beds, were placed in plastic trays suspended from plastic flotation collars in the intake canal of a nuclear power plant. Clams ranged from 2 to 15 mm long and were maintained according to a size-frequency distribution similar to a natural population under study. Mortality in 5 months was less than 10% as compared to nearly 90% for juveniles in natural beds. Maximum growth rate in sediment-free trays was 0.4 mm/week in September 1979. Mortality was 5% or less in trays which held sediments in the range of 0.5 to 1.0 mm grain size and which were covered with galvanized wire mesh. - J.L.M.

377
Conrad, Jon M. 1979.

Management of the Northeast clam resource: Commercial and recreational considerations. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass., and MIT Sea Grant Program, SP-112: 121-129.

The report is largely speculative, but contains some interesting estimates. For example, Massachusetts communities with active recreational shellfisheries in 1975 were estimated to be worth between $571 and $3,850 thousand dollars. Comparing these with commercial values for the same places, on one basis, the commercial harvest was worth approximately $788 thousand, the recreational harvest between $31 and $195 thousand; on another basis, the average price for a bushel of commercially harvested hard clam was $15.73, the per bushel value of the recreational catch was between $3.44 and $20.42 for one place and $4.28 and $32.17 for another. Thus, the per-bushel valuations might be approximately the same. Inshore shellfisheries provide opportunities for resource enhancement not found in most finfisheries. The comparisons possible, with limited information suggest that additional investment would be justified. There does not appear to be any consensus that nearshore shellfish beds have been excessively overfished. The opportunities for manipulation to improve yields appear to be available. Research should include: 1) demand and cost of commercially harvested clams; 2) effectiveness and cost of alternative measures of augmenting resource stocks; and 3) a socioeconomic profile of commercial and recreational users. This could be integrated with existing knowledge to manage the shellfisheries for improved and equitable yields. - J.L.M.

378
Conrad, Jon M. 1979.

Plenary session hard-shell clams. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass., and MIT Sea Grant Program, SP-112: 147-148.

The resource is primarily located in the Cape Cod area of Mass., Narragansett Bay area of R.I., and bays and coastal waters of Long Island, N.Y. It is essentially an open access fishery in Mass., managed by the Towns. In R.I. the state plays a larger role in management. On Long Island it is also Town management, but part of the resource is harvested through grants and leases. Additional research is needed on mortality at various stages of development. Genetic research for selecting disease-resistant stock could have payoffs. Predator control also is important. Economists might be helpful to assist in "costing-out" alternative values. Conclusions boiled down to: 1) a need to develop more flexible management for mixed open access/private leasing; 2) research is needed on a) mortality by stages of development, b) possibility of selective breeding, and c) predator control techniques; and 3) management to increase productivity should allow for broader social objectives such as seasonal employment and recreation. - J.L.M.

379
Cook, Ann K. 1975.

Delaware Sea Grant looks to the future. NOAA Magazine 5(2): 36-41.

Describes in popular terms the objectives and methods of operation of the University of Delaware recirculating seawater system for culture of bivalves, at Lewes, Del. - J.L.M.

380
Cook, Dick. 1978.

Culturing the clam - A virginia innovation. VIMS Mar. Resour. Bull. 10(4): 1-2, 5-6.

Traces the history of *Mercenaria mercenaria* culture in Virginia. Seed clams are bred from parents with fast growth to 2 mm in the laboratory. This takes 6 to 8 weeks. Seeds are planted on prepared beds of aggregate 1 1/2 to 2 inches deep. Wire baffles are installed to decrease current force, and a fence is added later to exclude predators. Seed clams are planted at $31{,}000/m^2$ ($250/ft^2$) and planting is complete by early Oct. Normally, hard clams take 3 yrs to reach littleneck size, but these fast-growing progeny take 20 to 22 months. Harvesting takes place at 16 to 18 months, when about 20% are legal size. The rest are harvested in 22 to 24 months. At that stage the price is at least 6¢ each. The laboratory at Wachapreague has trained people from most coastal states. The clam culture course costs $35/person. Salinity must average 20°/₀₀ for successful culture. Risks are storms, ice, damage by boats, predators, and poachers. - J.L.M.

381
Cook, Dick. 1979.

Clam culture, Virginia style. Sea Grant '70s 9(1): 7-8.

In the second phase of the hard clam culture program at Wachapreague the staff is teaching classes in clam culture and publishing a manual of hatchery operations. Now that the "bugs" are worked out, clam survival has reached 86-92%. The system raises clams from fast-growing parents to 2 mm size in the laboratory then planted in the natural environment on prepared aggregate beds of crushed stone or gravel. The beds are surrounded by baffles to cut down current force and allow the young clams to burrow. Later a plastic mesh fence is added to minimize predation by rays. Seed clams are planted at $3,100/m^2$ and planting is finished by October. Clams from selected parents reach marketable size in 20-22 months. When clams are between 16 and 18 months old baffles are removed and about 20% are taken, the rest are harvested at 22 to 24 months. Salinity must average 20 parts per 1000. - J.L.M.

382
Cook, R. A. 1975.

Rules and regulations by which we work. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany, p. 32-33.

The Department operates under statutory authority of the Environmental Conservation Law (ECL) and portions of the Public Health and Agriculture and Market Laws. This authority is extended by Rules and Regulations issued by the Department. Portions of the ECL that apply directly to the shellfish industry include issuing diggers and shippers permits, control of harvest areas, shellfish sanitation, maintenance of sanitary conditions, and enforcement of operating standards. The Department also is responsible for enforcement of the Tidal Wetlands Act of 1973 and its moratorium on wetland alterations. At the time of writing action was pending on hard clam marketing standards which specified grades of clams in the shell that can be sold by buyers. Grades were: "necks" - 1 inch in thickness or larger, but less than 1 7/16 inches thick; "cherries" - 1 7/16 inches in thickness or larger but less than 1 5/8 inches thick; and "chowders" - 1 5/8 inches thick or larger. Clams, under these standards, should be in a container labelled to show the grade as above, weight of contents, minimum number of clams, and name, address, and zip code of seller. The Department was opposed to federal legislation and rules and regulations promulgated re standards for chlorinator-macerator devices for marine toilets, believing that chlorinated and macerated wastes could have adverse effects on shellfish quality. The preferred method was holding tanks (for disposal of contents in approved fashion on shore). - J.L.M.

383
Cooper, R. A., S. B. Chenoweth, and N. Marshall. 1964.

Condition of the quahog, *Mercenaria mercenaria*, from polluted and unpolluted waters. Chesapeake Science 5(4): 155-160.

Hard clams were sampled from three general areas in Point Judith Pond, Rhode Island. Area A is in polluted waters. Area B is near A but is open to harvesting. Area C is open to harvesting and away from pollution influences. Condition of clams was compared using meat volume-shell length regressions and by comparing condition (K) by the formula, K=meat volume/shell length^n. Comparisons of $\bar{K}$ indicate that clams from A had higher $\bar{K}$ than area B which had a higher $\bar{K}$ than area C. Meat volume-shell length regressions showed that area B clams had slightly higher meat volumes than area A, which had significantly higher meat volumes than clams from area C. It was suggested that sampling variation of the slope n in the formula for K was responsible for differences in results of the two methods for comparison of conditions. It was concluded that differences between the 3 areas were not great. - D.L.

384
Cornell, Chris. 1978.

Making aquaculture pay: Tucked in the cellar of an old mill, Sea Plantations Inc. has found a way. Natl. Fisherman, Yearbook Issue 1978, 58(13): 124-127.

Describes operations of Sea Plantations Inc. of Salem, Mass. which are said to be operating at a profit in less than a year after incorporation. Purified seawater and temperature control are key requirements. Methods and results are described. Reared in tanks with quahogs are sea hares for alga control, and silversides and mummichogs, used in laboratory toxicological studies. Culture of lobsters and salmon is also contemplated. - J.L.M.

385
Costello, D. P., M. E. Davidson, A. Eggers, M. H. Fox, and C. Henley. 1957.

Methods for obtaining and handling marine eggs and embryos. Mar. Biol. Lab., Woods Hole, Mass., Lancaster Press, Inc., Lancaster, Pa., xv + 247 p.

Material is treated by Phyla. *Venus mercenaria* (p. 130-132) is one of several pelecypods discussed. *Callocardia convexa*, which is similar in appearance, is often found with *M. mercenaria*, and can be confused with it. *Callocardia* is smaller than mature *Venus*, is white, and has a smooth margin to its shell. Breeding season of hard clam is mid-June to mid-August, with a peak from late June to early July in the Woods Hole region. Individual batches will shed for about 20 days only. Water temp must be above the critical level of 23 to 25°C. Details of procuring and handling material are summarized from the literature. All papers cited are abstracted elsewhere in this bibliography. - J.L.M.

386
Cottrell, G. A. 1964.

Fractionation of binding particles of certain physiologically active substances from a molluscan ganglia (sic). Am. Zoologist 4(4): 409 (abstract).

Describes preliminary studies of binding of acetylcholine (ACh), 5-hydroxytryptamine (5-HT), and an unidentified cardio-excitatory substance in ganglia of *Mercenaria (Venus) mercenaria*. Homogenates prepared in 1.1 M glucose were separated into 3 primary fractions (S1, S2, and Su) by differential centrifugation. Further fractionation was achieved in a discontinuous sucrose gradient of 5 solutions ranging in concentration from 1.0 to 2.4 M. Three quarters of the ACh was recovered in sediments S1 and S2. Slightly more than half of this was in S2. Distribution of 5-HT was similar. Most of the unidentified factor was in sediments, most of it in S2. When S2 was resuspended in 1.1 M glucose and centrifuged over the sucrose gradient at 100,000 g for 90 min, partial separation of all 3 substances was achieved. Over 90% of ACh was at the top of the gradient, which corresponded to the solutions 1.1 M glucose, 1.0 M sucrose, and half of the 1.3 M sucrose. More than 60% of 5-HT was in the bottom half of the tube and most of this was below 1.7 M sucrose. Highest concentration of unidentified factor was in the fraction 1.3 to 1.7 M sucrose, whereas none was found in the most dense sucrose fraction where highest concentration of 5-HT was found. - J.L.M.

387
Cottrell, G. A. 1966.

Separation and properties of subcellular particles associated with 5-hydroxytryptamine, with acetylcholine and with an unidentified cardio-excitatory substance from *Mercenaria* nervous tissue. Comp. Biochem. Physiol. 17(3): 891-907.

Seventy percent or more of acetylcholine (ACh) and 5-hydroxytryptamine (5-HT) in *Mercenaria* ganglia is bound to particles which sediment when homogenates of this tissue, prepared in 1.1 M glucose, are centrifuged at high speed. Similarly, a large proportion of the unidentified cardio-excitatory factor, Substance X, is particle bound in *Mercenaria* ganglia. Particles binding each of these substances have been partially separated from each other by density gradient centrifugation. ACh particles were mainly associated with the least dense layers of the gradient, 5-HT with denser layers, and Substance X with layers of intermediate density. A fraction of 5-HT particles has been purified 20 times over the original homogenate. The level of ACh contamination of this fraction, if any, was below the limit of detection. Particles binding ACh and 5-HT release their active substances in a quantitatively similar manner to changes in pH, hypotonicity and increased temp. These substances apparently act as peripheral neurohumors and also mediate nerve activity at central synapses in mollusks. Clam nervous tissue contains abundant amounts of both, 40 µg/g wet weight of 5-HT and 40-90 µg/g wet weight of Ach. - modified author's abstract. - J.L.M.

388
Cottrell, G. A., and M. Maser. 1967.

Subcellular localization of 5-hydroxytryptamine and Substance X in molluscan ganglia. Comp. Biochem. Physiol. 20(3): 901-906.

5-Hydroxytryptamine (5HT) has been found in nervous tissue of many mollusks, but it is particularly abundant in *Mercenaria mercenaria*. It is believed that 5HT acts as a neurohumor. Extracts of molluscan ganglia, including those of hard clam, also contain a potent, unidentified, cardio-excitatory factor presently called Substance X. Electron microscope studies have demonstrated many types of small inclusion with vesicular profiles within nerve axons and their fine branches. It is believed that 5HT may be associated with these vesicles. Study of density-gradient fractions of *Mercenaria* ganglia homogenate under an electron microscope showed that Substance X is associated with "uniformly granulated vesicles" of 1,000 to 3,000 Angstroms diameter. It is still not possible to determine unequivocally the particular type of subcellular inclusion with which the indolealkylamine 5HT is associated. - J.L.M.

389
Cottrell, G. A., and N. N. Osborne. 1969.

Localization and mode of actions of cardio-excitatory agents in molluscan hearts. In Comparative Physiology of the Heart: Current Trends. F. V. McCann (ed.). Experientia Supplementum 15. Birkhauser Verlag, Basel, p. 220-231.

References to *Mercenaria (Venus) mercenaria* are by citation of papers abstracted elsewhere in this bibliography. - J.L.M.

390
Coues, E. 1871.

Notes on the natural history of Fort Macon and vicinity. Proc. Phila. Acad. Sci. 23: 120(131).

According to Jacot (1921), abstracted elsewhere in this bibliography, Coues recorded *Venus mercenaria*, *V. campechiensis*, and *V. mercenaria notata* from this area in N.C. It appears that Jacot gives Coues credit for the statement that *V. campechiensis* was common inside the barrier beach. - J.L.M.

391
Coughlan, John, and Alan D. Ansell. 1964.

A direct method for determining the pumping rate of siphonate bivalves. J. Cons. 29(2): 205-213.

Fourteen *Venus mercenaria* from 3 to 8.3 cm long were observed at 18° to 20°C. Pumping rate varied directly with wt of clam, and with other indices of size. Values obtained were higher than those of Rice and Smith (1958), abstracted elsewhere in this bibliography. Low rates were obtained when clam was digging or when flow of water through aquarium was low. Normally, siphons were extended a cm or 2 above the substrate, marginal tentacles extended and out-turned. Typical and maximum pumping rates were always associated with this appearance. When marginal tentacles were turned upwards or inwards, often with slightly restricted siphonal aperture, pumping rate was reduced. Changes in light intensity, slight tactile stimuli and water currents, and static water conditions caused this reaction. For comparisons of pumping rates, condition of animals used should be described. The apparatus used supplied dye to the clam and carried away the exhalent dye stream so as to retain visibility. - J.L.M.

392
Courtney, W. A. M., and G. R. W. Denton. 1976.

Persistence of polychlorinated biphenyls in the hard-clam *(Mercenaria mercenaria)* and the effect upon the distribution of these pollutants in the estuarine environment. Envir. Pollut. 10: 55-64.

M. mercenaria from the northern end of Southampton Water contained 0.11 ± 0.04 parts PCB/10^6 wet body weight. The visceral mass contained 10.0 ± 5.8 parts/10^6 after 18 days exposure to 12.5 parts/10^9 A1254. Oysters feed at a faster rate and accumulate twice as much DDT as hard clams. The maximum mean concentration factor for *M. mercenaria* exposed to 1.25 parts/10^9 was 1.8 x 10^3 for the visceral mass after 18 days. A tenfold increase in exposure level gave a fivefold increase in tissue concentration so that the biotic concentration factor is dependent upon the level of contamination, and falls as pollution increases. Larger PCB residues in visceral mass compared with muscular foot of *M. mercenaria* may be related to differences in lipid content of tissues, but the gut and contents were not separated from visceral mass prior to analysis. Contaminated *M. mercenaria* from Southampton and those exposed to 1.25 parts/10^9 A1254 in the laboratory showed little change in PCB content after 3 months in clean seawater. At a higher dosage there was a significant decrease in PCB residues in the foot after a month although the level in the visceral mass was unchanged after 6 months. Tissues of *M. mercenaria* contained a predominance of early eluting peaks compared with standard A1254, and feces and surface mud of their habitat also contained a predominance of late eluting peaks, it is possible that they exert a qualitative and quantitative effect on distribution of PCB in the system. Densities of 120 clams/m^2 have been found in Southampton Water, and may contribute, through recycling particulate matter on which they feed, to the increased proportion of higher chlorinated PCB isomers in the mud which they inhabit. - J.L.M.

393
Coutance, A. 1878.

De l'energie et de la structure musculaire chez les mollusques acephales. Paris.

This is available at Phila. Acad. Nat. Sci. It could not be sent on interlibrary loan because it is in poor condition. Cost of reproduction was 25¢/page, but we did not have a record of number of pages, and thought the publication would be of peripheral interest for our purposes. Search terminated. - J.L.M.

394
Cowgill, Robert W. 1972.

Susceptibility of paramyosin to proteolysis and the relationship to regions of different stability. Biochemistry 11(24): 4532-4539.

Paramyosin is one of the major contractile proteins extractable from adductor muscle of mollusks. Contractile units of molluscan muscle have thick and thin filaments. Paramyosin is the major component of thick filaments. Paramyosin molecules align to form a bipolar core of the thick filament which is covered by a surface layer of myosin. The core seems to modify interaction of myosin with actin of thin filaments, thereby having a specific regulatory role in maintaining muscle tension. Paramyosin molecules are well suited for such a role, for it is a large molecule, of 220,000 atomic mass units, rod-shaped, 1330 A long and 20 A diameter, consisting of 2 intertwined α-helical chains. Paramyosin from *Mercenaria mercenaria* was attacked rapidly by a variety of proteolytic enzymes. However, a fully helical segment of the molecule soon accumulated, which was resistant to further attack. Essentially the same segment of paramyosin appeared to be resistant to hydrolysis by all enzymes tested. The resistant segment was in the N-terminal two-thirds of the molecule. - J.L.M.

395
Cowgill, Robert W. 1974.

Location and properties of sulfhydryl groups on the muscle protein paramyosin from *Mercenaria mercenaria.* Biochemistry 13(12): 2467-2474.

Earlier studies showed that paramyosin was susceptible to proteolysis in such a way that a common segment or proteolytic-resistant core remained after attack by any one of a number of enzymes. Those studies were made with paramyosin which had all sulphhydryl groups oxidized to disulphide form. These results were not affected by state of oxidation of paramyosin, for the same paramyosin pepsin-resistant core (PPC-1) and paramyosin trypsin-resistant core (PTC-1) were obtained by proteolysis of paramyosin whether sulphhydryl groups were oxidized or reduced. But some physical properties of paramyosin do depend on state of oxidation of its sulphhydryl groups. Experiments reported in this paper showed that the N pair disulphide bond contributes to the high stability of the N-terminal segment of the paramyosin molecule. The C pair disulphide bond does not appear to stabilize the C-terminal region of the molecule. - J.L.M.

396
Cowgill, Robert W. 1975.

Segments of paramyosin formed by cleavage at sites of cysteine residues. Biochemistry 14(19): 4277-4279.

Helical muscle protein β-paramyosin of 200,000 daltons was treated for chemical cleavage of the polypeptide chain at the site of Cys residues. The protein cleaved into 2 segments: CCF-1 of 140,000 daltons, and CCF-2 of 60,000 daltons. CCF-1 was completely helical and CCF-2 was 85% α-helical. Molecular size, resistance to pepsin digestion, stability to heat and urea, and solubility of CCF-1 were similar to those of a pepsin-resistant segment PPC-1 described by the author in 1972. It was concluded that the CCF-1 segment arose from the N-terminal 2/3 of the paramyosin molecule. The properties of CCF-2 were distinctly different. It arose from the C-terminal 1/3, and had limited solubility at neutral pH which matched the low solubility of paramyosin. It was concluded that the CCF-2 region is responsible for the self-aggregating tendency of paramyosin at neutral pH and low ionic strength. - modified author's abstract - J.L.M.

397
Cowgill, Robert W. 1975.

Proteolysis of paramyosin from *Mercenaria mercenaria* and properties of its most stable segment. Biochemistry 14(3): 503-509.

The helical muscle protein paramyosin appears to consist of 3 segments of about equal size that differ in stability to guanidine hydrochloride and heat. The N-terminal segment is most stable, the C-terminal segment least. These differences were used to design proteolytic digestions to remove segments of low and intermediate stability specifically. At room temp only the C-terminal region was digested by pepsin or trypsin. Proteolytic removal of the C-terminal region caused the remaining 2/3 of the paramyosin molecule to accumulate as a segment (PPC-1) of 140,000 daltons still in stable helical conformation. Under more rigorous conditions, e.g., papain digestion of either paramyosin or PPC-1 in 4M guanidine·HCl, which might be expected to destabilize all but the N-terminal segment, all except the region that was cleaved. The N-terminal region accumulated as a helical segment of 74,000 daltons (PPC-2) if digestion was limited to 1.5 hr, or a segment of 58,000 daltons (PPC-3) if digestion continued for 24 hr. Stability of the 3 PPC segments to guanidine·HCl and heat was measured by change in fluorescence of tyrosyl residues upon loss of the helical form. Stability of segments corresponded well with stability of those regions in the paramyosin molecule from which the segments were thought to come. Amino acid composition of PPC segments and of paramyosin were all very similar. Prediction of relative stability of these helical proteins by inspection of gross amino acid composition does not appear promising. - modified author's abstract. - J.L.M.

398
Cox, Philip. 1916.

A supposed disease of quahaugs from New Brunswick. Contr. Can. Biol. Fish: 73-79.

The investigation was made because *Venus (Mercenaria) mercenaria* shipped from Buctouche to Chicago and New York suffered unusual mortalities in 1914, with losses up to 60% during shipment. The consignees reported the stock diseased, and refused further shipments. Clams were stored in floating trays at beginning of season, when harvest was greatest, until they were shipped to market. The water in which they were stored had higher temp and lower salinity, and circulation was poor. Handling methods were poor, and clams were subject to relatively great temp changes over extended periods of time. The conclusion was fairly obvious that improved handling methods would reduce mortalities, and experimental studies tended to confirm this conclusion. No evidence of disease was found. The following questions were suggested for research: 1) at what age and size are quahogs sexually mature, and do large and small clams spawn at the same time? 2) what proportion of clams of various sizes die normally each year, and does death usually follow spawning? 3) what is the effect of retention of ova in clams held out of water? 4) how do clams harvested at beginning of season (in May) compare with those on native beds, and what is the effect of storage on development of reproductive organs? - J.L.M.

399
Craig, Sally. 1967.

Toxic ions in bivalves. J. Am. Osteopath. Assn. 66(9): 1000-1002.

Pb, Hg, and Cu residues were determined in *Venus mercenaria* and *Spisula* sp. from Woods Hole, Mass. and Cape Henlopen, Delaware Bay. Concentrations of all 3 metals were higher in quahogs from Woods Hole (Woods Hole: Pb 2.57 ppm/clam, Cu 19.23 ppm, Hg 2.71 ppm; Cape Henlopen: Pb 1.09 ppm/clam, Cu 0.91 ppm, Hg 1.11 ppm). Average size of Woods Hole clams was greater (29.92 g vs 16.01 g for Cape Henlopen - presumably meat weights). - J.L.M.

400
Crane, Jules M., Jr., Larry G. Allen, and Connie Eisemann. 1975.

Growth rate, distribution, and population density of the northern quahog *Mercenaria mercenaria* in Long Beach, California. Calif. Fish Game 61 (2): 68-81.

A population of *Mercenaria mercenaria* unique to the west coast is well established in a lagoon in Long Beach, Calif., probably from introductions in 1951-1954 or later. Total population was estimated at 300,000 to 500,000 individuals. Density reaches 556 clams/m^2. They appear to be outcompeting other species for food and by being able to survive greater environmental stress. Growth rates averaged 7.2 mm/yr with a gain of 25.3 g/yr. Most rapid growth was in smaller (80 mm) clams. Most are in water more than 3 ft deep at low water. Most growth was from June to Nov. The lagoon has been closed to clamming since March 1971. The lagoon should be closed to clamming for 4 yrs, and bag and size limits established prior to opening. - J.L.M.

401
Crenshaw, Miles A. 1972.

The soluble matrix from *Mercenaria mercenaria* shell. ForschBer. Biomineral. Akad. Wiss. Lit., Mainz (Biomineral. Res. Rept.) 6: 6-11.

A water-soluble glycoprotein isolated from hard clam shell accounted for about 15% of the organic matrix. It was evenly distributed through the shell and was not destroyed when powdered shell was treated with aqueous sodium hypochlorite. Apparent molecular weight of the soluble matrix was 160,000. Weight ratio of protein/hexosamine/uronic acid was 165/20/1. Ester sulfate/hexosamine molar ratio was 1.8/1. Of total amino acid residues, 30% was aspartic acid, 16% glycine, and 10% serine. Aspartic acid was present in the protein as asparagine. Titration of soluble matrix with Ca in presence of excess Na, K, or Mg, using a calcium electrode, showed that Ca was bound selectively. Urea concentrations above 3 M eliminated the Ca binding. Soluble matrix appeared to be identical with intracrystalline matrix identified in ultrastructural studies of molluscan shell. Soluble matrix may have a role in starting calcification. - from author's summary - J.L.M.

402
Crenshaw, Miles A. 1972.

The inorganic composition of molluscan extrapallial fluid. Biol. Bull. 143(3): 506-512.

Inorganic composition of extrapallial fluid of *Mercenaria mercenaria*, *Mytilus edulis*, and *Crassostrea virginica* was significantly different from that of seawater. Ca was the principal ion, and Ca concentration was higher than that of blood plasma. K concentration of extrapallial fluid was lower than that of blood plasma. This demonstrated that extrapallial fluid is separated from blood, it is not formed by leakage from or damage to mantle cells, and it is different from skeletal extracellular fluid of vertebrates. Binding of Ca in the fluid was accomplished by a non-dialyzable component that appeared to be a glycoprotein. - J.L.M.

403
Crenshaw, Miles A., and Jerry M. Neff. 1969.

Decalcification at the mantle-shell interface in molluscs. Am. Zool. 9(3): 881-885.

Decalcification in *Mercenaria mercenaria* was studied through changes in chemical composition of extrapallial fluid, and by measurement of Ca^{45} deposition and solution. Clams were anaerobic soon after valves closed. Ca & CO_2 content of extrapallial fluid increased with increasing time of closure, pH dropped. Succinic acid produced by anaerobic metabolism was neutralized by dissolution of previously deposited shell. A 100 g clam lost about 2 mg of shell/hr. - J.L.M.

404
Crenshaw, Miles A., and N. Watabe. 1969.

The muscle attachment ot (sic) the shell of *Mercenaria mercenaria*. Am. Zool. 9(4): 1139.

Muscle fibers were attached directly to myostracum. No intervening adhesive epithelium was found. When shell was decalcified, the adductor retained its attachment to conchiolin of the shell. - J.L.M.

405
Croker, R. A., and A. J. Wilson. 1965.

Kinetics and effects of DDT in a tidal marsh ditch. Trans. Am. Fish. Soc. 94: 157.

406
Cronin, L. Eugene, M. Grant Gross, Maurice P. Lynch, and J. Kevin Sullivan. 1977.

The condition of the Chesapeake Bay - A consensus. In Proc. Bi-State Conf. on Chesapeake Bay. L. Eugene Cronin (Chm. Ed. & Planning Comm.). Chesapeake Research Consortium Inc., CRC Pub. 61: 37-61.

Hard clam stocks of the Bay appear to be in good condition, producing catches at least near the long-time average. No commercial culture is under way around the Chesapeake. No loss from severe winter in 1976-77 was observed in the middle or lower Bay. - J.L.M.

407
Culliney, John L. 1972.

Cinemicrographic studies of crawling behavior in larval and juvenile bivalves. Am. Malacol. Un. Bull. for 1971: 29.

Several New England bivalves were studied, but not *Mercenaria mercenaria*. - J.L.M.

408
Culliney, J. L., P. J. Boyle, and R. D. Turner. 1975.

New approaches and techniques for studying bivalve larvae. In Culture of Marine Invertebrate Animals, Plenum Pub. Co., New York. W. L. Smith and M. H. Chanley (eds.), p. 257-271.

Papers by Loosanoff and Davis in the 1950s and 1960s are described as classic works. Their comprehensive report (1963) on culture techniques was still the most important single work in the field, and should be consulted by anyone planning to work with bivalve larvae, as also should Walne (1964) and other papers abstracted elsewhere in this bibliography by Chanley and others. This paper adds refinements to basic culture techniques and calls attention to some problems under the headings: spawning and fertilization, maintaining swimming stages, feeding, effects of temperature, other factors such as salinity and pH affecting development, data acquisition and recording, and preservation of a reference collection. - J.L.M.

409
Cumming, Hugh S. 1917.

Investigation of the pollution of certain tidal waters of New Jersey, New York, and Delaware, with special reference to bathing beaches and shellfish bearing areas. U.S. Pub. Health Serv., Pub. Health Bull. 86, 150 p.

Although this report deals primarily with American oyster, clams are mentioned several times, and sometimes hard clam specifically. Conclusion was that most shellfish growing areas were free, or relatively free, of pollution, but that some were grossly polluted. The practice of moving oysters to creeks to "float" them before marketing increased the danger to consumers and it may have been that this practice was followed with clams. Where coliform counts were made on clam meats (presumably hard clam) they were lower than in oysters from the same waters: for example, in the Shrewsbury River, N.J. oyster scores were 23 and 14 colonies/cc, on agar at 37°C and 48 hrs incubation. Water at this location showed 100% *E. coli* in 10 cc, 75% in 1 cc, and 25% in 0.1 cc. At Red Bank, N.J. it was concluded that clams were safe in winter if the sewage disposal plant was working, but in summer the increase in human population was sufficient to ban raw consumption of shellfish. No part of Raritan Bay was entirely unpolluted. Along the N.J. coast, areas varied in water quality depending on population, local conditions, and summer influx of visitors. In some areas clams were well within safe limits, in others not safe, especially in summer. For example, in vicinity of Atlantic City hard clams were prolific, shellfishing was prohibited in certain areas, but many were taken for bait or for personal consumption in summer. In 1903, 3.8 million clams were consumed in Atlantic City and 5.2 million shipped out. For the N.J. coast as a whole, the oyster industry was declining and of little importance. The clam industry was important and the harvest was almost entirely in summer, when contamination was most likely. Publicity was needed to alert summer visitors to the dangers. An outbreak of typhoid at Atlantic City in 1902 was attributed to consumption of oysters and clams from the mouth of Penrose Canal. Protection against pollution was considered most important, not only for shellfish industry but also for tourist trade. Shellfish areas in Delaware Bay were considered safe, but some tributaries were grossly polluted. The shellfish industry in Delaware Bay was dominated by oyster. Appendices include detailed results of tests of water and shellfish quality, records of typhoid cases in certain areas, and a report on a typhoid outbreak in Ocean City, N.J. in which raw clams were suspected as the cause. This is a comprehensive report, which should be consulted for further details. - J.L.M.

410
Cumming, Hugh S., W. C. Purdy, and Homer C. Ritter. 1916.

Investigation of the pollution and sanitary conditions of the Potomac watershed, with special reference to self purification and sanitary condition of shellfish in the lower Potomac River. Treasury Dept., U.S. Pub. Health Serv., Hygienic Lab., Bull. 104, 239 p., 53 figs.
(Cumming was the principal author. Purdy did Plankton Studies: 130-191; Ritter did Hydrographic Data: 205-216 plus 6 charts.)

The study was concerned with sanitary conditions on oyster beds in the lower part of the estuary. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M.

411
Cummins, J. M., J. E. Higgins, and E. A. Robertson, Jr. 1967.

Occurrence of ciguatera-like biotoxin(s) in shellfish from the Gulf of Mexico. U.S. Pub. Health Serv., Gulf Coast Shellf. Sanit. Research Center, Dauphin Is., Ala. Tech. Rept. 67-7, 22 p.

412
Cummins, Joseph M., Abner C. Jones, and Alan A. Stevens. 1971.

Occurrence of toxic bivalve molluscs during a *Gymnodinium breve* "red tide". Trans. Am. Fish. Soc. 100(1): 112-116.

On the first day of sampling, when red tide condition was most severe, *Mercenaria campechiensis* from Venice Inlet on the west coast of Fla. contained 270 mouse units of toxin/100 g of meats. On the 3rd day hard clams still contained more than 100 mouse units/100 g. - J.L.M.

413
Cummins, Robert Jr. 1966.

Hard-clam explorations off southeastern United States. Comm. Fish. Rev. 28(12): 33-42.

Mercenaria mercenaria or *M. campechiensis* or both occur in waters of every state from Me. to Fla. and into the Gulf of Mexico. Most production is in southern New England and Middle Atlantic states. Little or no commercial production has been reported from the Fla. east coast, Ga., S.C., Pa., or N.H. Harvesting has been intermittent on the Fla. west coast and in southern Me. Total production from 1949 to 1964 inclusive ranged from about 13.3 to 21.0 thousand lbs of meats. Since 1948 little change in gears, marketing, or processing has taken place. General refinements have come about in sanitation, pollution abatement, culture of seed, and production of canned products like chowder. Prior to 1959 little was known about abundance and availability of hard clams in water deeper than 2 or 3 fathoms in the ocean south of Middle Atlantic States. On 7 cruises from Nov 1959 to Mar 1961, Silver Bay dredged at 271 stations from north of Cape Hatteras to south of Cape Kennedy. Depths were mostly from 4 to 8 fath. Gear was a modified Fall River dredge. Catch was southern hard clam, *M. campechiensis*. In taste and texture meats are similar to the northern species. Small numbers of ocean quahog, *Arctica islandica*, were taken. Commercial quantities of hard clam were found in Onslow Bay, N.C., which led to development of a small winter fishery by converted shrimp vessels. Average production was estimated at 44 to 55 bu/day which gave a gross return per boat day of about $100 to $125. No other commercial concentration of hard clam was found, but it is possible that they might exist in shallower water, where Silver Bay could not operate. - J.L.M.

414
Cummins, Robert, Jr., Joaquim B. Rivers, and Paul J. Struhsaker. 1962.

Exploratory fishing off the coast of North Carolina, September 1959-July 1960. Comm. Fish. Rev. 24(1): 1-9.

The area covered was the continental shelf out to 100 fathoms from Cape Hatteras south. Several gears, including a 14-tooth Fall River clam dredge, were used. *Mercenaria* sp. were found in greatest abundance between Cape Lookout and a point about 4 mi west of Beaufort Inlet in depths of 3 1/2 to 7 1/2 fath. Simulated commercial dredging produced an average catch of 7 1/2 bushels live clams/hr fished and a max catch rate of 13 bu/hr. Most clams were chowder-size (3-5 in long), yielding an average of 1 gal meats/90-lb bu. Dead clams were taken as frequently as live. Small numbers of hard clam were taken near Bogue In. and near the mouth of Cape Fear R., and abundant dead shell but no live clams near Drum In. It apparently was not determined whether the species was *Mercenaria mercenaria, M. campechiensis*, or both. - J.L.M.

415
Cunliffe, James E., and Michael J. Kennish. 1974.

Shell growth patterns in the hard-shelled clam. Underwater Nat. 8(4): 20-24, 47.

Mercenaria mercenaria adds a small increment of aragonite bounded by a thinner layer of conchiolin to its shell every day. The aragonite increments are deposited at night and the conchiolin by day. Thus, shell formation in *M. mercenaria* appears to coincide with light and dark cycles of the solar day. The thickness of daily increments varies during the year, thickest in summer, thinnest in winter. Other patterns suggest that shell deposition is also controlled by the fortnightly tidal cycle, thin increments deposited during neap tides, thick increments during spring tides. Periods of stress may also interrupt growth for one to several days. These interruptions or breaks are characterized by indentations of the outer shell layer, the most severe of which is the winter break. Less severe breaks may also be caused by spawning events, and by storms. Clams from creeks with heated effluents show a higher number of breaks and slower summer growth. There also appear to be three phases of growth according to age, each differing in the pattern of daily increments. During old age, clams sometimes appear to be able to resume the pattern of the middle period if transplanted from deep to shallow water. Counting surface rings has previously been used to determine age of clams. The new method suggests that such estimates are high by a factor of about 2. In fossil clams of several species it appears that the earth's rate of rotation is slowing down. During the Late Pennsylvanian Period (about 300 million yrs ago) there were about 18 more days per yr than at present. - J.L.M.

416
Curley, John R., Robert P. Lawton, John M. Hickey, and John D. Fiske. 1971.

A study of the marine resources of the Waquoit Bay-Eel Pond estuary. Mass. Dept. Nat. Resour., Div. Mar. Fish., Monogr. 9, iv + 40 p.

Quahog *(Mercenaria mercenaria)* was the principal commercial shellfish species in 1967. Areas of major concentration are illustrated on a chart. Growing season is six months, April to October. Temp range was from below 32°F to max of 79°F. Salinity ranged from 23°/oo to 33°/oo. Samples of 15 ft^2 of bottom had an average of 3 and max of 8 quahogs/ft2. Sublegal clams averaged 36 mm and legals 55 mm, and 31% were of legal size, in August 1967. In June 1968, 64 ft^2 samples were taken. Average number of clams was $1.2/ft^2$ and range was 0 to 12 clams/sample. Sublegal clams averaged 42 mm and legals 57 mm. Samples were 32% legal size. Most commercial harvesting was with tongs, some with hand rakes. Average production was 17 bu/acre. Total quahog harvest in 1967 was 2,459 bu. - J.L.M.

417
Curley, John R., Robert P. Lawton, David K. Whittaker, and John M. Hickey. 1972.

A study of the marine resources of Wellfleet Harbor. Mass. Dept. Nat. Resour., Div. Mar. Fish., Monograph 12, 37 p.

Wellfleet once produced more *Mercenaria mercenaria* than any other town in Mass. Commercial production in the late 1800s ranged from 1,800 bu to 2,500 bu/yr. Annual production in 1906 was 33,000 bu. In 1957 harvest was 6,000 bu, in 1960 it was 10,000 bu, and catch has remained essentially stable since. In 1969 42 commercial shellfish licenses were issued, 1,344 resident licenses, and 856 non-resident. Total harvest was 23,875 bu of quahogs. This is the most important commercial shellfish species in Wellfleet Harbor. The 1969 commercial harvest of 10,500 bu was about 44% of total harvest. (Abstracter's note: there is some confusion here. Table 24 gives commercial harvest as 22,900 bu, which, when the family harvest of 975 bu is added, comes to a total of 23,875 bu, but on the same page it is stated that 1969 commercial harvest was estimated at 10,500 bu by the Town Shellfish Constable. This figure is consistent with an earlier statement that the harvest has been about stable since 1960.) Some areas had concentrations of 7 to 8 quahogs/yd^2, but average concentration was less than 1 clam/yd^2. Environmental conditions were favorable for quahog growth and development. Ten-foot tides move large volumes of water over the beds, providing sufficient food, oxygen, and waste removal. Salinity range was 20 to 34°/oo. Water temps exceeded 49°F from April through Oct, a 7-month growing season. Water temps in low 70s in summer were adequate for spawning. This is the most northern area to support a continuously active quahog fishery. - J.L.M.

418

Currey, J. D. 1975.

A comparison of the strength of echinoderm spines and mollusc shells. J. Mar. Biol. Assn. U.K. 55(2): 419-424.

In general mollusk shells were stronger than those of echinoids. *Mercenaria mercenaria* shell had: dry specific gravity (s.g.) 2.80; effective s.g. 1.77; 7 specimens tested; crushing strength 181.9 MN/m^2, standard error (s.e.) of mean 13.4; strength/s.g. 65.0; effective strength/s.g. 102.8. Bone is 250 MN/m^2, concrete 50 MN/m^2, cast iron 800 MN/m^2, and glass 1,000/m^2. - J.L.M.

419

Currey, J. D., and J. D. Taylor. 1974.

The mechanical behaviour of some molluscan hard tissues. J. Zool., London 173(3): 395-406.

Shells or other hard parts of several gastropod and bivalve species, including *Mercenaria mercenaria*, 1 cephalopod, 1 insect, and 1 mammal, were tested for tensile strength, modulus of elasticity in bending, and modulus of rupture. Hard clam shells were fine crossed-lamellar to homogeneous in structure with parallel orientation. *M. mercenaria* had median values for tensile strength and modulus of rupture, and above average for elasticity. - J.L.M.

420
D'Agostino, Anthony. 1975.

Antibiotics in cultures of invertebrates. In Culture of Marine Invertebrate Animals. Walter L. Smith and Matoira H. Chanley (eds.). Plenum Press, New York, p. 109-133.

However small the inoculum of microorganisms originating in the water sample, gut, and body surfaces of animals, in the laboratory it may give rise to bacterial populations far denser than in nature. In crude culture, typical applications of antibiotics for *Mercenaria mercenaria* are: penicillin 100 to 670 μg/ml, streptomycin 50 to 100 μg/ml, and chloramphenicol 5 to 50 μg/ml. Isolates from bacterial swarms on dying clams killed *Venus mercenaria* larvae. Penicillin and streptomycin sulphate inhibited the isolates. Papers in which these results were reported are abstracted elsewhere in this bibliography. - J.L.M.

421
D'Agostino, Anthony. 1979.

Culture of crustaceans and other invertebrates. Proc. Symp. Mariculture in N.Y. State, N.Y. Sea Grant Inst. and Cornell Univ. NYSGI-RP-79-01: 38-46.

Hard clam is one of 5 species that offer the greatest potential. It will be regrettable if, by focusing on the cost-benefit analysis of the most costly and technically sophisticated culture systems proposed to date, it were to be made to appear economically unfeasible. - J.L.M.

422
Daiber, Franklin C. 1954.

Marine sports fishing investigations. Mar. Lab., Univ. Delaware, Dingell-Johnson Project, Ann. Rept. of the period July 1, 1953 - June 30, 1954, 15 p. (processed).

Average number of hrs fished, estimated man-hours of effort, clams per man-hour, and estimated total number of clams taken for a 2-week period in July 1953, were: hrs. fished 2.7 week days, 3.9 week end; total man-hrs 75 week days, 1,250 week end; clams per man-hr 16.2 week days, 41.1 week end; and total clams 1,220 week days, 51,380 week end. It was intended to interview clammers at Rehoboth Bay in 1954-55, but nothing was said in the report for that year. - J.L.M.

423
Dall, William Healey. 1889.

A preliminary catalogue of the shell-bearing marine mollusks and brachiopods of the southeastern coast of the United States, with illustrations of many of the species. Bull. U.S. Natl. Mus. 37 (revised reprint of 1889 edition, 1903), 232 p., 95 pls.

Lists the following species and varieties from localities Nova Scotia to Key West, the Tortugas, and Gulf of Mexico: Class Pelecypoda, Order Teleodesmacea, Suborder Veneracea, Family Veneridae - *Venus mercenaria* Linné, var. *mortoni* Conrad, *V. crispata* Deshayes, *V. rugosa* Gmelin, var. *rugatina* Heilprin, *V. pilula* Reeve, *V. cribraria* Conrad, *V. cancellata* Linne, *V. beaui* Recluz, *V. lamarckii* Gray, *V. granulata* Gmelin, *V. pygmaea* Lamarck, and *V. varicosa* Sowerby. Depths are given from low water mark to 300 fathoms (abstracter's note: units of depth are not identified directly, but the context appears to make it fathoms, which makes the extreme record, and some of the extreme depths for nominal species, such as 127 for *V. lamarckii* at Cape Hatteras, surprisingly deep. Some of the extreme southern ranges are also questionable, e.g., Yucatan for *V. mercenaria*, Rio Janeiro for *V. rugosa*, Trinidad for *V. cancellata*, etc.). Fossil records date back to Miocene and Pliocene. The 1903 reprint contains 21 additional plates, not included in the 1889 edition. - J.L.M.

424
Dall, W. H. 1902.

Synopsis of the family Veneridae and of the North American recent species. Proc. U.S. Natl. Mus. 26: 335-412.

Contains a complete synonymy of *Mercenaria mercenaria*. - from Wells, Ecology 38(1), 1957 - J.L.M.

425
Dall, William Healey. 1903.

Synopsis of the family Veneridae and of the North American recent species. Proc. U.S. Natl. Mus. 26: 335-412, pl. 12-16.

Venus mercenaria is the type species of the genus *Venus*. Shell large, heavy, earthy, trigonal; with faint radial and stronger concentric lamellar sculpture; lunule and escutcheon well defined; internal margins crenulate; pallial sinus small, triangular; two bifid cardinals in the left valve, one bifid and two anterior simple cardinals in the right valve, with a rugose area in each valve representing a supplementary cardinal below the ligament, the rugosities interlocking when the valves close; ligament strong and wholly exposed; posterior dorsal margin of right valve grooved to receive edge of left valve. The genus is American. It is *Mercenaria* Schumacher, 1817, and *Crassivenus* Perkins, 1869. *Venus mercenaria* Linnaeus, 1758, lives from Bay of Chaleurs, Gulf of St. Lawrence and at Sable Island, southward, locally, to Cape Cod, thence generally southward to the Florida Keys, westward to the Mississippi Delta and, sparsely, on the coast of Texas as far west as Corpus Christi Bay. Fossil from the early Miocene to recent times. This is the *Venus mercenaria* of Spengler, 1785, and subsequent authors; *V. meretrix* Bolten, 1798, not of Linnaeus, 1758; *Mercenaria violacea* Schumacher, 1817; *M. cancellata* Gabb, 1860; *M. antiqua* Verrill, 1875; and *Crassivenus mercenaria* Perkins, 1869. Varieties *notata, cancellata, radiata*, and *alba* are described. *Venus campechiensis* Gmelin, 1792, Chesapeake Bay and southward to Cuba; westward to Texas and southward to Yucatan, near low-water mark. Fossil from the Miocene to recent. This is the largest species of the family and the most ponderous. Characterized by high inflated beaks, blunt ends, white shell, frequently with zigzag brown lineation in the young externally, and a surface sculpture of dense, low, thin concentric lamellation. Young usually begin in a somewhat quadrate form, with more distant lamellation, without a purple border internally, but sometimes a purple flush in the cavity of the beaks. It passes through a series of mutations analogous to those of *V. mercenaria*. Various names have been given to young shells about 2 inches diameter, and several names to adults and their mutations. Varieties *alboradiata, quadrata, texana, tetrica, cuneata,* and *carolinensis* are described. - J.L.M.

426
Dance, S. Peter (ed). 1974.

The Collector's Encyclopedia of Shells. McGraw-Hill Book Co., New York, 288 p.

Phylum Mollusca, Class Bivalvia, Superfamily Veneracea, Family Veneridae, Genus *Mercenaria* Schumacher. Resembles *Chione* in shape, but much larger. Lunule heart-shaped or elongated, escutcheon long and narrow but border indistinct. Fine, sometimes lamellate, concentric ridges which are strongest around umbones. Radial ornament absent or limited to fine riblets between concentric ridges. Three cardinal teeth in each valve. No lateral teeth. Pallial sinus not very deep. Few species, in cool and temperate waters. *M. campechiensis* Gmelin, southern quahog. Very similar to *M. mercenaria* but much more inflated, heavier and strongly ridged concentrically over entire shell even in adults. Same color as *M. mercenaria* but may have a purplish stain on escutcheon and brown mottlings elsewhere. Inside white without purplish staining. 7 to 15 cm. Trans-atlantic, Caribbean. Common. *M. mercenaria*, northern quahog. Thick, heavy, broadly ovate, moderately inflated shell with long, well-curved posterior dorsal margin, which meets dorsal margin at a rounded angle. Ligament deeply inset. Lunule well defined, heart-shaped. Escutcheon indistinct. Numerous fine crowded concentric lines which are more prominent and wider spaced on umbones. In adults, ridges are worn away on median area of valves. Whitish, pale brown, grey or greyish brown, sometimes with brown zigzag markings. Inside white, usually with purple staining in region of muscle scars. 7 to 13 cm. Boreal, east coast of North America and introduced in western European coastal waters, Transatlantic, Caribbean, introduced in Humboldt Bay, Calif. Common. *M. stimpsoni* Gould. Large, thick, heavy, moderately compressed, ovate-trigonal shell resembling *M. mercenaria* in general appearance but more produced anteriorly, with more pointed umbones. Concentric ridges more lamellate, and radial riblets in grooves between ridges. Whitish. 7 to 10 cm. Japonic. Common. - J.L.M.

427
Darnell, Rezneat M. 1967.

Organic detritus in relation to estuarine ecosystem. In Estuaries. G. H. Lauff (ed.). Am. Assn. Adv. Sci., Pub. 83: 376-382.

428
Daugherty, F. M., Jr. 1951.

Effects of some chemicals used in oil well drilling on marine animals. Sewage Industr. Wastes 23(10): 1282-1287.

Mercenaria mercenaria was not used in these experiments. However, oysters were used, and sometimes showed results different than that for fishes. For that reason, the following are reported. Low toxicity compounds were sodium acid pyrophosphate, Quadrafos, Impermex, sodium polyphosphate, and Stabilite No. 9. These compounds were toxic to some test animals in concentrations ranging from 500 to 7,500 ppm. Caustic soda, oil well cement, Tannex, and white lime were fatal to many test animals in concentrations ranging from 70 to 450 ppm. These compounds have been designated toxic materials. Baroco drilling clay, Aquagel Baroid drilling mud, Carbonox, Jelflake, Fibertex, Mica, and Oilfos had no lethal effect on any test animal, and were designated as non-toxic materials. Generally low toxicity materials were more effective on oysters than fishes, whereas the converse was true for toxic materials. - J.L.M.

429
Davenport, C. B. 1903.

Animal ecology of the Cold Spring Harbor sand spit, with remarks on the theory of adaptation. Decenn. Pub., Univ. Chicago 10: 157-176.

Venus (Mercenaria) mercenaria is mentioned as one of the animals of the submerged zone of the outer beach. - J.L.M.

430
Davis, Charles C. 1968.

Mechanism of hatching in aquatic invertebrate eggs. Oceanogr. Mar. Biol. Ann. Rev. 6: 325-376.

The only reference to *Venus mercenaria* is to the work of Belding (1911), abstracted elsewhere in this bibliography, in which he is reported to state that the rather thick gelatinous covering of the egg is removed mechanically by action of the larval (trochophoral) cilia after about 10 hrs. - J.L.M.

431
Davis, Harry C. 1949.

On the culture of oyster larvae in the laboratory. Natl. Shellf. Assn. Convention Add. 1949: 33-38.

Larvae of the eastern oyster do not utilize as wide a variety of foods as do larvae of the hard clam *Venus mercenaria*. - J.L.M.

432
Davis, Harry C. 1953.

On food and feeding of larvae of the American oyster, *C. virginica*. Biol. Bull. 104(3): 334-350.

References to *Venus mercenaria* are mostly citations of other papers, abstracted elsewhere in this bibliography. However, differences in growth rate of oyster larvae were noted which could not be explained from type or quantity of food available. Variations in physical or chemical constituents of seawater were suspected. An experiment was conducted in which oyster larvae were cultured in laboratory seawater and water brought from Milford Harbor, Conn., in enamel buckets. A single culture of *V. mercenaria* larvae was started in laboratory seawater at the same time. At 14 days all oyster larvae were dead but *Venus* larvae grew normally and were healthy, most of them reaching setting size at 18 days. Other experiments showed no difference between oyster larvae grown in laboratory water or water from other sources. It was concluded that the effects on oyster larvae were caused by some widespread water condition to which hard clam larvae were not susceptible. The cause of this "water condition" was not identified. - J.L.M.

433
Davis, Harry C. 1954 (? publication date not given).

On food and feeding of larvae of the American oyster, *C. virginica*. Proc. Natl. Shellf. Assn. for 1952: 54-69.

Poor growth and high mortality in some experiments may have been caused by variations in water quality. An experiment was designed to compare laboratory seawater with water from Milford Harbor. Parallel cultures of oyster larvae were started, 2 in each type of water. A single culture of *Venus mercenaria* larvae also was set up in laboratory seawater. All cultures received about 50,000 cells/ml/day of mixed *Chlorella* for food. At 14 days all oyster larvae in both types were dead. *Venus* larvae appeared healthy and were growing normally, although growth was slower than average. At 18 days *Venus* larvae were at setting size and 55% of the straight-hinge larvae had survived. - J.L.M.

434
Davis, Harry C. 1958.

Survival and growth of clam and oyster larvae at different salinities. Biol. Bull. 114(3): 296-307.

Eggs of hard clam from Long Island Sound can develop into normal straight-hinge larvae only within the salinity range 20 to 32.5°/°° . At 35°/°° only 1% or less of eggs developed into shelled larvae, and at 17.5°/°° none. Even at 20°/°° only 16 to 21% of eggs reached this stage, and at 32.5°/°° only 34 to 52% reached shelled stage. Thus, optimum salinity for eggs was about 26.5 to 27.5°/°°. Growth of clam larvae was comparatively good at salinities 20°/°° and higher, up to 27°/°°. Rate of growth of larvae decreased at each successively lower salinity. At 17.5°/°° some larvae reached metamorphosis, but growth was slower than at 20°/°° and above. At 15°/°° larvae grew poorly, were sluggish and susceptible to attack by protozoa, fungus, and bacteria. At 15°/°° 95% were dead by 12th day and all died before setting. At 12.5°/°° a few hard clam larvae survived beyond 8th day, but mortality was 95% by this time. Rather than growing, these larvae decreased in size, and shells apparently were disintegrating. At 10°/°° or less larvae did not grow, and all died within 6 days. Lower borderline salinity for hard clam larvae appears to be about 17.5°/°° but clams probably are vulnerable to other environmental variables at these low salinities. Embryonic stages of hard clam can not tolerate as wide a range of salinity as can larvae. - J.L.M.

435
Davis, Harry C. 1960.

Effects of turbidity-producing materials in sea water on eggs and larvae of the clam *(Venus (Mercenaria) mercenaria)*. Biol. Bull. 118(1): 48-54.

Eggs and larvae of hard clam were exposed to different concentrations of kaolin, Fuller's earth, chalk, and natural silt. Some eggs developed normally in concentrations of 4 g/l of clay (kaolin), chalk, or finely ground Fuller's earth, but the percentage developing normally decreased as concentrations increased. In silt concentrations below 0.75 g/l percentage of clam eggs developing normally did not differ from controls, but at higher concentrations percent developing normally was progressively less. No eggs developed normally in silt concentrations of 3 g/l or higher. Larvae produced by eggs that had developed in high concentrations of each of the suspended materials were reared to metamorphosis after being returned to normal seawater. Larvae were not able to grow in concentrations of clay, chalk, or Fuller's earth as high as those in which eggs developed. Larvae did not grow, and mortality exceeded 90%, at concentrations of chalk above 0.25 g/l and clay and Fuller's earth above 0.5 g/l. Larvae grew normally in silt concentration of 0.75 g/l, and slightly faster than controls at lower concentrations of silt. Growth of larvae was retarded in silt concentrations of 1 to 2 g/l and was negligible at 3 and 4 g/l. Even at silt concentration of 4 g/l no appreciable numbers of larvae died within 12 days. Larvae were fed daily with a mixture of *Isochrysis* and *Monochrysis*. - modified author's summary - J.L.M.

436
Davis, Harry C. 1961.

Effects of some pesticides on eggs and larvae of oysters *(Crassostrea virginica)* and clams *(Venus mercenaria)*. Comm. Fish. Rev. 23(12): 8-23.

Several insecticides, weedicides, oils, organic solvents, antibiotics, bactericides, and disinfectants were applied at different concentrations to hard clam eggs, and larvae. Clam larvae that appear to have been invaded by active pathogens are frequently seen. The bactericides phenol, roccal, and dowicide A and G, soil fumigant nemagon, and fungicide nabam had widely varied effects on clam eggs. Nabam and dowicide G prevented normal development at each concentration tested. Roccal at 0.1 ppm permitted normal development. At 0.2 ppm it reduced the number of normal larvae by 55%, and at 1 ppm and higher it prevented normal egg development. In contrast, dowicide A and nemagon permitted normal development of clam eggs in concentrations up to 5 ppm and phenol was not toxic below 10 ppm. At low concentrations phenol appeared to increase the numbers of eggs developing normally. These compounds were of the same order of toxicity to clam larvae, but showed certain differences. Dowicide G was lethal at all concentrations tested, but nabam did not affect survival of larvae through the 12 days of the experiment at 0.5 and 1 ppm, although it almost completely prevented growth. Roccal, dowicide A, and nemagon appeared to be more toxic to larvae than to eggs. Similarly, although normal numbers of eggs developed to straight-hinge stage in 5 ppm dowicide A, all concentrations of 1 ppm and over were lethal to larvae. Nemagon, even at 10 ppm did not seriously affect egg development, but growth and survival of larvae were normal only at 0.25 ppm. Delrad, an algacide, was toxic to clam larvae at concentrations high enough to be an effective algacide. Phenol at 10 ppm had little effect on clam eggs but significantly reduced growth rates of larvae. At lower concentrations, however, phenol and low concentrations of dowicide A and certain concentrations of sulmet, chloramphenicol increased the rate of growth of clam larvae. But even with these compounds, too high a concentration can reduce growth and survival of clam larvae. Sulmet is now used routinely at Milford to prevent growth of harmful bacteria in larval cultures. Phenol, chloramphenicol, and even dowicide A might also be used. Weedicides used all belonged to the methyl urea group. Fenuron and monuron were most soluble and least toxic. In concentrations up to 5 ppm neither affected the percentage of clam eggs reaching straight-hinge. Diuron at 1 ppm significantly reduced the number of eggs developing normally, and at 5 ppm no clam eggs developed to straight-hinge. Neburon, the least soluble, prevented normal development of clam eggs at 2.4 ppm, the only concentration used. Order of toxicity of weedicides to clam larvae was the same as for egg development. Larvae grew better in each of 4 concentrations of fenuron than in controls. Monuron at low concentrations also increased growth of larvae but showed some toxicity at 1 ppm and up. Diuron did not seriously interfere with growth at 1 ppm and lower, but at 5 ppm drastically reduced growth and increased mortality. Neburon at 2.4 and 4.8 ppm caused 100% larval mortality. Two oils, orthodichlorobenzene and trichlorobenzene, are relatively insoluble in water and were comparatively harmless to clam larvae at concentrations tested. The first compound had no effect on egg development at concentrations less than 10 ppm. The second reduced the percentage of clam eggs developing normally, but even at 10 ppm over 50% of eggs did develop normally. The percentage of eggs developing normally was not affected by concentrations of acetone as high as 100 ppm, but 1 ppm of allyl alcohol caused about 50% reduction in number of eggs developing normally and completely prevented normal development at 2.5 ppm. The difference in effect of these solvents was even greater with clam larvae. Even 0.25 ppm of allyl alcohol killed all larvae within 8 days, but survival was not affected by 250 ppm acetone, and growth only slightly retarded. In tests with nemagon and sevin, results were the same whether stock solutions were made up in water or acetone. The insecticides guthion, sevin, lindane, toxaphene, aldrin, dicapthon, and Niagara Compound N-3514 were tested on clam eggs and larvae. Lindane was the least toxic. About 60% of clam eggs developed normally in concentrations up to 10 ppm, and no appreciable mortality of clam larvae occurred at this concentration, which is essentially a saturated solution, but larval growth was reduced. At 5 ppm and lower, lindane had no effect on survival or growth of clam larvae. At 10 ppm aldrin, 64% of clam eggs developed normally, but growth of larvae almost completely stopped at 0.25 and 0.5 ppm, although there was no mortality. At all higher concentrations of aldrin mortality was 100%. Toxaphene also was more toxic to clam larvae than eggs. Guthion was more toxic than sevin to clam eggs, but effects of the two on larvae were about the same. Dicapthon was about as toxic as guthion and sevin to clam eggs, but somewhat more toxic to larvae. Niagara Compound N-3514 (2-chloro-1-nitropropane) was most lethal of all insecticides tested to clam eggs and larvae. Concentrations as low as 1 ppm caused total mortality. With almost every compound tested, slowing of larval growth rate was the first evidence of toxicity. - J.L.M.

437
Davis, Harry C. 1962.

Effects of some pesticides on eggs and larvae of oysters *(Crassostrea virginica)* and clams *(Mercenaria mercenaria)*. Proc. Natl. Shellf. Assn. 51, August 1960: iii.

Listed by title only. - J.L.M.

438
Davis, Harry C. 1963.

The effect of salinity on the temperature tolerance of eggs and larvae of some lamellibranch mollusks. Proc. 16th Internatl. Congr. Zool., Vol. 1. John A. Moore (ed.): 226 (abstract).

A study of the effect of temperature on survival and growth of larvae of hard clam, *Mercenaria mercenaria*, has shown that rate of growth at different temperatures was critically affected by the type of food organisms available. Clam and oyster larvae were able to use naked chrysophytes such as *Monochrysis lutheri*, *Isochrysis galbana*, and *Dicrateria* sp., and show significant growth, at lower temperatures than those at which chlorophytes, such as *Chlorella* sp., which have cell walls, could be utilized. This implies that the enzyme systems that digest naked flagellates are active at lower temperatures than enzyme systems required to digest cell walls. Cells of *I. galbana* and *M. lutheri* are destroyed by temperatures of 27.5 to 30°C and growth of larvae receiving these foods at such temperatures is reduced. *Chlorella* sp. can tolerate temperatures of 33°C and the rate of growth of larvae receiving *Chlorella* sp. continues to increase with each 2.5°C increase in temperature up to 33°C. Temperature tolerance of clam and oyster larvae is also significantly affected by salinity. At near optimum salinity these larvae survive and grow over a significantly wider range of temperature than at salinities near the lower limits of tolerance. - J.L.M.

439
Davis, H. C. 1968.

Shellfish hatcheries present and future. Am. Fish. Soc., Ann. Meet. 1968. 98: 18 (abstract).

Data were given on food, temp, salinity, pH, and other requirements of larvae of *Mercenaria mercenaria* and American oyster, and susceptibility of these larvae to toxins and pathogens. Progress was reported on development of genetic strains and in culture methods to increase production in open waters. - modified author's abstract - J.L.M.

440
Davis, Harry C. 1969.

Shellfish hatcheries - Present and future. Trans. Am. Fish. Soc. 98(4): 743-750.

Some shellfish biologists and commercial producers believe that a new age in shellfish culture is at hand. Efforts to increase shellfish production date back to the Roman Empire. Hatchery and laboratory rearing are about 50 years old. Salinity, temperature, and pH tolerances are reasonably well known. Hard clam is not very tolerant of low salinity. Eggs will not develop to straight-hinge stage at salinities below 22°/°°. Larvae can survive and grow reasonably well at 17.5°/°° or somewhat below. The pH range for clam larvae must be kept between about 7 and 8.75. Pollution of various kinds must be avoided also, although clam larvae are somewhat more tolerant than oyster larvae. Larvae do better on some foods than others, and some forms produce toxic metabolites. Growth and survival of clam larvae are satisfactory over a fairly wide range of water temp, at least from about 17.5 to 30°C. Diseases can be prevented by rigid attention to cleanliness, but much more needs to be known about causative agents and their control. Genetic studies are needed to improve growth rates, disease resistance, meat content, and tolerance to various physical factors. Relatively high costs of hatchery production must be reduced by obtaining highest possible survival. Predator control will be necessary once juveniles are planted in natural environment. Possibilities also exist for utilizing warm water from power plants, and using shellfish to harvest phytoplankton in final sewage treatment ponds. - J.L.M.

441
Davis, H. C. 1971.

Design and development of an environmental controls system for culturing oyster larvae. Artificial Propagation of Commercially Valuable Shellfish. Univ. Del., Newark, p. 135-150.

SUNY - Stony Brook library reported that after considerable searching they were not able to locate or verify this title. Because it does not necessarily relate to *Mercenaria mercenaria* search was terminated. - J.L.M.

442
Davis, Harry C. (undated).

The effects of different salinities and temperatures on oysters and clams. Appendix F, U.S. Fish Wildl. Serv., 15 p.

Salinity range for development of straight-hinged clam larvae from embryos ranged from 20.0 to 35.0°/°° with an optimum of 26.0-27.5°/°°. Optimal growth of clam larvae occurred at 26.0-27.5°/°° or higher. The lower limit for larval growth for practical culture was 20.0°/°°. Juvenile clams (7.3-7.6 mm long) grew best at salinities of 26.0-27.0°/°°. Embryos developed into straight-hinged larvae within the temperature range 15.0°-30.0°C. Development was best between 23.0 and 25.0°C. Growth of larvae beyond the straight-hinged stage increased with increasing temperature in the range 15.0°-32.5° or 33.0°C. Optimum growth for newly set clams occurred from 20.0° to 25.0°C.

(Abstracter's note: The exact source of this reprint was not known.) - D.L.

443
Davis, Harry C., and Anthony Calabrese. 1964.

Combined effects of temperature and salinity on development of eggs and growth of larvae of *M. mercenaria* and *C. virginica*. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Bull. 63(3): 643-655.

Clam larvae can ingest foods at significantly lower temps than the minimum temp at which they can digest and assimilate food organisms used in these experiments. They can digest and assimilate naked flagellates such as *Monochrysis lutheri* and *Isochrysis galbana* at lower temps than those at which they can utilize algae with cell walls, like *Chlorella* sp. Minimum temp for appreciable growth of clam larvae fed naked flagellates was 12.5°C. Optimum salinity for growth of clam larvae was 27°/oo (the highest salinity tested) or possibly higher. There was no well-defined optimum temp for growth of clam larvae at any salinity; maximum growth occurred at temps from 25 to 30°C in almost all salinities. Effect of reduced salinity on clam larvae was to reduce range of temp tolerated. Effect on clam larvae was primarily a reduction of the range of temp tolerated, by heavy mortality at high temp. - modified authors' summary - J.L.M.

444
Davis, H. C., and P. E. Chanley. 1956.

Spawning and egg production of oysters and clams. Biol. Bull. 110(2): 117-128.

Hard clams were induced to spawn in the laboratory. The total number of eggs released by an individual female ranged from 8 million to 39.5 million and averaged 24.6 million eggs per clam. The most eggs released by a female at a single spawning was 24.3 million eggs. Correlation between eggs produced and shell cavity volume was 0.38 (significant at 0.05 level). Clams spawned at 3-, 7-, and 14-day intervals showed no significant difference in average number of eggs released in a season and no difference in number of spawnings per female. The correlation between number of times a female spawns and the number of eggs produced was about zero. - D.L.

445
Davis, H. C., and P. E. Chanley. 1956.

Spawning and egg production of oysters and clams. Proc. Natl. Shellf. Assn. 46: 40-58, plus tables and illustrations on unnumbered pages.

Three groups of *Mercenaria mercenaria* were induced to spawn in the laboratory at 3-, 7-, and 14-day intervals. There was no significant difference in total numbers of eggs released (number after spawning could no longer be induced) by clams in the 3 groups, nor any significant difference in average number of spawnings/female. Total numbers of eggs released by female clams ranged from 8 million to 39.5 million and averaged 24.6 million/clam. The highest number released by any clam at a single spawning was 24.3 million eggs. Correlation between number of eggs produced and shell cavity volume was 0.38 ($P = 0.05$). There was no correlation between number of times a female clam spawned and number of eggs produced. - modified authors' summary. - D.L. and J.L.M.

446
Davis, H. C., and P. E. Chanley. 1956.

Effects of some dissolved substances on bivalve larvae. Proc. Natl. Shellf. Assn. 46: 59-74.

Growth and survival of *Mercenaria mercenaria* larvae were not affected by addition of Vitamins A and B_{12}, biotin, calcium pantothenate, nicotinic acid, pyridoxine hydrochloride, riboflavin, thiamine hydrochloride separately, or by calcium pantothenate, pyridoxine hydrochloride, riboflavin, and thiamine hydrochloride in combination, although oyster larvae treated similarly grew faster than controls. Clam larvae survived at least 6 days in 1/100,000 $CuSO_4$, but oyster larvae were killed by concentrations of less than 1 ppm. The fungicidal antibiotic Malucidin reduced survival and growth of clam larvae even at concentrations at which it did not affect fungus. Streptomycin increased clam larval growth, but above a concentration of 1/1,000 growth decreased. Survival of streptomycin-treated larvae was only slightly better than that of controls. Effects of aureomycin were similar to those of streptomycin, but larval growth increases were less, with optimum at 3.2 ppm. At 320 ppm mortality of larvae was complete. Terramycin caused 100% mortality at concentrations of 1 ppm. Sulfa drugs tested did not accelerate survival and growth of clam larvae, and some reduced growth rates at concentrations tested. Larvae cultured in dinoflagellate blooms, or exposed to blooms in the natural environment developed abnormally and few grew into normal straight-hinge larvae. It was believed that the effects were caused by dissolved substances. Very low tolerances of oyster and clam embryos and larvae to many substances tested suggests that dissolved substances may be more important than formerly recognized in success or failure of oyster and clam spawning. (Abstracter's note: some experiments appear also to confirm the greater resistance of hard clam larvae to environmental change, as compared with oyster larvae.) - D.L. and J.L.M.

447

Davis, Harry C., and Robert R. Guillard. 1958.

Relative value of ten genera of micro-organisms as foods for oyster and clam larvae. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Bull. 58: 293-304.

A mixture of the Chrysophyceae *Isochrysis galbana* and *Monochrysis lutheri* with Chlorophyceae *Platymonas* sp. and *Dunaliella euchlora* provided better growth of *Mercenaria mercenaria* larvae than did equal quantities of any of single-species foods. *Chlorococcum* sp., *Isochrysis*, and *Monochrysis* were the 3 best single foods for clam larvae. Clam larvae can utilize several forms having cell walls, even from earliest larval stages. *Stichococcus* sp. and *Prymnesium parvum*, both highly toxic, were the only microorganisms tested that had no food value for clam larvae. *Isochrysis* showed no toxicity even at highest concentration tested. Optimum concentration of *Isochrysis* was at least double that of *Chlorella*. It was concluded that *Isochrysis* and *Monochrysis* produce little if any toxic metabolites. Presence and perhaps thickness of cell walls and degree of toxicity of external metabolites are probably important factors in determining usability of microorganisms as foods for bivalve larvae. - modified authors' summary - J.L.M.

448

Davis, Harry C., and Herbert Hidu. 1963.

Effects of pesticides on eggs and larvae of oysters *(C. virginica)* and clams *(V. mercenaria)*. Proc. Natl. Shellf. Assn. 52, August 1961: iii.

Listed by title only. - J.L.M.

449

Davis, Harry C., and Herbert Hidu. 1969.

Effects of pesticides on embryonic development of clams and oysters and on survival and growth of the larvae. U.S. Fish Wildl. Serv., Fish. Bull. 67(2): 393-405.

Fifty-two compounds were tested for their effects on embryos of hard clam, *Mercenaria mercenaria*, American oyster, *Crassostrea virginica*, and on their larvae. Pesticides included 17 insecticides, 12 herbicides, one nematocide, four solvents, and 18 miscellaneous bactericides, fungicides, and algicides. Most compounds affected embryonic development more than survival or growth of larvae. Some, however, drastically reduced growth of larvae at concentrations that had relatively little effect on embryonic development. It is necessary, therefore, to evaluate the effects of pesticides on all stages of the life cycle of an organism before the pesticide can be considered safe. Nevertheless, differences in toxicity to bivalve larvae among compounds of each category of pesticide are large enough that it should be possible to select compounds to control pest species without serious damage to commercial shellfish. - modified authors' abstract - D.L.

450
Davis, Harry C., and Herbert Hidu. 1969.

Effects of turbidity-producing substances in sea water on eggs and larvae of three genera of bivalve mollusks. Veliger 11(4): 316-323.

Species studied were American and European oyster and hard clam. Oyster embryos are less tolerant of silt, but more tolerant of kaolin (clay) and Fuller's earth than clam embryos. No embryos of either species developed normally at higher concentrations of silt, but significant numbers of both species developed normally in highest concentrations (4 g/l) of kaolin and Fuller's earth. The larger particles present in silt and, to a lesser extent, in kaolin and Fuller's earth, apparently were mainly responsible for adverse effects on oyster eggs, but smaller particles, most numerous in kaolin, were probably responsible for adverse effects on clam eggs. Silicon dioxide had little effect on clam eggs except when the smallest particles were at high concentrations. Many clam larvae, in the presence of smaller particles of kaolin and Fuller's earth, eventually lost their ability to reject these particles. They then began to ingest particles, the stomach became packed, and larvae died. In kaolin and Fuller's earth clam larvae were better able to reject small particles, hence had lower mortality. Hard clam larvae suffered severe mortality at comparatively low concentrations of the smallest particles of silicon dioxide. Effects of kaolin and Fuller's earth, particularly at high concentrations, on survival and growth of clam larvae were more drastic than would be expected from the effect of silicon dioxide particles of similar size. Silt had no deleterious effect on growth of clam larvae until concentrations reached 1 g/l, and growth was not reduced drastically until silt concentrations were in excess of 2 g/l. Clam larvae showed evidence of feeding even in 4 g/l of silt, although growth was negligible. Growth of clam larvae was drastically reduced by 0.5 g/l of kaolin or Fuller's earth, and all larvae were killed by 1 g/l of either substance. Growth of clam larvae was not seriously affected by silicon dioxide particles ranging from 5 to 50 μ at concentrations up to 2 g/l. Even in particles less than 5 μ growth of clam larvae which survived was fairly good. More rapid growth of clam larvae in lower concentrations of silt, kaolin, and Fuller's earth may be due in part to chelation or adsorption of toxins present in seawater or produced by algae or bacterial contaminants introduced with food. The experiments showed that bivalve larvae can tolerate turbidities higher than those normally encountered in natural waters, and that under certain circumstances low concentrations of turbidity-producing materials may be beneficial. But high silt concentrations, such as may be generated by dredging or filling, can be detrimental directly, or through lowered pH. It is possible also that in natural waters disturbing the bottom may release toxic bacteria, and organic enrichment sufficient to stimulate their reproduction. Thus, effects of dredging may be more serious than these experiments might suggest. - J.L.M.

451
Davis, Harry C., and Victor L. Loosanoff. 1953.

Utilization of different food organisms by clam larvae. Anat. Rec. 117(3): 646.

Different microorganisms were evaluated as larval foods using growth of *Venus mercenaria* larvae as the criterion. Growth of experimental lots was compared with a control which received no supplemental food. The species used, the numbers of cells fed per cc per day, and the lengths of larvae at 8 days were: control 124 μ; *Chlamydomonas* 20,000, 174 μ; *Chlorella* sp. 50,000, 165 μ; *Chromulina pleiades* 30,000, 155 μ; *Isochrysis galbana* 30,000, 150 μ; and *Porphyridium* sp. 50,000 122 μ. After the 10th day feeding of *Porphyridium* was discontinued and that culture was given 50,000 cells per cc per day of mixed phytoplankton, chiefly *Chlorella*. Within 5 days the larvae grew to 185-210 μ, the size at which metamorphosis normally begins.

Instead, they continued to grow and many retained a functional velum until 260-270 μ even though they also had a well-developed foot and gills. Thus, clam larvae may under certain conditions grow considerably larger than the size at which metamorphosis usually is complete. In all the other experiments the larvae metamorphosed in 10 to 12 days. In 5 yrs of culture work no larva larger than 240 μ with a functional velum had been seen. - J.L.M.

452
Davis, H. C., and V. L. Loosanoff. 1955.

A fungus disease in bivalve larvae. Proc. Natl. Shellf. Assn. 45: 151-156.

An organism tentatively identified as a fungus was found in many dead or dying larvae of *Venus mortoni* and hybrids of *V. mortoni* and *V. mercenaria.* In many clam larvae, growth occupies a large proportion of the space within the larval shell, so crowded together that details of thallus organization cannot easily be seen. Segments of the thallus mature into sporangia, each with an exit tube which releases zoospores to the surrounding water. A few infected larvae were found in many cultures. Only in a few cases did fungus become epizootic, but then within 2 to 4 days killed most of the culture. Larvae of all ages have been found parasitized. Optimum temp and salinity are not known, but all cultures have been about 19-27°C and 27°/°°. Most infected larvae soon drop to the bottom, stop growing, and die. The fungus has been identified tentatively as *Sirolpidium* sp. Attempts to control fungus with fungicides and ultraviolet light were not successful. - J.L.M.

453
Davis, H. C., and R. Ukeles. 1961.

Mass culture of phytoplankton as foods for metazoans. Science 134(3478): 562-564.

454
Davis, H. C., V. L. Loosanoff, and C. L. MacKenzie, Jr. 1961.

Progress in development of methods of chemical control of shellfish predators: Field tests of a chemical method for the control of marine gastropods. U.S. Fish Wildl. Serv., Biol. Lab., Milford, Conn., Bull. 25(3): 3-9.

Solutions of Sevin in orthodichlorobenzene (O.D.) were mixed with sand as an inert carrier and spread on shellfish grounds in Long Island Sound and Great South Bay. Gastropods of all kinds were affected strongly. The foot swelled greatly and snails were immobilized with the swollen foot extended, soon to be attacked by fishes, crabs, and sea stars. Sea Stars were affected but not killed. Most other animals, including hard clam and oyster, were affected little or not at all, and treatment appeared to have no effect on setting of oysters or sea stars. It was emphasized that this is primarily a method of control, not complete eradication. J.L.M.

455
Davis, H. C., V. L. Loosanoff, W. H. Weston, and C. Martin. 1954.

A fungus disease in clam and oyster larvae. Science 120(3105): 36-38.

Larvae of *Venus mercenaria* are especially suitable for experimental work. Usually they can be cultured through metamorphosis without difficulty. Heavy occasional mortalities appear to be associated with a fungus organism. The fungus appeared to be endemic in cultures, a few infected larvae appearing in many experimental lots. Preliminary observations showed certain distinctive features. Larvae of all stages of development may be infected, as well as juvenile quahogs. Culture temps ranged from 19 to 27°C at salinity approximately 27°/°°. Once infected, most larvae stop growing and die. It is not known if infected larvae can recover and develop normally. Fungus is transmitted by biflagellate zoospores which are released to the exterior of infected larvae. Within larvae, fungus develops as a contorted, looped, and sparsely branched torulose thallus with constrictions at intervals between swollen and often lobed segments. Segments mature into sporangia, each with a zoospore exit tube to the exterior, which may protrude a considerable distance from the larval shell. No sexual or resting stage was seen. Identity of the fungus was not determined specifically, but their simple organization, conclusive cellulose reaction to chloroiodide of zinc, and biflagellate zoospores suggested that it is a phycomycete. The genus *Lagenidium* was suggested by some characteristics, *Sirolpidium* by others, but *Sirolpidium* has never been found in an animal host. One or two new species may be involved. It is possible that the fungus affects the sequence of events in the food chain. - J.L.M. and W.J.B.

456
Davis, John D. 1966.

Mesodesma arctatum: Fossil and living specimens on Nantucket. Nautilus 80 (1): 1-3.

457
Davis, John D. 1969.

Polydora infestation of *Mercenaria mercenaria*. Nautilus 83(2): 74.

Quahogs from Nantucket Harbor, Mass., of which the posterior third had been exposed above the substratum, were infested with *Polydora*. Exposed parts of the shell had been damaged extensively with an extensive network of tubular excavations characteristic of *Polydora*. No remains of the worm were found. In one clam perforations had penetrated within the posterior adductor muscle scar, although no extensive damage had been done. - J.L.M.

458
Dean, David. 1975.

Raritan Bay macrobenthos survey, 1957-1960. U.S. Dept. Commerce, NOAA, NMFS Data Rept. 99, iii + 51 p.

Shells or living individuals of *Mercenaria mercenaria* were taken in 94 of 192 samples reported. The species was among the 30 most prevalent species of about 138 species taken. - J.L.M.

459
Dean, David, and Harold H. Haskin. 1964.

Benthic repopulation of the Raritan River estuary following pollution abatement. Limnol. Oceanogr. 9: 551-563.

460
DeBlois, N. F., and A. F. Eble. 1974.

Biology and ecology of hard clam relaying Cape May County, New Jersey. Bull. N.J. Acad. Sci. 19(1): 26-27.

Contaminated clams *(Mercenaria mercenaria)* were taken from Cape May Harbor and planted in Great Egg Harbor and in Great Sound, N.J. Clams were sampled 5, 15, and 30 days after transplanting and analyzed for total bacteria, total and fecal coliforms, and fecal streptococci. Glycogen was determined in adductor muscles, mantle, and digestive gland. Bacterial content of waters from the Great Sound and Great Egg Harbor sites varied from 5,400 to 13 MPN. Clams did not depurate well under these conditions. In July-August 1973 in Great Egg Harbor, even after 30 days, clams had 330 MPN (acceptable level 70 MPN or less). Glycogen content did not change significantly. In Great Egg Harbor clams appeared to deposit more glycogen than those from Great Sound. Phytoplankton content was about the same in both places. - J.L.M.

461
Deevey, Georgiana Baxter. 1948.

The zooplankton of Tisbury Great Pond. Bingham Oceanogr. Inst. Coll. Bull. 12(1): 1-44.

Veligers of *Venus (Mercenaria) mercenaria* were most abundant in late July and early August. At the end of July *Venus* was by far the dominant form among the more than 10,000 veligers per cubic meter found at this time. - J.L.M.

462
DeFalco, Paul (ed). 1967.

Chemical analyses of shellfish - Raritan Bay. Appendix G in Proc. Conf. on Pollution of Raritan Bay and adjacent Interstate Waters. Vol. 2, 3rd Sess. Fed. Water Pollution Control Admin., U.S. Dept. Interior, Northeast Research Ctr., Narragansett, R.I., p. 816-863.

Of some 400 shellfish samples collected in 1963 and 1964 (presumably *Mercenaria mercenaria*) 69 from representative areas were analyzed for certain trace metals and organic materials. Phenol values were higher than normal. Some degree of pollution by mineral oils was suggested. Levels of Cu, although somewhat elevated above normal baseline values, did not show gross contamination. Pb values were about 10 times as high as normal, which demonstrated possible contamination. Ni values also were about 10 times as high as expected. Contamination by Zn was not obvious, nor was Cr. Three pesticides, Lindane, Aldrin, and Dieldrin, were assayed. At least one was found in every area of the Bay. Areas I and II, at the inner end of the Bay, were most polluted; Area V, Sandy Hook Bay least. The report is well illustrated with charts and graphs. - J.L.M.

463
Delaney, D. L., and S. Krause. 1975.

A comparison of reduced α-paramyosin with β-paramyosin using transient electric birefringence. Biophys. J. 15(2) Pt. 2: 122a (abstract TH-POS-C4).

The α-paramyosin molecule, oxidized or reduced, is about 6% longer than β-paramyosin, in aqueous solution at pH 3.2 and at 1-2 mM ionic strength. Assuming a diameter of 20 A for each molecule, a length of 1200 A was calculated for β-paramyosin and 1275 A for α-paramyosin. The β-paramyosin and reduced α-paramyosin were prepared from the white portion of adductor muscle of *Mercenaria mercenaria* by ethanol extraction. - J.L.M.

464
Der Marderosian, Ara. 1969.

Marine pharmaceuticals. J. Pharm. Sci. 58(1): 1-33.

This comprehensive review paper contains information on *Mercenaria mercenaria* and many other plant and animal species. Hard clam contains a growth inhibitor, named mercenene, which has potential pharmacological use as an antitumor drug. The antimicrobial fraction has been named paolin I and the antiviral fraction paolin II. They are separable by cellulose ion-exchange chromatography, are relatively thermostable (95° for 45 min) and appear to be protein. Pepsin, however, does not digest them. Paolin I appears to be a mucoprotein with molecular weight 5,000 to 10,000. Another fraction, water-soluble Fraction C, was obtained from abalone and oyster. All these preparations have potent antibacterial and antiviral activity *in vitro* and *in vivo*. Paolin I and Fraction C reduced death rate by 27% of mice experimentally infected with *Streptococcus pyogenes*. Growth inhibition of a penicillin-resistant strain of *Staphylococcus aureus* was noted. When paolin II and Fraction C were used to treat monkey kidney tissue 24 hr prior to infection 99.9% inhibition of poliovirus and influenza A virus growth was obtained. Fraction C protected mice against experimentally induced infections of poliovirus and influenza B virus. Similar growth inhibition was obtained in tissue culture experiments against *Herpes simplex*, keratitis virus, adenovirus type 12, and tobacco mosaic virus. Crude extracts of paolins have not shown apparent toxicity. Mercenene is a water-soluble, heat-stable, poorly dialyzable glycopeptide with molecular weight 1,000 to 2,000. Activity varies with temp. Summer clam tissue extracts are 8 or 9 times as active as winter clam tissue extracts. Antitumor activity is shown against Krebs-2-carcinoma, Krebs-2-ascites, and sarcoma 180, even when administered several days after tumor implantation. Carcinolytic activity against a human HeLa cell line *in vitro* also has been noted. Mercenene had no effect on growth of normal human amnion cell line, and was apparently nontoxic in mice at therapeutic levels. - J.L.M.

465
Der Marderosian, Ara H. 1970.

Drugs from the sea - An overview. In Food-Drugs from the Sea, Proceedings 1969. Heber W. Youngken, Jr. (ed.). Mar. Tech. Soc., Washington, D.C., p. 211-253.

This review paper discusses mollusks, among other plants and animals. Papers cited on *Mercenaria (Venus) mercenaria* are reviewed elsewhere in this bibliography. The extensive list of literature cited contains 367 references. - J.L.M.

466
De Villafranca, George W., and V. Ena Haines. 1974.

Paramyosin from arthropod cross-striated muscle. Comp. Biochem. Physiol. 47(1B): 9-26.

Paramyosin prepared from adductor muscle of *Mercenaria mercenaria* was compared with similar preparations from muscle of *Limulus polyphemus*. It was concluded that *Limulus* paramyosin has a larger chain weight for the following reasons: paracrystals of *Limulus* had an average period of 726 A, *Mercenaria* 723 A; intrinsic viscosity of *Limulus* paramyosin 2.38 dl/g, *Mercenaria* 1.99 dl/g; sedimentation coefficients ($S_{20}°w$) 4.07 *Limulus*, 3.40 *Mercenaria*; molecular weights 284,000 Daltons for *Limulus*, 208,000 Daltons *Mercenaria*. SDS disc-gel electrophoresis of the 2 paramyosins previously incubated in 8 M urea also gave a larger chain weight for *Limulus* paramyosin. Tropomyosin was also identified in *Limulus*, so that the idea that paramyosin is "invertebrate tropomyosin" cannot be supported. This implies that paramyosin must have a function of its own. It may be a "catch muscle" protein. - modified authors' abstract - J.L.M.

467
Dewling, R. T., K. H. Walker, and F. T. Brezenski. 1972.

Effects of pollution: Loss of an $18 million/year shellfishery. In Marine Pollution and Sea Life. M. Ruivo (ed.). Fishing News (Books) Ltd., p. 553-559.

In the early 19th century, Raritan Bay (in N.J. and N.Y.) supported productive fin- and shellfisheries. Water pollution was a factor in the decline of fisheries in the Bay. Present commercial shellfish production is limited to *Mercenaria mercenaria* and *Callinectes sapidus*. The standing crop of hard clams could provide an annual harvest worth $3.85 million (at 1971 or 1972 prices) if water quality were suitable. The present harvest is worth only $40,000. Bacteria from more than 900×10^6 gal/day of unchlorinated and raw municipal wastes from a population of 3.8×10^6 persons enter the Bay. Nearly 75% of total wastes come from industry. Included are substances with high oxygen demand and various toxic materials. Other wastes come from cooling waters, recreational and commercial vessels, and overflows from combined storm-sanitary sewer systems. The most valuable shellfish industry in the Bay, the oyster industry, is gone. Soft clams survive in some areas.

Density of hard clams in the Bay varies from zero to over 3 clams/ft^2, with greatest densities on the N.Y. side. Geometric mean counts of coliform bacteria varied from 10,000 MPN/100 ml at the Narrows and 7,000/100 ml at the mouth of the Raritan River to less than 50/100 ml in Sandy Hook Bay. Samples of shellfish from 12 of 50 stations had more than 2,400 coliform organisms per 100 g of meats. Geometric means ranged from 610 to 16,000 MPN/100 g. None taken from waters with temp less than 8.5°C had total coliform MPN of 2,400 or more/100 g. *Salmonellae* were isolated from clam meats at 14 of 50 stations but were not necessarily associated with high coliform counts. *Salmonella derby* was the predominant serotype. Shellfish meats contained the following trace metals: Cu - 0-5 mg/kilo of meats, Zn - 40-60 mg, Pb - 0-0.3 mg, Cr - 0-0.2 mg, and Ni - 0-0.2 mg. Phenols were present at 35.2 mg/100 g tissue and mineral oils 0-4 mg. Recommendations were made for sewage treatment standards, improved practices at industrial plants, including laboratory controls, improved waste treatment on commercial and recreational vessels, and additional measures to safeguard water quality. - J.L.M.

468
Dexter, Ralph W. 1942.

Notes on the marine mollusks of Cape Ann, Massachusetts. Nautilus 56(2): 57-61.

Collections were made in the intertidal zone by hand picking and with a clam fork, in the subtidal zone with a naturalist's dredge. Intensive collecting was done in the Annisquam River, a tidal inlet, and samples were taken in Ipswich Bay, Sandy Bay, Gloucester Harbor, and along the eastern coast of Cape Ann. *Venus mercenaria* was collected in sand at spring low water on Annisquam beaches. - J.L.M.

469
Dexter, Ralph W. 1944.

Annual fluctuation of abundance of some marine mollusks. Nautilus 58(1): 18-24.

Abundance of 7 snail and 5 bivalve species was observed from 1933 to 1937. *Mercenaria (Venus) mercenaria* was not included. All species fluctuated widely in abundance over the 5-year period, *Littorina saxatilis* from no living specimens to an abundance averaging 2 snails/in^2 over a wide area. Depending on species, fluctuations were attributed to overfishing of commercial species, disappearance of eelgrass, severe winters, and predation. - J.L.M.

470
Dexter, Ralph W. 1944.

Ecological significance of the disappearance of eel-grass at Cape Ann, Massachusetts. J. Wildl. Mgmt. 8(3): 173-176.

Coincidentally with disappearance of eelgrass in the early 1930s and its slow return from 1933 to 1940 were declines and subsequent recoveries of soft clam and American lobster stocks. *Mercenaria mercenaria* is not mentioned. - J.L.M.

471
Dexter, Ralph W. 1945.

Zonation of the intertidal marine mollusks at Cape Ann, Massachusetts. Nautilus 58(4): 135-142.

Studies were made on the shores of Annisquam River during summers, 1935-37. Fifteen localities were sampled. *Mercenaria (Venus) mercenaria* apparently was not encountered. - J.L.M.

472
Dexter, Ralph W. 1947.

The marine communities of a tidal inlet at Cape Ann, Massachusetts: A study in bio-ecology. Ecol. Monogr. 17(3): 261-294.

473
Dexter, Ralph W. 1968.

Distribution of the marine molluscs at Cape Ann, Massachusetts. In Proc. Symp. Mollusca, Pt. I. Mar. Biol. Assn. India, Mandapam Camp: 214-222.

Annual surveys were made in summers of 1933-37 and 1956-61. Two species, *Crassostrea virginica* and *Mercenaria mercenaria*, had been introduced, but without much success. Winters usually are too cold for survival, and water temp too low for reproduction. Hard clam is not mentioned in lists of species collected. - J.L.M.

474
Dey, N. Dean. 1980.

Growth of sibling hard clams, *Mercenaria mercenaria*, in a controlled environment. Natl. Shellf. Assn., Abstracts, Technical Sessions: 22 (abstract).

Sibling populations of clams were raised in a controlled environment with excess algal food. Within each population wide variations among individuals were observed in shell length and volume. Populations were divided at an early stage into five successively larger size classes. Clams in the larger size classes always grew at a much more rapid rate than smaller clams at 18° and 25°C. Sibling populations in the laboratory show an obvious non-normal distribution of shell length within a few days of spawning. Early-setting clams grow at a more rapid rate than late-setting clams, but make up only a small fraction of the population. The size-frequency distribution of a sibling population maintained in the laboratory is strongly skewed toward the larger sizes. This is observed in hatchery-raised populations for at least a year after setting, indicating that the late-setting clams never match the growth rate of early-setting clams, and consequently remain small relative to the larger siblings. Growth of clams after setting for the first two months has three distinct periods. During the first 4 weeks growth continues at the larval rate. This rate of increase then decreases (growth pause), perhaps associated with growth of siphons, for about two weeks. Following the growth pause, rapid growth resumes, although at a somewhat reduced rate. With proper selection of early-setting larvae fast growing commercial strains, or uniform groups of clams, may be produced for work in toxicology and nutrition. In hatchery operations, where initial numbers are large, fast-growing larvae make up fewer than 5% of the population. - J.L.M. - J.L.M.

475
Dey, N. Dean, and Ellis T. Bolton. 1978.

Tetracycline as a bivalve shell marker. Proc. Natl. Shellf. Assn. 68: 77 (abstract).

Mercenaria mercenaria was exposed to tetracycline dissolved in filtered seawater to which algal food was added. Marking was vague at 0.5 and 5.0 mg L^{-1} but vivid at 25 to 200 mg L^{-1}. No deaths or morphological defects were noted. Algal species known to be good food sources produced the greatest incorporation of tetracycline. Tetracycline phosphate complex produced the best results. Tetracycline is useful in studies of shell growth and morphology and in field investigations. The technique could be used as an identification to combat poaching on leased grow-out grounds. - J.L.M.

476
DiDomenico, Dante A., and Richard L. Iverson. 1977.

Uptake of glycolic acid by a marine bivalve. J. Exp. Mar. Biol. Ecol. 28(3): 243-254.

Glycolic acid probably is the most important metabolite released by phytoplankton. Marine invertebrates, including *Mercenaria mercenaria*, can remove dissolved organic matter, such as amino acids, from solution. This can provide an important nutritional supplement. It was of interest to determine the capability of *M. mercenaria* to absorb glycolic acid from solution and to study the mechanism by which this was accomplished. It was found that the amino acid was accumulated by *in vitro* preparations of gill tissue from *M. mercenaria, M. campechiensis* and hybrids, probably by diffusion kinetics. Carbon-14 from labelled glycolic acid was found in the lipid fraction of gill tissue. Evolution of labelled CO_2 suggested that glycolic acid was metabolized in gill tissue. - J.L.M.

477
Dillaman, R. M., S. E. Ford, and K. M. Wilbur. 1980.

Measurement of small growth increments in molluscan shell. Natl. Shellf. Assn., Abstracts, Technical Sessions: 17 (abstract).

Measurement of small increments in *Mercenaria mercenaria* and *Argopecten irradians* shell under natural conditions is limited by the relative insensitivity of mechanical measuring devices. Radioisotope incorporation must be done under laboratory conditions where growth may be atypical. The authors have devised a method for measuring small growth increments which circumvents both problems. Animals are placed in ^{45}Ca medium for several hours where they deposit an isotopically labeled shell layer. They are then returned to natural growing areas or to any experimental situation. After a desired period, small pieces of shell are removed, painted on all but the inner surface and placed in a chamber where an etching solution flows over the surface at a constant rate and is collected by a fraction collector. Fractions are counted for ^{45}Ca and/or total calcium. Preliminary tests show that total calcium removed from the shell surface is constant from fraction to fraction. The peak of radioactivity falls into progressively later fractions as the animal grows for longer times in unlabeled seawater and deposits non-radioactive calcium over the ^{45}Ca-containing layer. The technique may be used to measure shell deposition in very slowly growing animals, or during short time periods in faster growing molluscs. - J.L.M.

478
Dimick, R. E., and W. P. Breese. 1965.

Bay mussel embryo bioassay. Proc. 12th Pac. NW Ind. Waste Conf., Univ. Washington, p. 165-175.

Mercenaria mercenaria is not mentioned. - J.L.M.

479
Dirnberger, Thomas, and Albert P. Kline. 1972.

A quantitative study of heavy metals in *Venus mercenaria*: Part II. Concentrations of zinc, cobolt (*sic*), mercury, lead, copper, and cadmium in the clam, *Venus mercenaira (sic)*. Proc. Pa. Acad. Sci. 46:17 (abstract).

Research substantiated previous conclusions that *Venus mercenaria* can concentrate heavy metals from ambient water. Details are not given. - J.L.M.

480
Dodgson, K. S., J. I. M. Lewis, and B. Spencer. 1953.

Studies on sulphatases. 3. The arylsulphatase and β-glucuronidase of marine molluscs. Biochem. J. 55(2): 253-259.

Mercenaria (Venus) mercenaria is not mentioned. M.W.S.

481
Doering, Peter Haines. 1976.

A burrowing response of *Mercenaria mercenaria* (Linnaeus, 1758) elicited by *Asterias forbesi* (Desor, 1848). Veliger 19(2): 167-175.

Mercenaria mercenaria renews burrowing in response to some chemical(s) from *Asterias forbesi.* This brings *Mercenaria* to rest at a greater depth, and is presumably a response designed to avoid predation. Squirting out the incurrent siphon can be elicited on siphonal contact with *A. forbesi*, and *Mercenaria* is more likely to squirt if chemical stimuli from *A. forbesi* are present. - J.L.M.

482
Doering, Peter H. 1976.

Mollusks practice self-defense. Maritimes 20(3): 1-3.

When starfish are present, quahogs bury deeper than in boxes where starfish are absent. In the laboratory it was shown that quahogs reach a deeper final position when they receive chemical stimulation from starfish than when they do not. The active substance which elicits the burrowing response in *Mercenaria mercenaria* belongs to a class of large steroid-like compounds called saponins. The clam squirts out its incurrent siphon upon siphonal contact with the starfish. It is more likely to squirt in response to mechanical stimulation when the chemical stimulus is also present. Thus the starfish may increase the number of squirts as it moves across a clam flat, thereby recognizing its prey. Clams sometimes remain at escape depths for at least a month when under constant exposure to starfish. - J.L.M.

483
Dougherty, Ellsworth C. 1959.

Introduction to axenic culture of invertebrate Metazoa: A goal. Ann. N.Y. Acad. Sci. 77: 27-54.

Mercenaria mercenaria is not mentioned. M.W.S.

484
Dougherty, William J., and Ronald Altman. 1962.

Viral hepatitis in New Jersey 1960-1961. Am. J. Med. 32: 704-716.

Studies of clam-related hepatitis were conducted by interview, and contacts with physicians, restaurants, wholesale and retail clam dealers, and clammers. In the general population consumption of raw clams among non-ill persons over 20 yrs old did not exceed 15% and averaged less than 10%. In Jan to Apr 1961, inclusive, 46 to 53% of adult patients with hepatitis had eaten raw clams, most of which were eaten in restaurants. Supplies of clams in wholesale markets in N.Y. and N.J. originated in Mass., R.I., Conn., N.Y., N.J., Md., Va., and N.C. Several large shippers in Va. bought clams in the N.Y. market and from Raritan Bay, N.J. These were held in Va. waters until prices were favorable, then shipped back to N.Y. markets. Of 459 patients with infectious hepatitis, 368 or 87% of cases traced came from sources consistent with Raritan Bay origin. Another study was made of patients with infectious hepatitis who had eaten clams from only one N.J. restaurant or market. Of 229 cases traced, 205 or 89.5% were from sources consistent with Raritan Bay. In counties bordering Raritan Bay incidence of hepatitis was higher than the State average. Such evidence led to closure of Raritan Bay to clamming on 1 May 1961 by authorities in N.Y. and N.J. Following closure, the incidence of hepatitis in adults with a history of clam consumption dropped sharply. From 1959 through 1961 the frequency of hepatitis cases per month in N.J. remained below 50 until Nov 1960, then rose rapidly to a peak of over 250 in March 1961, and dropped to a level between 100 and 150 in June 1961 and remained there to the end of the year. The winter of 1960-61 was severe and clams were taken from ice-free waters, many of which were contaminated. These studies showed that the source of infection usually could be located if an intensive effort was made. Outbreaks related to shellfish consumption often are not recognized because the product is distributed widely. It is conceivable that water could be considered safe by fecal coliform standards, yet still contain hepatitis virus. - J.L.M.

485
Dow, Robert L. 1952.

Shellfish survey methods. Convention addresses, Natl. Shellf. Assn.: 1-9.

Three *Venus* surveys made by plane table gave an average production of 1,508.83 bu/acre, with a range of error of minus 3.7 to plus 9.0%. Total acres was 15.4, and averaged estimated volume/acre was 1,563.83 bushels. - J.L.M.

486
Dow, Robert L. 1953.

An experimental program in shellfish management. Maine Dept. Sea Shore Fish., Fish. Circ. 10, 11 p.

Describes in some detail the steps followed in a successful clam management program in the Town of Wells, Maine. Social-political actions, scientific surveys and studies, and management measures are detailed. The species is not identified, but the name *clam* in Maine means *Mya arenaria*. - J.L.M.

487
Dow, R. L. 1954.

Problems of polluted shellfish growing areas. Paper presented to Am. Soc. Civil Eng., 5 Nov. 54, 8 mimeo. p.

488
Dow, R. L. 1955.

Infra and intra-tidal sets of *Venus* in Maine. U.S. Fish Wildl. Serv., 5th Ann. Conf. Clam Research: 33.

Commercially important sets of hard clam in intra-tidal areas have not often survived in Maine. The commercial fishery is limited to a portion of Casco Bay in the intra-tidal zone. Evidence from dredging operations showed that clams of all year classes from 1940 to 1951 inclusive, except 1950, had survived below low tide in Maquoit Bay, and those of all year classes from 1942 to 1951 inclusive, except perhaps 1945, had survived in Middle Bay. - J.L.M.

489
Dow, Robert L. 1958.

Sanitary criteria for shellfish by species and by area. Proc. Natl. Shellf. Assn. 48: 23-29.

To implement recommendations of the 1954 National Shellfish Sanitation Conference studies were conducted in Maine to evaluate the relative importance of hydrographic, geological, and biological factors in their influence on sanitary quality of shellfish growing areas. Among biological factors it was noted that where soft clam and hard clam *(Mercenaria mercenaria)* occurred in commercial concentrations in an area, hard clams were invariably found in places where the overlying waters were of high salinity. Thus, quahogs are less subject to contamination than soft clam in the same growing area. Because it can close its valves completely, whereas soft clam cannot, hard clam is less exposed to contamination from brief exposure to polluted fresh water. Soft clams stored alive will live only from 1/2 to 1/5 as long as hard clams. These biological differences mean that the same sanitary requirements should not apply to different shellfish species. - J.L.M.

490

Dow, R. L. 1965.

Shellfish survey methods. Maine Dept. Sea Shore Fish., Tech. Bull. 1, 14 p.

(Abstracter's note: the copy in our hands did not include the title page. It is likely that the author's name was given as Robert L. Dow.) Three principal methods were used to make population estimates of *Mercenaria mercenaria* and *Mya arenaria*: 1) compass and chain, 2) plane table, and 3) photo-enlarged shoreline survey. These methods are described and their advantages and disadvantages compared. About 143.5 acres were surveyed. Estimated populations were 38,242 bu of soft clams 1 inch in diam or larger. Production from these grounds was 36,734 bu. Range of error was from -6% to +26.7%. Density of *Venus* averaged 1,508.83 bu/acre, with a range of error from -3.7% to +9%. Type of sediment had little or no effect on accuracy of estimates. Estimates from large areas were most accurate. If the sampling fraction is 1/12,000 or greater, the error of estimate may be expected to be no greater than ± 10%. All *Venus* estimates were made by plane table. Data for the 3 grounds surveyed were: 1) 3.3 acres, est. pop. 6,637 bu, production based on resurvey 6,887 bu, production/acre 2,086.97 bu; 2) 5.1 acres, est. pop. 8,253 bu, production based on resurvey 7,568 bu, production/acre 1,483.92 bu; 3) 7.0 acres, est. pop. 9,193 bu, production based on resurvey 8,781 bu, production/acre 1,254.43 bu. - J.L.M.

491

Dow, Robert L. 1970.

The need for specific sanitary requirements for various species of shellfish. Paper presented at U.S. Public Health Service National Conference on Shellfish Sanitation, Sept. 9-10, 1954 (retyped May 1970), 2 p.

Hard clam *(Mercenaria mercenaria)*, blue mussel, soft clam,and American oyster behave bacteriologically and otherwise differently from each other. Some differences are environmental: location in relation to bottom; in relation to tidal zone; and influence of water quality on survival and well-being. Other biological and physiological differences are reflected in growth rates, feeding, spawning, shell structure, and viability. It might be well to establish sanitary requirements by area as well as by species. - J.L.M.

492

Dow, Robert L. 1971.

Renewable marine resource industry potential in Maine. Natl. Fisherman 51(10), Feb. 1971: 12A, 30A.

This is the first of a 2-part article under the title given above. This part is headed: *Huge potential seen for Maine aquaculture*. The paper includes an outline of the possible organization of a renewable marine resource industry, which would produce unprocessed products, processed foods, and nonfood products. Unique features of the coastal waters of Maine for aquaculture are: 1) 30 years of experience in the Dept. of Sea and Shore Fisheries; 2) experience in commercial-scale management of fisheries; 3) natural yields per acre of certain species in the State; 4) experience in raft culture of oysters; 5) a variety of natural features such as protected waters, open coasts, good tidal flow, and wide fluctuations in environmental conditions. For example, since March 1905, annual average sea surface temp has varied from 6.3°C to 11.1°C. The coast is oriented east and west, and most embayments open to the south. Successful artificial culture of *Mercenaria mercenaria* has been achieved, and hard clam management experiments in the 1940s and 1950s were estimated to have increased producer income from about $9,000 to $119,000 in the period 1947 to 1954. - J.L.M.

493
Dow, Robert L. 1971.

4. Natural yields of certain species. Second of two articles describing the "Renewable Marine Resource Industry Potential in Maine", under the heading "Dow Sees Maine Aquaculture Worth Far More Than Existing Industries". Natl. Fisherman 51(11): 1-C, 4-C.

Orr's Cove, Harpswell, surveyed on 25 Aug 1953, had 1952 year-class hard clam concentrations ranging from 0 to 80,000 clams/ft^2 of bottom. Two portions of the Cove, about 30,000 ft^2 in area, had an average population of about 40,000 quahogs/ft^2. This was 1.2 billion clams with an average diameter of 4 mm. Transplants of quahogs to below mean low water have survived 90% or more annually. Natural concentrations above mean low water survived 10% or less. Survey of Avery's Cove in Sept 1952 gave an estimate of 139.8 million quahogs of the 1952 year class, 3 mm in diameter on the average, on 10.7 acres. Survey in Brickyard Cove in Aug 1953 showed residual concentrations of 1952 year-class hard clams of 1,000 to 1,400 live clams/ft^2 on an area greater than 5 acres. Average size was 6 mm, and the population was estimated at 261.36 million clams. In a 3-yr period the 1952 year class of hard clams in Middle Bay produced 429 bu of clams, or 4,719 lbs of shucked meats/acre/yr. From Sept 1955 to Apr 1960 an area at West Bath produced 36,751 lbs of hard clam meats from 6 acres. In addition, 13,600 bu were transplanted to unoccupied growing areas. Spectacular sets of hard clam occurred in many growing areas in Maine in 1947 and 1952. Less than 1% survived from the 1st to the 2nd yr in most areas. The northern Gulf of Maine is near the northern limit of distribution of hard clam; survival to juvenile stages is sometimes very high, but mortality may be catastrophic before commercial size. Predators also flourished with the favorable temps that gave strong hard clam year classes. The possibility exists for transplantation to more favorable areas for rearing to market size. Shellfish growing areas of more than 70,000 acres are closed by pollution in Maine. Many are among the most promising biologically for aquaculture and later conditioning in clean water. It is estimated that with aquaculture a crop worth $500 million at the producer level could be grown by 1980, and $2 billion by 1990. An editor's note states that the first article, in the issue of the previous month, listed research projects bearing on aquaculture potentials in Maine. He notes that estimates are maxima, but that, even allowing for losses, farming techniques could improve over wild production. - J.L.M.

494
Dow, R. L. 1972.

Fluctuations in Gulf of Maine sea temperature and specific molluscan abundance. J. Cons. Internatl. Explor. Mer 34(3): 532-534.

Relict hard clam, *Mercenaria mercenaria*, populations survive in anomalous warm-water pockets of the northern Gulf of Maine. Extensive soft clam populations occupy the same shallow coves and many other areas too cold for hard clam reproduction and survival. Abundance peaks of the 2 species frequently coincide in geographical location but not in time. Prehistoric kitchen middens adjacent to a major growing area contain 4 alternate strata of hard and soft clam shells, indicating a cyclic and complementary abundance relationship. In the period 1939 to 1970 landings of soft and hard clam meats in Maine varied inversely. Peaks of soft clam production coincided with periods of relatively low sea temp; the peak of hard clam production came at a time of relatively high water temps. Inventories of standing stocks of clams supported the working assumption that landings were a reliable index of abundance during the period of observation. Predation by green crabs also was a factor in determining abundance. Between historic minimum and maximum sea temp limits the extremely unstable hard clam stocks have varied about 18,000:1 in abundance. - J.L.M.

495
Dow, Robert L. 1973.

Fluctuations in marine species abundance during climatic cycles. Mar. Tech. Soc. J. 7(4): 38-42.

Hard clam abundance is directly related to sea temperature. Three major year classes (1937, 1947, 1952) have occurred in Casco Bay, Maine. In those years mean annual surface water temperatures were 9.0°, 9.2°, and 10.1°C. Growth and survival to commercial size depend on favorable temperatures. Continued high temperature in the mid-1950s led to high mortalities from crab predation. Records of hard clam catches in Maine do not exist prior to 1931. Since that time greatest catches of hard clam have coincided with high mean annual water temperatures. Since 1939 the minimum has been 6.4°C in 1939, the maximum 11.1°C in 1953. (Abstracter's note: A correlation between two such sets of data does not necessarily prove cause and effect. The data presented for clam catches are for the same year as the mean annual temperatures. If the correlation has meaning, this would mean a direct kill of adult clams, or that temperature functions in some way to make clams of legal size less available to diggers. It could not be a temperature effect on spawning or on eggs, larvae, and young. The table in which temp and clam data are given contains information also on production of oysters (3 yrs later), lobsters (same yr), 3-yr-old bloodworms, 3-yr-old sandworms, scallops (6 yrs later), soft clams (5 yrs later), and shrimp (4 yrs later). Aside from the statistical questionability of the correlation method of establishing cause and effect, this evidence of data manipulation makes the conclusions questionable.) - J.L.M.

496
Dow, Robert L. 1975.

Reduced growth and survival of clams transplanted to an oil spill site. Mar. Poll. Bull. 6(8): 124-125.

Experiments were conducted with *Mya arenaria*. *Mercenaria mercenaria* is not mentioned. - J.L.M.

497
Dow, Robert L. 1977.

Effects of climatic cycles on the relative abundance and availability of commercial marine and estuarine species. J. Cons. Internatl. Explor. Mer 37(3): 274-280.

The northern Gulf of Maine, normally the habitat of boreal species, is intruded by vertebrates from the south in periods of relatively high sea temp, in sufficient numbers to support commercial fisheries. Abrupt and spectacular changes also occur in abundance of resident warm-water invertebrates, including *Mercenaria mercenaria*. Relationships between sea surface temp and landings of various commercial species in Maine were examined by simple linear correlation. Cause and effect were inferred. Except for the anomalous Gulf of St. Lawrence, the Gulf of Maine is the northern limit of the range of hard clam. The species is relatively abundant only when water temp is high enough to permit successful spawning and survival of progeny. In cold periods a nucleus of survivors, mostly old clams, continues in deeper waters. Some may be 25 yrs old or more, and intervals between commercially important survival of progeny may exceed 20 yrs. Hard clam was exhausted commercially in the area by 1937, when the first of 3 important year classes (1937, 1947, 1952) resupplied the fishery and extended the life of the fishery to 1962. Recently, an increase in annual mean water temp to 9.4°C has led to modest recovery of the stock and resumption of harvesting. From 1939 to 1962 inclusive a positive correlation of 0.80 ($r_{0.01}$=0.52) was found between hard clam landings and annual mean water temp in the same year. Similar correlations, some positive, some negative, were found for 23 other species. It was concluded that sea temp has been the principal environmental regulator of species abundance and availability in the Gulf of Maine. (Abstracter's note: it is puzzling that a positive and allegedly significant correlation between hard clam landings and water temp in the same year should be taken as evidence of a temp effect. Several years elapse between birth and attainment of commercial size, and this time lag could be expected to be at a maximum in the cold waters of the Gulf of Maine. Regardless of this fact, however, correlation analysis *per se* cannot prove cause and effect, although the method has been used at times, especially by fishery biologists, to draw conclusions about environmental effects. Often results are obtained by repeated trials, using different combinations of data, and this invalidates conclusions about statistical significance. This paper does not state that the results reported were obtained by trial and error, but the results reported in the tables lead one to suspect that this was done. Correlation coefficients are reported for data matched for the same year, as for hard clam and other species, and for pairs of data lagged by as much as 8 yrs. For most species, the rationale by which data were matched is not stated. The importance of temp in determining success of spawning and other biological variables at the northern limit of the species range is so well known that it is not necessary to draw on a questionable technique like correlation analysis to "prove" it.) - J.L.M.

498
Dow, Robert L. 1978.

Size-selective mortalities of clams in an oil spill site. Mar. Pollution Bull. 9(2): 45-48.

Mixed no. 2 fuel oil and JP5 jet fuel from an oil spill in Long Cove, Searsport, Maine became concentrated locally at levels up to over 250 ppm in intertidal sediments 15 to 25 cm below the surface. The spill was in March 1971, and oil continued to kill successive annual sets of *Mya arenaria* as they burrowed through overlying clean sediments into the oil concentration beneath. Nearly all dead clams were faster growing and larger than those that had survived for a longer time. Juvenile clams setting on the clean, redistributed surface sediments survived through 3 or more growing seasons. As they grew, they burrowed more deeply until they finally reached heavier oil concentrations. (Abstracter's note: *Mercenaria mercenaria* apparently was not involved. It could be assumed that, because quahogs do not dig as deeply, they might have been less affected.) - J.L.M.

499
Dow, Robert L. (no date - probably early 1970s).

Maine law affecting marine resources. Chapter 12 in Problems Influencing Use of Renewable Marine Resources. Partial report under a study carried out under the joint sponsorship of: The School of Law of the University of Maine and the National Science Foundation Office of Sea Grant Programs, p. 743-787.

Prior to World War II shellfish were looked upon as a standby food for hard times, a food not in keeping with American culture and affluence. In Maine the resource was considered primarily the property of all residents, and not as a resource to be exploited commercially. All that has changed, although traditions linger. For the most part management has not been based on scientific facts. Some kitchen middens have alternating layers of soft and hard clams, suggesting that the two species may alternate in abundance reciprocally. Temperature is suggested as the cause, based on recent observations that appear to show that hard clams thrive at higher water temperatures than soft clams. Optimum sea surface temperature for hard clam is 50.2°F., for soft clam 46.1°F. At extremes of temperature hard clam populations have fluctuated of the order of 18,000 to 1. In one 3-acre area (Brighams Cove) over a 10-year period yield of hard clams per acre per year was 6,600 lbs. In warm years, when hard clam production rises, conditions are apt to be optimum for two major predators also, green crab, *Carcinus maenas*, and rock crab, *Cancer irroratus*. Survival of the hard clam year class of 1952 was greatly reduced by crab predation and winter mortality. Hard clams were reared in hatcheries in 1951 and 1952. Recently, artificially reared juveniles were planted in growing areas, protected from predation by fences. To prevent freezing juveniles should be planted in subtidal waters. Hard clam aquaculture should be feasible in Maine. - J.L.M.

500
Dow, Robert L., and Dana E. Wallace. 1951.

A method of reducing winter mortalities of quahogs *(Venus mercenaria)* in Maine waters. Dept. Sea Shore Fish., Augusta, Me., Res. Bull. 4, 31 p.

High densities of hard clams (50 to 80/ft^2) were residue of a set in 1938, 39, or 40. Most were stunted to less than the State's legal size of 2 inches. The clams formed a windrow which had higher mortalities than clams in surrounding flats. Stunted clams grew well and had high survival when transplanted to less populated and less exposed areas. The following recommendations were made: 1) high density concentrations of quahogs should be transplanted before growth has created stratification of the population; 2) transplanting should be done as soon as possible after high concentrations have been discovered, so more clams can be transplanted with less effort; 3) transplanting should not cause points of elevation in the planted area, planting should be uniform with clams well spread out. - D.L.

501
Dow, Robert L., and Dana E. Wallace. 1952.

Observations on green crabs *(C. maenas)* in Maine. Maine Dept. Sea Shore Fish., Circ. 8, p. 11-15.

Green crab had recently become increasingly important in waters of the State as a predator of soft clam, *Mya arenaria*. In laboratory tanks green crabs could not eat quahogs, *Mercenaria mercenaria*, larger than 1/2-inch diameter. The crab is hardy, and burrows into the bottom to obtain food. Crabs use their large claws to scoop out burrows and kill their prey. - J.L.M.

502
Dow, Robert L., and Dana E. Wallace. 1953.

A method of reducing winter mortalities of *Venus mercenaria* in Maine waters. Natl. Shellf. Assn., Convention Addresses 1951: 15-21.

Although Maine does not have a very large hard clam fishery it is important to the economy of towns on Casco Bay. It is primarily an intertidal fishery. Good sets are infrequent; the last one was in 1947. Most of this year class was just reaching littleneck size in summer 1951. When heavy concentrations occur in an area their growth is often slow and mortality is high. Mortality is high when storms expose quahogs at low water in winter, and when density is so great as to make elevations or ridges in the normal gradient of the flat. Clams in depressions covered with sediment survive cold weather well. Clams near low water mark survive better than those higher on the beach. Transplantation to areas near or below mean low tideline, spreading clams thinly to allow room to dig and to grow, is feasible and beneficial. Transplanting should be done as early as possible because the same number of clams can be moved with less labor and at less cost. In summer 1950 they moved 3,012 bushels from an area that contained concentrations of clams as high as 167/ft^2. Sizes ranged from 27 to 59 mm and averaged 43 mm. - J.L.M.

503
Dow, Robert L., and Dana E. Wallace. 1954.

The seed quahog dredge, *Venus M.* Me. Dept. Sea Shore Fish., Fish. Circ. 15, 12 p.

A commercial fish pump of the type used to transfer herring from nets to carriers and from carriers to processing plants handled a maximum of 6 to 7 bu quahog seed/min. Breakage was negligible when the pump engine was operated at 580 to 600 rpm. More breakage occurred on deck than from dredging. With a larger pump and suction units it was believed that commercial quahog harvesting would be practical. - J.L.M.

504
Dow, Robert L., and Dana E. Wallace. 1954.

Shellfish management. Dept. Sea Shore Fish., Augusta, Me., 3 p. (mimeo.)

It is highly desirable to limit frequency of clam digging in any area. Commercial digging with a clam hoe ultimately destroys at least 50% of clams remaining on the flats by shell breakage and smothering of sub-legal clams or exposure to predation. Many clam grounds in Maine have relatively few small clams. Without controls area after area will go out of commercial production, and digging will be limited to areas in which small clams have survived to commercial size. A recent experiment showed that yields could be improved substantially by complete removal of marketable clams in an area, followed by closure to protect further natural sets. Digging should not begin when the first clams reach marketable size. An initial management program is proposed which will begin with a public informational meeting and formation of a small industry advisory committee. Surveys would evaluate clam populations, sizes, growth, predators, and competitors. Results of surveys would be presented and discussed at public meetings. Rotation schedules would be established for open and closed grounds, and periodic surveys would evaluate the condition of the stocks. Experiments would be carried on under various environmental conditions to evaluate the economic feasibility of predator control. Cooperative programs between adjacent towns would be encouraged. Local economic conditions and employment would be considered in making decisions. (Abstracter's note: In New England, clam means *Mya arenaria*, the soft clam. *Mercenaria mercenaria* is called quahog. The plan outlined probably would work equally well with hard clam.) - J.L.M.

505
Dow, Robert L., and Dana E. Wallace. 1955.

Commercial scale shellfish management experiments in Maine. 5th Conf. on Clam Research, 4 p. (mimeo.)

Experiments were conducted with *Venus (Mercenaria) mercenaria* and *Mya arenaria*. The project was cooperative with towns and commercial diggers. Small, slow-growing quahogs were transplanted, growing areas were rotated, harvesting was controlled, and in one area of dense natural set the area was closed, surplus seed was transplanted, and the residual population was harvested under control. Completed experiments with *Venus* cost $7,548 and produced a commercial product worth $119,369. - J.L.M.

506
Dow, Robert L., and Dana E. Wallace. 1955.

Experiments in the extension of the range of quahogs in Maine waters. Maine Dept. Sea Shore Fish., 3 p. (mimeo.) (retyped Nov. 1967.)

Experiments included 3 steps: 1) a small experimental plot of 1 to 5 bu, to determine survival and growth; 2) if step 1 was promising, 10 to 100 bu were planted; 3) if step 2 was a success attempts were made to build up the area by supplemental plantings and natural reproduction. Step 3 was not successful except in the Casco Bay area. Areas of plantings and general results are given in a table. - J.L.M.

507
Dow, R. L., and D. E. Wallace. 1955.

Natural redistribution of a quahog population. Science 122(3171): 641-642.

Approximately 95 percent of the quahog, *Venus mercenaria*, fishery in Maine is intertidal and limited to infrequent good sets which occur in limited areas of dense concentration. Shortly after setting, densities as high as 25,000 per square foot have been recorded, but mortality rates invariably exceed 90 percent by the end of the second season. Redistribution takes place among smaller size (3 mm in diameter) individuals and does not occur involuntarily among adults. One concentration of quahogs surrounded by barren flats from the 1947 year class was surveyed in Maquoit Bay, Maine before and after the winter of 1950-51 using a plane table and telescopic alidade. Population density averaged 79.5 clams per square foot, with a size range from 27 to 56 mm and a median diameter of 43 mm within an area of 3.28 acres. Winter mortality reduced the population by 40.3 percent primarily as a result of gales that removed sediment cover and were followed by alternate freezing and thawing air temperatures during low tide periods. Storms with the highest wind velocities were from the southeast and the greatest redistribution of individuals was toward the northwest a maximum distance of 387 feet. In spring the surviving population occupied an area of 6.81 acres and the physical center had been displaced 100 feet to the northwest. Density of animals, living and dead, decreased from 79.5 in October to 41.7 per square foot by the time of the resurvey. - W.J.B.

508
Dowd, R. M. 1972.

Dredging on Long Island. Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board. Center for the Environment and Man, Inc., Hartford, Conn., v+43 p.

In the Long Island area it was concluded that damage to shellfishes (species not named) would be confined to the boundary of the project. - J.L.M.

509
Doyle, Larry J., Norman J. Blake, C. C. Woo, and Paul Yevich. 1978.

Recent biogenic phosphorite: Concretions in mollusk kidneys. Science 199(4336): 1431-1433.

Two widely distributed bivalves, *Mercenaria mercenaria* and *Argopecten irradians*, with relatively high population densities, may have phosphorite concretions in the kidneys. This is the first demonstration of direct biogenic formation of phosphorite grains, principally amorphous calcium phosphate. Hard clams were collected from muddy sand which smelled strongly of H_2S, in a heavily polluted part of Narragansett Bay, R.I. These concretions appeared to be a normal excretory product under reproductive, environmental, or pollutant-induced stress. They may account for formation of some marine phosphorite deposits which are not easily explained by the chemical precipitation-replacement hypothesis. - J.L.M.

510
Drach, P. 1958.

Perspectives in the study of benthic fauna of the continental shelf. In Perspectives in Marine Biology. A. A. Buzzati-Traverso (ed.). Univ. Calif. Press, Berkeley, p. 33-46.

The paper deals primarily with techniques and general principles. *Mercenaria mercenaria* is not mentioned. - J.L.M.

511
Dragovich, Alexander, and John A. Kelly, Jr. 1964.

Ecological observations of macro-invertebrates in Tampa Bay, Florida, 1961-1962. Bull. Mar. Sci. Gulf Caribb. 14: 74-102.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

512
Dressel, David M., and Donald S. FitzGibbon. 1978.

The United States molluscan shellfish industry. In Drugs and Food from the Sea: Myth or Reality? Pushkar N. Kaul and Carl J. Sindermann (eds.). Univ. Oklahoma, Norman, p. 251-283.

Most of the clam industry is on the east coast and consists mostly of harvesting 4 species, of which hard clams, *Mercenaria mercenaria*, made up 17% by volume and 53% by value of the 4 species in 1973. This is the oldest of the clam fisheries in the United States, dating back to colonial times, but gaining prominence in the early 1900s when canneries opened. The west coast of Florida was a major producer of canned clams in 1913, and in 1943 the largest clam bed in the United States covered a 150 square mile area off west Florida. The war and resultant meat shortages increased the demand for clams, and by 1947 this bed was totally depleted. In the same year New England and Long Island also were recording peak landings. High water quality is needed for safe harvests. Resources in the major producing States of New York, Delaware, Virginia, and Maryland continue to decline from heavy harvesting. Hard clams, although still the most valued, are being displaced by other more abundant species of lesser value. The 4 species represent over 99 percent of total clam landings in the past 10 yrs, but increased effort to utilize other species is likely. - J.L.M.

513
Drinnan, R. E. 1964.

An apparatus for recording the water-pumping behaviour of lamellibranchs. Neth. J. Sea Res. 2(2): 223-232.

The apparatus was used with oysters and mussels. - J.L.M.

514
Drinnan, R. E. 1966.

Observations on the accumulation of heavy metals by shellfish in the estuary of the Miramichi River, N.B., 1961-63. Fish. Res. Bd. Canada, Manuscript Rept. Ser. (Biological), 8 p. + 8 tables.

Quahaugs were examined in Lower Miramichi Bay to investigate the possible relevance of zinc pollution to an unexplained mortality of *Mercenaria mercenaria* in the area in the past few years. All showed very low zinc scores, suggesting that Zn was not involved in mortality. Oysters in the same area had much higher Zn residues. This confirmed other observations that other shellfishes do not concentrate metallic elements to the same extent that oysters do. - J.L.M.

515
Driscoll, Egbert G. 1968.

Sublittoral attached epifaunal development in Buzzards Bay, Massachusetts. Hydrobiologia 32(1): 27-32.

Sixteen epifaunal species were identified encrusting dead valves of *Mercenaria mercenaria*, *Mya arenaria*, and *Aequipecten irradians* exposed for 1 yr on the bottom of Buzzards Bay, Mass. *Balanus amphitrite* shows a preferred orientation of the rostro-carinal axis parallel to growth lines of *M. mercenaria*. No preference for different bivalve shells was shown. - from author's summary - J.L.M.

516
Driscoll, Egbert G. 1970.

Selective bivalve shell destruction in marine environments, a field study. J. Sedimentary Petrol. 40(3): 898-905.

Massive shell destruction must take place in the first few yrs after death of organisms like bivalve mollusks. Otherwise, great masses of dead shell would accumulate in relatively short periods. Valves of *Mercenaria mercenaria*, *Argopecten irradians*, and *Mya arenaria* were submerged for 3 yrs in a shallow, low-energy, sublittoral environment. Shells with less surface area per unit weight are more rapidly buried in sediments, not only in low-energy, muddy bottom, but also on some higher energy sand bottoms. This causes selective destruction of shells by boring organisms, abrasion, and solution. Differential destruction is one possible explanation for absence of thinner, smaller, and lighter bivalves in certain fossil assemblages. Encrustation of exposed valves by firmly attached epifauna capable of fossilization may increase weight by as much as 25% in the 1st few years after death. Shells most likely to be buried and preserved are least likely to be heavily encrusted. This explains partly the surprisingly small numbers of encrusting organisms in many fossil communities. Durability of *M. mercenaria* and other similar bivalves during the 1st few yrs after death is of the order of 150 times as great in muddy, low-energy sublittoral environments as in the surf zone on a fine sand beach, and 1,000 times as great as in the surf zone of a gravelly sand beach. - from author's conclusions - J.L.M.

517
Driscoll, Egbert G., and Ruth A. Swanson. 1973.

Diversity and structure of epifaunal communities on mollusc valves, Buzzards Bay, Massachusetts. Palaeogeogr., Palaeoclimatol., Palaeoecol. 14(3): 229-247.

Mercenaria mercenaria shells were placed on each of 3 different sediment types: coarse, poorly sorted, shell-rich sand; very fine sand with large silt-clay fraction; and medium sand; in Buzzards Bay, Mass. for 1 year. Study of epifauna after recovery led to the following conclusions: 1) fossil epifaunas probably provide more reliable information on common species than on rare species; 2) sedimentary substrate is not a direct cause of homogeneity of epifaunas; 3) diversity is overestimated by the rarefaction method of analysis; 4) epifaunas associated with shell substrates deviate from the MacArthur "broken stick" model in such a way that rare species are rarer than predicted and common species more abundant; and 5) living epifaunal communities associated with shell substrates demonstrate a moderately good fit with the Preston truncated lognormal model of distribution of individuals within species. - from authors' conclusions - J.L.M.

518
Duffy, Francis James. 1980.

Clam-cleansing plant helps restore once-active Staten Island fishery. Natl. Fisherman 60(9): 52-53.

Staten Island once had a thriving shellfish industry, but growing pollution closed first the oyster beds and then the clamming areas in 1920. The fishery was reopened in 1940, but the U.S. Public Health Service found it necessary to close the clam beds again in 1961. A limited fishery was opened again in 1979 when William Ryan of the Great Kills Shellfish Corp. opened a depuration plant at Great Kills. Clammers operate under special permit for delivery to the plant. The future of clamming (*Mercenaria mercenaria*) in the area appears promising. - J.L.M.

519
Duffy, McFadden. 1977.

Louisiana clams ... A new fishery? Louisiana Conservationist May-June 1977: 11-15.

The article deals primarily with the southern hard clam, *Mercenaria campechiensis*. They apparently inhabit the ecological niche outside the one inhabited by oysters. They occupy a band along the entire Louisiana coast. In most cases they are roughly about six inches below the surface of the bottom, but can move vertically and slightly horizontally in the sediments. The stock size is not known. Presently they are most useful for making chowder, but can be used for mincing, dicing, or coarsely ground for other uses. In the first three months of 1977 an experimental fishery took over 7,000 bu of clams. The future of the fishery still needs to be proven. - J.L.M.

520
Dugal, Louis-Paul. 1939.

The use of calcareous shell to buffer the product of anaerobic glycolysis in *Venus mercenaria*. J. Cell. Comp. Physiol. 13(2): 235-251, ill.

When hard clams are kept out of water, CO_2 content of the mantle cavity fluid increases from 8 vols. % to 150 vols. %, CO_2 content of the central inner part of the mantle increases, and shell is visibly eroded under the central part of the mantle. If the clam is returned to seawater the CO_2 content of the mantle cavity fluid returns to normal. If removed from the water again, the process is reversed. The increase in CO_2 tension is small compared to the increase in total CO_2. Ca of the fluid increased more than CO_2, which shows that another acid or acids are formed. There is no great change in pH, which shows that the other acid is neutralized and buffered. Glass electrode titrations showed that the pk of that acid corresponds with the pk of lactic acid. This acid increases in concentration with total CO_2 and Ca. The sum of CO_2 and other acid is equivalent at any time to the Ca. It was concluded that clams survive out of water through anaerobic metabolism. A process like glycolysis forms an acid which is buffered by $CaCO_3$ dissolved from the shell, and part of the CO_2 coming from that $CaCO_3$ remains in solution. The CO_2 gained by the fluid is derived from the shell and is not produced by metabolism. Since the sum of CO_2 plus non-volatile weak acid is equivalent to Ca, these are the only participants in buffering. Calcareous shell is used for buffering products of glycolysis. - from author's summary - J.L.M.

521
Dugal, L.-P. and L. Irving. 1937.

Secretion of $CaCO_3$ from the shell by closed *Venus mercenaria*. Can. J. Med. 36: 81.

SUNY Library at Stony Brook could not locate this journal in any Union List. They did find the Canadian Medical Assn. J. 36 (1937) but the article was not on p. 81 nor was it listed in the volume index. Search terminated. - J.L.M.

522
Dugal, Louis-Paul, and Laurence Irving. 1937.

Increase in CO_2 and decalcification in certain pelecypods. Biol. Bull. 73(2): 379.

Mantle cavity fluid of *Venus mercenaria* gains CO_2 when the clam is held out of water. In a fresh clam the change is from 5 or 8 ml to 90 ml/100 ml of fluid in 5 to 6 days. When clams begin to die total CO_2 decreases. Return to water before death restores CO_2 to normal. In *Venus* the total CO_2 of the fluid increases rapidly, but pH decreases only from 7.4 to 7.2 and P_{CO_2} increases only from 3 to a max of 25 mm Hg, so it is evident that buffering capacity increases. Shell is eroded during these changes. A few analyses showed that the fluid gained Ca, which suggests that buffering is provided by solution of $CaCO_3$ from shell. Shell erosion is localized in the central inner part; only mantle tissue gains CO_2. Thus, buffering is effected by activity of a special tissue. - J.L.M.

523
Dugal, Louis-Paul, and Laurence Irving. 1937.

Sécrétion de carbonate de calcium per les *Venus mercenaria* fermées hermétiquement. Compt. Rend. Soc. Biol., T. 124(1): 526-528.

When *Venus mercenaria* is taken from the water it closes its valves hermetically and holds in its pallial cavity the water which it had taken at that moment. CO_2 content of this water is 5 to 8 cc/100 cc liquid. CO_2 content increases rapidly up to 60 cc/100 cc liquid. *V. mercenaria* can remain closed for long periods out of water. Specimens held in a desiccator contain an equivalent amount of CO_2 to those held in air. This great increase in CO_2 content is not caused by death processes, because the process is reversible if the clam is returned to seawater. Gill cilia and heart beat normally. No important difference in pH develops in the pallial cavity of clams held out of water, as compared with fresh clams. Concentration of $CaCO_3$ builds up in the same proportions as that of CO_2. Concurrently, erosion of the inside central portions of the valves occurs, that is, in the part bounded externally by the pallial line. It is evident that the increase in CO_2 concentration is caused by dissolution of $CaCO_3$ of the clam. CO_2 concentration in mantle is not uniform. It increases most sharply in the central part of the mantle in the same region as shell erosion. No significant increase in CO_2 occurs in other tissues. The central region of the mantle must therefore dissolve $CaCO_3$ of the shell and transport it to the liquid in the pallial cavity. During interruption of normal respiration it functions to buffer metabolic acids. Because the reaction is localized in a specific tissue, it seems that this provides a favorable material for study of the mode of Ca transport. - J.L.M.

524
Dugal, Louis-Paul, and Laurence Irving. 1938.

The relation of the shell to anaerobic metabolism in *Venus mercenaria*. Biol. Bull. 75(2): 352-353.

When *Venus mercenaria* is kept out of water the CO_2 content of mantle cavity fluid increases without much decrease of pH. Shell is visibly eroded under the center of the mantle. Ca in the fluid increases more than CO_2, which indicates formation of other acids. Small pH change indicates that the other acid is neutralized and buffered, and glass electrode titration shows that its pK corresponds with that of lactic acid. Volatile weak acid in the fluid as determined by titration agrees with CO_2 determined by Van Slyke method. The sum of CO_2 and other acid is equivalent to Ca. Thus, CO_2 gained by the fluid is derived from shell and not by anaerobic or aerobic metabolism. When the clam is out of water a process resembling glycolysis in vertebrate tissue forms an acid, which is neutralized by the shell through the living mantle. Part of the CO_2 dissolved from $CaCO_3$ of the shell remains in solution. Gains in CO_2 and in non-volatile weak acid are equivalent to gain in Ca, thus these are the only participants in buffering. The process depicts well-regulated use of shell for buffering products of glycolysis during anaerobic metabolism. - J.L.M.

525
Dunstan, W. M., and K. R. Tenore. 1972.

Intensive outdoor culture of marine phytoplankton enriched with treated sewage effluent. Aquaculture 1: 181-192.

526
Dunstan, William M., and Kenneth R. Tenore. 1974.

Control of species composition in enriched mass cultures of natural phytoplankton populations. J. Appl. Ecol. 11: 529-536.

In a series of 3 experiments in which cells were counted and identified during the 6th to 10th day of the daily 50% harvest, N, P, and Si definitely favored growth of diatoms. Addition of just N and P, or N, P, and trace metals stimulated a green micro-algae population. Addition of treated sewage effluent resulted in a 70-80% diatom culture. In another series of experiments the rate of daily dilution was varied and in two experiments in June a clear control of species composition resulted. In 10% daily dilution green micro-algae dominated while at 75% dilution diatoms dominated, particularly *Skeletonema costatum* (now *Stephanopyxis costata*). Results from experiments in July and August were not as definitive as those in June and the ubiquitous diatom *Cylindrotheca closterium* prevailed at all dilution rates. *Mercenaria mercenaria* is not mentioned. - J.L.M.

527
DuPaul, William D. 1972.

Mechanisms of isosmotic intracellular regulation in marine molluscs. Ph.D. thesis, College of William and Mary, 90 p.

Salinity caused changes in concentration of free amino acids and in the activities of alanine and aspartate aminotransferase were measured in gill tissue of *Mercenaria mercenaria*, *Mya*, and *Spisula*. Largest change in concentration of an individual free amino acid due to a salinity increase was noted for alanine which had a 5195% increase in *Mercenaria*, and a 411% and 282% increase in *Mya* and *Spisula*. Changes in concentration of alanine were reflective of salinity induced changes in amino transferase activities. Aspartic acid can serve as an indicator to determine metabolic pathways which are active in the process of intracellular osmotic regulation. Synthesis of alanine for osmoregulatory purposes is directly related to metabolic pathways involving synthesis of pyruvate. - J.L.M.

528
DuPaul, William D., and Kenneth L. Webb. 1974.

Salinity-induced changes in the alanine and aspartic aminotransferase activity in three marine bivalve molluscs. Arch. Internatl., Physiol. Biochim. 82(5): 817-822.

Mercenaria mercenaria, soft clam, and surf clam accumulate intracellular alanine when environmental salinity increases. At seawater salinities alanine makes up 50% to 90% of the total free amino acid (FAA) pool. The experimental increase in salinity was from 20°/°° to 30°/°°. The response had 2 major components, a "fast component" which acted during initial phases of osmotic stress for 2 days and a "slow component" for longer term adjustment. The fast component is important in preventing excessive tissue water loss and cell volume changes during periods of rapid osmotic adjustment. Large increases in alanine concentration occurred in *Mya* and *Spisula* during the first 2 days of stress, and aspartic acid concentration decreased in the same period. On the other hand, the fast component in *Mercenaria* consisted of a large increase in taurine concentration. The slow component response consisted largely of a further increase in the fast component constituent. In *M. mercenaria* concentration of alanine also increased considerably. Alanine aminotransferase levels were higher in *S. solidissima* than in the other 2 species and changed during the experiment. In all 3, activity levels were the same at the end as at the start of the experiment. In the 1st day alanine aminotransferase increased in surf clam and soft clam as alanine concentrations rose. In hard clam, where the large increase in alanine is delayed, alanine aminotransferase decreased during the first day. Aspartic aminotransferase activity decreased slightly in *Mercenaria* and did not regain the original level. Metabolic pathways for alanine accumulation appeared similar to those described for invertebrate facultative anaerobiosis. - J.L.M.

529
Eagar, R. M. C. 1978.

Shape and function of the shell: A comparison of some living and fossil bivalve molluscs. Biol. Rev. 53: 169-210.

This review paper cites the work of Stanley (1975), abstracted elsewhere in this bibliography. - J.L.M.

530
Eckhoff, David W., Neal E. Armstrong, and Martin Lang. 1971.

Ecological factors in Jamaica Bay. In Advances in Water Pollution Research. S. H. Jenkins (ed). Proc. 5th Internatl. Conf., vol. 2. Internatl. Assn. Water. Poll. Research: III-3/1-3/8.

Data are given for benthic animal diversity index as a function of sediment BOD. Organisms are not named, but it is known that *Mercenaria mercenaria* is an important part of the benthos of the Bay (on Long Island, N.Y.). Despite its proximity to New York City, Jamaica Bay had reasonably good dissolved oxygen levels, and BOD values in the 1.5 to 2.5 mg/l range, which was hardly indicative of a highly polluted system, although coliform levels were high and fisheries were depressed. - J.L.M.

531
Együd, Laszlo G. 1965.

Studies on autobiotics: Chemical nature of retine. Proc. U.S. Natl. Acad. Sci. 54(1): 200-202.

Retine is a growth-inhibitor found in calf thymus, mushrooms, human urine, and *Mercenaria mercenaria*. It is a natural keto-aldehyde, which is not identical with methylglyoxal because its activity is considerably higher. Isolation of retine is difficult, probably because alpha-keto-aldehydes are very unstable. Retine inhibited growth of transplanted malign tumors. It showed low polarity on gas chromatography. It appeared to contain a ketone group. The biologically active molecule had a low boiling point and could be partially distilled with chloroform, which indicated a small molecule. It also dissolved readily in common organic solvents. Carcinostatic activity of various glyoxal derivatives is known, and a great number have been synthesized and tested. Most were carcinostatic toward certain tumors and leukemia. One promoted cancerous growth under certain conditions, which supports the possibility that promine and retine are closely similar. The glyoxalase system acts on various α-keto-aldehydes as substrates, transforming them into lactic acid or its analogs in presence of glutathione. Glyoxalases, widely distributed among vegetable and animal tissues, including microorganisms, do not appear to fit into any currently accepted systems of carbohydrate metabolism. These enzymes may play a role in regulating cell growth. - J.L.M.

532
Eisler, Ronald. 1970.

Latent effects of insecticide intoxication to marine molluscs. Hydrobiologia 36(3-4): 345-352.

Test animals were adult quahaugs, *Mercenaria mercenaria*, and mud snails, *Nassa obsoleta*, from Sandy Hook Bay, N.J. exposed to various concentrations of 4 organochlorine insecticides and 4 organophosphorus compounds. All clams survived exposure for 96 hrs to concentrations of up to 10 mg/l of organochlorine insecticides and up to 25 mg/l of organophosphorus compounds. By the 133rd day post-treatment all clams appeared unaffected except those which had been exposed to 25 mg/l DDVP. Of these, 2 of 3 died on the 3rd and 4th days after treatment. The survivor died on day 62. Clams and snails appeared to be more resistant than various marine teleosts and decapod crustaceans. Treatment for 96 hrs, however, was not sufficient to evaluate adequately the effects of some insecticides on mollusks. - J.L.M.

533
Eisler, R. 1972.

Pesticide-induced stress profiles. In Marine Pollution and Sea Life. Mario Ruivo (ed). Fishing News (Books) Ltd., London, p. 229-233.

Obvious changes in stress profiles occurred when *Mercenaria mercenaria* were exposed for 96 hrs to various concentrations of methoxychlor or malathion. Results were quoted from a paper by Eisler and Weinstein (1967), abstracted elsewhere in this bibliography. - J.L.M.

534
Eisler, Ronald, and Melvin P. Weinstein. 1967.

Changes in metal composition of the quahaug clam, *Mercenaria mercenaria*, after exposure to insecticides. Chesapeake Sci. 8(4): 253-258.

Adult quahaugs survived for 96 hrs when exposed to malathion concentrations as high as 37,000 ppb and methoxychlor as high as 1,100 ppb. Each clam regularly extended its siphon and showed its mantle edge at least once daily. Behavior showed no detectable difference from that of controls. Thus, hard clams are more resistant to these insecticides than many marine fish and crustacean species. Clams will concentrate these substances in their tissues. Quahaugs in 19 l of seawater containing 4 ppb methoxychlor accumulated residues, wet weight, of 1,300 ppb in gills and 75 ppb in mantle. At concentrations of 22 to 1,100 in the medium absolute amounts of methoxychlor increased, but at a greatly reduced rate. Normal outward appearance and behavior of quahaugs containing whole body residues of 1,600 ppb methoxychlor suggests that clams may not be capable of detecting this insecticide at those levels. Analysis of whole animal and selected tissues showed that pesticide-exposed clams had different concentrations of certain metals in their tissues than controls. Quahaugs exposed to 1,100 ppb methoxychlor showed greatest differences from controls in levels of mantle Zn (+42%), muscle Ca (-42%), muscle K (+36%), mantle Ca (-35%), muscle Na (+32%), whole clam Ca(-31%), muscle Mg (+23%), and mantle K (+16%). The greatest changes shown when exposed to malathion were in mantle Zn (+61%), mantle Ca (-36%), and muscle Ca (-29%). Unlike clams exposed to methoxychlor, those exposed to 37,000 ppb malathion contained less K in mantle (-32%) than controls. Graphic profiles based on metal shifts among tissues might be used to identify unfavorable environmental conditions before obvious morphological or physiological changes occur. - J.L.M.

535
Eisler, R., G. R. Gardner, R. J. Hennekey, G. LaRoche, D. F. Walsh, and P. P. Yevich. 1972.

Acute toxicology of sodium nitrilotriacetic acid (NTA) and NTA-containing detergents to marine organisms. Water Research, Pergamon Press 6(9): 1009-1027.

Phosphates in detergents are useful water softeners, but excessive amounts contribute to eutrophication of natural waters. The monohydrated sodium salt of nitrilotriacetic acid (NTA) is an effective chelating agent, used alone or as partial replacement for polyphosphates in heavy-duty detergents. NTA is degraded only partially by activated sludge columns. Thus, discharge of large quantities of NTA into the environment is a matter of concern. Eleven invertebrate and fish species, including *Mercenaria mercenaria*, were used to screen toxicity of NTA and NTA-containing syndets. Quahaug and bay mussel were most resistant to sodium nitrilotriacetic acid (TL_{50}, 168 hr values) 10,000 mg/l. Quahaugs were more sensitive to syndet Ch and syndet Ga. No histopathological effects were observed. NTA was most toxic at comparatively low salinities. It was concluded that NTA might be hazardous to marine teleosts and higher invertebrates and that additional research should be done. - J.L.M.

536
Eissinger, Richard A. 1975.

Progress in central California shellfish seed production. Proc. Natl. Shellf. Assn. 65: 7(abstract).

International Shellfish Enterprises, a 4-yr old company, is presently expanding facilities to sell large quantities of oyster and clam seed. Clam seed of 3-7 mm will be available for planting. The hatchery and nursery tank farm will use warm water from a Moss Landing, Calif., power plant. - J.L.M.

537
Eldridge, Peter J. 1978.

Comparative survival and growth rates of hard clams, *Mercenaria mercenaria*, planted in trays subtidally and intertidally at varying densities in a South Carolina estuary. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978 (abstract: page not numbered).

Clam seed were planted at densities of 290, 869, and 1,160/m^2 and these densities were maintained throughout the experiment. Average size remained similar from May through December 1975, then clams at the lowest density grew faster than the others. At 290 clams/m^2 average length was about 45 mm in 19 months. At higher densities clams took 9 months longer to reach that size. Survival at 290/m^2 was significantly lower than at higher densities. - J.L.M.

538
Eldridge, Peter J., Arnold G. Eversole, and Jack M. Whetstone. 1979.

Comparative survival and growth rates of hard clams *Mercenaria mercenaria*, planted in trays subtidally and intertidally at varying densities in a South Carolina estuary. Proc. Natl. Shellf. Assn. 69: 30-39.

Seed clams, *Mercenaria mercenaria*, were planted in subtidal trays subtidally and intertidally at densities of 290, 869, and 1,159/m^2. Densities were maintained throughout the experiment. Average size was similar from May to December 1975, then clams at the lowest density attained an average length of about 44 mm 19 months after planting. Clams at intermediate density grew slower, and clams at highest density grew slower yet, taking approximately 12 months longer to reach an average length of about 44 mm. Survival was higher subtidally than intertidally. Survival of clams in the lowest density treatment was significantly lower than at higher densities. *Panopeus herbstii* was the most abundant predator. Experiments showed that survival was positively correlated with increased average size and cooler water temperatures. Shell or aggregate substrate and areas without extensive wave action or shifting substrate also improved survival. Survival approached 90 to 95% by the time clams had reached 16 to 17 mm average size. Clams averaging 13 mm long, planted at a density 290/m^2, can attain a mean size of 44 mm in about 18 months and 51 mm in 24 months. The following mariculture strategy was proposed for South Carolina. First, select a suitable habitat, not exposed to extreme wave action, and where clams are found. Next, creek bottom should be covered with shells or similar aggregate at approximately one bushel/m^2 in summer. In fall, when water temperatures are between 15 and 18°C and declining, clams 12 to 15 mm average size should be planted at approximately 300/m^2. Clams should attain average size of about 45 mm in early summer of the second year about 18 months after planting. The authors feel it would be risky for a private investor to undertake such a project at present. But a pilot project including economic feasibility would be a good candidate for a governmental supported activity. - J.L.M.

539
Eldridge, Peter J., Wayne Waltz, and Holland Mills. 1976.

Relative abundance of *Mercenaria mercenaria notata* in estuaries in South Carolina. Veliger 18(4): 396-397.

The best estimate of relative abundance of *M. mercenaria notata* was 1.23% of total clams sampled, varying from 0.71 to 2.17% in individual samples. This represents clams equal to or greater than 25 mm in width. It was assumed that the ratio held true for smaller clams as well. - J.L.M.

540
Eldridge, Peter J., Wayne Waltz, Robert C. Gracy, and Hurshell H. Hunt. 1976.

Growth and mortality rates of hatchery seed clams, *Mercenaria mercenaria*, in protected trays in waters of South Carolina. Proc. Natl. Shellf. Assn. 66: 13-20.

Commercial use of hard clam in S.C. has not been large because the size of the resource was not well known and markets were not developed. Hatchery seed from Coastal Zone Resources of N.C. were used. Planting was in metal-framed trays (119x58x14 cm). Trays were lined with 1/4 in (6 mm) galvanized hardware cloth with fiberglass insect screens in the bottom, then filled with sand or sand with shell to a depth of about 10 cm. To reduce predation by crabs, trays were covered with galvanized hardware cloth and wired shut. This reduced predation only partially. Trays were placed in intertidal zone in widely separated areas. Clams were planted at 200, 400, and 600/tray. Those that died were not replaced. Clams were counted and measured every 3 months. After 18 months 51.3% survived at Bull Bay, 45.1% at Clark Sound, and 49.8% at Albergottie Creek. Mean growth at different population densities at the same site did not vary appreciably, but clams at two of the sites grew nearly twice as rapidly as at Bull Bay. This may have been caused by the longer exposure at low tides at this site. Average monthly growth was 0.8, 1.5, and 1.8 mm. Growth rates varied with season, but growth continued throughout the year. Water temperatures never dropped below 10°C. - J.L.M.

541
Elliott, G. F., Jean Hanson, and J. Lowy. 1957.

Paramyosin elements in lamellibranch muscles. Nature 180(4597): 1291-1292.

In experiments with *Mercenaria mercenaria* and 4 other mollusks it was found that some tropomyosin can be left behind in the paramyosin ribbons when muscle is extracted with neutral hypertonic KCl solutions. It was concluded that water-insoluble tropomyosin is located in the paramyosin ribbons of lamellibranch smooth muscles. The ribbons are sub-units of the filaments in the intact fiber. It remains to be determined if these filaments also contain actomyosin and if tropomyosin is involved in the contractile mechanism. A full account of the structure of these muscles was to be published elsewhere. - J.L.M.

542
Eltringham, S. K. 1971.

Life in Mud and Sand. English Universities Press, London, vi + 218 p.

A general text. References to *Mercenaria (Venus) mercenaria* are few. The force that pulls the shell downwards in digging is only 5 to 6 gm in *Mercenaria mercenaria*, which has an axe-shaped foot, compared to 800 g in *Ensis arcuatus*, which has a bulbous terminal anchor. Burrowing sequence in a generalized bivalve, similar to *Mercenaria*, is illustrated. In some lamellibranchs, gametogenesis will begin at a particular environmental temperature but will not proceed to the production of gametes if temperature is experimentally prevented from rising further. *Venus mercenaria* under such conditions appears to be able to hold the gametes in cold storage and to release them when conditions are suitable. - J.L.M.

543
Engel, Robert H., and Marilynn J. Neat. 1970.

Glycolytic and gluconeogenic enzymes in the quahog, *Mercenaria mercenaria*. Comp. Biochem. Physiol. 37(3): 397-403.

Catalytic rates of glycolytic and gluconeogenic enzymes in quahog foot, mantle, and gill tissues were extremely low compared to rat liver. Mammalian tissues exhibit preferences for particular metabolic pathways, usually reflected in catalytic capacities of critical enzymes. Analogous preferences were not found in tissues of *M. mercenaria*. Absence of glucose-6-phosphatase in normal quahog tissue suggests that the clam cannot complete synthesis of glucose via glucose-6-phosphate. Glucose-6-phosphatase was not assayed in starved quahogs, but perhaps it may be activated under such conditions. Partially starved quahogs showed changes in glycogen, glucose-6-phosphate dehydrogenase, and fructose diphosphatase levels similar to those observed in mammalian tissue. - J.L.M.

544
Engel, Robert H., and Marilynn J. Neat. 1974.

Occurrence of specific and non-specific cholinesterases in the quahog, *Mercenaria mercenaria.* Comp. Biochem. Physiol. 48A(3): 407-410.

Cholinesterase activity was measured in foot, gill, and mantle tissue. Substrate saturation and specificity studies showed that gill enzyme was a specific cholinesterase, while mantle activity was ascribed to a non-specific cholinesterase. Quahogs were obtained from Duxbury Bay, Mass. - J.L.M.

545
Engel, R. H., M. J. Neat, and R. E. Hillman. 1972.

Sublethal chronic effects of DDT and Lindane on glycolytic and gluconeogenic enzymes of the quahog, *Mercenaria mercenaria.* In Marine Pollution and Sea Life. M. Ruivo (ed.). Fishing News (Books) Ltd., London, p. 257-260.

The study was made to determine if sublethal chronic doses of insecticides, at concentrations currently existing in estuarine waters, could alter activity of key regulatory enzymes and thus effect intermediary metabolism. It was clear that overall catalytic capacity of *Mercenaria mercenaria* was well below that of mammalian tissue. The most striking effect of DDT and lindane on hard clams appeared to be a consistent decrease in fructose diphosphatase activity as compared to controls. This suggested that chlorinated hydrocarbons may interfere with gluconeogenesis. Quahogs used in the study were under metabolic stress from partial starvation. Normal environmental variations which create similar stress might be exacerbated in presence of DDT or lindane. Exposure to chlorinated hydrocarbons also gave a slight but significant decrease in mantle lactic dehydrogenase. DDT reduced glucose-6-phosphate dehydrogenase content of gill tissue to almost nothing. Lindane gave a significant increase in foot glucose-6-phosphate dehydrogenase activity. It was concluded that glycolysis is an operative metabolic pathway in quahog tissue, and that it responds to stress such as starvation with compensating mechanisms analogous to those identified in mammalian tissue. Chronic exposure to sublethal doses of chlorinated hydrocarbons could lead to an increase in glucose degradation and suppression of gluconeogenesis. - J.L.M.

546
Engle, James B. 1964.

A brief history of Federal shellfish investigations in Chesapeake Bay. In The Bureau of Commercial Fisheries Biological Laboratory-Oxford, Maryland: Programs and Perspectives. U.S. Dept. Interior, Fish Wildl. Serv., Circ. 200, p. 1-7.

547
Engle, James B. 1966.

The molluscan shellfish industry, current status and trends. Proc. Natl. Shellf. Assn. 56: 13-21.

Hard clam, *Mercenaria mercenaria*, has filled an important role in the economy of the Mid-Atlantic and lower New England areas of the U.S. coast. Many oyster growers have turned to hard clam harvesting as a significant adjunct to the declining oyster business. About 50% of hard clam production comes from the Mid-Atlantic area, about 95% from Narragansett Bay, Long Island Sound, Long Island bays, Maryland and Virginia coastal bays, and lower Chesapeake Bay. A great natural expansion of the clam population has occurred in bays of Long Island. In New York State a minimum size law and selective harvesting with hydraulic dredges (on private grounds) have greatly assisted in cultivation, recruitment, and conservation of the resource. - J.L.M.

548
Engle, James B. 1970.

Oyster and clam management. In A Century of Fisheries in North America. Norman G. Benson (ed.). Am. Fish. Soc., Washington, D.C., Spec. Pub. 7: 263-276.

Hard clam is second in economic importance and pounds of meat produced (presumably as compared with all clam production in the United States). Range is from Canada to Mexico, but most commercial production is from N.Y., N.J., and Del. Commercial production in 1966 was 15.3 million pounds (meats), 21% of U.S. clam production by weight. This is still mainly a "wild fishery" with minimal management. Commercial categories of hard clam are described. Several commercial companies produce seed in hatcheries. Small littlenecks (Pennsylvania nicks) average 1,500 count/bu, and average 46 mm long (40-48 mm); New York littlenecks 1,200/bu, average 56 mm long (52-60 mm); large littlenecks, small cherrystones, cherrystones, large cherrystones, and medium chowders overlap in count and size; large littlenecks average 1,000 count and average 68 mm long (61-72 mm); large cherrystones 800 count, 77 mm (72-82 mm); medium chowders 500 count, 88 mm (83-92 mm); and large chowders 300 count, 97 mm (91-109 mm). Recently introduced hydraulic escalator dredge harvests hard clam efficiently with surprisingly little damage. Other gears are hand tools, scrape dredges, hand tongs, and rakes. Regulations from Maine to Florida are summarized in a table. Minimum legal size varied considerably between states, and some had no minimum size limit. Gears were variously regulated, or not at all. Closed seasons varied from none to various arrangements. Full potential yield is often prevented by inadequate management. Many regulations have political and sociological bases. Scientific research must be the foundation upon which intelligent management is based. Results must be communicated to management and industry. - J.L.M.

549
Environmental Protection Agency. 1971.

Report on the water quality of Long Island Sound. EPA, Water Quality Off., NE Region, CWT 10-29, ix + 38 p. and appendices.

New York waters of Long Island Sound contain 433,000 acres, of which over 100,000 are suitable for shellfish. Approximately 61,000 acres, including producing and non-producing bottoms, are closed to shellfishing. Connecticut has 83,000 acres of shellfish growing areas, about 15,000 of them closed to shellfishing (as of 1966 Pub. Health Serv. Natl. Register of Shellfish Growing Areas). Conn. Shellfish Commission administers about 57,000 acres of franchised, leased, and public shellfish grounds. Closed areas in N.Y. were: all of Long Island Sound west of a line between Byram R. on the north and Prospect Pt. on the south, including the entire Westchester County shoreline, East R., Little Neck B., and Manhasset B.; Hempstead Har; vicinity of Matinicock Pt; part of Oyster B. Har; part of Cold Spring Har; part of Huntington Har; part of Centerport Har; part of Northport Har; Nissequogue R; part of Port Jefferson Har; an area off Northville, where there is an oil unloading facility; vicinity of Mattituck In; vicinity of Inlet Pt. (Greenport sewer outfall); and vicinity of west end of Fishers Is. In N.Y. hard clams were harvested from closed beds of Westchester and Nassau Counties for transplantation to open waters along the south shore of Long Island. Long Island Oyster Farms Inc. constructed a hatchery at Northport at a cost of nearly $1 million. Appendix C. contains a copy of a letter from L.I. Oyster Farms and State of Conn. Shell Fish Commission, regarding economic losses to the shellfish industry caused by water pollution. Today (11 Feb 1971) shellfish grounds consist of about 64,000 acres, 46,000 under State control, 18,000 controlled by towns. These include 42,000 acres of oyster ground, 20,000 acres clam ground, and 2,000 acres scallops, in general located from Greenwich to Branford. From Branford to Stonington it was largely a sport shellfishery, although some commercial grounds were in this area. Total product value, commercial and sport, was estimated to be $2.5 million. About 35% of all shellfish grounds in Conn. were closed by pollution. Artificial spawning of oysters and clams is being done on Long Island. The letter gives descriptions of areas polluted and makes certain recommendations. - from notes made from an interlibrary loan copy of the report obtained from N.Y. State Library, Albany - J.L.M.

550
Epifanio, C. E. 1973.

A marine analogue to the husbandry of poultry on land. Proc. Del. Acad. Sci., 9 p.

A manuscript with the same title was received from Thomas Pickett, President Delaware Acad. Sci. with the information that this was a draft, to be published in vols. 3 & 4 of Del. Acad. Sci. in 1978. The date above must be in error. The paper describes briefly the procedures used in oyster and clam *(Mercenaria mercenaria)* culture at the University of Delaware. Brood stock is collected in spring from wild stocks and held in flowing seawater at 15°C. Cultured algae *(Phaeodactylum tricornutum)* are maintained in the water at 10^4 cells/ml. After 5 to 6 weeks conditioning bivalves can be spawned at any time, by transferring rapidly to 28°C seawater. This is often sufficient to stimulate release of gametes, but usually a male is sacrificed and some sperm introduced into the water as a further stimulus. Veliger larvae develop about 24 hrs after fertilization. They are fed with cultured *Isochrysis galbana* and *Monochrysis lutheri*. Clams complete larval development in an average of 10 days. Metamorphosed larvae set on sides and bottom of growing tanks. They detach later. Culture to market size has not yet been completed. Culture is in recirculating water in which conditions are highly controlled. Nitrification is accomplished in a submerged biological filter, ultraviolet radiation controls bacteria, and an activated carbon filter adsorbs dissolved organic compounds. Alkalinity and temp are controlled. Detailed records of conditions are maintained. Algal cultures produce up to 10^{13} cells/day. Fastest growing clams have grown to better than 30% of market size in 9 months. It is expected that market size will be reached in about 2 yrs. There do not appear to be any behavioral barriers to growing large numbers of clams in relatively small space. It appears possible to recycle nitrogenous excreta to greenhouse culture of algae. Food value of algal species varies greatly. More research is needed. Details are given more completely in published papers abstracted elsewhere in this bibliography. - J.L.M.

551
Epifanio, Charles E. 1976.

Culture of bivalve mollusks in recirculating systems: Nutritional requirements. In Proc. 1st Internatl. Conf. Aquacult. Nutrition, October, 1975. Sea Grant Coll. Program, Univ. Del. and U.S./Japan Aquaculture Panel, p. 173-194.

This review paper concludes that, although interest in nutrition of juvenile and adult bivalves has increased considerably, level of knowledge is low compared with that for decapods or fishes. No nutritionally adequate, formulated diet for bivalves has yet been developed. Research has been limited largely to determining which commonly cultured algal species are good foods, and to studying energetic efficiences of bivalves fed algal diets. The amount of control that can be exerted over chemical composition of algae is small compared to that possible with formulated diets, but when formulated diets are not available, it is reasonable to continue experimenting with modified algae. Reasons for failure of formulated diets to support normal growth of bivalves may be as much physical as biochemical. Different techniques should be developed for producing particles of appropriate size, texture, and other characteristics, as well as chemical composition. More detailed analyses of algal species which are good foods also should be done. Major obstacle to development of commercially viable intensive bivalve culture systems is continuing inability to produce massive algal cultures at reasonable cost. Solution of problems associated with mass culture of algae is needed, as well as improved information on nutritional requirements of bivalves. Papers cited with reference to *Mercenaria (Venus) mercenaria* are abstracted elsewhere in this bibliography. - J.L.M.

552
Epifanio, C. E. 1979.

Growth in bivalve molluscs: Nutritional effects of two or more species of algae in diets fed to the American oyster *Crassostrea virginica* (Gmelin) and the hard clam *Mercenaria mercenaria* (L.). Aquaculture 18: 1-12.

Mercenaria mercenaria were fed 15 different diets composed of various mixtures of four species of algae (*Carteria chui*, *Isochrysis galbana*, *Platymonas suecica*, and *Thalassiosira pseudonana*) for 6 weeks. Growth of hard and soft tissue was not correlated with gross chemical (protein, lipid, carbohydrate, or ash) or amino acid composition of the diets, but was related to presence or absence of particular algal species. Growth was generally least in diets containing large proportions of *C. chui* and greatest in diets containing large amounts of *I. galbana* or *T. pseudonana*. Diets containing *I. galbana* and *T. pseudonana* invariably supported greater growth than diets consisting of either species, indicating synergism in the relative food values of the species. *P. suecica* was a relatively poor food when used as the sole component of the diet, but its food value was markedly increased when fed in combination with either or both *I. galbana* and *T. pseudonana*. One possible explanation could be that *C. chui* and *P. suecica* are deficient in some growth promoting micronutrient found in relatively high quantities in *I. galbana* and *T. pseudonana*. If this acted in such a way that a threshold quantity were necessary for growth but that additional quantities did not increase growth, then nonadditive effects might be expected in diets combining deficient with replete algae. An alternative explanation involves the relative digestibility of various algal species. - J.L.M.

553
Epifanio, C. E. 1979.

Comparison of yeast and algal diets for bivalve molluscs. Aquaculture 16(3): 187-192.

Growth of young *Mercenaria mercenaria* (initial dry weight 10 mg soft tissue) was comparable to that of controls when the diet contained up to 50% yeast. It is clear that *Candida utilis* can replace 50% of the algae without loss. - J.L.M.

554
Epifanio, C. E., and R. F. Srna. 1975.

Toxicity of ammonia, nitrite ion, nitrate ion, and orthophosphate to *Mercenaria mercenaria* and *Crassostrea virginica*. Mar. Biology 33: 241-246. College of Marine Studies, Univ. Delaware, Newark, Del. - DEL-SG-5-76.

Surprisingly high tolerance toward chemicals tested was exhibited by both bivalve species. Juveniles and adults were about equally tolerant. Lethal and sublethal responses were tested. Highest concentrations tested on *M. mercenaria* were $8x10^{-2}M$ NH_4Cl, $10x10^{-2}M$ $NaNO_2$, $32x10^{-2}M$ $NaNO_3$, and $6x10^{-4}M$ Na_3PO_4. Ninety-six hour mean lethal tolerance limit (TL_m) of *M. mercenaria* ranged from 1.1 to $1.6x10^{-2}M$ (110 to 172 mg/l) for ammonia and 8.1 to $8.5x10^{-2}M$ for nitrite. Tolerances to nitrate and orthophosphate were so high as to make definition of a 96-hr TL_m ecologically meaningless. Sublethal effects were measured by rate of removal of the planktonic alga *Isochrysis galbana* from the water. Sodium phosphate did not affect feeding rates over the entire range tested, but each of the other 3 chemicals did. It was concluded that *M. mercenaria* is very unlikely to be exposed to acutely toxic concentrations of the 4 chemicals in the natural environment. Effluents even of secondarily treated domestic sewage rarely contain levels as high as the 96-hr TL_m reported. - J.L.M.

555
Epifanio, Charles E., Carla Mootz Logan, and Christine Turk. 1976.

Culture of six species of bivalves in a recirculating seawater system. Coll. Mar. Stud., Univ. Del., Newark and Lewes, Del. DEL-SG-1-76, 19 p.

This abstract includes a digest only of the work with *Mercenaria mercenaria* unless, for comparisòn, other information appeared to be merited. Experimental animals were reared from eggs fertilized in the laboratory from parents taken in local waters. The culture system was closed. No wild phytoplankton was in the system, thus clams received only algae provided experimentally. Water was purified periodically in waste treatment apparatus, and tanks and shellfish were cleaned with jets of fresh water. Shellfish were held above the bottom on plastic racks. Growth was measured by shell height, but dry tissue weight was measured occasionally. Clams had developed ripe gonads after one year's growth. Eight experimental groups were fed 4 species of alga, singly or in some combination. Amount fed was increased during the experiment. *Phaeodactylum tricornutum* alone proved to be a very poor diet. Clams did not grow appreciably and all died within 25 weeks. All other diets produced growth during a 46-week experiment. Best growth was given by a mixture of equal numbers of *P. tricornutum, Carteria chuii, Isochrysis galbana,* and *Croomonas salina.* This fastest growing group was cultured for 110 weeks. Average shell height was about 29 mm at end of experiment. In experiment 2 *Thallassiosira pseudonana* was substituted for *P. tricornutum.* Newly set *M. mercenaria* were fed equal numbers of the four algal species in the same quantities as before. Growth rate was double that in the first experiment. In experiment #3 *T. pseudonana* alone supported growth equal to the 4-species diet. In experiment 4 previous results with American oyster and hard clam were compared with the same feeding experiments on other bivalves (*Crassostrea gigas, Tapes semidecussata,* and *Ostrea edulis*). Results were essentially the same. Annual growth rate of the fastest growing hard clams in these experiments was nearly five times natural growth anywhere in the geographic range of the species. - J.L.M.

556
Epifanio, Ch. E., C. Mootz Logan, and Ch. Turk. 1976

Culture of six species of bivalves in a recirculating seawater system. Proc. 10th Europ. Symp. Mar. Biol., Vol. 1: 97-108.

Mercenaria mercenaria, fed diets of 4 algal species, *Carteria chuii, Croomonas salina, Isochrysis galbana,* and *Thallassiosira pseudonana,* grew to marketable size in 1 yr as compared to 3 to 5 yrs in the natural environment. *Phaeodactylum tricornutum* by itself was a poor diet. Hard clams did not grow appreciably on this diet and all clams died within 25 weeks. *T. pseudonana* was an excellent food. The recirculating culture system is described. - J.L.M.

557
Epifanio, Charles E., Richard Srna, and Gary Pruder. 1975.

Mariculture of shellfish in controlled environments: a prognosis. Aquaculture 5: 227-241.

Husbandry of any species in a controlled environment depends on detailed knowledge of biology of that species. Literature on hard clam is almost as voluminous as that on American oyster. The authors reviewed literature on food and feeding, oxygen requirements, production of CO_2, nitrogenous excreta, solid wastes, ammonia, nitrites and nitrates, pH, organic compounds, salinity, and temperature, for American oyster and hard clam, and concluded that much information necessary for controlled culture is not available, or is inferential at best, especially for *Mercenaria mercenaria.* Much more basic biological information must be gathered if design of workable culture systems is to succeed. "Close to nature" culture is technologically easier, and much present mariculture has followed this route. (Abstracter's note: This is a review paper, and details have not been given in this abstract because they are contained in abstracts of papers consulted by the authors, which also appear in this bibliography if they contain original information on hard clam. Inferences and comments on hard clam in the paper above which were not taken from the literature are summarized here: We can conclude that there is a range of algal cell concentrations wherein clams can filter most efficiently. This range will be different for each algal species, depending on size of algal cell and effects of its metabolites on the mollusk. Total inhibitory effect of a mixture of algae may be different from that of component species. Literature contains several quite different assessments of total amount of food eaten by clams and oysters. The animals appear to remove more cells from flowing than from standing water. Results of laboratory studies imply that they eat more than has been estimated from field experiments. There are no reported studies of respiratory quotient for hard clam, but there is no reason to suspect that it is very different from that of *Crassostrea virginica*, which was calculated by Galtsoff as 1.00 for carbohydrate, 0.79 for protein, and 0.71 for lipid, or a mean RQ of 0.85 ± 0.24. The authors found no published report on quantities of nitrogenous wastes excreted by hard clam, but assuming that the ratio of production of ammonia in a 100-gram clam is similar to that of American oyster they derived the following formula: $\log Q_{NH_3} = -0.344 \log W - 0.234$, where Q_{NH_3}=micromoles NH_3/g whole weight/hr at 25°C and W=whole weight(wet). Information on deposition of solid wastes does not exist for hard clam. The authors considered that total ammonia nitrogen may be safely maintained at 10 ppm in clam culture systems. There have been no studies of high levels of nitrates on marine organisms. The authors give a conservative estimate of upper limit of tolerance to nitrate for hard clam as about 325 ppm. They believe that pH should be maintained in a clam maricultural system above 7.8. Specific types of organic compound occurring in recirculated sea water are poorly known, as are their physiological effects on bivalves. Growth of *M. mercenaria* at temperatures above 23°C is not known, nor is the effect of temperature upon growth when quality and quantity of food is controlled. There is not sufficient information on filtering rates of hard clam of various sizes, nor on relations between biodeposition and body size. There have been no studies on effects of varying concentrations of ammonia, nitrites, or nitrates on clams. Latest literature citation is 1975, which suggests that the review is up to date through 1974.) - J.L.M.

558

Epifanio, Charles E., Gary Pruder, Michael Hartman, and Richard Srna. 1973.

An interdisciplinary study on the feasibility of recirculating systems in mariculture. Proc. 4th Annual Workshop, World Mariculture Soc. Louisiana State Univ., Div. Continuing Education, Baton Rouge, p. 37-52.

Once the biological filter was conditioned and the start up procedure documented, 20,000 juvenile hard clams, *Mercenaria mercenaria*, were introduced. The clams are held on screened baskets. They are fed at an algal concentration of 25,000 cells/mℓ. *Platymonas* sp., *Carteria* sp., *Nannochloris aculata*, and *Phaeodactylum tricornutum* were used as food. The carrying capacity of the system has not yet been determined. The tank was designed only for rearing juveniles smaller than 4 mm in width. - J.L.M.

559

Erspamer, V., and F. Ghiretti. 1951.

The action of enteramine on the heart of molluscs. J. Physiol. 115(4): 470-481.

560
Evans, John W. 1975.

Growth and micromorphology of two bivalves exhibiting non-daily growth lines. In Growth Rhythms and the History of the Earth's Rotation. G. D. Rosenberg and S. K. Runcorn (eds.). John Wiley & Sons, London, p. 119-124.

The author comments that Pannella and MacClintock's (1968) experimental study of growth lines in *Mercenaria mercenaria* seemed to establish without doubt that micro-growth lines were of solar daily duration, yet Pannella (1972) claimed that they were of lunar daily duration, even though his original counts do not bear out this contention. Counting growth lines is not easy and it is constantly necessary to make subjective decisions about whether a line is really a line, or where an annual or monthly series begins or ends. Thus, it is not surprising that counts often come out close to hypothetical values. - J.L.M.

561
Eversole, Arnold G. 1978.

Marking clams with rubidium. Proc. Natl. Shellf. Assn. 68: 78 (abstract).

Mercenaria mercenaria were successfully marked with rubidium by rearing seed clams in artificial seawater with an aqueous solution of rubidium chloride. Clams exposed for 48 and 96 hrs to 10.0, 1.0, 0.1, and 0.01 g/l RbCl had levels of Rb significantly higher than endogenous levels. Biological activity was not affected by presence of RbCl at concentrations less than 10.0 g/l. Significantly higher levels of Rb were present in tissue for up to 3 wks when clams were exposed to 1.0 g/l RbCl for 96 hrs, then transferred to uncontaminated water. Clams cultured for 96 hrs in vessels containing diatoms (*Phaeodactylum tricornutum*) exposed to 1.0 g/l RbCl had significantly more Rb than clams grown with unlabelled diatoms. Clams exposed to 1.0 g/l RbCl solutions with and without diatoms contained levels of Rb significantly higher than clams reared only with labelled diatoms. - J.L.M.

562
Eversole, Arnold G., Peter J. Eldridge, and William K. Michener. 1980.

Reproductive response to increased density: Some observations from molluscs. Natl. Shellf. Assn., Abstracts, Technical Sessions: 1 (abstract).

The amount of gonadal tissue in *Mercenaria mercenaria* grown at three population densities was compared. Clams at the lowest density were larger, weighed more, and had more gonadal tissue than clams from higher densities. Gonadal-somatic indices indicated that the density-dependent reduction of growth did not fully account for the reductions in amount of gonadal tissue. - J.L.M.

563
Farley, C. Austin. 1978.

Viruses and viruslike lesions in marine mollusks. Mar. Fish. Rev. 40(10): 18-20.

This report summarizes the known characteristics of molluscan viruses and attempts to categorize them into appropriate families. Pedoviridae: chlamydial parasite of *Mercenaria mercenaria*; nucleic acid - unknown, presumptively 2 DNA linear; symmetry - octahedral on the basis of 2- 3- 4-sided rotational planes in paracrystalline array; size- 50 nm, noneveloped virion; morphology and development - short tails visible in 4-sided plane of array at 45° angle from the square. Herpetoviridae: other possible herpes infections in mollusks based on similarity of intranuclear inclusions have been seen in *Mercenaria mercenaria*. Recent observations of gonadal "tumors" in hard clams indicate the presence of herpes-type intranuclear inclusions in affected cells. - J.L.M.

564
Farrington, John W., and James G. Quinn. 1971.

Studies on the fatty acids and hydrocarbons in recent sediments and benthic animals from Narragansett Bay, Rhode Island. In Abstract Volume, Second National Coastal and Shallow Water Research Conference, sponsored by Geography Programs, Office of Naval Research, University Press, Univ. of Southern Calif: 67.

Mercenaria mercenaria and sediment samples show a gradient of hydrocarbon distribution which might reflect chronic oil pollution for the benthos of the stations sampled. - J.L.M.

565
Farrington, John W., and James G. Quinn. 1973.

Petroleum hydrocarbons in Narragansett Bay. I. Survey of hydrocarbons in sediments and clams *(Mercenaria mercenaria)* Estuar. Coast Mar. Sci. 1(1): 71-79.

Surface sediments from 8 stations and hard clams from 3 stations in Narragansett Bay contain a very complex mixture of hydrocarbons not present in clams in relatively unpolluted Charlestown Pond nearby. This complex mixture is present in crude and fuel oils, and is not a likely product of recent biosynthesis by marine organisms. Sewage effluents and small oil spills are the most probable sources of the petroleum hydrocarbons. Residues in clams decrease from upper to lower estuary. Major oil spills had not been recorded in the area during the past 20 yrs. It is recommended that efforts to reduce constant dribbling of oil into the marine environment should accompany efforts to prevent occurrence of large accidental oil spills. - J.L.M.

566
Feder, Howard M. 1955.

On the methods used by the starfish *Pisaster ochraceus* in opening three types of bivalve mollusks. Ecology 36(4): 764-767.

Work of Reese (1942) on *Venus* is mentioned. No original data on hard clam. - J.L.M.

567
Federal Water Pollution Control Administration. 1967.

Proceedings of the Conference on the Pollution of Raritan Bay and Adjacent Interstate Waters. U.S. Dept. Interior, Washington, D.C., 3 vol., 1382 p.

Vol. 1 contains information about MPN total coliform, MPN fecal coliform, and presence of *Salmonella* in shellfish samples, but shellfish species are not named. Vol. 2 has papers on shellfish resources of Raritan Bay, by Robert Campbell; fish and wildlife resources, by Jacobson and Gharrett; chemical analyses of shellfishes by the Chemistry Section of the Northeast Research Center of the U.S. Public Health Service of H.E.W., Narragansett, R.I. Identified as appendices A, B, and G of the Report, these are abstracted elsewhere in this bibliography. Vol. 3 contains a statement by David H. Wallace on fish and shellfish resources, also abstracted elsewhere in this bibliography, and a copy of the Manual of Operations, National Shellfish Sanitation Program, Parts I, II, and III. - J.L.M.

568
Feingold, Alan O. 1973.

Hepatitis from eating steamed clams. J. Am. Med. Assn. 225(5): 526-527.

Steamed, as well as raw clams, may transmit the hepatitis virus. A 21-year-old male student and three other friends spent a weekend in early May on the Rhode Island shore. They dug clams. He ate them steamed and fried. His companions ate them raw as well. About 5 weeks later abdominal epigastric pains developed, and gradually the other symptoms. He required no other treatment than bed rest at home. Jaundice cleared after 10 days and health returned in 3 wks. Two of the other friends developed jaundice and concurrently underwent similar episodes. Family contacts received immune serum globulin prophylaxis, and no secondary cases developed. Steaming clams produces internal temps below what is necessary to inactivate the hepatitis virus. This accidental in vivo experiment, especially in conjunction with other cases, demonstrates that steamed clams may indeed transmit hepatitis. - J.L.M. and M.W.S.

569
Feng, S. Y. 1966.

Biological aspects of hard clam purification. Proc. Natl. Shellf. Assn. 56: 3 (abstract).

Clam activity is affected by temp and salinity and may be increased by addition of organic materials such as glucose. Laboratory populations had a definite diurnal cycle of activity. Activity of clams may be increased by manipulation of light. In all studies some *Mercenaria mercenaria* were inactive for several days, which could affect a purification procedure. At lower temps (5°C) clams are more likely to retain viral particles. Viruses are not completely eliminated or destroyed when seawater is changed repeatedly or treated with ultraviolet light, or both. - J.L.M.

570
Feng, S. Y. 1967.

Further studies in clam depuration. Proc. Natl. Shellf. Assn. 57:2 (abstract).

In a study of elimination of viral particles by hard clams, *Mercenaria mercenaria*, two bacteriophages, *Staphylococcus aureus* phage 80 and *Escherichia coli* phage S-13, were used as virus models. Hard clams experimentally contaminated with the two phages were treated in recirculating and flow-through seawater systems. Seawater, ranging from 20 to 22°/°° salinity, was irradiated by UV light before reaching clams. Experiments were carried out from 10° to 20°C and flow rates from 50 to 150 gallons per hour. Purification rates of the two bacteriophages by hard clams were independent of temperatures (10°, 12°, 15°, 18°, and 20°C) and flow rates (50, 100, and 150 gallons per hour). Elimination is characteristically an initial rapid removal followed by a more gradual, 6-day attrition of viral particles. Clams apparently eliminate the two bacteriophages at different rates: *S. aureus* phage 80, the less hardy of the two, is eliminated much faster than is *E. coli* phage S-13 which resembles poliomyelitis virus in size, shape, and nucleic acid content. - D.L.

571
Feng, S. Y. 1969.

Responses of some estuarine bivalves to temperature and salinity changes. In Proc. Conf. on Shellf. Culture. Nassau-Suffolk Regional Marine Resources Council, p. 49-57.

(Abstracter's note: Much of this paper is a valuable review of the literature on the subject. Details are contained in other abstracts in this compendium. Only previously unreported studies by Feng are contained in the following abstract.) Osmotic concentration of body fluids in hard clam tends to remain high as external medium is diluted. Closing of shell gives temporary protection by decreasing permeability. Hard clams were held in water ranging in salinity from 0 to 40°/°° for 24 hours. From 0 to 20°/°° shells remained tightly closed. Above 20°/°° clams extended the siphon. Internal osmotic concentrations were isotonic at 28°/°° or slightly hypotonic (at 39°/°°) to the external medium. A figure is presented to give a quick visual concept of the combined effects of temperature and salinity on development of eggs and survival and growth of larvae of hard clam. Information on responses to pollutants, thermal and osmotic and other stresses, is needed to evaluate ecological consequences of altered natural conditions, assessing immediate and long-term effects on shellfishes, and providing sound countermeasures. - J.L.M.

572
Feng, S. Y., J. S. Feng, and T. Yamasu. 1977.

Roles of *Mytilus coruscus* and *Crassostrea gigas* blood cells in defense and nutrition. In Comparative Pathobiology. Vol. 3. Invertebrate Immune Responses. Lee A. Bulla, Jr. and Thomas C. Cheng (eds.). Plenum Press, New York, p. 31-67.

Acid phosphatase was not present in lysosomes of *Mercenaria mercenaria* (Janoff and Hawrylko, 1964). - J.L.M.

573
Feng, S. Y., E. Z. Steever, V., H. H. Haskin, and A. Hamwi. 1966.

Activity of the hard clam, *Mercenaria mercenaria*, as a function of temperature, salinity and water quality. Natl. Conf. Depuration, Kingston, R.I., July 19-22, 1966 (abstract), 2 p. (xerox).

Activity of 2 clam stocks, from Raritan and Delaware Bays, was observed at 5 levels of temp and 6 levels of salinity. Criteria of activity were closing and opening of valves, extension of siphons, probing of foot, production of fecal strings, and pumping as detected by a suspension of carmine particles. Winter clams from temps of 4° to 9°C and salinities of 17°/oo to 20°/oo, and summer clams from temps of 24° to 26°C and salinities of 25°/oo to 27°/oo were the experimental animals. Clams were less sensitive to temp than to salinity change, except for Raritan Bay summer clams. At salinities less than 25°/oo these clams showed no activity change with temp; at salinities above 25°/oo activity of Raritan Bay summer clams was independent of salinity change. Winter clams of both stocks were 20% more active. Equations are given for combinations of temp and salinity which produced the same response in the 2 clam stocks winter and summer. Pumping rate was sensitive to water quality. The rate dropped 30% to 50% during a phytoplankton bloom. In effluent water of a UV purification system with a bottom made of a certain kind of plastic, pumping was first totally inhibited, but later recovered slightly. (Abstracter's note: it is not clear whether this abstract was published, or merely handed out at the meeting.) - J.L.M.

574
Fernando, Henry E. 1952.

Blocking of action of acetylcholine by barbiturates. Science 115(2976): 43-46.

In anesthetic doses all barbiturates inhibit convulsions caused by strychnine poisoning, tetanus, and epilepsy. They have been used in chemotherapy since 1912, but knowledge of mode of action has been scanty. Barbiturates also are important antidotes for poisoning of insects and mammals by chlorinated hydrocarbon insecticides such as DDT and dieldrin. Hearts of *Venus mercenaria* were used to study action of barbiturates on activity of acetylcholine (ACh). It is suggested that efficiency of barbiturates as anticonvulsants depends mainly on their blocking of the action of ACh. - J.L.M.

575
Field, G. W. 1909.

A report upon the mollusk fisheries of Massachusetts. Wright and Potter Printing Co., State Printers, Boston, 243 p., and numerous unnumbered plates.

The introduction, by G. W. Field, occupies only the first 15 pages. Most of the report comes under the title: *The shellfisheries of Massachusetts: Their present condition and extent*, which occupies pages 16 to 233, by D. L. Belding assisted by F. C. Lane. Pages 36 to 80 deal with quahaug, *Venus mercenaria*. It was concluded that the quahaug fishery was declining. Demand was increasing, prices rising, and more men entering the industry. It was predicted that before long the industry would collapse. Overfishing was identified as the cause, and quahaug farming as the remedy. Growth of the animal varies greatly with its location in relation to water currents. Fast-growing hard clams, in better currents, grew from 1 1/2 to 2 1/2 inches in a year. Average growth was between 1/2 and 3/4 inch/yr. The industry and its trends are described in great detail. The report as a whole, including the introductory section, advocates strongly that private control of bottoms is the only logical method of management. Public control, through uncoordinated efforts of communal ownership under town control, and bad laws, were believed to be the major reason for declining shellfish production. - J.L.M.

576

Field, I. A. 1922.

The biology and economic value of the sea mussel, *Mytilus edulis*. Bull. U.S. Bur. Fish. 38: 127-259.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

577

Fingerman, Milton. 1957.

Lunar rhythmicity in marine organisms. Am. Nat. 91(858): 167-178.

Mentions Bennett's 1954 paper, which demonstrated tidal and lunar rhythms in opening and closing of *Venus mercenaria*. - J.L.M.

578

Fischer, P. 1865.

Acclimatation, en France, de Mollusques exotiques. J. Conchyl. 13: 65-66.

According to Heppell (1961) Fischer reported an attempted introduction of quahog in 1861 and 1863 in the Arcachon Basin. Clams when received were in excellent condition, and in 1864 clams laid down in 1861 had grown by about 2 cm. Later the clams disappeared, leaving no descendants. - J.L.M.

579

Fish, Charles J. 1927.

Seasonal distribution of the plankton of the Woods Hole region. U.S. Fish Wildl. Serv., Fish. Bull. 41: 91-179.

Later in July larvae of *Venus (Mercenaria) mercenaria* were found. These remained throughout the summer and until late in the fall. - J.L.M.

580

Fishtein, Mark B. 1969.

A preliminary investigation of the anti-carcinogenic properties of mercenene. J. Amer. Osteopath Assn. 68(10): 1054-1056.

"Crude extract" of raw *Mercenaria mercenaria* meats, including fluid inside the valves, were administered to 4-week-old male albino mice of the Swiss-Webster strain with sarcoma 180. Weights of tumors in experimental groups were markedly less than in controls. Three mice of one group were not killed, and were given injections of clam extract daily. In 2 of these mice inhibition and regression of sarcoma 180 continued for 36 and 42 days, respectively, which exceeded mean survival time of controls (27 days). Tumor reappeared in both mice and death followed, possibly because some tumor cells remained dormant. In the 3rd mouse, inhibition and regression of the tumor was complete. Seven months after implantation of sarcoma 180 this mouse was alive and healthy, with no sign of tumor. It was concluded that mercenene is of value in treatment of sarcoma 180. The work was to be extended. - J.L.M.

581
Fiske, John D. 1968.

The Massachusetts estuarine research program. Proc. Natl. Shellf. Assn. 58: 3 (abstract).

In the Pleasant Bay estuary 11,255 bu of quahaugs were taken in 1 yr from about 640 acres of bottom. Production was valued at about $199/acre. The year is not given, but it would be from the early to mid-1960s. - J.L.M.

582
Fiske, John D., John R. Curley, and Robert P. Lawton. 1968.

A study of the marine resources of the Westport River. Mass. Dept. Nat. Resour., Div. Mar. Fish., Monograph 7, vi+52 p.

Despite many attempts to improve the shellfisheries of the Westport River, Mass., the overall trend has been downward. *Mercenaria mercenaria* has been the mainstay of commercial and subsistence shellfishermen, and the species has remained the most reliable economic shellfish resource in annual harvest. In 1966 1,747 bu of quahogs were harvested by Westport permit holders, most of it by family permit holders. Average production per acre was about 13 bu. Ranges of water temp and salinity in quahog production areas were 36° to 78.3°F in the lower east branch of the River and salinities from 10 to 33°/₀₀ from May through November; and 36° to 73°F and 12°/₀₀ to 31°/₀₀ during the same period in the west branch. Temperatures seldom reach 76°F, which was suggested by Belding (1931) as required for quahog spawning. However, from June to Sept 70°F is reached, which is near optimum for spawning. The major factor limiting quahog abundance seems to be lack of favorable bottom. Eelgrass has been invading formerly productive bottoms. Hard clams grow poorly in eelgrass, which interferes with circulation and food supply. Future dredging projects might improve circulation and favor quahog production. - J.L.M.

583
Fitzpatrick, George, and Albert F. Eble. 1973.

Preliminary investigations of the ecological aspects of re-laying the hard shell clam, *Mercenaria mercenaria*. Bull. N.J. Acad. Sci. 18(1): 20 (abstract).

Three samples of *M. mercenaria* were transplanted from a polluted to an unpolluted estuary. Total coliform levels were measured in transplanted clams, and depuration of *Escherichia coli* was observed in 2 samples. Coliform levels rose before any decrease occurred. Rates of depuration were related directly to water temp and salinity. At temps below 10°C and salinities below 18°/₀₀ rates of depuration decreased. Glycogen levels in foot and anterior adductor muscle increased initially, then were related directly to water temp. Stress was an important factor in voluntary movement of adult clams, but movement of clams was unimportant in planning transplants because voluntary movement is small. - J.L.M.

584
Flanagan, John. 1974.

Spawning breaks in the hard clam, *Mercenaria mercenaria*. Bachelor's thesis, Princeton Univ., 68 p.

Growth of hard clam slows drastically during spawning. The regular pattern of increment deposition is interrupted by a break followed by a few thin daily additions. Twenty of 34 shells examined satisfied paleontologists' criteria for having left a spawning record on shell. Spawning breaks were identified by previous plankton samples which contained hard clam larvae. Spawning breaks were found in 59% of samples, and this was attributed to sexual dimorphism. - J.L.M.

585
Flemer, David A., William L. Dovel, Hayes T. Pfitzenmeyer, and Douglas E. Ritchie, Jr. 1968.

Biological effects of spoil disposal in Chesapeake Bay. J. San. Eng. Div. 94(SA4) Proc. Am. Soc. Civil Eng., Paper 6081, Aug.: 683-706.

Natural populations of most benthic species are at their lowest levels of abundance in Nov and Dec, just before recruitment of juveniles. Late fall appears to be the season when dredging would have least effects. *Mercenaria mercenaria* is not mentioned. - J.L.M. & M.W.S.

586
Florey, Ernst. 1967.

The clam-heart bioassay for acetylcholine. Comp. Biochem. Physiol. 20(2): 365-377.

The clam-heart bioassay is sensitive, specific, and convenient. Accuracy of better than ±10% can be obtained by matching reduction in amplitude of ventricular beat produced by known concentrations of acetylcholine (ACh) and by tissue extracts. Isolated ventricle is mounted in a bath of known volume and contractions are recorded on a kymograph or by a mechanoelectric transducer on a chart recorder. ACh standards are made up in buffered saline of pH 6.5. The following steps are taken: 1) establish range of sensitivity of test ventricle; 2) establish range of effects of applying ACh concentrations in 10 steps of 20% difference, covering a 10-fold increase in concentration; 3) bioassay proper in which known and unknown ACh concentrations are matched. Pharmacological (blocking agents), enzymatic (cholinesterase) and chromatographic procedures are used to detect interfering substances in tissue extracts and to establish that detected activity is indeed caused by ACh. Methods of calculating data and determining degree of accuracy of individual determinations are illustrated by examples. Relative molar quantities of various cholinesters that cause inhibition of *Mercenaria* ventricle equivalent to that produced by a molar quantity of ACh equal to 1 are: carbamylcholine 80, propionylcholine 105, butyrylcholine 625, acetyl-β-methylcholine 1,100, choline 14,000, and benzoylcholine 15,000. ACh was by far the most active of 16 related compounds. - J.L.M.

587
Florey, Ernst, and M. A. Cahill. 1977.

Hemodynamics in lamellibranch molluscs: Confirmation of constant-volume mechanism of auricular and ventricular filling. Remarks on the heart as site of ultrafiltration. Comp. Biochem. Physiol. 57(1A): 47-52.

Mercenaria mercenaria and *M. campechiensis* are mentioned only in reference to the work of Tiffany (1972) abstracted elsewhere in this bibliography. - M.W.S. and J.L.M.

588
Florey, Ernst, and Harriet J. Merwin. 1961.

Inhibition in molluscan hearts and the role of acetylcholine. In Nervous Inhibition. Ernst Florey (ed.). Pergamon Press, Oxford, England, p. 136-143.

Among invertebrates only mollusks have a heart with morphological and physiological properties comparable to that of vertebrates. The molluscan heart is chambered, and blood enters atria through large veins and leaves ventricle through 1 or 2 aortae. In most mollusks the heart receives a double innervation of acceleratory and inhibitory nerve fibers. The great sensitivity of several mollusk hearts (including *Mercenaria mercenaria*) to acetylcholine (ACh) and the fact that ACh causes cardiac inhibition also are similarities to vertebrate hearts. Textbooks say that heartbeat in mollusks is myogenic, but a number of species have ganglion cells in walls of the atria and ventricle. *Venus mercenaria* apparently has no nerve cells in the heart. Hearts of *Venus* and many other lamellibranchs are used as test objects in bioassays for ACh. For the heart of *V. mercenaria* it is reasonably well established that ACh is the transmitter substance of the cardio-inhibitory fibers. During nervous inhibition a substance is released which has the same effect on heart as ACh. Eserine prolongs the inhibition produced by stimulation of the inhibitory nerve supply, and Mytolon (benzoquinonium chloride), which prevents ACh action, blocks action of inhibitory nerves. Welsh (1957) believed that 5-hydroxytryptamine (5HT) was the accelerating transmitter in *Venus*, but there is little evidence for this except that this compound occurs in ganglia of hard clam and heart is rather sensitive to 5HT. Anodal current has been reported to produce decreased heart rate and relaxation in *Venus*, where ACh is inhibitory, but others have stated that the same inhibition by anodal current occurs in heart of *Mytilus*, where ACh excites. Intriguing problems are posed by existing rather fragmentary observations on mollusks. They merit greater attention. - J.L.M.

589

Florkin, Marcel. 1966.

Nitrogen metabolism. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.). Academic Press, New York, Vol. II: 309-351.

Contains references to *Mercenaria (Venus) mercenaria* abstracted elsewhere in this bibliography. Also omits some important references. - J.L.M.

590

Florkin, Marcel, and Bradley T. Scheer (eds.). 1972.

Chemical Zoology. Vol. VII. Mollusca. Academic Press, New York, xxi+567 p.

Mercenaria mercenaria is mentioned numerous times, but spasmodically, to illustrate where necessary. The references are all abstracted elsewhere in this bibliography. - J.L.M.

591

Flower, H. Butler. 1979.

Shellfish mariculture in New York State. Proc. Symp. Mariculture in N.Y. State, N.Y. Sea Grant Inst. and Cornell Univ. NYSGI-RP-79-01: 19-22.

Describes briefly mariculture operations carried out by Shellfish Inc. and Bluepoints Co. of West Sayville, the Shinnecock Indian project, Long Island Oyster Farms at Northport, the Shelter Island Oyster Co. at Greenport, and Frank M. Flower and Sons Inc. at Bayville. Commercial shellfish hatcheries are relatively new, and are still in the process of demonstrating that they are economically viable. - J.L.M.

592

Foehrenbach, Jack. 1972.

Chlorinated pesticides in estuarine organisms. J. Water Poll. Contr. 44(4): 619-624.

Mercenaria mercenaria from 10 locations along the north and south shores and eastern end of Long Island, N.Y. were analyzed for residues of DDT, DDE, DDD, dieldrin, endrin, aldrin, heptachlor, lindane, and heptachlorepoxide, from October 1968 to July 1970. At least 12 animals were used for each analysis. Of the chlorinated hydrocarbons, only DDT, DDD, DDE, and dieldrin were found. Residues of DDT+DDD+DDE ranged from 0.000 to 0.115 mg/kg wet weight organic tissue. Dieldrin ranged from 0.000 to 0.093 mg/kg. All values were well below limits set for shellfishes by Food and Drug Administration. Animals at higher trophic levels, such as birds, had much greater residues. Thus, animals feeding on hard clam could be affected adversely. Little is known about long-term effects of low-residue concentrations. Thus all synthetic chemicals should be used with caution. - J.L.M.

593
Foehrenbach, Jack, Ghulam Mahmood, and Dennis Sullivan. 1971.

Chlorinated hydrocarbon residues in shellfish (Pelecypoda) from estuaries of Long Island, New York. Pestic. Monit. J. 5(3): 242-247.

From Oct 1968 to July 1970 shellfish samples were collected monthly from 10 estuaries along the north and south shores and eastern end of Long Island. Six species of bivalve mollusk were examined, including *Mercenaria mercenaria*. Of 9 compounds for which analyses were made, only DDT, DDE, DDD, and dieldrin were found. At some stations species examined were not the same in all months. Most samples were hard clam, but at some stations other species were substituted, sometimes always. It was concluded that stations on the north shore had higher residues than those on the south shore. Residue levels varied between species: blue mussels had highest levels, hard clams lowest. At stations 6 and 5, close to large agricultural areas, residues were highest regardless of species. Hard clam has about the same concentration factor for dieldrin as do other bivalve species. Agricultural use contributed little to dieldrin residues, which were more frequent and usually higher in areas near country clubs, estates, and large residences. - J.L.M.

594
Foley, David A. 1972.

Molluscan leukocytes as models for cellular defense. Proc. Pa. Acad. Sci. 46: 13 (abstract).

Studies of *in vitro* phagocytosis of bacteria by granulocytes of *Mercenaria mercenaria* are referred to but not described. - J.L.M.

595
Foley, David Allen. 1974.

Studies on hemolymph cells of marine pelecypods. Ph.D. Thesis, Lehigh Univ., Bethlehem, Pa., 208 p.

Small numbers of granulocytes of *Mercenaria mercenaria* degranulate *in vitro*. Electron microscopy showed 2 types of hemolymph cell in *M. mercenaria*, the granulocytes of light microscopy, and agranular cells. Granulocytes contained 3 organelles: 1) granules; 2) prominent Golgi apparati; and 3) centrosomes. Granulocytes were associated with experimentally introduced bacteria more often and to a greater degree than the other 3 types of hemolymph cell. At 4°C no phagocytosis occurred. At 22° and 37°C phagocytosis was extensive. Hemolymph cells of all types aggregated rapidly *in vitro* at 20°C but not at 0°C. Aggregation also was influenced by divalent cations. Activities of acid phosphatase, alkaline phosphatase, and nonspecific esterase were demonstrated cytochemically in all 3 cell types in *M. mercenaria*. Activity of acid and alkaline phosphatases in granulocytes were greater than in any of the other cell types. β-glucuronidase activity was demonstrated in certain types of cell. Lysozyme, a lysosomal hydrolase, was localized in hemolymph cells and serum of *M. mercenaria*, but major part of the activity was in cells. Lysozyme is relatively heat-stable, salt-dependent, and has an acidic optimal pH. - modified from Dissertation Abstracts International 35(8), 1975: 4125B - J.L.M.

596
Foley, David A., and Thomas C. Cheng. 1974.

Morphology, hematologic parameters, and behavior of hemolymph cells of the quahaug clam, *Mercenaria mercenaria*. Biol. Bull. 146(3): 343-356.

Live clams from Buzzards Bay, Mass. and Great (South) Bay, N.Y. were obtained from a commercial source. Three morphological types of leucocyte were found. These were similar in clams from the 2 areas. High variability in total cell counts was taken as evidence of differences in total numbers of leucocytes circulating in individual clams, hence differences in physiological state of clams. The same cell types from clams taken in different areas appeared to have the same nuclear size and spreading characteristics, and it was assumed that the same leucocytes occur in *M. mercenaria* from all different geographical populations. No definitive statement was possible as to interrelationships between granulocytes, hyalinocytes, and fibrocytes of quahogs. Results of vital staining of inclusions in leucocytes contradicted earlier conclusions by Zacks (reported elsewhere in this bibliography). Inclusions referred to as granules or specific granules take up Janus Green B and neutral red. No separate, large population of granules stained selectively with Janus Green B when a mixture of both stains was used. It was concluded that hard clam contains only one type of cytoplasmic granule. Leucocytes of all 3 types are capable of adhering to glass, and to each other. Agglutination occurs *in vitro* and is more pronounced if leucocytes are mixed with seawater or homologous serum. Occasionally granulocytes fuse to form multinucleate cells. In adherence and spreading of leucocytes, spike-like processes are formed with fans of ectoplasm stretched between them. These processes, which usually occur on granulocytes and rarely on hyalinocytes, may serve a protective function by trapping microorganisms. These findings make it possible to attempt to answer some important basic questions on the role of the 3 types of cell in hemolymph of *M. mercenaria* in internal defense against foreign materials. - J.L.M.

597
Foley, David A., and Thomas C. Cheng. 1975.

A quantitative study of phagocytosis by hemolymph cells of the pelecypods *Crassostrea virginica* and *Mercenaria mercenaria*. J. Invert. Pathol. 25(2): 189-197.

Hard clams used in this study were obtained from N.J. coastal waters. Fresh hemolymph cells were exposed to known concentrations of *Bacillus megaterium*, *Escherichia coli*, and *Staphylococcus aureas* in vitro. All 3 types of hemolymph cell of hard clam became associated with bacteria, either in the contact and adherence stage or the engulfment stage. Granulocytes were the most important agents in phagocytosis. Association indices for hard clam were higher at 22 and 37°C than at 4°C. The authors postulated that nonself materials adhere with less frequency at 4°C, hence are not phagocytosed at this temp. - modified authors' abstract - J.L.M.

598
Foley, David A., and Thomas C. Cheng. 1977.

Degranulation and other changes of molluscan granulocytes associated with phagocytosis. J. Invert. Pathol. 29(3): 321-325.

The loss of cytoplasmic granules, which have been shown to be lysosomes, from granulocytes of *Mercenaria mercenaria* during in vitro phagocytosis of *Bacillus megaterium* has been demonstrated semiquantitatively. Known as degranulation, this process represents the morphological basis of release of lysosomal enzymes from granulocytes into serum associated with phagocytosis. In addition to degranulation associated with phagocytosis there is rearrangement of lysosomes, appearance of large vacuolated areas in the cytoplasm, contraction of cell margins, and appearance of atypically large granules in granulocytes of *M. mercenaria*. - J.L.M.

599
Folmar, Leroy C. 1977.

Acrolein, dalapon, dichlobenil, diquat, and endothal: Bibliography of toxicity to aquatic organisms. U.S. Fish Wildl. Serv., Tech. Paper 88, 16 p.

The only reference to *Mercenaria mercenaria* is to the effects of endothal on eggs and larvae, quoted from Davis and Hidu (1969) abstracted elsewhere in this bibliography. For eggs, toxicity was at 50 mg/l (ppm), 50% dead in 48 hrs. For larvae, toxicity was at greater than 10 mg/l, 50% dead in 10 days. - J.L.M.

600
Ford, Ted B. 1971.

Effects of Hurricane Camille on Louisiana's oyster growing areas east of Mississippi River-Lake Borgne to California Bay and other marine fisheries industries. La. Wildl. Fish. Comm., New Orleans, p. 79-86.

From the xerox copy received through interlibrary loan it is not possible to determine exactly what publication contained this paper. It is probably the Annual Report of the Commission. The hurricane did serious damage to the oyster industry, especially seed beds east of the Mississippi River. Siltation and deposits of marsh grass were heavy in some places. Other areas apparently escaped damage. Physical losses to boats, camps, gear and equipment, planting grounds and seed grounds, and personal losses of homes and possessions were substantial. Louisiana has no hard clam industry. - J.L.M.

601
Foster, W. 1972.

No title given. Maine Dept. Sea Shore Fish.

According to Ryther and Tenore (1976), listed elsewhere in this bibliography, Foster cultured *Mercenaria mercenaria* and other mollusks in warm effluent from the Central Maine Power Co., Mystic Station, Wiscasset Harbor. In late spring, summer, and early fall, marked enhancement of growth was observed. In late fall, winter, and early spring, the mollusks clearly were pumping and feeding actively, but because food was scarce they lost weight and their condition deteriorated. Later, he fed artificially cultured marine phytoplankton to these mollusks in winter, and they responded by growing throughout winter. No paper by Foster was cited, which suggests that this information was by personal communication. - J.L.M.

602
Fowler, Bruce A., Douglas A. Wolfe, and William F. Hettler. 1975.

Trace metal uptake and toxicity to shellfish. Envir. Health Perspectives 10, Conf. on heavy metals in the environment II: 262-263 (abstract).

Randomly selected hard clams, *Mercenaria mercenaria*, were placed in seawater of 26°C and 35°/₀₀ salinity containing 0, 0.1, 1, or 10 ppm Hg^{2+} or Cd^{2+}. After half the animals in 10 ppm dose groups gaped, all experiments were terminated. Heavy mortality in high-dose groups of hard clam did not appear until 5 days with Hg and 7 days with Cd. Oysters were more susceptible. The most readily detectable histological changes were clumping nuclear material and cytoplasmic ramification in columnar epithelial cells lining the gut. Electron microscopy of mantle epithelial cells showed a dose-dependent increase in electron-dense cytosomes in Hg-treated clams. This was not observed in Cd-treated animals. X-ray microanalysis showed high iron concentrations in reaction to mercury within these cytosomes. - J.L.M.

603
Fox, D. L. 1953.

Animal Biochromes and Structural Colours. Cambridge Univ. Press, London, 379 p.

604
Fox, Richard E. 1978.

An estimate of the recreational hard clam harvest from Great South Bay, New York. N.Y. State Dept. Envir. Conserv., Stony Brook, N.Y., PL 88-309, Proj. 3-263-R, Natl. Mar. Fish. Serv., 5 p., 3 figs., 3 tables (manuscript rept).

Estimated recreational harvest of *Mercenaria mercenaria* in 1977 was 4,806 bushels from 29 May through 30 September. Most of this catch was made in July and August (75.1% of the season's harvest). Catch rates declined from 0.127 bu/man/hr in June, to 0.087 in July, 0.083 August, and 0.066 September.

It is suggested that legal-sized clams declined in availability through the season because commercial harvesting was intensive in areas popular with recreational clammers. It was estimated that 31,434 clamming trips were conducted, with an average of 14.4 trips/season/individual. About 2,183 individuals were estimated to have done recreational clamming in Great South Bay in 1977. - J.L.M.

605
Fraenkel, G. 1954.

The distribution of vitamin B_T (carnitine) throughout the animal kingdom. Archives Biochem. Biophys. 50(2): 486-495.

The most impressive outcome of this study was the very wide distribution of carnitine throughout the animal kingdom. The assumption that carnitine was of special importance in muscle metabolism was the underlying idea of several tests. In spite of the difference in function of the two muscles, smooth and striated, carnitine content was exactly the same in both muscles of *Mercenaria mercenaria*. - J.L.M.

606
Francis, Joe D., and Lawrence Busch. 1973.

Sea-related industries in New York State: Industry and manpower projections. A report to the National Oceanic and Atmospheric Administration. Dept. Rural Sociol., N.Y. State Coll. Agric. Life Sci., Cornell Univ., Ithaca, xi+188 p.

Information on the hard clam industry was obtained from published statistics. Hard clam landings had increased from a low of 2.5 million pounds in 1954 to nearly 8 million in 1970, and this was the major cause of the upward trend in landings of all shellfish species. Pollution and overfishing were identified as threats to the industry. Since 1950, per capita consumption of clams and some other seafoods in the United States has been increasing. In 1971 the State of New York had about 400,000 acres of bottom suitable for shellfish culture, 13% of which was closed to harvesting and marketing of shellfishes. - J.L.M.

607
Franz, David R., and Gordon L. Hendler. 1971.

Benthic ecology of a shallow bay: Macrobenthos. In 2nd Natl. Coastal and Shallow Water Research Conf., Abstract Vol. Univ. S. Calif. Press: 78 (abstract).

Mentions studies begun in 1968 in Beebe Cove, near the mouth of the Mystic River, Conn. *Mercenaria mercenaria* is not mentioned. - J.L.M.

608
Fredericq, Henri. 1947.

Les nerfs cardio-regulateurs et la theorie des mediateurs chimiques. Biol. Rev. 22(4): 297-314.

Favorable and unfavorable arguments are summarized relative to the hypothesis that action of cardio-regulatory nerves of invertebrates is mediated chemically. Only findings relating to *Venus* are given here. In several mollusks atropine and acetylcholine (ACh) are synergistic and non-antagonistic. Atropine does not inactivate cardio-inhibitory nerves of *Venus*. Hearts of almost all invertebrates are sensitive to ACh, which inhibits molluscan hearts but accelerates hearts of crustaceans and some other species. Cholinesterase is constantly present in cardiac tissues of numerous mollusks. In all invertebrates, cardiac action of ACh is enhanced by eserine, which also stimulates cardio-regulatory nerves of *Venus mercenaria*. It was concluded that cardio-inhibitory nerves of *V. mercenaria* probably are cholinergic. - J.L.M.

609
Freeman, John A., and Karl M. Wilbur. 1948.

Carbonic anhydrase in molluscs. Biol. Bull. 94(1): 55-59.

Carbonic anhydrase was found in nearly all of 12 pelecypod species and 8 gastropod species examined. It catalyses hydration of CO_2 and it is suggested that the enzyme plays a role in deposition of carbonate in shell. In *Venus mercenaria* ratios of no extract to extract of 2.6, 4.8, and 2.5 were observed in mantle edge; 3.3, 2.6, and 4.1 in mantle without edge; and 0.8, 1.4, and 2.0 in mantle cavity fluid. In the same species ratios of heated extract to extract of 3.4 and 7.2 were found in mantle edge; 4.8 in mantle without edge; and 1.5 and 3.5 in mantle cavity fluid. Negligible activity in some species (not hard clam) suggested that shell can be deposited in absence of this enzyme. - J.L.M.

610
Fretter, V., and A. Graham. 1964.

Reproduction. Chapter 4 in Physiology of Mollusca. Vol. 1. K. M. Wilbur and C. M. Yonge (eds.). Academic Press, New York, p. 127-164.

V. mercenaria is the best example of a bivalve as a consecutive hermaphrodite, which has a winter pause between 2 sex phases. (I think this is what he was trying to say, although it is not clear because he uses vague terms like "the former" and "this type".) "In *Venus*, as in *Teredo diegensis*, a very small proportion of genuinely gonochoristic animals, both male and female, occurs." Later, in discussing *Ostrea*, he says: "As in *Venus* and *T. diegensis*, a small proportion of animals is not hermaphroditic." - J.L.M.

611
Friedl, Frank E. 1972.

Amino acid deamination in the marine clam *Mercenaria campechiensis*. Am. Zool. 12(3): xxxii (abstract).

Two pathways for deamination of L-amino acids have been observed in southern quahog: one described as a dehydratase with at least L-Serine as a substrate, the second of which may be a broadly specific oxidase acting on L-Leucine. - J.L.M.

612
Fries, C., and M. R. Tripp. 1976.

Effects of phenol on clams. Mar. Fish. Rev. 38(10): 10-11.

Gill and digestive tract epithelia are damaged by phenol at concentrations of 1 ppm or greater for 24 hrs or longer. Gills showed moderate to extensive epithelial necrosis, hemolymph sinuses were distended and contained an amorphous precipitate. At higher concentrations of phenol (10 ppm and up) damage was massive. Gut epithelia showed similar effects. Posterior portions of hind gut epithelium did not appear to be quite as sensitive. Other tissues showed variable effects. - J.L.M.

613
Fries, C. R., and M. R. Tripp. 1977.

Cytological damage in *Mercenaria mercenaria* exposed to phenol. In Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms. Douglas A. Wolfe (ed.). Pergamon Press, p. 174-181. (Ecosystems and Organisms on title page, Organisms and Ecosystems on cover.)

Adult clams were exposed to 1, 10, 100, 1000, 10000, 25000, and 50000 parts per billion of phenol in artificial seawater (25°/₀₀) for 24 hrs. Controls were in artificial seawater. Gills, gut, digestive gland, and blood cells (hemocytes) were damaged. Basophilic tissue staining was evident at lower concentrations, moderate necrosis and sloughing of ciliated epithelial layers at higher concentrations. Blood sinuses were distended and contained precipitated hemolymph. In gills, only chitinous supporting rods remained at 50000 ppb phenol. Electron microscopy also showed damage to epithelial cells. Cell and nuclear membranes remained intact at low concentrations; intracellular organelles (lysosomes, mitochondria, etc) were in various stages of disintegration. At 10000 ppb cell membranes ruptured. Hemocytes showed extensive intracellular damage; at 1000 ppb and above only the hyaline cells remained intact. - authors' abstract - J.L.M.

614
Frizzell, D. L. 1936.

Preliminary reclassification of Veneracean pelecypods. Bull. Mus. Roy. d'Hist. Nat. Belgique 12(34): 1-84.

Proposed separation of *Mercenaria* from *Venus* as a distinct genus. - from Wells, Ecology 38(1), 1957 - J.L.M.

615
Frontali, N., L. Williams, and J. H. Welsh. 1967.

Heart excitatory and inhibitory substances in molluscan ganglia. Comp. Biochem. Physiol. 22(3): 833-841.

In several mollusks an antagonistic cardio-regulatory action of acetylcholine (ACh) and 5-hydroxytryptamine (5-HT) has been demonstrated. Dopamine also occurs in mollusk ganglia. An unidentified heart-excitatory factor, presently called Substance X, also has been found. Eluted fractions were assayed on isolated hearts of *Mercenaria mercenaria* treated with 1-methyl-lysergic acid butanolamide and with Mytelase to counteract 5-HT and ACh. Extracts from ganglia of *M. mercenaria* gave four peaks of cardio-excitatory activity. Extracts from hard clam hearts gave only three. The first 3 peaks were completely inactivated by proteolytic enzymes, but the 4th was not inactivated. ACh, 5-HT, and dopamine have low molecular weights. Substance X is considered to be a mixture of several compounds. - J.L.M.

616
Frost & Sullivan, Inc. 1974.

Fish farming in the U.S.A. Frost & Sullivan, Inc., New York, N.Y. Privately published by photo-offset from typescript, vi+199 p.

Diminishing supplies of marine fishery products can be offset by mariculture. The study projects present and future clam markets in the U.S. as follows: 1973 - 0.4 lbs; 1976 - 4.0 lbs; 1979 - 6.0 lbs; 1982 - 9.2 lbs. (Abstracter's note: it is not clear whether these are per capita markets or whether the legend to the table should have specified millions of lbs. The figures are for clams produced by mariculture, not total market amounts.) It was concluded that mariculture has great potential for growth and profit. The report considers 5 groups of fish and shellfish, and aquaculture and mariculture generally around the world. Virtually all clams consumed in the U.S. are produced in domestic waters. Quahog is the principal species. Techniques for spawning and rearing larvae are well established. Wild clams are used as breeding stock. Best results are obtained with a hybrid of northern and southern quahog (*Mercenaria mercenaria* and *M. campechiensis*), which grow faster and produce about twice the yield of parent strains. Spawning is stimulated by temp shock, alternating water temp between 20 and 30°C at 30 min to 8 hr intervals. Eggs are released into a sperm suspension. Extraneous materials are removed by sieving and placed in culture tanks of filtered water. Water is replaced about 3 times/week. Larvae are fed fresh algae. This is currently a limiting factor because only fresh unprocessed algae can be used. If algae were available year-round, clam production could be increased significantly. About 1,000 clams can be reared to 5 mm in 4 l of water. As soon as possible, young clams are planted in seawater, usually at 500 clams/m^2. Site selection is important for success. Salinity should be in excess of 25°/oo. Substrate should be a sand-mud mixture and free of continual wave action. Water should be relatively shallow, and tidal currents are necessary to provide food and remove metabolic wastes. Under suitable conditions clams will grow about 1.5 mm/month. Half-shell size will be reached in about 2 yrs. Growth rate could possibly be improved by fertilizing beds to improve food production. Artificial food could also be used to improve growth. Clams have no known diseases. Principal predators are crabs. To reduce predation beds usually are protected by pens or cages. This costs about $1,200/acre. Clam farming is expensive but offers potential for high return. At stocking density of 500 clams/m^2 about $5x10^6$ clams/ha can be produced in 2 yrs. At a wholesale price of 3¢/clam, gross income/ha would be $150,000, about $40,400/acre in 2 yrs. Table 33 clarifies the basis of projections of production of farm-raised clams. Figures are in millions of pounds. Projected total demand for clams in the U.S. went from $79.3x10^6$ lbs in 1973 to $95.6x10^6$ in 1982. In discussing prices and uses of clams, no distinction is made between high-priced littleneck quahogs and low-priced surf clam. (Abstracter's note: this leads to total confusion. In discussing feeds for mollusks no distinction is made between differences in food requirements between oyster and hard clam. If the quality of the entire report were to be judged on the basis of the sections dealing with mollusks, it would receive low marks. Material on clams is very superficial and demonstrates a lack of first-hand experience with the clam industries of the U.S., developments in clam mariculture, and the literature. No literature citations are given, and no list of references is included. The report contains many errors of interpretation, and several contradictions. This illustrates once again the frequently poor quality of work done by professional contractors and the futility of spending money on such projects.) - J.L.M.

617
Fujita, Tsuneo, and David E. Mann, Jr. 1958.

Further studies on *l*-arterenol tachyphylaxis in the isolated *Venus mercenaria* heart. J. Am. Pharmaceut. Assn. 47(2): 90-93.

A tachyphylactic response to a pharmacological agent is a diminished response to successive doses of the same agent within a limited time. This paper confirmed initial observations of Pless and Mann (unpublished) by showing that the response to *l*-arterenol was progressively altered by pretreatment with increasing concentrations of ephedrine sulphate, and sufficiently high concentrations completely blocked the typical *l*-arterenol response. Fresh heart was generally refractory to either 1×10^{-5} or 2×10^{-5} concentrations of *l*-arterenol when suspended in fluid in which tachyphylaxis had previously been demonstrated. Great variations in response to repeated administrations of *l*-arterenol were observed. - J.L.M.

618
Furfari, Santo A. 1966.

Depuration plant design. U.S. Dept. H.E.W., Pub. Health Serv., Natl. Shellf. Sanit. Progr., Washington, D.C., vi+119 p.

The body of this report contains no significant reference to hard clam but the appendices do, mostly as figures or tables. Apparently all this information has been obtained from the literature. Since these papers have been summarized under their own titles in this bibliography, it does not seem necessary to repeat the information here. - J.L.M.

619
Furfari, S. A. 1976.

Report on shellfish purification points up need for more research. Comm. Fish Farmer 2(6): 40-41.

This is a summary of a paper delivered at the World Technological Conference on Aquaculture held in Kyoto, Japan, 26 May to 2 June 1976. Viral accumulation and depletion rates follow those of coliform organisms for the species studied. Removal of virus is no longer an issue. The crux of the matter is the initial level of virus in the mollusk. Controlled purification of molluscan shellfish is an integral and mandatory part of shellfish industries in England, France, and Spain. It has been used sporadically in Portugal, Japan, and Canada, but has never been an important part of the shellfish industry in the United States. Commercial purification plants have been used for *Mercenaria mercenaria* and other species. There has been distrust of the value of viral depuration, especially of hepatitis, but commercial and pilot purification plants in the U.S. and Canada have demonstrated the economic, technical, and biological feasibility of the process. - J.L.M.

620
Furman, Edwin, John German, George King, Stephen Lane, Richard Miller, and Nelson Slager. 1975.

Attitudes and issues raised by the industry. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst.; Albany, p. 48-50.

This paper is a summary, prepared by the editors of the volume, of issues discussed by the panel named above. Depuration was a controversial issue. Some endorsed it as a means of making a tremendous food resource available for harvest and consumption, others opposed it as a process that has not been completely proven and offers potential for a shellfish-related outbreak of disease. There were also concerns about effects on the market, either through overproduction or through loss of consumer confidence. Opinion was equally and bitterly divided on the issue of leasing bottom to private planters. The Department believes that a leasing policy should be found that will be beneficial to both segments of industry. Almost all participants recognized pollution as a serious problem. The need to halt progressive closure of grounds and to reverse the trend was stressed. Some evidence of increasing salinities in shellfish areas has raised fears of reduced setting and increased predation. The role of increased sewage treatment and discharge of liquid wastes into the ocean as a factor in reduced groundwater flow into the bays needs attention. Illegal export of "seed" clams (clams under 1-inch thick) to Pennsylvania was noted as a problem that needs correction. Improved law enforcement was noted with approval, but action in courts needs tightening. Transplanting programs were endorsed and expansion was recommended. - J.L.M.

621
Futch, C. R., and J. M. Torpey. 1966.

Florida clams, a resource with a future. Fla. Bd. Conserv. Mar. Lab., Salt Water Fish. Leafl. 3, 6 p.

M. mercenaria and *M. campechiensis* occur in Florida, the first most commonly on the east coast, the second most commonly in the Gulf of Mexico. Adult *M. mercenaria* are usually 3-5 inches long. A notable characteristic is the smooth central area on the outside of the valves, which are dirty gray to white outside, white inside, usually with purple around the margin. *M. campechiensis* is found from Chesapeake Bay to Texas and in Cuba. Adults are 3-6 inches long, with a more rounded, heavier shell with deeper ridges and no smooth area. It also usually lacks purple staining. Spawning begins in April at about 73°F and continues through August. Larvae are planktonic for about 2 weeks. Optimum salinity is 20-35°/oo. Hard clams live from near mean high tide to over 50 ft deep, but are most common on shallow water flats. Growth is rapid from October through June and reduced in summer. Total annual growth is about double that of northern hard clams. The greatest enemy is blue crab, which consumes vast numbers of juveniles. Other predators are worms, whelks, sea stars, octopus, stone crab, and skates. Commercial hard clam production began in Florida about 1880. In 1908 large beds were discovered in Collier and Monroe Counties near the Ten Thousand Islands (Gulf of Mex.). Peak production was in 1932, and landings remained high through 1945. Landings declined from 1945 to 1950, gradually increased until 1962, dropped in 1963, but came back strongly in 1964. Availability of markets in the Middle Atlantic states was responsible for this increase. Hard clams are harvested on shallow bars with bullrakes or tongs in water 3-4 feet deep. Feasibility of clam farming was established by experiments at Alligator Har. *M. mercenaria* 1.3-1.7 in long were planted in mud-sand flats in 1 1/2 ft of water at low tide, most on fenced plots, at 10-75 clams per ft^2. Growth was poor in crowded areas (.16-.2 in in 7 mo) but good at concentrations of 10-50 clams/ft^2 (.42-.49 in in 7 mo). Mortality was negligible on fenced plots. All clams on unprotected plots were killed by blue crab and whelks. Recommendations for clam mariculture are given: no pollution, optimum salinity, avoid very hard or very soft substrates, pick a site protected from rough weather, use healthy seed, trial plantings first, use 1/2 inch-long seed to reduce predation, do not plant more than 50 clams/ft^2, monitor frequently for predators and poachers, plant in shallow water for easy harvesting, bring product to market as quickly and cheaply as possible for maximum profit. Surf clam, marsh clam, and coquina clam are discussed briefly. - J.L.M.

622
Gabbott, P. A. 1975.

Storage cycles in marine bivalve molluscs: A hypothesis concerning the relationship between glycogen metabolism and gametogenesis. In Proc. 9th Europ. Mar. Biol. Symp. H. Barnes (ed.). Aberdeen Univ. Press, Aberdeen, Scotland, p. 191-211.

Loss of glycogen by bivalves is associated with the reproductive cycle. It is assumed that vitellogenesis takes place at expense of stored glycogen reserves. Conversion of pre-stored glycogen into lipid reserves of developing eggs may be analogous to the glucose-fatty acid cycle in vertebrates. Little is known about interconversion of glucose and glycogen in marine bivalves. A second assumption is that control of glycogen metabolism is essentially the same as in vertebrate systems. If so, it is possible that glycogen metabolism and gametogenesis are controlled by the same regulators. In mammalian liver the main regulators of glycogen metabolism are hormones, mediated by cyclic-AMP and blood glucose. In bivalves the corresponding regulators might be internal neuro-endocrine factors controlling reproductive cycle and level of blood sugar, both of which are influenced by temp, food, and other external factors. *Mercenaria mercenaria* is not mentioned, but the mechanisms probably are similar to those of the bivalves discussed. - J.L.M.

623
Gaddum, J. H., and H. Kwiatkowski. 1938.

The action of ephedrine. J. Physiol. 94(1): 87-100.

Ephedrine increases the yield of the substance liberated by nerves so that its properties can be studied more easily. The substance is not noradrenaline, epinine, corbasil, or adrenalone, but may be adrenaline. These actions of ephedrine are attributed to inhibition of amine oxidase. *Mercenaria mercenaria* is not mentioned. - M.W.S. and J.L.M.

624
Gaddum, J. H., and M. K. Paasonen. 1955.

The use of some molluscan hearts for the estimation of 5-hydroxytryptamine. British J. Pharmacol. Chemother. 10(4): 474-483.

The study was done principally to find a sensitive method for assay of 5-hydroxytryptamine (5-HT) in tissue extracts from mollusks living in British marine waters. The heart of *Spisula (Mactra) solida* was found most useful because it is much more easily available in Great Britain than *Venus mercenaria*. Earlier work by others on *Venus mercenaria* is cited frequently. These papers are abstracted elsewhere in this bibliography. - J.L.M.

625
Gainey, L. F., Jr., and M. J. Greenberg. 1977.

Physiological basis of the species abundance-salinity relationship in molluscs: A speculation. Mar. Biol. 40(1): 41-49.

626
Galtsoff, Paul S. 1926.

New methods to measure the rate of flow produced by the gills of oyster and other molluscs. Science 63(1626): 233-234.

The paper does not mention mollusks other than oysters, but it might be assumed from the title that the methods could apply to hard clam. The methods described allow collection of water after it has passed over the gills, and measurement of rate of flow and pressure inside the gill cavity. Valves are forced apart and held open by inserting a glass rod. A rubber tube is inserted into the gill cavity and the spaces are packed with cotton. The oyster is placed in a tank and water pumped through the tube is collected in a graduate. Gill cavity pressure is measured by plugging the tube and watching the level of water rise until equilibrium is reached. Experiments showed that rate of flow was a function of temp, reaching a maximum at 25°C and slowing with decrease in temp. At 7.6°C cilia were still beating but no current was produced. At 5°C beating stopped. Counting phytoplankton in the discharged water showed that more than 99.5% of diatoms and dinoflagellates were caught by the gills. - J.L.M.

627
Galtsoff, Paul S. 1930.

Biology and cultivation of shellfish. In Progress in Biological Inquiries, 1928. Rept. U.S. Comm. Fish., Washington, D.C., p. 732-737.

628
Galtsoff, Paul S. 1934.

Anat. Rec. 60, suppl. 98: (Paper not seen).

Sexual reaction of male *Ostrea virginica* is non-specific. It can be provoked by sperm of *Venus mercenaria*, etc. - J.L.M.

629
Galtsoff, Paul S. 1964.

The American oyster *Crassostrea virginica* Gmelin. U.S. Dept. Interior, Bur. Comm. Fish., Fish. Bull. 64, iii+480 p.

Experiments on muscle extracts of *Mercenaria mercenaria* tend to support the hypothesis that, parallel with the actomyosin system which produces initial tension of the adductor muscle, there is a second, or paramyosin system, capable of maintaining the tension developed by the first one by crystallization of the paramyosin component caused by a pH shift within the muscle. This can effectively freeze the adductor muscle at any state of contraction. In bivalve mollusks exchange of gases takes place primarily in the gills, but the mantle also has a role in respiration. In *M. mercenaria* oxygen consumption of the mantle was 11.73-15.52 mm^3/hr/g of dry tissue, in the gills 815-912. Similar differences were observed in all seasons, though absolute values differed. In bivalves with long and narrow siphons like *Mercenaria*, water leaving the exhalent siphon probably has a uniform oxygen content. In species lacking siphons the cloaca opens as a wide cone-shaped slot, and the stream of water contains considerable and variable amounts of outside water, depending on the distance from the epibranchial chamber. - J.L.M.

630
Galtsoff, Paul S., and H. R. Seiwell. 1928.

Oyster bottoms of North Carolina. U.S. Bur. Fish., Econ. Circ. 66, 11 p.

631
Ganaros, Anthony E. 1954.

On the ecology of *Mya arenaria* L. and *Venus mercenaria* L. in Maquoit Bay and Falls Cove, Maine. Unpub. ms Rutgers Univ., New Brunswick, N.J.

SUNY Library at Stony Brook was unable to verify this reference. Search terminated. - J.L.M.

632
Ganong, W. F. 1890.

Southern invertebrates on the shores of Acadia. Trans. Royal Soc. Canada 8(4): 167-185.

In all the southern part of the Gulf of St. Lawrence and at certain other sheltered and isolated points on the coasts of New Brunswick, Nova Scotia, and possibly Newfoundland, are certain groups of species of a distinctly southern facies, mingled with northern forms. These southern forms all are specifically identical with native forms to the south of Cape Cod, yet are entirely cut off from them, except for similar small isolated colonies on the coasts of Maine and Massachusetts. *Venus mercenaria* was one of these southern species, having been reported from Gulf of St. Lawrence, Sable Island, Halifax Harbor, St. Margaret's Bay and vicinity, St. Mary's Bay, Casco Bay, and Massachusetts Bay. *Venus mercenaria* had been reported as occurring on the whole coast of Nova Scotia, but that is too broad a statement. Dredgings in the harbor of Portland, Maine, have shown deposits of shells of *V. mercenaria* and other southern species, none of which is now found alive there. In the Casco Bay region and near Damariscotta, Maine, Indian shell-heaps contain large quantities of oyster and quahog shells, at places where these mollusks are now entirely extinct or are very scarce and small. Their persistence as living forms in these isolated places probably depends on water temp in the reproductive season. Sable Island, which lies directly in the path of the cold Labrador Current, has great sandy shoals and very slight tides, so that the waters are heated by the sun, and this is not mixed with colder waters, which are too slow on the shoals to supply cold water fast enough. The origin of southern species in these isolated spots can be explained only if it is assumed that they are survivors from a time when marine climate was warmer. These matters are discussed in some detail. - J.L.M.

633
Gardner, G. A. A. 1973.

Shellfish farming progress. Fish. Ind. Res. 3(3): 2-4.

Could not locate. Search terminated. - J.L.M.

634
Garrett, M. A., Jr., and L. G. Schifrin. 1977.

Economic impacts of tropical storm Agnes in Virginia. In The effects of tropical storm Agnes on the Chesapeake Bay Estuarine System. Chesapeake Research Consortium, Inc. Johns Hopkins Univ. Press, Baltimore, CRC Pub. 54, p. 597-610.

Hard clams, *Mercenaria mercenaria*, survived the fresh water of Agnes with one prominent exception. Clams that had been relocated from the James River to the York River and tributaries for cleansing suffered almost 100% mortality. Since only relocated clams were affected, a combination of stress and low salinity was apparently responsible. An estimated 7,035 bu of hard clams were affected, a direct loss of $42,410. - J.L.M.

635
Garrey, Walter E. 1905.

The osmotic pressure of sea water and the blood of marine animals. Biol. Bull. 8: 257-270.

Blood obtained by section of the foot of *Venus mercenaria* had the same freezing point (1.82°C below zero) as the seawater from which the clam came. Therefore, their blood has the same osmotic pressure as seawater. Dilution or concentration of aquarium water always causes an equivalent change in the blood. - J.L.M.

636
Gasteiger, E. L., John Gergen, and Paul Haake. 1955.

A study of the distribution of homarine (N-methyl picolinic acid). Biol. Bull. 109(3): 345-346.

The quaternary ammonium compound homarine was found in Porifera, Coelenterata, Ctenophora, Annelida, Mollusca, Echinodermata, and Arthropoda. Maximum concentrations were in arthropods and mollusks. Within the Mollusca *Venus* and *Pecten*, tissues contained considerably less homarine than *Loligo*, *Busycon*, and *Nassa*. The compound was not found in Vertebrata or in freshwater mollusks and arthropods. It was suggested that homarine has an osmoregulatory function. - J.L.M.

637
Gates, John M., and George C. Matthiessen. 1971.

An economic perspective. In Aquaculture: A New England Perspective. Thomas A. Gaucher (ed). New England Marine Resources Information Program, Sea Grant, Univ. R.I., Narragansett, p. 22-50.

Two biological and 3 economic criteria were used to rate species as potential subjects for aquaculture in New England. Eleven species were rejected, 2 others were not subjected to further analysis after preliminary evaluation, and 5, including *Mercenaria mercenaria*, were selected. Details were to be developed as part of a continuing study. The concept of mixed systems was abandoned for the moment. - J.L.M.

638
Gates, J. M., G. C. Matthiessen, and C. A. Griscom. 1974.

Aquaculture in New England. Univ. R.I., Sea Grant. Mar. Tech. Rept. Ser. 18, 77 p.

The study was commissioned to establish economic, biological, and technical criteria to evaluate suitability of certain species for commercial culture in the region; to apply those criteria to species judged to be of present or potential economic importance; and, for the most suitable species, to define and analyze the most critical economic, biological, and technical requirements for profitable culture, and the extent to which those requirements have been met. Five species were finally selected, of which *Mercenaria mercenaria* was one. Commercial production through aquaculture is at least marginally feasible, and can be expected to attract more producers, provided that adequate bottoms are available for lease. A large human population accustomed to eating clams exists in New England. Thus, consumer resistance to increased production might be relatively easy to overcome. In certain respects this species may be more readily cultured than other commercial mollusks. Adults held at slightly below 20°C may be induced to spawn at almost any time. Fertilized eggs are rather sensitive to low salinities and fail to develop in water below 22°/₀₀. Larvae are hardier: optimum salinity is about 27°/₀₀ (range about 15 to 30°/₀₀). Optimum temp is 25 to 30°C. At 30° setting may begin in 7 days after spawning. Larvae are also less particular in food requirements than oyster larvae, also less sensitive to pollutants. Juveniles have voluminous food requirements and culture of food does not appear to be practical for these stages. Juveniles will survive well in nature if protected by fencing or aggregates. Commercial clam rearing facilities for larvae probably must rely on large volumes of living diatoms or naked dinoflagellates. Some *Chlorella* may also be used. The major technical problem is provision of enough food for postlarval stages. Hard clam does not grow rapidly, and takes a minimum of 2 yrs to grow to market size. Culture of juvenile clams to market size under totally artificial conditions would require very large amounts of phytoplankton and culture under these conditions has not been reported in detail. It would seem far more practical to grow these stages in the natural environment. This creates some problems in New England, because the natural continuous range of the species is from Cape Cod southward. To the north, populations are restricted to areas where local seasonal warming of water permits spawning. Even in southern New England setting intensity may be highly variable. Thus, hatchery culture probably would be a necessary adjunct. Predation on juveniles is a serious problem, and some form of protection probably would be necessary. Feasibility of large-scale fencing has not been demonstrated. Slow growth, especially in colder areas, might require 3 or more yrs until harvesting. Culture in a controlled environment probably would be too costly. Not enough information was available to estimate costs of culture in a natural environment. It was suspected that the degree of profitability is highly variable, and that existing operations are of marginal profitability at present. The picture could improve with rising prices. Political and social climates for assertion of exclusive culture rights in natural areas are not particularly favorable. To compete successfully with other industries, activities, and uses or misuses of the environment, aquaculture must demonstrate long-term viability and social and economic benefits. Its failure to do so has come from inadequate technology and unfavorable socio-political climates. Public action to provide opportunity is needed. Recommended are: pilot plants, use of domestic wastes, understanding of water quality tolerances, and provision of areas of high quality for culture. - J.L.M.

639

Gaucher, Thomas A. 1970.

Thermal enrichment and marine aquiculture. In Marine aquiculture. William J. McNeil (ed). Oregon State Univ. Press, p. 141-152.

The only specific mention of *Mercenaria mercenaria* is with reference to the work of the University of Southampton in Great Britain, where three waste products (CO_2 gas, domestic sewage, and heated water) were used in a combined algal and shellfish culture system to produce a useful product, at the same time substantially reducing the polluting effects of the wastes. Exposing clams to artificially warmed water creates characteristics in the population similar to those in populations occurring southward in the geographic range. - J.L.M.

640
Gaucher, Thomas A. (ed). 1971.

Aquaculture: A New England Perspective. New England Marine Resources Information Program, Sea Grant, Univ. R.I., Narragansett, 119 p.

Some papers in this conference report have been abstracted elsewhere in this bibliography. In addition, it contains papers on legal aspects and hatchery design and operation which do not contain specific reference to *Mercenaria mercenaria*. - J.L.M.

641
Gaucher, Thomas A. 1971.

A technological perspective. In Aquaculture: A New England perspective. Thomas A. Gaucher (ed). New England Marine Resources Information Program, Sea Grant, Univ. R.I., Narragansett, p. 7-21.

Detailed evaluation of 10 species as potential subjects for aquaculture in New England, according to 9 criteria, rated *Mercenaria mercenaria* 6 on a scale from 0 to 9, with 9 as highest possible score. Negative characteristics were growth rate, conversion efficiency, and availability of commercial feeds. - J.L.M.

642
Geckler, J. R., and T. A. Wandstrat. 1964.

Uptake and retention of Rhodamine B by quahog clams, *Mercenaria mercenaria*. Chesapeake Sci. 5(3): 134-137.

Concern had been raised that dye used to trace water movements in the natural environment might stain clams and so affect their market value. Laboratory experiments with *Mercenaria mercenaria* showed that at high concentrations of dye (60 to 250 mg/liter) clams avoided dye by withdrawing siphons and closing valves. At 8.4 mg/l there was some avoidance reaction, but siphons remained exposed, reacting with sporadic openings and closings of the apertures. At 4.7 mg/l and less, clams appeared to siphon normally. Between 4.7 and 0.45 mg/l gills and body tissues stained in 15 min. At 0.25 mg/l clams became pink in 30 min. At 0.09 mg/l clams held up to 48 hrs did not stain. At 0.045 mg/l and less no color was taken up in 120 hrs. Outer surfaces of clam shells were stained at 0.96 mg/l and above. Below 0.45 mg/l inclusive, shells did not stain. It was concluded that relatively few clams would be stained by concentrations of Rhodamine B commonly used in tracer studies. If staining did occur, the results showed that siphoning action and metabolic breakdown of dye would clear the flesh in a few days. - J.L.M. and M.W.S.

643
Geiser, John. 1977.

Transplant program means dollars for hard-pressed N.J. clammers. Natl. Fisherman 58(8), Dec. 1977: 2-B.

The N.J. Dept. of Environmental Protection began transplants of hard clams, *Mercenaria mercenaria*, from polluted to clean waters, 8 yrs ago when clams were transplanted from Lakes Bay in Atlantic County to Great Bay. In 1977 the program was expanded when clams were moved from Tuckerton Creek in Ocean County to Great Bay. Clammers had been unable to make a living from depleted beds in the few remaining clean waters of the State. In 5 days 89 men took 1.5 million clams, mostly littlenecks and cherrystones. Summer clamming continued poor, however, and a special appeal was made to the Governor's office. In September a transplant from Manasquan River to Barnegat and Great Bays began. In 10 days 76 men harvested and transplanted 1,216,500 hard clams under State supervision. The Manasquan had not been used for clamming in 17 yrs. The following week clams were transplanted from Shark River. Clammers paid $25 each for permits and $42 to lease 1/2-acre individually marked lots where each man replanted his own clams. If clams tested acceptable for human consumption at the end of a month they were certified for harvest and sale; if not, they were held for additional 15-day periods until acceptable. Clammers were able to harvest 5,000 to 6,000 clams worth $50 per 1,000 on the first day at Manasquan. - J.L.M.

644
Geiser, John. 1978.

Transplant setup puts life in N.J. clamming industry. Natl. Fisherman 59(8): 31.

The State Department of Environmental Protection has expanded the transplant program to include any clammers who wish to participate. The program may involve more than 150 bay clammers who will be able to earn $50 to $100 a day. N.J. has been experimenting with transplanting *Mercenaria mercenaria* from condemned to clean waters for 8 years. Clams are harvested under the supervision of marine police and taken to unpolluted waters for 30 days. - J.L.M.

645
Geiser, John. 1978.

N.J. clammers in opposing camps as state drops transplant project. Natl. Fisherman 59(2): 21.

A state proposal to transplant hard clams from Monmouth County has been scrapped, and New Jersey's clammers have been divided into two opposing camps. Most clammers are heartbroken, but others wish to keep the clams in Monmouth County until the water is cleaned up or depuration plants are built. - J.L.M.

646
George, W. C. 1952.

The digestion and absorption of fat in lamellibranchs. Biol. Bull. 102(2): 118-127.

Several lamellibranch species were used in these experiments, including *Mercenaria mercenaria*, but no specific results are given for this clam. *Crassostrea virginica* and *Modiolus demissus* were the principal experimental animals, but it is assumed that the results and conclusions apply generally also to hard clam. Emulsions of olive oil and peanut oil stained with Sudan stains were fed to the bivalves, and also were mixed with mince of crystalline styles and other parts. Samples of experimental material were then examined to see if fat had been absorbed and how. Material was stained with Nile blue sulfate to see if neutral fat had been split to fatty acid and glycerine. Free droplets of neutral fat are hydrolyzed in the stomach. Droplets of stained fat in the form of fatty acid appeared in large numbers in ciliated epithelium of stomach and ducts of digestive gland, but none was found in non-ciliated epithelium of alveoli of the digestive gland. Droplets of emulsion were ingested by leucocytes in the lumen of the gut. Neutral fat in leucocytes was hydrolyzed. Evidence of passage of leucocytes with ingested fat back into blood spaces or tissues was lacking. Emulsion injected into the cavity of the heart or mixed in hanging drops of blood was ingested by leucocytes. Hydrolysis occurred in blood cells. Evidence of hydrolysis of neutral fat by plasma was lacking. Neutral fat was hydrolysed in stained emulsion mixed with minced styles. Sometimes hydrolysis took place in emulsion mixed with minced digestive gland, sometimes not. Evidence for deposition of stained fat in tissues was lacking. - modified author's summary - J.L.M.

647
Gerschenfeld, H. M. 1964.

A non-cholinergic synaptic inhibition in the central nervous system of a mollusc. Nature 203(4943): 415-416.

648
Gerschenfeld, H. M., and E. Stefani. 1965.

5-Hydroxytryptamine receptors and synaptic transmission in molluscan neurones. Nature 205(4977): 1216-1218.

649
Ghiretti, F. 1966.

Respiration. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.). Academic Press, New York, Vol. II: 175-208.

Contains references to *Mercenaria (Venus) mercenaria* abstracted elsewhere in this bibliography. - J.L.M.

650
Gibbons, Euell. 1964.

Stalking the Blue-Eyed Scallop. David McKay Co., Inc., New York, xiv + 332 p. (Chapter 3: Quahog or Littleneck: The Wampum Clam *(Venus mercenaria)*.)

This account of *Mercenaria mercenaria* contains nothing new, and consists mostly of recipes. There is also a line drawing of the inside and outside of the shell on page 17. - J.L.M.

651
Gibson, F. A., and C. B. Duggan. 1970.

Experiments with the American hard-shelled clam *(Mercenaria mercenaria)* 1969. Ireland Dept. Agric. Fish., Fishery Leafl. 24, 6 p., 1 table, 1 figure.

About 4,000 hatchery-reared seed clams were obtained from the Station at Conway, North Wales, in April 1969. About 900 each were planted within plastic mesh covered wooden frames to protect them from predators such as green shore crab, *Carcinus maenas*, at Wexford Harbour, Bannow Bay, Cork Harbour, and Oysterhaven. In addition, about 400 were placed in a heated water lagoon associated with the Electricity Supply Board power station on the estuary of the River Shannon. The sites were examined three times, the last being in October and November 1969. Two sites were suitable for growing clams, Wexford Harbour and Cork Harbour, where the increment more than doubled the length at planting, from 13.5 mm to 31.0 mm at Wexford to 13.0 mm to 30.0 mm at Cork, with only 17% and 25% mortality, respectively. At the other two sites growth was slow and survival poor. The best growth rate was found to be at extreme low water spring tide level, the deepest at which clams were planted. Clams at the power station were not examined closely enough to give data at this time. - J.L.M.

652
Gibson, F. A., and C. B. Duggan. 1973.

American hard-shelled clam experiments in Irish waters. Ireland Dept. Agric. Fish., Fishery Leaflet 49, 6 p.

Results of experiments with 3 lots of clams, totalling 18,800, showed that the hard clam, *Mercenaria mercenaria*, can be grown and fattened in 2 areas, Wexford and Cork Harbours, to marketable size in 3 to 4 yrs, with mortalities ranging from 16% to 27%. To offset predation, particularly by *Carcinus maenas*, juvenile clams up to 25 mm size must be protected by mesh covered frames. Each frame, 2 ft x 2 ft can accommodate about 250 seed clams. Stocking at higher densities increases mortality and decreases growth. Costs of building frames and maintaining and servicing them are considerable. Hard clams are relatively easy to rear in hatcheries, and large quantities of seed can be produced. Costs are high, however, and the economic viability of a commercial operation cannot be said to have been proven. The clam can not reproduce in Irish waters because ambient temperatures are too low. - J.L.M.

653
Giese, Arthur C. 1966.

Lipids in the economy of marine invertebrates. Physiol. Rev. 46(2): 244-298.

Lipid levels in bivalves usually are considerably lower than in chitons. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M. and M.W.S.

654
Gilmour, T. H. J. 1974.

The structure, ciliation, and function of the lips of some bivalve molluscs. Can. J. Zool. 52(3): 335-343.

The 12 species described, all members of subclass Pteriomorphia, all have devices to prevent swallowing of excess water. It is suggested that in all bivalves water currents are generated by the food-collecting apparatus. Echinoderms have gill slits to allow excess water to escape, and this has had great evolutionary implications, but in bivalves the mechanism is less conspicuous. *Venus (Mercenaria) mercenaria* is not mentioned, but the conclusions are generally applicable. - J.L.M. and M.W.S.

655
Ginsburg, Robert N., and Heinz A. Lowenstam. 1958.

The influence of marine bottom communities on the depositional environment of sediments. J. Geol. 66(3): 310-318.

656
Ginter, Jay J. C. 1974.

Marine fisheries conservation in New York State: Policy and practice of marine fisheries management. 2 vols. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N.Y: I-21, II-5, iii-83; vol. 2, vi + 64 p.

A compilation of legislation enacted in the State on fishery matters and an analysis of the impact of these laws. It is concluded that the State has no cohesive fishery management policy which presents long-range objectives. New York cannot manage its living resources without such a plan, which includes adequate information on all fishing activities, and adequate cooperation from other states. - J.L.M.

657
Glancy, Joseph B. 1947.

History of the shellfish industry in Great South Bay, New York. Part I. Unpub. (?) ms., 11 p.

This manuscript deals primarily with oysters and the oyster industry, but important information on hard clam is included. Hard clams have been taken in abundance, particularly since March 1931, when a new inlet broke through to Moriches Bay, the neighboring bay to the east, which connects with Great South Bay. This produced great environmental changes in Great South Bay, unfavorable for oyster production but favorable to hard clam. Baymen did not confine themselves to one shellfish species, but shifted from one to another as market conditions, season, and relative abundance changed. Most hard clamming was in summer, mostly in the middle and western part of the Bay. From the early 1800s to 1931 oysters and clams would reproduce and set in the eastern part of the Bay and live, but grew slowly and usually were not fat. Waters were too fresh and tidal currents too slow. Conditions in the western part of the Bay were more suitable for growth and fattening but young set was more readily destroyed. (Abstracter's note: presumably from predation.) As early as 1789 the towns on the Bay were wrestling with shellfish problems. In that year the Brookhaven Town Trustees ruled that no oysters or clams should be taken by non-inhabitants of the Town. They also dictated that permission must be obtained to ship shellfish out of the Town, and set a fee of 5 shillings for each ton burden of craft carrying such shipment, and for clams 2 pence for every 100. In 1857 the Town of Islip asked the State Legislature to pass legislation giving them jurisdiction over a part of the Bay which allegedly belonged to Brookhaven. Brookhaven Town was able to prevent this move. The dispute was finally settled in 1880, when the two towns concluded a reciprocal agreement which allowed Brookhaven baymen to harvest shellfish in Islip waters. Islip paid $1,500 to Brookhaven (presumably to give Islip baymen the reciprocal privilege). Conflict between public ground clammers and holders of leased grounds began early. In 1898 baymen and Brookhaven Trustees tried to prevent dredging on leased ground, but this was defeated. Scarcity of shellfish is not a new development. About 1810 oysters ceased to spawn in the Bay and gradually became scarcer until 1825-1830. Whether hard clam became more abundant at this time is not mentioned. In 1933, after the inlet opened up at Moriches Bay, salinity at Smith's Point in the eastern part of Great South Bay increased almost to full ocean content. Hard clam stocks were increasing, which partly compensated for loss of oysters. Increased salinity was most beneficial for clam reproduction and growth. Previous to the break only occasional clam sets occurred in the eastern Bay, and growth was so stunted east of Nicoll's Point that almost all clammers worked west of the Point. After 1931 setting and growth were satisfactory in all parts of Great South Bay and Moriches Bay, and clammers worked these areas with profit. Baymen were anxious to prevent the inlet from closing. The history of shellfishing in Great South Bay is a history of the inlets. From 1931 to 1933 Glancy grew hard clams from egg to adult clams over an inch long. In hatchery jars, larval period was 9 days, and he believed larval development would be more rapid in the Bay. He thought that this might explain why good clam sets occur when oyster sets fail. Larval life of oysters is twice as long, which would increase the probability that larvae would be flushed out. After setting hard clams grew very slowly. In November, at age 6 months, when hibernation began, the largest were scarcely 1/4 inch. In 1932, '33, '38, and '42 gills of oysters and clams took on a dark color. The reason was not determined. In years when Bay water remains clear, so that bottom can be seen at 3 ft or more on calm days, oysters and clams always grow well and become fat. When waters are turbid growth is poor and meats thin. Turbidity was almost always caused by very small algae at densities of 100,000 to 200,000/drop of water. Under such conditions, when visibility of light-colored objects was less than 1 ft, oysters and clams seemed unable to feed. Some observers associated these blooms with almost complete disappearance of eelgrass. It was concluded that the shellfisheries of Great South Bay had a bright future, provided management were intelligent and Bay waters were kept clean. - J.L.M.

658
Glancy, Joseph B. 1956.

Biological benefits of the Moriches and Shinnecock Inlets with particular reference to pollution and the shellfisheries. Unpublished report to District Engineer, N.Y. Corps of Engineers, 18 p.

Describes the history of Moriches Inlet, which closed from natural events about 1886 and was reopened by a storm in 1931. Between 1946 and 1952 attempts were made to stabilize the channel by dredging and stone revetment and construction of 2 jetties. The inlet was reopened in 1953 with the aid of a hurricane. Salinities in the eastern part of Great South Bay increased substantially after the first reopening in 1931. Prior to that time almost no clams, and few oysters, were marketed from eastern Great South Bay, Moriches and Shinnecock Bays, because salinities were too low for growth and fattening. After 1931 high salinities favored increased abundance and activity of oyster drills, which destroyed most of the oyster set. Clams, however, were relatively resistant to drill predation, and increased clam production more than made up for loss of the seed oyster industry. Oyster reproduction was not affected, and the author concluded that if drills could be controlled all of Great South Bay and the other two bays would be suitable for growth and marketing of clams and oysters. Prior to the Woods Hole Studies of the early 1950s, Dr. Vanderborgh and Glancy knew that algae called "small forms" were the immediate cause of decline of the oyster industry. They had attributed it to restriction of water flow through Fire Island Inlet, but the Woods Hole work showed conclusively that duck farm wastes were the cause. Studies of the blooms of phytoplankton "small forms" by J. B. Lackey and by A. C. Redfield and a group from Woods Hole, Mass. attributed the later decline of the oyster and clam industries to starvation from absence of suitable food. Blooms were attributed to pollution from duck farms. Luxuriant growth of a serpulid worm, *Hexagonus hydroides*, which also had adverse effects upon shellfish production, also was attributed to the "small forms". Water in the bays was turbid and yellowish, and fishing, as well as shellfishing, was poor. The public questioned the edibility of oysters and clams. When Moriches Inlet was closed in 1951-53, blooms were the heaviest ever seen and extended throughout all 3 bays. By 1953 clams were weak and meats were so thin that dealers were refusing to market them. The author concluded that reopening of the Inlet in 1953 saved the clam industry. Salinities rose quickly and "small forms" virtually disappeared. When "small forms" were not in excess of 100,000/ml, growth and fattening of clams and the few remaining oysters was excellent, and the worms disappeared. The new clam and oyster industries which sprang up after Moriches Inlet broke through in 1931 were always menaced by the public health aspects of duck farm pollution, and harvesting was permitted only in winter when shellfish were hibernating. It was concluded from the various studies in the 1950s that opening of Moriches and Shinnecock Inlets, by raising salinity, created optimum conditions for growth and fattening of shellfish and also removed pollution. A warning was given, however, that growing human population and industry on Long Island was a threat, which must be reduced to a minimum by maintaining the flushing power of the inlets. It was recommended also that Fire Island Inlet should be relocated in its natural position just west of Fire Island Light. The value of oyster and clam production in Shinnecock, Moriches, and Great South Bays is reviewed. It was estimated that improved water conditions would make available 1,000 acres for oyster and clam farming to produce 100 bu oysters and 25 bu hard clams/acre, and 15,000 acres of public grounds, exclusive of Islip waters, which would produce an average of 10 bu clams/acre. Estimated annual production of hard clams would be at least $800,000 by 1960 (in 1956 dollars) if inlets were maintained. Normal hard clam production in Islip waters in Great South Bay had been about 150,000 bu/yr. As Moriches Inlet closed, production dropped below 20,000 bu by 1954. After the inlet was opened, heavy clam sets occurred in 1954 and 1955, and production from Islip waters was expected to rise to 150,000 bu by 1960. With maintenance of proper circulation in the 3 bays, clam production from public and private grounds combined could rise to $1.5 to $1.6 million by 1960. Costs of maintenance of the inlets were judged to be economically beneficial from improvement in shellfish production alone. - J.L.M.

659
Glancy, Joseph B. 1965.

Method of raising shellfish seed in a simulated habitat. Patent no. 3,196,833, July 27, 1965.

The method of producing shellfish seed in a favorable habitat which comprises placing shellfish larvae in a contaminant free and nutrient including environment and exposing the larvae and environment to periods of direct solar radiation. - J.L.M.

660
Glud (sic), John B. 1949.

Notes on clam investigations conference. U.S. Dept. Interior, Fish Wildl. Serv., Boothbay Harbor, Me., p. 1-9.

Venus mercenaria was mentioned, but no conclusions drawn. - J.L.M.

661
Glud (sic), John B. 1949.

Fish and Wildlife Service clam investigations. Convention Addresses, Natl. Shellf. Assn. 1949: 50-57.

A preliminary report on investigations authorized by PL 556 of the 1948 Congress to study hard clam, *Venus mercenaria*, and soft clam, with particular respect to the biology, propagation, and methods of cultivation. Seven states were selected for study. No results are yet reported. - J.L.M.

662
Glud (sic), John B. 1951.

The effect of man on shellfish populations. Trans. 16th. N. Am. Wildl. Conf., p. 397-403.

This paper deals primarily with *Mya arenaria* and there is no mention of *Mercenaria mercenaria* except in the recorded discussion. There it was said that horseshoe crab is not such a serious predator of hard clam as it is of soft clam. The general principles discussed in the paper would apply just as well to hard clam as to other species. - J.L.M.

663
Glude, John. 1952.

The hydraulic clam rake, a new method of gathering seed clams. Addresses delivered at the convention of the National Shellfisheries Association August 1952: 163-166.

This is mostly about soft clams. One cove at West Bath had small quahogs at a density of 300/ft^2. These were stunted by overcrowding and likely to freeze in a cold winter. A number were caught by the rake. These now average about 1 inch in length, and are large enough to be raked into windrows and forked into a basket for transplanting. If the set had been discovered a year ago when the clams were smaller the hydraulic rake would have been practical. - J.L.M.

664
Glude, J. B. 1955.

Report of clam investigations for fiscal year 1955. Atl. States Mar. Fish. Comm., N. Atl. Sect., 18th Meeting, 15 Nov. 55, Appendix, 10 mimeo p.

Laboratory studies showed that green crab will eat *Venus* but prefer other clam species. Small *Venus* are preferred to large. In Greenwich Bay, R.I. a shortage of littleneck clams in 1954, predicted from previous sampling, came about. The 1954 catch of "necks" was the smallest since 1950. Total catch of hard clams fell steadily from 1950 to 1954. In 1954 the number of clams under legal size had increased, and this led to increased production of "necks" in 1955. Density of sub-legal sizes was about 5.35 clams/ft^2, all apparently clams of a single year class. This was in an area which had not received sets in the past few years. The Tidal Spat Trap was used in Wickford, R.I. to test its ability to collect seed *Venus* for use in clam farming. At the end of the spawning season the trap contained 60 live *Venus*/ft^2. - J.L.M.

665
Glude, J. B. 1955.

The tidal spat trap, a new method for collecting seed clams. Proc. Natl. Shellf. Assn. 45: 106-115.

The Fish and Wildlife Service was directed in 1948 by Congress to determine the causes of the decline of the soft and hard clam fisheries along the Atlantic coast and to develop methods to increase production. Clam farming either takes natural set on leased or owned bottom and harvests at the desired size, or moves seed from other areas, sometimes protecting against predation. Three principal methods of getting seed are: 1) collect juveniles from natural set; 2) artificial propagation; or 3) collect spat or juveniles by some device. Young hard clams are seldom found in heavy concentrations. Usual bottom samples in R.I. contain 1-20 clams/ft^2. The only exception was the summer of 1951 in Greenwich Bay when samples as high as 600 *Venus*/ft^2 were taken, but this was unusual. The best natural source of juveniles seen was in Casco Bay, Me. Hard clams in Me. set in years of high temp; a cold cycle might prevent reproduction. The tidal spat trap is a box which fills and empties with the tide, and a system of check valves to force outgoing water through a sand filter. Larvae are brought into the box by the tide and held by the sand. A diagram is given. Traps were tested at Boothbay Harbor, Me., Wickford, R.I., and other locations. Results depended on location, time, and presence of mature larvae. Over 1,000 hard clam larvae/ft^2 of filter have been taken in 4 days. Methods now are needed to hold seed until it is predator-resistant. - J.L.M.

666
Glude, John B. 1955.

Why blame the clam digger? In Dividends from research. Prog. Fish Cult., April 1955: 94-95.

Decline of the soft clam, *Mya arenaria*, fishery in New England is attributed to predation, not overharvesting of the resource, as had commonly been believed. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M.

667
Glude, John B. 1955. (Discussion leader).

Summary of knowledge of *Venus*. 5th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv., p. 75-76.

We know times of spawning and setting, and seasonal patterns of larval abundance. It has widely fluctuating and highly localized year class strength. Year class strength can be predicted one or two years in advance. We can determine age and growth. Growth rates vary in time and space. It can be transplanted. Seed can be produced by artificial propagation. Seed from natural reproduction is available in large quantities in certain places and times. It can be farmed in certain areas. Mortality in limited areas and under specified conditions is known. Relation between present fishing intensity and probable yield is known for Greenwich Bay. Predation is most important on *Venus* under one inch long. Green crabs and horseshoe crabs can be excluded from intertidal areas by fencing. No mass mortalities attributable to parasites or diseases have been observed. We think clams do not remain in place after setting, but are redistributed by hydrographic conditions or by movement. At present levels of abundance there is no relation between number of adults and number of progeny that reach commercial size from variations in mortality. Length of larval stage is related to temperature. Currents are important in determining distribution. Further exploration would disclose additional sources of natural seed. Mortality of *Venus* above 20 mm is low in Rhode Island. We do not know the food, extent of movement of young and adults, or what determines distribution, behavior, and survival of larvae. We do not know enough about the effects of environment on survival from the time they set until they reach the stage at which year class strength can be predicted, or enough about causes of variations in growth. We do not know if experimental procedures for artificial propagation can be applied to commercial scale seed production. We do not know the effect of the fishery on clams not harvested, the mechanics of productivity, or how to estimate and control predation on subtidal *Venus* populations, or what is the minimum population level at which commercial fishing is no longer profitable. - J.L.M.

668
Glude, John B.

Clam and Chesapeake oyster investigations 1948-57. U.S. Fish Wildl. Serv.

Could not locate. Search terminated. - J.L.M.

669
Glude, John B. 1966.

Criteria of success and failure in the management of shellfisheries. Trans. Am. Fish. Soc. 95(3): 260-263.

The paper deals with oyster and razor clam fisheries of Washington State, oyster fishery of Chesapeake Bay, and soft shell clam fishery of New England. Criteria for evaluating successful management are common to all, and to *Mercenaria mercenaria* and other bivalves: 1) that the resource can be harvested at a profit; 2) that the resource is maintained at a level to produce maximum sustained economic yield; and 3) each participant has an opportunity to obtain an adequate share of the harvest. Recreational and commercial shellfisheries are evaluated. - J.L.M.

670
Glude, John B. 1968.

Management and development of molluscan resources on the Pacific coast of the United States. Proc. Symp. Mollusca, Cochin, India, Pt. 3: 890-898.

671
Glude, John B. 1974.

Recent developments in shellfish culture on the U.S. Pacific coast. In Proc. 1st. U.S.-Japan Meeting Aquacult. U.S. Dept. Commerce, NOAA Tech. Rept. NMFS Circ. 388, p. 89-95.

Hard clams are defined as *Tivela stultorum*, *Protothaca staminea*, *Saxidomus nuttali*, and *Tapes semidecussata*. It is not clear from the context whether or not the author also includes *Siliqua patula* in the hard clam category. (Abstracter's note: although *Mercenaria mercenaria* has been introduced on the west coast of the United States, and quantities are now being produced commercially by a hatchery in California, the species is not mentioned in this paper.) - J.L.M.

672
Glude, John B. (ed.). 1977.

NOAA aquaculture plan. U.S. Dept. Commerce, Natl. Oceanic Atmosph. Admin., Natl. Mar. Fish. Serv. and Off. Sea Grant, vi+41 p.

World aquaculture production has about doubled in the last 5 yrs and produces about $6x10^6$ metric tons, or about 10% of world fish production. In the U.S. only 3% of landings and 2% of total consumption of fishery products comes from private aquaculture. Solution of some biological, technological, institutional, or marketing problems could lead to increased U.S. production. Expansion of aquaculture will require coordinated efforts of Federal and state agencies, universities, and private industry. NOAA proposes to take the lead in these efforts. *Mercenaria mercenaria* is listed with medium-priority species, which have distinct potential for aquaculture but have not reached commercial production for one reason or another. Private aquaculture ventures are located on Long Island, N.Y., Wilmington, N.C., and several other places. From the context, it is not apparent that the writer realized that 5 hatcheries on Long Island were rearing hard clam until recently. The operation described raises hard clam and oyster in a hatchery and holds young in trays in the warm effluent of a power plant to accelerate growth. At appropriate size clams then are planted on private beds. The operation was too new to determine economic success. The same company also selectively harvests natural clam sets from its beds and sometimes moves seed clams to areas where growth and survival are better. The N.C. venture has a hatchery capable of producing more than 4 million seed clams for sale or planting. It was too soon to judge economic success. The State of Virginia produces seed clams in its hatchery at Wachapreague. Survival has been improved by placing coarse material like gravel on beds before planting. This procedure did not work in Fla. A Sea Grant program at Univ. of Del. cultures clams using artificially produced algal foods. Marketable size is reached in 1/3 the time required for wild stocks in Delaware Bay. Increasing demand for clams, limited supply, sedentary habits, and the fact that they obtain their own food at no additional cost, make clam aquaculture attractive. A major problem is how to rear juveniles until they are large enough to be planted on intertidal or subtidal beds (e.g., until they are resistant to predators). Most NOAA programs on hard clams have been terminated. In 1976 clam programs included occasional pathological studies and development of processing techniques. Sea Grant was supporting studies of intensive culture methods in Del. Future NOAA programs should include expansion of pathology and genetics studies and research on biology and technology of aquaculture. Funding for all clam species should be increased from present level of about $100,000/yr to $800,000/yr by 1985. Plans for multispecies programs are discussed and NOAA aquaculture programs in fiscal year 1976 are listed. - J.L.M.

673

Glude, John B., and Warren S. Landers. 1953.

Biological effects of bullraking vs. power dredging on a population of hard shell clams, *Venus mercenaria*. Natl. Shellf. Assn., Convention Addresses 1951: 47-69.

In Narragansett Bay, R.I., an intensive hard clam fishery has operated for many years. Digging with tongs or bullrakes is permitted in any unpolluted waters. Power dredges are restricted to a much smaller area, except that for a short time during WWII other areas were opened to dredges to increase food production. A long-standing controversy exists between the 2 segments of industry. Hand diggers claim that dredges tear up the bottom and break clams, bury small clams so deeply that they smother, and sometimes overplow the bottom causing currents to scour and prevent new set from surviving. Dredgers claim that they are cultivating the bottom and preventing it from compacting, that they improve the bottom, inducing new sets and increasing growth rates. Fishing methods are described in detail. A 3-acre test area was closed to commercial clamming. Four bullraking areas were laid out at one end, a control area in the center and 4 dredging areas at the other end. These 3 were separated by 25-ft corridors, and similar corridors separated the plots from the perimeter of the 3-acre plot. Two bullrakers were hired to harvest appropriate areas and dredge boats were chartered for the others. Rakers worked a plot until the catch reached a pre-established minimum value, then moved to another. Dredging in a plot continued until the same quantity of clams over 60 mm long had been obtained from the corresponding quarter of the bullrake area. The minimum size taken efficiently by the dredge was about 60 mm. Underwater photos were taken of the bottom. Size distribution of clams in the area was determined before the experiment. After fishing, bottom samples were taken with a clamshell bucket which sampled 5 ft^2 to a depth sufficient to get all clams. Dredging caused slightly more breakage: 1.2% in 1949, 0.7% in 1950. Bullraking breakage was: 0.1% in 1949, 0.3% in 1950. Gear caused most breakage in dredging, handling caused most damage in raking. On the bottom, dredging broke 2.9% when rocks were present, 1.0% when not. No evidence of important breakage of undersized clams or clams less than 60 mm long was found on any plot. No evidence of significant smothering appeared. Virtually no setting took place in 1949 or 1950, thus effects on setting could not be determined. The surface of the bottom was almost identical in control and test plots 1 to 3 mo after the experiment. Both test areas showed reductions in number of other living forms as compared with the control. Size composition of remaining clams on the dredged and tonged areas differed because raking takes a larger number of clams below 60 mm. The implications of this for recruitment are not known. Before the experiment the 3-acre plot contained 2 size groups of clam, one peaking at less than 40 mm, the other at about 60 mm. The group of larger clams disappeared from the control area from 1949 to 1950 even though no clams were removed in the experiment. This unexplained difference was not caused by sampling error. The same group almost disappeared from the raked area also. Illegal clamming was suspected. It is clear that no significant biological effects on hard clam populations came about from the direct operation of one gear as compared to the other. The biological effects of size selection by the two harvesting methods were not determined. - J.L.M.

674
Glude, John B., and Warren S. Landers. 1953.

Biological effects on hard clams of hand raking and power dredging. U.S. Dept. Interior, Fish Wildl. Serv., Spec. Sci. Rept.- Fish. 110, 43 p.

Three test areas in Narragansett Bay, Rhode Island were established to study the relative biological effects of power-dredging and hand raking on a population of hard clams. A clamshell bucket was used to census clam populations. One area was exclusively bull-raked, one was clammed with a Nantucket dredge, and the control area was not harvested at all. During the 2 years (1949-1950) breakage of commercial sized clams by bullraking averaged 0.2%, breakage by dredging averaged 0.95%. During the same period a population survey was conducted using a power dredge. This dredge reported 1.0% breakage on smooth bottoms and 2.9% clam breakage on rocky bottoms. Undersized clams (below 47-48 mm in length) were not broken in significant numbers by either method of clamming. The dredge takes mainly clams above 60 mm, but there was no significant breakage of clams below 60 mm in the dredged areas. Neither dredge nor bullrake appeared to cause mortalities by smothering clams. There was no significant difference in bottom composition (physical and biological) between dredged and raked areas, but both had fewer living forms than the control area. Efficiency ratios for bullrake and dredge were determined. Maximum efficiency for the rake was for clams above 55 mm long, but some 36-55 mm clams were retained. Maximum efficiency of the dredge was for clams above 70 mm with partial efficiency for clams between 35 and 70 mm. It was concluded that there is no biological basis for restricting bullraking or dredging. (Abstracter's note: it must be assumed that biological overharvesting is avoided.) - D.L.

675
Godcharles, Mark F. 1971.

A study of the effects of a commercial hydraulic clam dredge on benthic communities in estuarine areas. Fla. Dept. Nat. Resources, Mar. Research Lab., St. Petersburg, Tech. Ser. 64, 51 p.

The gear was a Maryland soft clam escalator dredge. Virtually everything in its path was collected. The dredge was much more efficient than hand tools, inflicted fewer mortalities, and can bring into production clam beds with marginal population densities. Water jets penetrated the substrate to 18 inches and uprooted seagrasses and benthic algae. Traces of tracks were visible 1 to 86 days after dredging. In most cases the substrate hardened within a month but some spots remained soft for over 500 days. Trenches in grass bed stations remained visible longest, and were deepest in shallow water where propeller wash scoured loose sediments. Differences in silt/clay content at experimental and control sites immediately after dredging were negligible after a year. Seagrasses and algae did not recolonize dredged areas, and such areas should not be dredged. On other substrates little or no damage was seen. Increased efficiency and reduced damage could be realized by adding slats to the conveyor belt and installing a propeller guard. Unpublished data from the Long Island Sound hard clam fishery showed that continued use of escalator harvesters increased catches of littleneck and cherrystone clams and catches of chowder clams declined. No increased set was seen in any test area in Fla. - J.L.M.

676
Godcharles, Mark F., and Walter C. Jaap. 1973.

Exploratory clam survey of Florida nearshore and estuarine waters with commercial hydraulic dredging gear. Fla. Dept. Nat. Resources, Mar. Research Lab., Profess. Pap. Ser. 21, iii+77 p.

Fla. clam production has been dominated by three species, *Mercenaria mercenaria*, *M. campechiensis*, and *Macrocallista nimbosa*. Some *Rangia cuneata* are taken. Quahog landings have been reported for almost 100 yrs. Sampling was done from Fort Pierce on the east coast (27°30' N) south to part way down the Keys, and north and west to the vicinity of Panama City (30°10' N). Greatest depth sampled was 14 m. The southern quahog was found from Alligator Har. to Shark Pt. (Everglades), most abundantly in Lower Tampa

Bay and off passes. Most productive stations in open Gulf were off Charlotte Harbor. The species seldom was taken deeper than 9.2 m. In some areas quahogs were associated with seagrasses. *M. campechiensis* from Tampa Bay and Charlotte Har. were smaller than those from open Gulf. *M. mercenaria* supports a small east coast fishery, but none was taken in areas covered by this survey, nor was any clam identified as a hybrid or subspecies. Although the paper contains 1 small-scale location chart and 16 large-scale charts, many place names mentioned in the text are not included. Detailed fishing logs are contained in 2 appendix tables. There is also an extensive list of literature cited. - J.L.M.

677
Godcharles, Mark F., and Walter C. Jaap. 1973.

Fauna and flora in hydraulic clam dredge collections from Florida west and southeast coasts. Fla. Dept. Nat. Resources, Mar. Research Lab., St. Petersburg, Spec. Sci. Rept. 40, 89 p.

Reports collections made in 1970 and 1971 by locality, depth, and numbers of organisms. Extensive collections of *Mercenaria campechiensis* are listed. - J.L.M.

678
Goddard, C. Keith, and Arthur W. Martin. 1966.

Carbohydrate metabolism. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.) Academic Press, New York, Vol. II: 275-308.

Refers to work of Dugal (1939) abstracted elsewhere in this bibliography. - J.L.M.

679
Godwin, Walter F. 1967.

Preliminary survey of a potential hard clam fishery. Ga. Game Fish. Comm., Mar. Fish. Div., Brunswick, Contr. Ser. 1, 23 p.

A small hard-clam fishery existed in Georgia from at least 1880 to 1932. The recorded peak catch was 43,000 pounds in 1908; from then to 1932 no more than 2,000 lbs annually were reported. Factors causing the decline are obscure. The survey was undertaken in 1966 and 1967 to determine the feasibility of reestablishing a fishery. Subtidal samples were taken with an oyster dredge, intertidal samples with rakes and tongs. Of 269 stations, clams were taken at 35, but commercial abundance was found at only 4 intertidal locations and 2 subtidal. Species were *Mercenaria mercenaria* and *Rangia cuneata*. Maximum abundance of *M. mercenaria* was 138/100 ft^2 at station 45, 134/100 ft^2 at station 103, 151/100 ft^2 at station 140. Each area was less than 1 acre. Few clams below legal size were taken. Densities of *M. mercenaria* were either too low for commercial harvesting or areas containing hard clams were too small to support a commercial fishery. The study was to be continued. The sampling log contains information on size range, mean length, water depth, bottom type, and current velocity. - J.L.M.

680
Godwin, Walter F. 1968.

The growth and survival of planted clams, *Mercenaria mercenaria*, on the Georgia coast. Ga. Game Fish Comm., Mar. Fish. Div., Brunswick, Contrib. Ser. 9, 16 p.

Planted clams must be protected by screening to reduce blue crab predation. It was concluded that costs of protection would be prohibitive on a commercial scale. Laboratory-reared quahogs from North Carolina 13 to 26 mm long were held from Aug 1967 to June 1968 in covered and uncovered trays on bottom in six areas, and suspended off bottom in another area. Suspended experiments were unsuccessful and were terminated. Mortality in protected trays ranged from 0 to 60%. In unprotected trays mortality was 100%, except for one experiment in an intertidal zone, in which mortality was 48 to 60%. Average monthly growth was about 3 mm or slightly more except in the intertidal zone, where it was about 1.9 mm/month. Greatest growth was observed in samples low on tidal flats with firm sand and mud bottom. In protected areas of proper salinity and bottom type clams could be grown to market size in one year at very high densities (75 clams/ft^2). Salinity should be at least 25°/°° and protection should be provided against predators. - J.L.M.

681
Godwin, Walter F. 1968.

The distribution and density of the hard-clam, *Mercenaria mercenaria*, on the Georgia coast. Ga. Game Fish Comm., Mar. Fish. Div., Brunswick, Contr. Ser. 10, 30 p.

The fishery in Georgia extended from about 1880 to 1932, mostly as incidental catch in the oyster industry. Potential for reestablishment of the fishery was investigated from July 1966 to June 1968 because reduction of catches in some northern states had opened markets. Most sampling was done with modified oyster dredges and basket rakes. Of 432 areas sampled, clams were found in only 41, less than 10%. Certain bottom types were clearly preferred. Most clams were found in firm sand and mud mixtures, or mixtures of sand, mud, and shell. Protection from wave action also appeared to be important. Clams were not found in salinities under 18°/°°, and density increased with increasing salinity to a maximum at 27 to 29°/°°. Greatest abundance was at salinities from 27 to 32°/°°. In areas with clams, density ranged from one to 193 clams/100 ft^2. Most populations were in the intertidal zone. Little commercial potential was noted. Clams were restricted to small areas. Recreational clamming was possible. - J.L.M.

682
Goggins, P. L. 1961.

Paralytic shellfish poison. In Proc. Shellf. Sanit. Workshop. U.S. Pub. Health Serv., Washington, D. C.: 252-265.

683
Goldberg, Edward D. (Chm). 1980.

The International Mussel Watch. Report of a workshop sponsored by the Environmental Studies Board, Commission on Natural Resources, National Research Council. National Academy of Sciences, Washington, D.C., xvi + 248 p.

This report contains few references to *Mercenaria mercenaria*. On page 55 are two figures illustrating ultraviolet fluorescence spectra of a 2- and 3-ring aromatic hydrocarbon fraction isolated from *Mercenaria mercenaria* and clams "spiked" with No. 2 fuel oil (from Farrington and others 1976). On page 107 Romeril (in press) is cited as measuring loss of elements from *M. mercenaria* held several days in the laboratory. A drop in zinc and copper concentrations of 9 and 12 percent respectively through the first 35 hrs after field collection was noted. Subsequent to this decrease concentrations were constant, confirming the relatively long half-life of these elements in this species. On page 178 it is said that only gross sites of toxic action have been found. In *M. mercenaria* metabolic alterations have been found indicative of increased glucose use and decreased gluconeogenesis (Roberts 1976). On page 216 it says that quahogs are opened by cutting the ligament and wrenching the shell apart to tear the muscle. With a quahog knife the animal is shucked free of both valves and dropped into fixative. Care should be taken to prevent tearing the mantle. - J.L.M.

684 Goldin, Abraham, John M. Venditti, Stewart R. Humphreys, and Nathan Mantel. 1958.

Quantitative evaluation of chemotherapeutic agents against advanced leukemia in mice. J. Natl. Cancer Inst. 21(3): 495-511.

The research was done with chemical agents. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S.

685 Goldstein, B., and O. A. Roels. 1979.

The effect of different algal protein concentrations on the nitrogen balance of juvenile *Mercenaria campechiensis*, the southern hard clam. In Abstr. of Papers submitted for the 42nd Ann. Meeting, Am. Soc. Limnol. Oceanogr., Inc., Mar. Sci. Research Ctr., State Univ. of N.Y., Stony Brook, N.Y., June 18-21, 1979.

Five different algal protein concentrations were presented to duplicate populations of juvenile *M. campechiensis*. The experiment ran four weeks with weekly culling to return population weights to initial values. The following nitrogen compounds were assayed daily: nitrate, nitrite, ammonia, soluble protein, dissolved free amino acids, urea, total dissolved nitrogen, and particulate protein. Particulate protein of culled animals and weekly tank deposits of shellfish were also assayed. Algal cell densities of $5x10^4$ to $1x10^5$ cells/ml gave maximum weight increases. - J.L.M.

686 Goldstein, B. B., and O. A. Roels. 1980.

The nitrogen balance of juvenile *Mercenaria campechiensis* at different feed levels. Natl. Shellf. Assn., Abstracts, Technical Sessions: 19 (abstract).

Isochrysis was fed at four different cell densities/ml: $5x10^5$, $1x10^5$, $5x10^4$, $1x10^4$, to juvenile hard clams *M. campechiensis*. Each treatment went to duplicate populations of 100 animals; each population had a whole wet weight of 10 grams. Total flow rate to each was 120 ml/minute. A quantitative and qualitative nitrogen balance for juvenile hard clams in a continuous flow system was calculated; 85 to 95% of all incoming nitrogen was accounted for in the different treatments. Ammonia and DFAA were excreted but urea was not. Nitrate and nitrite were generally unaffected by passage through the shellfish culture chambers although very small amounts were taken up by algae present in the copius biodeposits of shellfish receiving the densest treatment. High levels of soluble protein are associated with high levels of PPN. Apparently soluble protein is taken in along with or as a result of ingestion of particulate protein. Protein stripping efficiency, protein retention efficiency, food chain efficiency, ecological efficiency, protein conversion efficiency, and gross growth efficiency were all maximal for those animals receiving an average weekly inflow algal protein concentration of 5.75 μgat particulate protein nitrogen/liter. - J.L.M.

687 Goodwin, C. Lynn. 1973.

Distribution and abundance of subtidal hard-shell clams in Puget Sound, Washington. Wash. Dept. Fish., Tech. Rept. 14, v+81 p.

The study was directed at *Saxidomus giganteus* and *Protothaca staminea*. The similarity of these species to *Mercenaria mercenaria* suggests that methods used could be applied to that species also. Surveys were done by SCUBA divers, who collected samples with small hand-held venturi dredges. Divers could make direct observation of the bottom, and reliable samples were collected at less expense than by coring devices or grab dredges. About 15 samples/day could be taken. Estimated standing crops varied from 0.06 to 1.93 lbs/ft^2 for *Saxidomus* and 0.00 to 0.70 for *Protothaca*. (It is not specified whether these weights were live weight or weight of meats. We assume that whole clams were weighed because shucking was not mentioned.) Standing crops averaged over large areas were: *Saxidomus* 46 to 1,144 g/m^2, *Protothaca* 0 to 448 g/m^2. Lower values for *Protothaca* reflect smaller size of clams rather than lower abundance. Average weights of commercial-sized clams were 151 to 161 g and 39 to 45 g respectively. Altogether, 25 species were taken. *Mercenaria mercenaria* was not included. - J.L.M.

688
Gordon, J., and M. R. Carriker. 1978.

Growth lines in a bivalve mollusk: Subdaily patterns and dissolution of the shell. Science 202 (4367): 519-521.

Scanning electron micrographs of sections of the prismatic shell of the bivalve *Mercenaria mercenaria* show narrow subdaily growth striations. The width of these narrow lines, formed by concentrations of organic material, corresponds to the quantity of shell material that would be expected to dissolve during periods of anaerobic metabolism. The pH in the extrapallial fluid decreases when the valves are closed, and the amount of dissolution of shell is related to the duration of valve closure. - from authors' abstract - J.L.M.

689
Gosselin, Robert E. 1958.

Influence of viscosity on metachronal rhythm of cilia. Fed. Proc. 17: 372 (abstract 1468).

The work was done with *Mytilus* and *Modiolus*. *Mercenaria mercenaria* is not mentioned. - J.L.M. and M.W.S.

690
Gould, Augustus A. 1870.

Report on the Invertebrata of Massachusetts. 2nd edition, comprising the Mollusca. W. G. Binney (ed.) Wright and Potter, State Printers, Boston. *Venus mercenaria*: 133-134; *Venus notata*: 135-136.

The section on *V. mercenaria* includes the synonymy and a detailed description of morphology of valves. Brought from Wellfleet and other towns on Cape Cod to Boston market. More abundant in the south, and in N.Y. and Phila. markets supersedes *Mya arenaria* almost completely. It may be found in variable abundance in all the region of Cape Cod, and scantily in all parts of Massachusetts Bay. Maine coast far to the east of Portland; Halifax, Sable Island, Prince Edward Island, Fishing Banks; Gulf of St. Lawrence. Quahog is the common name in Mass. A footnote describes the derivation of the word. The section on *V. notata* is similar. It is recognized that this may be a local variety of *V. mercenaria*, but some consistent differences are noted. *V. praeparca* is described as the same as *V. notata* but with zigzag lines missing. - J.L.M.

691
Gracy, Robert C. 1976.

Survey of South Carolina's hard clam *Mercenaria mercenaria* resource. Proc. Natl. Shellf. Assn. 66: 101-102 (abstract).

Shortage of hand labor, regulations prohibiting most mechanical harvesting, lack of knowledge of subtidal clam beds, and limited local markets have made clamming an incidental fishery in the oyster industry in S.C. The State made a survey in areas not leased to oyster planters from Mar 1973 to June 1975 inclusive. Eighteen thousand yd^2 samples have been inspected and 4 commercially valuable clam beds have been located. Sampling was with patent tongs. Information was gathered on species of clam, numbers, sizes, location, bottom type, and water depth. Experimental mechanical clam harvesting was permitted in 1974-75. Clam landings increased by 1.4 million lbs over the previous season. - J.L.M.

692
Grady, George F., Thomas C. Chalmers, and the Boston Inter-Hospital Liver Group. 1965.

Viral hepatitis in a group of Boston hospitals. I. A retrospective study of 1675 patients. New England J. Med. 272(13): 657-661.

Records of patients thought to have contracted viral hepatitis from 1951 through 1962 were reviewed at 9 Boston hospitals. Among the 30% who had a confirmatory epidemiologic history, mortality was confined to those thought to have acquired hepatitis from transfusions. One in 8 died, but most deaths were among older patients or those who also had cancer. By contrast only one of more than 200 patients with naturally acquired infectious hepatitis died, and that patient also had another infection. The type of epidemiologic history, or lack of it, appeared to be correlated with the subsequent course of hepatitis among hospitalized patients, i.e., there was some indication that youth and better health were conducive to less severe effects. Sources of naturally acquired infections were not identified. Therefore *Venus (Mercenaria) mercenaria* and other shellfish species are not mentioned. - M.W.S. and J.L.M.

693
Grady, George F., Thomas C. Chalmers, and the Boston Inter-Hospital Liver Group. 1965.

Viral hepatitis in a group of Boston hospitals. II. A prospective controlled epidemiologic study. New England J. Med. 272(13): 662-666.

Records of 1,675 patients with hepatitis hospitalized in Boston from 1951 through 1962 showed that 2/3 had acquired the disease without exposure to conventionally recognized sources such as transfusions or jaundiced persons. It was suggested that many may have contracted hepatitis from obscure potential sources such as ingestion of raw shellfish. Each patient was interviewed. One hundred adults with hepatitis and 100 appropriately matched controls were studied. The 75 patients in which hepatitis was unrelated to transfusions had eaten raw clams to a significantly greater degree than controls. The species of clam was not identified. It was most likely *Mercenaria mercenaria* or *Mya arenaria*, but because quahogs are most likely to have been eaten raw, *M. mercenaria* was the most likely source of infection. Clams had been eaten in restaurants or had been gathered personally, usually from polluted waters. No restaurant was involved disproportionately. - J.L.M.

694
Graham, Herbert.W. 1968.

Trends in the marine fisheries of the continental shelf of the eastern United States. Trans. Am. Fish. Soc. 97(1): 77-82.

The clam fishery is an interesting case of substitution of species. Soft shell and quahaug fisheries in New England have declined slowly from water pollution and habitat destruction. The loss has been more than compensated for by development of the surf clam fishery in the middle Atlantic states. Since 1954 total clam production in the eastern United States has been rising sharply. The increase can be expected to continue because known reserves are not fully exploited. History of clam landings since 1930 is illustrated for the Atlantic coast and Gulf of Mexico, but not by species. - J.L.M.

695
Graham, R. A., and C. P. Mangum. 1969.

Further studies of the feeding response in the onuphid polychaete *Diopatra cuprea*. Va. J. Sci. 20(1): 111 (Abstract).

D. cuprea continually tests the medium for presence of food stimuli by drawing large quantities of water into its tube. When stimuli reach a threshold, the worm gives a feeding response that causes ingestion. A diffuse jet of clam juice directed toward the anterior opening of the tube of the worm induces the feeding response. Juice from *Mya arenaria* contains several substances which elicit the response: the amino acids serine, tyrosine, valine, and phenylalanine; and a larger molecule of about 17,000 to 20,000 molecular weight. This larger molecule is not present in *Mercenaria mercenaria*. The molecule is believed to be a polypeptide, but other possibilities exist. - J.L.M.

696
Grassle, Judith P. 1976.

The genetic component of variable growth and survival in seed quahogs. In Marine Resources Development and Management. A Report on the Woods Hole Oceanographic Institution Sea Grant Program for July 1975-June 1976. NOAA Sea Grant 04-6-158-44016. Dean F. Bumpus (coordinator): 6.

Four enzyme systems have been found by electrophoretic techniques in hatchery stocks and wild populations of *Mercenaria mercenaria*. These represented 7 distinct polymorphic genetic loci: PHI, LAP 1, LAP 2, TO, PGM 1, PGM 2,and PGM 3. - J.L.M.

697
Grave, Caswell. 1905.

Investigations for the promotion of the oyster industry of North Carolina. In U.S. Comm. Fish and Fisheries, Part XXIX. Rept. of the Commissioner for the year ending June 30, 1903: 247-315, 6 pls.

Venus (Mercenaria) mercenaria is not mentioned. - J.L.M.

698
Greenberg, M. J. 1958.

The action of indoles on the heart of *Venus mercenaria*. Ph.D. Thesis, Harvard Univ.

Not available in Dissert. Abstr. Internatl. - M.W.S.

699
Greenberg, M. J. 1960.

The responses of the *Venus* heart to catechol amines and high concentrations of 5-hydroxytryptamine. British J. Pharmacol. Chemother. 15(5): 365-374.

Catechol amines have a characteristic excitation effect on isolated heart of *Venus mercenaria*. This response was not obtained with phenethylamine, tyramine, ephedrine, mescaline, histamine,or basic n-alkylamines. 5-hydroxytryptamine (5HT) had a distinctive effect at high concentrations (above 3×10^{-6} M) different from that at lower doses. At high concentrations the response was dominated by increase in muscle tone. Hearts exposed to high concentrations of 5HT and other tryptamine analogs for long periods became tachyphylactic to low doses of these substances. High doses of 5HT still excited the tachyphylactic heart but the response was like that to catechol amines. When high bath temps (equivalent to summer temp) made the heart insensitive to 5HT, high concentrations of 5HT again had the catechol amine effect. Catechol amines have been found in ganglia of *V. mercenaria*, which suggests strongly that catechol amines have a role in normal functioning of *Venus*, specifically in seasonal variations in performance of the heart. Results of the study also provided new methods for testing specificity of action of excitatory compounds. - J.L.M.

700
Greenberg, M. J. 1960.

Structure-activity relationship of tryptamine analogues on the heart of *Venus mercenaria*. British J. Pharmacol. Chemother. 15(5): 375-388.

Isolated ventricle of *Venus mercenaria* is highly sensitive to 5-hydroxytryptamine (5HT), hence was an excellent preparation for study of effects of various indole analogs and other excitor agents. Specific activity of tyramine and phenethylamine and non-specific excitatory action of indole and skatole showed that the indole ring is neither necessary nor sufficient for 5HT-like activity. Tryptamine analogs differ in mode of action and potency. Congeners without a 5-hydroxyl group tended to act more slowly and irreversibly, and less strongly than 5HT. Methyl substitution also increased the time of action and difficulty of reversal. Potency of such compounds may be increased or decreased depending upon position of substitution and presence of the 5-hydroxyl group. - J.L.M.

701
Greenberg, M. J. 1963.

The effect of changes in rate on the amplitude of beat of bivalve hearts. Proc. 16th. Internatl. Congr. Zool. 2: 109 (abstract).

Quiescent, isolated ventricles of *Mercenaria mercenaria* can be induced to beat by electrical stimulation. Changes in amplitude of an isotonic preparation induced by alterations in rate of stimulation can then be determined. Height of contraction decreases as general interval between beats is decreased from 20 sec to 0.1 sec at 25°C. Tone rises markedly as interval becomes smaller than 1 sec. The amplitude-interval relationship helps in understanding phenomena observable in performance of isotonic bivalve heart preparations. Acetylcholine (ACh) usually decreases amplitude and frequency of normally beating bivalve hearts. Near threshold, only frequency is depressed, while amplitude of beat increases. Drugs which primarily increase frequency and tone, like epinephrine, produce diminished contraction at near threshold doses. 5-Hydroxytryptamine (5HT) usually increases amplitude, but this effect can be blocked selectively, and then 5HT also decreases amplitude while increasing rate of beat. Effects of agents on interval-dependent processes appear to be important components of bivalve heart drug responses. As bath temp of *Mercenaria* heart preparations is increased from 4° to 35°C, frequency increases linearly while amplitude peaks at about 10° to 15°C. The amplitude-interval relationship suggests that this nonlinearity might happen, at least in part, from superposition of a frequency-dependent change on a set of temperature-dependent changes. Occasional preparations beat in sustained bouts separated by periods of quiescence. The first beat of the bout is large; successive contractions decrease until a lower equilibrium value is reached. Sometimes bouts are very short (4-5 contractions) and equilibrium is never achieved. This is "rest contraction". Another phenomenon is appearance of frequent extrasystoles in irregularly beating ventricles. Similar phenomena have been observed in mammalian hearts. Intropic and chronotropic control mechanisms probably are similar in mammalian and molluscan cardiac muscle. - J.L.M.

702
Greenberg, Michael J. 1965.

A compendium of responses of bivalve hearts to acetylcholine. Comp. Biochem. Physiol. 14: 513-539.

About 400 ventricles from some 40 bivalve species were isolated and challenged with a wide range of acetylcholine (ACh) doses. Results varied with species. Even exceptionally high concentrations (10^{-3} M) of ACh produced no increase in tone or frequency of beat of the heart of *Mercenaria mercenaria*. Frequency, tone and amplitude are not independent. Amplitude decreases as frequency is increased to 12/min (10-15°C). At higher frequencies systolic tone begins to rise, but diastolic tone also rises. An inverse relation between force and frequency has been demonstrated only in *M. mercenaria* among bivalves. Actions of ACh and 5HT on quiescent heart of hard clam are similar to those demonstrated by Greenberg and Jegla (1963) q.v. In *M. mercenaria*, depressor action of ACh mimics release of this neurohumor from inhibitor neurons running to the heart from the visceral ganglion. There is no evidence that the tone increase produced by high concentrations of ACh is physiological. ACh contracture of the anterior byssus retractor muscle of blue mussel is an analog of the action of cholinergic excitor nerve fibers. But no data show that excitatory cholinergic neurons exist in bivalve hearts. In over 30 experiments it was not possible to stimulate beating of *Mercenaria* hearts made hypodynamic by cooling and keeping clams dry in a refrigerator for a week. Only the depressor response of the heart to ACh is well established as mimicking a physiological role of endogenous neurohumor. (Abstracter's note: This is primarily a comparative review paper, although it does contain some original data. Out of context, the references to *M. mercenaria* are somewhat disjointed.) - J.L.M.

703
Greenberg, M. J. 1966.

Species specific effect of acetylcholine on bivalve rectums. Science 154 (3752): 1015-1017.

Experiments on 2 species of *Katelysia* showed that the pharmacology of rectums was very different. Discernible differences in pharmacology of *Mercenaria mercenaria* and *M. campechiensis* were not observed. - J.L.M.

704
Greenberg, Michael J. 1969.

The role of isoreceptors in the neurohormonal regulation of bivalve hearts. In Comparative Physiology of the Heart: Current Trends. F. V. McCann (ed.) Experientia Supplementum 15. Birkhauser Verlag, Basel: 250-265.

A generalized outline of pharmacology of 4 presumed neurotransmitter substances on hearts of bivalve mollusks has emerged from research over about 25 years. Most of the conceptual outline was developed in the laboratory of John H. Welsh on heart of *Mercenaria (Venus) mercenaria*. Acetylcholine (ACh) has been shown to be a depressor neurohumor. Curare-like drugs are the most effective ACh-blocking agents. 5-Hydroxytryptamine (5HT or serotonin) is an excitor transmittant. Lysergic acid diethylamide (LSD) mimics the action of 5HT on many molluscan muscle preparations. On hard clam heart the maximally effective dose is incredibly low. Effective blocking agents for 5HT and LSD are 2-bromo-*d*-lysergic acid diethylamide (BOL) and methysergide (UML). Effects of catecholamines, such as epinephrine and norepinephrine, are varied and depend on animal and dose. Usually tone and frequency are increased. No effective antagonist to action of any catecholamine has been found. Dopamine, and more rarely other catecholamines, have been found in ganglia and some other bivalve tissues, but a physiological role of dopamine in regulation of bivalve hearts was not considered likely. A group of cardio-active substances, which may be polypeptides, have been extracted from clam ganglia and hearts. They are called collectively Substance X. These may play a role in starting, and long-term maintenance of, cardiac rhythmicity in bivalves and other mollusks. Study of drug actions on other species, many unrelated to *Mercenaria*, has brought out a number of exceptions to this theoretical pharmacological outline. Most of these responses have been markedly different from those of *M. mercenaria*. The various mechanical responses of bivalve hearts to neuromuscular drugs seem to have arisen independently many times during the history of the Class. Once having appeared, however, they are sufficiently stable so that knowledge of the Family of a particular species often allows prediction of how its heart will react to pharmacological agents. Bivalve hearts as a group are a tool for attack on the general problem of species variability in chemical transmission and the pharmacology associated with this process. Wide occurrence of ACh, 5HT, and catecholamines (mainly dopamine) in nervous systems of bivalves is well established. Components of Substance X may also have universal distribution. Enzymes involved in synthesis and oxidation of 5HT have been identified in various molluscan tissues, as has acetylcholinesterase. Species differences in acetylcholinesterase activity in hearts of oysters and hard clams can account for observed differences in responses of these organs to ACh. Receptors are identified by challenging the heart with a series of ketoamyltrimethylammonium ions. Depressor receptors respond optimally to 4-ketoamyltrimethylammonium. *Mercenaria* and oyster hearts have only this type of receptor. *Tresus* and *Spisula* also respond optimally to the 3-keto compound, and have excitor as well as depressor receptors. Upon adsorption of the neurohumor to its receptor, the resulting complex, perhaps by changing the molecular conformation of the membrane, alters membrane permeability more or less selectively. Species variation would seem to rest: 1) with quantitative differences in concentration of neurohumors, enzyme systems, and receptor sites; and 2) with variability of receptors, and of the particular association they make from among available ionic channels. - J.L.M.

705
Greenberg, Michael J. 1970.

A comparison of acetylcholine structure-activity relations on the hearts of bivalve molluscs. Comp. Biochem. Physiol. 33(2): 259-294.

The experiments described in this paper deal with *Mytilus planulatus, M. edulis, Spisula solidissima* and *Tresus capax*. *Mercenaria mercenaria* is referred to frequently, but only with reference to published work abstracted elsewhere in this bibliography, especially what are described as a series of classical investigations on the isolated "standard" heart of *M. mercenaria* by Welsh and Taub (1948-1953). - J.L.M. and M.W.S.

706
Greenberg, Michael J., and Thomas C. Jegla. 1962.

The pharmacology of the rectum of *Mercenaria (Venus) mercenaria*. Amer. Zool. 2(3): 412 (abstract).

The rectum is located within the ventricle, to which it is attached at either end. Longitudinal muscle occurs in this segment. An isolated rectum was prepared by stripping all ventricular muscle and suspending the rectum from a 500 mg isotonic lever in a seawater bath at 15°C. 5-Hydroxytryptamine (5HT) excites the rectum. Threshold is about $3x10^{-8}$ M. Low doses (10^{-6} M) often induce rhythmic activity. Higher concentrations inhibit beat and greatly increase tone. Benzoquinonium chloride ($5x10^{-5}$ M) antagonizes this positive intropic effect and induces a vigorous beat. Curare (10^{-5} g/ml) also inhibits the tone increase with 5HT. Atropine ($5x10^{-5}$ M) either has no effect or potentiates the positive tonotropic effect. Atropine has no effect on rhythmicity induced by 5HT. With increasing concentration acetylcholine (ACh) first depresses, then increases tone of a nonbeating rectum. Depressor threshold is about 10^{-8} M; max depression is achieved between 10^{-7} and 10^{-6} M. Excitor threshold is $3x10^{-6}$ to 10^{-5} M. Guts induced to beat by 5HT respond to ACh as do hearts of most bivalves (but not *Mercenaria*). Tone, amplitude and frequency of beat are decreased by low concentrations, while higher doses produce large tone increase and obliterate beat. All actions of ACh are at least partially blocked by benzoquinonium chloride. It is suggested that 5HT not only acts directly on gut musculature, but also excites neurons which release ACh. Beat at low 5HT concentrations is explained by a requirement of a precise 5HT:ACh ratio for beat. - J.L.M.

707
Greenberg, M. J., and T. C. Jegla. 1962.

Histology of the bivalve rectum. Am. Zool. 2(3): 526 (abstract).

Mercenaria mercenaria is not mentioned specifically but it probably was one of many species examined. The wall of the rectum has an outer layer of connective tissue and an inner layer of secretory simple ciliated columnar epithelium lining the lumen and resting on a basement membrane. The connective tissue layer has 3 conspicuous components: 1) longitudinal collagen fibers, 1-3 μ diam, from the periphery to the center of the layer; 2) longitudinal unstriated muscle cells usually occupy the middle region of the wall - these cells (250x4 μ) have a central nucleus and peripherally distributed myofibrils - muscle inserts on the collagen fibers, which pleat when the rectum shortens; 3) a layer of elastic and reticular fibers between musculature and basement membrane. The wall: lumen ratio varies from 0.3 to 0.025 in species examined. Extent of folding of inner rectal wall is related to size of animal. Small animals like *Donax* have smooth-bore rectums, but in larger species the wall is highly sculptured. - J.L.M.

708
Greenberg, M. J., and T. C. Jegla. 1963.

The action of 5-hydroxytryptamine and acetylcholine on the rectum of the Venus clam, *Mercenaria mercenaria*. Comp. Biochem. Physiol. 9(4): 275-290.

Experiments were done on isolated rectum of large quahogs suspended under 500 mg tension in an aerated, water-jacketed bath of artificial seawater at 15°C. Movements are assumed to be caused by longitudinal muscle fibers. Circular muscle is also present, but contractions of this muscle could not account entirely for the effects observed. Drugs were added directly to the bath and expressed as molar concentration in the bath. Movements were recorded by kymograph. 5-Hydroxytryptamine (5HT) excites the rectum. Low doses often induce rhythmical activity; higher concentrations inhibit beat and increase tone. 5HT is mimicked by tryptamine and lysergic acid diethylamide and antagonized by methylsergide. Benzoquinonium chloride, d-tubocurarine, and morphine (the latter slightly) antagonize tone increase and augment beat induced by 5HT. Atropine potentiates tone increase; its effect on beat is related to its tonotropic effect. Acetylcholine (ACh) produces phasic and tonic responses. The first is a transient tension increase. The tonic effect is bimodal; low concentrations diminish and high concentrations augment rectal tone. Tone, amplitude, and frequency of recta stimulated to beat by 5HT are decreased by low concentrations of ACh, large doses increase tone and obliterate beat. Low doses of benzoquinonium (10^{-5} M) augment ACh tone increase; higher doses usually are antagonistic, depending also on ACh concentration. Atropine ($5x10^{-5}$ M) is a more effective antagonist than an equimolar dose of benzoquinonium. The effect of ACh apparently depends on rectal tension prior to dose. 5HT appears to stimulate cholinergic nerves as well as exciting rectal musculature directly. Multiple sites of action of ACh are suggested. The paper describes some of the pharmacology of hard clam rectum, shows how data obtained can elucidate the nature of components of the organ, and suggests some interactions. - expanded authors' abstract - J.L.M.

709
Greenberg, Michael J., and Donald A. Windsor. 1962.

Action of acetylcholine on bivalve hearts. Science 137: 534-535.

The effect of acetylcholine (ACh) on isolated ventricles of 39 bivalve species from 20 families most frequently excites and depresses the heart. Responses do not appear to be distributed phylogenetically, but there is some uniformity of response within families. Venerids for the most part show no excitation; *Mercenaria mercenaria* shows only depression. Bivalve heart muscle conforms closely to other molluscan muscle in its pharmacological reactions to ACh. - W.J.B. and J.L.M.

710
Greenberg, M. J., R. A. Agarwal, L. A. Wilkens, and P. J. B. Ligon. 1973.

Chemical regulation of rhythmical activity in molluscan muscle. In J. Salanki (ed.) Neurobiology of Invertebrates. Mechanisms of rhythm regulation. Akademiai Kiado, Budapest, Hungary: 123-142.

Discovery of chemical transmission of nerve impulses across neuro-neural and myo-neural synapses in vertebrates led to at least 2 lines of investigation in molluscs and other animals. Attempts were made to identify vertebrate neurohumors, acetylcholine (ACh), and catecholamines, in molluscan ganglion extracts; and molluscan pharmacology developed as these substances were tested on molluscan muscle preparations, and as effective antagonists were found. Some preparations, particularly hearts, were extremely sensitive to known transmitter substances and ganglion extracts, and they soon supplanted such standard objects as frog heart as bioassays in neurochemical studies of mollusks. 5-Hydroxytryptamine (5HT) was identified at about the same time in molluscan and vertebrate tissues, and the role of 5HT as a neurotransmitter was first proposed for a molluscan system. Recently, excitatory and inhibitory substances other than the compounds named above were reported in molluscan ganglia and other tissues. In *M. mercenaria* such chemically undefined components were obtained from pooled ganglia and heart hemolymph which had excitatory effects on *Mercenaria* heart. *Mercenaria* heart also has been used to assay extracts of ganglia and muscle from other organisms. Two questions arose: are any of the active components common to all mollusks? and do the active substances in extracts play a physiological role in the living mollusk? Studies beginning with extracts of *M. mercenaria* ganglia have helped to answer these questions. Extracts of molluscan ganglion and nerve may augment or depress beat of isolated heart preparations, and induce rhythmical activity in quiescent hearts and other muscles of mollusks. Seven cardioactive substances, including ACh and 5HT, have been found. 5HT has long been known to induce rhythmical activity, but peak C, another cardioexcitor component, also has oscillogenic activity, and it is often effective when 5HT is not. An enzyme in molluscan ganglion extracts abolishes peak C activity. Peak C, perhaps in concert with 5HT and other substances, apparently is responsible for oscillogenic action of ganglion extracts. Its physiological role might be long-term regulation of rhythmical activity of cardiac and visceral muscle in mollusks. It is suggested that these substances act by modifying binding of Ca^{++} to cell membrane. - J.L.M.

711

Greene, Gregory T. 1975.

Incremental shell growth patterns as affected by environment in *Mercenaria mercenaria*. Unpublished B.A. thesis, Princeton University, 77 p.

Daily growth markings, and winter and summer slowdowns or breaks in growth, were studied from microscopic markings and other characteristics of longitudinal sections of valves of *Mercenaria mercenaria*. The winter growth period usually begins in December, and summer slowdowns usually in July and August, in Great South Bay, N.Y. Highest growth rates were in spring (April-May) and fall (October-November). Clams in sand grew 58% faster, on the average, than clams of the same age in mud. Mud clams showed numerous growth breaks and generally slower year-round growth. Clams from shallow, still waters varied the most in growth. Daily and seasonal growth patterns were more subdued in clams from deep water. Spawning marks were seen on only a few shells. No tidal patterns in growth were observed. - from author's summary - J.L.M.

712

Greene, Gregory Trevor. 1978.

Population structure, growth and mortality of hard clams at selected locations in Great South Bay, New York. A thesis presented to the graduate school in partial fulfillment of the requirements for the degree of Master of Science in the Marine Environmental Sciences Program, State Univ. of N.Y. at Stony Brook, xi + 199 p.

Growth rates of clams *(Mercenaria mercenaria)* in the Bay are highest in spring and fall. Reductions in growth occur during summer and winter, apparently in response to unfavorable environmental conditions. On the average clams reach legal harvestable size in 3 to 3 1/2 yrs, but individuals take as little as 2 1/2 yrs or as long as 4 yrs or more. Significant variations in growth occur at different locations in the Bay. Year classes are detectable in size frequency distributions and can be used to determine size of clams in the 3 or 4 most recent yearly sets at particular locations. In heavily clammed areas most clams are under 4 yrs of age and harvests from such areas consist mainly of clams from a single year class, in which clams are just reaching harvestable size. Unclammed areas contain much larger and older clams, and relatively few seed and small littlenecks. Whelks and moonsnails are the most important predators at the present time. These are most abundant relative to numbers of clams in areas of high salinity, and least abundant in areas of low salinity, especially near river mouths. They eat an average of about 3.5 clams each per month at 20°C. In high salinity areas these predators are abundant enough to have substantial impact on adult clam populations. Total yearly natural mortality of large seed clams (41 mm long) averaged 11.4 percent. - J.L.M.

713
Greene, Gregory T. 1978.

Growth and mortality of hard clams, *Mercenaria mercenaria*, at selected locations in Great South Bay, New York. In Sea Grant Assn., Student abstracts. Oregon State Univ. Sea Grant Coll. Progr. Communic. Staff: 24.

Extensive natural populations of *Mercenaria mercenaria* in Great South Bay, Long Island, N.Y. are threatened by intensive harvesting. Research to determine natural growth rates, to estimate mortality rates, and to identify major predators and assess their impact on the resource, and to estimate size frequency distributions on harvested and unharvested beds, are under way. - J.L.M.

714
Greene, G. T. 1978.

Growth of clams *(Mercenaria mercenaria)* in Great South Bay, New York. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978, Abstracts: page not numbered.

Growth rates were determined by analysis of shell growth structure of individual clams, size frequency distributions of samples, and planting-recovery experiments. Natural stocks were sampled at 15 locations in a variety of Bay environments. Growth rates were highest in spring and fall. Seasonal effects were most pronounced in very shallow waters. Growth rates were greatest at stations with well circulated waters and sandy sediments, lowest at stations with silty sediments near river mouths. Maximum sizes varied greatly with location. At some stations clams blunted and essentially stopped growing at 5 or 6 yrs old and 60 to 70 mm long. At other stations blunting did not occur until age 8 or 9 and 90 to 100 mm long. Most clams reached legal harvesting size (1 inch thick or 48 mm long) after 3 to 3 1/2 yrs. Some clams required as little as 2 1/2 yrs or as much as 4 1/2 yrs to reach legal size. - J.L.M.

715
Greene, G. T. 1979

Growth of clams (*Mercenaria mercenaria*) in Great South Bay, New York. Proc. Natl. Shellf. Assn. 69: 194-195 (abstract).

Growth rates were highest in spring and fall. Seasonal effects were most pronounced in clams from shallow waters. Significant variations were found in clams from different stations, and growth was greatest in well circulated waters and sandy sediments, poorest at stations with silty sediments near river mouths. Maximum sizes also varied greatly. At some stations clams blunted and essentially stopped growing at 5 or 6 yrs and length 60 or 70 mm. At other stations they did not blunt until 8 or 9 yrs and length of 90 to 100 mm. In most areas most clams reached harvestable size in 3 to 3 1/2 yrs. Some clams required as little as 2 1/2 yrs or as much as 4 1/2 yrs to reach harvestable size. Information on growth rates will be valuable to management programs. - J.L.M.

716
Greene, Gregory T., and D. Scott Becker. 1977.

Preliminary report of an assessment of the effects of the unusually severe winter of 1976-77 on the mortality of the hard clam *(Mercenaria mercenaria)* in Great South Bay, New York. Manuscript report from Marine Sciences Research Center, State University of New York, Stony Brook, N.Y., ii+8 p., ill.

The winter of 1976-77 was one of the coldest on record in the Long Island area. Ice up to 2 ft thick covered most parts of Great South Bay for about 1 1/2 months. Clammers reported heavy kills of hard clams after ice broke up. Thirty-one stations in areas of the Bay controlled by the towns of Islip and Brookhaven were sampled with rakes and tongs. Where possible, 200 or more clams were taken. Mortality did not appear to be excessively high in most places. The exception was Patchogue Bay, where mortalities ranged from 3.3 to 27.2% of samples. Average mortality for 8 stations in this area was 12.4%, and average mortality for all other stations was 1.6%. All clams were measured. Subsamples were taken to measure shelf life under commercial conditions. Other subsamples were used to test for differences in condition of meats. Results of these studies are to be reported in a final paper which will include all data and analyses. - J.L.M.

717
Greene, G. T., and D. S. Becker. 1978.

Winterkill of hard clams in Great South Bay, New York 1976-77. 1978 North-eastern Fish and Wildl. Conf., Fish. and Wildl. Abstr., 1 p. (not numbered)

Mortality at 31 stations in the Bay was quite variable and ranged from 0 to 27.2%. Mortality showed no strong relation to any variable measured: depth, salinity, substrate particle size, substrate organic content, and clam density. Mortality 10% and higher was confined to one small area of the Bay and apparently was not caused by winter stress alone, but to a combination of characters, perhaps including disease. Mortality in the rest of the Bay over winter was not extreme and averaged 1.6%. Shelf life, represented by the time taken for the first 10 clams of 30 to die under constant temp and humidity, varied from 15 to 38 days and showed no strong correlation with mortality or any other variable. Some clams survived for 59 days out of water, the duration of the experiment. - J.L.M.

718
Greene, Gregory T., and D. Scott Becker. 1978.

Winterkill of hard clams in Great South Bay, New York, 1976-77. In Sea Grant Assn., Student abstracts. Oregon State Univ. Sea Grant Coll. Progr. Communic. Staff: 24.

(Not formal publication of research results - for information only.) *Mercenaria mercenaria* survived extensive cold and ice very well, except for the population in Patchogue Cove. High mortality there was probably caused by a combination of factors perhaps including disease and pollution, aggravated by winter stress. Effects of severe winter actually may have been beneficial to the clam resource, because ice halted fishing on beds normally heavily exploited, and because a major predator (*Callinectes sapidus*, blue crab) apparently was hurt by cold. - J.L.M.

719
Greene, G. T., A. C. F. Mirchel, W. J. Behrens, and D. S. Becker. 1978.

Surficial sediment and seagrasses of eastern Great South Bay, N.Y. Marine Sciences Research Center, State Univ. of N.Y., Stony Brook, Spec. Rept. 12, Ref. 77-9, ii+30 p.

Purpose of the study was to provide basic information on sediment distribution for scientific management and planning for the hard clam industry. Eleven of 186 stations contained *Mercenaria mercenaria* shell. Six of these 11 stations contained shells of dead young *Mercenaria* 4 to 16 mm long. The others contained fragments of much larger hard clams. Three clam species, *Mulinia lateralis*, *Ensis directus*, and *Gemma gemma*, apparently were numerically more abundant than hard clam. The section on sediment quality in relation to hard clam is based on a literature review of papers abstracted elsewhere in this bibliography. It is pointed out that a relation between clam abundance and a substrate variable does not necessarily show cause and effect. Factors like water circulation that lead to formation of a particular type of substrate may be the critical factors affecting clam density. Abundance of clams also is affected by harvesting, so that a productive clam ground could have lower densities than other less-harvested areas. Areas of high shell density could have higher clam densities because clammers are discouraged by the difficulty of working in shelly bottoms. Thorough knowledge of the relationships between sediment type and hard clam biology will require further study. - J.L.M.

720
Grigg, Richard W., and Robert S. Kiwala. 1970.

Some ecological effects of discharged wastes on marine life. Calif. Fish Game 56(3): 145-155.

Mercenaria mercenaria is not mentioned. - M.W.S.

721
Guberlet, J. E. 1925.

Malacobdella grossa from the Pacific coast of North America. Pub. Puget Sound Biol. Sta. 5: 1-13.

Including commensals in *Mercenaria mercenaria*. - J.L.M.

722
Guillard, R. R. 1958.

Some factors in the use of nannoplankton cultures as food for larval and juvenile bivalves. Proc. Natl. Shellf. Assn. 48: 134-142.

This paper is based on feeding experiments with larval and juvenile oysters and *Venus mercenaria* in 1956 and 57. It is full of detailed information and thus difficult to reduce to an abstract. Food quantity is considered a relatively simple question. Quantity and concentration are important. Larvae are maintained at concentrations of 3 to 15/ml, while phytoplankton concentrations vary from 10 to 100 thousand cells/ml, depending on size of cells. Careful studies of phytoplankton concentrations in nature show that they approach these laboratory concentrations at times. In Great South Bay, N.Y. undesirable blooms of *Stichococcus* and *Nannochloris* exceeded $2x10^6$ cells/ml at times. Juveniles seemed to do fairly well on about 3 times the rate fed to larvae. The right kind of food is more important and difficult. Growth of animals is the only criterion by which value can be measured at present. Clam larvae can use more foods than oyster larvae can, and juveniles can utilize an even wider range of foods. Chrysophytes and diatoms were especially good for juveniles. Naked flagellates that were best for larvae were relatively good also for juveniles, but cryptomonads were useless to larvae. Factors other than nutritive content affected acceptability. Presence and thickness of algal cell walls and production of toxic substances by algae were important. Best results will be obtained by using a mixture of cultures of 2 or 3 small naked flagellates, especially chrysophytes, for larvae, and supplement this with cryptomonads and diatoms for juveniles. Use of cultures rather than natural phytoplankton creates another problem. Impure cultures may be toxic under certain circumstances. Sometimes larvae may grow normally to straight-hinge stage, then die. It is believed that toxicity is caused by bacteria that get into cultures during handling. Erratic results in feeding experiments tend to coincide with use of impure cultures, especially at room temp. Algal cultures should be started from bacteria-free stocks and grown at the lowest temp that provides rapid growth. - J.L.M.

723
Guillard, Robert R. L. 1959.

Further evidence of the destruction of bivalve larvae by bacteria. Biol. Bull. 117(2): 258-266.

Various organisms, like the fungus *Sirolpidium*, can destroy clam larvae in experimental cultures, but evidence that bacteria are harmful has been largely circumstantial. This paper presents evidence that two clones of bacteria isolated from an infected *Venus mercenaria* larva destroyed healthy larvae, while other clones did not under similar conditions. In final experiments larvae were reared under aseptic conditions, excluding the possibility that contaminating microorganisms were the direct cause of death and bacteria were secondary invaders. Available evidence favors the hypothesis that the mechanism was invasion or contact, not an exotoxin liberated into the medium. It is not implied that bacterial metabolites are without influence, for high concentrations stopped growth of clam larvae entirely. Bacteria in algal food cultures sometimes caused abrupt decrease in larval growth rate without immediate extensive mortality. It was not possible to tell if bacteria destroy larvae in nature, where both usually are less concentrated than in cultures. Use of antibiotics to control bacteria in larval cultures is apparently more effective when water supply is changed regularly and 2 or more antibiotics are used alternately. The same antibiotics will not prevent growth of injurious bacteria in algal cultures used as food. If impure algal cultures must be used to raise larvae, the algae should be kept at the lowest temp allowing reasonable growth. One of the virulent clones isolated was a species of *Vibrio*, the other was *Pseudomonas*. Mortality caused by these bacteria at 20, 25 and 30°C did not vary significantly, but both virulent clones grow well at 30°C and higher, which is relatively uncommon for marine bacteria from the Milford area. Thus, high temps in laboratory larval cultures favor these strains. - J.L.M.

724
Gulf States Marine Fisheries Commission. 1959.

Annotated bibliography of unpublished estuarine research in the Gulf of Mexico.

Could not locate. Search terminated. *Mercenaria mercenaria* or *M. campechiensis* probably included. - J.L.M.

725
Gunter, Gordon. 1955.

Mortality of oysters and abundance of certain associates as related to salinity. Ecology 36(4): 601-605.

726
Gunter, Gordon. 1956.

Some relations of faunal distributions to salinity in estuarine waters. Ecology 37(3): 616-619.

727
Gunter, Gordon. 1971.

The molluscan resources of the Gulf of Mexico. FAO Fish. Repts. 2(71.2): 111-115.

Hard clam belongs to the genus *Mercenaria*. On the Fla. west coast production has varied from 102,720 kg of meats in 1962 to 1,580 kg in 1966. Figures may not be accurate because *Rangia cuneata* is confused by some with cherrystone hard clam. The author listed *Mercenaria mercenaria* as a potential source of food in the Gulf of Mexico, but did not mention *M. campechiensis*. - J.L.M.

728
Gunter, Gordon, and Gordon E. Hall. 1963.

Biological investigations of the St. Lucie estuary (Florida) in connection with Lake Okeechobee discharges through the St. Lucie Canal. Gulf Research Rept. 1(5): 189-307.

729
Gunter, Gordon, and Gordon E. Hall. 1965.

A biological investigation of the Caloosahatchee estuary of Florida. Gulf Research Rept. 2(1): 1-71.

730
Gunter, G., B. S. Ballard, and A. Venkataramaiah. 1973.

Salinity problems of organisms in coastal areas subject to the effect of engineering works. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Contract Rept. H-73-3, x+176 p.

The report contains a summary of the influence of salinity on marine invertebrates, and sections on specific invertebrate and vertebrate groups, including Mollusca. *Mercenaria mercenaria* is not cited specifically, but the principles and mechanisms discussed are pertinent. - J.L.M.

731
Gurski, Edwin, and Albert F. Eble. 1973.

Studies of the blood cells of the hard clam, *Mercenaria mercenaria.* Bull. N.J. Acad. Sci. 18(1): 20 (abstract).

Large and small amoebocytes of *Mercenaria mercenaria* varied in phagocytic activity: small amoebocytes engulfed yeast cells faster and accumulated more yeast cells per amoebocyte. Rate of phagocytosis increased with yeast concentration. Phagocytic activity was reduced when a coverslip was applied. Total blood counts at 20°C and 25‰ were 2,400,055=$\bar{x}$, 738,155-s. Blood cell counts did not vary significantly between 15° and 24°C. Amoebocytes in counting chambers invariably gathered in irregular clusters of 20 to 50 cells. Within 8 to 10 min all clusters dispersed. At 4°C clumping did not occur. - J.L.M.

732
Gusey, William F. 1976.

The fish and wildlife resources of the Middle Atlantic Bight. Environmental Affairs, Shell Oil Co., Houston, Texas, 2nd printing, revised. Clams and quahogs: 513-529.

Range of *Mercenaria mercenaria*: Gulf of St. Lawrence to Gulf of Mexico; *M. campechiensis*: north to New Jersey. Hard clam supports the 2nd most valuable mollusk fishery in the Middle Atlantic Bight. Brief notes on natural history are included. *Mercenaria* can tolerate high levels of pollution and can survive low oxygen. Thus, large beds may be found in polluted areas where competitors, natural predators, and man pose little threat. Charts show distribution of hard clam state by state from N.C. to Mass. Commercial landings 1951 to 1974 are given in a table and graphically. Brief comments are included on condition of stocks and management of the harvest. (Abstracter's note: discussion of hard clam, life discussions of all fisheries, reflect lack of personal experience with details. Conclusions should be accepted with caution. The charts are of dubious value.) - J.L.M.

733
Gustafson, Alton H. 1955.

Protecting *Venus* sets from green crabs by fencing. 5th Conf. on Clam Research, 4 p.

Green crab, *Carcinides maenas*, is a serious predator of *Mercenaria mercenaria* up to one inch long. A hard clam seed bed of about 5 acres was found above mean low water level in Brickyard Cove, Me. in 1953. Density was 200 to 1,500 clams/ft^2 ranging from 2 to 15 mm long (mean 10 mm). Green crab predation had begun and was spreading. The cove is long and narrow. A fence was built across the cove at the narrowest point. One-inch mesh chicken wire 2 ft wide was fastened to wooden stakes; one section was 1/4-inch mesh hardware cloth. A few inches of the wire extended into the substrate. A wooden flange was nailed to the top of the stakes to prevent crabs from climbing over. Crabs were caught with baited traps inside and outside the fence. The catch outside was about 3 times the inside catch. It was concluded that the fence prevented a considerable number of crabs from reaching the seedbed. It was difficult to maintain a tight fence, and breaches were made during storms. A better designed and sturdier fence, with closer supervision, could be effective. Total cost of materials was about $75. - J.L.M.

734
Gustafson, Alton H. 1955.

Growth studies in the quahaug, *Venus mercenaria*. Proc. Natl. Shellf. Assn. 45: 140-150.

Hard clam grows from tide levels to at least 50 ft depth. Brunswick is the center of clam digging in Maine. Despite its abundance and commercial importance, surprisingly few studies of its ecology or growth have been made. In one year at one site clams planted at 17 mm increased 17 mm; 27 mm clams increased by 18.13 mm; 37 mm clams increased 14.85 mm; 57 mm clams increased 12.37 mm; and 77 mm clams increased 6.52 mm. At another site initial size and increments were: 18 mm - 13.6 mm; 28 mm - 14.71 mm; 38 mm - 11.79 mm. Data from other areas in the State show considerable local differences. In general, growth in Me. is greater than Prince Edward Is., equal to or greater than in Mass., and greater than in R.I. Seasonally in Me. growth began in late Mar or early Apr and ceased by 1 Dec. Percentage of total year's growth was greatest from mid-July to mid-Sept, which is later than in R.I. - J.L.M.

735
Gustafson, Alton H. 1962.

Growth and ecological studies on the quahog, *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 51, August 1960: iii.

Listed by title only. - J.L.M.

736
Gustafson, A. H., and Dana E. Wallace. 1962.

Observations on the post-setting fate of natural populations of quahogs in Maine. Proc. Natl. Shellf. Assn. 51, August 1960: iii.

Listed by title only. - J.L.M.

737
Hackney, Anne Gray. 1944.

List of Mollusca from around Beaufort, N. Carolina, with notes on *Tethys*. Nautilus 58(2): 56-64.

The area is interesting because it is far enough south for many Florida species to live, and far enough north for those of the Virginian Province. *Venus mercenaria* was very common; *V. mercenaria notata* not common, but living specimens sometimes found; and *V. campechiensis* much less common than *V. mercenaria*. - J.L.M.

738
Hale, Stephen S. 1976.

The role of benthic communities in the nitrogen and phosphorus cycles of an estuary. In Mineral cycling in Southeastern Ecosystems. F. G. Howell, J. B. Gentry, and M. H. Smith (eds.) ERDA Symposium Series 1975. (CONF-740513): 291-308. Univ. R.I. Mar. Reprint 57.

Station C was on sandy silt and was dominated by quahog (*Mercenaria mercenaria*). It was situated at about 41°30'N. 71°25'W. Benthic oxygen uptake as a function of temperature was 2.25 temp.+11.19 with no differences between communities; benthic ammonia release as a function of temp. was 12.26 temp. -48.78 for *Ampelisca*, 6.52 temp.-19.70 for *Nephthys-Nucula*, and 8.66 temp.-34.09 for *Mercenaria*, with *Ampelisca* significantly greater than the other two; benthic ammonia release as a function of oxygen uptake was 0.09 O_2-25.72, with no significant differences between communities; benthic phosphate release as a function of temp. was 2.28 temp.-14.34 for *Ampelisca*, 1.27 temp.-4.99 for *Nephthys-Nucula*, and 1.01 temp.-9.04 for *Mercenaria*, with the slope for *Ampelisca* significantly greater than for *Nephthys-Nucula* and *Mercenaria;* and benthic phosphate release as a function of oxygen uptake 0.01 O_2-5.93, with no significant differences between the three communities. Over a temp. range from 3.2 to 22.4°C ammonia flux at the sediment surface varied from -4.28 to 276.10 μmoles/m^2/hr. Nitrate was transported in both directions across the sediment-water interface, varying from -66.31 to 43.43 μmoles/m^2/hr. Nitrite flux was relatively unimportant. Phosphate uptake and release ranged from -9.43 to 41.63 μmoles/m^2/hr. Few significant differences were found among the three communities (p 0.05). Temperature exerted a strong influence on the fluxes of ammonia and phosphate. The fluxes measured can have significant effects on nutrient concentrations of the overlying water. - J.L.M.

739
Hall, William R., Jr. 1979 (?)

The hard clam. Delaware Marine Adv. Serv. Publ., Univ. Del. Sea Grant College Program 12, 6 p.

The name of the hard clam, *Mercenaria mercenaria,* comes from the Latin mercenari which means "hired for wages" or "Hired one". Covers in brief the biology, commercial and recreational clamming, and shucking and storage of clams. - J.L.M.

740
Halsey, John F., and William F. Harrington. 1973.

Substructure of paramyosin. Correlation of helix stability, trypsin digestion kinetics, and amino acid composition. Biochemistry 12(4): 693-701.

Analysis of kinetics of tryptic proteolysis of paramyosin prepared from adductor muscle of *Mercenaria mercenaria* suggested that 2 reaction classes were present. Measurements of viscosity and mass during the digestion reaction showed that the fast-reaction class was likely a clustered set of susceptible peptide bonds. A light meromyosin particle, "light paramyosin", was isolated from the proteolytic reaction products at the end of the fast reaction. Paramyosin had a multiphasic "melt" curve, including 2 cooperative transitions with T_m values of 44 and 64°. The structure melting at 44° (amounting to about 1/3 of the paramyosin mass) was the region cleaved preferentially to low molecular weight peptides during preparation of light paramyosin. The trypsin-sensitive region was the helical region of low thermal stability. Estimated helix-stabilizing characteristics gave good correlation with observed thermal stabilities. The demonstrated properties of the paramyosin molecule led to hypotheses about its role in the catch mechanism of molluscan muscle. It was suspected that a cooperative phase change in individual molecules may occur in the low thermal stability region during catch. The bonding arrangement of paramyosin in the thick filament core, in which there is a systematic arrangement of gaps between molecules and no end-to-end bonding, could allow a conformational change within individual molecules without affecting specific interactions between overlap regions of neighboring molecules. Thus, the basic 145-A spacing would be preserved. - modified authors' abstract - J.L.M.

741
Halstead, B. W. 1972.

Toxicity of marine organisms caused by pollutants. In Marine Pollution and Sea Life. Mario Ruivo (ed.) Fishing News (Books) Ltd., London: 584-594.

Cites a personal communication from Sister Arline C. Schmeer dated 1 July 1970 in which she stated that the anti-tumor substance mercenene, produced by *Mercenaria mercenaria* under normal conditions, declines in effectiveness when clams are stored in polluted waters. - J.L.M.

742
Hammack, Gloria M., and staff. 1971.

Bibliography of Aquaculture. Coastal Plains Center for Marine Development Services, Wilmington, N.C., Pub. 71-4, vii+245 p.

Contains 787 references, each with an abstract, on fishes, crustaceans, and mollusks. Included are a title and an author index. References to hard clam are in papers abstracted elsewhere in this bibliography. - J.L.M.

743
Hammen, Carl S. 1964.

Carbon dioxide fixation in marine invertebrates: A review. In Symposium on Experimental Marine Ecology. Nelson Marshall, H. Perry Jeffries, Theodore A. Napora, and John McN. Sieburth (eds.) Grad. School Oceanogr., Univ. R.I., Narragansett Mar. Lab., Occ. Pub. 2: 48-50.

CO_2 should be regarded not simply as an end-product of metabolism, but as an essential compound in metabolic reactions of higher and lower forms. Among many other invertebrates, *Mercenaria mercenaria* assimilates C^{14} from labelled bicarbonate in seawater and incorporates it into acids of the citric acid cycle. Experiments with 5 g mantle tissue of *M. mercenaria* showed that the species incorporated 74% of radioactivity at origin in succinic acid and lesser percentages in fumaric, malic, citric, isocitric, and α-ketoglutaric acids. - J.L.M.

744
Hammen, C. S. 1968.

Aminotransferase activities and amino acid excretion of bivalve mollusks and brachiopods. Comp. Biochem. Physiol. 26(2): 697-705.

Total aminotransferase (AT) activities and rates of amino acid loss were directly proportional, and inversely proportional to the logarithm of total body weight. Lowest activity of aspartate AT among 8 species was found in *Mercenaria mercenaria*. Hard clam was also lowest in alanine AT. Ammonia made up about 67% and amino acids about 29% of identified products. It was concluded that bivalve mollusks have cell membranes permeable in both directions to many small molecules, promoting ease of uptake or loss for excretion, osmotic adjustment, or nutrition. This relatively free permeability is coupled with an amino acid metabolism capable of continuous replacement of useful compounds lost to the medium. - J.L.M.

745
Hammen, C. S. 1969.

Lactate and succinate oxidoreductases in marine invertebrates. Mar. Biol. 4(3): 233-238.

Nineteen species (Porifera to Arthropoda) of marine invertebrate and one fish were studied to determine ability of tissue extracts to catalyze lactate and succinate dehydrogenase reactions in both directions. The ratio pyruvate-reductase/lactate-dehydrogenase (PR/LD), indicating the probability of lactic acid production, was 1,968 in flounder muscle, much lower in all invertebrates. Extremes of the ratio fumarate-reductase/succinate-dehydrogenase (FR/SD), indicating the probability of succinic acid production, were 0.24 in *Mercenaria mercenaria* and 7.6 in American oyster. PR/LD appears to be related to the capacity for vigorous muscular activity, which sustains rapid movement of larger animals. FR/SD appears to be related to tolerance of temporary anaerobiosis. Oxidoreductase activities in tissues of hard clam were: mantle PR 0.413, LD 0.060, PR/LD 6.85, FR 0.019, SD 0.082, and FR/SD 0.23 (values expressed in μ moles/min/g tissue); muscle PR 1.350, LD 0.192, PR/LD 7.03, FR 0.019, SD 0.080, and FR/SD 0.24; heart PR 1.698, LD 0.263, PR/LD 6.45, FR 0.019, SD 0.080, and FR/SD 0.24. - J.L.M.

746
Hammen, C. S. 1971.

Metabolism of brachiopods and bivalve mollusks. Acta Salamanticensia Serie de Ciencias 36: 471-478.

Lingulid brachiopods and most mollusks possess succinate oxidoreductases of the type that favor oxidation of succinate, in contrast to most other marine invertebrates. This metabolic adaptation permits these animals to withstand temporary anaerobiosis. Lactate dehydrogenases of all molluscan classes appear to be D-specific. *Venus (Mercenaria) mercenaria* is not mentioned, but the conclusions apply. - J.L.M.

747
Hammen, C. S. 1974.

Succinate and lactate oxidoreductases of 3 bivalve mollusks. Fed. Proc. 33: 403 (abstract 1089).

Succinic acid is a major end-product of anaerobic glycolysis in mollusks, lactic acid minor. Extracts of adductor muscle of *Mercenaria mercenaria*, *Mytilus edulis*, and *Crassostrea virginica* were used in oxidoreductase assays. Assay mixtures contained nicotinamide adenine dinucleotide (NAD) or dichlorophenolindophenol (DCIP). Relations between substrate concentration and reaction velocity were determined for pyruvate reduction (PR), lactate oxidation (LO), fumarate reduction (FR), and succinate oxidation (SO). Results were expressed as apparent Michaelis constants (Km) and maximal velocities (V). Reductase properties varied little: Km of PR 0.54 to 0.61 mM, and Km of FR 25 to 30 mM. Oxidase properties were more varied: Km of LO from *Mercenaria* twice that of the others, 250 vs 120 mM; Km of SO of *Crassostrea* 3 to 4 times that of the others, 120 vs 30 and 40 mM. Species varied little in V of oxidases. - J.L.M.

748
Hammen, C. S. 1975.

Succinate and lactate oxidoreductases of bivalve mollusks. Comp. Biochem. Physiol. 50B(3): 407-412.

Succinic acid is a major end product of anaerobic glycolysis in mollusks, lactic acid minor. Assays were made of adductor muscle extracts of *Mercenaria mercenaria*, *Mytilus edulis*, and *Crassostrea virginica* to test the hypothesis that production of the 2 acids is controlled partially by properties of enzymes catalyzing the final step in each pathway. Reductase properties varied little between species. Apparent Michaelis constants (K_m) of pyruvate reduction were 0.54-0.61 mM, K_m of fumarate reduction 25-30 mM. Oxidase properties were more varied: K_m of lactate oxidation from *Mercenaria* (250 mM) was twice as great as the other 2 species; K_m of succinate oxidation from *Crassostrea* 3 to 4 times as great as the others. *Mytilus* had the greatest maximal velocity for both reductases, but varied little in velocity of oxidases. - modified author's abstract - J.L.M.

749
Hammen, C. S. 1979.

Metabolic rates of marine bivalve molluscs determined by calorimetry. Comp. Biochem. Physiol. 62A(4): 955-959.

Mercenaria mercenaria mean weight 91.6 g, and at a temp of 21.0°C produced heat at 3.08 J/hr/g wet, and consumed oxygen at 2.68 µmol/hr/g wet. Oxygen consumption rates of *Mercenaria* vary with pumping rates, which were probably sub-maximal in the animal used, which was confined to a small volume of sea water. - J.L.M.

750
Hammen, C. S., and Susan C. Lum. 1966.

Fumarate reductase and succinate dehydrogenase activities in bivalve mollusks and brachiopods. Comp. Biochem.Physiol. 19(4): 775-781.

Fumarate reductase (FR) and succinate dehydrogenase (SD) activities of 6 species of marine bivalve mollusk were determined by standard methods at pH 7.4 and 25°C, on tissue homogenates. In *Mercenaria mercenaria*, body weight 120.6 g, SD activity was 17.04 mumoles/min/100 g tissue, FR activity 8.64, and the ratio SD/FR was 1.97. Clams of whole body weight 94.5 g had SD activity 24.30 mumoles/min/100 g tissue, FR activity 8.28, and the ratio SD/FR was 2.94. This was almost the lowest SD activity of the 4 burrowing bivalves examined and the highest FR activity. Thus, SD/FR ratio was about the lowest of all 4. - J.L.M.

751
Hammen, C. S., and P. J. Osborne. 1959.

Carbon dioxide fixation in marine invertebrates: A survey of major phyla. Science 130(3386): 1409-1410.

752
Hamons, Frank. 1971.

Sonar tested as aid to shell fish surveys. Comm. Fish. News, Md. Fish Wildl. Admin. 4(1): 1.

The method, using a side-look sonar system, was used for American oyster and soft clam. It is accurate, but slow. Bottom types also can be detected. The method could be used for *Mercenaria mercenaria* surveys. - J.L.M.

753
Hamons, Frank L., and Ranford M. Sapp. 1971.

Reconnaissance and inventory of shellfish in Chesapeake Bay - Present techniques and proposed systems - A management problem. Proc. Natl. Shellf. Assn. 61: 3-4 (abstract).

Resurvey and relocation of oyster bottom is a necessary adjunct to initial charting of clam bottoms. The survey is presently being done with a standard hydraulic escalator dredge, which is ineffective in many areas and in some cases detrimental to the bottom. A plan to map and classify over 450,000 acres of bottom using a combination of remote sensing with high resolution side-look sonar and dredging equipment is described. - J.L.M.

754
Hampson, George R., and Edwin T. Moul. 1978.

No. 2 fuel oil spill in Bourne, Massachusetts: Immediate assessment of the effects on marine invertebrates and a 3-year study of growth and recovery of a salt marsh. J. Fish. Res. Bd. Canada 35(5): 731-744.

On a visit to Winsor Cove on Oct. 18, 1974 (8 days after the spill) quahaug *(Venus mercenaria)* and other species of bivalves were lying on the sediment surface with shells gaping and siphons extended. When probed, these bivalves showed little or no response. Four and three animals were found at Bassett's Island in two locations on Oct. 12, 1974. - J.L.M. and M.W.S.

755
Hamrick, Tom. 1974.

Clamming prospects bright. Natl. Fisherman 55(7): 11A, 31A.

Although only about 7,000 bu of clams are being dug along the South Carolina coast presently for commercial sale, extensive exploration with two seagoing hydraulic clam dredges is showing considerable promise in some waters. Out of town buyers are reportedly interested in setting up purchasing stations. The lower Santee River appears to contain a commercial clam colony. State marine officials are determining the potential for production of *Mercenaria mercenaria* which can be sustained without damage to the resource, including how many boats can operate profitably. - J.L.M.

756
Hamrick, Tom. 1978.

S.C. clam dredging boosts appreciation of little-used food. Natl. Fisherman 59(1): 30.

Hydraulic clam harvesting which produced 28,000 bags of *Mercenaria mercenaria* last year worth $120,000 has an even brighter future. This year is the fifth season in the Santee River estuary. Only 7 escalators will be permitted to operate again this year. - J.L.M.

757
Hamrick, Tom. 1978.

S.C. shellfish landings show production doubling. Natl. Fisherman 59(2): 11.

Mercenaria mercenaria, a seafood you could not even give away a couple of years ago in S.C., now has a thirsty local market. They are becoming increasingly popular in the south. - J.L.M.

758
Hamrick, Tom. 1979.

Scientists heartened by clam mariculture advances in S.C. test. Natl. Fisherman 59(9): 51.

Artificially planted seed clams (*Mercenaria mercenaria*) will grow to marketing size in 19 months, even when planted at 300 clams/yd^2. Survival rate was 45%, and once clams attained a length of one inch survival shot up to 99%. Since crabs are most active in warm weather, seed clams planted in fall would be large enough in spring to avoid consumption by mud crabs. Survival of 50% will make mariculture economically feasible. - J.L.M.

759
Hamwi, Adel. 1968.

Pumping rate of *Mercenaria mercenaria* as a function of salinity and temperature. Proc. Natl. Shellf. Assn. (1967) 58: 4 (abstract).

Pumping rates of hard clams were measured at temperatures 6-32°C and salinities 15-40°/₀₀ using colored seawater. At a salinity of 25±2°/₀₀: no pumping occurred below 6°C and above 32°C; pumping increased as temperatures were raised from 7-12°C; no change in pumping occurred from 12-18°C; maximum pumping occurred at 24-26°C; pumping decreased at temperatures above 26°C. At temperatures 25±1°C: no pumping occurred at salinities below 15°/₀₀ and above 40°/₀₀; maximum pumping occurred at salinities between 23 and 27°/₀₀. - D.L.

760
Hamwi, Adel. 1969.

The respiratory physiology of *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 59: 3 (abstract).

Pumping and respiratory rates of hard clam were measured under a variety of combinations of temperature, salinity, and oxygen tension. There was a linear relationship between pumping and respiratory rate suggesting regulation of water transport in relation to metabolic rate. Oxygen uptake was a power function of tissue weight, the exponent was 0.3561 for wet weight and 0.3556 for dry weight. Weight specific respiration was a function of pumping rate and decreased with increasing size of clam. Oxygen deprivation resulted in an oxygen debt which was paid during first hours of subsequent aerobic period in which utilization coefficient was high and decreased gradually to a constant level. When external O_2 was reduced to critical value of 5 mg O_2/liter, the clam increased efficiency of oxygen removal from water. Below the critical concentrations, O_2 consumption declined continuously. O_2 consumption increased with decreasing salinity, indicating a euryhaline response. O_2 consumption increased with increasing temperature up to about 26°C above which consumption dropped rapidly. - D.L.

761
Hamwi, Adel. 1969.

Oxygen consumption and pumping rate of the hard clam *Mercenaria mercenaria* L. Ph.D. Thesis, Rutgers Univ., New Brunswick, N.J., 185 p.

Pumping rates were measured by replacing incurrent flow by a metered stream of colored seawater, oxygen consumption polarigraphically and calculated by difference between incurrent and excurrent water. Pumping rate was a function of total weight, and nearly proportional to surface. At S=25±2°/₀₀ pumping stopped below 6° and above 32°C. Between 7° and 12°C pumping increased moderately. Above 18°C it increased to a maximum between 20° and 26°C, and above 26°C pumping decreased abruptly. At 25±1°C pumping of non-acclimated clams was completely inhibited below 15 and above 32°/₀₀. After acclimation the upper salinity limit increased to about 36°/₀₀, the lower limit remained unchanged. Maximum pumping rate was between 23 and 27°/₀₀. Pumping was more sensitive to temp than to salinity change, and when the two factors were interacting maximum pumping occurred in the ranges 17 to 24°C and 18 to 26°/₀₀. Pumping rate was reduced progressively with silt content, by as much as 93% with 2 g silt/liter of water. Response to sudden upward changes in temp was rapid. Oxygen consumption was a function of clam weight. Q_{O_2} was a function of pumping rate, and decreased with increasing size of clam. Pumping rate and oxygen consumption were related linearly, suggesting regulation of water transport by oxygen demand. Oxygen consumption increased with temp to about 25°C, then dropped rapidly. Maximum O_2 consumption was at 21 to 25°C and 21.5 to 25.5°/₀₀. O_2 consumption was more sensitive to salinity than to temp change. Percent O_2 utilized was more sensitive to salinity than to temp change. With decreasing O_2 concentration down to about 5 mg/liter *Mercenaria* regulated O_2 consumption by increasing efficiency of O_2 withdrawal. Below this value O_2 consumption declined continuously. Deprived of O_2, clams incurred an oxygen debt, which was paid during the first hours of the subsequent aerobic period, in which utilization coefficient was high, then decreased gradually to a more or less constant level. - modified from Dissert. Abstr. Internatl. 1970: 3433B-3434B - J.L.M.

762
Hamwi, Adel, and Harold H. Haskin. 1969.

Oxygen consumption and pumping rates in the hard clam *Mercenaria mercenaria*: A direct method. Science 163(3869): 823-824.

Respiratory rate (or pumping rate) of hard clam is a direct function of oxygen consumption (or vice versa). This suggests regulation of water transport by oxygen requirement rather than by feeding. This is in contrast to the generally accepted idea that respiration in bivalves is only incidental to water flow maintained for feeding. The method is described and the apparatus illustrated. - J.L.M.

763
Hancock, D. A. 1973.

The relationship between stock and recruitment in exploited invertebrates. In Fish Stocks and Recruitment. B. B. Parrish (ed.) Cons. Internatl. Expl. Mer, Rapp. Proc.-Verb. 164: 113-131.

The author quotes John Glude (pers comm) who knew of no instance where extremely high abundance of spawners of *Mercenaria* has in itself led to low recruitment, nor where low recruitment could be attributed to insufficient spawners. Most of the paper deals with stock-recruitment relationship in cockle *(Cardium edule)* which, for lack of better information on hard clam, might be used to infer relationships, or to plan research on hard clam stocks. - J.L.M.

764
Hanker, Jacob S., Jerry M. Neff, Peggy E. Yates, Kenneth H. Wilson, and Floyd E. Bloom. 1971.

Histochemical and cytochemical studies on the localization of membrane-bound NADH diaphorase (NADH-D) and monoamine oxidase (MAO). J. Histochem. Cytochem. 19(11): 720 (abstract).

New methods were used, which depend upon deposition of small amounts of cupric ferrocyanide (Hatchett's Brown) at sites of enzyme activity. In mantle edge of *Mercenaria mercenaria* enzyme activity was mainly associated with the outer mitochondrial membrane, but extramitochondrial deposits were associated occasionally with the plasma membrane of mucocytes. - J.L.M.

765
Hanks, James E. 1952.

The effect of changes in water temperature and salinity on the feeding habits of the boring snails, *Polinices heros* and *Polinices duplicata*. In 5th Rept. Investig. Shellf. Mass. (Woods Hole Oceanogr. Inst.), Mass. Dept. Conserv., Div. Mar. Fish: 33-37.

These two species of boring snail are considered serious predators on *Mya arenaria* and *Venus mercenaria* in Mass. The experiments reported apparently were done on *M. arenaria* only. (Abstracter's note: other studies have shown that *Mya* is more vulnerable to snail predation than *Venus (Mercenaria)* because the valves are thinner, but the conclusions probably are generally applicable to *Mercenaria*.) Rate of clam consumption decreased as water temp was lowered, and as salinity was lowered. *P. duplicata* did not feed at water temps lower than 5°C or 6°/°°. *P. heros* fed at water temps down to 2°C but not at 10°/°° or below. - J.L.M.

766
Hanks, James E. 1962.

Feeding habits of newly metamorphose clam drills, *Polinices heros* and *P. triseriata*. Proc. Natl. Shellf. Assn. 51, August 1960: iii.

Listed by title only. - J.L.M.

767
Hanks, Robert W. 1965.

Effect of metallic aluminum particles on oysters and clams. Chesapeake Sci. 6(3): 146-149.

Experiments were done on *Crassostrea virginica* and *Mya arenaria*. *Mercenaria mercenaria* is not mentioned. Fine particles of metallic aluminum are used as targets in photogrammetry. They could be hazardous to marine life. The experimental mollusks removed aluminum particles from the water by filtering, but no increase of aluminum was detected in bivalve tissues or in water samples. These bivalves apparently react to aluminum particles as they would to any other inorganic material in the same size range. - J.L.M.

768
Hanks, Robert W. 1968.

Benthic community formation in a "new" marine environment. Chesapeake Sci. 9(3): 163-172.

769
Hanlon, David P. 1975.

The distribution of arginase and urease in marine invertebrates. Comp. Biochem. Physiol. 52(2B): 261-264.

Six specimens of *Mercenaria mercenaria* in 4 trials produced an average of 0.3 μ Moles of ornithine/hr (range 0 to 1.0) from the hepatopancreas. This was the lowest arginase level found in 15 species of coelenterate, brachiopod, mollusk, arthropod,and echinoderm. Highest arginase activity was found in crustacea. In 3 separate tests of 4 *M. mercenaria* each, 4 trials in each test, hepatopancreas produced 5.7 (range 5.4 to 6.0) μ Moles of NH_3/g/hr, mantle 19.2 (19.0 to 19.4), and gills 29.2 (28.6 to 29.6). With the exception of the brachiopod *Lingula* and gastropods *Littorina* and *Busycon*, these were the highest urease activities found in the same 15 species. *Mercenaria*, with significant levels of urease, did not excrete urea in detectable amounts. - J.L.M.

770
Hanlon, David P., Lois Lane,and Ancil Jones. 1969.

Comparative aspects of molluscan enolases. Am. Zool. 9(3): 582 (abstract 212).

The enzyme enolase (2-phospho-D-glycerate hydro-lyase, EC 4.2.1.11) catalyzes one reversible step in the glycolytic pathway, and therefore is ubiquitous in plants and animals. Thus, enolase might be a useful probe for studies in comparative enzymology. Chemical and physical investigations were made of enolases of 3 pelecypods, including *Mercenaria mercenaria*. Incubation of enzyme with p-chloromercuribenzoate (p-CMB), a sulfhydryl group reagent, inhibited enolase from 2 species but had no effect on hard clam enolase. Apparently, mutations have given rise to enolases structurally dissimilar in certain regions. Other evidence showed that little if any change occurred at the catalytic site. - J.L.M.

771
Hanna, G. Dallas. 1966.

Introduced mollusks of western North America. Occas. Pap. Calif. Acad. Sci. 7(48): 1-108.

Records of *Venus (Mercenaria) mercenaria* on the west coast date back to 1901. These were dead valves, hence not proof that the species was established. A living specimen was reported from the San Francisco region in 1940. An attempt was made to plant the species in Newport Bay, Calif., in 1940, but this apparently failed. An unrecorded planting in Humboldt Bay, Calif. was obviously successful because a bed of living hard clams exists there. In 1956 small experimental plantings were made in Drake's Estero and Tomales Bay, Calif. A small planting was made in Catalina Harbor, Calif. in 1959. Bat rays are supposed to have destroyed these 3 plantings. The California Dept. of Fish and Game made plantings in Humboldt Bay in 1960, in Drake's Estero and Tomales Bay in 1963, and in Morro Bay, Drake's Estero, and Tomales Bay later in 1963. Survival is reported from the 1960 and first 1963 plantings. Another planting was made in San Francisco Bay in 1963. Experiments to establish the species in Puget Sound, Washington were confined to the laboratory up to Sept. 1963. - J.L.M.

772
Hanson, Jean, and J. Lowy. 1959.

Evidence for a sliding filament contractile mechanism in tonic smooth muscles of lamellibranch molluscs. Nature 184(4682): 286-287.

Mercenaria (Venus) mercenaria is not mentioned, but the discussion is generally applicable. Structural evidence for a sliding filament contractile mechanism in cross-striated muscle is well established, based on the following points: 1) existence of 2 kinds of filament; 2) existence of bridges between them; 3) discontinuity of filaments along the fibril; 4) constancy of filament length at different muscle lengths; 5) changes in relative positions of the 2 kinds of filament as the muscle shortens; and 6) similarity of X-ray diffraction patterns at different muscle lengths. Information about smooth muscles is much less complete, but 1 and 2 have been demonstrated in funnel retractor and mantle muscles of *Loligo* and pharynx retractor of *Helix*. This paper concludes from electron micrographs of *Mytilus edulis* that 1 and 2 are true and 3 and 4 very likely true. Similar results were obtained for the translucent (yellow) part of adductor muscle of *Gryphaea angulata*. - J.L.M.

773
Hanson, Jean, and J. Lowy. 1961.

The structure of the muscle fibres in the translucent part of the adductor of the oyster *Crassostrea angulata*. Proc. Royal Soc. London, Ser. B 154(955): 173-193.

Venus is mentioned only in reference to a paper by Selby and Bear (1956), abstracted elsewhere in this bibliography. - M.W.S. and J.L.M.

774
Hanzel, Melvin E., and Gary P. Carlson. 1974.

Azoreductase activity in the hard clam, *Mercenaria mercenaria* (L.). J. Exp. Mar. Bio. Ecol. 14(3): 225-229.

Hard clam is deficient in ability to carry out mixed function oxidase reactions, but can reduce nitro groups to amino groups. The azo linkage is commonly found in pesticides, industrial dyes, food colorings, and drugs. Thus, hard clam can detoxify certain components of pollutants. Azoreductase activity of the hepatopancreas was higher at 37°C than at 22°C and pH optimum was 8.0. The reaction was stimulated by flavin mononucleotide and inhibited by air. The 105,000 g soluble and the microsomal fractions of the hepatopancreas were active. - J.L.M.

775
Hare, P. E., and P. H. Abelson. 1968.

Racemization of amino acids in fossil shells. Carnegie Inst. Wash. Yearbook 66: 526-528.

The proteins of all living forms consist principally of L-amino acids. Why was one isomer chosen, and what factors determined the choice? The present study was devoted to determining the optical configuration of amino-acids in Recent and fossil *Mercenaria* shells. The results indicate that for most amino acids the mixture of stereo forms accumulating in a primitive ocean would be racemic. If some unknown process presented a slight advantage to one form or another, racemization would tend to vitiate that advantage. On the other hand, once a decision was made to use the L form, supplies of it would be replenished by racemization from the D form as the L isomer was used up. - J.L.M.

776
Hare, P. E., and R. M. Mitterer. 1969.

Laboratory simulation of amino-acid diagenesis in fossils. Carnegie Inst. Wash. Yearbook 67: 205-208.

Experiments indicated that pH can be a significant factor in the stability of some amino acids. A sample of *Mercenaria* showed that a sample heated dry showed little or no reaction, in contrast to those heated in presence of water or water vapor. In subsequent experiments changes observed in Recent shell fragments were analogous to and duplicated changes found in natural series of fossils. To study the kinetics in more detail, modern shell was heated at 165°, 140°, 125°, 105°, and 90° for periods of 1 hr to over 3 months. Amino-acid ratios changed systematically with time of heating, in a fashion analogous to fossil shells. - J.L.M.

777
Harnne, Howard, and Aasine R. Cassara. 1979.

Anglers guide to Long Island. IRCS Corp., Woodbury, N.Y., 152 p., 7 maps.

Contains a brief review of hard clam biology, catch levels, methods of harvesting, market sizes, and other facts. - J.L.M.

778
Harriman, Donald M. 1955.

Application of the shellfish industry method. In 5th Conf. on clam research, Boothbay Har., Me. U.S. Dept. Interior, Fish Wildl. Serv: 15-18.

Estimates of probable yield were made by 2 methods. The area was contoured and the area covered by each contour was measured by planimeter. This was multiplied by the average density of quahogs as determined by sampling. This method produced an estimate of 1200 bu. The second method was to multiply the total area by the mean of all samples. This gave an estimate of 1400 bu. Actual production was 1525 bu. - J.L.M.

779
Harris, W. H., and M. Cohen. 1971.

Water quality deterioration and marginal pollution in Jamaica Bay, New York City. Abstr. 2nd Coastal Shallow Water Res. Conf., Univ. S. Calif. Press, 96 p.

780
Harrison, W., and Marvin L. Wass. 1965.

Frequencies of infaunal invertebrates related to water content of Chesapeake Bay sediments. Southeast. Geol. 6(4): 177-187.

781
Harry, Harold W. 1942.

List of Mollusca of Grande Isle, Louisiana, recorded from the Louisiana State University Marine Laboratory. La. State Univ., Mar. Lab., Occ. Pap. 1, 13 p.

Class Pelecypoda, Order Teleodesmacea, Family Veneridae. *Venus mercenaria mercenaria* Linne: rather common; on oyster bed 1 mi northeast of Grand Terre; bottom of mud and shells; 6 ft; a living specimen. *Venus campechiensis campechiensis* Gmelin: dead shell only. - J.L.M.

782
Harry, Harold W. 1968.

An alternate view on the phylogeny of the Mollusca. In Proc. Symp. Mollusca, Pt. 1. Mar. Biol. Assn. India, Mandapam Camp: 170-187.

The phylogeny of the Mollusca to class level is traced by noting the advent, modification, and loss of particular characters, relative to similar courses of events of numerous other characters. Incipient segmentation in ancestral stages is assumed. Bivalvia arose from Probivalvia by losing the radula, labial, and buccal commissures; reduction of ganglia to cerebrals, pedals, and viscerals. Obliteration of segmentation left a single pair of gills which became suspended by a muscular septum, which on contraction caused a pumping action. Lips of the mouth were further pulled out to form labial palps, which at first had an appendage which gathered food from the substrate. A byssal gland appeared in the foot, or perhaps only beyond the protobranchs. - J.L.M.

783
Harry, Harold W. 1976.

Correlation of benthic Mollusca with substrate composition in lower Galveston Bay, Texas. Veliger 19(2): 135-152.

Mercenaria mercenaria was collected, but not discussed. Abundance was highest at stations at which the percentage of sand/shell was 80 or higher. - J.L.M.

784
Harshbarger, J. C., S. C. Chang, and S. V. Otto. 1975.

Chlamydia infections in clams. 2. Ultrastructure of the *Chlamydia* and an infecting virus. Soc. Invertebr. Pathol., Ann. Meeting (8th). Corvallis, Oregon: 29 (abstract).

We assume that the following paper (#785) contains essentially the same information in greater detail. - J.L.M.

785
Harshbarger, John C., Sing Chen Chang, and Sara V. Otto. 1977.

Chlamydiae (with phages), mycoplasmas, and rickettsiae in Chesapeake Bay bivalves. Science 196(4290): 666-668, ill.

Mercenaria mercenaria from the Chesapeake Bay area contained amorphous, basophilic, finely granulated intracytoplasmic inclusions in digestive tubule cells. Examination by transmission electron microscopy detected pleomorphic bodies representing the 3 life stages of chlamydia in each inclusion: 1) large, round to oval, 400-900 nm, double membrane-bound, germinal initial bodies containing fine reticular strands of nucleic acid and a peripheral layer of ribosomes; 2) lobulated, 400-600 nm, contracted intermediate bodies with a nucleoid core, peripheral ribosomes, and corrugated double plasma membrane; and 3) small, round, dense 200-300 nm infectious elementary bodies. Some chlamydiae contain phage particles 50 nm in diam in a crystal lattice array. Corroborative fluorescent antibody analyses remain to be done. Because hard clam and other species examined (soft clam and American oyster) are eaten raw, these findings have important public health significance. Bivalves may be alternate hosts for zoonotic chlamydial, rickettsial, and mycoplasmal microorganisms. Discovery also of a chlamydial phage suggests a potential control mechanism. - J.L.M.

786
Hart, James C. 1945.

Typhoid fever from clams. Conn. Health Bull. 59: 289-292.

The principal reason for the tremendous drop in cases of typhoid in Conn. has been improved water supplies and better methods of disposal of sewage. Present cases come usually from contact with a typhoid carrier or from eating uncooked clams from polluted water. Recently, each summer or fall, occasional cases of typhoid occur in which the only possible source of infection appears to be raw clams. In 1945 an outbreak occurred in Fairfield County. Of 14 cases, 2 died, and most had eaten raw clams a short time before. Consumption was traced to 2 restaurants. Outbreaks in the New York area also were traced to these restaurants. The supplier was located and he agreed to stop operations. It was suspected, but not proven, that the clams came from contaminated waters. After sale of clams from this source stopped, no new cases of typhoid fever appeared. As a result of the outbreak the Board of Health of the Town of Greenwich required a permit from the health officer for digging shellfish in Town waters. The species of clam is not identified, but raw consumption identifies it almost certainly as *Mercenaria (Venus) mercenaria*. - J.L.M.

787
Hartland, Bonnie J. 1978.

Studies on antibacterial mechanisms in the hemolymph of the American oyster, *Crassostrea virginica*, and the quahog clam, *Mercenaria mercenaria*. In Sea Grant Assn., Student abstracts Oregon State Univ. Sea Grant Coll. Progr. Communic. Staff: 24-25.

Hemolymph cells of both species phagocytized *Escherichia coli*, *Salmonella typhimurium*, *Shigella flexneri*, and *Vibrio parahemolyticus*. Whole hemolymph usually was more effective than separate phases. Bacteria were cleared less effectively when they were exposed by intracardial inoculation than when they were ingested. Under depuration for 72 hrs percent recovery of indicated pathogenic bacteria was less than 1% after 24 hrs, under optimum environmental conditions. Depuration was more effective at 20°C than at 6°C. - J.L.M.

788
Hartland, Bonnie J., and John F. Timoney. 1979.

In vivo clearance of enteric bacteria from the hemolymph of the hard clam and the American oyster. Appl. Envir. Microbiol. 37(3): 517-520.

American oyster and hard clam, *Mercenaria mercenaria*, were contaminated experimentally with *Escherichia coli*, *Salmonella typhimurium*, and *Shigella flexneri* by intracardial injection or by the natural route of ingestion. Bacterial inactivation in hemolymph was monitored for 72 hrs after exposure to these enteric pathogens at 20° to 6°C. At 6°C mean bacterial uptake by ingestion and subsequent clearance were significantly lower than at 20°C. However, substantial bacterial clearance from hemolymph occurred for shellfish at each temperature. At 20°C viable bacteria were no longer detectable after 24 hrs in hemolymph of clams or oysters after exposure to contaminated water containing $4x10^3$ bacteria per ml. - from abstract in Sea Grant notice of new publication. - J.L.M.

789
Hartman, Michael, Charles E. Epifanio, Gary Pruder, and Richard Srna. 1973.

Farming the artificial sea: growth of clams in a recirculating seawater system. Proc. 26th. Ann. Sess. Gulf Caribb. Fish. Inst.: 59-74.

Hatchery-reared hard clam larvae were held in 400 l conical tanks. Water was changed, and larvae fed daily on a mixture of *Monochrysis lutheri*, *Isochrysis galbana*, and *Nannochloris* sp. in the ratio of cell numbers 2:2:1, respectively. Total concentration of algal cells was $5x10^4$ cells/ml. Larvae were allowed to set in the growing tanks. Waste treatment was by submerged biological filter, ultraviolet light, and activated carbon filter. Ammonia, pH, and dissolved oxygen were measured 3 times a week. Ammonia, nitrates, reactive phosphorus, pH, alkalinity, salinity, and dissolved oxygen were measured weekly in the waste treatment reservoir. Water temp was measured daily. Eight groups of clams were used, each receiving a different diet. Initial number of clams in each group was 250,000. This was reduced as the experiments progressed, but each tank contained the same numbers. A 9th control group was held in raw flowing seawater and given no additional food. Shell height was the index of growth. The experiment showed that it is possible to culture hard clam in a recirculating seawater system. A diet of *Phaeodactylum tricornutum* alone is not sufficient. Diets of *Platymonas* sp. with *P. tricornutum* and *Rhodomonas* sp., or with *Isochrysis galbana* substituted for *Rhodomonas*, gave fastest growth. A diet of *Phaeodactylum* and *Rhodomonas* gave poorest growth. Other mixtures gave intermediate growth. Growth in all groups, except that fed *Phaeodactylum* only, showed a sharp upward inflection after 13 weeks. Either this pattern is characteristic of *M. mercenaria* or none of the diets was good for newly metamorphosed clams but several were good for larger stages. The fastest growing group had a mean shell height of 0.46 cm after 22 weeks. If growth were linear from time of metamorphosis clams would be 1.09 cm in a year. This would be faster than under natural conditions. - J.L.M.

790

Haskin, Harold H. 1950.

Growth studies on the quahaug, *Venus mercenaria.* Natl. Shellf. Assn., Convention Addresses 1949: 67-75.

Length, height, thickness, volume, and weight of all sizes available were measured. When height, width, or cube root of weight is plotted against length the relationship is a straight line. Thus, there is no change in proportions with growth. If the relationship is plotted from averages of groups of 10 clams, one variable can be estimated from the other with an error of less than 5%. On this basis it was decided to use weights. Clams ranging in size from 10,000/bu to less than 200/bu were planted at Cape May. Weight increments for the 1947 growing season were measured. The smallest showed greatest gain: 570% weight increment; the largest increased only 7%. At this location 1 bu of seed clams weighing about 1/3 oz each would yield 18 bu medium-sized clams in 5 growing seasons. Relative growth in the same area in 1948 and in 4 other areas in 1948 was less than in the 1947 experiment. One-oz seed planted under conditions existing at Cape May in 1947 would grow to chowder size in 3 to 5 yrs. Under 1948 conditions 7 yrs would be needed. Some exchange between the clam and its environment, limited by surface area of clam, controls season's growth. As the clam grows, the ratio surface area/volume becomes unfavorable and growth slows. At a certain stage the clam reaches a size at which it will grow only in favorable growing yrs. For Cape May in 1947 that limiting size was 250 g, for Surf City in 1948 it was 150 g, for Raritan Bay in 1948 it was 64 g. In Raritan Bay in 1948 five size groups were transplanted. The 3 smaller sizes, all below the theoretical limit of 64 g for the area, held their high meat quality. The 2 larger sizes, "too big for their new environment" declined sharply in meat quality, to about 2/3 initial level. These studies have shown: 1) the time required for seed to grow to market size, 2) great differences in growth rate for the same year in different localities, 3) growth is limited by surface area, 4) the size limit for a given area will tell a clam farmer whether to grow cherrystones, chowders, or neither, 5) a low theoretical size limit for an area indicates it unsuitable for "laying out" larger clams for any considerable time. Cape shore clams were nearly 200 g average weight in 7 yrs, Raritan Bay clams only about 75 g at the same age. - J.L.M.

791
Haskin, Harold H. 1952.

The selection of food by the common oyster drill, *Urosalpinx cinerea*, Say. Proc. Natl. Shellf. Assn., Ann. Meeting, Atlantic City, N.J., 21-24 August 1950: 62-68.

Mercenaria (Venus) mercenaria is not mentioned. Drills were attracted to certain oysters by some chemical attraction, not by thickness of shell. Rate of growth, rather than size and age *per se*, appeared to be the principal factor determining attractiveness of oysters to drills. - J.L.M.

792
Haskin, Harold H. 1952.

Further growth studies on the quahaug, *Venus mercenaria*. Proc. Natl. Shellf. Assn. 42: 181-187.

Growth rates of hard clam vary greatly from season to season. In the period 1947-1950, 1947 was the best growing year, 1948 poorest. Clams grown from 10 g seed would produce medium-size clams in 4 yrs if 1947 growth rates prevailed, 8 yrs at 1948 rates, 6 yrs at 1949 rate, and 5 yrs at 1950 rate. Years 1948 and 1949 were hot, dry summers, 1947 and 1950 cool and wet. A composite growth for all 4 yrs showed that 10 g seed made the greatest absolute weight gain (34 g) in the 3rd season after planting. By the 6th season it levelled off at 12-16 g. Growth in various areas in N.J., including Raritan Bay, is highly variable. On the Cape May shore clams reached about 200 g in 8 yrs, in Jarvis Sound less than 50 g in the same time. Raritan Bay was intermediate. Thus, Jarvis Sound had best growth in an earlier study, poorest in the present one. Raritan Bay growth improved from the previous study. Great differences in amounts of nutrients also were found between these areas. Plantings where growth was best were swept with strong tidal currents and received quantities of land drainage. Best growth was also in areas with sparse clam populations. One season's growth data are not sufficient to predict growth rates at one location. Growth rate is well correlated with available food. Land drainage and circulation patterns also are important. - J.L.M.

793
Haskin, Harold H. 1954.

Age determination in mollusks. Trans. N.Y. Acad. Sci. 16(6): 300-304.

Preliminary studies on hard clam revealed that size frequency relations were an unreliable index of age due to sporadic sets and depletion due to fishing. Growth checks on the shells could not be interpreted confidently without further knowledge of the population. Marked clams (4-10 cm long) were planted in six areas along the New Jersey coast. Annual average increments in weight were obtained for each area and relative growth curves were plotted. Seed clams down to 1 gram in weight were planted and after one season were approximately 10 grams, indicating that 10 gram clams in this area were 2 years old. Using this information, absolute growth curves could be constructed. These growth curves provide a basis for interpretation of growth rings on clam shells. - D.L.

794
Haskin, Harold H. 1962.

The hard clam population of Raritan Bay, survey of April 9-13, 1962. A Report to the Commissioner of Health, and the Commissioner of Conserv. and Econ. Devel. of the State of New Jersey, 3 p. + 2 figs.

Hard clams were abundant in two major areas, one along the Raritan Bay channel west of the Navy pier, and the second in Sandy Hook Bay. The standing crop in these two areas is estimated at 600,000 bushels. The population along the Raritan Bay channel is composed mostly of chowder-size clams in mud bottom. The Sandy Hook Bay populations were predominantly of smaller sizes. Dredge hauls in the Raritan Bay area had very little trash. Sandy Hook Bay was covered with macaroni mud, tubes of a burrowing arthropod, that interfered with dredging but was seasonal in occurrence. Smaller areas of high clam abundance north and west of Keansburg have shelly, trashy, bottom, but not enough to preclude efficient clamming. Figures in the survey are minimal. The survey was designed to cover the Bay area extensively and not intensively. Sampling was not sufficient to locate all areas, and some may have been missed entirely. Lower proportions of small clams may have been a consequence of the sampling gear, which did not catch some necks and undersized clams. - (Abstracter's note: the figures were not included with the copy we received, and we did not think it worthwhile to get them.) - J.L.M.

795
Haskin, Harold H. 1964.

The distribution of oyster larvae. In Symposium on Experimental Marine Ecology. Nelson Marshall, Harry P. Jeffries, Theodore A. Napora, and John McN. Sieburth (eds.) Univ. R.I., Grad. School Oceanogr., Kingston, Occ. Pub. 2: 76-80.

Gradually increasing salinities will stimulate older stage oyster larvae to swim. With decreasing salinity larvae tend to remain quiescent on the bottom. These responses may be affected by light conditions, which should be noted in interpreting results of laboratory experiments. These responses to salinity can help to explain how larvae remain in an estuary under the influence of a net flow of water seaward. *Mercenaria mercenaria* is not mentioned. - J.L.M.

796
Hastings, Louise B. 1976.

Index to the taxonomic names in Edwin A. Joyce, Jr., 1972, A partial bibliography of oysters, with annotations. Fla. Dept. Nat. Resources, Mar. Research Lab., St. Petersburg. Suppl. to Spec. Sci. Rept. 34, 40 p.

This is a useful adjunct to the bibliography cited, which contains 4117 titles, mostly abstracted, with a subject index. Scientific names of non-molluscan species also are indexed. - J.L.M.

797
Haven, Dexter. 1970.

A study of the hard and soft clam resources of Virginia. U.S. Fish Wildl. Serv., Comm. Fish. Resources Devel. Act, Final Contract Rept., 69 p.

Hard clams *(Mercenaria mercenaria)* grow slowly in parts of Chesapeake Bay. Off Gloucester Point it may take 4 to 5 yrs to grow to commercial size (1 1/2 to 2 inches). Growth in James River is more rapid and commercial sizes may be reached in 4 yrs. Most clams collected were large, 2 1/2 to 4 inches long. Clams from 1 to 2 inches were relatively much less abundant. If large numbers of young had been added each yr, small sizes would be more abundant. Predation or competition may be significant factors in the sparse populations. At Gloucester Point only a few small clams are added in several yrs. In Hampton Roads, however, young are entering in considerable numbers. Recovery of a depleted hard clam bed might take 5 to 10 yrs in certain places. In areas of moderate or high recruitment clams may be harvested at higher rates. Working the bottom with a hydraulic escalator dredge did not measurably increase the set. Yorktown had only slightly higher maximum rate of recruitment, 0.7 clams/yd^2/yr. The replacement rate of various grounds should be carefully considered before opening up to hydraulic dredging. - J.L.M.

798
Haven, Dexter S. 1978.

Underutilized species of shellfish in Virginia waters. In Proc. Interstate Seafood Seminar, Oct. 4 to 7, 1977. William R. Hess, Jr. (ed.) Va. Polytech. Inst. and State Univ. Extension Div. and Dept. Food Sci. Technol., Seafood Processing Research and Extension Unit, Hampton, Va: 76-84.

People in Virginia have always eaten oysters, scallops, or hard clams *(Mercenaria mercenaria)* and they are familiar with these species. A number of other species are not so well known and are underutilized at present. -- J.L.M.

799
Haven, Dexter, and Jay D. Andrews. 1957.

Survival and growth of *Venus mercenaria*, *Venus campechiensis*, and their hybrids in suspended trays and on natural bottoms. Proc. Natl. Shellf. Assn. 47: 43-49.

Artificially reared clams of nearly the same size and age were grown in wooden boxes filled with sandy mud, suspended about one foot above the bottom. *M. mercenaria* is the native species in Virginia, but *M. campechiensis* and reciprocal hybrids of the two species were also placed in boxes. Mortality of *M. mercenaria* was low in all seasons of the 2-yr experiment. *M. campechiensis* had heavy mortality in the 2 winters, and none survived the 2nd winter. Mortality of *M. campechiensis* was low from April to Oct. Mortalities of hybrids on the average were intermediate between parents, but nearer to the northern species. Clams placed on the bottom, unprotected, had heavy summer mortality, probably from blue-crab predation. All clams began growth in Apr or early May and ceased in Nov. Hybrids and southern species increased in weight from 0.5 to almost 11 g in 1955 and to 29 g in 1956. Northern species grew little more than 1/2 as fast as the others, only to 17 g by end of the 2nd growing season. Clams in suspended trays outgrew those on bottom. Yield cannot be determined until clams reach marketable size, but at the end of the experiment hybrids had greatest yield (biomass). High survival rate of *M. mercenaria* suggested that they might eventually provide higher yields to clammers although they grew more slowly than hybrids. The test was fairly rigorous because winters of 1954-55 and 1955-56 were the coldest in a decade. - J.L.M. and D.L.

800
Haven, Dexter, and Paul Kendall. 1973.

A survey in the Elizabeth River, Virginia, for oysters, clams and shell in the vicinity of the proposed TRANSCO construction site. Xerox copy.

There were insignificant quantities of hard clams in the 375.4 acres sampled. Only 12 clams were recovered in the 362 samples which covered 363 square yds. - abstract of M.C.'s abstract.

801
Haven, Dexter S., and Joseph G. Loesch. 1973.

Summary, conclusions, and recommendations based on an investigation into commercial aspects of the hard clam fishery and development of commercial gear for the harvest of molluscs. Va. Inst. Mar. Sci., 108 p.

Hard clams are widely distributed in Chesapeake Bay, in heavy to moderate concentrations in six areas totaling about 19,000 acres. These 6 areas are: north side of the lower York River and the Coleman Bridge vicinity; Tue-Marsh-Back Creek area; Poquoson Flats; the southern section of the Willoughby-Crumbs Banks area; Hampton Flats; and lower James River. No other commercially significant concentrations of clams were found in lower Chesapeake Bay and its tributaries. About 95% of hard clams harvested in Chesapeake Bay are taken with patent tongs from areas of high and moderate densities. Tong operators take from 1000 to 3000 clams per day on areas of moderate densities, and up to 7500 clams per day in areas of high abundance. Tong operators state that they cannot make a living in areas of low densities. Because the clam resource is geographically concentrated, it is vulnerable to overfishing. Fishery scientists and managers must monitor the resource closely to detect signs that there is danger of overfishing, including: increased natural mortality, reduction in recruitment, or decrease in catch per unit effort. The clam resource is vulnerable because recruitment is poor over most of the bay. Good recruitment, indicated by high abundance, low average length, and high percentages of littlenecks and cherrystones are limited to the aforementioned six areas. Clams were planted experimentally in the lower James and York Rivers where most of the fishery operates. Growth rates in these areas were slow relative to growth in higher salinity waters. Littleneck size is attained in about 2 1/2 years, and cherrystone size in 4 1/2 years by clams in the Hampton Flats; however, it takes 4 and 8 years respectively for clams in similar areas in lower York River. Chowder clams range from 8 to 20 years old. When high rainfall depresses salinity below normal, growth is slowed and mortality increases. The Virginia hard clam fishery probably has operated near MSY in recent years. Catch per unit effort, measured as weight per license, decreased when effort increased. (Abstracter's note: This is inevitable, but not necessarily a sign of over-harvesting.) It was recommended that effective effort be stabilized until the resource can be analyzed in detail and goals of management are specified. The following options for hard clam management would allow increased landings without being detrimental to stocks presently fished: 1) permit commercial dredging for clams in Chesapeake Bay in waters greater than 18 feet (MLW) because it is not economically feasible to clam these low density areas with tongs; 2) encourage lessees of MSX-affected oyster beds with good hard clam resources to enter the fishery; 3) determine if private hard clam mariculture is a feasible commercial operation. Extension of the open season in lower James River would increase landings, but would affect the presently available stock. Harvesting costs could be reduced by allowing use of more efficient gear, but this would displace men and gear now in the fishery or reduce the stock. An adequate statistical program should be implemented as soon as possible. Management program should be re-evaluated at least annually on the basis of vital statistics obtained and socio-economic conditions in the fishery. Clam farming was investigated in the York River. Plastic netting (1/4 inch mesh) did not protect seed clams from predators. Survival of seed was higher on gravel bottoms at 5 feet (MLW) than on natural bottoms, but gravel bottoms less than 1 foot (MLW) were not effective protection. Hatchery reared clams grew at the same rate as wild clams. Seldom do more than 10% of small clams (1-3 mm) survive for one year and often none survive. In one test plot (5 feet, MLW) survival of larger seed (4-8 mm) ranged from 33-38%. In one test plot no large seed survived. The risk of clam farming is high, so 1/4-1/2 acre plantings in 10-15 feet (MLW) should be tested. Seed should be at least 5 mm. Further clam farming research should be conducted emphasizing clams 5-10 mm or larger planted at depths of 10-15 feet or greater. - D.L.

802
Haven, Dexter S., and Reinaldo Morales-Alamo. 1966.

Aspects of biodeposition by oysters and other invertebrate filter feeders. Limnol. Oceanogr. 11(4): 487-498.

803
Haven, D. S., W. J. Hargis, Jr., J. G. Loesch, and J. P. Whitcomb. 1977.

The effect of tropical storm Agnes on oysters, hard clams, soft clams, and oyster drills in Virginia. In Symposium held May 6-7, 1974 at College Park, Maryland. Chesapeake Research Consortium, Inc. CRC Pub. 54. Johns Hopkins Univ. Press, Baltimore: 488-508.

High mortality of hard clams *(Mercenaria mercenaria)* held in leased areas in the York and Poquoson Rivers probably resulted from stress of moving and marginal salinities. Light mortality of undetermined magnitude occurred in the York River in very shallow water along shore from the mouth to about 19.3 km up-river. Elsewhere, mortalities were about normal. - J.L.M.

804
Haven, Dexter, Michael Castagna, Paul Chanley, Marvin Wass, and James Whitcomb. 1966.

Effects of the treatment of an oyster bed with Polystream and Sevin. Chesapeake Sci. 7(4): 179-188.

Application of a Polystream-Sevin formulation did not control oyster drills on a half-acre plot in Hog Island Bay, near Wachapreague, Va., and oyster production was not increased. Most macroinvertebrates were affected adversely. Mortalities of *Mercenaria mercenaria* were low, about 8% on the treated area and 1% on the control plot. - J.L.M.

805
Hawkes, Alfred L. 1961.

A review of the nature and extent of damage caused by oil pollution at sea. Trans. 26th. N. Am. Wildl. Nat. Res. Conf.: 343-355.

Mercenaria mercenaria supports an industry in R.I. which grosses over $2 million/yr for diggers. Quahogs seem to be virtually immune to oil pollution. According to R.I. Dept. of Health, quahogs flourish in Narragansett Bay near Providence where the Bay bottom is literally paved with oil. Meats, however, have strong oily odor and taste. Thus, an oil spill could damage the industry and affect consumer acceptance even if clams survived. - J.L.M.

806
Hazel, Joseph E., and Thomas R. Waller. 1969.

Stratigraphic data and length of the synodic month. Science 164(3876): 201-202. (With commentary by Giorgio Pannella and Copeland MacClintock.)

The paper criticises a paper by Pannella, MacClintock, and Thompson (1968) (abstracted elsewhere in this bibliography) for errors in age assignments of specimens, including *Mercenaria campechiensis ochlockoneensis* (Mansfield), discrepancies in radiometric dates, and weaknesses in primary growth banding data. Replotting the Pannella et al. data, the authors concluded that there was no significant change in length of synodical month from Maestrichian to late Paleocene, but a rapid decrease from late Paleocene to the present. In their response, Pannella and MacClintock admitted to taxonomic error, explained some of their procedures, but suggested that it was premature to draw some of the conclusions made by their critics. - J.L.M.

807
Heald, Eric J. 1970.

Fishery resources atlas I - New York to Florida. Univ. Miami, Sea Grant Program (Estuarine and coastal studies), Sea Grant Tech. Bull. 3, vi + 225 p.

Venus mercenaria occurs from Maine to south Florida in most sheltered bays along the entire coast. The commercial fishery in 1965 produced 11,383,000 pounds from New York to Florida. The hard clam industry is the most valuable commercial fishery in New York State. Charts are given showing general areas of production in each State. - J.L.M.

808
Hechtel, G. 1968.

Invertebrate survey of Flax Pond,- Summer - 1967. Mar. Sci. Research Ctr., State Univ. N.Y., Tech. Rept. Ser. #1, 39 p.

Of 14 environments examined, *Mercenaria mercenaria* was found in only three, in muddy sand and mussel beds in Smith's Pond, Child Channel, and Flax Channel-Gull Inlet. Hard clam apparently was not abundant in any area. - J.L.M.

809
Hedgepeth, Marvin. 1974.

The effects of salinity shocks and low oxygen levels on ATPase activity in two estuarine bivalves. M. A. Thesis, College of William and Mary.

ATPase activity in the gill of *Mercenaria mercenaria* transferred from ambient salinity to higher and lower salinities was monitored for 72 hrs. Increases in gill ATPase activity were recorded for bivalves transferred to higher salinities while corresponding decreases occurred when they were transferred to lower salinities. Oxygen depletion caused lowered ATPase activity. Fluctuations in ATPase activities were detectable within 6 hrs after transfer. Results indicate that gills are a major site of ionic or osmotic regulation. - M.C. (Confirmed by examination of original thesis.) - J.L.M.

810
Hedgepeth, M. E., and M. P. Lynch. 1974.

Salinity related changes in ATPase levels in the Virginia oyster, *Crassostrea virginica*, and the hard clam, *Mercenaria mercenaria*. Proc. Va. J. Sci. 25(2): 64 (abstract).

Animals were transferred from ambient salinity to higher and lower salinities, and compared with controls kept at ambient salinity. Significant increases in gill ATPase activity were recorded for animals transferred to higher than ambient salinities, and significant decreases in ATPase levels when transferred to lower than ambient salinities. Fluctuations in ATPase levels were detectable within 6 hrs after transfer. Under similar environmental conditions, ATPase levels in oyster and hard clam are approximately equal. Results could indicate that the gills are a major site of ionic regulation. - J.L.M.

811
Hedgpeth, Joel W. 1950.

Notes on the marine invertebrate fauna of salt flat areas in Aransas National Wildlife Refuge, Texas. Inst. Mar. Sci., Univ. Tex. 1(2): 103-119.

812
Hedgpeth, Joel W. 1953.

An introduction to the zoogeography of the northwestern Gulf of Mexico with reference to the invertebrate fauna. Pub. Inst. Mar. Sci., Univ. Tex. 3(1): 107-224.

No original data on *Venus* or *Mercenaria*. - J.L.M.

813
Hedgpeth, Joel W. 1954.

Bottom communities of the Gulf of Mexico. In Gulf of Mexico, its origin, waters and marine life. Paul S. Galtsoff (coordinator). U.S. Fish Wildl. Serv., Fish. Bull. 55(89): 203-214.

Although clam beds had been reported in various places, the only study that had been made to date was in the Chandeleur Islands area, which showed 5 distinct concentrations of *Venus mercenaria*. - J.L.M.

814
Hedgpeth, Joel W. (ed.). 1957.

Treatise on Marine Ecology and Paleoecology. Geol. Soc. Am., Mem. 67, Vol. 1, Ecology, viii+1296 p.

Contains references to *Mercenaria (Venus) mercenaria* but no original data. General applications to hard clam should be sought in chapters on salinity, temp, carbonates and carbon dioxide, and Mollusca. - J.L.M.

815
Heeb, M. A. 1973.

Large molecules and chemical control of feeding behavior in the starfish *Asterias forbesi*. Helgol. Wiss. Meeresunters. 24(1-4): 425-435.

A. forbesi has a chemically mediated behavioral response suitable for use as a bioassay in studies of chemoreception. Protein extracts from *Crassostrea virginica* and *Mercenaria mercenaria* chemically induced humping reflex in seastars. Extracts from clam were always more active. The highest molecular weight-range fraction from clam tissue was the most active. In laboratory and field tests, higher molecular weight fractions induced searching activity in seastars at speeds of up to 8 cm/min. - modified author's summary - J.L.M.

816
Heffernan, W. Paul, and Victor J. Cabelli. 1970.

Elimination of bacteria by the northern quahaug *(Mercenaria mercenaria)*: Environmental parameters significant to the process. J. Fish. Res. Bd. Canada 27(9): 1569-1577.

Clams were contaminated artificially in the laboratory with *Escherichia coli* in concentrations ranging from 10^2 to 10^4 cells/100 ml for accumulation periods of 1 to 14 days. Clams were then transferred to seawater free of *E. coli* for 48 to 72 hrs. Elimination of bacteria to low residual levels depended on initial *E. coli* content, which was a function of the organism in contaminated water. Extending the contamination period from 6 hrs to 14 days did not adversely affect ability of clams to cleanse themselves. After 48 hrs of depuration, numbers of *E. coli* in excess of 17 colony-forming units/100 g (sensitivity level of the assay method) were not found. Clams were able to cleanse themselves within 48 to 72 hrs just about as well at 10°C as at 20°C. At salinities 25 to 31°/°° cleansing was acceptable in 48 hrs. At 20°/°° elimination was poor. Most clams closed their valves when salinity was reduced to 22°/°°. After 4 wks conditioning at 20°/°° elimination proceeded equally well at salinities of 20 to 30°/°°, but not at 15°/°°. At water flow rates below 13 ml/min/animal (about 1 gal/min/bu) elimination of *E. coli* was reduced. Increasing water turbidity reduced accumulation of bacteria by clams, until at 25 Jackson turbidity units of bentonite few clams could accumulate to levels higher than the surrounding water. Increased turbidity appeared to enhance depuration. The greater the initial contamination, the longer it took to depurate to a particular level. When ambient temperature of water from which clams were collected prior to contamination was less than 10°C elimination of *E. coli* was decreased. In the depuration process, variability in response of individual clams must be considered. The results of this study were similar to studies of elimination of poliovirus, although viral elimination is less effective at temperatures below 15°C. - J.L.M.

817
Heffernan, W. Paul, and Victor J. Cabelli. 1971.

The elimination of bacteria by the northern quahaug: Variability in the response of individual animals and the development of criteria. Proc. Natl. Shellf. Assn. 61: 102-108.

Distributions of residual ET coliform levels in individual quahaugs after depuration were dependent on initial level of contamination and on the manner by which they were polluted. Higher residual levels were obtained with naturally polluted clams than with those artificially contaminated with *E. coli*. This means that tests made with artificially contaminated clams are suspect. About 1% of clams cannot be expected to reduce appreciably their level of ET coliforms. Therefore, depuration should be restricted to moderately polluted clams. It is possible that in heavily polluted water clams deposit coliform organisms at some site which is less accessible than the digestive gland to elimination of organisms via normal feeding-cleansing mechanisms. This raises questions about the validity of a bacterial system as an indicator of viral depuration. This needs investigation. Fifteen trials showed that depuration of moderately contaminated quahaugs produced a product that in terms of coliform organisms was as good or better than that currently accepted from certified grounds. - J.L.M.

818
Hegyeli, Andrew. 1964.

Temperature dependence of the activity of the antitumor factor in the common clam. Science 146(3640): 77-78.

Watery extracts of *Mercenaria mercenarius* (obviously *M. mercenaria*) possess a factor which inhibits growth of tumors. The activity of this factor varies in clams taken in different seasons from 2,800 to 3,000 retine units/kg wet weight in August to 346 retine units/kg in February. High summer activity can be restored in clams taken from 5°C water by holding them in warm water (e.g., 15.5°C or higher) for 4 weeks before preparing extracts. - J.L.M.

819
Heilprin, A. 1887.

Explorations on the west coast of Florida and in the Okeechobee Wilderness. Wagner Free Inst. Sci. Phila: 1-134.

According to Hutton et al. (1956), abstracted elsewhere in this bibliography, Heilprin reported *Venus cancellata* from Boca Ciega Bay, Fla. - J.L.M.

820
Heip, Carlo. 1975.

On the significance of aggregation in some benthic marine invertebrates. In Proc. 9th Europ. Mar. Biol. Symp., Harold Barnes (ed). Aberdeen Univ. Press: 527-538.

Mercenaria mercenaria is not mentioned, but several bivalve species are discussed. The general principles are applicable. Most benthic marine invertebrates have an aggregated spatial pattern. Some important exceptions are found in bivalvia, which do not copulate, therefore do not need to aggregate, and may be driven by competition for food toward a uniform distribution. Pattern formation is the result of 2 opposing forces: 1) the risk of not finding a partner, against the risk 2) of not finding enough food. In most benthic marine invertebrate populations the strategy appears to be a reduction in risk of failing to find a partner at the cost of an increase in risk of not finding food. Aggregation in the species studied was not mechanical, but an active process. (Abstracter's note: The literature contains much evidence that *M. mercenaria* is not uniformly distributed. Some authors have attributed this, at least in part, to the effects of environmental variables, of which the nature of the substrate is an important one. On the other hand, there is fairly obvious survival value in aggregation. Mass spawning in an aggregated stock can be triggered by spawning of a few individuals, but in sparse populations this may not happen, which could be to the detriment of successful spawning and setting. That such aggregation may be an active rather than a passive process, although it is not a search for a reproductive partner directly in sessile bivalves, is the demonstrated tendency of oyster larvae to set on living adults.) - J.L.M.

821
Henderson, Jean T. 1929.

Lethal temperatures of Lamellibranchiata. Contr. Canad. Biol. Fish., N.S. 4(25): 399-411.

Six *Venus mercenaria* were tested. Rate of heating was 0.5°C in 5 min. At 40°C one gaped widely and was removed from the water. At 40.5°C all gaped and 2 were removed; another was removed at 41°. At 41.5° the remaining 2 still responded to stimulus; they were removed at 44.5 and 46°. All lived except the last. The lethal point was taken to be 45.2°C. The only species of 18 tested which had a higher lethal point (48.5°C) was *Ostrea virginiana (Crassostrea virginica)*. It was concluded that normal living temps and lethal temps are positively correlated. - J.L.M.

822
Henderson, Stephen P. 1978.

Shellfish hatcheries, an industry view. In Drugs and Food from the Sea: Myth or Reality? Pushkar N. Kaul and Carl J. Sindermann (eds.) University of Oklahoma, Norman: 263-271.

Hatchery spawning and rearing of shellfish is a delicate process to begin and control, and the hatchery product is met in the market with mixed reaction. This paper discusses the hatchery process without reference to specific molluscs. It points out that the market is about 2 billion seed per year, and this can be supplied by hatcheries if certain conditions are met. Once that is achieved, International Shellfish Enterprises believes that the future is optimistic. - J.L.M.

823
Hendrickson, S. A. 1975.

Ongoing shellfish management programs. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 25-27.

The Department began a formal shellfish transplant program in 1964. Major purpose was to reduce standing crops of shellfish in certain closed waters to levels no longer attractive to poachers, thus reducing potential health hazards and reducing problems of law enforcement. The second objective was to make an unusable resource available under acceptable sanitary conditions. In 10 years over 215,000 bu of hard clams were transplanted to grounds around the shores of Long Island. In 1973 federal funds were provided to give 50% matching grants for transplants and introductions of spawning stock by interested towns on Long Island. Funds are administered, and supervision of transplants provided by the State. Allowances were $50,000 in 1973, $80,000 in 1974, and the 1975 budget allocated $50,000. The Department also conducts shellfish population surveys. It is proposed to expand these surveys as funds become available. Conflicts sometimes develop between private shellfish farmers and those who harvest public grounds. The Department is responsible to attend to the interests of both segments of industry. By law, the State cannot, however, lease lands to private planters if independent baymen can make a living by harvesting wild crops there. Plans were developing at the time of writing to offer certain areas of bottom for leasing. Cooperation of all segments was invited. - J.L.M.

824
Heppell, D. 1961.

The naturalization in Europe of the quahog, *Mercenaria mercenaria* (L.). J. Conchol. 25(1): 21-34.

In the U.S. hard clams, unlike oysters, are eaten in all seasons. Meat content of both species is influenced by spawning, but the muscular foot keeps the volume of clam meat at a higher level. The number and position of hinge teeth are of primary importance in taxonomy of the Veneridae. *V. verrucosa* is the type species for *Venus* L. *Mercenaria* Schumacher, which has no anterior lateral hinge tooth, is the type species of *Mercenaria*. Attempts were made from time to time to introduce the quahog to British and French waters. Almost all failed, but the species has appeared in places with no history of introduction attempts. The first recorded finding in Britain was about 1859 at Bootle. This was a dead shell, believed to be from ballast. In 1864 *M. mercenaria* was found living in the Humber estuary. By 1889 it was abundant. The colony now is believed to be extinct. Failure of colonization attempts in the 19th century was thought to be caused by failure to recognize that this was an estuarine species. Another attempt in more brackish waters was made in 1883 in the Dee, but this also failed, although the vigor of these clams was proven by their survival for at least 16 months in an aquarium. In the 1920s hard clam shells were found on oyster ground in Menai Straits at Caernarvon. They probably came in shipments of American oyster. There was no evidence of successful breeding. In the 1950s and 1960s several quahog colonies were discovered in the vicinity of Southampton Water. In France introductions were attempted in the Arcachon Basin in 1861 and 1863. By 1864 the first lot had grown about 2 cm. Apparently the colonies did not spawn. About 1910 a successful introduction was made in the Seudre Basin. These clams spawned prolifically, and a commercial fishery was in operation in the 1950s. This is a mariculture operation, in which clams are handled much as oysters are in France, holding them in claires in which gills and mantles become green from feeding on *Navicula ostrearia*. In Brittany importation of American clams began about 1936, where they were laid down mostly in the River Belon. After the war this operation was resumed in 1954. Clams were held only a short time in local waters, then sold, but a few remained. From prewar plantings large clams, up to 14 cm long and up to 500 g, were found in claires in the Gulf of Morbihan and River Penerf in the 1950s. Old clams also were found in places where none had been introduced, from which it was assumed that some successful breedings had occurred. A recently dead valve was found in Zeeland, Neth. in 1933 and a live specimen in Ostend Harbor in 1937. It was not certain whether these were imported from France or that this was evidence of a natural extension of range. Life history of hard clam is described from American literature. From ages of clams taken in European waters it was calculated that they could have been spawned in a summer when water temp was distinctly above average. In England temp was considered to be adequate for spawning, at least on the south coast. The colony discovered in 1956 at Lee-on-the-Solent was 7 1/2 yrs old, which meant that they were spawned in the notoriously hot summer of 1949. In 1955 the weekly max sea water temp in Southampton Water was higher than 20°C from mid-July to mid-Sept and a successful spawning took place in that year. Assuming that min temp for spawning of quahog is 20-21°C, conditions for spawning in Southampton Water are reached in most years. Type of substrate is important for survival and growth of quahog, and unsuitable bottom may explain failure of some introductions. Aside from unsuccessful introductions already mentioned the following attempts or fortuitous plantings were made: 1) estuary of the Humber River - accidental introductions with American oyster - no evidence of breeding - water temp too low; 2) Hilbre Island - clams laid down for storage - no permanent colony survived. - J.L.M.

825
Heusser, C. J. 1949.

History of an estuarine bog at Secaucus, New Jersey. Bull. Torrey Botan. Club 76(6): 385-406.

826
Hibbert, C. J. 1976.

Production studies of a bivalve population on an intertidal mudflat, with particular reference to the energy budget of *Mercenaria mercenaria* (Linné). Ph.D. Thesis, University of Southampton (England), 225 p.

The community was dominated by *M. mercenaria* and *Cerastoderma edule*. Total biomass, 27 to 129 g/m^2 ash-free dry weight, was high compared to previous studies of intertidal and sublittoral sites. Predators remove an estimated 10.7 tonnes ash-free dry weight/m^2/yr. Total production of 3 species, *M. mercenaria, C. edule*, and *Venerupis aurea* (34 to 87 g/m^2/yr) was significantly higher than comparable studies. The scavenger-decomposer food chain receives 18.2 tonnes/yr. Growth of *M. mercenaria* was studied and compared with other hard clam populations, and temperature effects and factors limiting growth were discussed, but details are not contained in the summary. Seasonal cycle in ash-free dry weight for an individual of constant length increases rapidly in early summer as gonad proliferates, then decreases sharply with spawning. Weight declines in winter as food reserves are used up. Shell length and shell weight showed no obvious seasonal relationship, but a significant annual cycle in percentage organic content of shell had distinct peaks at beginning and end of growing season. Three peaks in calorific content were identified, in July, Sept, and Feb. Recruitment was irregular. Successful recruitment at Hamble probably depends on spawning of stocks in the Test River, where conditions are more favorable for larval development. Two mortality types were observed, in juveniles and adults. These were related to predation. Weight-specific respiration (QO_2) decreased with increasing size of clam, and fell within the range reported for other bivalves. Feces and pseudofeces made up a relatively consistent proportion of food consumption (mean 59%). Total energy consumption (1292 Kcals/m^2/yr) was deposited largely as feces (759 Kcals) or excreted (160 Kcals). Other observations are mentioned without specific results. - from thesis summary - J.L.M.

827
Hibbert, C. J. 1976.

Biomass and production of a bivalve community on an intertidal mud-flat. J. Exp. Mar. Biol. Ecol. 25(3): 249-261.

The study was made in Southampton Water, the estuary of the Test and Itchen rivers, on the mud flat of Hamble Spit at the mouth of the River Hamble in the south of England. Sampling area was about 60 ha, with 4 transects about 200 m apart and with stations at 100 m intervals. Two surveys were made in winter, in 1972 and 1973. Number of stations was 30. Stations were placed in four groups, based on time of exposure on ebb tide, percent mud, and total bivalve biomass. Of 12 bivalve species identified, *Cerastoderma edule* and *Mercenaria mercenaria* dominated. Stations in Group I (above mean tide level - 2.6 m or more above Port Datum) contained negligible numbers of mollusks. Group II, with coarse sediments, was about 1.25 to 2.6 m above Port Datum and had 503 g/m^2 live weight biomass of *C. edule* and 180 g/m^2 of *M. mercenaria*, with total biomass all species of 772 g/m^2; Group III, about 0.8 to 1.8 m above Port Datum had 1969 g/m^2 *C. edule* and 1195 g/m^2 *M. mercenaria*, and coarse sediments; Group IV, about 0.55 to 0.9 m above Port Datum, was true mud flat, with 454 g/m^2 *C. edule* and 750 g/m^2 *M. mercenaria*. Groups III and IV had total biomass of 3,315 and 1,205 g/m^2 respectively. Recruitment to the *Mercenaria* population was sporadic. "Successful" years were correlated with summers of low water in the River Test, which was assumed to favor retention of larvae. Recruitment to stocks of other species, however, apparently did not vary greatly. Average shell lengths of *M. mercenaria* measured between January and March 1972 and 1973 were: end of 1st yr 10.6 mm, 2nd yr 24.4 mm, 3rd 37.6 mm, 4th 49.0 mm, 5th 56.6 mm, 6th 61.3 mm, and 7th 67.6 mm. Ages were estimated from shell rings. The relation between ash-free dry weight of meats and shell length was expressed by the average equation: log weight = 3.328 log length -5.641; between mean biomass and annual production in g ash-free wt/m^2 was Group II biomass 7.73, production 3.99, P/B 0.52; Group III biomass 50.04, production 14.00, P/B 0.28; and Group IV biomass 36.54, production 6.19, P/B 0.17. Growth rates were similar over a wide range of sediment types, contrary to findings of other authors. Percentage of mud in bottom samples ranged from 3 to 93. It was concluded that other factors have an important influence on growth. Small clams, less than 25 mm long, probably are eaten by several predators, including *Carcinus maenas*, smaller wading birds, and fishes. Most gull and wading bird predation was on Groups II and III, in which 80% of mortality was attributed to predation. Mortality was highest in Group II, lowest in Group IV, related to period of exposure and depth of water. Herring gulls took 95 g ash-free dry weight of *Mercenaria* per bird per yr, and a total annual removal of 1.9 tonnes ash-free dry weight. Relation of shell weight to shell length of *M. mercenaria* is expressed by the equation: log shell wt in g =2.96 log length in mm -3.586. Shell contains 2.68% organic matter.

Year class	Mercenaria/m^2	Annual increment in mean wt	Production increment
Gp II:1972	2.41	0.019	0.05
1971	0.88	0.148	0.13
1970	4.75	0.466	2.21
1969	0.88	0.759	0.67
1968	1.25	0.637	0.80
1967	0.13	0.629	0.08
1965	0.38	0.123	0.05
Gp III:1972	2.43	0.018	0.04
1971	3.67	0.141	0.52
1970	12.29	0.448	5.51
1969	1.00	0.733	0.73
1968	9.43	0.617	5.82
1967	0.43	0.609	0.26
1966	0.58	1.094	0.63
1965	4.15	0.119	0.49
Gp IV:1972	3.44	0.019	0.07
1971	2.59	0.147	0.38
1970	2.13	0.467	0.99
1969	0.71	0.765	0.54
1968	2.13	0.642	1.37
1967	0.71	0.635	0.45
1966	0.24	1.141	0.27
1965	2.36	0.124	0.29
<1965	1.41	1.301	1.83

- J.L.M.

828
Hibbert, C. J. 1977.

Growth and survivorship in a tidal-flat population of the bivalve *Mercenaria mercenaria* from Southampton Water. Mar. Biol. 44(1): 71-76.

Hard clam in Southampton Water, England probably was introduced in 1925, when a "few dozen" clams were placed opposite Marchwood Power Station in the River Test. Now it has spread throughout Southampton Water and the eastern Solent, living mainly in the intertidal zone. To derive smooth growth curves for clams sampled between July 1972 and Sept 1973 it was assumed that no growth occurred from Oct to April in 1967 to 1972 year classes and no growth until June in 1965 and 1966 year classes. Growing season was assumed to be from about May or July until Sept. A year's growth (estimated from fig. 1) was from about 5 mm shell length in July to about 25 mm in Sept (14 months later) for the 1972 year class, and from about 68 mm to 73 mm over the same period for the 1965 year class. Seasonal cycles in flesh weight and calorific content appeared to be related to gonad proliferation and subsequent spawning. Recruitment is sporadic and probably depends on spawning of upstream populations, where conditions are more favorable for larval development. Successful sets every 3 or 4 yrs appear to be related to low summer water flow in the River Test. Growth at Hamble was closely related to water temp. Growth did not begin until water temp rose above 9°C, and ceased by Oct although temps were still above 11°C in Nov. Absence of phytoplankton may be the main growth-limiting factor at end of season. Mortality was caused largely by predation. Predation on clams less than 2 yrs old probably is mainly attributable to shore crab *Carcinus maenas*. Small clams also are eaten by certain demersal fishes and some birds. Herring gulls were principal predators on larger clams. - J.L.M.

829
Hibbert, C. J. 1977.

Energy relations of the bivalve *Mercenaria mercenaria* on an intertidal mudflat. Mar. Biol. 44(1): 77-84.

From measurements of filtration rate and oxygen consumption, growth and survivorship, an energy budget was constructed. The mudflat was about 60 hectares. Estimated consumption of 1,292 kcal/m^2/yr was deposited mainly as feces and pseudofeces (759 kcal) or excreted (160 kcal); 29% (374 kcal) was assimilated of which 241 kcal were used for respiration, 72 kcal for flesh production, and 61 kcal for gamete production. *M. mercenaria* contributed significantly to other trophic groups in Southampton Water. Predators removed an estimated 55 kcal/m^2/yr, and the scavenger/decomposer chain took 829 kcal. Water temp varied from a low in Feb (av temp 6.5°C) to high in Sept (av temp 18.9°C). Filtration rates varied directly with shell length and temp. Annual mortality in the population was calculated to be 125.4 kcal/m^2/yr. - J.L.M.

830
Hidu, Herbert. 1965.

Effects of synthetic surfactants on the larvae of clams *(Mercenaria mercenaria)* and oysters *(Crassostrea virginica)*. J. Water Poll. Control Fed. 37(2): 262-270.

Clam larvae were exposed to 8 surfactants in various concentrations. Cationic surfactants were the most toxic, anionic surfactants were intermediate in toxicity, and nonionics were least toxic. Surfactants ranging from 0.01-5.00 mg/l with a mean concentration of 1.44 mg/l, significantly reduced survival of developing embryos and growth and survival of developed veliger larvae. Development of fertilized eggs was halted at lower concentrations than concentrations causing mortality of veliger larvae. - D.L.

831
Hidu, Herbert. 1972.

A working bibliography of Maine aquaculture. Univ. Me. Sea Grant Progr., Ira C. Darling Ref. 72-10, 94 p.

This is a preliminary working list, not checked for accuracy. References to *Mercenaria (Venus) mercenaria* are abstracted elsewhere in this bibliography. - J.L.M.

832
Hidu, Herbert. 1978.

Setting of estuarine invertebrates in Delaware Bay, New Jersey, related to intertidal-subtidal gradients. Internatl. Rev. Gesamten Hydrobiol. 63(5): 637-662.

833
Hidu, Herbert, and James E. Hanks. 1968.

Vital staining of bivalve mollusk shells with alizarin sodium monosulfonate. Proc. Natl. Shellf. Assn. 58: 37-41, ill.

Post-metamorphic *Mercenaria mercenaria*, placed in a 5-20 ppm alizarin sodium monosulfonate solution and seawater, deposited red shell material which remained as a red band after removal from the solution. Larval *M. mercenaria* treated with 0.25-0.75 ppm alizarin for 48 hours produced check marks on shells. Markings persisted for the length of the study (18 months) and may be useful in ecological studies. - D.L.

834
Hidu, Herbert, and Haskell S. Tubiash. 1966.

A bacterial basis for the growth of antibiotic-treated bivalve larvae. Proc. Natl. Shellf. Assn. 54: 25-39.

Addition of 100 to 300 parts per million of the antibiotic "Combistrep" (dihydrostreptomycin-streptomycin sulfates) to hard clam larval cultures increased larval growth more than 100% over control cultures. Growth increased 25% in larval cultures fed live flagellates and Combistrep as compared to cultures fed live flagellates but no Combistrep. Addition of Combistrep to filtered UV-treated seawater increases the number of bacteria in proportion to the concentration of Combistrep. In bacteria free larval cultures with Combistrep, larval clam growth did not increase. This suggests that bacterial flora in Combistrep-treated cultures may be utilized by clam larvae as food. - D.L.

835
Hidu, Herbert, and Ravenna Ukeles. 1964.

Dried unicellular algae as food for larvae of the hard shell clam, *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 53: 85-101.

Three species of unicellular algae preserved by drying can be utilized as food by larvae of hard shell clam, *Mercenaria mercenaria*. The chlorophyte, *Dunaliella euchlora*, and the chrysophyte, *Isochrysis galbana*, freeze-dried, gave clam growth and survival comparable to that obtained when these species were fed at similar rates as live algae. Heat-dried samples of green alga, *Scenedesmus obliquus*, mass-produced in Japan, also gave good growth and survival of clam larvae. Sulmet (sodium sulfamethazine) increased growth and reduced mortality of clams when used with the dried foods. Agitation of clam cultures proved advantageous when used with dried *S. obliquus* but gave variable results with the other two species of dried algae. Dried unicellular algae under suitable culture conditions possess desirable physical and nutritive properties for an ideal nonliving food for mollusks. If adequate culture techniques are developed, dried algae may find wide application, as in rearing juvenile clams and oysters. - modified authors' abstract. - D.L.

836
Higgins, William J. 1974.

Intracellular actions of 5-hydroxytryptamine on the bivalve myocardium. I. Adenylate and guanylate cyclases. J. Exp. Zool. 190(1): 99-109.

Effects of the neurotransmitters 5-hydroxytryptamine (5HT) and acetylcholine (ACh) on adenylate and guanylate cyclase activity in ventricles of *Mercenaria mercenaria* and *Macrocallista nimbosa* were examined. Adenylate cyclase activity and intracellular adenosine cyclic monophosphate (AMP) were increased by 5HT. ACh had no effect. Neither agent altered ventricular guanosine cyclic monophosphate (GMP) significantly. Positive correlation between excitatory action of 5HT and simultaneous increase in intracellular cyclic AMP strongly suggested that this nucleotide mediates 5HT excitation. But classical pharmacological evidence is lacking. Cyclic AMP, dibutyryl cyclic AMP, and phosphodiesterase inhibitors have no effect on mechanical activity of isolated bivalve ventricles. - modified author's abstract - J.L.M.

837
Higgins, William J. 1974.

Cyclic AMP-mediated calcium accumulation by bivalve heart microsomes. Am. Zool. 14(4): 1246.

The nucleotide cyclic AMP is thought to exert intracellular actions by activating cyclic AMP-dependent protein kinases which, in turn, phosphorylate substrate proteins. This kinase was purified from ventricles of *Mercenaria*

mercenaria and used to phosphorylate native heart cell proteins. This augments microsomal $^{45}Ca^{++}$ accumulation by 23%, which suggests a possible mechanism for regulation of intracellular Ca++ and therefore of contractility. - J.L.M.

838
Higgins, William J., and Michael J. Greenberg. 1973.

Adenyl cyclase of the molluscan heart. Fed. Proc. 32(3) Pt. I: 568 (abstract 1978).

Adenyl cyclase and its product, cyclic AMP, were present in ventricles of 5 bivalves and 1 gastropod examined. Cyclic AMP concentration in ventricles of *Mercenaria mercenaria* was increased by 5-hydroxytryptamine (5HT), a cardio-excitatory agent in mollusks, at 10^{-6}M, to 2.3 times control level. The usual cardio-depressor, acetylcholine (ACh), had no effect on cyclic AMP level. UML 491 (1-methy-(+)- lysergic acid butanolamide) at $2x10^{-6}$M blocked 5HT-induced positive inotropic response and elevation of adenyl cyclase activity. Therefore adenyl cyclase of clam heart may be linked to and regulated by the 5HT receptor. Role of the enzyme and its relation to the contractile mechanism is still unknown, for cyclic AMP, its dibutyryl derivative, and the phosphodiesterase inhibitor, theophylline, had no effect on the inotropic response recorded from isolated ventricles suspended in organ baths. - J.L.M.

839
Hill, Robert B., and John H. Welsh. 1966.

Heart, circulation, and blood cells. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.) Academic Press, New York. Vol. II: 126-174.

This important review paper refers extensively to *Mercenaria (Venus) mercenaria*, especially in the section on pharmacology of hearts. All papers referred to are abstracted elsewhere in this bibliography, but this chapter should be referred to for an understanding of the status of knowledge up to about 1964. The chapter deals with the nature of circulation in mollusks, and nature of molluscan heart. Included are: mechanics of heart and circulation; physiology of molluscan cardiac tissue; control of the heart; cardioregulatory substances; pharmacology of hearts; and blood cells. - J.L.M.

840
Hillman, Robert E. 1961.

Formation of the periostracum in *Mercenaria mercenaria*. Science 134: 1754-1755.

Histochemical tests using Millon's reaction, the argentaffin reaction, and 3,4-dihydroxyphenylalanine on mantle of northern quahog, *Mercenaria mercenaria* L., suggest the epithelium of the inner surface of the first mantle fold and the underlying secretory cells function together in formation of periostracum. The periostracum of bivalve mollusks consists largely of a quinone-tanned protein. Secretory cells supply a phenolic substrate which, when oxidized, provides quinones capable of tanning the periostracum. - W.J.B.

841
Hillman, Robert Edward. 1962.

A histological and histochemical study of the mantle of the northern quahog, *Mercenaria mercenaria*. Ph.D. Dissertation, Univ. Del., 61 p., 7 pl.

The mantle margin of *Mercenaria mercenaria*, from pallial line to mantle edge, thickens and terminates in 4 folds. Marginal epithelium varies from cuboidal to columnar cells, apparently related to rates of synthetic and secretory activity. The inner surface of the mantle has ciliated cuboidal cells, the epithelium surrounds loose connective tissue. Adjacent to the 4th fold of the mantle edge medially is a prominent ridge which has 3 types of secretory cell. This ridge and the 4th fold apparently aid in removal of debris from mantle cavity. At least 3 types of mucus appear to be produced in the mantle.

Acid mucopolysaccharides underlie the outer epithelium of the 1st fold. The 4th fold contains a relatively large amount of mucus, but at least some mucus is found in all folds and in the secretory ridge. Mantle epithelium generally lacks glycogen, except on the inner surface of the 1st fold. Connective tissue of the mantle, the area around the groove between the 1st and 2nd folds, and the area at the base of the 2nd fold were relatively high in glycogen. Nearly all epithelial cells, and underlying the epithelium enclosed by the pallial line, had rather high concentrations of lipids. It is suggested that lack of glycogen and abundance of lipids in the mantle may be related to gametogenesis. When glycogen stored in mantle is transferred to gonads, lipids may remain as a source of energy. - from Dissertation Abstracts Internatl. 23(7), 1963: 2634-2635, pagination of thesis is given as 225 p. - J.L.M.

842
Hillman, R. E. 1963.

The quahog, a clam that rids itself of sand by "dribbling". Univ. Del., Estuarine Bull. 7(1): 13-15.

Mercenaria mercenaria has a self-cleansing mechanism by which it frees itself of debris, and it thus does not have to be washed before eating. The mantle consists of 2 broad membranous sheets of living tissue united in the hinge region. Each half is in contact with the valve it secretes. The mantle margin is thick and deeply grooved into 3 separate folds, which are just inside the lips of the shell. These folds form a living curtain between the clam and its environment when valves are open. The outermost fold is secretory and lies next to the shell, the middle fold is sensory, and the inner is a muscular flap which controls water flow into mantle cavity. Quahog mantle has a 4th fold and an adjacent ridge of secretory tissue around the mantle edge; both form mucus. The base of the 4th fold is supplied with muscle fibers. If sand is pumped onto mantle surface by incurrent siphon, ciliary activity carries it to the mantle edge. There it is coated with mucus and is trapped in the groove between the secretory ridge and the 4th fold. Mucus-wrapped debris then is exuded between mantle margins to the outside. - J.L.M.

843
Hillman, Robert E. 1964.

The functional morphology of the fourth fold of the mantle of the northern quahog, *Mercenaria mercenaria* (L.). J. Elisha Mitchell Sci. Soc. 80(1): 8-12.

In contrast with other well-known bivalves the mantle margin of *Mercenaria mercenaria* terminates in 4 rather than 3 folds. Cells of the 4th, innermost fold, and an adjacent ridge of tissues, secrete copious amounts of mucus and mucoid substances which, with activity of fold and ridge, apparently aid in removing detritus and pseudofeces from mantle cavity. Histological details are illustrated. - J.L.M.

844
Hillman, Robert E. 1968.

Histochemical studies of mucus in the mantle of two species of venerid clams. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 564-567.

Mercenaria mercenaria and *M. campechiensis* produce copious amounts of several types of mucus in the mantle margin. Physiological roles of these substances are not yet fully defined, but they appear to serve several important functions, such as calcification, removal of debris, and perhaps others. Much more work is needed to clarify these processes. - J.L.M.

845
Hillman, Robert E. 1968.

Histochemistry of mucosubstances in the mantle of the clam, *Mercenaria mercenaria*. I. A glycosaminoglycan in the first marginal fold. Trans. Am. Microsc. Soc. 87(3): 361-367.

Sections of mantle from hard clam were subjected to a variety of histochemical reactions for mucosubstances. Results of reactions on the first, or outer, fold showed that a sulphated connective tissue glycosaminoglycan is secreted beneath the outer epithelium in the area where most new shell is deposited. The mucus was strongly alcianophilic at pH 1.0 and 2.5, and alcianophilia persisted when tissues were stained with alcian blue in concentrations up to 0.6 M magnesium chloride. The material also reacted strongly with aldehyde fuchsin and high iron diamine when those reagents were followed by alcian blue. Mucus also was periodic acid-Schiff positive, which is unusual for sulphated connective tissue mucosubstances. Testicular hyaluronidase had no effect on staining characteristics of mucus. Because mucus was localized in the shell-forming area of the mantle, and von Kossa reactions for calcium were positive, it was suggested that this mucus may play some vital role in shell deposition. - modified author's abstract. - J.L.M.

846
Hillman, Robert E. 1969.

Histochemistry of mucosubstances in the second fold of the mantle of the quahog. Proc. Natl. Shellf. Assn. 59: 5 (abstract).

In the second fold of the mantle edge of the hard clam are two mucous cell types, one secreting a sulfated acid mucopolysaccharide, the other forming a neutral mucosubstance. The neutral substance is PAS-positive before and after diastase digestion. It exhibits a positive PAS reaction following staining with alcian blue at pH 2.5 before and after hyaluronidase digestion. The acid mucopolysaccharide stains intensely with alcian blue at pH 2.5 and less at pH 1. It retains alcianophilia in magnesium chloride solution up to 1.0 M, and after testicular hyaluronidase digestion. It also reacts strongly with iron diamine and aldehyde fuchsin when followed by alcian blue. Portions of the acid stain with less intensity than others. This material may be a precursor to the final, strongly sulfated acid mucopolysaccharide. Acid mucopolysaccharide and neutral mucosubstance are probably related in function and may be involved with calcium metabolism within the mantle. - modified author's abstract - D.L.

847
Hillman, Robert E. 1969.

Histochemistry of mucosubstances in the mantle of the clam, *Mercenaria mercenaria*. II. Mucosubstances in the second marginal fold. Trans. Am. Microsc. Soc. 88(3): 420-425.

In the 2nd fold of the mantle edge of hard clam are 2 mucous cell types, one secreting a sulphated acid mucopolysaccharide or glycosaminoglycan, the other forming a neutral mucosubstance. The neutral mucosubstance was periodic acid-Schiff (PAS)- positive prior to and following diastase digestion. It also had a positive PAS reaction after staining with alcian blue at pH 2.5, prior to and following hyaluronidase digestion. Usually glycosaminoglycan stained intensely with alcian blue at pH 2.5 and somewhat less intensely at pH 1.0. Portions of the material retained alcianophilia in solutions of magnesium chloride up to 1.0 molar, and after testicular hyaluronidase digestion. The material also reacted strongly with iron diamine and aldehyde fuchsin when these reagents were followed by alcian blue. Methylation extinguished alcianophilia in acid mucosubstance, but was partially restored after saponification. Hard clams were collected from Duxbury Bay, Mass. periodically to detect seasonal effects, if any. A portion of the material secreted by 2nd-fold cells is similar to heparin. Heparin-like material might aid in handling of Ca by the clam, and perhaps other ions such as Na and Cl. Its quality and quantity may depend on salinity. The remainder of the acid mucopolysaccharide material could be heparin precursor in varying degrees of acidity and sulphation. The neutral mucosubstance also varies in quantity, possibly in relation to variation in glycosaminoglycan. Mucous secretions in the 2nd fold are distinctly different from those in the 1st fold, suggesting a completely different function, and adding support to the hypothesis that these materials play a far more sophisticated role in life activity of the clam than suspected previously. - J.L.M.

848
Hillman, Robert E. 1970.

An unusual occurrence of internal calcification in the mantle of the quahog. Proc. Natl. Shellf. Assn. 60: 5 (abstract).

During investigations of mucosubstances in the mantle of the hard clam, one clam was found with an internal deposit of calcium carbonate. Histological investigations showed that calcification was due to an involution of the outer epithelium of the mantle. Histochemical studies showed deposits of glucosaminoglycan underlying the epithelial cells. This material was alcianophilic at pH 1.0 and 2.5 and reacted with aldehyde fuchsin following the alcian blue/aldehyde fuchsin reaction. More acidic mucous material was found in the mantle connective tissue around the involution than is normally found in mantle connective tissue. The relationship between glycosaminoglycans and calcification was discussed. - D.L.

849
Hillman, Robert E. 1971.

The role of mucosubstances in the quahog. Proc. Natl. Shellf. Assn. 61: 5 (abstract).

Based on the results of histochemical studies of mucosubstances in the mantle of the quahog, *Mercenaria mercenaria*, several physiological roles are proposed for various mucosubstances, particularly connective tissue mucus. Besides assisting in such expected functions as lubrication, food capture and protection, it is proposed that quahog mucous materials aid in active transport across cell membranes, especially for handling calcium for shell deposition and osmo-regulation. It is also suggested that one glycosaminoglycan may serve as a vehicle for sorting certain sulfated compounds and releasing them as needed by the quahog. - D.L.

850
Hillman, Robert E. 1973.

Mucus in marine invertebrates. Littoral Lines 8.

851
Hillman, Robert E. 1974.

Effect of salinity on mucus in the mantle of the quahog, *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 64: 3-4 (abstract).

Six separate groups of hard clams were held in seawater, one group at salinity 35°/₀₀, one at 30°/₀₀, one at 25°/₀₀, one at 20°/₀₀, one at 15°/₀₀, and one at 10°/₀₀. After one week histochemical studies were made of the first fold of the mantle edge. Salinity and mucus production were related in that as salinity increased, the amount of reactive acid mucopolysaccharide increased. - modified author's abstract - D.L.

852
Hillman, Robert E. 1978.

Invertebrate mucus: Model systems for studying diseases in man. <u>In</u> Drugs and Food from the Sea: Myth or Reality? Pushkar N. Kaul and Carl J. Sindermann (eds.). Univ. Okla., Norman: 17-25.

It is quite possible that mucus production in the mantle of the hard clam, *Mercenaria mercenaria*, is similar in the mechanisms involved, to mucus production in certain human disease processes such as arthritis and cystic fibrosis. Most mantles of bivalve mollusks terminate in three folds, but in *M. mercenaria* is an enlarged fourth fold which contains an unusually large amount of mucus. Results of all histochemical procedures indicate that the material in the first fold of hard clam mantle is a moderate to strongly acidic, sulfated mucosaccharide. From the juxtaposition of the material with shell secreting area of the mantle, it might be assumed that this material plays some role in calcification. Analysis of the structure, and its similarities to those acid mucosubstances associated with calcification in other organisms, may provide more information on the function of glycosaminoglycans in the process of calcification. Results of histochemical reactions for mucosubstances in the second fold suggest that there are probably two types of mucous cells present. Mucus secretions in the second fold are distinctly different from those in the first fold, adding support to the theory that the materials are playing far more sophisticated roles in the life activity of the clam than previously suspected. If some mucopolysaccharide production in the quahog is related to osmoregulation, and if cystic fibrosis is a disease associated with cellular osmoregulation, then the formation and function of mucopolysaccharides in the hard clam may prove to be a good lower animal model system for studying the pathology of cystic fibrosis. - J.L.M.

853
Hillman, Robert E., and Carl N. Shuster, Jr. 1962.

Observations on the mantle of the northern quahog, *Mercenaria mercenaria* L. Proc. Natl. Shellf. Assn. 51: 15-22.

The hard clam possesses a fourth fold of its mantle edge which was thought to aid in voiding of debris through secretion of mucus from the mucus gland cells found there. There was a cuboidal type and flask-shaped cell also present. Schiff-positive material was found localized primarily in the connective tissue, pallial muscle fibers, and around the groove between the sensory and muscle folds. Cytochrome oxidase activity was found mainly from near the hinge to the pallial line and in the distal part of the pallial border folds. Succinic dehydrogenase activity was mainly in the area behind the pallial line and at the inner and middle fold juncture. - D.L.

854
Hillman, Robert E., and Carl N. Shuster, Jr. 1966.

A comment on the origin of the fourth fold in the mantle of the quahog, *Mercenaria mercenaria*. Chesapeake Sci. 7(2): 112-113.

Based on histological similarity between the fourth fold and other sections of the mantle edge of *Mercenaria mercenaria* and on gross observations; it is determined that the fourth fold probably arises in one of three ways: (a) from a split in the typical inner muscular fold, (b) as a folding-over of the inner surface of the mantle margin, or (c) from a combination of the inner surface of the mantle margin and the inner surface of the third mantle fold. The third alternative is most probable. - J.L.M.

855
Hinegardner, Ralph. 1974.

Cellular DNA content of the Mollusca. Comp. Biochem. Physiol. 47A(2): 447-460.

Cellular DNA content of 110 species of Mollusca is reported, including *Mercenaria mercenaria* and *M. campechiensis*. DNA content correlates positively with chromosome number and, within families, with body size. The more generalized molluscs tend to have higher amounts of DNA than specialized species. *Mercenaria mercenaria* and *M. campechiensis* each have 19 chromosomes, shell length in southern quahog was 127 mm and DNA content 2.3 pg, shell length in northern quahog was 102 mm and DNA content 2.0 pg. - J.L.M.

856
Hochachka, P. W., and T. Mustafa. 1972.

Invertebrate facultative anaerobiosis. Science 178(4065): 1056-1060.

The unique pattern of anaerobic carbohydrate metabolism in invertebrate facultative anaerobes serves to couple other substrate-level phosphorylations to the glycolytic reactions, increasing the potential yield of high-energy phosphate compounds. Two important coupling sites have been identified: 1) succinate dehydrogenase catalyzes fumarate reduction to succinate; the reaction ultimately regenerates NAD, supplying coenzyme for α-ketoglutarate dehydrogenase; 2) alanine aminotransferase catalyzes formation of alanine and α-ketoglutarate, supplying substrate for α-ketoglutarate dehydrogenase; succinyl CoA formed by the α-ketoglutarate dehydrogenase reaction can be utilized to "drive" substrate-level phosphorylation of GDP (or IDP) to GTP (or ITP). Cosubstrates for these coupling reactions, fumarate for the 1st and pyruvate for the 2nd, arise from glucose. Hence the 2 coupling reactions are a means to achieve simultaneous mobilization of glucose and glutamate during anoxic excursions. This reinterpretation of anaerobic energy metabolism raises the possibility of new chemotherapeutic approaches to control of helminth parasites in domestic animals and man. *Mercenaria mercenaria* is not mentioned. - modified authors' conclusions - J.L.M. and M.W.S.

857
Hodge, A. J. 1952.

A new type of periodic structure obtained by reconstitution of paramyosin from acid solutions. Proc. U.S. Natl. Acad. Sci. 38(10): 850-855.

It was possible under certain conditions to cause at least one constituent of native paramyosin (obtained from white portions of adductor muscle of *Venus*) to undergo a reconstitution process from solution, forming protein fibrils with a type of repeating structure distinctly different from native paramyosin. The new type of periodic structure was designated as paramyosin long-spacing (PLS). The apparently homogeneous major component found in media of relatively high ionic strength, which in itself seems capable of giving rise to PLS, appeared to be a complex of a highly asymmetrical component and a 2nd uncharacterized component. PLS fibrils arose from these elongated complex units by lateral aggregation as ionic strength was increased. - J.L.M.

858
Hoese, H. D. 1972.

Invertebrates. In Biology. U.S.L. studies on the Chandeleur Islands. H. Dickson Hoese and Jacob M. Valentine, Jr. (eds). Univ. Southwestern La., Off. Institutional Research, Research Ser. 10: 33-45.

Collections were made along the length of the island chain by snorkel diving, trawl, and dredge. Only a few living *Mercenaria mercenaria* were found, mostly in shallow sandy flats near Redfish Point. About 3 months after Hurricane Camille large numbers of attached hard clam valves were found on South Breton Island. Bottom scour well below normal burying depth was noted. It was estimated that 70,000 clams 8 to 15 cm long (av 12) were killed. They probably came from the Sound, not the Gulf. - J.L.M.

859
Hoff, John C., and Ronald C. Becker. 1969.

The accumulation and elimination of crude and clarified poliovirus suspensions by shellfish. Am. J. Epidemiol. 90(1): 53-61.

Mercenaria mercenaria is mentioned only in citing work of several authors whose papers are abstracted elsewhere in this bibliography. - J.L.M.

860
Holland, Janice Katherine. 1946.

A cytological study of the method of formation of the crystalline style in *Venus mercenaria*. M.S. thesis, Brown University: iii+39 p.

The long narrow cells lining the minor typhlosole, and to a lesser extent the cells lining the major typhlosole, secrete the major parts of the mucin and glycoprotein components of the crystalline style. The shorter, broader cells lining the style sac contain granules which stain with orange G and which may prove to represent enzymes or their precursors which are found in the style. An adequate supply of oxygen is essential for formation of a well developed style. Extra-cellular absorption of food particles can take place in the style sac as well as in the intestine. Small particles of food are capable of being incorporated into the substance of the style. - from author's summary - J.L.M.

861
Holmsen, Andreas A. 1965.

R.I. quahogers make a living despite handraking methods. Maritimes, Univ. R.I. 9(1): 4-6.

Over 90% of the commercial quahog harvest in R.I. was taken with bullrakes and tongs. The number of commercial clammers using manual methods had dropped from nearly 3,000 in 1955-56 to less than 1,000 in a decade. Responses to a mail questionnaire showed that, of 872 commercial hand harvesters, about 26 were oystering and about 87 were students. The remaining 759 quahogers received from none to about 90% of their income from clamming. Only 168 people could be classified as full-time clammers, who derived 75% or more of their income from that source. Analysis of returns from clammers 25 to 45 yrs old showed that the average net return/hr of work was $2.84, better than the hourly wage of production workers of $2.02. Gross return was $24.30/day, expenditures $3.25/day, depreciation $1.20/day, for a net return of $19.85/day. It was concluded that hand harvesting of quahogs in R.I. could yield a reasonably good return to strong, able-bodied men, but that they would be hurt the most if natural events or increased dredging intervened. - J.L.M.

862
Holmsen, Andreas. 1966.

The Rhode Island quahog industry - some economic aspects. Bulletin #386, Agricultural Experiment Station, University of Rhode Island: 1-43.

The number of handrakers in Rhode Island has declined from a high of 2,837 in 1955-56 to about 900 in 1965. When the average price received was 8.28¢/pound of clams, a full time handraker netted $4,487 for the 1962-63 season. Dredging for clams in Rhode Island is restricted to December 1 to March 31, and to certain areas. Dredgers are limited to 30 bushels a day. In the 1962-63 season, the average price received per bushel was $7.54, and the net return to the dredgeboat owner for the season was $2,768 or $41 per day. In 1963, the 15 largest hard clam dealers in Rhode Island handled an ex-vessel value of clams close to $1.3 million, and 74% of the clams were sold to out-of-state markets. Landings of hard clam in Rhode Island have declined over the past 10 years. In 1955 5,020,000 pounds of meats were landed, in 1964 only 1,827,000 pounds. Prices received for clams fluctuate seasonally. Prices for littlenecks peak in February and September and are lowest in April. The following recommendations were made: 1) better utilization of polluted stocks; 2) increased dredging; 3) increase use of rotational harvesting pattern; 4) private leasing of grounds; 5) seeding with juvenile clams; 6) develop hatchery programs. - D.L.

863
Holmsen, A. A. 1966.

The economics of dredging quahogs in Rhode Island. Maritimes 9(3): 10-13.

Handraking accounts for 90% of the hard clam harvest in Narragansett Bay, but a limited amount of power dredging is done in certain areas. Dredging season is 1 December to 31 March, and only in 3 areas, one of which is closed by pollution. The dredging fleet is close to 40 boats. In 1963 licenses were held by 39 dredge boats, with a daily catch limit of 30 bushels. Prices were good, boats worked an average of 53 days, and harvested an average of 734 bu of average price $7.54/bu. Most boats are owner-operated and have a captain and one deck hand. Dredging is not a full-time occupation. In 1963 only 38% of net income of dredge boat owners came from dredging. Average age of fleet is 28 yrs, most were built in the 1930s. Most boats are tied up for the rest of the year, but a few work at other occupations. Boat values may vary, but in January 1964 the average estimated value was $6,000 plus $850 for equipment. If the owner does not operate the vessel he splits the returns, minus all expenses, with the captain. No standard payment for deckhands is set, but a fairly frequent arrangement was $1.00/bu or somewhat more for smaller clams. Fuel costs were $8.25 average, ranging from $7.00 to $12.80 for gasoline power and $4.90 to $8.40 for diesel. Painting and repairs are held to a minimum, but may rise in a good year when more money is available. Average costs in 1963 were $728/vessel for maintenance and repair, $109 for permits and other expenses, $180 for depreciation, and $271 for interest, for a net daily return of $52, and a seasonal return of $2,768. If days taken for repair and maintenance are included, net daily return drops to $41. However, individual vessel returns ranged from a high of $7,150 to a low of $45 loss. It is important that boat and equipment be in top shape so that breakdowns and lost days are kept to a minimum. - J.L.M.

864
Holmsen, Andreas, and Joseph Stanislao. 1966.

Economics of quahog depuration. Department of Food and Resource Economics. University of Rhode Island, Agricultural Experiment Station, Bulletin No. 384, 36 p.

Estimated costs to transplant clams from polluted to clean waters where they could cleanse themselves were $1.40-$4.53 per bushel. Under present conditions in Rhode Island, it was estimated that transplanting would cost about $1.85 per bushel. A design for a depuration plant for hard clams utilizes water sterilized with ultraviolet light. The plant would be capable of depurifying 324 bushels of clams per day. Total cost of depuration in the model plant was estimated at 25.4¢ per bushel. It was concluded that depuration by a plant using ultraviolet light is economically superior to transplanting clams. - D.L.

865
Hood, L. F., R. R. Zall, and R. L. Conway. 1976.

Conversion of minced clam wash water into clam juice: waste handling or product development? Food Prod. Devel., Nov. 1976: 86, 88.

The paper describes a process developed at the plant of the Shelter Island Oyster Co., Greenport, Long Island, N.Y., for producing a marketable food product from waste water from a surf-clam processing operation, and thereby reducing BOD of plant effluent. The technique could be applied to hard clam if it were (e.g., chowder clams) processed in a similar way. - J.L.M.

866

Hopkins, Hoyt S. 1924. (Vol. 29 of Anat. Rec. is dated 1925 but the issue no. 2 was dated Dec. 1924.)

Respiration in the tissues of mollusks in relation to age. Anat. Rec. 29(2): 91 (abstract).

Amounts of O_2 used by excised adductor muscle of *Venus mercenaria* of similar dimensions is proportional to surface area rather than mass, which suggests that O_2 is utilized mainly at the surface. Rates are higher for muscles of small clams. Assuming that rings on shell of *Venus* are laid down annually, it appears that tissue metabolism is inversely proportional to age, high in young animals (2-5 yrs old), falling off to nearly 1/3 in clams over 10 yrs old. Using adductor muscle has an advantage over using intact living animals by eliminating the effects of nervous system, blood supply and hormones on metabolism. - J.L.M.

867

Hopkins, Hoyt S. 1930.

Age differences and the respiration in muscle tissues of mollusks. J. Exp. Zool. 56(2): 209-239.

Study of excised adductor muscles of *Venus mercenaria* showed a falling off in oxygen respiration with age, which was not accounted for by changes in amount of active indophenol peroxidase. Rate of respiration and peroxidase content were greater in "closing" muscle than in non-striated, nacreous portion of adductor. Respiratory rate in the 2 kinds of muscle in adductor was correlated with their catalase activity. It was assumed that red portion of the adductor of *Venus* was closing muscle, and thus probably displays more activity than the white part. Its homologue in bay scallop, *Pecten irradians*, is the striated portion of adductor. Unlike its homologue in scallop, red muscle appears to retain its tonic properties in large measure, thus differs little from white muscle. Red muscle of *Venus* was higher in catalase than white. Respiration was somewhat higher in red than in white adductor muscle. Peroxidase activity was considerably higher in red than in white muscle. Various workers have differed as to whether age can be determined accurately from concentric lines of growth on external surface of *Venus* shell. When the valve is broken across from umbo to margin a stratified nacreous layer is exposed which has alternate lamellae of bluish-white and cream-colored material. Cream-colored strata correspond to concentric ridges on the surface, bluish-white to depressions between. The inner shell surface of clams collected alive in summer almost always has some color, thus the pigment may be derived from abundance of plant food ingested in summer. Study of nearly 700 shells by this method detected all ages up to 24 yrs. A few had 40 or more growth layers, so thin near the margin that interpretation was difficult. These apparently old clams were only about 8 cm long, whereas the largest collected (11 to 14.5 cm) rarely exceeded 20 yrs, which suggested that great size is incompatible with long life. This may be an illustration of Rubner's principle, in which length of life is inversely proportional to rate of metabolism. Causes of differences in rate of growth of hard clam have not been determined. - J.L.M.

868

Hopkins, Hoyt S. 1934.

Catalase and oxidative processes in animal tissues as possible factors in adaptation. Biol. Bull. 67(1): 115-125.

O_2 consumption of thin sections of muscle in seawater saturated with O_2 varied widely between species. *Venus mercenaria* in 2 hrs at 27.5°C used 33.8 mm^3/g of tissue/hr, *V. campechiensis* 28.9 mm^3 (6 and 4 experiments respectively). Inadequate diffusion of O_2 into tissue seemed to be unimportant as a factor limiting rate of O_2 consumption. Depletion of catalase in unsectioned muscle during 4 hrs after excision did not exceed 10%. In 60 experiments with 30 *Venus mercenaria* (290 mg of muscle) O_2 used was 38.5 mm^3/g/hr, catalase 19.8 mm^3/g/hr, ratio O_2/catalase 2.16 ± 0.80; 12 experiments with 10 *V. campechiensis* (289 mg muscle) used 35.6 mm^3/g/hr O_2 and 11.5 mm^3/g/hr catalase, ratio O_2/catalase 4.33 ± 1.83. *V. mercenaria* did not bear mutilation well; removal of a shell segment without visible injury to mantle was usually fatal. Intertidal species, or species from mud flats, usually had greatest amounts of muscle catalase; species from sandy substrate and not exposed to air the least. Difference in muscle catalase in the 2 species of *Venus* from N.C. waters was considered striking. Some clams were difficult to identify, and may have been hybrids. One individual of the southern quahog gave a reading of 41 for catalase, although it was less than 14 in all others. *V. mercenaria*, the northern species, can live on sandy beaches, mud flats, even in marsh grass areas, can tolerate semi-stagnant conditions, and can live on beaches exposed at low tide 2/3rds of the time. *V. campechiensis* lives in sand or on mud shoals along river channels, at low water line or at considerable depths. It seldom occurs more than a few inches above low water level. These differences in tolerance and vertical distribution help to explain differences in catalase and O/c quotient. In *V. mercenaria* the lower O/c quotient is associated with the greater power of survival of mature clams as compared with young when kept out of water. Relatively inactive species like *V. mercenaria* have more muscle catalase than active forms. The function of catalase is to decompose H_2O_2 formed in tissues preventing its accumulation in toxic amounts. Molecular (inactive) O_2 appears in the reaction, thus it does not promote oxidation directly, but is still available for oxidases to act upon. A large amount of catalase, by destroying H_2O_2, retards oxidation with peroxidase, but does not entirely prevent it, since peroxidase reacts with a much lower concentration of peroxide than does catalase. Thus, the role of catalase in animals exposed to oxygen deficiency is to conserve metabolic activity. - J.L.M.

869
Hopkins, Hoyt S. 1939.

Seasonal differences in the oxygen exchange and glycolysis of tissues in the clam *Venus mercenaria*. Anat. Rec. 75 (suppl.): 133.

An age difference in O_2 respiration had the same magnitude winter and summer. In summer, respiratory rate of gill tissue was 21% greater in young clams than in old when respirometers were oscillated, 16.8% greater when not shaken. In winter and early spring O_2 exchange in gills of young clams was 7.4% higher than in old with a shaking rate of 30 oscillations/min, 6% lower without shaking. At a shaking rate of 60, O_2 exchange was 13.3% higher. Mantle tissue from young clams had respiration rates in winter more than 20% greater than from old clams, thus resembling muscle. In winter, muscle tissue of old clams was 164 µl CO_2 liberated from seawater+bicarbonate in N, in summer 174; young clams in winter 161, summer 193. In winter gill of old clams 117, summer 160; gill of young in winter 68, summer 193. Mantle tissue, like muscle, showed small seasonal differences: old clams in winter 348, summer 337, young in winter 302, summer 373. Results showed a selective condition of hibernation in gill metabolism, particularly of young clams, related to their sluggish activity in winter and spring. - J.L.M.

870
Hopkins, Hoyt S. 1941.

Growth rings as an index of age in *Venus mercenaria*. Anat. Rec. 81 (suppl.): 53-54.

In Beaufort, N.C. clams marked by notching the shell margin were recovered after 1 to 7 yrs. With few exceptions, newly formed growth layers in shell sections corresponded with number of years of growth. Exceptions were large, old clams with slow growth rate; small clams planted near high tide mark, where growth was retarded; occasional clams recovered from shelly bottoms, which showed evidence of interrupted growth. In slow-growing clams shell laminae were so thin as to be difficult to see, and winter growth so indistinct as to be overlooked. Age of old or retarded clams therefore could be underestimated. Clams from N.C., in sections of shells, showed as many as 45 growth layers. In some from N.Y. as many as 70 to 80 layers were seen, and these clams were larger. (Abstracter's note: it is not clear if layers means years.) - J.L.M.

871
Hopkins, Hoyt S. 1946.

The influence of season, concentration of seawater and environmental temperature upon the oxygen consumption of tissues in *Venus mercenaria*. J. Exp. Zool. 102(2): 143-158.

Tissues of young hard clam have a higher rate of respiration than those of older clams. Adductor muscle had the lowest rate, but also had the greatest average difference in O_2 consumption between old and young. Gill tissue had the highest rate of consumption, and mantle intermediate. For gill tissue the difference in rate between old and young clams is distinctly less in winter than in summer. The seasonal difference in muscle tissue is small. Alterations in salinity, pH, and temp of seawater produced absolute changes in rate of respiration of gill tissue, without affecting relative age difference much. The same was true for temperature and muscle tissue. Moderate fasting in summer by clams of different ages abolished the age difference for gill tissue. Increase in respiratory rate in summer of young clams over old was apparently related to increase in ciliary activity, which may be controlled by hormones. Excised gill tissue from N.C. clams had a lower respiratory rate than that of N.Y. clams when both were held at 25°C. N.C. clams at 25°C had a lower respiratory rate than N.Y. clams at 20°C. - J.L.M.

872
Hopkins, Hoyt S. 1949.

Metabolic reactions of clams' tissues to change in salinity. I. Ciliary activity, narcotic and cyanide effects, and respiratory quotient. Physiol. Zool. 22(4): 295-308.

Rate of O_2 consumption of *Venus mercenaria* gill tissue was inversely proportional to seawater density between 1.012 and 1.030 for clams living in seawater of density 1.024. Rate of respiration in seawater 1.015 was more than 40% higher for gill and 12% higher for mantle tissue than in density 1.025. It was 15% lower for muscle sections. Ciliary activity in seawater diluted to 60% did not increase activity of frontal cilia, although it augmented gill respiration. Ciliary activity actually was definitely lowered as compared with that in natural seawater, so that ciliary activity can be eliminated as a factor in increased respiration. Isotonic NaCl solution increased O_2 consumption of gill tissue by 47%. This was largely suppressed when $CaCl_2$ was present in the same concentration as in seawater. In a 3:2 or 1:1 mixture of isotonic NaCl with seawater there was no increase in respiratory rate. M/1,000 cyanide had no effect on O_2 consumption of gill in summer, but produced moderate inhibition in fall, about 60% in mantle and muscle tissues. Augmented respiration of gill and mantle in diluted seawater was inhibited relatively more by cyanide than in natural seawater. Average respiratory quotient of gill was 0.87 in seawater of density 1.025, and 0.94 in 1.015. It is probable that *V. mercenaria* has more power of osmotic regulation than other species. This may be reflected in respiratory responses of certain excised tissues in dilute seawater. - J.L.M.

873
Hopkins, Sewell H. 1956.

Odostomia impressa parasitizing southern oysters. Science 124(3223): 628-629.

Mercenaria mercenaria, placed in aquaria with *Odostomia impressa* and oysters, did not attract the snails as oysters do. A few snails may crawl up on quahogs but did not stay long. - J.L.M.

874
Horton, Donald B. 1971.

Conference recommendations. In Aquaculture: A New England Perspective. Thomas A. Gaucher (ed.). New England Marine Resources Information Program, Sea Grant, Univ. R.I., Narragansett: 1-6.

Two panels evaluated species for commercial aquaculture potential. The technical panel concentrated attention on high priced species and used growth rate, conversion efficiency, availability of food, hardiness, simplicity of larval development, and whether or not the species was indigenous, as criteria. The economic panel evaluated species on the basis of market volume, price, and price flexibility, and concentrated on species with best potential for increasing regional income. One panel chose 7 species as best, the other chose 6. *Mercenaria mercenaria* was on both lists. - J.L.M.

875
Hoskin, George P., and Somsong P. Hoskin. 1977.

Partial characterization of the hemolymph lipids of *Mercenaria mercenaria* (Mollusca: Bivalvia) by thin-layer chromatography and analyses of serum fatty acids during starvation. Biol. Bull. 152(3): 373-381.

In 12 specimens of *Mercenaria mercenaria* from Barnegat Bay, N.J., serum fractions contained sterols (81%), free fatty acids (6%), sterol esters (11%), and triglyceride (2%). Absolute amounts of cholesterol and triglyceride were 5.2 to 7.5 mg/100 ml and about 1 mg/100 ml, respectively. More total lipid and nearly all triglyceride were in cell fraction of hemolymph. Cholesterol was 18% of hemolymph cell sterols and 13% of serum sterols. Sera of *M. mercenaria* taken in March and June from Buzzards Bay, Mass. contained at least 22 fatty acids, of which the most important in order of decreasing abundance were $C_{20:5}$, $C_{16:0}$, $C_{22:6}$, $C_{18:1}$, and $C_{20:1}$. Starved clams had relatively greater amounts of $C_{16:0}$, $C_{16:1}$, $C_{18:0}$, and $C_{18:1}$ and reduced levels of $C_{20:1}$ and $C_{20:5}$. $C_{20:5}$ was 20% lower on day 30 than on day 0. - from authors' summary - J.L.M.

876
Houser, Leroy S. (ed.). 1965.

National Shellfish Sanitation Program Manual of Operations. Part 1. Sanitation of Shellfish Growing Areas. 1965 revision. U.S. Dept. Health, Educ. Welfare, Pub. Health Serv., Div. Envir. Eng. Food Prot., Shellf. Sanit. Br., Washington, D.C. Pub. 33, 32 p.

No specific mention of *Mercenaria (Venus) mercenaria*, but clams are mentioned. The procedures described apply to all edible shellfish species and shellfish harvesting grounds. Among other things, it is pointed out that shellfish from water having a median coliform MPN not exceeding 70/100 ml, and which is also protected against chance contamination with fecal material, will not be involved in spreading disease which can be attributed to initial contamination of shellfish. This is not surprising because a water MPN of 70/100 ml is equivalent to a dilution ratio of about 8 million ft^3 of coliform-free water/day for fecal material from each person contributing sewage to the area. - M.W.S. and J.L.M.

877
Hoyaux, J., R. Gilles, and Ch. Jeuniaux. 1976.

Osmoregulation in molluscs of the intertidal zone. Comp. Biochem. Physiol. 53(4A): 361-365.

Three gastropod and 3 bivalve species were used, but not *Mercenaria*. Experimental mollusks behaved as poikilosmotic animals when acclimated gradually to diluted media. When transferred directly to the more dilute medium they reacted by a "shell-closing" mechanism. - J.L.M.

878

Hoyle, G. 1964.

Muscle and neuromuscular physiology. Chapter 10 in Physiology of Mollusca. Vol. 1. K. M. Wilbur and C. M. Yonge (eds.). Academic Press, New York: 313-351.

Pink adductors are found in *Teredo* and *Venus*, possibly from presence of hemoglobin (Fox 1953). Smooth muscles of *Mercenaria* (white parts), when disintegrated mechanically, release paramyosin elements in the form of long, flat ribbons (Elliott et al. 1957). Thus, the thick filaments must contain several paramyosin ribbons stacked together with surfaces apposed. - J.L.M.

879

Hubbard, J. W. (sic), and Sanderson Smith. 1865.

Catalogue of the Mollusca of Staten Island, N.Y. Ann. Lyceum Nat. Hist. N.Y. 8: 151-154.

Venus mercenaria is listed as abundant. According to Jacot (1920), abstracted elsewhere in this bibliography, the initial J. was in error. The correct name was Eber Ward Hubbard. - J.L.M.

880

Hughes, Roger N. 1969.

A study of feeding in *Scrobicularia plana*. J. Mar. Biol. Assn. U.K. 49(3): 805-823.

Work of other authors on *Venus mercenaria* is mentioned, but this paper contains no original data. - J.L.M.

881

Huguenin, John E. 1975.

Development of a marine aquaculture research complex. Aquaculture 5: 135-150.

The new Environmental Systems Laboratory at Woods Hole, Mass., under direction of John Ryther, is discussed: setting of requirements, approaches adopted, design problems, experiences to date, and the unique physical plant. The essence of the project is a marine phytoplankton-bivalve mollusk food chain using *Mercenaria mercenaria* and other bivalves. It includes a much more complex food web, including a flatfish, lobster, abalone, benthic worms, and seaweeds as secondary components. - J.L.M.

882

Humes, A. G. 1953.

Ostrincola gracilis C. B. Wilson, a parasite of marine pelecypods in Louisiana (Copepoda, Cyclopoida). Tulane Stud. Zool. 1: 99-107.

List only.

883

Humes, Arthur G. 1954.

Mytilicola porrecta n. sp. (Copepoda: Cyclopoida) from the intestine of marine pelecypods. J. Parasitol. 40(2): 186-194.

In June 1947 both sexes of a new species of *Mytilicola* were taken from intestines of ribbed mussel, recurved mussel, and *Venus mercenaria mercenaria* Linne in marshes and bayous behind Grand Isle and Grand Terre, Barataria Bay, La. The copepod was most common in mussels, and only one was found in *Venus*. The species is described and named. - J.L.M.

884
Humes, Arthur G., and Roger F. Cressey. 1960.

Seasonal population changes and host relationships of *Myocheres major* (Williams), a cyclopoid copepod from pelecypods. Crustaceana 1: 307-325.

Myocheres major was found sporadically in small numbers in *Venus mercenaria* from Cotuit Bay, Mass. in summer. *Tagelus gibbus* was the preferred host. - J.L.M.

885
Humphries, E., and F. C. Daiber. 1967.

Shellfish survey of Indian River Bay and Rehoboth Bay, Delaware. Northeast Marine Health Sciences Lab., U.S. Pub. Health Serv., Narragansett, R.I., Tech. Rept.

List only.

886
Hunt, D. A. 1970.

Sanitary control of shellfish and marine pollution. In Marine Pollution and Sea Life. Mario Ruivo (ed). Fishing News (Books) Ltd., London: 565-568.

Mercenaria mercenaria is not mentioned, but the discussion is pertinent to that species. Membership and operation of the U.S. National Shellfish Sanitation Program are described. Division of responsibility between state and federal agencies, and reasons for preferring *E. coli* rather than coliform organisms as a group as an index of pollution, are discussed. The first shellfish-associated epidemic of infectious hepatitis was reported in Sweden in 1955, soon followed by outbreaks in Raritan Bay, N.J. and Pascagoula, Miss. Heavy metals as well as infectious hepatitis are of concern. Depuration is one means of purification, but variations in biological activity of individual bivalves pose problems. Sea clams are also affected, and areas off Sandy Hook, N.J. and off the mouth of Delaware Bay, each with a radius of 9.7 km from the center of ocean dump sites have been closed to harvesting. - J.L.M.

887
Hunt, Daniel A. 1979.

Microbiological standards for shellfish growing waters - Past, present and future utilization. Proc. Natl. Shellf. Assn. 69: 142-146.

It is difficult at best to establish a line in a river, cove, or estuary that will reasonably guarantee that all shellfish below that line will always be safe for consumption. The control agency has two alternatives: 1) to prohibit sale of shellfish which have not been retort-processed or otherwise heat-treated to inactivate pathogens. This would not provide protection against toxic chemicals or marine biotoxins. The other alternative, chosen by the founding fathers of NSSP in 1925, is 2) to maintain sanitary controls which will result in harvesting and marketing of safe shellfish. Shellfish grown in contaminated areas can be harvested and marketed if they are properly relayed or depurated according to NSSP guidelines. Theoretically there should be no viable sewage organisms in "approved" growing areas. In the real world, however, this is an impractical goal. The NSSP standard is as follows: the coliform median MPN does not exceed 70/100 ml, and not more than 10% of samples ordinarily exceed an MPN of 230/100 ml for a 5-tube decimal dilution test in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions. The limitation of the upper 10% at an MPN of 230 made allowance for the variability of the method. Approximately 1/2 of the samples taken from a routine sampling station in an "approved" growing area can exceed a coliform MPN of 70. The most common misinterpretation of the standard is to classify an area as "approved" when a critical investigation shows that the area should be classified as "conditionally approved" because of intermittent sewage treatment plant failure or other adverse conditions. In 1975 FDA proposed Shellfish Safety Regulations that included growing area standards. Strong opposition prevented their acceptance. But court cases have upheld the closures in 1942 and 1977 in New York. The significance of the standard and the concept that the public health interest is served by controlling quality of growing area waters was supported. State agencies could not afford to test every lot of shellfish harvested from their waters for bacterial and viral pathogens. We do not have an acceptable procedure for detection and enumeration of the most significant pathogen, the infectious hepatitis virus. There is not a State program in existence which could offer safe raw shellfish on the basis of lot by lot certification by sampling for pathogens, nor is it economically feasible to examine thousands of water samples for enteric pathogens even on a monthly basis. The validity of NSSP microbiological standards has been challenged throughout the history of the program, and efforts will continue. In view of the increased stress on estuaries, it is unfortunate that this is so. As the courts have stated, the shellfisherman's problem is the encroachment of pollution, not the growing area standard. - J.L.M.

888
Hurst, John W., Jr. 1952.

Quahaug propagation studies in Maine. U.S. Fish Wildl. Serv., 3rd Ann. Conf. Clam Research: 12-14.

In the vicinity of Brunswick, Me. the quahaug population is very limited and good sets are obtained only every 7 to 10 yrs. Experimental hatchery rearing was attempted to examine the feasibility of providing seed artificially. Preliminary studies failed to rear larvae to setting stage. Ions of heavy metals in the water were suspected. Plans were underway to determine why larvae did not survive. The discussion cited several examples of unexplained variations in success in rearing larvae of marine animals which were thought to have been caused by unidentified variations in water quality. - J.L.M.

889
Hurst, John W. 1955.

Oil pollution of shellfish. 5th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Fish Wildl. Serv.: 23-24.

Very small quantities of oil (kerosene) will make quahogs take on oily flavors. Three oil spills in 1953 demonstrated this. - J.L.M.

890
Hurst, John W., Jr. 1974.

Shellfish standards in growing areas. Proc. Natl. Shellf. Assn. 64, 5 p., 4 figs.

Differences between bivalve species and between growing areas with respect to bacterial water standards are emphasized. Illustrations show relation between average shellfish coliform content and average coliform content of surrounding water at 8-17°C, 20-23°C, and less than 8°C. Hard clam was lower than oyster or soft clam at 8-17°, intermediate at low MPNs and lowest at higher MPNs (above ca 70MPN) at 20-23°C, and intermediate at less than 8°C. - J.L.M.

891
Hurst, J., E. Premuzic, and J. Bairdi (sic). 1972.

Studies on the physiology of the molluscan "anti-tumor" substance. In Food-Drugs from the Sea, Proceedings 1972. Leonard R. Worthen (ed.). Mar. Tech. Soc., Washington, D.C.: 231-246.

Mercenaria mercenaria, Spisula solidissima, and other marine invertebrates were examined. Growth-inhibiting substance in clam liver extracts was effective against normal proliferating system in mouse, and to a lesser extent against neoplastic growth. Growth inhibiting substance was similar, if not the same, to the anti-tumor agent reported by others, because both were obtained by the same extraction procedures, O.D. (optical density?) profiles at 280 mμ for Sephadex fractions of extracts were almost identical for all preparations, and anti-tumor activity and growth-inhibiting activity were found in equivalent fractions. The authors, however, were unable to obtain a definite dose response curve for anti-tumor activity of clam liver extracts against Bittner mammary tumor. If the growth inhibiting agent is part of a normal control system, tumor cells which have regressed into embryonic types may no longer be sensitive. It was planned to assay this substance against spontaneous mammary tumor. That the growth inhibiting substance from clam livers is part of a mechanism for regulating normal cell growth is suggested by correlation between seasonal variation of inhibitor and clam body weight. Anti-tumor activity was highest in May, but was not assayed for June and July extracts. This did not agree with findings of others. Patterns of anti-tumor activity with season were correlated roughly with erythropoietic inhibiting activity. Clam larva systems were even more sensitive to small amounts of inhibitor, and might provide a good screening system to select extracts for mammalian assays. Results suggest that mammals possess growth regulatory mechanisms not unlike those of invertebrates, if so, this could be a useful therapeutic tool. - from authors' discussion - J.L.M.

892
Hutchins, Louis W. 1947.

The bases for temperature zonation in geographical distribution. Ecol. Monogr. 17(3): 325-335, ill.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

893
Hutchinson, Roger W., and Jens Knutson. 1978.

Shellfish market review, November 1978. U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Current Economic Analysis S-41: 1-48.

Gives total landings of clams by species 1960-1977, total landings of hard clams by state 1960-1977, supplies and utilization of clams by species and by month 1977-1978, prices by species by month 1974-1978 (exvessel), and prices by species by month 1973-1978. - J.L.M.

894
Hutton, Robert F., Bonnie Eldred, Kenneth D. Woodburn, and Robert M. Ingle. 1956.

The ecology of Boca Ciega Bay with special reference to dredging and filling operations. Fla. State Bd. Conserv., Mar. Lab., Tech. Ser. 17(1), 86 p.

Only 2 specimens of *Mercenaria campechiensis* were taken at 15 stations. The species obviously was not abundant there. - J.L.M.

895
Hyman, Libbie H. 1967.

The Invertebrates. Vol. 6. Mollusca I. McGraw-Hill, New York, 792 p.

List only.

896
Idler, D. R., and U. H. M. Fagerlund. 1955.

Marine sterols I. Isolation of 24-methylenecholesterol from molluscs. J. Am. Chem. Soc. 77(15): 4, 142-144.

According to Thompson (1964) abstracted elsewhere in this bibliography, these authors reported 230 mg total cholesterol per 100 g of clam meats (species not given). - J.L.M.

897
Idler, D. R., and P. Wiseman. 1971.

Sterols of molluscs. Internatl. J. Biochem. 2(11): 516-528.

Seven pelecypod species were investigated, but no member of the family Veneridae. Cholesterol was the major sterol in most pelecypods examined. - J.L.M.

898
Idler, D. R., and P. Wiseman. 1972.

Molluscan sterols: A review. J. Fish. Res. Bd. Canada 29(4): 385-398.

"Chalinasterol" and "ostreasterol" are mentioned as examples of an erroneous identification of a poorly characterized heterogeneous sterol mixture. A new sterol was isolated by Bergmann (1934) from *V. mercenaria*, 2 other pelecypods, and 2 gastropods. He called it "ostreasterol", thinking it was isomeric with stigmasterol. Later he suggested it was identical with "chalinasterol", which had been isolated by others. The sterol was assigned the structure $\Delta^{5,\,22(23)}$-campestadiene-3β-ol, on evidence based solely on resemblance of physical properties. Isolation and identification of 24-methylenecholesterol in the mid-1950s cleared the confusion and proved both sterols were heterogeneous. Thompson (1964 - abstracted elsewhere in this bibliography) found that fats made up 2% of the meat and sterols an average of 0.08% of the meat in *Mercenaria mercenaria*. (Abstracter's note: because the identifications of Bergmann apparently were in error, we did not search for his papers.) - J.L.M.

899
Ingersoll, Ernest. 1887.

The oyster, scallop, clam, mussel and abalone industries. In The fisheries and fishery industries of the United States, by G. Brown Goode and a staff of associates, Sect. V, Vol. II, Pt. XX, U.S. Comm. Fish Fisheries: 507-626 (b)-Fishery for quahaugs: 595-608.

The quahaug *Venus mercenaria* stands next to *Mya arenaria* in commercial importance. The common name is sometimes pronounced quaw'g, and farther east, pooquaw or poquau. Size, shape, and color are described. It is very abundant from Cape Cod to Fla. North of Cape Cod it is relatively rare and local. On the coast of Maine and the Bay of Fundy it occurs in only a few special localities, in small, sheltered bays where the water is shallow and warm. In the southern parts of the Gulf of St. Lawrence, where the water is shallow and much warmer than on the coast of Maine, it again occurs in some abundance, constituting a genuine southern colony with other similar species, surrounded north and south by boreal fauna. Quahaugs are on sandy and muddy flats just below low water mark, and also on oyster beds where these do not form rocky reefs. It spends much of its time crawling about with shell upright and partly exposed, leaving behind a well-plowed furrow. The broad opening of the mantle allows the foot to be extended from any part of the ventral side. Foot and mantle edges are white, siphon tubes yellowish or brownish-orange toward the end, more or less mottled or streaked with dark brown or sometimes with opaque white. Flesh of very old clams loses its white color and becomes a dirty yellow-brown. Young sometimes are present in tremendous numbers. In summer 1870 the shallow sand beach opposite Babylon, Long Island, N.Y. was crowded for 10 miles with young quahaugs from pin-head size to that of a silver 3-cent piece. The succeeding winter was very mild and these clams survived in water only 2 to 4 feet deep. The same season large numbers were deposited at East Point, in Raritan Bay, N.J., where they were so thick that a handful of sand contained a hundred or so. In Sept quahaugs begin to sink from the surface of the bottom to about 2 inches below, where they remain until spring. Harvesting is described in some detail. In Raritan Bay a good day's catch was about 2,400 to 2,800 "count" clams. Clams were taken by hand, or with tongs, rakes, or dredges. Indian uses of quahaugs are described in considerable detail. "Modern" clam bakes also are described. Principal markets were New York and Philadelphia. In the Gulf of St. Lawrence quahaugs were never eaten. Production from

Cape Cod was much reduced. Marthas Vineyard once was bordered by good quahaug ground, but not now. Yields were large in Narragansett Bay and Providence River. Connecticut statistics were scarce, but production was also rather large, and distribution was said to cover a wider area than formerly, although quantity was less. Production is also mentioned at City Island in the East River. Along the north shore of Long Island clams were harvested at Flushing Bay, Little Neck (a few), Roslyn, Glen Cove, and Port Washington. Along the south shore of Long Island was a great supply of clams which were shipped to New York City. In Great South Bay it was asserted that distribution was gradually shifting eastward, the present limit being Brown's Point. A firm in Islip was packing clams and clam chowder in cans. At Amityville one person was planting small clams for later harvest. Production from New York Bay was substantial. Production along the New Jersey coast is described. Chesapeake Bay is described as highly productive, but information was incomplete. Catches were shipped to Baltimore, Norfolk, and Yorktown. In North Carolina not many clams were harvested. Some experiments in bringing clams from Okracoke to Norfolk were attempted, but they were unprofitable. - J.L.M.

900
Ingle, Robert M. 1952.

Studies on the effect of dredging operations upon fish and shellfish. Proc. 5th Ann. Meeting, Gulf Caribb. Fish. Inst.: 106 (abstract).

Shellfishes did not suffer damage when suspended from the dredge itself (presumably in the plume). Larger particles of mud did damage on the bottom in the immediate vicinity of dredging, but did not extend beyond 400 yds, and usually much less. Dredging controlled to take account of local conditions is suggested as the best solution. Damage to fishery resources by dredging is frequently overrated. - J.L.M.

901
Ingle, Robert M., and William K. Whitfield, Jr. 1962.

Oyster and clam culture in Florida. (Revised ed). Fla. State Bd. Conserv., Educ. Ser. 5, 25 p.

The copy received by interlibrary loan from the library of the Marine Research Laboratory, Fla. Dept. Natural Resources agreed in all respects with this citation except authors and title, which is: Oyster Culture in Florida. It was originally issued in 1949 and revised in 1953 and 1962. The text contains no mention of hard clam. - J.L.M.

902
Ingram, William Marcus. 1957.

Handbook of selected biological references on water pollution control, sewage treatment, water treatment. Pub. Health Serv., Biblio. Ser. 8, Pub. 214, U.S. Dept. H.E.W.

Revision of handbook of same title published in 1953. Four main headings are: 1) selected biological references on water treatment; 2) on sewage treatment; 3) on water pollution control; and 4) on organism identification. - From abstract 1571 in Sport Fishery Abstracts 3(2): 77 (1957). - J.L.M.

903
Ingram, William Marcus, and Thaddeus A. Wastler III. 1961.

Estuarine and marine pollution - Selected studies. On biological, bacteriological, and physical aspects, with major emphasis on the United States literature. U.S. Dept. H.E.W., Pub. Health Serv., Div. Water Supply & Poll. Control, Robt. A. Taft Sanit. Eng. Center, Cincinnati, Ohio Tech. Rept. W61-4, iv+30 p.

A useful listing of 264 papers under the headings noted in the subtitle, including two general references. Canadian as well as U.S. titles are included. Most recent dates were 1960, the earliest 1916. Over 80% of the titles were published after the end of the 2nd world war, and over 50% from 1955 to 1960. No title mentions *Mercenaria (Venus)* species directly, but many are pertinent to effects of pollution on shellfishes. An index would have been helpful, especially if it had included key words in the bodies of the papers. - J.L.M.

904
Ino, Takashi. 1972.

Controlled breeding of molluscs. In Coastal Aquaculture in the Indo - Pacific Region. T. V. R. Pillay (ed.). Fishing News (Books) Ltd., London: 260-272.

Methods of inducing spawning of *Mercenaria* are discussed with citations of papers by Loosanoff and others, abstracted elsewhere in this bibliography. - J.L.M.

905
International Commission on Zoological Nomenclature. 1954.

Opinion 195: Designation, under the plenary powers, of a type species for the genus *Venus* Linnaeus, 1758 (Class Pelecypoda) in harmony with accustomed usage. Opin. Decl. 3(14): 191-198. Also in Bull. Zool. Nomencl. 4 (1950): 304-305.

Designates *Venus verrucosa*, an eastern Atlantic form, as the type species of this genus, thus establishing *Venus* as the generic name of the eastern Atlantic forms. - from Wells, Ecology 38(1), 1957 - J.L.M.

906
Interstate Sanitation Commission. 1939.

Report relative to shellfish industry in New York Harbor. Federal Works Agency, Works Projects Admin. for the City of New York, Rept. of official Project No. 465-97-3-131, sponsored by Interstate Sanitation Comm., 264 p.

As a minimum estimate 70,000 acres of tidal waters in the State produce clams in such an abundance as to furnish an industry. A maximum estimate of the value of these clams is $200,000 which gives an estimate of $3 an acre. Thus, clammers, if they owned the ground and planted it with oysters, could reap an income many times greater than they do now. The life-history of *Venus mercenaria* is almost entirely unknown. - J.L.M.

907
Irukayama, K., et al. (other authors not cited). 1962.

Studies on the origin of the causative agent of Minamata disease. 2. Comparison of the mercury compound in the shellfish from Minamata Bay with mercury compounds experimentally accumulated in normal shellfish. Kumamoto Med. J. 15: 1-12 (in English). Also issued as Japan. J. Hyg. 16: 467-475.

Reports experiments on exposure of *Venus japonica* to 0.3 ppm of various inorganic and organic mercury compounds for 4-12 days. Remarkable concentration ability was observed, higher for alkyl mercury compounds than for inorganic compounds. No organic Hg was found in *Venus* exposed to inorganic compounds, which led the authors to conclude that organic Hg must be accumulated directly from seawater. (From Keckes and Miettinen, 1972. In Marine Pollution and Sea Life. Mario Ruivo (ed.). Fishing News (Books) Ltd., London.) - J.L.M.

908
Iversen, E. S. 1968.

Farming the Edge of the Sea. Fishing News (Books) Ltd., London, 301 p.

Distribution, early life history, age and growth of *Mercenaria mercenaria* are described, and techniques and problems of clam farming are discussed. Information was obtained from personal experience and from published papers abstracted elsewhere in this bibliography. As the author has emphasized, this is not a handbook, but a general account of important principles. Economic aspects are not considered. - J.L.M.

909
Jackim, E., G. Morrison, and R. Steele. 1977.

Effects of environmental factors on radiocadmium uptake by four species of marine bivalves. Mar. Biol. 40(4): 303-308.

Experimental animals were *Mya arenaria, Mytilus edulis, Mulinia lateralis,* and *Nucula proxima. Mercenaria mercenaria* is not mentioned. - M.W.S. and J.L.M.

910
Jacobson, Fred L., and John T. Gharrett. 1967.

Joint statement at Conf. on Pollution of Raritan Bay and adjacent Interstate Waters. 3rd Sess., Vol. 2. Fed. Water Pollution Control Admin., U.S. Dept. Interior. Paul DeFalco (ed.): 683-698.

The statement covers fish and wildlife resources of Raritan Bay generally. Commercial shellfish resources included hard and soft clam, and blue crab. About 50% of the project area was considered to be commercial hard clam habitat. Hard clams were present in sand bottom, sticky sand and mud, shell or gravel beds, but not in black mud. Sunlight, water temp, evaporation, rainfall, and winds, all were factors in determining distribution of hard clam resources. History of hard clam production in the Raritan Bay area was one of steadily decreasing harvests as spreading pollution forced closure of beds. As recently as 1958 the annual harvest of *Mercenaria mercenaria* was worth $500,000. In the mid-1960s only a limited area in Sandy Hook Bay remained open to clamming, and the annual harvest was worth only $40,000. New York had plans to transplant contaminated clams to clean waters, which would make available for harvesting a catch worth $750,000 annually. Standing crops were estimated at 3.444 million bushels in N.Y. waters and 1.393 million in N.J. waters of the Bay. At current prices averaging $7/bu the value of this standing crop was estimated to be over $34 million, and under optimum conditions about 550,000 bushels/yr, worth about $3.85 million could be harvested. Current markets could absorb about half of that amount, and proper market development could promote sale of the rest. Similar estimates and figures are given for soft clam, blue crab, and commercial and recreational finfisheries and shellfisheries. - J.L.M.

911
Jacobson, Morris K. 1943.

Marine Mollusca of New York City. Nautilus 56(4): 139-144.

A new list, compiled more than 20 yrs after Jacot's listing, covers much the same geographic area, concentrating on Jacot's stations 4 and 5 on the Rockaway peninsula and adding 2 more stations. Station 6 was just east of the Marine Parkway Bridge on the Rockaway shore of Jamaica Bay, and station 7 at 117 St. near the Yacht Club, where *Odostomia* were found in large numbers. *Venus mercenaria* was not common at stations 4 and 5. *V. mercenaria notata* was identified uncertainly because valves were worn. - J.L.M.

912
Jacot, Arthur. 1920.

On the marine Mollusca of Staten Island, N.Y. Nautilus 33: 111-115.

Collections were made along the southeast shore of Staten Is. Great Kills Bay was formed by a sand-spit dropped by Lower New York Bay waters as they struck the current of the Kills which flow out at this point. At the base of the spit is a small influx of sand where the waters of the Bay have been cutting across recently, and a new fauna was being introduced, which included young of *Venus mercenaria*. Earlier works on Staten Is. mollusks are reviewed, with no mention of *V. mercenaria*. It is concluded that expansion of the city had led to a decrease in marine fauna. - J.L.M.

913
Jacot, Arthur P. 1921.

Some marine molluscan shells of Beaufort and vicinity. J. Elisha Mitchell Sci. Soc. 36: 129-145.

Venus mercenaria Linne is listed as abundant, inside barrier island in mud near surface between tides. *V. campechiensis* is reported as common inside. One specimen of *Venus campechiensis quadrata* Dall was taken, also inside the barrier island. *V. mercenaria notata* was recorded from this area by Coues (1871), abstracted elsewhere in this bibliography. - J.L.M.

914
Jaffe, M. J. 1970.

Acetylcholine: A new plant hormone regulating phytochrome mediated responses in mung bean roots. Plant Physiol. 46 (suppl): 2.

Presence of the hormone in mung beans was demonstrated with standard ventricle assay of *Venus mercenaria*, and analytical procedures. ACh couples photoconversion of phytochrome to various cellular and morphogenic responses. - J.L.M.

915
Jaffe, M. J. 1970.

Evidence for the regulation of phytochrome-mediated processes in bean roots by the neurohumor, acetylcholine. Plant Physiol. 46(6): 768-777.

Mercenaria mercenaria ventricle was used to assay content of acetylcholine (ACh) in seedlings of mung bean, *Phaseolus aureus*. The ventricle was ligated with lengths of cotton thread at auricular junctures and removed surgically. One thread was fastened at the bottom of a perfusion chamber and the other to the end of a lever which operated an electronic strain gauge in circuit with a multiple gain recorder. It was not uncommon for a ventricle to beat regularly for 7 hr after a recovery period of about 1/2 hr. The effect of ACh is to inhibit ventricular beat, and this response is fairly specific for ACh. The ventricle was perfused with 5 μM eserine sulphate, which makes *M. mercenaria* even more sensitive to ACh or benzoquinonium sulphate, which desensitizes it to ACh, as well as atropine sulphate. (Abstracter's note: these are the author's words, which are ambiguous.) The ventricle of *M. mercenaria* proved to be sensitive to authentic ACh and to bean root extracts, and it was very much more sensitive than abdominis rectus muscle of frog. Later, root extract was proven by other methods to contain ACh. - J.L.M.

916
Jaffe, M. J., and Linda Thoma. 1975.

The effects of gibberellic acid and two plant growth retardants on the beat of the clam heart. Comp. Biochem. Physiol. 51C(2): 309-311.

Heart beat of *Mercenaria mercenaria* was inhibited by 25% with 30 μM gibberellic acid (GA), 160 μM N-dimethylamino succinamic acid (B-9), 7 μM (2-chloroethyl) trimethyl-ammonium chloride (CCC), and 2 nM acetylcholine chloride (ACh). CCC is a quaternary ammonium compound, B-9 a tertiary ammonium compound, and GA has no nitrogen. Frequency of beat was more sensitive to most treatments than was amplitude. Whatever the precise mode of action of these compounds, it is probable that they can affect the ACh system in clam ventricle at physiological concentrations. GA probably is a natural product of microflora on which the clam feeds, but clams may also be exposed to runoff from agricultural land, which might subject them to effects from growth retardants. It is interesting that compounds which affect growth and the ACh system in plants are also capable of affecting an animal organ that is sensitive to ACh. - J.L.M.

917
Janoff, Aaron, and Eugenia Hawrylko. 1964.

Lysosomal enzymes in invertebrate leucocytes. J. Cell. Comp. Physiol. 63(3): 267-271.

Lysosomes are subcellular granules or vacuoles delimited by a single membrane and containing a wide spectrum of acid-hydrolases. The study used *Mercenaria mercenaria* and *Asterias forbesi* to find out if lysosomal enzymes exist in amoebocytes of coelomic fluid of invertebrates. In hard clam the mantle-cavity fluid was examined. In leucocytes from 72 clams the following units of enzyme were found per 100 μg of protein: acid-phenolphthalein phosphatase 0.9 ± 0.4, acid RNA-ase 2.0 ± 0.4, beta glucuronidase 9.0 ± 1.6. Acid-phenolphthalein-phosphatase activity was slight, acid-RNAase activity very high, and beta-glucuronidase activity appreciable in quahog leucocytes. Subcellular distribution of enzymes was not finally determined. At least a partial association of hydrolases with the granule fraction of leucocytes was noted. - J.L.M.

918
Jarvis, Norman D. 1943.

Principles and methods in the canning of fishery products. U.S. Fish Wildl. Serv., Research Rept. 7, 366 p.

Venus mercenaria is found from the New England states to the coast of Texas. It is usually found below low tide and does not burrow deeply into the bottom. They are abundant in the southern states and the most productive beds are on the Gulf coast of Florida, in the vicinity of the Everglades. Shells of Florida hard clams are much thicker and heavier, although meats are little, if any, heavier than in the north. Individual clams in the shell in the south may weigh as much as 2 pounds. Quahogs are taken by hand tongs and dredges of the same type used for oysters. They are also taken by "treading". Long-handled rakes are used in some sections of the Atlantic coast, short rakes are used in treading, and ordinary shovels are used at times. From clam beds to cannery is usually not more than a few miles. The canning operation is described. Canned hard clams are often variable in quality. Discoloration and "seaweed" flavor and odor sometimes appear. These defects may be largely overcome by removing the dark body mass when washing the meat, but this adds to the cost of packing and is not often done. Two types of clam chowder are canned, "Manhattan", "Rhode Island", or "Coney Island" chowder; and the "New England" variety. Soft clams or quahogs are used, although quahogs are preferred by some packers, as the clam flavor is stronger. Recipes are given. Burnham and Morrill are credited with establishing the first clam cannery in the United States at Pine Point, Maine in 1878. - J.L.M.

919 Jaume, Miguel L. 1946.

Moluscos marinos litorales del Cabo Catoche, Yucatan, Mexico. Rev. Soc. Malacol. "Carlos de la Torre" 4(3): 95-110.

In Spanish. *Venus campechiensis* is reported from Progreso, Chenkan y Sabancuy. Distribution is from Virginia to Texas. - J.L.M.

920 Jeffries, H. P. 1962.

Environmental characteristics of Raritan Bay, a polluted estuary. Limnol. Oceanogr. 7: 21-31.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

921 Jeffries, Harry Perry. 1967.

Chemical responses by marine organisms to stress. Phase 1. Tech. Rept. No. 1, Grad. School Oceanogr., Narragansett Mar. Lab., Univ. R.I., Kingston, Ref. 67-4: iv+58 p.

Hard clam populations in areas only 9 miles apart had persistent differences in fatty acid composition which did not change after 3 1/2 months of transplantation to a common environment. It was concluded that the difference was genetic, although induction by specific environment was also recognized. - J.L.M.

922 Jeffries, H. Perry. 1968.

Chemical responses by marine organisms to the quality of the environment. In Proc. Ann. North Eastern Reg. Antipoll. Conf., Univ. R.I.: 84-93.

After 3 1/2 months in Narragansett Bay *Mercenaria mercenaria* from Pt. Judith Pond differed in fatty acid composition from clams native to Narragansett Bay. Pt. Judith clams had higher relative concentrations of 14:0 and 16:1 but less 18:0 than those from the Bay. A small, but distinctive qualitative difference also was noted on chromatograms between 20:1 and 18:4 peaks. Another difference was prevalence of short-chain acids (less than C_{12}) in Pt. Judith clams. In a short experiment the next summer, clams from a polluted area in upper Pt. Judith Pond had exceptionally low concentrations of 16:0 between 14.6% and 19.4%, but this appeared to be a peculiarity of the year. Experiments were to be repeated over a longer period. - J.L.M.

923 Jeffries, H. Perry. 1971.

Biochemical ecology of coastal ecosystems. In Abstract Volume, Second National Coastal and Shallow Water Research Conference, sponsored by Geography Programs, Office of Naval Research. University Press, Univ. Southern Calif.: 119.

Free amino acids can be used to show abnormality resulting from pollution. The ratio of taurine to glycine, for example, is at least twice as high in *Mercenaria mercenaria* subjected to hydrocarbon wastes as it is in clams from clean estuarine waters. This appears to be a permanent "biochemical tag" that is not lost when clams are transplanted. - J.L.M.

924
Jeffries, H. Perry. 1972.

A stress syndrome in the hard clam, *Mercenaria mercenaria*. J. Invert. Pathol. 20(3): 242-251.

Hard clam, *Mercenaria mercenaria*, shows a general response to environmental variation and infection. The molar ratio of free taurine to glycine in gill and mantle tissues climbs above 3, while alpha-amino acids and carbohydrates decrease. Subtle adjustments in the total pattern of free amino acids and fatty acids also occur, but these can be readily seen by changes in biochemical diversity and equitability. In an estuary long polluted with hydrocarbons, the clam population had a patchy distribution and a short life-span. These variations were attributed to a culmination of abnormal complications superimposed on natural responses to a seasonally changing environment. The process apparently starts after a tarlike irritant collects in epithelial tissue and eventually plugs the renal sac. This leads, indirectly, to invasion of shells by *Polydora* sp., a polychaete rarely found in hard clams. A syndrome with many facets soon becomes clear, but the situation can be identified and its results predicted by observing responses of taurine and glycine in stressed and normal populations. When the molar ratio of taurine to glycine is less than 3, the population is normal; if it lies between 3 and 5, a chronic stress is indicated; at values greater than 5 the situation is acute. - modified author's abstract - D.L.

925
Jegla, Thomas C., and Michael J. Greenberg. 1968.

Structure of the bivalve rectum. I. Morphology. Veliger 10(3): 253-263.

Mercenaria mercenaria 75 to 125 mm long had rectums with an average diameter of 1400 μ, height of columnar cells and basement membrane 81.4 μ, thickness of the wall 284.5 μ, and ratio epithelium to wall 0.29; *Mercenaria campechiensis* 75 to 150 mm long had rectums with an average diameter of 1270 μ, height of columnar cells and basement membrane 40.7 μ, thickness of the wall 181.5 μ, and ratio epithelium to wall 0.22. Total range of these average measurements in 38 bivalves was diameter of the rectum 5140-64 μ, height of columnar cells and basement membrane 116.0-8.5 μ, thickness of the wall 406.3-8.5 μ, and ratio epithelium to wall 1.0-0.05. Variation was large, but familial similarities in rectal construction were found. - J.L.M.

926
Jegla, Thomas C., and Michael J. Greenberg. 1968.

Structure of the bivalve rectum. II. Notes on cell types and innervation. Veliger 10(4): 314-319.

Probably no peristalsis occurs in the intestine of *Mercenaria mercenaria*, but spontaneous contractions of *in vitro* preparations of rectums have been observed. The histological architecture of the rectum supports the view that conduction in this organ is by way of nerves rather than muscle. Observations of *Mercenaria* rectum show that although longitudinal nerve fibers are present, they are small. There are ganglion cells present. Multiple innervation of muscle cells is not ruled out. The muscle fibers appear to to be smooth muscle having the classical appearance at physiological lengths and oblique or helical bands at excessively short lengths. In relaxed or stretched rectums the muscle fibers are without visible fibrils or have fibrils parallelling the long axis of the fiber, whereas in highly contracted rectums dense bands appear in the fibers which give the appearance of a diamond lattice pattern. The myo-fibrils do not appear to be helically wound around the periphery as they are in the heart, but are dispersed throughout the core of the fiber. - J.L.M.

927
Jensen, Albert C. 1974.

Managing shellfish resources under increasing pollution loads. Proc. Gulf Caribb. Fish. Inst., 26th Ann. Sess., Oct. 1973: 173-180.

In 1972 New York produced more than 52% of national catches of *M. mercenaria*, 8.5 million pounds of meats with landed value of $13.2 million, and 1.1 million pounds of oyster meats at $2.5 million landed value. A total retail value of $150 million is suggested. Most were harvested from about 425,000 acres of bottom controlled by the State. The rest came from bottoms owned by towns or private individuals under Colonial grants made in the 17th century. In 1973 13,000 acres more were closed to shellfishing. One source of pollution is duck farms. Abatement is proceeding but not complete. The population of Suffolk County is growing by 3.3% annually. National growth is less than 1% per yr. Only 7% of the population is served by sewers, thus 93% dispose of wastes into cesspools and septic tanks. Many builders of tract homes construct small sewage treatment plants, which chlorinate and give secondary treatment, then discharge to lagoons or cesspools, to seep into the sandy soil. In Bay Shore Cove, a polluted area closed to shellfishing, it is suspected that most coliform bacteria come from land runoff. Long Island has more than 2,000 recharge basins, which receive much storm water from streets and parking fields in Nassau and Suffolk Counties. The Great South Bay watershed has an estimated population of up to 100,000 dogs which produce about 10 tons of feces per day. Much of this probably washes directly into the Bay during storms. Such runoff often contains very high counts of coliform bacteria, also pesticides and heavy metals. The New York Pure Waters Program has already improved conditions in such places as the Hudson and East Rivers. In many shellfish growing areas pollution is increasing because human population is growing faster than waste water facilities. The State operated a pilot-plant depuration facility for a while, which cleansed clams in 48 hours. No commercial depuration facility for hard clam exists on Long Island, although there is one for soft clam. Transplanting of clams to certified areas is permitted. Depuration period usually is 30 days. To the end of 1973, 168,156 bushels of hard clam had been transplanted. This reduces expense of patrolling closed areas, reduces public health hazards, and makes available a resource that otherwise might be wasted. Other activities of State and local governments encourage industry to make maximum use of clean waters. The population of Suffolk County is expected to double by 2000. This probably will lead to more closures of shellfish grounds. The State will make every effort to minimize adverse effects on shellfisheries. - J.L.M.

928
Jensen, A. C. 1975.

The legal mandate to manage. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 10-15.

Mercenaria mercenaria is not mentioned specifically, but the paper reviews federal and state laws and policies relating to fisheries, including those affecting the hard clam industry in New York. - J.L.M.

929
Jensen, Albert C. 1975.

The economic halo of a red tide. Proc. 1st Internatl. Conf. on toxic dinoflagellate blooms. V. R. LoCicero (ed). Mass. Sci. Technol. Found., Wakefield, Mass.: 508-516.

An unusual red tide developed in September 1972 in coastal waters from Me. to Mass. Traces were found as far south as Cape Cod, whereas usually such blooms have not been observed south of northern Me. Harvest and sale of hard clam, among other mollusks, were banned. Conn. and N.Y. halted import and sale of shellfish from affected states. No evidence of a bloom was seen in N.Y. waters, but the public avoided seafood products, especially hard clam. Wholesalers reported a 25 to 50% decrease in demand for shell- and finfishes, restaurant sales on Long Island were off as much as 50%. Wholesale prices for clams from unaffected areas were down about 25% at Fulton Market in N.Y. City. These reports may have been exaggerated, but the record showed that although clam landings in 1972 had been uniformly higher than average, landings were down substantially in 1973, coincidentally with the bloom farther north. Erroneous reports in the local press probably were responsible for consumer resistance, although scientific surveys in New York waters found no evidence of toxic dinoflagellates. Red tides are reported occasionally in New York waters, but investigations have consistently shown that the causative organisms are harmless. An informational system developed by industry and State and federal agencies responded quickly, and may have prevented more damaging responses. - J.L.M.

930

Jensen, David. 1958.

Some observations on cardiac automatism in certain animals. J. Gen. Physiol. 42(2): 289-302.

Spontaneously beating hearts of *Venus mercenaria* are extraordinarily sensitive to inhibition by very low doses of acetylcholine (ACh) and it was of interest to test ACh for excitatory activity on hypodynamic clam hearts. On 20 spontaneously hypodynamic *Venus* hearts ACh ($1:10^{11}$ to $1:10^{6}$) was completely ineffective in producing or stimulating a beat. Threshold for inhibition in a fresh heart was about $1:10^{10}$. Cocaine and ergonovine maleate were markedly stimulatory. It was considered most surprising that proguanil was able to stimulate molluscan cardiac tissue, which indicates at least superficially basic differences in organization of different tissues, for proguanil inhibits mammalian heart tissue and is antagonistic with ACh in this respect. ACh was only inhibitory on clam hearts, and stimulation by cocaine in presence of ACh inhibition was in direct contrast to experiments on rat heart. It was concluded tentatively that rhythmic activity of myogenic tissues does not depend upon an acetylcholine-cholinesterase mechanism, but upon another biochemical process which may act upon and within cell membranes themselves, perhaps through changes in permeability and ionic transport. Gradual decrease of rhythmic activity in an isolated heart is a type of heart failure. An understanding of stimulatory and pacemaker effects has important medical implications. Research on *Venus* is important because beat is myogenic and the heart is extremely sensitive to ACh. - J.L.M.

931

Jensen, L. D., et al. 1974.

Environmental responses to thermal discharges from the Indian River Station, Indian River, Delaware. Cooling water studies for the Electric Power Research Institute, Dept. Geogr. & Envir. Engin., The Johns Hopkins Univ., Research Project RP-49, Rept. 12: 106-126.

See Jones, Jensen, and Koss (1974). - J.L.M.

932

Jodrey, Louise H. 1953.

Studies on shell formation. III. Measurement of calcium deposition in shell and calcium turnover in mantle tissue using the mantle-shell preparation and Ca^{45}. Biol. Bull. 104(3): 398-407.

Studies were made on *Crassostrea virginica*. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M.

933
Johnson, Alan A. (ed.). 1970.

Water pollution in the Greater New York area. Gordon & Breach, N.Y., xix + 211 p.

The 4 sessions covered Physical Aspects of New York Bight and Estuaries, Chemical Aspects, Biological Aspects, and Engineering Aspects. No significant mention of shellfishes is included. - J.L.M.

934
Johnson, Charles W. 1934.

List of marine mollusca of the Atlantic coast from Labrador to Texas. Proc. Boston Soc. Nat. Hist. 40(1): 1-204.

The Boreal Province extends from northern Nova Scotia to Cape Cod, Mass. (North of that is the Arctic Province, characterized by the southern boundary of floating ice.) The Transatlantic Province extends from the southern shore of Cape Cod to the vicinity of Cape Canaveral, Fla. It can be subdivided further into the Virginian, from Cape Cod to Cape Hatteras, and the Carolinian, Cape Hatteras to Florida. The Transatlantic Province is characterized by the typical American genus *Busycon*, the region in which the oyster can be successfully propagated and in which *Venus mercenaria* abounds. Bathymetric distribution also is important and more complicated. Phylum Mollusca, Class Pelecypoda, Order Teleodesmacea, Family Veneridae, Genus *Venus* Linne 1758, Subgenus *Mercenaria* Schumacher 1817, *Venus mercenaria mercenaria* Linne 1758, Gulf of St. Lawrence to Fla. and Gulf of Mexico. *V. mercenaria notata* Say 1822, Mass. to Fla; *V. mercenaria alba* Dall 1902; *V. mercenaria subradiata* Palmer 1927 (*radiata* Dall, not Dillwyn) - these varieties are locally associated with the typical form. *V. campechiensis campechiensis* Gmelin 1792 (*V. mortoni* of authors), Virginia to Texas; *V. campechiensis alboradiata* Sowerby 1855, Gulf of Mexico; *V. campechiensis subcampechiensis* Palmer 1927 (*quadrata* Dall, not Deshayes); *V. campechiensis texana* Dall 1902, Texas. - J.L.M.

935
Johnson, Paul W., and John McN. Sieburth. 1976.

In situ morphology of nitrifying-like bacteria in aquaculture systems. Appl. Envir. Microbiol. 31(3): 423-432.

Slimes were scraped from surface of substrate, combined with culture waters and enriched cultures, centrifuged, and pellets prepared for thin sectioning. Sections were examined by transmission electron microscopy. Bacteria with the morphology of species of *Nitrosomonas* and *Nitrosococcus* were observed in preparations from marine culture systems for *Mercenaria mercenaria*. The quahaug culture system had the greatest diversity of bacteria with intracytoplasmic membranes. Three to 4 morphological types of bacterium with different arrangements of cytomembrane were present. - J.L.M.

936
Johnson, W. H., and V. P. Thompson. 1970.

The pH mediated aggregation of the large filaments of catch muscles. Biophys. Soc., Progr. and Abstr., 14th. Ann. Meeting: 84a (Abstract WPM-L9).

Large filaments isolated from white adductor muscle of *Venus mercenaria* showed large visible aggregation when pH was lowered from 7.0 to 6.3. Crude muscle homogenates were prepared at ionic strength 0.1 and large filaments isolated in a centrifuge. Actin removal is assisted by centrifugation with "clearing phase" conditions in presence of EGTA. Myosin can be removed from filaments by lowering pH and increasing ionic strength. Phase contrast and electron microscopy showed that ionic strength requirements for aggregation follow the solubility curve for paramyosin, yet large longitudinally oriented aggregates form with myosin present. No Ca ion dependence was found. Gluteraldehyde, as typically used in muscle fixation, dispersed these aggregates. - J.L.M.

937
Johnson, William H., Joseph S. Kahn, and Andrew G. Szent-Gyorgyi. 1959.

Paramyosin and contraction of "catch muscles". Science 130(3368): 160-161.

Isotonic shortening of glycerol-extracted preparations of catch muscles of *Venus mercenaria* and *Mytilus edulis* was inhibited at pHs and ionic strengths at which extracted paramyosin crystallizes. Isometric tension development is scarcely altered under the same conditions. The "catch" mechanism is explained as crystallization of paramyosin, which "freezes" the muscle at any length or in any state, inhibiting shortening and increasing resistance to stretch. It is assumed that actomyosin and paramyosin are at least functionally separated in catch muscles. - modified authors' abstract - J.L.M.

938
Johnston, Richard L., and Albert F. Eble. 1972.

Histology, histochemistry, and biochemistry of the digestive gland of *Mercenaria mercenaria* (Bivalva). Bull. N.J. Acad. Sci. 17(2): 44.

Sections of digestive gland of *M. mercenaria* had ciliated ducts of 2 sizes, a larger main duct and a smaller pre-tubular duct. Smaller ducts ultimately terminated in tubules, where final stages of digestion occur. The transition zone between pretubular duct and tubule was very abrupt; duct cells were eosinophilic, columnar, and had several nucleoli in the spherical nucleus; tubule cells were cuboidal and basophilic, usually with a single prominent nucleolus. Distribution and content of acid phosphatase, x-amylase, and non-specific esterase in the digestive gland also were studied, but not described. - J.L.M.

939
Johnstone, Kathleen Yerger. 1957.

Sea Treasure. A Guide To Shell Collecting. Houghton Mifflin Co., Boston. The Riverside Press, Cambridge, ix+242 p.

Pearls produced by *Mercenaria mercenaria* and some other mollusks are of no value. Purple or white pearls sometimes produced by *M. mercenaria* look like purple and white beads, but have no luster. The name *Mercenaria* came from Indian use of quahogs as money. Indians made "peak", "wampumpeak", "runtees" of 2 kinds, and "pipes". Peak was made from white part of shell, wampumpeak from the purple border. This "famous purple wampum" was twice as valuable as peak. These 2 types were exactly alike except in color. Each piece was shaped like a tube, one inch long or less, and about 1/8 inch in diameter. These were first made around Narragansett Bay and Long Island Sound, and were sometimes called "sewan". Runtees were oval beads drilled lengthwise, or flat round buttons drilled edgewise. Pipes were shaped like peak, but were 2 to 3 inches long and greater in diameter. Eventually, wampum made from *M. mercenaria* replaced other kinds of shell money in the southeast. Shell money was strung, and was measured by cubits, the distance from tip of little finger to elbow. English traders valued wampumpeak at 18 pence/yd and peak at ninepence. When some Dutch and English traders found out how to make counterfeit wampum the market was flooded with it, and shell wampum soon disappeared from trade. - J.L.M.

940
Jones, R. D., L. D. Jensen, and R. W. Koss. 1974.

Benthic invertebrates. In Environmental responses to thermal discharges from the Indian River Station, Indian River, Delaware. Rept. 12 to Electric Power Research Institute, Palo Alto, Calif., EPRI Pub. 74-049-00-3: 106-126.

Mercenaria mercenaria was found in small numbers only in downstream stations, below the discharge canal. It ranked 78 in order of abundance among 97 species or groups of species collected. Details by station are given in appendices C & D, pages 183-196 of the entire report. - J.L.M.

941
Jørgensen, C. C. Barker. 1943.

On the water transport through the gills of bivalves. Acta Physiol. Scand. 5(4): 297-304.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

942
Jørgensen, C. Barker. 1949.

Feeding-rates of sponges, lamellibranchs and ascidians. Nature 163(4154): 912.

The only lamellibranch mentioned is *Mytilus edulis*. - J.L.M.

943
Jørgensen, C. Barker. 1952.

On the relation between water transport and food requirements in some marine filter feeding invertebrates. Biol. Bull. 103(3): 356-363.

Mercenaria (Venus) mercenaria is not mentioned. *Ostrea virginica* and 2 ascidians filtered 10 to 20 liters of water for each ml of O_2 consumed. - M.W.S. and J.L.M.

944
Jørgensen, C. Barker. 1955.

Quantitative aspects of filter feeding in invertebrates. Biol. Rev. 30(4): 391-454.

This paper, although it does not mention *Mercenaria (Venus) mercenaria* specifically, is an extensive review of the literature on filter feeding, mostly published since the review by Yonge (1928). It contains important generalizations that apply to lamellibranchs as a group. Gills of suspension-feeding lamellibranchs propel and filter water. Most investigators have assumed that filtration is performed mainly by latero-frontal cilia of the gill filaments, but MacGinitie stated that during normal feeding water is filtered through sheets of mucus on gill surfaces. A variety of sorting devices, especially on gills, has been developed in different species. Sorting is performed according to size, shape,and density of particles. Qualitative sorting has been demonstrated in oysters. - J.L.M. and M.W.S.

945
Jørgensen, C. Barker. 1960.

Efficiency of particle retention and rate of water transport in undisturbed lamellibranchs. J. Cons. 26(1): 94-116.

Mytilus edulis and *Pecten latiauratus* were the experimental animals. *Venus (Mercenaria) mercenaria* is mentioned only with reference to Rice and Smith (1958) abstracted elsewhere in this bibliography. - M.W.S. and J.L.M.

946
Jørgensen, C. Barker. 1966.

Biology of suspension feeding. Pergamon Press, Oxford, xv+357 p.

In stomachs of veligers of *M. mercenaria* Carriker (1961) did not observe freshly consumed food particles larger than 1-2 μ, but veligers of *O. edulis* seemed to remove flagellates of 2-10 μ more efficiently from water than those of 1-2 μ (Cole 1937). *V. mercenaria* cleared suspensions of a minute green alga and a small diatom at low rates (Rice and Smith 1958); rates of water transport were not measured. In natural surroundings *V. mercenaria* remains open about 90% of the time at suitable temps (Loosanoff 1939). *V. striatula* cleared suspensions of the alga Phaeodactylum at low rates. Rate of water transport by hard clam is largely independent of concentration of particles when only small amounts of suspended matter are present, and also independent of quality of particles with regard to food value. When suspended bentonite concentration varied from 50-1,000 mg/l there was no observable effect on rate of clearance by *Meretrix* (Chiba and Oshima 1957). Water is drawn through interfilamentary slits of bivalves by action of lateral cilia. Particulate matter is retained on the gill, either by directly touching frontal surfaces of filaments, where they are trapped in mucus, or by straining action of large latero-frontal cilia when these are present. Latero-frontal cilia beat towards the frontal surface of filaments, thus throwing particles on frontal ciliary tracts. Intermittent beating of latero-frontal cilia has been observed in *Venus*; resting cilia are stated to form a sieve straining particles from the current passing between filaments, whereas active cilia throw collected particles on to frontal tracts of adjacent filaments (Ansell 1961). Young larvae of *Crassostrea* were able to grow only on a few of the algae tested, whereas larvae of *M. mercenaria* and *Mytilus edulis* utilized most algae provided they were small enough (Loosanoff and Davis 1963). Apparently possession of thick cell walls reduces food value of algae by making cell contents unavailable. Thus *Chlorella* and especially *Stichococcus* often were inferior food as compared with naked flagellates or diatoms. Direct experiments on value of organic detritus as food have been few and difficult to interpret. Loosanoff et al. 1951 obtained only restricted growth in veligers of clam fed on "detritus" from bottom of tidal pools or bottom of a large plankton-culture tank. Growth on a diet of bacteria has been obtained with *Mytilus* (ZoBell and Landon 1937; ZoBell and Feltham 1938). None of 13 species of marine bacteria was found to be of value as food to veligers of *C. virginica* (Davis 1953). Allen (1962) found *Venus* to assimilate 77-95% of ^{32}P- labelled *Nitzschia* cells retained by feeding organs; e.g., 23-5% passed out with pseudo- and true feces. Percent assimilated appeared to decrease with increased concentration of algae in water. - J.L.M.

947
Jørgensen, C. Barker. 1976.

Comparative studies on the function of gills in suspension feeding bivalves with special reference to effects of serotonin. Biol. Bull. 151(2): 331-343.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

948
Jørgensen, C. Barker, and Edward D. Goldberg. 1953.

Particle filtration in some ascidians and lamellibranchs. Biol. Bull. 105(3): 477-489.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

949
Joyce, Edwin A., Jr. 1972.

A partial bibliography of oysters, with annotations. Fla. Dept. Nat. Resources, Mar. Research Lab., St. Petersburg, Spec. Sci. Rept. 34, vi+846 p.

This extensive bibliography of 4117 titles contains 81 references to *Mercenaria mercenaria*, 19 to *M. campechiensis*, 10 to *Mercenaria*, and one each to *M. m. alba*, *M. m. texana*, and *M. meretrix*, 67 to *Venus mercenaria*, 10 to *Venus*, 3 to *V. campechiensis*, 3 to *V. gallina*, 3 to *V. m. mercenaria*, 4 to *V. striatula*, and 1 to *V. verrucosa*, according to the index to taxonomic names issued as a supplement in 1976. Most of these listings are abstracted in Joyce's bibliography, and all are abstracted in the present bibliography. - J.L.M.

950
Judge, John R. 1966.

Inhibition of the effects of leukemogenic viruses in mice by extracts of *Mercenaria mercenaria*. Proc. Soc. Exp. Biol. Med. 123: 299-302.

Ammonium sulphate extracts of *Mercenaria mercenaria* were prepared and partially purified by Sephadex G-25 column chromatography. This extract was tested for inhibition of murine leukemias induced by Moloney and Friend viruses. Mean survival time of mice inoculated with Moloney virus transplantable leukemia was prolonged. Splenomegalic response in mice infected with Friend virus was inhibited, but longevity was not extended. - J.L.M.

951
Jullien, A., and D. Vincent. 1938.

Sur l'action de l'acetylcholine sur le coeur des mollusques. L'antagonisme curare-acetylcholine. Compt. Rend. Acad. Sci., Paris 206(3): 209-211.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

952
Jullien, H., D. Vincent, M. Bouchet, and M. Vuillet. 1938.

Observations sur l'acetylcholine et la choline-esterase du coeur des Mollusques. Ann. Phys. et Phys. Biol. 14: 567-574.

According to Welsh and Slocombe (1952) cholinesterase in small amounts was found by these authors in *Venus mercenaria* heart. Presence of this substance as well as acetylcholine led Welsh and Slocombe to postulate that repetitive stimulation of clam heart released ACh. - J.L.M.

953
Kaas, P. 1937.

Venus mercenaria L., een nieuwe mollusk voor de Nederlandsche Fauna. Basteria 2(4): 58-60.

According to Heppell (1961) a single left valve, fresh enough still to bear remains of the periostracum, was found at Westkapelle-Domburg in Zeeland, Neth. on 14 March 1933. Kaas also mentioned discovery of a living specimen in the sluice basin of Ostend Harbor. This specimen is preserved in the Koninklijk Natuurhistorisch Museum in Brussells. - J.L.M.

954
Kahler, George A., Frank M. Fisher, Jr., and Ronald L. Sass. 1976.

The chemical composition and mechanical properties of the hinge ligament in bivalve molluscs. Biol. Bull. 151(1): 161-181.

Ligament tissue of *Mercenaria mercenaria* is 25.2±1.1% protein, 86.2±7.5% $CaCO_3$, and 0.13% carbohydrate. No lipid was detected. Ratio of $CaCO_3$ to protein was 3.42. Major components of ligament and shell protein are glycine 289.7/1,000, methionine 230.2/1,000, aspartic acid 115/1,000, and proline 102/1,000. Thirteen other amino acids were detected. Principal feature is the high glycine content in the organic phase. Absence of hydroxyproline and hydroxylysine, acid residues diagnostic of collagen, is significant. Alanine, usually an important constituent of structural proteins, is relatively scarce in ligament hydrolyzates. Sulphur-containing amino acids are significant. Elastin and resilin are thought to have rubbery elasticity, but methionine and cystine/2 are characteristically low or absent in these substances, as they are in collagen. Only the aragonite phase of $CaCO_3$ was observed. Resilience is inversely correlated with $CaCO_3$ and cystine/2 concentration. Glycine is correlated directly with resilience. Strength factor (opening moment/g of shell) of *Mercenaria* ligament was intermediate (about 1,000 as compared with over 2,500 for *Mytilus* and about 200 for *Aequipecten*). Recovery of inner ligament from compression probably is mediated by easing of steric strains induced during compression. - J.L.M.

955
Kan-no, Hisashi. 1969.

A note on the study of the spawning season and the culture of the hard clam, *Mercenaria mercenaria*, at Sapelo Island, Georgia in 1968. Unpub. ms. Tohuku Regional Fish. Res. Lab., Shiogama, Miyogi, Prefecture, Japan, 7 p., 3 figs., 4 tables, 11 pls.

Gonads developed rapidly from Feb to April; spawning occurred between mid April and early May as water temp ranged from 19° to 25°C. From May to Sept gonads were absorbed into the body. Mass culture of hard clam was attempted following the methods of Loosanoff and Davis (1963) in May and June. Approximately 30% of mature clams spawned. Survival rate was 31% for May and 4% for June. From May to Dec clams grew to about 5 mm in length. - M.C.

956
Kane, T. E. 1950.

Interview system, Greenwich Bay. Ann. Conf., Clam Investigations, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 20.

Purposes: to estimate removal of quahogs from Greenwich Bay, to estimate seasonal variation in various characters, and to trace utilization of year classes. Results: average daily catch per man 3/4 to 1 1/2 bu/day necks; 1/2 to 2 bu/day large; av. number of men/day about 50 (35-76); av. no. hours/day/man about 5 1/2; most heavily fished areas, southern and western sections; shifts in operations Aug-Oct east to west; total est. catch to date (Aug. 1 - Nov. 11) 4,500 bu necks, 3,600 bu large. Problems: removal of illegal clams reported to be as high as 80% of total, but probably exaggerated; market for necks higher, price $6; large lower in price, no market except to canneries, $2.75/bu. - J.L.M.

957
Kaplan, Eugene H., J. R. Welker, and M. Gayle Kraus. 1974.

Some effects of dredging on populations of macrobenthic organisms. Fish. Bull. 72(2): 445-480.

Populations of epi- and infauna were studied from 10 months before, to 11 months after, a navigation channel was dredged through a small, shallow lagoon on the north fork of Long Island, N.Y. in the Town of Southold. Included was a special survey of the hard clam population, which supports a substantial sport fishery and a small commercial fishery. Less than a year after dredging commercial clammers reported no substantial difference in the size of their catch, which was 4 to 5 bu/day. Apparently release of flocculent and suspended material by dredging caused no mass mortality of clams. Four major clamming areas were sampled before and after dredging. Clams not directly exposed to mechanical disturbance survived the dredging process, even within 400 m of the channel. Considerable reductions in clam populations on the beds later suggests that some mortality-producing factor was at work. Effects of dredging in the channel area itself were obvious. Few clams survived. Average numbers of clams/m^2 in 3 areas were 7.5, 7.8 and 12.1. After dredging these numbers had dropped to 2.9 and 0.3. The third area apparently was not sampled again. - J.L.M.

958
Kaplan, E. H., J. R. Welker, M. G. Kraus, and S. McCourt. 1975.

Some factors affecting the colonization of a dredged channel. Mar. Biol. 32: 193-204.

Mercenaria mercenaria was most common in bottoms with high percentage of silt and organic matter. It was a dominant form at 5 of 15 stations before dredging. About 2 months after dredging two stations had very high biomass, primarily because large *Mercenaria mercenaria* were present. No hard clams had been taken at these stations before dredging. Eleven months after dredging, numbers of organisms and standing crop of all species were significantly lower than before dredging. Current velocities were reduced in most places. Succession did not occur, but colonization began soon after dredging at most stations. - J.L.M.

959
Karas, Nick. 1978.

Clamming & crabbing: A do-it-yourself plan. Leisure. In Newsday, Sunday 3 Sept 1978: 1, 5-6.

Popular accounts of life histories of blue crab and clams in N.Y. waters. Fishing methods and seasons are discussed. Some illustrations are matched with incorrect names, and some scientific names are incorrect. It is not mentioned that blue crab is a voracious predator of clams, including hard clam. A summary of rules and regulations is given. - J.L.M.

960
Karney, Richard C. 1980.

Shellfish propagation on Martha's Vineyard. Natl. Shellf. Assn., Abstracts, Technical Sessions: 3 (abstract).

The program of the Martha's Vineyard Shellfish Group, a consortium of the Shellfish Departments of five Island towns, has concentrated for 4 yrs on nursery-raft culture methods for hatchery-reared seed quahogs, *Mercenaria mercenaria.* Economical, sand-filled wooden trays suspended from floats gave best growth and survival. Over 80% of seed quahogs raft-cultured in 1979, total 480,000, survived. Seed quahogs as small as 2mm have been successfully cultured in rafts. - J.L.M.

961
Kassner, Jeffrey. 1978.

L.I. town has sophisticated management plan for shellfish. Natl. Fisherman 58(9): 5B.

Describes management of the hard clam *(Mercenaria mercenaria)* fishery by the Town of Brookhaven, N.Y. The industry has been expanding at an annual rate of 10 to 15%. In 1976 over 1,400 commercial shellfishing permits were issued, and it was estimated that recreational diggers numbered 2,000. The industry is important to the local economy. A Shellfish Advisory Commission was created in 1976 to manage the Town's 22,000 acres of shellfish beds. Open meetings are held monthly. Goals are to conserve the resource and realize its full economic, social and biological potential. Present and planned activities are to describe the fishery, assess numbers of baymen and recreational clammers using the resource, location of stocks, scientific research to determine optimum sustainable yields, develop programs for conservation and improvement, and compilation of historical data on trends in production, prices, catch, and effort. - J.L.M.

962
Keck, Richard T., Don Maurer, and Henry Lind. 1975.

A comparative study of the hard clam gonad developmental cycle. Biol. Bull. 148(2): 243-258.

Observations made monthly for 34 months in 2 areas of Delaware Bay (near Roosevelt Inlet and at Cape Henlopen) were compared with observations published by Loosanoff (1937) for Long Island Sound and Porter (1964) for N.C., both of which are abstracted elsewhere in this bibliography. Reproductive cycles of male and female *Mercenaria mercenaria* were in phase, and spawning activity in 1971-1973 was adequate to provide ample larval stocks. Partial spawning occurred in Delaware Bay from June to Oct. Peak spawning was in August. Henlopen clams produced more eggs/unit area of gonad section, Roosevelt Inlet clams produced larger eggs, which possibly represented a difference in reproductive potential. Henlopen clams regenerated large numbers of ovocytes rapidly, which slowly increased in size in winter and spring. Roosevelt Inlet clams developed slowly in size and number of ova for a long period. Normal spawning temps in Del. were 25-27°C. Henlopen clams developed similarly to Long Island Sd. clams, but the timetable was about a month earlier (June-Sept vs July-Aug). Roosevelt In. clams showed a pattern different from L.I.S. and N.C. In general, gonadal developmental patterns in Delaware were intermediate between L.I.S. and N.C. Environmental factors were credited with producing subtle differences in reproductive physiology between the 2 localities in Delaware Bay. Hard clams retain a relatively high proportion of glycogen or condition index even after spawning. This allows immediate gonadal redevelopment in fall. - J.L.M.

963
Keck, Richard, Don Maurer, and Robert Malouf. 1974.

Factors influencing the setting behavior of larval hard clams, *Mercenaria mercenaria.* Proc. Natl. Shellf. Assn. 64: 59-67.

The setting preference of hard clam larvae was studied in the laboratory in reference to substratum's particle size, chemical composition, and treatment with pheromones. Larvae preferred setting in sand over setting in mud, and in sediment treated with clam liquor rather than untreated sediment. There was no statistically significant association between setting and sediment size other than the preference for sand over mud. - D.L.

964
Keck, Richard, Les Watling, and Don Maurer. 1972.

Survey of Delaware's hard clam resources - Delaware Bay. 1971-1972 Ann. Rept. to Natl. Mar. Fish. Serv., 103 p.

Covers Delaware waters of Delaware Bay. Hard clam ranges from mouth of Bay to Woodland Beach, Del., about 38 miles up, optimum development is up to about 20 miles from Bay mouth. Only 2 areas in 336 dredge samples yielded more than 6 bu/hr, a marginal commercial density. Clam sizes appeared to be less at lower salinities. In 375 Petersen grab samples only 10 juvenile hard clams were taken. Modal size of all clams was 11.0 to 11.9 cm. No significant correlation was observed between predator abundance and density of clams, but importance of predation on juveniles was noted. Spawning was from June through Sept. Gametogenic activity was low in winter and accelerated in March. Many clams were ripe in April and May. Glycogen content was higher in fall, winter and spring than in summer. In the intertidal area glycogen levels varied much more than in subtidal zone. Laboratory studies showed that higher sets were obtained in sand than in mud and survival was better in sand. Setting was enhanced by treating sediment with clam liquor. It was concluded that hard clam resources in Delaware were not at commercial levels in most places. Small populations were explained by loss of larvae from tidal flushing, unstable bottoms, low nutrient values for phytoplankton, extensive predation, overharvesting, and unknown effects of trace metals. - from authors' summary - J.L.M.

965
Keck, Richard, Don Maurer, William Daisey, and Lee Sterling. 1973.

Hard clam. In Marine Invertebrate Resources. Ann. Rept. 1972-1973. Submitted to Dept. Nat. Resources and Envir. Control Field Sta., College of Marine Stud., Univ. Delaware, Lewes, Del.: 17-32.

Most commercial production of hard clam in Delaware comes from Indian River and Rehoboth Bays. Density of clams in these bays was moderate and had decreased since the 1967 study. Seed clams were reared in the laboratory and held until they reached about 1 mm. They were then transplanted to two locations in Rehoboth Bay. Half were protected from predators with aggregate made by crushing surf clam shells, half were unprotected. Approximately a year later about 7 percent had survived in the protected area, less than 7 percent in the unprotected. Details of a special suction sampler are given. Experiments with hard clam larvae showed that there was no apparent preference for setting on particle sizes ranging from 50 μ to 1 mm. Clams were not capable of selecting between different sizes of sand, but did select sand in preference over silt. Clams also selected natural sediments in preference over identical material from which organic matter and micro-organisms had been removed by heating. Experiments also showed that larvae had a strong preference for sediments that had been treated with clam liquor. (Abstracter's note: this paper is so poorly prepared that I had to puzzle over it for some time to extract these conclusions, and I may not have interpreted everything correctly. I noted also that several citations in the text were not in the list of literature cited. For future reference, these are: Keck et al. 1971, Wilson 1958, Pratt 1953; there also are several errors in dates, and other missing references not specific to hard clam, which I did not bother to include above.) - J.L.M.

966
Keen, A. Myra. 1951.

Outline of a proposed classification of the pelecypod family Veneridae. Min. Conch. Club S. Calif. 113: (pages not given).

Accepts separation of *Mercenaria* from *Venus* as a distinct genus, based on absence of an anterior lateral hinge tooth, and other relationships. Also places these 2 genera in separate sub-families. - from Wells, Ecology 38(1), 1957 - J.L.M.

967
Keen, A. Myra. 1971. (With the assistance of James H. McLean.)

Marine mollusks from Baja California to Peru. 2nd ed. Sea Shells of Tropical West America, Stanford University Press, Stanford, Calif.: xiv+1064.

Genus *Mercenaria* Schumacher, 1817, *Venus* of authors. Hinge with a roughened area under the ligament; sculpture predominantly concentric, with fine radial ribs. 464. *Mercenaria apodema* (Dall, 1902). This resembles the Atlantic *M. campechiensis* (Gmelin, 1791) but is a creamy white, has rounded concentric ribs that are not lamellar, and has a narrower roughened area on the hinge. Length 47 mm; height 43 mm; diameter 28 mm. A single valve was collected nearly a century ago at Panama, and the species has not since been reported in the literature. A complete specimen in the Stanford University collection that matches well the original figure and description was found in the 1940s by Mr. A. Sorensen at Guaymas, Mexico. Unfortunately, this specimen was not taken alive, so that positive proof has yet to be furnished for the occurrence of *Mercenaria* in the Panamic province. - J.L.M.

968
Keen, A. Myra, and Don L. Frizzell. 1939. (Second Printing. 1946.)

Illustrated key to west North American Pelecypod genera. Stanford University Press, Stanford, Calif., 30 p.

Mercenaria is the only representative of the genus. - J.L.M.

969
Keep, Josiah. 1901.

Exotic mollusks in California. Nautilus 14(10): 114-115.

On the Alameda shore of San Francisco Bay several dead valves of *Venus mercenaria* were collected. Living specimens were not found, but it was the author's opinion that live quahogs would be found in deeper water. - J.L.M.

970
Kehr, Robert W., Benjamin S. Levine, C. T. Butterfield, and Arthur P. Miller. 1941.

A report on the public health aspects of clamming in Raritan Bay. Fed. Security Agency, U.S. Public Health Serv., District No. 1, iv+119 p.

The survey was made at request of N.Y. State Conservation Dept. for a ruling

on suitability of the Great Kills-Princess Bay area in Raritan Bay for harvesting market clams. Bacteriological examinations were made of Bay water and hard clam samples. Coliform densities in macerated clam meats were equal to, or exceeded by 1.5 times, coliform density of overlying waters at 10°C and above. During hibernation, below 4°C, coliform densities in clams were low. Between 4 and 10°C clams had about 0.5 to 0.8 of the coliform density of surrounding waters. On the average, 60% of hard clams reaching market would contain 1.3 times the mean coliform content of waters from which they were taken. Estimated coliform densities in clams dug from open (certified) waters of New Jersey and New York in the Raritan Bay area were 130 and 44/100 ml of emulsified clam meats, respectively. Rough estimates, based upon admittedly incomplete data, led to the assumption that few cases of typhoid fever occurred in New York City from eating raw clams dug from certified waters. Estimated incidence of *Eberthella typhosa* in hard clam meats was 6 organisms/1×10^6 coliforms. It was concluded that occasional cases of typhoid fever could develop from eating clams polluted with sewage to the degree present in Raritan Bay. It was pointed out that it is obvious that no line could be drawn on one side of which clams are safe for consumption, and on the other side of which they are unsafe. Any shellfish polluted by coliforms of sewage origin are potentially a source of typhoid, despite absence of traceable outbreaks from such sources. An arbitrary standard was recommended which would reduce estimated total coliform content of annual production of clams to satisfactory level. A reduction of 50% in total coliforms per annual production below those that prevailed at the time in clams from approved waters was judged to be satisfactory. On that basis, a standard of 70 coliforms/100 ml in waters overlying shellfish beds was recommended for harvesting hard clams to be eaten raw. This standard was recognized as a compromise between potential dangers of intestinal infections, and comparative rarity, and perhaps complete absence, of actual infections from shellfish from approved sources. Suggested closed areas in Raritan Bay were illustrated. It was suggested also that allowance should be made for increased coliform counts during periods of high land water discharge. Future studies were suggested, including obtaining basic data in support of different standards winter and summer. It was suggested that 50 coliforms/100 ml when clams are active and 100/100 ml in the hibernation period might be equivalent to a single standard of 70/100 ml.
- J.L.M.

971
Kellogg, J. L. 1892.

A contribution to our knowledge of the morphology of the lamellibranchiate mollusks. Bull. U.S. Fish Comm. 10: 389-436 + plates.

The paper must be read to extract all details that apply to hard clam. Eleven species were examined in detail. Included here are only direct references to *Venus mercenaria.* The brittle shell is almost entirely lime. Position of adductor muscles is marked on the interior by glossy, more or less oval areas, and a line of the same glistening appearance runs from one adductor scar to the other, near and parallel to ventral border of shell. This pallial line folds inward posteriorly, making a deep loop into which siphons can be retracted. Each adductor muscle has 2 kinds of fiber, one darker than the other. The darker is interior to the lighter and is larger. Muscle fibers are striated. Fibers of the darker portion are more compact and firm, and probably supply most of the force required to keep the shell closed. Fibers of the lighter portion are not so closely packed, and can contract more quickly to close the shell. Two pairs of foot-retractor muscles are easily seen in *Venus*, attached to the shell close to adductors and joining the anterior and posterior parts of the foot. The foot occupies the whole ventral surface of the visceral mass, extending slightly backward as well as forward. It is flattened from side to side and the anterior end is ploughshare-shaped and greatly protrusible. It is more or less sharp or heel-like on its ventral surface. The foot is made up of muscle fibers, irregularly distributed vertically and horizontally, leaving everywhere spaces connected with the vascular system. Blood forced into these spaces causes extension of the foot for digging. In the region of the posterior end of the stomach the sexual gland forces its way down between the more scattered foot muscles. Ventral borders of the mantle are fused and connected with gills. Mantle wall is richly supplied with blood spaces.

Mantle edge is relatively greatly thickened and has sensory organs for touch, and in some species for vision. The muscular mantle edge usually has 3 folds longitudinally. A primary fold may become greatly enlarged and develop several secondary folds. Cells of some folds secrete horny cuticle. Tentacles are always present in definite folds. Over the outer surface of the mantle are many gland cells next to the shell which secrete a sticky substance that becomes impregnated with lime and forms new shell layers. Posterior parts of mantle lobes are modified to form separate openings for inflow and outflow of water. In the branchial chamber hang gills. The upper parts of the gills form the floor of the epibranchial chamber, into which water tubes open. The epibranchial chamber opens into the base of the cloacal siphon, which also receives the end of the rectum from above. The lower or branchial siphon opens into the branchial chamber, but at its base there stretches across its whole upper part a membrane, which covers all but the lower part of the base of the branchial siphon. It does not extend straight across from one side to the other, but presents the appearance of a deep notch extending upward. The mouth lies in the median line between the 2 labial palps and just behind anterior adductor muscle. It is not sharply marked off from the oesophagus. Labial palps take food collected upon the gills from their anterior ends and by cilia pass it into the mouth. The oesophagus proceeds nearly vertically upward to the stomach. The stomach is an enlargement of the alimentary canal, placed in the dorsal part of the visceral mass close to its dorsal wall. The liver mass is closely applied to stomach walls, with ducts that open into the stomach at different points. The stomach narrows posteriorly to open into the convoluted intestine. The crystalline style is a diverticulum of the stomach or intestine. The style is evidently a product of secretion of the epithelium of the diverticulum. Its function is unknown. Liver is paired, one half on each side of visceral mass. The greater part of the visceral mass is made up of the generative mass and the liver. Generative mass is a large gland, surrounding the liver, and forming the posterior part of the visceral mass. In *Venus* it penetrates into spaces between the uppermost muscle bundles of the foot. The spermatozoan "head" is elongated and conical. The heart lies in an extensive pericardium, which in *Venus* is a very large cavity. The aortae break up, not into capillaries, but into irregular blood spaces. In the gill filaments blood channels are of more regular size. Blood is colorless and contains many corpuscles. From the ventricle the anterior aorta carries blood forward along the dorsal wall of the visceral mass, over the stomach, then down into the foot. Many branches are given off to liver, sex glands, palps, digestive tract, and foot. In species with a posterior aorta it is distributed to mantle folds, siphons, and posterior adductor. From the irregular sinuses into which arteries empty, blood is collected in larger vessels and carried to the sinus venosus beneath the pericardium. Then it traverses the walls of the nephridia, where waste products are excreted, and on to the gills, then back to the auricles of the heart. Surfaces of the body, particularly those of the mantle, may play a more important part than gills in aerating blood. The nephridium is immediately below the pericardial chamber. Nervous system consists of 3 pairs of ganglia: cerebral, visceral, and pedal. The otocyst is connected with the pedal ganglia. Four gills hang in the branchial chamber, which in *Venus* is extremely large. Gill filaments have a vascular connection with one another at their inner edges. Spaces are left here and there to allow water to enter the water tube of the gill. The great primary folds include about 70 filaments. These folds are sometimes divided into 2 secondary folds. At the primary reentering angle is a partition between lamellae, consisting principally of muscle bundles, between which exists a blood channel. From these channels is sometimes given off a huge blood sinus into the water tube on either side of the partition. A large and active form like *Venus* must require considerable food and sufficient aeration of blood. The narrow gill filaments, not large enough to contain much blood, seem to be specialized for obtaining food. The large blood sinuses may provide for adequate aeration. The paper is profusely illustrated with drawings. - J.L.M.

972
Kellogg, J. L. 1900.

The ciliary mechanisms in the branchial chamber of the Pelecypoda. Science 11( ).

Obviously an erroneous citation. Search terminated. - J.L.M.

973
Kellogg, James L. 1901.

Clam and scallop industries of New York State. Albany. Bull. N.Y. State Museum 8(43): 603-631.

Hard clam supplies have diminished over the past 2 years from Islip and other important clam-producing areas of L.I. Over-harvesting and growth of the oyster industry have probably contributed to the decline. There is a great need for knowledge of hard clam life history. - D.L.

974
Kellogg, James L. 1901.

The clam problem and clam culture. Bull. U.S. Fish Comm. 19: 39-44, 1 chart.

Over the greater part of the New England coast the supply of clams has suddenly diminished to an alarming extent. Areas formerly productive are now barren. Overharvesting is believed to be the reason, and continued attrition makes it unlikely that beds can recover. Demand is increasing and prices rising (large clams were selling in Fulton Market for 6¢ each). An extensive discussion of the history of the clam flats at the mouth of the Essex River, Mass., by the end of the 19th century already virtually unproductive, covers the socio-political problems associated with attempts to rehabilitate the stocks. All attempts failed because people in the industry took the short- rather than the long-range view. Leasing bottoms, with adequate protection of crop from poaching, closed seasons to allow beds to recover, and plantings of young clams are recommended as alternatives for management. (Abstracter's note: the species is not mentioned, not even in the form of a vernacular name that could be used for fairly certain identification. At the time this paper was written, the major commercial clam resource in the area was *Mya arenaria*, with *Mercenaria mercenaria* a poor second.) - J.L.M.

975
Kellogg, James L. 1901.

Observations on the life history of the common clam, *Mya arenaria*. Bull. U.S. Fish Comm. 19: 193-202, 3 figs.

Venus mercenaria is mentioned twice, to say that the foot of *Mya* is of the plowshare-shaped variety found in *Venus* and some other bivalves, and that in young *Venus*, as in *Mya*, the foot is relatively much larger than in the adult, and extends from the anterior side of the visceral mass, just under the mouth, far back on its ventral side. - J.L.M.

976
Kellogg, James L. 1903.

Feeding habits and growth of *Venus mercenaria*. N.Y. State Museum Bull. 71, Zoology 10, Univ. of the State of New York Bull. 296, 27 p. + index + 8 figs.

The paper begins with some pessimistic statements about the impending extinction of hard clams and lobster, which in the light of today's knowledge, were too extreme. *Venus mercenaria* grows most abundantly below low tide, but also is found between tides. The animal lies but a short distance below the surface and feeds by means of siphons extending up to the surface of the bottom. A steady stream of water enters one tube and leaves the other. The margin of the first tube is crowned by short, tactile tentacles. Both shell valves are lined on their inner surfaces by thin, fleshy flaps, the mantle folds, which enclose a large space, the mantle or branchial chamber. This is essentially a closed space, excepting for the siphonal openings. Two large, conspicuous folds, the gills, arising from the side of the body, hang free in the mantle chamber. They perform an important function in addition to aeration of the blood - that of food collection. Just anterior to the gills, and behind the large anterior adductor muscle, are two small folds, the labial palps. The mouth opening is on the median line behind the anterior adductor muscle, hidden from view by the closely applied palps. It is a funnellike entrance to the digestive tract. When gills are removed, the main mass of the body is exposed, made up chiefly of a large colored gland, the digestive gland, and the greatly developed sexual organs. This body is called the visceral mass, to distinguish it from the muscular foot on its ventral surface. In a large clam the foot may be projected two or three inches from the edge of the shell. Its distension is caused by a large quantity of blood pumped from the heart. The foot is an organ of locomotion, and is also used in burrowing. The gill is not a solid flap or fold, but a minute basketlike structure with an outer and inner wall enclosing a space between. The walls are made of extremely fine rods placed side by side, and irregularly fused with each other by secondary lateral growths of tissue. Outer and inner walls of the gill are also held together by partitions between them. The gill is thus basketlike, the walls made up of rods between which are spaces, which put the interior chamber in communication with the mantle space. The rods contain an interior space in which blood flows. Microscopic study shows that the rods are covered on their outer surfaces with innumerable short cilia. Other cilia are present on the rods than those which cause water to enter the gills. These long cilia are arranged in bands which project out laterally between contiguous filaments so as to strain the water which enters the gill, thus preventing all floating matter from entering. The food of the clam is almost instantly cemented together by a sticky mucus, secreted by special glands in the rods or filaments, and the whole mass moves with some velocity toward the free edge of the gill. On this free margin is a groove into which material collected on the faces of the gill is turned. This groove is also lined with ciliated cells, and the whole mass is carried forward toward the palps. The palps are covered on their inner surfaces nearest the mouth with a set of very fine parallel ridges, which are capable of many movements. When their inner faces touch the edges of the gills any material being brought to this region is transferred onto the ridges of the palp. Cilia on the palp carry the matter on across the ridges and finally force it into the mouth. Experiments with grains of carmine show that definite cilia currents exist. All converge at a definite point just above the line of the base of the muscular foot. Material which touches this surface, instead of being taken toward the mouth, is forced in the opposite direction. Clams undisturbed in the bottom may be seen from time to time to discharge a strong jet of water from both siphons. This serves the purpose of removing masses of material which the animal can not use as food. This is not the only means of discharging undesirable material. The mantle is also ciliated. Everything is swept downward toward the free edge of the mantle, falls into a line parallel with the edge, and is then directed backward, but can not be carried out of the incurrent siphon against the stream which is entering. In a little bay beneath the base of the siphon, where it is out of the current, the material is collected. By contraction of the adductor muscles, and the resulting emptying of the mantle chamber, the collected mass is expelled. If much mud is entering large quantities of it must be collected on the gills and be sent forward toward the mouth. If the palps are withdrawn so as not to touch the gills, material will accumulate in the anterior parts of the gill grooves until the masses are so large that they fall off into the space of the mantle chamber below. They would be discharged when the mantle space was emptied. Close examination of the inner faces of the palp shows a narrow strip around its margin which is without ridges. Both of these margins are very densely ciliated. When suspended material falls on the upper margin, it is carried up onto the surface of the ridges and across them to the mouth. Anything which touches the other margin is swept with great rapidity in the other direction, out to the end of the palp, where it accumulates and is finally thrown off into the mantle chamber below. Enough has been said about the food of *Venus* to make it clear that if it were raised on beaches or flats we should not find as rapid a growth as if it were never exposed, for feeding is impossible without water currents. In one experiment in the natural environment several clams 1 3/16 inches long were planted. Six months later they had grown to 1 12/16 inches, or an increase in volume of 222%. Between tide lines, hard clams 1.25 inches long increased 2.5 times or more in volume in half a year. Presence of seaweed interfered with growth of clams by interfering with water movement, but if weeds could be controlled, as in the intertidal zone, artificial culture should be possible. No wandering tendency was observed. Growth in racks above the bottom was not satisfactory. The only enemy observed was *Lunatia* which burrows into the umbo. Nothing appears to place difficulty in the way of artificial culture. The illustrations show the body parts discussed, the paths of ciliary movement, the gills, and the ways in which food and debris are taken into the gills or discarded. - J.L.M.

977
Kellogg, James L. 1905.

Notes on marine food mollusks of Louisiana. Gulf Biol. Sta., Cameron, La., La. State Board Agric. Immigr., Baton Rouge, Bull. 3: 6-43.

This report deals primarily with the oyster resource and industry. In comparing the industry in Louisiana with Long Island Sound it is stated that the Long Island Sound industry has been successful enough to cover the natural clam beds, especially on the south side of Long Island. "A clam-canning concern located here would have been forced out of business by the oystermen if it had not reached down the coast to the Carolina sounds for its supply. Six years ago the owner of this, the largest clam-canning establishment in the country, told the writer that his orders, then amounting to 10,000 quart cans a day, were increasing, and that with the spreading of oyster beds over the clam bottoms, he thought he could see the end of the business on Long Island. The oyster laws of New York made it possible for the selectmen of the various towns on the shore to lease the clam bottoms to oystermen - who will pay a revenue." *Venus mercenaria* was found in abundance on the west shore of the Chandeleur Islands. - J.L.M.

978
Kellogg, James L. 1910.

Shell-Fish Industries. Am. Nature Ser. Group IV. Working With Nature. Henry Holt and Co., New York, xvi+361 p.

Venus mercenaria is given as the best example to illustrate anatomy of the ancestral bivalve. Anatomy and physiology are described in some detail, with illustrations, and with reference to *Ostrea virginica* and other species, as well as hard clam. Most of the book is devoted to a description of oyster culture in Europe, Japan and the coastal areas of the United States. Lesser space is given to *Mya arenaria* and scallops. Chapter 21, p. 321-332, describes the hard clam industry of the Atlantic and Gulf of Mexico coasts. Although it is often found in the intertidal zone, hard clam is most abundant in deeper water, where it is continually submerged. It grows to a depth of at least 50 ft and probably considerably deeper. Abundance had decreased considerably. In 1898 a company which had been marketing 10,000 cans of hard clam daily for years abandoned Great South Bay, Long Island, for North Carolina because the supply in N.Y. virtually failed. Excessive digging had reduced hard clam abundance on most other bottoms. South of Chesapeake Bay, and into the Gulf of Mexico, the stocks were scarcely used. Experiments showed that clams grew better when they were continually submerged than in the intertidal zone. Although it was believed that hard clams migrate laterally, this was not confirmed by observation. Continually submerged, quahaugs 1 1/4 in long at planting increased in volume on one bed 222% in 6 months. On another bed clams 1 3/8 in long increased only 78% in volume. Reduced growth was attributed to reduction in water flow by attached algae. In favorable areas between tide lines 1 1/4-inch clams increased in volume from 155 to 255%. "Little neck" size is reached in a little more than 2 yrs after fertilization. In eelgrass beds, it might take as much as 8 yrs to reach the same size (2 in long). Water currents were important for growth. Hard clams reproduced normally and grew in waters of 1.009 to 1.025 salinity. Natural enemies of adults are few, but young may be vulnerable to predators, especially after setting and before complete burial. The declining quahaug industry could be firmly established and developed by artificial culture. Clammers received as much as $4/bu for littlenecks. On the half shell in a Boston or New York restaurant, prices were $50/bu. Control of harvest in New England usually was in the hands of town selectmen, and management usually was neglected. Artificial production had not been encouraged. The only efforts at conservation had been to declare an occasional closed season. Improved laws and enforcement were needed. Dense aggregations of hard clam, similar to those often observed with soft clam, were not common. Yet quahaugs are hardy, can withstand large changes in salinity and temp, and can endure long exposure to air, even in hot weather. Territory available for culture is more extensive than that for soft clam. Under suitable conditions a planter could plant at least 120 bu of seed clams 1 3/4 in long in early May and by the first of November harvest 600 bu of 2 1/2 in clams. Cost would be $5/bu or less, return about $3/bu. Yields would be less or more depending on characteristics of bottom and environmental conditions. The author believed that possibilities for development of a quahaug industry in the south were promising. - J.L.M.

979

Kelly, C. B. 1956.

Public Health Service research on shellfish bacteriology. Proc. Natl. Shellf. Assn. 46: 21-26.

Rate of accumulation of coliform organisms by quahaugs varies markedly with temp. Relative coliform density and its rate of increase with increasing water pollution were considerably greater at temps above 8°C than below. Larger numbers of coliform organisms were present at water temps between 8 and 17°C than at higher or lower temps. The paper contains information on oysters and soft clams also. At low and moderate temps (below 18°C) density of coliform organisms was greater in soft clam than in quahaug or oyster. Findings are generally applicable to hard clam. - J.L.M.

980

Kelly, C. B. 1965.

Research activities at other Public Health Service shellfish sanitation centers. In Proc. Northwest Shellf. Sanitation Research Planning Conf., U.S. Dept. Health, Educ., Welfare: 54-57.

The ability to accumulate virus was demonstrated with *Mercenaria mercenaria*, and viral polluted clams were depurated within 48 to 96 hrs. Most of the virus was confined to digestive diverticula, and there was no penetration of organic cells. The parallel behaviour of bacteria and virus in the depuration process is reassuring for the success of depuration. - J.L.M.

981

Kendrick-Jones, John, William Lehman, and Andrew G. Szent-Gyorgyi. 1970.

Regulation in molluscan muscles. J. Mol. Biol. 54(2): 313-326.

Factors which regulate contraction of molluscan muscles by interacting with calcium are associated with myosin. Purified myosin preparations from smooth red adductor muscle of *Mercenaria mercenaria* bind calcium with great affinity. ATPase activity of this myosin combined with purified actin requires Ca. Actin-containing thin filaments of these muscles do not bind Ca, and although they activate the ATPase of rabbit myosin this activity is not Ca-dependent. Thin filaments of mollusks, however, combine readily *in vitro* with the relaxing proteins of rabbit, and then behave like rabbit preparations. Components responsible for Ca binding and for Ca dependence of ATPase cannot readily be removed from molluscan myosin and are not obtained from molluscan muscles or actomyosins by procedures successfully applied to rabbit preparations. Tropomyosin does not appear to be necessary for regulation of molluscan actomyosin by Ca. It is likely that in mollusks the Ca-binding component interacts directly with myosin to prevent cross-bridge formation. - modified authors' abstract - J.L.M.

982
Kendrick-Jones, John, Eva M. Szentkiralyi, and Andrew G. Szent-Gyorgyi. 1976.

Regulatory light chains in myosins. J. Mol. Biol. 104(4): 747-775.

Regulatory light chains which bind to desensitized scallop myofibrils with high affinity and restore calcium control were found in *Mercenaria mercenaria* and other molluscan and vertebrate myosins. Although these myosins all have a similar subunit structure and contain about 2 moles of regulatory light chain, only scallop myosin or myofibrils can be desensitized by treatment with EDTA. The regulatory light chains of mollusks restore full calcium binding and also resensitize purified scallop myosin. - J.L.M.

983
Kennedy, Donald. 1958.

Electrical activity of a "primitive" photoreceptor. In Photoreception. Part III. Physiology of Photoreception. Ann. N.Y. Acad. Sci. 74(2): 329-336.

The study was done on crayfish (species not identified). *Venus (Mercenaria) mercenaria* is not mentioned. - M.W.S.

984
Kennedy, Donald. 1960.

Neural photoreceptors in a lamellibranch mollusc. J. Gen. Physiol. 44(2): 277-299.

This paper deals primarily with *Spisula solidissima*, but initially attempts were made also to record impulse activity in siphonal nerves of *Venus mercenaria* and *Mya arenaria*. Photoreceptor elements in these 2 species are scattered through the siphonal wall, and the siphonal nerve and its branches contain numerous afferent fibers from them. Bursts of impulses could be evoked from the entire siphonal nerve or from its peripheral branches when the siphon was illuminated. These impulses were of low amplitude and came from a large number of fibers. They occurred at onset and cessation of stimulus, but there was little sustained activity during prolonged exposure. Fibers mediating this response come from a large number of receptor units, for even fine peripheral branches of the siphonal nerve showed multifiber discharges. On the basis of spike amplitudes the fibers must be much smaller than large motor fibers of the same nerve or the numerous tactile afferents encountered. In *Spisula* no such multifiber discharges were recorded from siphonal nerve or its branches, but single fiber activity showing light responses was encountered when recordings were made from the central end of the pallial nerve near its point of entry into the visceral ganglion. It has been known for a long time that siphons of lamellibranch mollusks contain photoreceptors which stimulate withdrawal of the siphon on illumination or darkening. - J.L.M.

985
Kennedy, V. S., and J. A. Mihursky. 1971.

Upper temperature tolerances of some estuarine bivalves. Chesapeake Sci. 12(4): 193-204.

Mercenaria mercenaria is mentioned, but no original data included. - J.L.M.

986
Kennedy, V. S., and J. A. Mihursky. 1972.

Effects of temperature on the respiratory metabolism of three Chesapeake Bay bivalves. Chesapeake Sci. 13(1): 1-22.

Respiratory rates of *Macoma balthica*, *Mulinia lateralis*, and *Mya arenaria* decreased with increasing size and varied directly with temp from 1° to 30°C. High temps (30°) depressed metabolism of cold-acclimated *Mulinia* and *Mya*. The only mention of *Mercenaria mercenaria* is by reference to another paper, abstracted elsewhere in this bibliography. - M.W.S. and J.L.M.

987
Kennedy, V. S., W. H. Roosenburg, M. Castagna, and J. A. Mihursky. 1974.

Mercenaria mercenaria (Mollusca: Bivalvia): Temperature-time relationships for survival of embryos and larvae. U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Fish. Bull. 72(4): 1160-1166. (essentially the same paper was published under the same title in Mihursky et al. 1974, The thermal requirements and tolerances of key estuarine organisms, *q.v.*).

Cleavage stages, trochophore larvae, and straight-hinge veliger larvae were exposed to 11 different temperatures (17.5-43.1°C) for 8 different time periods (1-360 min). Mortality increased with temperature increase, and at higher temperatures with increase in time exposure. Temperature tolerance increased with age. Cleavage stages were most sensitive to higher temperature, straight-hinge larvae least sensitive. By multiple regression techniques, predictive equations were developed. In discussing results the authors commented that little precise information exists on temperature range for spawning, other than Carriker's observation that in Little Egg Harbor, N.J. hard clams spawn between 22 and 30°C with maximum frequency between 24 and 26°C. - J.L.M.

988
Kennedy, V. S., W. H. Roosenburg, M. Castagna, and J. A. Mihursky. 1974.

Mercenaria mercenaria (Mollusca: Bivalvia): Temperature-time relationships for survival of embryos and larvae. In The Thermal Requirements and Tolerances of Key Estuarine Organisms. J. A. Mihursky et al. Univ. Md., Center for Envir. and Estuar. Research, Prince Frederick, Md., N.R.I. Ref. No. 74-132: 101-124.

This is the manuscript of an almost identical paper published in U.S. Dept. Commerce, NOAA, Fish. Bull. 72(4): 1160-1166. 1974. The abstract reads: To estimate the effects of entrainment of *Mercenaria mercenaria* embryos and larvae in the cooling water systems of steam-electric power plants, we used a thermal gradient apparatus. Cleavage stages, trochophore larvae and straight-hinge veliger larvae were subjected to 11 different temperatures for 8 different time periods. There was a direct relationship of mortality with increased temperature and at higher temperatures, with increased exposure period. As the animals aged, temperature tolerance increased, with cleavage stages most sensitive to higher temperature and straight-hinge larvae least sensitive. Multiple regression analysis of percentage mortality on temperature and time produced estimating equations that allow prediction of percentage mortality under different temperature-time combinations. Entrainment of *M. mercenaria* embryos and larvae in cooling systems of power plants should be as short as possible to keep mortality to a minimum. An original abstract under the listing of the published paper. - J.L.M.

989
Kennish, Michael J. 1976.

Monitoring thermal discharges: A natural method. Underwater Nat. 9(4): 8-11.

Mercenaria mercenaria grows by secreting an increment of calcium carbonate each day, 1 to 150 μ thick, at outer shell margins. Thickness of the band depends on water temperature. Microstructure of the shell therefore shows a daily record of response to environmental variables, especially temperature. At Barnegat Bay, N.J. in 1973, samples of quahog were collected at 31 sites close to and remote from thermal effluent from a power plant. In addition, more than 2,700 healthy clams, 20 to 65 mm high, were collected from several N.J. estuaries, marked, and planted within the influence of the effluent and at a control site, in 1974 and 1975. Live and dead specimens of transplanted clams were collected at intervals during 1974 and 1975. Valves were sectioned, and acetate-peel replicas were made for examination of microstructure. Results showed that *M. mercenaria* is an excellent monitor of thermal discharges. Severe stress is exerted in summer, when water temp is at a max. Daily growth increments are reduced by 10 to 30% within influence of the plume as compared with clams at control sites.

There is a progressive reduction in thickness of daily growth bands from the center of the Bay to the creek in which effluent is discharged. Thermal effects are not evident when water temperatures are lower. In summer the effect is seen in clams within a 1.6 km radius of the discharge creek. Summer growth of transplanted clams was reduced by 60 to 90% after transplantation to the discharge site, as compared with growth in their natural environment. Optimum temperature for growth of *M. mercenaria* is about 20°C. Temperatures at the bottom in the mouth of Oyster Cr. (effluent) ranged from 28 to 34°C. Thermal discharges also occasionally interrupt the daily growth process. Breaks in growth occur suddenly and appear as large V-shaped indentations in outer prismatic shell layer, when rapid changes in water temp occur (as much as 5°C within several hours). Such breaks are followed by extremely thin increments, demonstrating severe physiological shock. These breaks were most frequent in clams close to the effluent and the number per clam decreased sharply in all directions away from the thermal plume. No thermal-shock breaks were found more than 1.6 km away. A large part of the clam population within the affected area monitors every major operational change at the power plant. The effect on the Bay as a whole is minimal, because severe effects are confined to an area with radius about 0.8 km. Hard clam is an economically feasible and practical indicator organism for monitoring effects of thermal discharges and many other environmental variables in the coastal zone. - J.L.M.

990
Kennish, Michael J., and Richard K. Olsson. 1975.

Effects of thermal discharges on the microstructural growth of *Mercenaria mercenaria*. Environmental Geol. 1: 41-64.

Temperature increase has had an effect on *Mercenaria mercenaria* living within the limits of the stressed area. Analysis of growth increments on the valves of 3- and 4-yr olds gave the following conclusions: 1) subdaily, daily, bidaily, tidal (fortnightly), monthly, and annual periodicity growth patterns were reflected; 2) summer growth in areas affected by thermal effluent were lower than in areas unaffected; 3) in *Mercenaria* unaffected by effluent growth was greatest in summer, least in winter; 4) growth was higher in sands than in muds; 5) *Mercenaria* in Barnegat Bay grew most rapidly in the second yr; 6) growth cessation in the Bay corresponded to summer (heat) shocks, winter (freeze) shocks, thermal shocks, major storms, spawning periods, neap tides, and local disturbances of unknown origin; 7) more than 80% of all growth breaks were shock breaks related to periods of temperature stress; 8) thermal-shock breaks were conspicuously developed in, and restricted to, *Mercenaria* subjected to thermal effluent; these breaks accounted for most of the growth breaks at the mouth of Oyster Creek; 9) shutdowns, massive load reductions, and rapid renewal of operations at the generating station correlate exactly with thermal-shock breaks; 10) spawning occurred in June and early July when water temps were rising from 21° to 25°C; 11) spawning breaks were absent for 1971 and 1973 from the microstructure of the clams most strongly affected by thermal effluent; and 12) growth breaks occurred most frequently in old *Mercenaria*. Growth in *Mercenaria* is strongly dependent on environmental factors, and temp is the most important. Quahogs affected by thermal effluent are adversely affected by temp extremes and by temp fluctuations. It is suggested that shutdowns of the nuclear power station be made in fall as far as possible to avoid chance overlap of spawning, and shutdowns or renewals of operations be made over a span of at least a week. More research is needed to determine the effects of substrate and food supply on growth. Also future research should determine whether mortality is related to effluent or is unrelated. - J.L.M.

991
Kerfoot, William B., and S. Andrew Jacobs. 1976.

Cadmium accrual in combined wastewater treatment-aquaculture system. Envir. Sci. Technol. 10(7): 662-667.

Trace amounts of Cd were introduced in isolated links in the sewage/seawater-plankton-shellfish food chain at Woods Hole. The phytoplankton species *Prasinocladus tricornutum*, and a mixture of diatoms dominated by *Phaeodactylum tricornutum* and *Chaetoceros simplex*, increased rapidly in metal concentration until equilibrium was reached, proportional to the concentration introduced. *Mercenaria mercenaria* and *Crassostrea virginica* continually increased in concentration. The algae were the principal source of accumulation in the aquaculture system. Safe levels of Cd for human consumption of shellfishes were calculated from known human body burden and natural accumulation and transfer of Cd from phytoplankton to bivalves. The critical concentration in municipal effluent for culture of plankton as food for clams would be 0.003-0.005 μg/ml. This points up the importance of quality of effluent and dilution seawater for an aquacultural system using nutrients from treated sewage. - J.L.M.

992
Kerkut, G. A., C. B. Sedden, and R. J. Walker. 1966.

The effect of DOPA, α-methyl DOPA and reserpine on the dopamine content of the brain of the snail, *Helix aspersa*. Comp. Biochem. Physiol. 18(4): 921-930.

Dopamine was the only catecholamine found in *Mercenaria mercenaria* cerebral, visceral, and pedal ganglia. Concentration was 22 μg/g wet tissue, which was only 10% of the value reported by Sweeney (1963), abstracted elsewhere in this bibliography. The discrepancy is not explained. - J.L.M.

993
Kerr, N. M. 1970.

Harvesting of marine biological resources by dredging. Proc. Inst. Mar, Eng. Symposium, Ocean Eng. Section, Glasgow: 14-23.

This is an interesting paper, although it does not deal with hard clam harvesting. Essentially it describes development of a hydraulic suction dredge, which has the advantage of continuous dredging, rather than frequent lifts to empty the bag. Considerable effort was devoted to obtaining the best catch per unit time, and to reducing breakage. The paper is liberally illustrated by diagrams, and might be worth study by clam dredgers. - J.L.M.

994
Kerswill, Charles J. 1941.

Some environmental factors limiting growth and distribution of the quahog *Venus mercenaria* L. Ph.D. Thesis, Univ. Toronto, 104 p., 18 fig., 2 appendices. (Also cited under same title and date as a Manuscript Report, Fish. Res. Bd. Canada, Atl. Biol. Sta. 187, 104 p. - this ms rept. was not seen.)

Kellogg (1903) and Belding (1912) did extensive work on rapidly diminishing abundance of hard clam in N.Y. and Mass. Their recommendations apparently were adequate, and no more research was done on quahog for over 20 yrs until resumed in 1935 by Loosanoff. In Canada, quahaug is a warm-water form at the northern limit of its range. It occurs only where seawater temp reaches high levels early in summer. Malpeque Bay is one of the most important centers of production. There the stocks were reduced in 1916 by improperly controlled harvesting and by disease, as oyster was. The Prince Edward Island Biological Station was established in 1930 on the Bideford River near the center of production to develop cultural methods to restore the oyster resource. The Kerswill study began in 1938. Limited funds restricted research to only one outside area, Tatamagouche Bay, N.S., where environmental conditions are much different from Malpeque Bay: tidal range is much greater. Natural habitat of quahaug is Gulf of St. Lawrence to Gulf of Mexico. Its occurrence on the Pacific coast is attributed to accidental planting with eastern oysters. In the northern part of its natural range hard clam is found only in more sheltered and shallow bays and rivers, where its distribution parallels that of American oyster. Distribution is limited to P.E.I. and Northumberland Strait shores of N.B. and N.S. It is now absent from some places where it formerly existed along the north shore of P.E.I. Quahaugs usually live just under the surface of the sea bottom, but sometimes on hard bottom of intertidal zone the dorsal portion of the valves and the ligament are uncovered with substrate. Siphons are very short and project only a few mm beyond the posterior edges of the valves. Large quahogs (6 to 8 cm long) are inactive although they have a powerful foot. If placed on the surface of the sea bottom large quahaugs bury in a short time, but once below the surface there is no horizontal movement. Smaller animals are more active. At 2 to 3 cm long they can travel up to 1 ft horizontally in 2 months in summer. At 5 cm they have a larger foot relative to size of valves and are more active in burrowing, but move little horizontally. All sizes can regain the surface if buried under several inches of bottom in summer. Quahaugs are inactive at low temps. In May 1939 when water temp was 10°C clams left on the surface of the sea bottom did not bury for several days. In midsummer they disappeared from view in less than 1 hr. In Bideford River spawning in 1939 and 1940 was in late June and early July at a bottom temp of 23°C and continued until Sept. In 1939, length of free-swimming period was about 12 days. A single-thread byssus is used for attachment of small clams under 10 mm long. Growth rates in Canada are slow. Five yrs or longer are needed to reach minimum legal length of 1 3/4 in. Clams up to 25 yrs old are found frequently. Commercial fishing is done with rakes from anchored dories or with tongs. In intertidal zone clams are hand picked or taken by treading. Heavy rakes and tongs damage clams, but they can survive considerable damage. An experiment showed that clams with considerable pieces of shell broken away to expose mantle did not survive. When shells were cracked right across, or valve edges chipped without exposing much mantle, breaks were filled in. Growth was studied by notching shells. Fifty were planted in each of 8 beds 4x2 ft from near high water in hard sandy bottom to below low water in a mixture of sand and mud. Some were planted in wire screen boxes sunk in the bottom, but these became clogged with algae and growth was retarded. Growth rings on external shell appear to be reliable indices of age. Lighter colored new shell increased in width during summer. Clams late in summer had a final band of lighter color of about the same width as previous bands. In general, larger clams had narrower bands. Notched clams had lines on shells at the position of the notch, but always fainter than annual lines. Similar indefinite lines were seen between definite check marks, but check marks were always distinguishable, especially at edges of shell. Some shells had so many lines that age reading was difficult, but these made up less than 5% of all clams. Large numbers of rings may have been caused by frequent disturbance by oyster raking. Clams in harder bottom, where they would be less disturbed, did not have such rings. Chief difficulty in reading age from lines was in identifying first season's growth, because shell wore away near the umbo, and because the first-formed shell inturned with increase in size. It was possible to detect the check line produced at the end of the first growing season in most cases when it became clear that the line was much nearer tip of umbo than first expected. A light check line is produced on shell at the time of notching. The most convenient dimension for measuring size of clams was height (greatest distance from umbo to ventral margin), but length and thickness also were measured. Attempts to spawn quahaugs in the laboratory were only partially successful. Quahaugs do not spawn in marked bursts like oysters and mussels, but produce larvae gradually over a long period when water temp is high enough. Thus it is not often possible to follow broods of larvae in nature. In 1939 about 70% of the season's growth was between 13 July and 6 Sept. There was no evidence that salinity limited growth on Bideford River beds. During most of the growing season salinity fluctuations there are usually slight. The same is true for Tatamagouche Bay. Bideford growing season is short. Usually there is no growth before 1 June and little if any after 15 Sept in either of 2 study areas. Growth rate is not controlled by temp alone; other factors are operative. Growing season is limited by min bottom temp of about 10°C. In Bideford River the area suitable for good growth above low water is very small because tidal amplitude averages only 3 ft. Intertidal zone is exposed for long times at low spring tides. In Tatamagouche tidal amplitude is about 8 ft and exposure on low spring tides is much shorter, therefore growth is good over wide areas of the extensive intertidal zone. In Bideford River growth below low water is not influenced by depth up to 10 ft deep. Growth rate is much reduced in eelgrass, and appreciably reduced by eelgrass near but not on the beds. But eelgrass may favor setting of young. Growth rate is proportional to amount of water circulating. Probably the most important factor determining more rapid growth in down river locations than locations near head of tide is the greater circulation. Crowding on the bottom in Bideford River did not influence growth, except in wire containers held above bottom, where fouling interfered. In Bideford River distribution of settled clams was not limited by salinity or temp. Set was found to within a few hundred yards of head of tide. In the laboratory clams survived exposure to low salinity and even fresh water for days at ordinary summer temp. Highest temp recorded at Bideford in 1939 and 1940 in the intertidal zone was 35°C. Clams survived this temp in the laboratory for at least 8 hr in fresh and 25 hr in seawater. Max temp for survival, at temp increments of 1° to 1 1/2°C/hr, was between 39.5 and 40°C. Larger clams were affected by high temp sooner than smaller, but smaller clams were affected by lowered salinity sooner than larger. Clams survived high temp in increased salinity as well as in ordinary seawater. In Tatamagouche Bay distribution of small clams appeared to be determined by location of settlement of larvae. A few occurred just below high water, but abundance increased to a max near half-tide level, and fell off suddenly farther out. No small clams were found out as far as low water. General distribution is limited by temp which must be reached before spawning will occur. In 1938, '39 and '40 spawning in Bideford River did not begin until temp reached at least 23°C, then continued as a gradual process to about 1 Sept. On shores of Tatamagouche Bay exposure is not important in limiting distribution of small quahaugs after setting. No evidence of mortality was seen except by drilling, in collections made to within 100 ft of high water. In Bideford River clams can survive exposure to air in summer for at least 60% of the time, thus inhabiting intertidal zone from low water to above half-tide level, but winter survival is hazardous in any part of the intertidal zone. Presence of eelgrass favors establishment and survival of young clams on very soft bottom following setting. Unusually intense storms in cold weather may kill many clams in the intertidal zone, probably because they are hibernating and cannot regain the surface if buried, or bury if exposed. In warm weather clams can regain the surface if buried to a depth of several inches below normal position, but they are very inactive in horizontal movement. It is improbable that distribution would be influenced by voluntary horizontal movement. In Tatamagouche Bay mortality was very high from drilling by *Polinices heros*, which is the only predator there. No serious losses were seen in Bideford River from drilling, although *P. heros* was present downriver. Disease has been reported frequently. Large numbers died in Malpeque Bay apparently from disease in 1915. In 1940 disease was reported in N.S. and in P.E.I. No disease had been reported in Bideford River and Malpeque Bay since 1915. The disease has not been identified. Growth was slow. In the most favorable places 5 to 6 yrs were required for minimum legal length of 1 3/4 inches. Marked reduction in abundance about 1912 can be attributed to removals in excess of rate of production and growth. Present distribution of quahaugs in Bideford River was limited by scarcity of breeding stock. Planting of medium to large clams (several hundred) in one area led to increased set nearby. Clams mature at early age in Canada. Active spermatozoa form in some in 2nd year and mature ova in third year and older. In experimental studies to test effects of crowding, clams were placed 6 in apart, 2 1/2 in apart, and touching each other. Growth was not affected. Laboratory studies showed that clams would survive for long periods at extremes of temp and salinity greater than found in natural habitat. Clams buried 6 in deep by a storm all died. - J.L.M.

995

Kerswill, C. J. 1941.

The growth of quahogs in Canada. Fish. Res. Bd. Can. Prog. Rep. Atl. 30: 3-4.

Hard clams of Prince Edward Island averaged about 5 mm long after their first season. Spawning occurred when water temperature was about 23°C in July and August. Since growth occurs only when water temperature is above 10°C and water is colder than this after about September 15, the growing period in the first season is short. In Canada it takes 5 to 6 years for clams to reach marketable size of 1 3/4 inches long. Growth was greatest in areas of unobstructed bottom where water can circulate unimpeded. In the intertidal zone, clam growth increased toward low water. - D.L.

996
Kerswill, C. J. 1949.

Effects of water circulation on the growth of quahaugs and oysters. J. Fish. Res. Bd. Canada 7(9): 545-551.

Quahaugs were planted in marked plots, trays or special boxes at various depths below low tide level. They were held in natural environment through growing season, and effects of water circulation were measured by change in shell height. Most differences in growth rate can be interpreted as caused by differences in water circulation. Clams in trays planted on bottom grew appreciably more than those in plots. Differences in water flow were measured with a current meter. Clams planted in plots with heavy growth of eelgrass grew very little as compared with those in clear bottom. Those in light eelgrass had intermediate growth. Clams in suspended trays in vertical series grew more rapidly near the surface of the water than near bottom. Clams grown in special boxes designed to control the amount of water circulation showed the same responses, fast growth with unimpeded flow, slower when circulation was limited. Experimental results were compared against growth of quahaugs on natural beds in the vicinity, one upriver, one down. Ten-year-old clams at the downriver bed averaged nearly 70 mm in shell height. Clams of the same age upriver, where water circulation was less, were about 20 mm smaller. Differences between natural beds might be caused at least partially by salinity and temp differences, but these differences were considered small as compared with water flow. It was suggested that the important effects of water circulation were to alter availability of food, and perhaps cleansing exposed ends of siphons. - J.L.M.

997
Kidder, Gerald M. 1976.

The ribosomal RNA cistrons in clam gametes. Develop. Biol. 49(1): 132-142.

The only reference to *Mercenaria mercenaria* is on the last page, where it is noted that the satellite may be of common occurrence among marine mollusks, since preparative CsCl gradients have indicated its presence in *Mytilus edulis* and *Mercenaria mercenaria*. - J.L.M. and M.W.S.

998
Kinne, O. 1963.

The effects of temperature and salinity on marine and brackish water animals. I. Temperature. Oceanogr. Mar. Biol. Ann. Rev. 1: 301-340.

The effect of temp on growth has been studied in some detail in various aquatic animals. Examples are *Venus mercenaria* (Loosanoff and Nomejko, 1951). In *Venus mercenaria* gametes remain viable until the next season (Loosanoff and Davis 1951). This review paper undoubtedly has other references to *Mercenaria (Venus) mercenaria* without naming the organism specifically. Major headings are temperature and function, temperature and structure, and adaptation to temperature. There is an extensive bibliography. - J.L.M.

999
Kinne, Otto. 1967.

Physiology of estuarine organisms with special reference to salinity and temperature: General aspects. In Estuaries. G. H. Lauff (ed.). Am. Assn. Adv. Sci., Pub. 83, Washington, D.C.: 525-540.

No mention of *Mercenaria (Venus) mercenaria*. - J.L.M.

1000
Kirk, R. G. 1979.

Marine fish and shellfish culture in the member states of the European economic community. Aquaculture 16(2): 95-122.

Work at Conwy has shown that rearing the quahog *(Mercenaria mercenaria)* through to the 10 mm size is relatively easy with a survival rate of about 25%. *M. mercenaria* is relatively slow-growing in north European waters and is very readily attacked by crabs when planted without suitable protection. When soft mud was seeded with 10 mm quahogs under a covering of plastic mesh, growth was good and survival more than 80% over a 2-year growing period. Some measure of protection is essential. - J.L.M.

1001
Kjerfve, Bjorn. 1976.

The Santee-Cooper: A study of estuarine manipulations. In Estuarine Processes. Vol. 1. Uses, Stresses, and Adaptation to the Estuary. Martin Wiley (ed.). Academic Press, New York: 44-56.

In the early 1940s the Santee River, S.C., once the 4th largest river on the U.S. east coast, was diverted into the tidally dominated Cooper River, reducing the Santee discharge substantially. Resultant increase in salinity and other changes created a favorable environment for *Mercenaria mercenaria* and led to a new fishery where one had not existed before. Prior to 1973 no hard clams were taken commercially in the Santee estuary. In 1974-75 almost 31,000 bushels were taken, about 73% of total S.C. landings of hard clam. Other effects of diversion were adverse. For example, shoaling of Charleston Harbor has required an annual dredging expenditure of nearly $5 million. Plans to redivert most of Cooper R. flow to the Santee could destroy a lucrative shellfishery worth $277,000 in landed value and still growing. - J.L.M.

1002
Kjerfve, Bjorn, and J. E. Greer. 1978.

Hydrography of the Santee River during moderate discharge conditions. Estuaries 1 (2): 111-119.

The Santee River, S.C. was diverted into the tidally dominated Cooper River as part of a hydroelectric power project. This created conditions in the Santee estuary favorable to shellfish, but also caused severe shoaling in Charleston Harbor at the mouth of the Cooper River. A rediversion canal is now under construction to alleviate shoaling and dredging problems in the Cooper, but this threatens to destroy an oyster industry which produced 373,295 U.S. bushels in 1976, with landed value of $759,063, and a hard clam industry which produced 19,710 bushels worth $208,686 in 1976. At least 81% of this clam catch came from the Santee. Rediversion is expected to reduce salinity drastically and to increase amounts of fine-grained suspended sediments in the Santee. - J.L.M.

1003
Klashman, L. M., K. H. Walker, and R. T. Dewling. 1969.

Pollution control in the Raritan Bay area. Fed. Water Poll. Control Adm., Hudson-Delaware Basins Off., N.J., CWA 10-3, 35 p.

Could not locate. We have another, same authors, same title. Search terminated. - J.L.M.

1004
Klashman, Lester M., Kenneth H. Walker, and Richard T. Dewling. 1970 (?).

Pollution control in the Raritan Bay area. In Developments in Water Quality Research. Proc. Jerusalem Internatl Conf. on Water Quality and Pollution Research, June 1969: 289-310.

The paper mentions analyses of shellfish meats and clam meats, but nowhere clearly identifies species. Table 3 contains the only mention of a species, "soft-shell clams" *(Mya arenaria)*, but *Mercenaria* may have been included in the category "Others". Salmonellae were isolated from clam meats taken at 14 of 50 sampling stations. Of the 14, 9 had geometric mean total coliform densities greater than 2,400/100 g of clam meat. Geometric mean coliform density in shellfish from the other 5 stations ranged from 180 to 1,200 per 100 g. *Salmonella derby* was the predominant serotype of 13 serotypes identified. Clam meats containing *Salmonella* came from two areas: the northerly sector of the Bay, off Staten Is. to and across the N.Y.-N.J. state line, where coliform counts were highest; and along the state line in an area bounded roughly by Great Kills, Staten Is., and Keyport and Keansburg, N.J. Shellfish samples also contained high phenol and mineral oil concentrations at several stations, and traces of Cu, Cr, Zn, Pb, and pesticides. Recommendations are made for pollution abatement. - J.L.M.

1005
Kobayashi, Naomasa. 1971.

Fertilized sea urchin eggs as an indicatory material for marine pollution bioassay, preliminary experiments. Publ. Seto Mar. Biol. Lab. 18(6): 379-406 (Article 26).

Mercenaria mercenaria is not mentioned. The paper is an interesting example of use of sea urchin developmental stages as indicators of water pollution. - J.L.M.

1006
Kobayashi, Shinjiro. 1964.

Studies on shell formation. X. A study of the proteins of the extrapallial fluid in some molluscan species. Biol. Bull. 126(3): 414-422.

Fourteen species, including *Mercenaria mercenaria*, were used. Extrapallial fluid of *M. mercenaria* appeared to have 4 protein fractions, but they could not be clearly resolved. Blood also had 4 protein fractions, but there were differences in migration velocity between blood and extrapallial fluid. The general conclusion was that extrapallial fluid of species with a calcite shell contains a single protein fraction, whereas species with an aragonite shell or calcite and aragonite *(Modiolus)* have 3 or more protein fractions. - J.L.M.

1007
Koff, Raymond S., and Lorna J. D. Connelly. 1975.

Failure to detect hepatitis B surface antigen (HB_SAg) in certified shellfish in New England. Gastroenterology 68(4), Pt. 2 of 2: A-222/1079 (abstract).

The major known viral hazard from eating bivalve mollusks is hepatitis A. HB_SAg was detected recently in clams from a polluted bed contaminated with untreated sewage in Maine. Tests were made on clams from the open market in Boston. Samples were taken at 3-4 month intervals from clams harvested on certified beds in Mass. HB_SAg was not detected. It is not likely that mollusks contaminated with hepatitis B would differ as vehicles of infection from hepatitis A contaminated clams, but no epidemiological evidence linked shellfish ingestion with hepatitis B. - J.L.M.

1008
Koff, Raymond S., George F. Grady, Thomas C. Chalmers, James W. Mosley, Betsy Lee Swartz, and the Boston Inter-Hospital Liver Group. 1967.

Viral hepatitis in a group of Boston hospitals. III. Importance of exposure to shellfish in a nonepidemic period. New England J. Med. 276(13): 703-710.

During a period of declining incidence of hepatitis, 270 adult patients with viral hepatitis and an equal number of matched control patients were interviewed. The 70 patients with hepatitis after transfusion and 15 who admitted narcotic addiction had no other potential exposures more frequently than their controls. The remaining 185 patients had often been exposed to jaundiced persons or patients known to have hepatitis, compared to controls, but a number of less obvious potential exposures occurred so frequently in patients with hepatitis, compared to controls, that these were thought to be significant sources of nonepidemic hepatitis. These included contact with acutely ill but not jaundiced young children, ingestion of raw clams and oysters, out-of-state travel, and tissue penetrations by physicians. Ingestion of steamed clams was also significantly more common in the hepatitis group, suggesting a causal relation between ingestion of cooked shellfish and hepatitis. Ingestion of raw shellfish and steamed clams seemed to be as common a source of infection as contact with jaundiced persons. Raw shellfish consumption was reported by 34 patients with hepatitis, and only by 10 controls, among 185 of each group; raw clams were reported by 25 patients, only 8 controls; raw oysters by 12 patients, only 3 controls; steamed clams by 13 patients, only 2 controls. Results were statistically significant at P=0.05 or better. Eating of fried clams was reported by 24 hepatitis patients and 30 controls; the difference was not statistically significant. This last result was explained by the fact that fried clams are often *Spisula*, which comes from offshore waters, less polluted, and that in addition such clams may be sterilized by cooking. Steamed clams are usually *Mya*, and it is common to consider them done when valves gape, which does not necessarily allow time for sterilization. Clams eaten raw are usually *Mercenaria mercenaria*. - J.L.M.

1009
Kohn, Alan J. 1964.

Mollusks. Science 145: 518-519.

At the symposium on Mollusca held at the Zoological Society of London, 4-5 March 1964, A. Ansell described seasonal biochemical changes in *Venus mercenaria* and noted that successful reproduction in British waters occurred only at Southampton. Suitable water temperatures for spawning, above 18°C, occur at Southampton. The seawater is warmed by industrial cooling systems. - W.J.B.

1010
Kominz, D. R., F. Saad, and K. Laki. 1957.

Vertebrate and invertebrate tropomyosins. Nature 179(4552): 206-207.

Tropomyosins, proteins found widely in vertebrate and invertebrate muscles, all have sedimentation constants falling along the same line and extrapolating to an $S_{20},w(c=0)$ of about 3.0. Lysine-arginine distribution and total anionic charge of a given tropomyosin can be correlated with the phylum to which the animal belongs. An apparent exception to these regularities was found when squid tropomyosin was compared with tropomyosin found to be abundant in smooth-muscle adductor of *Venus*. The clam had a low net charge and inversion of its lysine and arginine values. Ammonium sulphate fractionation of clam tropomyosin yielded a main fraction (about 80%) precipitating between 28 and 40% saturation, called tropomyosin A, and a second fraction precipitating between 45 and 65% saturation, called tropomyosin B. Tropomyosin B had the same lysine and arginine values as squid tropomyosin, and approximately the same charge. This apparently was the first time that 2 tropomyosins had been isolated from a single muscle. Abundance of tropomyosin A, and the small amount of myosin that can be isolated from clam muscle, suggest that tropomyosin A is part of the contractile system in clam adductor muscle. Detailed accounts were to be published later. - J.L.M.

1011
Kominz, D. R., F. Saad, and K. Laki. 1957.

Chemical characteristics of annelid, mollusc, and arthropod tropomyosins. Conf. Chem. Musc. Contraction, Tokyo, Igaku Shoin Ltd.: 66-76.

Venus mercenaria was among the mollusks studied. Tropomyosin B, corresponding to vertebrate tropomyosin, was present in mollusks and arthropods. Tropomyosin A was present in annelids, pelecypods, and gastropods. All tropomyosins followed the same sedimentation-concentration curve. The sum of the arginine and lysine residues was always about 140, and the lysine/arginine ratio was characteristic of the type of tropomyosin; in *Venus* 78/67. Tropomyosin A appeared to be a subunit in the labile pelecypod myosin molecule, reinforcing evidence that a tropomyosin subunit is present in the stable vertebrate myosin molecule. - from authors' summary - J.L.M.

1012
Kominz, D. R., F. Saad, J. A. Gladner, and K. Laki. 1957.

Mammalian tropomyosins. Arch. Biochem. Biophys. 70(1): 16-28.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1013
Koppenheffer, Tom L., and Kenneth R. H. Read. 1969.

The adductor muscle myoglobins of the bivalve mollusc *Mercenaria mercenaria* L. Comp. Biochem. Physiol. 31: 829-832.

The adductor muscle myoglobin of *Mercenaria mercenaria* has an apparent molecular weight of 17,400. It consists of 2 major components, Mb-1 and Mb-2, which are separable by ion exchange chromatography and disc gel electrophoresis. - J.L.M.

1014
Korringa, P. 1947.

Relations between the moon and periodicity in the breeding of marine animals. Ecol. Monogr. 17(3): 349-381.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1015
Korringa, P. 1968.

The basic principles of shellfish farming on the continental coast of Europe. In Proc. Symp. Mollusca, Pt. III. Mar. Biol. Assn. India, Mandapam Camp: 818-823.

This paper deals with oysters and mussels. The principles reviewed would apply generally to *Mercenaria*. - J.L.M.

1016
Korringa, P. 1976.

Farming the cupped oysters of the genus *Crassostrea*. Elsevier Sci. Pub. Co., Amsterdam-Oxford-New York, ix+224 p.

Chapter 2, which deals primarily with oyster farming in Long Island Sound by the Bloom Brothers Oyster Company, contains a brief description of the Company's hard clam operations. All oyster companies in Long Island Sound harvest some hard clams. It was estimated that Long Island Oyster Farms Inc. earned 5% of its income from *Mercenaria mercenaria*, Bloom Oyster Co. 66%, Radel Oyster Co. 25%, Frank Flower and Sons 50%, Shellfish Inc. 90%, and Bluepoints Co. 99%. Hard clams cannot be harvested with a normal oyster dredge, but require a special hydraulic clam dredge. The Bloom Co. clam dredge has a narrow blade, 6-inch teeth, and uses jets of water to soften the bottom in front of the teeth. The bag holds 10 to 15 bushels. The peak season for clams is June to August inclusive, which is the off season for oysters. Because clams live in the bottom, and are less densely distributed than oysters, they are somewhat more difficult to harvest, but Bloom Co. can take 25 to 35 bu/hr and lands about 75 bu of littlenecks/day. In clam season over 90% of vessel time is devoted to clamming. Most of the clam industry harvests from natural beds, but the Company has grounds in polluted waters in Norwalk Harbor, Conn., from which it transplants up to 700 bu/day to clean waters near Darien. After a month's depuration period, clams can be harvested for market. Some efforts have been made to produce clams in hatcheries, but young are extremely vulnerable to predation, and survival rates are very low. Rational exploitation and protection of natural clam beds appear to be the most promising procedure. Prices of clams have risen considerably in the last 10 yrs, from $19/bu for littlenecks to $30/bu (yrs not specified). Cherrystones sold for $22/bu in 1972. Bloom Co. sells mostly littlenecks. They produced about 20,000 bu/yr in 1970 and 1971. - J.L.M.

1017
Korringa, P. 1976.

Farming marine organisms low in the food chain. Developments in aquaculture and fisheries science, 1. Elsevier Sci. Pub. Co., Amsterdam, xv + 264 p.

This book deals principally with seaweed and mussel farming. *Mercenaria mercenaria* is mentioned only once, to say that farming systems have been tried in England and on the Atlantic coast of the United States using seed produced in hatcheries but it is still too early to speak of commercial success. Chapter 9 describes farming (or more accurately semi-farming) of little neck clams, *Venerupis decussata*. - J.L.M.

1018
Koshtoyants, Ch. S., and J. Salánki. 1958.

On the physiological principles underlying the periodical activity of *Anodonta*. Acta Biol. Acad. Sci. Hung. 8: 361-366.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1019
Kowalevsky, A. 1889.

Ein beitrag sur kenntnis der exkretionsorgane. Biol. Zentr. 9: 65-76.

According to Martin and Harrison (1966), abstracted elsewhere in this bibliography, when a mixture of indigo sulfonate and carmine was injected into *Venus* and other mollusks it was separated into its components, indigo sulfonate accumulating in organs of Bojanus, carmine in pericardial glands. Uptake of indigo sulfonate by organs of Bojanus after physiological injection indicates that secretion occurs there. Reabsorption of materials from urine is considered to take place here also. (This paper was not seen by us.) - J.L.M.

1020
Kraeuter, John N., and Michael Castagna. 1978.

An analysis of gravel, pens, crab traps and current baffles as protection for juvenile hard clams *(Mercenaria mercenaria)*. Proc. Eighth Ann. Meeting, World Maric. Soc: 581-592.

The Wells-Glancy method is the simplest and appears to be one of the most cost effective means of raising bivalve larvae to the setting stage. After metamorphosis newly set hard clams are placed in flowing seawater tables for growth to 2 mm, the size required for planting. Gravel and baffles were highly significant, and the interaction effect between baffles and gravel was greater than either variable effect alone. Survival based on BxG interaction data was between 10% and 22% through September. There was no survival when gravel was absent. When baffles were absent but gravel was present survival was 1 to 3%. In the 11 month period (Oct-Sept) growth was 17 mm or 1.5 mm/month. Protection by a combination of gravel and baffles was statistically superior to any of the individual or combined effects of the four variables for the first 11 months. - J.L.M.

1021
Krahl, Vernon E., and Melvin H. Bulmash. 1969.

Studies on living ciliated epithelium. Am. Rev. Respir. Disease 99(5): 711-718.

Cinemicrography of gill epithelium of *Venus mercenaria*, with or without vital staining of mucus-secreting cells, was used to study ciliary water currents, ciliary motion, and rate of ciliary beating under normal and experimental conditions. Lidocaine, pontocaine, atropine and isoproterenol were cilio-inhibitory to various degrees, and in some cases eventually ciliostatic. Pontocaine halted ciliary activity and destroyed many epithelial cells. Tobacco smoke dissolved or suspended in seawater produced reversible ciliostasis. - modified authors' summary - J.L.M.

1022
Kranz, Peter M. 1974.

The anastrophic burial of bivalves and its paleoecological signifiance. J. Geol. 82: 237-265.

Mercenaria mercenaria belongs to a group of shallow-burying siphonate suspension feeders, which are strong, moderately rapid to rapid burrowers, generally able to escape 15-50 cm of burial in their native sediment. The short siphons restrict it to a zone near the sediment-water interface. They face the constant problem of disinterment by water currents, but can cope because they have evolved extensive mantle fusion. This not only confines and directs the water jet, but also strengthens it. *M. mercenaria* is among the groups of bivalve mollusks least affected by radical changes in sediment type (e.g., burial in sediment different from native sediment), but in general radical change from the native sediment type will significantly reduce escape ability. Larger clams are better able to escape burial than smaller. Limited available evidence suggests that changes in temperature, salinity, and oxygen affect escape ability only at extreme ends of tolerance range of mollusks. Rapid burrowing bivalves usually also escape rapidly. *M. mercenaria* 6.8 cm long on the average burrowed at 43.7 cm/hr, the 10th most rapid of 24 species examined. The type of foot is highly correlated with escape potential. The foot of *M. mercenaria* is extremely flexible and operates largely by fluid pressure. Escape burrowing is triggered by being cut off from the overlying water. Some shell rotation may accompany the pushing of the foot and ejection of water by the siphon, to allow the clam to escape vertically. *M. mercenaria* can escape between 10 and 50 cm of native sediment, but if material in sedimentation is radically different from native, escapement potential may be reduced. - J.L.M.

1023
Kraus, Muriel Gayle. 1971.

The colonization of a dredged channel in Goose Creek, Long Island. A thesis submitted to the Department of Biology of Hofstra University in partial fulfillment of the requirements for the Degree of Master of Arts, vi + 76 p.

From April to June 1967 a channel was dug 75 ft wide, 7 ft deep, and 2,700 ft long from the inlet down the center of the Bay. Fifteen stations along center of channel were sampled in March 1967, before dredging began, and in August and October 1967 and April and June 1968. *Mercenaria mercenaria* was most common in substrates with a high percentage of silt and organic matter but also containing shell. The species was dominant at most stations in the middle of the transect before dredging. In April 1968 stations B and G, in or near the inlet, had very high biomass of large hard clams, probably washed in by dredging. Hard clams were absent at these stations in June 1968. Hard clams or hard clam shells were found at almost all stations. - J.L.M.

1024

Krause, A. K. 1902.

Invest. of habits and life history of *Venus mercenaria*. Annual Rept. of Comm. of Inland Fisheries of Rhode Island - 1902.

List only.

1025

Krause, A. K. 1903.

Preliminary report on the habits and life-history of the quahaug-*(Venus mercenaria)*. R.I. Commrs. Inland Fish., 23rd. Ann. Rept., Providence: 50-54, fig. 19.

Notes conflicts in opinion among fishermen, and absence of satisfactory answers in the literature. Quahaugs were present in all parts of the Bay (presumably Narragansett Bay), from intertidal zone to considerable depths. Small quahaugs were very abundant in Mill Cove, Wickford. They were most numerous in immediate vicinity of stones, clumps of seaweed and eelgrass, large shells, and other objects. In intertidal zone in cold weather many come to the surface. In Mill Cove 425 clams were dug within a 3-ft radius. Six quahaugs dug on 20 Aug 1902 were 15 to 23.5 mm from hinge to edge of shell, 16 to 27 mm long, and 8 to 13.5 mm thick. Replanted and dug again on 5 Sept and 20 Sept these clams had increased to 19-24.5 mm and 18.5-26 mm hinge to lip, respectively, 19.5-28 mm and 20-30 mm long, and 9.5-14 mm and 12-14.5 mm thick. Average growth was 3.75 mm in length from 20 Aug to 26 Sept. Clams notched at edge of shell and planted in a box of sand on 10 Sept grew an average of 2 mm hinge to lip by 16 Oct in intertidal zone. Clams planted in natural conditions on 16 Oct and remeasured on 19 January 1903 grew only 1 mm on the average, which was interpreted as demonstrating slower growth in winter. It was recognized, however, that depth of water and kind of substrate might also be responsible for differences in growth. - J.L.M.

1026

Krause, Sonja, and Donald E. Delaney. 1974.

Transient electric birefringence of paramyosin in solution. Fed. Proc. 33(5), Pt. 2: 1521 (abstract 1683).

Transient electric birefringence data, using square voltage pulses, were obtained in aqueous solutions of *Mercenaria mercenaria* paramyosin at concentration near 1 mg/ml, pH 3 to 10, and at very low buffer concentrations. Deductions are made about physical structure of paramyosin molecule. - J.L.M.

1027

Kraybill, Herman F. 1964.

Use of chemicals on or near shellfish growing areas - - The Public Health Service viewpoint. Proc. 5th. Natl. Shellf. Sanitation Workshop, U.S. Dept. Health, Educ., Welfare: 226-230.

A one-year sampling analysis study was made in Rhode Island to determine movement, uptake, and retention of DDT in shellfish during a community spraying operation for mosquito control. Thirty-seven samples of *Mercenaria mercenaria* were examined. DDT levels were below the FDA residue tolerance of 7 ppm on fresh fruits and vegetables. However, one needs to assess pesticide levels in terms of the additive level of total intake of other foods containing insecticides. - J.L.M.

1028
Krijgsman, B. J., and G. A. Divaris. 1955.

Contractile and pacemaker mechanisms of the heart of molluscs. Biol. Rev. 30(1): 1-39.

This valuable review paper makes numerous references to *Venus* but does not give the species. The heart mechanism of mollusks is by no means completely understood, but conclusions can be drawn. The systolic mechanism is situated in muscle fibers of heart wall. These muscles are powerful enough to propel blood through the system, in which capillaries often present considerable resistance. The mechanism of diastole is related to hydrodynamic conditions in pericardial cavity. Contraction of ventricle creates suction, which, through the pericardial fluid, expands the auricles. The pacemaker mechanism is myogenic and diffuse. The basis of myogènic automatism is chemoreception of muscle fibers. Chemical stimulus to heart muscle probably is provided by a metabolite produced by the beating heart. Stretching muscles lowers the threshold for this metabolite. Antagonism between mono- and divalent cations in their action on heart has been demonstrated. The pacemaker system is influenced by extrinsic regulatory nerves: inhibitory fibers which probably are cholinergic, and accelerating fibers which may be adrenergic. Atropine, ergotamine and possibly also eserine act differently on molluscan heart than on hearts of vertebrates. These compounds therefore are not suitable for investigating the contingent neurohumors of molluscan heart. - J.L.M.

1029
Krishnaswamy, S., J. E. G. Raymont, and J. Tundisi. 1967.

Succinic dehydrogenase activity in marine animals. Internatl. Rev. Ges. Hydrobiol. 52(3): 447-451.

The succinic dehydrogenase complex is an integral part of metabolic oxidative mechanisms in many animals. It has a key role in terminal oxidation of carbohydrates, fats, and amino acids. Its occurrence in marine species had so far received little attention. Porifera, Coelenterata, Mollusca, and Crustacea from southern English waters were studied. *Venus mercenaria* gill tissue had a mean activity of 7.50 μg/mg/24 hr, with a range of 5.80 to 12.00. This activity was much higher than that of *Cardium* or *Mytilus*, or *Carcinus*, in fact it was higher than that of any other animal studied. The activity was inhibited by sodium malonate, which suggested possible existence of the tricarboxylic acid cycle. - J.L.M.

1030
Kritchevsky, David, and Shirley A. Tepper. 1961.

The free and ester sterol content of various foodstuffs. J. Nutrition 74(4): 441-444.

According to Thompson (1964), abstracted elsewhere in this bibliography, these authors reported 122 mg/100 g total cholesterol in clam meats (species not given). - J.L.M.

1031
Krug, Glenn, Jeffrey Lindenbaum, and Yu Chen Lin. 1972.

The effect of mercenene on the in vitro glucose utilization in Krebs-2 carcinoma cells. Proc. Pa. Acad. Sci. 46: 18 (abstract).

Respiration and glycolysis were used to study utilization of glucose by Krebs-2 carcinoma cells in presence and absence of mercenene (crude aqueous extract of *Mercenaria mercenaria*). No results are given. - J.L.M.

1032
Kurtz. 1860.

Catalogue of the shells of N. & S. Carolina.

According to Jacot (1921), abstracted elsewhere in this bibliography, this is a list without localities. We decided that it was not worth the effort to search for this paper. The incomplete reference above is all that was given by Jacot. - J.L.M.

1033
Lackey, James B. (1951). - date uncertain.

The rehabilitation of Great South Bay. Unpub. ms report 25 p. including tables (available in J.L.M. personal library - source not known).

Declining production and poor condition of *Crassostrea virginica* and *Mercenaria mercenaria* were reported. Great South Bay was a good setting and fattening area for oyster until about 1940. In the next decade the oyster industry declined and might vanish. Scallops were completely gone. Clams were still harvested in quantity, but quality was not as good as before. Appearance of water was bad. Phosphates were unusually high (more than 20 times the amount that could produce algal blooms). Nitrates were low (1/30 to 1/5 of the expected amount). In summer the varieties of plankton organisms decreased, and numbers of organisms, with one exception, were lower than expected by comparison with other waters. The exception was a very small green alga of 2 to 8 μ. This was called "small form" by J.B. Glancy. For 19 yrs it increased to bloom proportions between 1 May and 1 June and lasted as a bloom until December. The bloom was yellow-green. As many as $4.5x10^6$ cells/ml were found in Bay water. No large population of any other plankton organism was present. Fertilization of Bay waters was attributed to wastes from duck farms, mostly from Moriches Bay, and poor flushing. Sludge was present in Carmans and Forge rivers. The duck industry began about 1890. By 1924 the total population was $1.5x10^6$ ducks, by 1930 $2.0x10^6$, 1933 $3.0x10^6$, 1941 $6x10^6$, and 1950 $5.9x10^6$. Great South Bay is about 100 mi^2 or $2.5x10^9$ ft^2. Shellfish grounds occupied about half of the Bay and the shellfish population averaged 3 animals/ft^2. Therefore the total population was about $3.75x10^9$ shellfish. At 375 mollusks/bu this equals about 10 million bushels. Possible abatement measures are to 1) treat duck farm wastes, 2) exclude Moriches Bay water by a bridge across the channel at Smith's Point with tidal gates to control flow. - J.L.M.

1034
Lackey, James B., George Vander Borgh (sic), Jr., and Joseph B. Glancy. 1954.

General character of plankton organisms in water overlying shellfish-producing ground. Natl. Shellf. Assn., Convention Addresses 1952: 152-156 (date of publication estimated).

The relation of kinds and quantities of food organism to abundance and condition of specific bivalves is not discussed except to note that in Great South Bay, Long Island, N.Y., where plankton abundance was very high, oysters were in such poor condition as to be useless. Examination of plankton at Woods Hole, Mass., Long Island Sound, Gardiners, Peconic, and Great South Bays, N.Y., and Solomons and St. Mary's City, Md. led to the general conclusion that any inshore water probably can provide enough plankton to maintain a large and thriving shellfish population. Preferred foods probably were diatoms and dinoflagellates for adult shellfishes and relatively small plankton populations probably were best. The critical factor was kind, rather than abundance of food, and for larvae smaller plankton flagellates were best. Hard clam is mentioned. - J.L.M.

1035
Ladd, H. S. 1951.

Brackish-water and marine assemblages of the Texas coast, with special reference to mollusks. Univ. Tex., Inst. Mar. Sci., Pub. 2(1): 125-164.

Shells of *Venus mercenaria* were found on Padre Island. - J.L.M.

1036
Laki, K. 1957.

A simple method for the isolation and crystallization of tropomyosin from the muscles of the clam, *Venus mercenaria*. Arch. Biochem. Biophys. 67(1): 240-242.

A method is described which yields tropomyosin of high purity from adductor or foot muscles of hard clam. The extract was identified as tropomyosin because in salt-free solution it was very viscous but viscosity was reduced by addition of salts, it had sedimentation properties similar to other tropomyosins, and it had a characteristic amino acid composition. Most "contractile" proteins of *Venus* muscle have been named "paramyosin" because X-ray and electron-microscopic properties are different from those of myosin. A possible identity of *V. mercenaria* tropomyosin with "paramyosin" was under investigation. - J.L.M.

1037
Lambert, L. 1949.

Note complémentaire sur le clam *(Venus mercenaria)*. Rev. Trav. Off. Pêches Marit. 15: 118-122.

According to Heppell (1961), Lambert reported introductions at Concarneau, St-Armel, Sarzeau,and elsewhere in France, none of which was successful. - J.L.M.

1038
Landers, W. S. 1950.

Growth studies of *Venus mercenaria* - 1950. Ann. Conf., Clam Investigations, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 29-30.

Marked clams at Wickford, 2nd to 3rd year 18 mm, 3rd to 4th yr 12 mm, 4th to 5th yr 8 mm. Modal shifts of length-frequencies Cornelius Island, 1st to 2nd yr 19 mm, 2nd to 3rd yr 14 mm. Distribution of modes in length-frequencies of Cornelius Island clams shows the 0 yr-class has a peak at 6-7 mm, growth from 0 to 1st yr is about 20 mm. Sizes at various ages of Wickford (Cornelius Is) quahogs are: end of 1st summer 7 mm; 2nd summer 27 mm; 3rd 45 mm; 4th 57 mm; 5th 65 mm. Some Wickford clams will reach marketable size (48 mm) at end of 3rd summer, but most not until during 4th summer. - J.L.M.

1039
Landers, Warren S. 1952.

Growth of *Venus* in Wickford, Rhode Island. 3rd Ann. Conf. on Clam Research, Boothbay, Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 88.

Clams grew as follows:

Original length	Mean lengths end of 1st yr	end of 2nd yr
28-29	44-46	51-56
45	56-57	62-63
56-58	64-65	68-71

Some became legal length in 3rd summer, but most not until the 4th summer. - J.L.M.

1040
Landers, Warren S. 1953.

Spawning and setting of *Venus mercenaria* in Wickford Harbor, 1950-1952. 4th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 30-31.

The Harbor has hard bottom along bars and points of land projecting into the Harbor, and soft bottom in coves and in back of 2 large islands. Currents are slow, maximum velocity about 1 knot in the main channel. Salinity seldom varies from 25 to 30 ppt. Spawning begins in late May or early June, reaches a peak in June and decreases from then on. It may continue at a fairly intense rate all summer, or virtually ceases about mid-July. Temperature controls the beginning and length of spawning. It usually ceases for all practical purposes by the end of September. Maximum abundance of hard clam larvae during the 3 yrs was: straight hinge 8,000/35 gal, mature larvae ready to set 400 to 500/35 gal water. Density has been low: 1950, 2.5/ft^2; 1951, 1.8/ft^2; and 1952, 1.5/ft^2. - J.L.M.

1041
Landers, Warren S. 1954.

Seasonal abundance of clam larvae in Rhode Island waters, 1950-52. U.S. Dept. Interior, Bu. Comm. Fish., Spec. Sci. Rept.-Fish. 117, 29 p.

Begins with a review of early life histories of *Mya arenaria* and *Venus mercenaria*, including descriptions of larvae. *Venus* begins to spawn in late May or early June when water temp reaches about 20°C. Spawning continues for the remainder of summer, usually decreasing in intensity until it ceases in Sept. Isolated late umbone stages can occasionally be found well into winter. In 1950 *Venus* larvae first appeared in the week of 11 June, in late May in 1951 and 1952. In 1950 spawning continued at relatively high levels until nearly mid-Sept, but in 1951 and 1952 spawning was nearly completed by mid-July. Water temp was consistently lower in 1950. There are some indications that clams on shallow flats spawn earlier than those in deeper water. Earliest shelled larvae ranged in length from 90 to 100 microns, metamorphosing larvae to 225 microns. - J.L.M.

1042
Landers, Warren S. 1954.

Notes on the predation of the hard clam, *Venus mercenaria*, by the mud crab, *Neopanope texana*. Ecology 35(3): 422.

Laboratory experiments showed that mud crabs will kill most hard clams 10 mm long or less in aquaria, whether clams are buried in substrate or without substrate. Clams 14 mm or longer were not touched. In a field experiment hard clams 2 to 6 mm long were planted in fall and recovered in winter. Only 258 of the original planting of 2,000 clams were recovered. It was suspected, although not proven, that most mortality was caused by mud crab. - J.L.M.

1043
Landers, Warren S. 1955.

Summary of early life history studies of the hard clam in Rhode Island. In 5th Conf. on clam research, Boothbay Har., Me. U.S. Dept. Interior, Fish Wildl. Serv.: 9-11.

Spawning begins in both areas about the first of June and produces the most abundant larvae. In hot summers spawning in Wickford Harbor is virtually over by mid-July. Abundance of all stages of quahog larvae is usually greater in Wickford Harbor than in Greenwich Bay, from 2 to 7 times as abundant in early larvae and 2 to 11 times as abundant in mature larvae. Seasonal larval mortalities ranged in Wickford Harbor from 95 to 97% and in Greenwich Bay from

94 to 99.7%. Setting is about as good in Greenwich Bay despite a scarcer larval population. - J.L.M.

1044
Landers, Warren S. 1955.

Venus predators in Rhode Island. 5th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 60-61.

Forms definitely proven to be *Venus* predators are *Polynices duplicata*, *Urosalpinx cinerea*, *Eupleura caudata*, and *Neopanope texana*. Suspected predators are *Callinectes sapidus*, *Limulus polyphemus*, and *Carcinides maenas*. *Polynices* is not a major predator. Oyster drills are serious pests, drilling 15% to 50% of set. Mud crabs have the potential to be the most destructive because they can crush and consume very small *Venus*. - J.L.M.

1045
Landers, Warren S. 1966.

Infestation of the hard clam, *Mercenaria mercenaria*, by the boring polychaete worm, *Polydora ciliata*. Proc. Natl. Shellf. Assn. 56: 4-5 (abstract).

Juvenile *M. mercenaria* were infested accidentally in laboratory trays in absence of sand substrate. Experimental infestation was successful. At water temps of 20 to 22°C newly hatched *P. ciliata* larvae metamorphosed in 14 to 20 days, then many settled on clams and formed tubes. Perforation of the shell of 5 to 8 mm clams took 18 to 20 days, and about twice as long for 30 to 35 mm clams. The umbone region appeared to be especially vulnerable. Internal mud blisters typical of *Polydora* were present 30 days after perforation. Mortality was not significantly higher in infested clams. In a sand substrate clams were not invaded by *Polydora* larvae unless they failed to bury completely. When clams burrowed in, worms disappeared and further shell damage ceased. *P. ciliata* is apparently not an enemy of clams under natural conditions, but under certain conditions in a hatchery the worm could be a problem. - J.L.M.

1046
Landers, Warren S. 1967.

Infestation of the hard clam, *Mercenaria mercenaria*, by the boring polychaete worm, *Polydora ciliata*. Proc. Natl. Shellf. Assn. (1966) 57: 63-66.

The boring polychaete *Polydora ciliata* was found to attack clams raised in running sea water with no burrowing substrate. In a subsequent experiment, chi-square analysis showed a significant difference (at the 95% confidence level) in the number of dead clams when comparing *P. ciliata* infested clams with non-infested clams, but in later studies the differences were not significant. Infestation occurred within 18 days for 5-8 mm long clams, but took 39 days for clams 30-35 mm long. *P. ciliata* caused mud-blisters to form on the clam shells. Clams that have burrowed into a substrate were not susceptible to attack by *P. ciliata*. - D.L.

1047
Landers, Warren S., and Edwin W. Rhodes, Jr. 1968.

Growth of young clams, *Mercenaria mercenaria*, in tanks of running sea water. Proc. Natl. Shellf. Assn. 58: 5 (abstract).

Young hard clams were placed in tanks (30' by 4') with sand and running sea-water. Equal volumes of clams: 18, 13, 10, and 8 mm long, for periods of 30-117 days produced the growth ratios: 1.0, 1.9, 2.7, and 2.9, respectively. Clams 10-18 mm long grew equally well at densities of 8, 16, and 67 ml of clams per square foot. Clams 3-18 mm long grew equally well at water flows from 15-56 gpm. At 9 gpm, growth of 8-18 mm long clams decreased 33%, and growth of 2-5 mm long clams decreased over 50%. Clam growth was considerably better at the intake end of the tank than at the discharge end. Fouling of tanks by barnacles, mussels, and tunicates reduced clam growth. Irradiating water with UV light was able to control mussels only. - D.L.

1048 Langston, W. J. 1978.

Persistence of polychlorinated biphenyls in marine bivalves. Mar. Biol. 46(1): 35-40.

Elimination of dichlorobiphenyl from *Cerastoderma edule* was much more rapid than from *Macoma balthica* or *Mercenaria mercenaria*. - J.L.M.

1049 LaRoche, Gilles, G. R. Gardner, Ronald Eisler, E. H. Jackim, P. P. Yevish, and G. E. Zaroogian. 1973.

Analysis of toxic responses in marine poikilotherms. In Bioassay techniques and environmental chemistry. Gary E. Glass (ed.). Ann Arbor Sci. Publishers, Inc., Ann Arbor, Mich.: 199-216.

Short-term bioassays and field observations are valuable in identifying toxicological responses, but realistic appraisal of environmental exposure also is necessary. Subtle damage which could affect survival should be sought and identified. Fig. 28 shows gill areas of a control *Mercenaria mercenaria* illustrating in histological section the ciliated gill lamellae. Fig. 29 shows changes produced by as little as 0.25 mg/l or 250 mg/l (ppb) of $CuCl_2$ over 96 hrs. The ciliated columnar cells at tips of gill lamellae have disappeared. Columnar epithelium appears to have been replaced by cuboidal cells, which may be interpreted as an aspect of the regenerative process from destructive action of Cu^{++}. Without cilia, it is realistic to conclude that the clam would starve. Anatomical changes suggest that loss of cilia would limit survival in an animal exposed to sublethal concentrations of $CuCl_2$. - J.L.M.

1050 Larsen, Peter F. 1979.

The distribution of heavy metals in the hard clam, *Mercenaria mercenaria*, in the lower Chesapeake Bay region. Estuaries 2(1): 1-8.

Populations of hard clam were sampled at 30 sites in lower Chesapeake Bay in 1972 and 1973. Subsamples were taken for analysis of cadmium, copper, and zinc. Highest values of all three metals occurred in the James River. Absolute levels, in parts per million, varied from zero to 0.8 for cadmium, 1.1 to 7.9 for copper, and 5.0 to 112 for zinc. Relatively high and relatively low values often occurred within the same sample. Concentrations of zinc are generally comparable to those found by others in the U.S. and Britain. Broader ranges in Chesapeake Bay were caused by larger numbers of sites and individuals sampled. Average copper values also were comparable from all North American sites, but higher concentrations were found by others in the U.S. and U.K. Average values of cadmium were also comparable, except for one published in the U.K. The higher levels in the James River shows that this river probably is contaminated by these metals. Salinity of the sampling site must be considered before cadmium and zinc data can be interpreted. A standard action-level would be adequate to denote pollution by copper. - J.L.M.

1051 Lavelle, S. M. 1970.

Observations on the anti-growth activity of *Mercenaria* clam extract. 10th Internatl. Cancer Congr., Abstr. 1298: 789.

Deep-frozen extract of *Mercenaria* (mercenene) was tested for effect on growth of methylcholanthrene tumors, promotion and initiation of 2-stage carcinogenesis of mouse skin, regeneration of amputated newt forelimb, and healing of through wounds of rabbit ear. Extract was applied twice daily to test areas. Mercenene reduced growth of tumors in initiated and promoted skin, and slowed regeneration and wound repair. It had less action on complete carcinogenesis. Mercenene appears to contain a general inhibitor of growth. - J.L.M.

1052
Laverack, M. S. 1968.

On the receptors of marine invertebrates. Oceanogr. Mar. Biol. Ann. Rev. 6: 249-324.

The only reference to *Venus* is to visual receptors in siphonal nerves, as reported by Kennedy (1960), abstracted elsewhere in this bibliography. - J.L.M.

1053
Lavoie, Marcel E. 1956.

How seastars open bivalves. Biol. Bull. 111(1): 114-122.

Venus is mentioned, but no original data are presented. The thrust of this paper is to demonstrate that sea star does not need to produce a toxin to aid it in opening a bivalve. - J.L.M.

1054
Lear, Donald W. 1962.

Reproducibility of the most probable numbers technique for determining the sanitary quality of clams. Appl. Microbiol. 10(1): 60-64.

Experiments were done with *Mya arenaria*, but the conclusions probably apply also to *Mercenaria mercenaria*. Reproducibility of results from clam meats was less than that from water analysis. Entrapped air bubbles in ground clam meats lower the density of the sample material, producing inaccurate aliquots for inocula, and interfere with attainment of homogeneity in brei. The results do not invalidate the technique for examination of molluscan shellfishes, but special preparation techniques probably are necessary. - J.L.M.

1055
Leathem, Wayne, and Don Maurer. 1976.

Phylum Mollusca: A guide to the Mollusca of the Delaware Bay region. Marine Studies Complex, Univ. Del., Lewes, Del. DEL-SG-18-76, 43 p.

Mercenaria mercenaria is identified as a member of the Class Bivalvia, Subclass Heterodonta, Order Veneroida, Family Veneridae. Class, Subclass, and Order are described briefly. An illustrated glossary of bivalve terms and a key are included. - J.L.M.

1056
Leatherland, T. M., and J. D. Burton. 1974.

The occurrence of some trace metals in coastal organisms with particular reference to the Solent region. J. Mar. Biol. Assn. UK 54(2): 457-468.

Mercenaria mercenaria from the Solent, an open embayment off the mouth of Southampton Water, which is the estuary of the River Test and other streams, contained rather uniform concentrations of Hg except in gills, which contained concentrations higher by a factor of about 2.5 as compared to that in whole organism. Concentrations of Hg ranged from 0.16 to 0.83 ppm dry weight in various tissues, 1.46 ppm in gills. Residues decreased seaward. As ranged from 1.8 ppm to 12.2 ppm, and also was distinctly higher in gills (highest value in other tissues or whole samples was 9.3 ppm). Cd in whole tissues was 0.30 to 0.60 ppm, and Sb 0.006 to 0.015. Relatively high concentrations of Zn tended to occur in organisms with elevated levels of Cd. Zn was not reported for quahog, but in other animals it was much higher in ppm dry weight than any other metal measured. - J.L.M.

1057
LeBosquet, M., Jr. 1956.

Sewage treatment protects shellfish growing areas. Proc. Natl. Shellf. Assn. 46: 35-38.

Although it does not mention hard clam specifically, this paper contains a useful non-technical description of primary and secondary sewage treatment and the effects of storm overflows. - J.L.M.

1058
Lee, Henry. 1977.

Use of shells found a good way to save clams from predators. Natl. Fisherman 57(1): 11A.

An acre of flats is now expected to gross $12,000 annually with low investment and costs, according to Walter F. Godwin. Small clams that otherwise would have been eaten by crabs went under the shells and survived. The carrying capacity of shelled areas reached 48 clams per m^2. About 150 cu yds of shell an acre is all right. Scallop shells were used because they were most available. Additional research is necessary to improve yields. - J.L.M.

1059
Lee, Richard E. 1944.

A quantitative survey of the invertebrate bottom fauna of Menemsha Bight. Biol. Bull. 86: 83-97.

Mercenaria (Venus) mercenaria is **not** mentioned. - M.W.S.

1060
Lehman, W., J. Kendrick-Jones, and A. G. Szent Gyorgyi. 1971.

Regulatory factors in molluscan muscles. J. Gen. Physiol. 57: 248 (abstract).

In adductor muscles of *Mercenaria mercenaria*, components which regulate contraction by interacting with Ca are associated with myosin. Purified myosin preparations from these muscles bind Ca with great affinity. Their ATPase activity, even when combined with purified actin, required 10^{-6} to 10^{-5} Ca. Tropomyosin is not required for Ca dependence of ATPase activity or for Ca binding in the molluscan system, and reconstituted actomyosin preparations which are free of tropomyosin have a strict Ca requirement. Tropomyosin, however, can be obtained from thin filaments of mollusks. The preparation forms paracrystals with a 395 A period, sediments as a single component in the ultracentrifuge, moves as a single band in SDS-acrylamide gel electrophoresis having an estimated chain weight of 38,000. *Mercenaria* tropomyosin can combine with rabbit actin, with rabbit troponin complex, and can substitute for rabbit tropomyosin in a reconstituted rabbit actomyosin system. The component responsible for Ca regulation cannot readily be dissociated from molluscan myosins. - J.L.M.

1061
Leibovitz, Louis. 1978.

Shellfish diseases. In Health, Disease, and Disease Prevention in Cultured Aquatic Animals. Selected papers presented at a conference sponsored by Norden Laboratories, Lincoln, Nebr., 9-10 June 1975. Mar. Fish. Rev. 40(3): 61-64 (MFR paper 1300).

Common shellfish diseases are listed and known specific etiologic agents, including viral, bacterial, fungal, protozoan, and metazoan parasitic and infectious agents, are discussed. Predators, toxic substances, and fouling organisms also produce serious economic losses. Outbreaks of cholera have been attributed to shellfish consumption in Europe and Africa. The only hosts specifically mentioned are oysters, and species are not named. Studies of the Long Island, N.Y., oyster industry described certainly apply to *Crassostrea virginica* and *Mercenaria mercenaria*. A pathogenicity model is described for testing pure bacterial isolates obtained from larval cultures in commercial hatcheries. Results suggested that almost all bacterial isolates at high concentrations ($>10^5$/ml) are pathogenic for shellfish larvae, but only "true" pathogens kill at very high dilutions ($<10^3$/ml), which suggests that true pathogens require larvae for growth. Presence of higher concentrations, even of sterile nutritive broth, produces a lethal effect, which suggests that food concentrations, dead or decaying algal foods, or larvae, may aggravate the pathogenic effect of extrinsic and intrinsic microbial concentration. At high concentrations of bacteria or equivalent culture media, lethal effects are rapid and are not associated with protozoan activity. At lower levels lethal effects are more gradual and are associated with intense protozoan proliferation and activity. Without knowledge of the presence of experimental bacterial inoculum it could be concluded that protozoa are the primary pathogen. Results of field studies tended to support these conclusions. Each hatchery was different in techniques and methods of operation. The need to define characteristics for optimum performance is apparent. - J.L.M.

1062
Leibovitz, Louis. 1978.

Bacteriologic studies of Long Island shellfish hatcheries: An abstract. Mar. Fish. Rev. 40(10): 8.

A total of 1,279 cultures were taken from sick and healthy oyster and clam larval cultures and their ingredients, and 710 pure bacterial isolates were identified. Sixty-six percent of all bacteria isolated and identified from intake water samples were gram negative, and 15.7 percent were gram positive. Well water had a higher percentage of gram-positive organisms than bay water. Dominant gram-negative isolates were *Pseudomonas* 33%, *Flavobacterium* or *Cytophaga* 10.4%, *Acinetobacter* 8.7%, *Aeromonas* 4.9%, *Enterobacteriacea* 3.8%, *Vibrio* 3.2%, and *Achromobacter* spp. 1.5%. Well water counts were lower but contained a higher percentage of *Aeromonas*, *Vibrio*, and *Flavobacterium* or *Cytophaga*, and less *Enterobacteriacea* than bay water. Sick clam larval cultures were associated with a drop in percentage of *Flavobacterium* or *Cytophaga*, *Aeromonas*, and *Enterobacteriacea* spp. Each hatchery (of 5) larval culture medium had its own distinctive bacterial flora. High bacterial counts were associated with warm weather, increased storage and culture time, and high organic content. - J.L.M.

1063
Leibovitz, Louis. 1978.

A study of vibriosis at a Long Island shellfish hatchery. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978, Abstracts: page not numbered.

Summarizes results of a 5-yr study of bacterial flora of incoming well and Bay water, stock and pooled algal cultures, and oyster larval cultures. Water quality studies also were made of incoming Bay and well water for 3 yrs. Hard clam is not mentioned, but the results presumably are applicable also to *Mercenaria mercenaria*. *Vibrio* spp. were present at low frequencies throughout the shellfish growing season, but were the dominant bacterial population in incoming Bay water during a single peak period each yr, which was of variable duration and occurred in spring or summer. Ammonia levels of incoming water dropped sharply during peak *Vibrio* periods. These peaks also were associated with increased total bacterial counts and suspended organic content of incoming Bay water. Although peaks occurred annually, outbreaks of hatchery vibriosis, with high oyster larval mortality, did not occur each yr. Hatchery vibriosis began during peak concentrations of *Vibrio* spp. in incoming Bay water, but persisted in the hatchery after peak periods had passed, when *Vibrio* could not be detected in incoming water. - J.L.M.

1064
Leidy, Joseph. 1855.

Art. XI. - Contributions towards a knowledge of the marine invertebrate fauna of the coasts of Rhode Island and New Jersey. J. Acad. Nat. Sci. Phila. 3(2): 135-152, ill.

Mollusks are not included. - J.L.M.

1065
Lennon, Robert E. 1967.

Clearance and registration of chemical tools for fisheries. Prog. Fish-Cult. 29(4): 187-193.

Various chemicals are used, or might be used, for treatment of fish diseases, as anaesthetics, as dyes for marking, as toxicants for reclamation of lakes and streams, and as insecticides and herbicides at hatcheries and in fish habitats. The paper deals with fishes and freshwater, but the discussion is generally applicable to shellfishes and marine habitats. The Food and Drug Administration has drawn up research requirements which include studies of toxicity, efficacy, and residues of a compound in fishes. Procedures under Veterinary Investigational Drug Regulations, in fisheries, and in industry are outlined. Progress to date in meeting FDA requirements has been small and slow. A tentative program has been drafted for 15 chemicals over a 5-year period. - J.L.M.

1066
Le Pennec, M., and D. Prieur. 1977.

Les antibiotiques dans les elevages de larves de bivalves marins. Aquaculture 12: 15-30.

This review paper concludes that most existing antibiotics have been tested alone or in combination, very frequently in arbitrary fashion and without preliminary study to determine which was most suitable. The results have been variable, at times contradictory and not repeatable. The papers dealing with *Mercenaria mercenaria* are abstracted elsewhere in this bibliography. - J.L.M.

1067
Letourneau, Rene. 1978.

The plight of the shellfisherman. Upstream, Save the Bay, Inc., Dept. Envir. Mgmt. 2(1): 4.

The President of the recently formed Rhode Island Shellfishermans Association says the problem is in the conditional area. In summer, students, school teachers, and residents compete with professional shellfishermen. Student licenses should be limited to prevent areas from being fished out. Shellfishermen would like to negotiate lines and open more of the Barrington Beach area to shellfishing. Politics is the biggest problem. - J.L.M.

1068
Levinton, Jeffrey. 1973.

Genetic variation in a gradient of environmental variability: Marine bivalvia (Mollusca). Science 180: 75-76.

Six bivalve mollusk species were sampled for genetic variability at two enzyme-synthesizing loci. Effective number of alleles and absolute number of alleles decreased with depth of burial in sediment, intertidally, and with depth of water subtidally. It is proposed that environmental variability regulates genetic variability at these two loci. *M. mercenaria* was intermediate among *Mytilus edulis* and *Modiolus demissus* with higher values, and *Macoma balthica*, *Mya arenaria*, and *Nucula annulata* with lower numbers of alleles and lower effective numbers of alleles. - modified author's abstract - J.L.M.

1069
Levinton, Jeffrey S. 1974.

Trophic group and evolution in bivalve molluscs. Palaeontology 17(3): 579-585.

Mercenaria mercenaria is not mentioned, but the Veneracea are included in Fig. 1, which shows survivorship of several groups in geological time. It is concluded that rate of mortality of suspension-feeding taxa is higher than that of deposit feeders. Deposit-feeding marine benthic invertebrates ingest sediments and feed principally upon bacteria, whereas suspension feeders feed mainly upon phytoplankton. The distinction is important because predictability of phytoplankton is less than that of within-sediment bacteria. Consequently, suspension-feeding populations fluctuate more in abundance than deposit-feeders. Long-term mortality rates for genera of Veneracea are 1.5%/million yrs, as compared with deposit-feeding Nuculoida at 0.8%/m.y. - J.L.M.

1070
Levinton, Jeffrey S. 1977.

Ecology of shallow water deposit-feeding communities Quisset Harbor, Massachusetts. In Ecology of Marine Benthos. Bruce C. Coull (ed.). Univ. S.C. Press, Belle W. Baruch Library in Marine Sci. 6: 191-227.

Nucula proxima appeared to be attracted to the siphon holes of *Mercenaria mercenaria*; this resulted in sediment destabilization and excessive turbidity at the sediment-water interface, which was strongly inhibitory to a suspension feeder like *Mercenaria*. This attraction may explain the relative rarity of *Mercenaria* in the eelgrass habitat, despite its abundance in non-*Nucula* sandy bottoms nearby. Two figures are given to illustrate the relationship. - J.L.M.

1071
Levinton, Jeffrey S., and Richard K. Bambach. 1969.

Some ecological aspects of bivalve mortality patterns. Am. J. Sci. 268: 97-112.

The paper deals with shallow-water muddy-bottom bivalve associations. *Mercenaria mercenaria* is not mentioned. Size distribution, growth, and survivorship are considered. A logarithmic growth model is proposed as a convention for relating size and relative age in bivalves. - J.L.M.

1072
Lewis, Alan G. 1967.

An enrichment solution for culturing the early developmental stages of the planktonic marine copepod *Euchaeta japonica* Marukawa. Limnol. Oceanogr. 12(1): 147-148.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1073
Lewontin, R. C. 1957.

The adaptations of populations to varying environments. Cold Spring Har. Symp. Quant. Biol. 22: 395-408.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S. and J.L.M.

1074

Li, C. P. 1960.

Antimicrobial activity of certain marine fauna. Proc. Soc. Expt. Biol. Med. 104: 366-368.

Following the discovery that canned abalone juice had an inhibitory effect on experimental poliomyelitis in mice, and that frozen fresh abalone juice inhibited *Staphylococcus aureus* in vitro, a number of marine animals were tested as possible sources of antimicrobial agents. Abalone juice, oyster juice and extract, and *Venus mercenaria* extract, demonstrated antimicrobial activity; the others were negative. When a penicillin-sensitive strain of *Staphylococcus aureus* was used as a test organism, clam extract showed rather consistently a 3 mm inhibiting zone around the absorbent paper disc; oyster extract was negative. By a fluid method of assay, clam extract also showed moderate inhibitory action against a penicillin-resistant strain of *S. aureus*. The active agent was heat stable and nondialyzable. - J.L.M.

1075

Li, C. P. 1972.

Further research on anticancer agents from the sea. In Food-Drugs from the Sea, Proceedings 1972. Leonard R. Worthen (ed.). Mar. Tech. Soc., Washington, D.C.: 396 (abstract).

When newborn hamsters were inoculated subcutaneously with adenovirus-12 and treated with clam (presumably *Mercenaria mercenaria*) extracts 4 or 5 days later, about 50% were protected from developing tumors later in life. Clam extract cannot kill virus in that condition, but could immunize animals against cancer as BCG does. Clam extracts injected directly into tumor in hamsters caused complete regression in 50% of the animals. There may be other components in clam extracts, some of which inhibit, others of which stimulate, immunity. Discovery of tumors in clams makes the problem more complicated. - J.L.M.

1076

Li, C. P., W. G. Jahnes, and N. M. Tauraso. 1970.

Studies on inhibition of viral oncogenesis. II. Inhibitory effect of L-asparaginase, clam liver extract and methotrexate on Rous sarcoma virus focus formation. Arch. Ges. Virusforsch. 32(2-3): 236-243.

Effect of clam liver extract (CLE) on Rous sarcoma virus (RSV) focus formation was to reduce consistently the number of foci. It was significant when the dose of CLE was more than 10 mcg% and especially when virus multiplicity of the inoculum was high. Methotrexate (MTX) had the strongest inhibitory activity, but when given to hamsters inoculated with adenovirus-12, CLE had an inhibitory effect on tumor formation at least equal to that of MTX. - J.L.M.

1077

Li, C. P., B. Prescott, B. E. Eddy, and E. C. Martino. 1968.

Local chemotherapy of neoplasm in hamsters with clam extract. 9th Internatl. Cancer Congr., Abstracts of papers: 33.

Health Sciences Library at Stony Brook has Proc. 9th Internatl. Cancer Congr., but this abstract is not in the volume. No record of publication of abstracts in any form. J.L.M. and M.W.S.

1078

Li, C. P., B. Prescott, W. G. Jahnes, and E. C. Martino. 1962.

Antimicrobial agents from mollusks. Trans. N.Y. Acad. Sci., Ser. II, 24(5): 504.

Mercenaria (Venus) mercenaria is not mentioned. The original discovery that commercial canned abalone juice had antiviral properties, and new research that demonstrated antibacterial and antiviral activity in extracts from abalone and oyster are described. These active substances were designated paolin 1 and 2, from a Chinese word meaning abalone extract. - J.L.M.

1079

Li, C. P., B. Prescott, E. C. Martino, and O. C. Liu. 1968.

Antineoplastic activity of clam liver extract. Nature 219(5159): 1163-1164.

Average weight of a whole shucked *Mercenaria mercenaria*, including mantle cavity fluids, was about 30 g and liver about 1 g. Final yield of dried extracts was about 0.6% of wet liver or 0.02% of whole clam by weight. Extraction procedure is described. When extracts were autoclaved or heated at 100°C for 1 hr biological activity was destroyed. Mice were treated with 3 to 10 daily subcutaneous injections of extract in the left scapular region. Mice were weighed before treatment and 7 days after implantation of leukaemic cells. The treatment prolonged mean survival time of treated mice over untreated controls. Ten additional preparations of clam liver extract were tested, each according to a different schedule of treatment. Every preparation showed definite antileukaemic activity. Extracts of whole clam, including liver, also showed some activity. Preliminary studies showed that other parts of the body also contained the active principle, but liver was used because it was easy to dissect out and probably contained greatest amounts of active material. The extract is not suggested as an antileukaemic drug for man because it is toxic and its activity cannot match that of drugs currently available, such as methotrexate. This drug was used in the experiments described, and it usually increased mean survival time by 110% or more. Antileukaemic activity in clam liver is an interesting phenomenon and further study may provide useful implications. - J.L.M.

1080

Li, C. P., B. Prescott, B. E. Eddy, E. W. Chu, and E. C. Martino. 1968.

Studies on inhibition of viral oncogenesis. I. Reduced tumor incidence in hamsters inoculated with adenovirus 12 and treated with clam extracts. J. Natl. Cancer Inst. 41(5): 1249-1253.

Extracts of whole meats, or of liver (digestive diverticulum), of *Mercenaria mercenaria* reduced incidence of tumor formation in hamsters induced by adenovirus 12. A total amount of 63 to 85 mg/hamster of crude whole clam extract, administered in 12 to 14 daily injections, was effective. Clam liver extract was effective in much smaller doses (1.9 mg divided into 2 or 3 injections). Clam extract may have suppressed tumor development by interfering with the process of transformation of normal cells into malignant cells rather than by inhibiting virus, or it may have acted directly on tumor cells which had just been transformed. Both sexes of hamster responded to clam extract, but males probably were more responsive. It was not certain whether reduction of tumor formation was caused by non-specific toxicity of clam extract, which retarded normal growth of hamsters and thus development of tumors. Further work was in progress using another antitumor agent which does not affect hamster growth. - J.L.M.

1081
Li, C. P., N. M. Tauraso, B. Eddy, B. Prescott, and E. C. Martino. 1972.

Studies on inhibition of viral oncogenesis. III. Effect of clam extracts and methotrexate on tumor formation in male and female hamsters induced by virulent and attenuated adenovirus-12. Arch. Ges. Virusforsch. 36(3-4): 284-295.

Newborn hamsters were inoculated subcutaneously at birth with adenovirus-12, Hollinshead strain. Four to 5 days later they were treated with *Mercenaria mercenaria* liver extracts (CLE). Tumor incidence in males, treated and control, was statistically lower than in females. Treated hamsters of both sexes had significantly fewer tumors than controls. During the study the virus lost much of its oncogenicity, but all animals inoculated with virulent or attenuated virus responded to treatment. A total dose of 100-350 mcg/hamster in 2 to 3 injections within 12 days after birth prevented some hamsters from developing tumors in later life. Eleven assay experiments, using 663 hamsters over several years, showed that treatment with clam extracts reduced tumor incidence by 50% or more as compared to controls. - modified authors' summary - J.L.M.

1082
Li, C. P., B. Prescott, B. Eddy, G. Caldes, W. R. Green, E. C. Martino, and A. M. Young. 1965.

Antiviral activity of paolins from clams. Ann. N.Y. Acad. Sci. 130, Art. 1: 374-382.

Certain substances present in abalone, oyster, queen conch, squid, sea snail, and *Mercenaria mercenaria* possess significant antibacterial and antiviral activity *in vitro* and *in vivo*. Antitumor activity also has been reported. Ammonium sulphate extracts were prepared from *Mercenaria mercenaria* taken in Aug and Sept (because clams have been reported to possess greater antitumor activity in summer) and separated by Sephadex G-25 into fractions. The major fractions had molecular weights of 9,000 to 10,000, 1,400 to 6,400, and 700 to 1,300. They inhibited herpes simplex virus and adenovirus type 12 in tissue cultures. A mixture of fractions 1 and 2 (highest molecular weights) had no effect on herpes simplex virus keratitis in rabbits, but either the ammonium sulphate extract or fractions 1 and 2 reduced tumor formation in hamsters induced by adenovirus type 12. - amended authors' summary - J.L.M.

1083
Li, C. P., N. M. Tauraso, B. Prescott, B. E. Eddy, R. C. Hoye, E. C. Martino, G. Caldes, and C. Gorschboth. 1972.

Intratumor therapy in rodents with aqueous clam extracts. Cancer Res. 32(6): 1201-1205.

Aqueous extract of *Mercenaria mercenaria* was injected directly into and around small, superficial, slowly growing solid s.c. adenovirus 12 and SV40 virus-induced tumors in hamsters. Treatment was daily or at selected intervals. Half of 74 treated hamsters showed complete tumor regression within 4 weeks of the first injection. No systemic toxicity was observed. Hamsters apparently were normal 4 to 9 months after tumor regression. The remaining treated tumors grew after partial regression and killed the hosts. Controls were 75 tumor-bearing hamsters, which were untreated or treated with placebos, including 8.5% NaCl and heated clam extract. All control tumors grew and killed the hamsters. One-third of melanomas in CDF_1 mice, similarly treated, showed complete regression. (Abstracter's note: this paper cites some problems of cancer chemotherapy. The drug may be deactivated by the liver or removed by binding to plasma proteins or by rapid excretion. In general, tumors have a relatively poor blood supply and drugs can reach the inner area of the tumor only by diffusion. Thus, although a drug may be a highly selective tumor inhibitor, it may not reach all tumor cells in high concentration. These facts are important in interpretation of effectiveness of mercenene in cancer therapy, especially when experimental studies that demonstrate high antitumor specificity are based on injection into tumors.) - modified authors' summary - J.L.M.

1084
Lin, Chi-Chung. 1972.

Electron microscope study of the spermatozoa of the hard-shelled clam *Venus mercenaria* (Mollusca) by negative staining. Trans. Ky. Acad. Sci. 33(3-4): 57-63.

The head of the sperm is conical and streamlined, and appears to be longer in isotonic seawater than under the electron microscope. The acrosomal membrane appears to rupture more easily near the anterior part of the head than farther back. This was consistent with the fact that the acrosome commonly ruptures immediately before or during passage of sperm through egg investment. Extrusion of the acrosome filament has been detected, which adds *V. mercenaria* sperm to the list of mollusk sperm which contain droplets of material that can be extruded as a filament. The mitochondrial region of the sperm head has the greatest diameter, which suggests that mitochondria gather into spherical masses at or around the posterior end of the head. The tail attaches to the mitochondrial region, and is long and thin, 8 to 10 times the length of the head. The tail is very thinly covered with cytoplasm. About 9 microtubules can be counted from the tail flagellum, but the exact number needs further determination. Microtubules are fairly resistant to macerating and digesting actions of phosphotungstic acid (PTA). Details of the ultrastructure of *Venus* sperm remain to be described. - J.L.M.

1085
Lindsay and Woelk (sic - probably Woelke). 1960.

Production of clam and oyster seed. In Fisheries, vol. III, by Moore, McLeod, and Reed. Wash. State Dept. Fish.: 81-85.

This was requested through interlibrary loan on 27 Sept 1977, but could not be located. It is almost certainly the elaborate set put together as a monument to Milo Moore. It is unlikely that the paper cited contains information about *Mercenaria (Venus) mercenaria.* Search terminated. - J.L.M.

1086
Linton, Edwin. 1915.

Note on trematode sporocysts and cercariae in marine mollusks of the Woods Hole region. Biol. Bull. 28: 198-209.

Among 13 molluscan species examined, including *Venus mercenaria,* several crustacea, and an annelid, larval trematodes were found only in *Ilyanassa obsoleta* and *Pecten irradians.* - J.L.M.

1087
Lippson, Alice Jane (ed.). 1973.

The Chesapeake Bay in Maryland - An atlas of natural resources. Natural Resources Inst., Univ. Md., Contr. 500, Johns Hopkins Univ. Press, viii + 56 p.

Hard clams are limited to the higher salinity areas of Chesapeake Bay and are not found in water where salinity is less than about 15°/₀₀. In the Maryland part of Chesapeake Bay they are found in Tangier and Pocomoke Sounds. The higher salinity of Chincoteague Bay has permitted establishment of stable populations of hard clams, and there is a commercial and a sport fishery there. In the bay they fluctuate with salinity and abundance of blue crabs. Near the Maryland-Virginia border there have recently been enough *Mercenaria mercenaria* to support a small fishery with escalator harvesters. - J.L.M.

1088
Liu, O. C., and R. J. Cipolla. 1967.

Study of antiviral factor from shellfish. Bact. Proc. 1967: 162 (abstract V164).

PR8 influenza A virus and 11-day chick embryos were used to test antiviral activity of extracts from various organs of *Mercenaria mercenaria.* Digestive diverticula (livers) were found to contain most activity; other organs and shell liquor contained very little. The factor was resistant to 50% chloroform, 25% acetic acid, and heat at 56°C for 120 min, but completely destroyed by 0.25% trypsin. Several other shellfish species from the west coast contained a similar factor in liver. - J.L.M.

1089
Liu, O. C., H. R. Seraichekas, and B. L. Murphy. 1966.

Fate of poliovirus in northern quahaugs. Proc. Soc. Exper. Biol. Med. 121: 601-607.

Uptake of type I poliovirus in hard clam occurred rapidly, reaching a maximum in a few hours and was maintained at that level as long as sufficient virus was present in the water. As the amount of virus in seawater was reduced, viral content of the clam was reduced. Most virus taken up by the clam was found in approximately equal amounts in digestive diverticula and hemolymph, little in other parts of the body. Continuous increase in viral content of clam feces indicated that viral uptake was a continuous process. Virus was not found intracellularly or chemically bound to any cell. This implies that virus can be cleansed from the digestive system if the clam is placed in viral free waters. Although virus was found in hemolymph in this experiment, it was probably due to high levels of contaminants used. In nature, such high levels are unlikely to occur and contamination of hemolymph should not be a significant problem. - D.L.

1090
Liu, O. C., H. R. Seraichekas, and B. L. Murphy. 1966.

Viral pollution of shellfish. 1. Some basic facts of uptake. Proc. Soc. Exper. Biol. Med. 123(2): 481-487.

Four experiments were conducted by polluting hard clams with a strain of type I poliovirus in a flowing water system. A higher uptake of virus was achieved by clams in water of low viral content than in high viral content. Clams were placed in sediment to simulate natural conditions, and polluted with virus of approximately 10 PFU/ml of sea water. When examined, the digestive diverticula had 3000-9000 PFU/g of poliovirus, over 90% of the virus found in the clams. By incubating pseudofeces in poliovirus polluted sea water, over 80% of the virus was adsorbed onto the mucus at all temperatures tested (4°-37°C). - D.L.

1091
Liu, Oscar C., Helen R. Seraichekas, and Bert L. Murphy. 1967.

Viral depuration of the northern quahaug. Appl. Microbiol. 15(2): 307-315.

Three strains of human enterovirus and 2 running-seawater systems were used to evaluate the feasibility of using the self-cleansing mechanism as a practical way of obtaining virus-free *Mercenaria mercenaria.* Infectious hepatitis virus was not available, but it was felt that results with other viruses were meaningful. Some previous studies had thrown some doubt on this approach, leading to the conclusion that although depuration of bacterially contaminated shellfish has been successful, depuration of virus-polluted bivalves was not likely because the contaminants were different. It was concluded that failure of these investigators to depurate soft clams and oysters was caused by their use of standing rather than running water.

Efficiency of viral depuration was a function of water temp within the range (5 to 20°C) tested. Reduction of salinity to 50-60% of the original level stopped the process completely, but 25% reduction had no significant effect. Depuration in a large tank was equally as efficient as that in small experimental tanks under the conditions of the experiment. In some European countries which depurate shellfish, no obvious hepatitis outbreaks associated with shellfish have occurred in 40 yrs, which inspires confidence in commercial application of the method. More information is needed before the process can be adopted with complete confidence in the United States. - J.L.M.

1092

Liu, Oscar C., Helen R. Seraichekas, and Bert L. Murphy. 1967.

Viral pollution and self-cleansing mechanism of hard clams. In Transmission of Viruses by the Water Route. Gerald Berg (ed.). Interscience Publishers Div., John Wiley & Sons, New York: 419-437.

Cites unpublished data of Feng and Haskin, who showed that maximal uptake of virus occurred within 2 to 3 hr in oysters and *Mercenaria mercenaria* polluted with large quantities of staphylococcal phage in seawater. In clean seawater, initial reduction in viral content was considerable, but complete elimination was not achieved after several transfers to clean seawater over more than 100 hr. Viral elimination was much faster at 15° than at 5°C. In recirculated seawater (Atwood et al.-also unpublished) quahaugs accumulated coxsackievirus B5 rapidly during the 1st 2 days in contaminated water. Then viral content declined as viral content of the water declined, but more slowly in clams than in water. The authors of this paper experimented with *M. mercenaria* exposed to LSc 2ab strain of poliovirus 1. In polluted waters viral pollution of clams occurred rapidly and maximum pollution of various organic systems was reached in a few hrs. High level of pollution was retained as long as sufficient virus was present in the water. As viral content of seawater was reduced, viral content of clams decreased correspondingly. These results agreed with those of some workers, but not with others. Reduction of viral content of shellfish was not slower in this study than reduction in surrounding seawater. It was not clear whether the discrepancy was caused by use of different species, e.g. oysters vs clams, or by differences in experimental conditions. When shellfish were held in stationary polluted seawater most virus was distributed equally in digestive diverticulum and in drained fluids, which presumably contained most of the shell liquor and some hemolymph. In polluted running seawater, uptake of virus was considerably higher in diverticulum and much reduced in fluid portions. This suggested that naturally polluted shellfish should accumulate most virus in the digestive system, but this was not investigated. The authors concluded that the self-cleansing mechanism appears uniformly efficient, provided that shellfishes are held under conditions that favor activity. Contrary results of others were attributed to poor aquarium systems. Running water systems, not standing or recycling, appear to be essential. Depuration in clean flow-through water for 48 to 96 hrs reduced virus concentrations to non-detectable levels in meats and shell liquor. Some problems remain to be solved before predictable commercial application is possible. - J.L.M.

1093

Liu, O. C., H. R. Seraichekas, D. A. Brashear, W. P. Heffernan, and V. J. Cabelli. 1968.

The occurrence of human enteric viruses in estuaries and shellfish. Bact. Proc. 1968: 151 (abstract V42).

In an estuary in Rhode Island, approximate viral isolation rates were: raw sewage from a nearby sewage treatment plant 100%; seawater 28%; quahaugs 33%; and oysters 55%. This confirmed a previous report that in estuaries shown by bacterial examination to have various levels of fecal pollution, human enteric viruses can be isolated from water and shellfishes, including *Mercenaria mercenaria*. - J.L.M.

1094
Loesch, Joseph G. 1974.

A sequential sampling plan for hard clams in lower Chesapeake Bay. Chesapeake Sci. 15(3): 134-139.

Using a relatively small hydraulic tow dredge, densities of *Mercenaria mercenaria* were estimated at 3 stations in the York River, Va. One was classified as a high-density area after 2 standard tows, one as medium-density after 8 tows, and one as low-density after 6 tows. An average of 4.2 tows/station was required to classify 167 sites. This represented a considerable saving of effort over a fixed, predetermined sampling plan. The sequential sampling plan was constructed easily from limited a priori knowledge of hard clam abundance and the fishery. Such a plan can be used to monitor relative abundance, with considerable saving of time over more detailed surveys. - J.L.M.

1095
Loesch, Joseph G. 1977.

A comparison of frequency distributions of hard clam, patent-tong catches. Chesapeake Sci. 18(1): 79-80.

A commercial patent-tong fishery for *Mercenaria mercenaria* operates in the York River, Va. Fishermen believe that catches have declined. The reality of this contention was tested by comparing frequency distributions of standardized catches in 1963 and 1972. The only difference was that occasional large catches made in 1963 exceeded highest catches in 1972. Although average catch was slightly lower in 1972, median catch increased. When the data were analyzed by the Kolmogorov-Smirnov two-sample test, the only difference was reduced range and smaller variance of 1972 catches. Views of clammers were not substantiated. - J.L.M.

1096
Loesch, Joseph G., and Dexter S. Haven. 1973.

Preliminary estimates of growth functions and the size-age relationship for the hard clam, *Mercenaria mercenaria*, in the York River, Virginia. Proc. Natl. Shellf. Assn. 63: 3 (abstract).

Two groups of hard clam ranging from the smallest size practical for individual marking through the larger sizes (approximately 30-90 mm in length) were measured, code-marked and planted in similar natural substrates at two locations in the York River. Both groups have been harvested, remeasured, and planted annually, and growth functions determined from length increments. - authors' abstract - D.L.

1097
Loesch, Joseph G., and Dexter S. Haven. 1973.

Estimated growth functions and size-age relationships of the hard clam, *Mercenaria mercenaria*, in the York River, Virginia. Veliger 16(1): 76-81.

Hard clam 30-90 mm long were marked and planted in 2 experimental plots, one on each side of the River. An indelible Felt Riter pen produced marks that lasted up to 3 yrs. Clams were recovered about once a year, measured, and replanted. Substrate was sand-mud with scattered shell. Depth was about 7 ft at MLW. Growth functions were derived by the Walford transformation method (regression of year x+1 on year x). Growth was more rapid in 1968-69 than in 67-68 or 69-70. Growth functions in 67-68 and 69-70 were approximately $Y = 12 + 0.85X$, in 68-69 of the order of $Y = 18.6 + 0.766X$. Calculated asymptotic sizes were 79-82 mm. These were believed to be too low. Relatively low salinity was suspected as the major factor limiting growth. Estimated asymptotic growth sizes would not be reached until age 22 yrs, but for all practical purposes growth ceases at 14 or 15 yrs. It was estimated that clams in this area would not reach littleneck (legal) size until 4 yrs nor cherrystone size until 8 yrs. They are then at about 56% and 81% of asymptotic size, respectively. Derived estimates of age-size relationship appeared to be reasonable, but the authors suggested that this should be checked by microscopic studies of transverse shell sections. - J.L.M.

1098
Loesch, Joseph G., and Dexter S. Haven. 1973.

Estimates of hard clam abundance from hydraulic escalator samples by the Leslie method. Chesapeake Sci. 14(3): 215-216.

Using the Leslie method, which uses the relationship between catch per unit of effort and cumulative catch in a sequential sampling scheme to estimate total abundance, numbers of clams on 7 half-acre plots were estimated. Then all clams on the plots were harvested and total counts compared with estimates. Differences between estimated and absolute abundance varied from zero to 7.6%. Depending on density of clams on the plots, time saved by subsampling ranged from an average of 7.7 hrs to as much as 14.2 hrs. (Abstracter's note: Assuming that the plots were precisely 1/2 acre each, densities ranged from 18.4 to 64.2 bu/acre. The average was 38.6 bu/acre.) - J.L.M.

1099
Loewi, O. 1921.

Title not given. Arch. Physiol., Bonn 189: 239.

Earlier observations on *Venus mercenaria* failed to give clear evidence for an opposing excitatory mechanism to release of acetylcholine (ACh) by electrical stimulation of visceral ganglion, which slowed beat and decreased amplitude, or stopped the heart. Budington (1904) found no acceleration when different ganglia were stimulated electrically. Carlson (1905) showed some excitation following recovery from inhibition. In several other molluscan species Carlson observed excitation only, following stimulation of ganglia or direct stimulation of heart. He concluded that some molluscan hearts are supplied only with inhibitor nerves, others with excitor nerves, and some with mixed nerves. Whether excitor nerves release, in molluscan heart, a substance comparable to adrenalin seems not to have been demonstrated, at least not for *V. mercenaria*. - modified quotation by Welsh (1953) from Loewi's paper, which is abstracted elsewhere in this bibliography - J.L.M.

1100
Lombard. 1886.

The temperature of the clam.

This reference is given in the bibliography of Belding (1916), abstracted elsewhere in this bibliography. It is given here in its entirety, as cited. According to Belding, Lombard recorded the temperature of a clam, possibly *Venus mercenaria*, with a thermo-electric instrument. The temp was 1/4°F higher than the surrounding water. - J.L.M.

1101
Loomis, F. B., and D. B. Young. 1912.

Art. III. - On the shell heaps of Maine. Am. J. Sci., 4th. Ser. 34(199): 17-42.

Examination of 8 shell heaps showed quahog remains at Sawyer's Island and White Island. Early layers were *Venus mercenaria*, later *Mya arenaria* was the species eaten. It was deduced that the original purpose in coming to the seashore was for fishing and possibly hunting, not for clams or quahogs. No trace of iron implements was found, which was interpreted to mean that the heaps were formed prior to about 1627. The bases of the heaps were estimated to have been laid down 300 to 500 years previously. (Abstracter's note: chronological positions of hard clam and soft clam remains may provide clues to the time at which relict populations of living hard clams were isolated from a more widely distributed habitat.) - J.L.M.

1102
Loosanoff, Victor. 1936.

Sexual phases in the quohog (sic). Science 83(2151): 287-288.

Young *Venus mercenaria*, 0.6 to 0.7 cm long, collected from Long Island Sound near Milford, Conn. in October, had distinctly bisexual gonads with very strong male predominance. Most had fully ripe spermatozoa in the central part of the lumen, and small ovocytes and indifferent gonia in the inner walls of the follicles. Apparently functional spermatozoa are found in follicles of many young clams throughout winter. The following spring the follicles are gradually extended until they occupy spaces around the stomach and between the digestive gland and the muscular body wall. Many animals at this stage may be taken for true males, but presence of young ovocytes with mitochondrial bodies and yolk nuclei indicated the bisexual character of gonads. When water temp reaches the critical point in midsummer, ripe spermatozoa are discharged. Soon after, 2 distinct types of individual are distinguishable as definitive males and females. In males a 2nd period of spermatogenesis begins in autumn and continues slowly through winter. Spermatozoa are discharged late the next summer at a shell length of 3 cm or more. Those young destined to become females have follicles with empty lumina as sperms are discharged. At the end of the initial male phase the follicles remain distended with only a thin layer of undifferentiated cells and small ovocytes along the inner walls. Numerous phagocytes usually invade the follicles and devour the pycnotic and degenerated male cells. Ovogenesis begins in spring and follicles contain mature ova in June and July. With few exceptions, adults are of separate sexes, although gonads of most adult males contain small ovocytes somewhere along the walls of the follicles. Adult males contain mature sperms at all times except for a short post-spawning period. Adult females also contain large ova at all seasons. Thus, primary gonads of *V. mercenaria* are protandric, although not exclusively so. A few individuals develop into females without passing through a functional male phase. - J.L.M.

1103
Loosanoff, Victor L. 1937.

Spawning of *Venus mercenaria* (L.) Ecology 18(4): 506-515.

Spawning of hard clam in Long Island Sound occurred at temperatures below 24.0°C. In the lab, spawning occurred at temperatures from 23.0°-30.2°C. Most males spawned at 25.0-26.0°C and most females at 29.0°C. At temperatures 25.0-30.0°C it took longer to induce females to spawn than males. The latent period of spawning reaction is generally shorter at higher temperatures. No method was found to induce spawning at temperatures lower than 23.0°C. Only a few times did raising of water temperature or addition of gametes or both induce spawning. Attempts to fertilize eggs artificially extracted from female clams were unsuccessful. - D.L.

1104
Loosanoff, Victor L. 1937.

Development of the primary gonad and sexual phases in *Venus mercenaria* Linnaeus. Biol. Bull. 72(3): 389-405.

Examination of hard clams from Long Island Sound showed a primary bisexual gonad formed when the clam length was 4-6 mm. Primary gonad formed from associations of germinal cells in the connective tissue at the level of or slightly below the heart. Lumen soon appeared in gonad follicle, and germinal cells began rapid proliferation. Primary gonad contained antecedent cells of both sexes but its protandric nature was manifested by rapid proliferation of spermatogenic cells. A few individuals developed as females without passing through a functional male phase. Functional spermatozoa were seen in gonads of 5-7 mm clams in October and November.

Some of these clams had discharged spermatazoa at this time. Definitive males and females became distinguishable in September of their second year, after they have spawned as males. In males a second period of spermatogenesis begins in autumn and continues at a reduced rate in winter. Many small ovocytes are retained by the male sexual gland. Gonads of clams to become females after their male phase, remain empty and distended through winter. Ovogenic activities began in spring when water temperature approached 15°C. Three true hermaphrodites were found in 650 clams studied. - D.L.

1105
Loosanoff, Victor L. 1937.

Seasonal gonadal changes of adult clams, *Venus mercenaria* (L.). Biol. Bull. 72(3): 406-416.

Spawning of hard clam in Long Island Sound was completed at the end of August or early September. Post-spawning males began gametogenetic activities by late September or early October and continued until hibernation in mid-December when water temperature was about 5°C. Except for a brief post-spawning period, mature adult males contain mature spermatazoa every season of the year. Soon after female clams discharged the bulk of their ripe eggs, ovogenetic activities began. Ovocytes continued growing rapidly in late fall and growth occurred although at a much reduced rate during winter. By the end of May, the females are sexually mature and will discharge their eggs when water temperature is at the point which induces spawning. - D.L.

1106
Loosanoff, Victor L. 1937.

Spermatogenesis in the hard-shell clam (*Venus mercenaria* Linnaeus). Yale J. Biol. Med. 9: 437-442.

Describes in detail, for the first time, with illustrations, the various stages of spermatogenesis in quahogs. - J.L.M.

1107
Loosanoff, Victor L. 1939.

Effect of temperature upon shell movements of clams, *Venus mercenaria* (L.). Biol. Bull. 76(2): 171-182.

An apparatus which measures and records shell activity of bivalves was described. Forty-seven hard clams attached to the apparatus for 399 days were subjected to temperatures from -1.0°-28.0°C. The length of time that shells remained open partly depended on water temperature. Hibernation began when water temperature was decreased to 5.0 and 6.0°C. In the range 3.9°-10.9°C, the average time shells remained open increased from 4 to 88% of the total time with increasing temperature. There was no such correlation in the temperature range 11.0-27.9°C, in this range, shells were open 69-90% of total time. Clams remained open 90% of total time at temperatures 21.0-22.0°C. There was considerable variation in behavior among clams under identical environmental conditions. - D.L.

1108
Loosanoff, Victor L. 1941.

Pearl in quohog (sic). Am. Naturalist 75(759): 399-400.

Well-formed, lustrous pearls (or pearls of any kind), are very rarely found in hard clams, probably because the edge of the mantle is firmly attached to the shell along its pallial line. This excludes foreign particles which might serve as a nucleus. A clam at least 5 yrs old taken from a tributary of Milford Harbor, Conn. contained a pearl of perfect oval shape 1.4 cm long, 1.1 cm wide, and weighing 3.1 g. It was milky white with a delicate pink tint. Both valves of the clam had a healed scar from umbo to edge. At the edges of the shell this produced a deep V-shaped notch. Formation of the pearl probably was induced at the time the shell was broken, by introduction of a sand grain or piece of shell. - J.L.M.

1109
Loosanoff, V. L. 1942.

Possibilities of developing hard-clam fishery in Connecticut waters. In Bienn. Rept. Shell-fish Commissioners, State of Conn., 1941-1942: 13-15.

At the time of writing the yield of *Venus mercenaria* annually in Conn. was only 178,000 lbs of meats valued at $22,426, but this could be increased by cultivation. It was estimated that a hard clam farm could yield as much as 600 bu of 2 1/2-inch clams per acre per year. Most hard clams spawn at one year old. Spawning begins when water temp reaches about 73°F, in late July or August. Each female releases millions of eggs 1/325 inch in diam. Setting occurs in 10 to 14 days, depending on water temp. Young clams burrow into the bottom at about 1/8 to 1/4 inch long. After that they are relatively stationary. Clams grow best in warmer waters. Most become inactive in fall, when water temp drops to about 42°F. Therefore, the animal grows only from May to mid-November, fastest from mid-July through September. Average length at the end of the first growing period in New England waters usually is less than 1/4 inch. In succeeding years average length is about 1.1, 2.0, 2.5, 3.0, and 3.2 inches at age 1 1/2 to 5 1/2 yrs. Maximum length is about 5 1/2 inches and maximum age 20 to 25 yrs. Principal enemies are cockles and conch. Sea stars are not serious predators of buried clams. Hard clams live from almost high-tide level to more than 50 ft deep. Shallow flats below low water mark were not used for oyster cultivation and could be utilized for clam farming. Fine sand and mud in the ratio 2 parts sand: 1 part mud is most desirable. Water should be free of pollution. The area should be sheltered from wind and rough water, and water should be at least 3 ft deep at low tide. If clam setting occurs nearby, problems of transporting young clams will be absent. Various methods of harvesting seed clams are suggested. Digging of flats just prior to setting often helps in getting better sets. Preparation of ground for planting requires removal of thick grass, stones and other debris which would interfere with harvesting or with predator control. It is best to plant in relatively warm weather, when clams are active and will burrow soon after planting. If water circulation is good, as many as 25 seed clams/ft^2 of bottom can be planted. Some clearing of seaweeds and predators may be necessary. - J.L.M.

1110
Loosanoff, Victor L. 1944.

Soft and hard clams of the Atlantic coast of the United States. U.S. Fish Wildl. Serv., Fish. Leaflet 13, 11 p.

Essentially repeats information contained in other papers by the author and others. Included are distribution and habitat, reproduction, growth, enemies, cultivation, food value, sanitary control, and regulation of fisheries. Eight papers on hard clam, abstracted elsewhere in this bibliography, are listed. - J.L.M.

1111
Loosanoff, V. L. 1946.

Commercial clams of the Atlantic coast of the United States. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Leafl. 13, 12 p.

Venus mercenaria is one of only 4 clam species of commercial importance on the Atlantic coast of North America. Before the war only hard and soft clam were taken commercially, now ocean quahog and surf clam are taken. About 10% of hard and soft clams came from private beds, the rest from uncultivated public grounds. Hard clam ranges from Maine to Fla., but is most common in Mass., R.I., N.Y., N.J., and Va. They live from almost high tide level to over 50 ft deep, but are usually most abundant on flats several ft below low tide. Because they can exist on almost every kind of bottom and over a wide depth range, possibilities for clam farming are promising. Nearly all develop as males, but, usually during the 2nd yr, about half change to female. Some may spawn at 3 or 4 months, but most hard clams spawn at 1 yr. Spawning begins when water temp reaches about 73°F. Spawning season is longer in southern waters. Several million eggs, 1/325 inch in diam, can be discharged by a female in one season. Setting takes place in 10 to 14 days, depending on temp. At 1/8 to 1/4 inch young clams burrow into the bottom; they can crawl, but are essentially stationary. Growth is affected by currents, depth, salinity, and temp. Good currents are needed to provide food and oxygen and to keep beds clean. Natural beds are in brackish water of salinity 10 to 28°/₀₀. In the intertidal zone clams do not feed when exposed, and growth is retarded. Most clams become inactive when water temp falls to 42°F and remain inactive until spring. Thus, in northern waters clams grow only from May to mid-Nov. Growth is fastest from mid-July through Sept. Growth varies with locality. In New England average size at end of first growing season usually is less than 1/4 in. Size increases to about 1.1, 2.0, 2.5, 3.0, and 3.2 in at ages 1 1/2 to 5 1/2 yrs respectively. The few clams which reach 5 1/2 inches are 20 to 25 yrs old. Principal enemies are *Neverita duplicata* and *Polinices heros*, which perforate the shell in the umbo region, and *Fulgur caniculatus* and *F. carica* which break the edges of the clam shell and insert the probiscis to feed on the meat. Sea stars attack and devour clams lying on the bottom, but are not dangerous to clams in their burrows. Waterfowl and some bottom-feeding fishes also are predators. At present the supply of hard clams exceeds demand. Cultural methods could be used to increase the supply. A hard-clam farm could yield up to 600 bu of 2 1/2-inch clams per acre per yr. Chief requirements are good water circulation and sufficiently firm bottom. At least 3 ft of water at low tide is best, to avoid effects of severe winters. Water should be clean and well protected from wind and rough water. A nearby source of seed clams is important. Hard clams usually set less abundantly than soft clams. Seed should not be planted in cold weather because they will not burrow. Bottom should be cleaned of debris and predators. In good water circulation as many as 25 seed clams/ft^2 of bottom can be planted. The edible portion makes up about 16 to 19% of the total weight. About 12 pints of meats can be obtained from a bushel. - J.L.M.

1112

Loosanoff, Victor L. 1950.

Variations in Long Island Sound oyster set. Atl. Fisherman, Jan. 1950, 30: 15, 47.

(Identified by a footnote as excerpts from a paper by Dr. Loosanoff.) Good sets of oysters in Connecticut are infrequent. It is concluded that absence of proper food may be the cause. This is supported by the observation that if predation were the cause, larvae of clams (not identified, but almost certainly *Mercenaria (Venus) mercenaria*) and other mollusks would have suffered a similar fate, which they do not. In the laboratory, oyster larvae apparently could not assimilate certain plankton forms, and did not grow, although the same foods were readily assimilated by clams. This was true even if oyster larvae were the dominant mollusk in cultures. In the field, clam larvae of all stages are almost always present during summer, but oyster larvae seem to disappear within a few days of hatching. - J.L.M.

1113

Loosanoff, V. L. 1954.

New advances in the study of bivalve larvae. Am. Scient. 42(4): 607-624.

The work had 5 principal objectives: to open up a field for studies of physiological and ecological requirements; interest in heredity and selective breeding; identification of mollusk larvae in plankton collections; study of larval diseases and parasites and their control; and preliminary steps toward producing commercial supplies through artificial propagation. Methods of spawning, food requirements, effects of temp and other environmental factors, and larval diseases and parasites are discussed. Data are given for hard clam *(Mercenaria mercenaria)* and other molluscan species. - J.L.M.

1114
Loosanoff, Victor L. 1956.

On utilization of salt water ponds for shellfish culture. Ecology 37(3): 614-616.

In large bodies of water like Long Island Sound shellfish beds are vulnerable to damage by storms, and control of predators is difficult. These problems might be avoided by using relatively small bodies of water which are well protected and easier to manage. Preliminary steps to determine suitability of specific bodies of water are suggested: 1) a general survey to determine total area and depth distribution, character of bottom and area suitable for shellfish, presence and condition of native shellfish in different parts of the pond, and occurrence and distribution of enemies; and 2) study changes in salinity, temp, and pH; dissolved O_2 with depth; seasonal changes in nutrients and plankton; tidal range and direction and velocity of currents; if the pond has no connection with the outside, and currents are sluggish, consider the possibility of installing circulating and aerating devices. Possibilities of controlling tidal flow in ponds with narrow openings also should be considered, as should be the possibility of salinity control. With this knowledge of local conditions and an understanding of industry and culture practices, and of the biology and ecology of the species, plans can be made and experiments designed to make maximum use of the pond. Certain devices and methods that might be used to improve conditions are discussed. The species in mind was American oyster, but it is pointed out that these techniques would be applicable to *Venus mercenaria* and other bivalves. - J.L.M.

1115
Loosanoff, V. L. 1958.

Challenging problems in shellfish biology. In Perspectives in Marine Biol. A. A. Buzzati-Traverso (ed.). Univ. Calif. Press, Berkeley: 483-495.

This is mainly a review article. It discusses physiologically different races within molluscan species, their temperature relationships, salinity, tolerance to silt, differences in food requirements, quality and quantity of planktonic food, genetics of mollusks, hatchery practices, disease control,and control of predation. References to *Mercenaria mercenaria* cite papers abstracted elsewhere in this bibliography. - J.L.M.

1116
Loosanoff, V. L. 1959.

You, too, can now hatch clams. Prog. Fish Cult. 21(1): 35.

Venus mercenaria and *Crassostrea virginica* can be cultivated artificially, routinely and in large numbers, from egg to a size large enough to be planted as seed. Spawning of hard clam can be induced any time of year. Ecological and physiological requirements of larvae, control of disease, parasites and predators, and other problems are mentioned but not discussed in detail. Already about a million seed clams had been distributed for experimental planting. - J.L.M.

1117
Loosanoff, V. L. 1959.

Condylostoma- an Enemy of Bivalve Larvae. Science 129(3342): 147.

An unidentified species of *Condylostoma* was observed feeding on *Venus mercenaria* and *Crassostrea virginica* larvae in laboratory cultures with high concentrations of organisms. *Condylostoma* is a ciliated protozoan ranging in size from 400 to 900 μ, but is not common in natural shellfish growing areas. Members of the closely related family Folliculinidae, common on oyster beds, and other members of the suborder Heterotrichina may be natural predators of bivalve larvae. - W.J.B.

1118
Loosanoff, Victor L. 1959.

The size and shape of metamorphosing larvae of *Venus (Mercenaria) mercenaria* grown at different temperatures. Biol. Bull. 117(2): 308-318.

Size at metamorphosis has been suggested as one criterion for identification of lamellibranch larvae. Others have maintained that size may be a function of environmental variables. Four experiments were conducted to settle the question for hard clam larvae. Numbers of days required from fertilization to setting varied with temperature from about 20 days (range 16-24) at 18°C to about 7 1/2 days (range 7-9) at 30°C. The relationship appeared to be linear. No significant differences in mean length at setting were found at five temp levels from 18 to 30°C. Extrapolation beyond these limits is not valid, however. The length/width ratio did not change significantly with temp, neither did maximum length. The results should be interpreted with caution, because growth rates and sizes at various stages will vary with amounts and quality of food, or with numbers of larvae per unit volume of water. It had formerly been assumed that eggs and larvae of the southern hard clam, *M. campechiensis*, might have just as long a pelagic life as the northern counterpart, *M. mercenaria*. If so, then eggs of the southern species would cleave and develop more slowly than those of the northern species at a given temperature. To test this, clams of both species were ripened under identical conditions in the laboratory, and fertilized eggs of both were grown at 21°C. Rates of growth were almost identical and setting of larvae began at the same time. - J.L.M.

1119
Loosanoff, Victor L. 1960.

Some effects of pesticides on marine arthropods and mollusks. In Trans. 2nd Seminar on Biological Problems in Water Pollution, 20-24 Apr 1959. C. M. Tarzwell (ed.). U.S. Dept. HEW, Pub. Health Serv., Robt. A. Taft Sanitary Eng. Center, Cincinnati: 89-93.

Lists about 100 chemicals which are toxic to arthropod predators of oysters, including green crab, *Carcinides maenas*, which is also a clam predator. Some of these are also harmful to oysters, especially larvae, but they can be used to create chemical barriers to migration of some predators. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1120
Loosanoff, Victor L. 1961.

Recent advances in the control of shellfish predators and competitors. Proc. Gulf Caribb. Fish. Inst., 13th Ann. Sess., Nov. 1960: 113-128.

In hatchery trays and troughs an amphipod, *Corophium cylindricum*, interferes seriously with recently set *Venus mercenaria*. The amphipod can be exterminated easily with water solutions of several insecticides, such as Guthion, Dipterex, Parathion, Lindane, TEPP and Sevin, at concentrations of 1.0 ppm or lower. Such concentrations do not noticeably affect algal cultures, and they do not affect bivalves or other larvae which are fed treated *Chlorella*. The paper deals principally with predator control on oyster grounds, using water solutions of pesticides, direct chemical treatment, chemical barriers, prevention of fouling, repelling drills from set collectors, baits, and other uses of chemicals. Most treatments and techniques also would be applicable to hard clam. The author recognized that any chemical entering natural waters may be a pollutant, and the review was made with that problem in mind. - J.L.M.

1121
Loosanoff, V. L. 1961.

Effects of turbidity on some larval and adult bivalves. Proc. Gulf Caribb. Fish. Inst. 14th Ann. Sess: 80-95.

Results of these experiments strongly supported the view that lamellibranchs feed most efficiently in relatively clear water. New data reported were for American oyster. Data on *Venus mercenaria* were from work of H. C. Davis, abstracted elsewhere in this document. - J.L.M.

1122
Loosanoff, V. L. 1962.

Long Island Sound spawning and setting observations, Summer 1961. Comm. Fish. Rev. 24(2): 35.

Mercenaria mercenaria is not mentioned. - M.W.S.

1123
Loosanoff, V. L. 1962.

Controlling experimental conditions in studies of eggs and larvae of aquatic forms. Am. Zool. 2(3): 426-427 (abstract).

Mercenaria mercenaria can now be induced to spawn any day of the year. Reliable production of certain species of algae in unialgal and bacteria free cultures assures a good supply of live foods. Dried algae, including such unicellular forms as *Scenedesmus* sp., and especially freeze-dried naked flagellates such as *Isochrysis galbana* and *Monochrysis lutheri* proved to be excellent foods. Antibiotics and certain chemicals help to control pathogenic bacteria in larval cultures, thus preventing mortality due to disease. Good control of environmental conditions allows extensive studies to be made on the effects of factors such as light, temp, salinity, turbidity, pH, quality and quantity of food, inter- and intra-specific competition and water currents on development of young mollusks. Controlled conditions also lead to study of diseases of larval and juvenile mollusks, and open the field of selective breeding of species of commercial importance. - J.L.M.

1124
Loosanoff, V. L. 1963.

Laboratory technique of hard clam culture. Proc. Natl. Shellf. Assn. 52, August 1961: iii.

Listed by title only. - J.L.M.

1125
Loosanoff, Victor L. 1964.

New shellfish farming. Trans. 29th N. Am. Wildl. Nat. Res. Conf. (1964): 332-337.

Deterioration of the coastal environment and growth of human populations may require mariculture to produce adequate protein from animals. To replace diminishing natural set, hatchery culture must be substituted. Mollusks reared in hatcheries must then be grown to market size, which will require, among other things, predator control. Scientists of the U.S. Bureau of Commercial Fisheries have developed techniques by which they can maintain in the laboratory ripe, ready-to-spawn oysters and *Mercenaria mercenaria* year-round. Clams can be induced to spawn in winter by gradually increasing water temp over a 3-week period, or spawning can be delayed in summer by holding clams at lower temp. Basic technique for rearing larvae is to change water every 2 or 3 days to get rid of metabolic products. Under sanitary conditions 50 to 100 larvae per cc of water can be grown to metamorphosis without undue mortality or delay in growth rate. The most suitable food organisms are known, and mass culture methods have been developed. Freeze-dried algae also are a suitable food. Effects of temp and turbidity on larvae are understood. Epizootic mortalities of larvae occur from time to time. These are caused by fungi or bacteria found in seawater. Various agents such as certain chemicals, sulfa drugs, and antibiotics can be used to control such diseases. Genetic studies promise to allow selection for desirable characteristics, such as breeding at lower temps, disease resistance, fatter meats, and rapid growth. Growth to market size is not a difficult problem if suitable bottoms are selected, or suspended culture is used. Predation by drills, sea stars, crabs, and other animals must be controlled, but methods are available for control. Improvements in mechanical methods for shellfish farming also will be needed. (Abstracter's note: It is true that all these things are possible, and many of the techniques have been developed to the point of practicality. The chief problems are economic. If costs can be held to reasonable levels, clam mariculture certainly is possible. It is not clear yet that costs are reasonable.) - J.L.M.

1126
Loosanoff, Victor L. 1965.

Mariculture...Its recent development and its future. Agric. Engin. 46(2): 73,93-97.

A popular account of the potentialities of mariculture from algae to mollusks and crustaceans, and results of some work of the laboratory at Milford, Conn. The author concludes that the future of mariculture is bright, but that the science is still in its infancy. *Mercenaria mercenaria* is mentioned, among other species. - J.L.M.

1127
Loosanoff, V. L. 1966.

Problems in identification of bivalve larvae. Proc. Natl. Shellf. Assn. 56: 5 (abstract).

The abstract contains virtually no information not suggested by the title. - J.L.M.

1128
Loosanoff, Victor L. 1971.

Development of shellfish culture techniques. In Proc. Conf. Artif. Propag. Comm. Valuable Shellf. - Oysters. Coll. Mar. Stud., Univ. Del., Newark: 9-40.

Concludes that during the 1st 4 decades of the 20th century no reliable, generally acceptable methods for rearing bivalve larvae had been developed. Stripping of ripe eggs of *Mercenaria mercenaria* did not work because the germinal vesicle remains unbroken and prevents fertilization. Conditioned clams could be induced to spawn many times during the same spawning season by appropriate manipulation of temperature. Pulverized dry algae were difficult to use as larval food because the particles needed to be ground small enough for ingestion. However, algae such as *Ulva* or *Laminaria*, ground 20 years before and dried, was used successfully to rear *M. mercenaria* larvae to metamorphosis. Hard clam larvae are not as highly selective of food as oyster larvae. This historical review contains numerous references to *M. mercenaria*, all of which are abstracted elsewhere in this bibliography. This paper is a useful summary of developments, especially for *Crassostrea virginica*, but the techniques and conclusions apply generally to commercial bivalves. It concludes that the Bureau of Commercial Fisheries Laboratory at Milford, Conn. played an important role in development of the methods described. The contributions of Harry C. Davis are recognized, as also are those of other scientists and administrators who assisted. Edwin Fordham of Stratford, Conn. is recognized as the first practical shellfish hatchery operator in the United States, who was rearing bivalve larvae in 1954 at a hatchery on the Housatonic River. - J.L.M.

1129
Loosanoff, Victor L. 1972.

Research requirements for development of molluscan farming in the United States. In Progress in Fishery and Food Science. Remedios W. Moore (ed). Univ. Washington Pub. Fish., New Ser. 5, Seattle: 165-179.

This review article discusses *Mercenaria mercenaria*, among other species, under such headings as improvement of rearing methods for larvae and juveniles, selective breeding, diseases and their control, enemies and their control, contents and possible therapeutic qualities of meats, utilization of thermal effluents, purification and detoxification, improving farming methods, and revision of laws. The paper contains no new data, but it does introduce ideas and suggestions for further attention. The author concluded that shellfish culture in the U.S. is still in a relatively primitive stage. - J.L.M.

1130
Loosanoff, V. L. 1973.

Urgent problems of molluskan farming. World. Maricult. Soc., Proc. 4th. Ann. Workshop: 341-352.

The paper does not deal specifically with *Mercenaria mercenaria*, but problems discussed are common to all species. Needed are methods to purify mollusks that have become toxic from feeding on toxic plankton, better understanding of the physiology of nutrition and development, and broad use of specifically prepared foods, studies of epizootics and methods of their control, radical changes in laws respecting mariculture, and training of future mariculturists. Although mariculture is often referred to as an ancient art that has been practiced for over 2,000 yrs, it has made virtually no progress in that time. Principal constraints on molluscan farming, until recently, were from limited budgets. - J.L.M.

1131
Loosanoff, V. L., and H. C. Davis. 1949.

The spawning of quahaugs in winter and culture of their larvae in the laboratory. Convention addresses, Natl. Shellf. Assn. 1949: 58-66.

Active and rapid gametogenesis begins in *Mercenaria (Venus) mercenaria* soon after the completion of spawning, and by the end of October active spermatozoa can be found in virtually all follicles of males. Thus, except for a brief post-spawning period, spawning can be completed at all seasons. Ova develop similarly. Clams are conditioned by raising temp slowly or immediately to about 20°C. Under the latter conditions clams were brought from near 0°C to spawning in 8 days. Conditioned clams are induced to spawn by raising the temp to 32° to 34°C. Some groups spawned at temps as low as 20.6°C. Clams provided spawn for 5 or 6 weeks before most were spent. Temp was more important than stimulation by addition of sperm or eggs. The egg measures about 70 μ in diameter, and differs from eggs of many other lamellibranchs because it is surrounded by a thick gelatinous envelope the diameter of which varies between 163 and 170 μ. The larva enters the trochophore stage about 12 hrs after fertilization. By this stage the gelatinous envelope is gone. A shell covers the animal within 24 to 36 hrs after fertilization, and in another 8 to 12 hrs the veliger or straight hinge stage is reached. This veliger swims with a well-developed velum. By the 6th day it is in early umbo stage, in 8 days in medium umbo stage, and in 10 days in late umbo stage, and in 12 days some of the mature, ready-to-set larvae may be as large as 227 to 210 μ. Just prior to this stage the larvae begin to undergo very prominent changes. The velum begins to disappear and some functions are taken over by a foot. The ciliated foot first aids in swimming, but gradually is used to glide over the bottom and to crawl. Many larvae reached setting stage in about 12 days. Length of the prodissoconch is 210 to 225 μ, or sometimes up to 240 μ. Larvae are not too selective in their food. On almost a pure culture of *Chlorella*, however, they grew more slowly and suffered heavier mortality. Cultivation of clam larvae to setting is relatively easy. - J.L.M.

1132
Loosanoff, Victor L., and Harry C. Davis. 1950.

Conditioning *V. mercenaria* for spawning in winter and breeding its larvae in the laboratory. Biol. Bull. 98(1): 60-65.

Hard clam larvae were reared in the laboratory. Adult clams were removed from 0.0°C waters of Long Island Sound and placed in trays of running seawater 5.0-7.0°C. Water temperature was raised several degrees every few days until it reached 20.0-22.0°C. Clams were now conditioned to spawn and were induced to spawn by raising water temperature several more degrees. Embryos were filtered and placed in jars where they were fed mixed plankton cultures, primarily forms less than 5 μ in size. Morphology of the developing larvae was given. Most larvae reached setting stage in 12 days, but some cultures at 24.0°C set in 10 days. - D.L.

1133
Loosanoff, V. L., and H. C. Davis. 1951.

Delaying spawning of lamellibranchs by low temperature. Sears Found., J. Mar. Res. 10(2): 197-202.

Venus mercenaria and several other bivalves can be spawned artificially in winter by gradual increase in water temp to that at which they spawn in summer. Conditioning for spawning in late fall and winter is possible only after recovery from summer spawning, a stage that may not be reached until the end of October by some bivalves. Adult hard clams from Long Island Sound were transplanted to Boothbay Harbor, Me., where the water is about 5 to 8°C cooler in summer. The transplant was made in May, and the clams were brought back to Milford, Conn. in Sept of the same year. The clams were ripe, with extremely thick gonads and were easily induced to spawn. Another batch was brought back in October, with identical results. Clams held in cool water through summer can be stimulated to spawn at any time from fall to the following spring. - J.L.M.

1134
Loosanoff, V. L., and H. C. Davis. 1953.

Some observations on larvae of *Venus mercenaria* carried on at Milford during the past year. 4th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 7-8.

Cultures of *Chlorella* sp., *Chromulina pleiades*, *Isochrysis galbana*, a species of *Chlamydomonas*, and a blue-green alga, *Porphyridium*, were fed to *Venus* larvae. All but *Porphyridium* gave good growth to setting. *Venus* larvae survived to setting even in concentrations of *Chlorella* as high as 500,000 cells/cc but died in 1 million *Chlorella*/cc. Optimum concentration may be about 250,000 cells/cc. - J.L.M.

1135
Loosanoff, Victor L., and Harry C. Davis. 1963.

Rearing of bivalve mollusks. Adv. Mar. Biol. F. S. Russell (ed.). Academic Press, N.Y. 1: 1-136.

Belding in 1912 could not raise hard clam larvae. He concluded that there was no practical method for rearing to straight-hinge stage because the egg was small and delicate. Wells in 1927 carried larvae to metamorphosis. At Milford, Conn., of 21 species or hybrids, larvae of American oyster and hard clam have been studied most intensively. The equipment is described and figured in detail: storage tanks, pumps, piping, filters, and ultraviolet light to eliminate undesirable organisms. To condition for out-of-season spawning mollusks must be kept in running seawater at temp of 18-20°C or higher. Warm seawater is also needed for rearing larvae and juveniles in winter. The heat exchanger is described. Temp of about 24°C is optimal for growth of algae which are best larval foods (e.g. *Isochrysis galbana*). Gametes from mollusks placed directly in water of about 20°C are no less viable than those from mollusks conditioned gradually. Obtaining spawn from hard clam is relatively simple in summer. Merely raise water temp a few degrees and add sperm suspension. But hard clam larvae can be raised year-round by proper manipulation. The entire conditioning period for clams in winter takes about 2 to 3 wks; less in spring. In Long Island Sound hard clams may continue to spawn until late August or mid-September. They do not completely recover until end of November. Many complex physiological processes lead to accumulation of reserve materials, of which glycogen is most important. Clams cannot be conditioned to spawn during this period. But to supply ripe clams from late August to late November it is possible to delay gonadal development until late fall by reducing water temp. One way of doing this was to take clams early in the season, e.g., late May, and transplant to Maine, where summer water temp averages about 7°C lower. *M. mercenaria* does not resorb undischarged gonad material in fall as oysters do. In Maine waters Long Island Sound clams retain sperm or eggs through summer and can be induced to spawn in fall, winter or spring, always producing gametes which develop into normal larvae. Hard clam also can spawn several times per year provided that changes in ecological conditions, especially temp, are controlled so that they recover rapidly from spawning. Method of spawning ripe clams in summer is: ripe clams are placed in glass spawning dishes with about 1 liter of seawater of the same temp at which they were conditioned. Dish is partly immersed in a large tray which is filled with hot water, thus quickly raising temp in dish to desired level. Attempts to fertilize eggs stripped from females usually fail because germinal vesicles remain intact. This can be avoided by breaking down vesicles in a weak solution of NH_4OH, but the percentage of normally developing larvae is relatively low. In a single spawning a female clam may release as many as 24.3 million eggs. There is no significant difference in viability of spawn produced by hard clams of different ages, ranging in length from 37 to 110 mm. The egg proper of hard clam measures only 70-73 μ, but total diameter of egg and surrounding gelatinous membrane is about 170 μ. Abnormal development of eggs and larvae may occur. Cultures in which less than 50% of eggs develop into normal straight-hinge larvae were discarded. Sometimes abnormality is associated with kind of food, e.g., some hard clam larvae will cease to feed in presence of *Chlamydomonas* sp., become emaciated, and die. Others in the same culture will feed and grow normally. Clam larvae that are abnormal from overcrowding, low temp, or high turbidity often grow to metamorphosis if returned to favorable conditions. Dense algal blooms may also cause abnormal development. Plankton samples collected during or immediately after heavy algal blooms are often devoid or almost devoid of bivalve larvae. Heavy blooms of dinoflagellates also may cause abnormal development. New vessels of soft glass may contain substances toxic to clam eggs or larvae. Growth rate of veligers from straight-hinge to metamorphosis is affected principally by food and temp, especially temp. Hard clam larvae kept at near 30°C began to set as early as 7 days after fertilization, at 18°C only after 16 days. Clam larvae from the same parents, under identical conditions, varied considerably in growth and time to metamorphosis. Clam larvae can endure and even grow in very turbid water. Clams will grow from egg to metamorphosis at temps from 18 to 30°C. At temps much higher or lower, metamorphosis is inhibited. Early cleavage eggs have a narrower temp tolerance than more advanced stages. In cultures at constant temp of 24°C and good food, like *Isochrysis galbana*, hard clams begin to set 12 days after fertilization. They can not tolerate low salinities as oysters can. Optimal salinity for development of eggs was about 27.5°/°°. Normal larvae did not develop at 17.5°/°° or lower. Upper limit was 35°/°° but few normal larvae were produced. Straight-hinge larvae grew reasonably well at 17.5°/°°, but at 15°/°° none metamorphosed. Hard clam larvae seem to be able to utilize most microorganisms small enough to be ingested. Larvae can grow and metamorphose on a restricted diet, even a single algal species like *Chlorella* or some other species. There was no evidence that organic detritus is utilized. Hard clam larvae can select certain foods from a mixture. They can regulate food intake and thus survive in heavy concentrations of food, but over a long time this regulatory capacity is impaired and larvae may become choked with food and die. Optimal concentrations of food cells depended on their size. Large food cells must be in lower concentrations per unit volume of water than smaller cells. Dense concentrations of certain foods like *Chlorella* affect clam larvae mechanically by interfering with swimming and feeding, and chemically by production of toxic external metabolites. Some organisms have high food value as foods for clam larvae, others cannot be utilized at all. Larval growth rates vary with type of food. With some organisms, like *Monas* sp., unfed controls grew and survived better than experimental larvae. Many clam larval cultures did well on dried and pulverized *Ulva*, but problems arose because it was difficult to grind particles small enough, material settled to the bottom, where it was unavailable, and decomposition fouled cultures. Using dried *Scenedesmus* and *Chlorella*, agitating cultures, and controlling bacteria, eliminated these problems. Overcrowding of clam larvae is not so serious a problem as it is with other bivalves, but crowded clam larvae grow more slowly. At densities as high as 250 eggs per ml most developed into normal straight-hinge larvae. Metamorphosis is a gradual process for hard clams. Advanced larvae have a functional velum and a foot, and alternatively swim and crawl, perhaps for days. It is suggested that this may have survival value by postponing metamorphosis if environmental conditions are unfavorable. Hard clam larvae may metamorphose at about 175 μ but usually not until 200-210 μ long. Regardless of temp, larvae are always about the same size at setting. Eggs and larvae of *M. campechiensis* grown at the same temp as *M. mercenaria* do not necessarily grow more slowly, as was formerly believed. A fungus, *Sirolpidium zoophthorum*, can affect larvae of northern and southern hard clam and their hybrids, often assuming epizootic proportions in *M. mercenaria*. Larvae of all ages and juvenile clams up to 400 μ long can be infected severely and die. Bacterial infections can be controlled with antibiotics or ultraviolet light. Routine use of certain chemicals also can improve larval survival and control many fouling and competing organisms. Larvae of hybrids between northern and southern hard clam often metamorphose at a higher rate than parents, and growth of young hybrids may also show hybrid vigor. Larvae of *M. mercenaria* are not too selective of substrate for metamorphosis, but metamorphose in containers made of a variety of substances. Light or darkness apparently has no effect on time of setting, and larvae showed no detectable reaction to light. - J.L.M.

1136
Loosanoff, Victor L., and Harry C. Davis. 1963.

Shellfish hatcheries and their future. Comm. Fish. Rev. 25(1): 1-11.

Shellfish hatcheries are needed because the supply of natural seed is dwindling and also unpredictable. By selection, quality of product can be improved for rapid growth, fatness of meats, and resistance to low salinity and temperature. A good, clean water supply is a necessity. Methods developed at Milford have made it possible to maintain ripe spawners throughout the year. It is possible to grow a million clam larvae per sq ft of table space every 15 days. This requires supplementary food, but at lesser densities phytoplankton present in the water may be sufficient. Clam larvae can be grown to metamorphosis on pulverized dried *Ulva* or *Laminaria*. One problem is that unutilized food settles to the bottom and develops rich bacterial flora which affect clam larvae unfavorably. Later, larvae of *Mercenaria mercenaria* grew well on dried *Scenedesmus*, some reaching metamorphosis in 10 days at 24°C. Hard clam larvae may develop from eggs in the temp range 18 to 30°C. At the upper limit they may begin to set as early as the 7th day after fertilization. Optimum temp range is between 25 and 30°C for larvae and about 25°C for juveniles. Temp may be important in assimilation of certain foods by larvae. Optimal salinity for developing eggs of hard clam from Long Island Sound is about 27°/₀₀, and normal larvae will not develop at 17°/₀₀ or less. The staff at Milford is prepared to offer suggestions to hatchery operators about handling certain problems, such as control of disease, and control of competing organisms. Studies required to improve shellfish hatchery operation include choice of location, genetic studies, development of spawning stocks adapted to a variety of environmental conditions, improved methods for obtaining set on a large scale, control of undesirable pests and competitors, large scale transplantations, development of better foods for larvae and young, methods of protection against predators, especially for small clams, methods of purifying contaminated clams, and improved mechanization of operations. - J.L.M.

1137
Loosanoff, Victor L., and Harry C. Davis. (no date).

Methods for hatchery cultivation of clams, oysters and other commercial mollusks.

Cited as in preparation in 1963. We have assumed that this is represented in papers published by the same authors in 1963 (Comm. Fish. Rev. 25(1): 1-11 and Adv. Mar. Biol., Academic Press, N.Y. 1: 1-136) abstracted elsewhere in this bibliography. - J.L.M.

1138
Loosanoff, Victor L., and James B. Engle. 1942.

Use of complete fertilizers in cultivation of microorganisms. Sci. 95(2471): 487-488.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1139
Loosanoff, Victor L., and Robert R. Marak. 1951.

Culturing lamellibranch larvae. Anat. Rec. 111(4): 545-546 (abstract 217).

Descriptions of larvae of 4 bivalves recently cultured in the laboratory and grown to or beyond metamorphosis are given. Other species which have been cultured successfully, including *Venus mercenaria*, are named. - J.L.M.

1140
Loosanoff, V. L., and W. S. Miller. 1950.

On sex reversal in adult clams, *Venus mercenaria*. Anat. Rec. 108(3): 619-620.

Most hard clams pass through a protandric male phase, but adults, with few exceptions, are of separate sexes. Examination of about 100 clams showed that sex reversal in adults is rather uncommon. Clams were induced to spawn in the laboratory and the sex was then etched on the shells. In the next spawning season none showed a change in sex. - J.L.M.

1141
Loosanoff, V. L., and T. Murray, Jr. 1974.

Maintaining adult bivalves for long periods on artificially grown phytoplankton. Veliger 16: 93-94.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1142
Loosanoff, Victor L., Harry Davis, and Paul Chanley. 1953.

Lack of relation between age of oysters or clams and quality of their spawn. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Biol. Lab., Milford, Conn., Bull. 4, 2 p.

Studies on *Venus mercenaria* showed that clams of different sizes and ages had no significant differences in viability of spawn. Differences between clams of the same size group often were as great as differences between individuals of different groups. Larvae from clams of all sizes were carried successfully to setting. Thus, clams of all age groups can be used safely as spawners. However, large clams are preferable for 2 reasons: 1) they have demonstrated their fitness to exist under the conditions of their natural environment; and 2) they produce more spawn/clam than smaller clams. - J.L.M.

1143
Loosanoff, V. L., H. C. Davis, and P. E. Chanley. 1953.

Lack of relation between age of oysters or clams and quality of their spawn. Oyster Inst. N. Am., Trade Rept. 133: 1-2.

This paper also was issued as Bull. 4 (Vol. 17) of the Fishery Biological Laboratory, U.S. Fish and Wildlife Service, Milford, Conn. on 21 July 1953, as a 2-page, duplicated issue. The abstract appears above. - J.L.M.

1144
Loosanoff, Victor L., Harry C. Davis, and Paul E. Chanley. 1953.

Behavior of clam larvae in different concentrations of food organisms. Anat. Rec. 117(3): 586-587 (abstract).

Larvae of *Venus mercenaria* were fed concentrations of food organisms ranging from 6,500 to 1×10^6 cells/cc of water. Foods were a pure culture of *Chlorella* sp. averaging 8 μ in diam, and a mixed culture, largely small *Chlorella* averaging about 3 μ. With large cells optimum concentrations were about 50,000 cells/cc; when small cells were fed, 400 to 500 thousand were needed. Heavy concentrations of food killed larvae. This again depended on cell size. Larvae died within a few days in 350,000 cells/cc of large *Chlorella* and sometimes within 24 hrs in 750,000 cells/cc. When small cells were fed, larvae grew well in 750,000 cells/cc. In large concentrations the filtrate, the cells, or a combination of the two, may be lethal. Larvae do not feed merely mechanically, but appear to have a mechanism for controlling food intake. When cell concentration was heavier than optimum, many larvae had fewer organisms in their stomachs than in lower concentrations. In a heavy concentration for a long time, the regulating mechanism was lost and larvae became choked with food cells. If not too seriously injured, larvae removed to seawater containing optimum concentrations of food expelled excess food and developed normally. Qualitative selectivity of food also was observed. In a mixture of *Porphyridium* (3 μ) and *Chlamydomonas* (10 μ), larvae neglected the smaller cell in favor of the larger. - J.L.M.

1145
Loosanoff, Victor L., Harry C. Davis, and Paul E. Chanley. 1953.

Effect of overcrowding on rate of growth of clam larvae. Anat. Rec. 117(3): 645-646.

Rates of growth and survival were determined in cultures maintained at different densities but receiving the same concentration of food, and cultures in which an increase in larval population was accompanied by a proportional increase in food. Food was a unialgal culture of *Chlorella* sp. Larvae in all cultures grew to metamorphosis but their rate of growth was inversely related to population density. In the first set of experiments (4 levels of larval density) larval populations varied from 6.5 to 50 larvae/cc, and rate of growth was inversely related to population density. In the second series (also 4 levels) larvae in the least crowded culture grew faster than those in the next higher density. The next group died within 4 days, and the densest culture within 48 hrs. - J.L.M.

1146
Loosanoff, V. E., H. C. Davis, and P. E. Chanley. 1955.

Food requirements of some bivalve larvae. Proc. Natl. Shellf. Assn. 45: 66-83.

Bivalve larvae fall into 2 groups, those like American oyster, which can utilize only a few of many food forms, and those like *Venus mercenaria*, which can thrive on most food organisms of the right size. When oyster and hard clam were held under identical conditions and fed mixed nannoplankton in which cells of small green algae predominated, larvae of hard clam grew rapidly and metamorphosed in about 13 days, while those of *Crassostrea virginica* stopped growing on reaching straight-hinge stage and eventually died. (Abstracter's note: This is a review paper.) - J.L.M.

1147
Loosanoff, Victor L., Harry C. Davis, and Paul E. Chanley. 1966.

Dimensions and shapes of larvae of some marine bivalve mollusks. Malacologia 4(2): 351-435.

Among other species, *Mercenaria mercenaria* and *M. campechiensis* were reared and grown past metamorphosis from eggs or recently released larvae of known parents. Photomicrographs and length-width measurements of larvae are given. In laboratory cultures only a few straight-hinge larvae of *M. mercenaria* were less than 100 μ long, and most fully formed straight-hinge veligers were approximately 105x80 μ. An umbo is visible at a length of about 125-130 μ. The umbo becomes better defined as larvae grow, but never as prominent as in *Anomia*, *Crassostrea* or *Teredo*. Some larvae begin to metamorphose at only 170 μ long, but most at 200-215 μ. Larvae longer than 230 μ are uncommon. At metamorphosis length is only 5-15 μ greater than width. Larvae of *M. mercenaria* from widely separated areas did not differ in size at metamorphosis, nor did larvae reared at 5 different temperatures. Larvae of *M. campechiensis* were hatched from parents taken at Apalachicola, Fla. All stages were identical to similar stages of *M. mercenaria*. Early straight-hinge veligers were 100-110 μ. Metamorphosis occurred most commonly at 175-215 μ. Spawning behavior of the two species was also virtually the same. When grown under identical conditions, including temperature, larvae grew at the same rate and began to metamorphose at the same time. Reciprocal crosses of the 2 species produced viable larvae which grew to metamorphosis and then to adult stage. These hybrids were fertile, and their larvae also were reared to adult stage. - J.L.M.

1148
Loosanoff, V. L., J. E. Hanks, and A. E. Ganaros. 1957.

Control of certain forms of zooplankton in mass algal cultures. Science 125(3257): 1092-1093.

In one experiment, adult and juvenile bivalves of several species including *Venus mercenaria*, were kept for one month in running water to which a Dipterex-treated culture of *Chlorella* was added continuously. All mollusks behaved normally, fed well, grew, and showed no unusual mortality. - J.L.M.

1149
Loosanoff, V. L., C. L. MacKenzie, Jr., and H. C. Davis. 1960.

Progress report on chemical methods of control of molluscan enemies. U.S. Fish Wildl. Serv., Biol. Lab., Milford, Conn., Bull. 24(8): 3-20.

This is a progress report on studies underway. It deals principally with boring snails and sea stars. Experiments were done first in the laboratory, then evaluated by field tests. In the laboratory, a barrier made of sand 8 inches wide mixed with orthodichlorobenzene stopped all oyster drills which came in contact with it for approximately 14 months. *Polydora* larvae apparently were not affected, nor were *Crepidula*, oysters, tunicates, Teredo and other invertebrates. After 14 months the chemical began to lose its strength. Barriers also were effective against sea stars, but a heavy coat of silt destroyed their effectiveness. Effectiveness of other chemicals and mixtures of chemicals also was tested. On a 12-inch wide barrier, *Urosalpinx* and *Thais* were stopped at the edge of the barrier, *Nassa* penetrated 4 inches, and *Polinices* 8 to 10 in. A small experimental barrier was established on tidal flats outside the Milford laboratory. Sea stars that traversed it usually were carried across by wave action. Oysters and *Venus mercenaria* were placed directly on the barrier. Adult clams survived, but none was able to dig into the substrate through the barrier. Small clams were placed inside and outside the barrier. All dug in. Deaths were insignificant, and clams inside the barrier did not grow more slowly than those outside. The chemical was still active after 14 months. Clams survived for 10 days after being kept in the laboratory in mixtures of orthodichlorobenzene and tetrachloroethylene, and a mixture of orthodichlorobenzene and monochlorobenzene in seawater at a rate of 10 ppm. This was much higher than concentrations contemplated under field conditions. A large barrier laid down in Long Island Sound retained its integrity for 9 months despite severe storms. Oysters survived on the barrier. No mortality of other animals was observed. No clam mortality was observed in another experiment, even when treated sand was laid down over a ground at 3 yd^3/acre. Another commercial compound, the insecticide Sevin (1-naphthyl-N-methylcarbamate), which is relatively harmless to humans, showed promise as a predator deterrent, as did 2-chloro-1-nitropropane and lindane. - J.L.M.

1150
Loosanoff, V. L., C. L. MacKenzie, Jr., and H. C. Davis. 1962.

Progress report on development of methods of chemical control of molluscan enemies. Proc. Natl. Shellf. Assn. 51, August 1960, iii.

Listed by title only. - J.L.M.

1151
Loosanoff, V. L., C. L. MacKenzie, Jr., and L. W. Shearer. 1959.

Use of chemical barriers to protect shellfish beds from predators. U.S. Dept. Interior, Fish Wildl. Serv., Bu. Comm. Fish., Biol. Lab., Milford, Conn.; Bull. 6, Vol. 23: 1-11. (It was noted at bottom of p. 2 that the paper would appear with slight changes in Vol. 50, Proc. Natl. Shellf. Assn.)

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1152
Loosanoff, V. L., C. L. MacKenzie, Jr., and L. W. Shearer. 1960.

Use of chemicals to control shellfish predators. Science 131(3412): 1522-1523.

Many enemies of oysters and clams can be controlled by heavy oils like orthodichlorobenzene mixed with dry sand or other inert carriers to anchor them in place on shellfish beds. - J.L.M.

1153
Loosanoff, V. L., W. S. Miller, and P. B. Smith. 1951.

Growth and setting of larvae of *Venus mercenaria* in relation to temperature. J. Mar. Res. 10(1): 59-81.

Larvae of *Venus mercenaria* were grown to metamorphosis in 4 experiments at constant temps of 30, 27, 24, 21 and 18°C ± 1°C. Smallest straight-hinge larvae were 86x64 μ (length x width), largest 236x228 μ. Within the range 18 to 30°C, growth was usually, but not always, more rapid at high than at low temp. Small temp differences were not important for growth. At 30°C some larvae set on the 7th day after fertilization and setting was complete 5 to 7 days later. At 18°C first setting was 16 days after fertilization, the latest 8 days later. Larvae metamorphosed at a length of 175 to 236 μ, most frequently at 200 to 210 μ. Larvae grown at lower temps were not larger at setting. Larvae from the same source and under identical conditions varied widely in size. Range of larval lengths and modal length varied widely between experiments at the same temp. Eggs placed in 15°C water immediately after fertilization did not usually develop to straight-hinge stage, but if eggs were held at room temp for 9 hrs before being placed in 15°C water, some would develop to straight-hinge larvae. Eggs placed in 33°C water soon after fertilization developed abnormally and most died. If zygotes were held at about 22°C for 2 days after fertilization, then transferred to 33°C, larvae would develop rapidly and normally. Organic debris does not appear to be better than living phytoplankton as larval food. When larvae were fed 2 types of detritus they starved and died. Clean and carefully attended cultures of larvae developed well without continuous aeration. Cultures containing 50 to 100 larvae/cc of water were not overcrowded and grew to metamorphosis. - J.L.M.

1154
Loosanoff, V. L., W. S. Miller, and P. B. Smith. 1951.

Growth and setting of larvae of *Venus mercenaria* in relation to temperature. Proc. Natl. Shellf. Assn. 41: 75-97.

This paper is virtually identical with an article with an almost identical title that appeared in J. Marine Research in 1951. For that reason this has not been abstracted. - J.L.M.

1155
Loring, Richard H. 1979.

Aquaculture. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass., and MIT Sea Grant Program, SP-112: 105-107.

One problem with the Federal program is the diversity of agencies, Dept. of Agriculture for catfish and trout, Dept. of Interior for salmon, and NOAA for marine work. This may well kill things for years to come. Even if a measure does pass, OMB is against new programs and will not fund them even if Congress overrides a Presidential veto. Probably the greatest obstacles that aquaculture must overcome are the socio-bio-political constraints. The Kyoto Declaration on the future of aquaculture in June 1976 was favorably impressed with the potential of aquaculture, and recommended attention by national and international agencies. - J.L.M.

1156
Lotsy, John P. 1895.

The food of the oyster, clam and ribbed mussel. Rept. U.S. Commr. Fish. for 1893(19): 375-386.

Stomachs of *Mercenaria mercenaria*, soft clam, ribbed mussel, and American oyster from the James River, Va. were examined and contents compared. Oysters and clams also were held in glass dishes and faeces were examined, to determine what had been digested and what had passed through intact. Most diatoms in oyster and clam excrement had been digested. Decaying organic matter taken in apparently was not digested. Hard clams presented with diatom cultures accepted the material. When hashes of fish or shrimp were offered, hard clams either closed their siphons, or forcibly ejected the material almost as soon as it was taken in. The same results were obtained with soft clam. It was concluded that the food of these bivalves was almost exclusively diatoms, and that the food supply was a function of the rate of water flow over the natural beds. Although copepods also were abundant in the water they were hardly ever found in mollusk stomachs. The possibility that dissolved organic matter can be utilized was rejected. - J.L.M.

1157
Lough, R. Gregory. 1975.

A reevaluation of the combined effects of temperature and salinity on survival and growth of bivalve larvae using response surface techniques. U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Fish. Bull. 73(1): 86-94.

Response surface technique was used to reevaluate the combined effects of temperature and salinity on *Mercenaria mercenaria* as determined by Davis and Calabrese (1964). The mathematical model used was: $Y=b_o+b_1(T)+b_2(S)+b_3(T^2)+b_4(S^2)+b_5(TXS)$, where Y=% survival or growth, b_o=a constant, T= linear effect of temperature, S=linear effect of salinity, T^2=quadratic effect of temperature, S^2=quadratic effect of salinity, and TXS=interaction effect between temperature and salinity. Survival from fertilization to the veliger stage was affected most by T^2, S^2, and TXS. Maximum survival (100%) was estimated at temperatures and salinities above 7.2°C and 28°/°°. Survival of larvae after 10 days was affected most by T, S, and TXS. Maximum survival (80%) was estimated to occur between 19° and 29.5°C and salinities between 21 and 29°/°°. These larvae had narrower temperature tolerance, but greater tolerance to low salinity than developing embryos. Growth of larvae over the 10 days was affected most by TXS, T, T^2, and S. Maximum growth (80%) occurred between 22.5° and 36.5°C and salinities between 21.5 and 30°/°°. Combined 10 day survival and growth was affected by all variables in the equation, but more by salinity than temperature. Optimum temperature and salinity to maximize larval growth and survival to 12 days was 21.5°-33°C and 22-31°/°°. Embryos and larvae should be reared under two different sets of conditions. Juvenile clams may have yet another set of optimum conditions than late larval clams. - D.L.

1158
Loveland, R. E. 1962.

Further evidence for a transmitter action of 5-hydroxytryptamine in the heart of *Mercenaria (Venus) mercenaria.*

Cited as ms in preparation. This is interpreted to be a paper published by Robert E. Loveland (1963), under a somewhat different title, abstracted elsewhere in this bibliography. - J.L.M.

1159
Loveland, Robert E. 1963.

5-Hydroxytryptamine, the probable mediator of excitation in the heart of *Mercenaria (Venus) mercenaria.* Comp. Biochem. Physiol. 9(2): 95-104.

The cardio-regulator nerves of hard clam are thought to be composed of inhibitory and excitatory fibers. Excitatory fibers are probably less important because inhibition is more readily evoked by stimulating cardio-regulatory nerves in an untreated or normal heart. No anatomical evidence is available to support the hypothesis that the 2 kinds of fiber actually exist. 5-Hydroxytryptamine is the most probable mediator of excitation in heart of *M. mercenaria.* It has been found in nerve and heart tissue in relatively high concentrations. Its synthesis from its immediate precursor, 5-hydroxytryptophan, occurs in presence of nerve extracts of *Mercenaria.* The pattern of excitatory response to 5-HT is similar to that caused by stimulating cardio-regulator nerves. Also, 5-HT is among the most reactive tryptamine derivatives on heart. Iproniazid, an inhibitor of monoamine oxidase, multiplied the action of 5-HT and nervous excitation. Rate of destruction and multiplication of 5-HT was low. Substances which blocked applied 5-HT, such as methysergide and 2-bromo-D-lysergic acid diethylamide, also decreased or blocked nervous excitation. Decreased concentration of endogenous 5-HT in nerve tissue of *Mercenaria* produced a decrease or loss of evoked excitatory response, and when, from tachyphylaxis, heart lost its sensitivity to 5-HT, there was concomitant loss of ability of heart to respond to action of excitor fibers. 5-HT has never been collected and chemically identified in perfusate from stimulated heart-nerve preparation of *Mercenaria.* This is an important criterion for determining that a substance is a neurotransmitter. From the results of these studies, however, it can be concluded that 5-HT, or a similar compound, is the probable augmentor substance in hard clam heart. - J.L.M.

1160
Loveland, Robert E. 1963.

Some aspects of the cardioregulation system in *Mercenaria (Venus) mercenaria.* Proc. 16th Internatl. Congr. Zool. 2: 106 (abstract).

The hard clam heart is innervated symmetrically by 2 lateral nerves, entering the auricle on either side. These nerves presumably have their origin in the visceral ganglion. After passing through the inside of the auricle, branches of the nerve end abruptly on the surface of the auriculo-ventricular valve. Nerve fibers are most concentrated in this region, and few fibers can be seen in the ventricle. Neurons in cardioregulator nerves are of 2 distinct types. One contains agranular vesicles and resembles a typical unmyelinated motor neuron. The other is filled with granular vesicles and appears to be a neurosecretory cell. Glial cells are associated with both types. Heart muscle cells are probably syncytial and are imbedded in a rather homogeneous matrix. Mitochondria are localized and cytoplasmic bridges join the muscle fibers. The nature of the nerve endings and relationship of cardioregulator fibers to heart muscle cells have not been determined. It is speculated that innervation is highly localized and that a wave of excitability spreads out over the heart via the syncytium of ventricular muscle cells. - J.L.M.

1161
Loveland, R. E. 1963.

Some aspects of cardio-regulation in *Mercenaria mercenaria*. Ph.D. Thesis, Harvard Univ.

Not available in Dissert. Abstr. Internatl. - M.W.S.

1162
Loveland, Robert E., and David S. K. Chu. 1967.

Relating oxygen consumption to pumping rates in *Mercenaria mercenaria*. A. Zool. 7(4): 738 (abstract 113).

Oxygen consumption was measured at salinity 22°/₀₀ and temp 25°C. Assuming QO_2 and pumping rate to be related the following equation predicts the relationship:

$$Y= \frac{\Delta P}{(p/cc)(t)} .X^n, \text{ where } Y=$$

pumping rate in L/hr, p=oxygen consumption in mls O_2, p/cc=oxygen tension, t= time in hrs, and X= total wet weight in g. For constant salinity and temp the equation converts to:

$$Y=k_c.QO_2.X^{n+1}=(0.01414)X^{n+0.474}.$$ - J.L.M.

1163
Loveland, R. E., and S. K. Chu. 1969.

Oxygen consumption and water movement in *Mercenaria mercenaria*. Comp. Biochem. Physiol. 29: 173-184.

Oxygen consumption in ml O_2/g wet weight/hr declines with increasing wet weight. Pumping rate increases with wet weight. Efficiency of withdrawal of O_2 was constant for clams of all weights: 2.91 l. of water pumped for each 1.0 ml of O_2 removed. Experiments were conducted at 25°C and 22°/₀₀ salinity. It is not necessary to assume that a clam which can obtain its required food intake from a relatively small volume of water, needs to pump large quantities of water to supply the O_2 needed to metabolize that food. - J.L.M.

1164
Lowden, Ronald D. 1965.

The marine Mollusca of New Jersey and Delaware Bay (38°56' North Latitude to 40°30' North Latitude) an annotated checklist. Proc. Phila. Shell Club 1(8-9): 5-61.

The copy received from Univ. Calif. Library, Berkeley, is a xerox copy of a typed manuscript, with no indication of the source. The date and citation above are accepted as given. Phylum Mollusca, Class Pelecypoda, Order Eulamellibranchia, Suborder Heterodonta, Superfamily Veneracea, Family Veneridae, Subfamily Venerinae, *Mercenaria (Mercenaria) mercenaria mercenaria* Linne, 1758, northern quahog, 3" to 5"; Gulf of St. Lawrence to Florida and Gulf of Mexico; introduced to Humboldt Bay, Calif.; *M. mercenaria notata* Say, 1822, 3" to 4"; locally associated with the typical form; *M. mercenaria alba* Dall, 1902; *M. mercenaria subradiata* Palmer, 1927, locally associated with the typical form. Included is a very detailed map of the New Jersey coastline, giving many place names, with tidal data. - J.L.M.

1165
Lowenstam, Heinz A. 1954.

Factors affecting the aragonite:calcite ratios in carbonate-secreting marine organisms. J. Geol. 62(3): 284-322.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1166
Lowey, Susan, Joseph Kucera, and Alfred Holtzer. 1963.

On the structure of the paramyosin molecule. J. Mol. Biol. 7(3): 234-244.

Light-scattering, viscosity and sedimentation experiments on solutions of *Venus mercenaria* paramyosin from adductor muscle showed that the paramyosin molecule is a rod, 1330 A long and 20 A in diameter, of 220,000 atomic mass units. The hypothesis that the molecule is made up of 2 adjacent α-helical chains is consistent with the diameter and mass per unit length found in this study, and with other available data. (Abstracter's note: The 40 literature citations (without titles) probably include some papers which mention *Mercenaria mercenaria*. Some are abstracted elsewhere in this bibliography, but we did not attempt to find and read others.) - modified authors' abstract - J.L.M.

1167
Lowman, F. G., T. R. Rice, and F. A. Richards. 1971.

Accumulation and redistribution of radionuclides by marine organisms. In Radioactivity in the Marine Environment. Natl. Acad. Sci., Washington, D.C.: 161-199.

This comprehensive review paper discusses a variety of marine organisms from plankton to fishes, but does not refer specifically to *Mercenaria mercenaria*. It is concluded that in estuarine and nearshore marine environments bottom sediments are close to sites of photosynthesis and to sites of fallout and terrestrial additions of radionuclides. In such regions, bottom sediments and their associated epiphyton often influence significantly the distribution of added radionuclides. Where large populations of sessile filter feeders exist they may exert profound effects upon rates of sedimentation of added trace elements and radionuclides. - J.L.M.

1168
Lowry, Oliver H., Nira J. Rosebrough, A. Lewis Farr, and Rose J. Randall. 1951.

Protein measurement with the Folin phenol reagent. J. Biol. Chem. 193(1): 265-275.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1169
Loy, G., and A. F. Eble. 1974.

Locomotion and phagocytic behavior of the amebocytes of the hard clam, *Mercenaria mercenaria*, as revealed by time-lapse cinemicrography. Bull. N.J. Acad. Sci. 19(1): 27 (abstract).

Large and small granulocytes are the 2 principal types of hard clam amebocyte. Small granulocytes were active and usually flowed unidirectionally. Movement was by rapid extensions of ectoplasm. Granules of endoplasm flowed rapidly in the same direction. Endoplasmic granules were active even when cell locomotion ceased. Mitochondria especially were highly plastic and usually took the form of large blunt granules, but would stretch into elongated structures temporarily. Cells adhered firmly to the cover slip, mostly in their "posterior" region, then suddenly released contact to "catch up" with the main portion of the cell. Large granulocytes adhered to the cover slip as large flat cells. No motion was detected by direct viewing, but time-lapse studies showed an extremely active waving motion of the ectoplasmic border of the cell. All granule types were in constant motion, and granules were always confined to a small area around the nucleus. Large granulocytes moved very slowly by a sliding motion. When yeast cells were added, small granulocytes rapidly flowed into a cluster of yeast cells, ectoplasmic extensions flowing between and around until all yeast cells were incorporated as phagosomes. Each phagosome consisted of a membrane wall surrounding a clear area containing the yeast cell. Large granulocytes phagocytosed yeast cells by enveloping them with wave-like extensions of the outer ectoplasm. - J.L.M.

1170
Loy, Gmae, and A. E. Eble. 1976.

Locomotion and phagocytic behavior of amebocytes of the hard clam, *Mercenaria mercenaria*, as revealed by time-lapse cinemicrography. Proc. Natl. Shellf. Assn. 65: 4 (abstract).

Large and small granulocytes from blood sinuses of the posterior adductor muscle were studied. Small granulocytes were relatively active and flow usually was unidirectional. Cells moved by rapid extensions of ectoplasm, followed by rapid flow of advancing endoplasm. Even when cell motion ceased temporarily endoplasmic granules showed much movement. The highly plastic mitochondria usually took the form of large blunt granules, which would stretch into long sausage-shaped structures briefly. Cells adhered firmly to cover slips. Large granulocytes adhered to cover slips as large flat cells. Viewed with Nomarski interference phase optics, granules appeared as distinct mounds and ridges. Time-lapse studies at 30 frames/min showed extremely active waving motion of the ectoplasmic border. All granule types were in constant motion in the endoplasm, and were always confined to a small area around the nucleus. This large cell moves very slowly by a sliding motion. Boiled, washed yeast cells were engulfed by phagocytosis. At 40 frames/min small granulocytes flowed into a cluster of yeast cells. Ectoplasmic extensions of granulocytes flowed rapidly in and around until all yeasts were incorporated as phagosomes. A membrane wall surrounded a clear area containing the yeast cell. As many as 8-10 yeast cells were engulfed in a few minutes. Large granulocytes phagocytized yeast cells by enveloping them with wave-like extensions of the outer ectoplasm. - J.L.M.

1171
Lucas, Albert. 1969.

Remarques sur l'hermaphrodisme juvenile de quelques Veneridae (Bivalvia). Malacologia 9(1): 275-276 (Proc. 3rd. Europ. Malacol. Congr.).

Juvenile hermaphrodism in Veneridae is of 3 types: 1) previtellogenic ovocytes and spermatocytes; 2) previtellogenic ovocytes and presence of spermatozoa; and 3) ovocytes with vitellus and presence of spermatozoa. *Venus verrucosa* belongs in the first type, *V. striatula* in the second, and *Venus striatula* and *Mercenaria mercenaria* in the third. - J.L.M.

1172
Lucas, A. 1975.

Sex differentiation and juvenile sexuality in bivalves (sic) Molluscs. Pub. Staz. Zool. Napoli 39 (suppl.): 532-541.

Juvenile stage follows postlarval stage. Primary germinal cells are localized in ventral region of pericardium. In adult stage gonad is localized in or near the foot. In juveniles, tubules lie between pericardic and pedal regions. Besides undifferentiated gonia, these tubules contain sexual cells differentiated as male, as female, or as ambisexual. Juvenile hermaphroditism occurs in *Mercenaria mercenaria* and some other species, which are gonochoric as adults. Juvenile sexuality, gonochoric or hermaphroditic, seems to be a general phenomenon in bivalves. It has been found in 21 species belonging to 12 families. Juvenile sexuality is not functional, but it shows that protogonia are ambisexual, even in gonochoric species. Data on *Venus striatula* are included. - J.L.M.

1173
Luduena, F. P., and Theodore G. Brown, Jr. 1952.

Mytolon and related compounds as antagonists of acetylcholine on the heart of *Venus mercenaria*. J. Pharmacol. Exper. Therap. 105(2): 232-239.

The acetylcholine (ACh) blocking effect of various ganglionic and neuromuscular blocking agents was determined on isolated hearts of *Venus mercenaria*. No blocking activity at concentrations as great as 1:10,000 was shown by d-tubocurarine, decamethonium and dihydro-beta-erythroidine. Tetraethylammonium bromide (TEA) and various benzoquinone derivatives reduced the inhibitory effect of ACh on *Venus* heart, and at higher concentrations blocked the inhibitory effect. WIN 2747, Mytolon, [2,5-bis (diethylaminopropylamino)-benzoquinone benzochloride], the most potent compound tested, was about 1,000 times as active as TEA. No correlation was found between ACh blocking activity on *Venus* heart and ganglionic blocking, curarimimetic or anticholinesterase activities. Positive correlation between ganglionic blocking activity in mammals and ACh antagonism on *Venus* heart would have made it possible to use *Venus* heart for screening ganglionic blocking agents. The high sensitivity to Mytolon might have practical value as the basis of a bioassay method for quantitative determination of this drug in biological material. - modified authors' summary - J.L.M.

1174
Lutz, Richard A. 1978.

The bivalve "larval ligament" as an exclusively post-larval feature. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978, Abstracts: (page not numbered).

Morphological structures of bivalves formerly referred to as "larval ligaments" are postlarval features. Presence of a ligament pit on the ventral surface of the hinge apparatus of small planktonic bivalves shows that attachment or byssal secretion has occurred, and the size and development of this structure helps to determine the extent to which the process has proceeded. If secretion of the dissoconch shell marks the end of metamorphosis, the prodissoconch-dissoconch boundary is useful in distinguishing true juveniles from "metamorphosing" postlarvae. - J.L.M.

1175
Lutz, Richard A., and David Jablonski. 1978.

Micro- and ultramorphology of larval bivalve shells: Ecological, paleoecological, and paleoclimatic applications. Natl. Shellf. Assn., 70th Joint Ann. SINA-NSA Conv. & Meeting, 18-22 June 1978, Abstracts: (page not numbered).

Identification of larval bivalve shells is difficult or impossible with routine microscopic procedures. A method is suggested whereby individual larval or early postlarval material of certain closely related species may be differentiated through routine examination of hinge apparatus. Species are not mentioned, but the methods described might be applicable to *Mercenaria mercenaria*. - J.L.M.

1176
Lutz, Richard A., and Donald C. Rhoads. 1977.

Anaerobiosis and a theory of growth line formation. Science 198(4323): 1222-1227.

Although a 1/1 correspondence has not been established, deposition of increments in bivalves correlates well with shell valve movements. Valves of many species usually close at low tide and open at high tide, and the number of increments and number of tides are highly and positively correlated. This rhythmicity usually is most pronounced in intertidal bivalves, but *Mercenaria mercenaria* in the subtidal zone shows pronounced biological rhythms in relative harmony with the tidal cycle. When valves are open and clam is pumping a shell layer rich in $CaCO_3$ is deposited. When valves are closed clams deposit an organic-rich layer or line, concentrate conchiolin at the growing edge, or undergo a period of shell erosion. This is hypothesis, based on morphology and correlation of deposition with environmental and biological rhythms. Microstructural growth increments within the shell are interpreted as reflections of alternating periods of shell deposition and dissolution occurring during aerobic and anaerobic respiration. Acidic end products of anaerobic metabolism, succinic acid and alanine, are neutralized by $CaCO_3$ from the shell, leaving a relatively insoluble organic residue at the mantle-shell interface. With resumption of aerobic respiration this organic material is reincorporated within the shell. *Mercenaria mercenaria*, the one species in which shell deposition and decalcification cycles have been demonstrated conclusively, has a particularly well-preserved record of growth within the shell. The conclusion is almost paradoxical that shell destructive processes provide a relatively complete and detailed record of short- and long-term growth. Analyses of relationships between ambient oxygen concentrations and shell structural types may eventually prove useful for determining dissolved O_2 gradients in Phanerozoic marine environments. - J.L.M.

1177
Lynch, Gerald Lawrence. 1976.

Fishery cooperatives in theory and in practice. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N.Y., xi + 122 p.

Organization of the Great South Bay Farmer's Cooperative was stimulated in the 1960s by a water pollution situation which threatened but never occurred. The cooperative was formed in 1968. The principal objectives were: stabilization of income, improved quality control. One way in which the Great South Bay organization gained was by using 7 grades of clam: four grades of littleneck, two of cherrystone, and one of chowder. - J.L.M.

1178
Lynch, John, and Candace Corson. 1972.

A guide to the Long Island Sound ecosystem. Compiled by authors, directed and assisted by Robert B. Gordon and Donald C. Rhoads. Dept. Geology Geophys., Yale Univ., New Haven, Conn., 235 p. + 17 p. insert (unpub. summary of a summer study by 2 students).

Contains information, including bibliographies, on many aspects of ecology of the Sound, including a section on the shellfish industry. Several papers cited appear to be unpublished reports, probably available in files of the respective agencies. - J.L.M.

1179
Lynch, Maurice P. 1977.

Fisheries and wildlife. In Proc. Bi-State Conf. on Chesapeake Bay. L. Eugene Cronin (Chm. Ed. & Planning Comm.). Chesapeake Research Consortium Inc., CRC Pub. 61: 189-219.

The most valuable fishery data base is commercial fishery statistics compiled by National Marine Fisheries Service, despite certain inherent deficiencies. Largest biases in stock assessment based on these data are probably for long-lived species like oysters, hard clams, and finfishes. Relative sizes of soft clam and blue crab stocks probably are estimated fairly closely by commercial harvests. *Mercenaria mercenaria* is distributed widely in lower Chesapeake Bay, on the east side up to Pocomoke Sound, on the west side to the mouth of the Rappahannock River. Commercial quantities available to patent tongs exist only in 6 small areas totalling about 19,000 acres in the lower James and lower York Rivers and along shore between these rivers. In Virginia, landings have fluctuated between 0.7 and 2.5 million lbs/yr, with no downward trend, but the fishery is approaching the point of maximum sustainable yield. Limiting factors have been low levels of recruitment, and predation. No known disease is prevalent. The report summarizes major fishery problems in the Bay and offers 7 recommendations for fishery management generally. - J.L.M.

1180
Lynch, M. P., and J. Claiborne Jones. 1977.

Public health aspects of tropical storm Agnes in Virginia's portion of Chesapeake Bay and its tributaries. In The Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System. Chesapeake Research Consortium, Inc. Johns Hopkins Univ. Press, Baltimore, CRC Pub. 54: 625-635.

On June 23, 1972, Virginia waters in Chesapeake Bay and its tributaries were closed for the taking of shellfish for direct human consumption. Portions of the Bay and tributaries were reopened on July 20, 1972, and by October 5 all areas were opened except those permanently closed. Higher than usual coliform levels in Virginia waters appeared to be primarily associated with runoff from the initial rains. With the exception of economic dislocations in the shellfish industry caused by the closings, the public health impacts were minimal. - J.L.M.

1181
MacBride, E. W. 1912.

Oyster culture and clam fishing, Prince Edward Island. Contr. Can. Biol. Fish. 1906-1910(13): 217-220.

Most of this paper deals with the oyster fisheries, to study which the author had made a trip to the Island. He received complaints on arrival about damage to oyster beds by fishing for *Venus mercenaria*. This was a fairly new fishery, legal during the closed season for oysters. This clam lies buried in the mud with the posterior surfaces of the edges of the valves just showing above the silt. Harvesting was done with a large rake with 9-inch teeth, which disturbs the bottom. There was no reason for fishing hard clams on oyster beds because the characteristic bottom for clams was blue mud, which is unsuitable for oysters. Large clams, called "bulls", were found around the edges of oyster beds, but were not marketable. The preference was for clams of intermediate size, which have tenderer foot tissues. It was concluded that oysters may invade a clam bed and the older clams may survive. The author believed that new hard clams could not establish themselves on an oyster bed. He stated that oyster and hard clam fisheries could exist side by side if the areas for each are defined. Considerable numbers of hard clams were opened, but none showed gonad development. It was concluded that July is not part of the breeding season in P.E.I. - J.L.M.

1182
MacClintock, Copeland, and Giorgio Pannella. 1969.

Time of calcification in the bivalve mollusk *Mercenaria mercenaria* (Linnaeus) during the 24-hour period. Geol. Soc. Am., Abstracts with programs for 1969, Pt. 7: 140 (abstract).

An experiment in the natural environment, beginning in August, in which hard clams were notched and one removed each hr for 52 consecutive hrs, showed that all deposition takes place at nearly uniform rate at night. Very little shell is deposited during the day. Major breaks marking increments were related to the non-deposition period between the two low tides during daylight. It was concluded that calcification is restricted to a few hrs of physiological activity. A simple increment is deposited when this activity is not interrupted by a low tide at night. Otherwise a complex increment with a marked break inside is formed. Shifting of this line toward the margin in adjacent increments parallels the 50-min daily tidal shift. - J.L.M.

1183
MacCrimmon, H. R., J. E. Stewart, and J. R. Brett. 1974.

Aquaculture in Canada: The practice and the promise. Fish. Res. Bd. Canada, Bull. 188, 84 p.

Contains 3 papers: Freshwater aquaculture in Canada by Hugh R. MacCrimmon; Potential for culture of invertebrates in Canada by James E. Stewart (abstracted elsewhere in this bibliography); and Marine fish aquaculture in Canada by J. R. Brett. Quahaugs *(Mercenaria mercenaria)* are among those species that could be cultured on a small scale until further technical and market data can be obtained. - J.L.M.

1184
MacGinitie, G. E. 1932.

The role of bacteria as food for bottom animals. Science 76(1978): 490.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1185
MacGinitie, G. E. 1937.

The use of mucus by marine plankton feeders. Science 86(2235): 398-399.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1186
MacGinitie, G. E. 1939.

Littoral marine communities. Am. Midl. Nat. 21(1): 28-55.

No specific mention of *Mercenaria mercenaria*. - J.L.M.

1187
MacGinitie, G. E. 1941.

On the method of feeding of four pelecypods. Biol. Bull. 80(1): 18-25.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1188
MacInnes, John R., Edwin W. Rhodes, and Anthony Calabrese. 1974.

A new electronic system for counting and measuring bivalve larvae. Chesapeake Sci. 15(3): 174-176.

In large-scale growth studies, measurement with ocular micrometers is tedious and time-consuming. The system described consists of a microscope, television camera and monitor, and a digital analyzer. Magnified images from the microscope are transmitted to the monitor. On command, larval images in an entire field are counted and measured. Particles smaller than clams can be eliminated by a lower-limit selecter. Projected length, longest dimension and area can be measured. Analysis of length-height ratios from 1,600 larvae showed that the relationship is very uniform, confirming that length is as useful as area. Over 80 μ, area increases slightly more rapidly in relation to length. The aspect ratio (T), defined as $T = L^2/4A$, where L = longest diameter and A = area, declines slightly with increasing size, at least in larvae over 100 μ. Differences in shape factors might be useful for separating larvae of different species. The probable error of measurement is similar to that of the manual method. - J.L.M.

1189
MacIntosh, F. C., and W. L. M. Perry. 1950.

Biological estimation of acetylcholine. In Methods in Medical Research, Vol. 3. R. W. Gerard (ed.). Year Book Publishers Inc., Chicago: 78-92.

No known pharmacologic test object responds specifically to acetylcholine (ACh). At the time of writing the most useful biological methods for assay of ACh appeared to these authors to be longitudinal muscle of leech, rectus abdominis muscle of frog, and blood pressure of cat. These preparations and methods are described. Comments by John H. Welsh included the information that isolated *Venus* heart had been used for ACh determinations in the U.S.A. for 6 yrs. Sensitivity is high; threshold concentration of ACh is about 10^{-10}. The log-concentration-action curve is very steep and nearly linear between 20% and 80% inhibition, permitting differences in ACh concentration as small as 0.0002 μg/ml of bathing fluid to be distinguished. No substance has been found to have higher activity on the heart, and other tissue substances such as K appear to interfere in no way with the assay. Anti-cholinesterases potentiate the action of ACh only 2-3 fold, hence the method of potentiation by eserine cannot be used to identify ACh. For rapid estimation of small amounts of ACh or small differences in ACh content of extracts, *Venus* heart probably is superior to other standard assay preparations. - J.L.M.

1190
MacKenzie, C. L. 1970.

Oyster culture modernization in Long Island Sound. Am. Fish Farmer 1(6): 7-10.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1191
MacKenzie, Clyde L., Jr. 1971.

Control of oyster drills, *Eupleura caudata* and *Urosalpinx cinerea*, with the chemical Polystream. Fish. Bull. 68(2): 285-297.

The pesticide Polystream on commercial oyster beds in 4 States was effective in drill control where currents were less than 2.7 km/hr. About 85% of the *Eupleura* and 66% of the *Urosalpinx* were killed. Best results were obtained in spring. Surviving drills did not feed for several months, and numbers remained low for 2 yrs. Only small numbers of *Mercenaria mercenaria* and other invertebrates and fishes were killed. After treatment, clams and other organisms had small residues of the chemical in their tissues, but residues were lost gradually. - modified author's abstract - J.L.M.

1192
MacKenzie, Clyde L., Jr. 1977.

Predation on hard clam *(Mercenaria mercenaria)* populations. Trans. Am. Fish. Soc. 106(6): 530-537.

Principal predators of hard clam are oyster drills *(Urosalpinx cinerea* and *Eupleura caudata)*, moon snails *(Polinices duplicata* and *Lunatia heros)*, whelks *(Busycon canaliculatum* and *B. carica)*, crabs *(Neopanope sayi, Cancer irroratus* and *Callinectes sapidus)*, and sea star *(Asterias forbesi)*. Predation can be heavy in the natural environment. Studies in the laboratory and on natural populations are described. Study areas were in Sandy Hook Bay, N.J., Great South Bay and Northport Harbor, Long Island, N.Y., and off New Haven and Milford, Conn. Dense clam populations were found in places where predators were virtually absent, scarce, or where bottom materials were sand and stones in about equal quantities. Smallest clams are most vulnerable, successful predation declines sharply as clams grow, and largest clams are impervious except to whelks. In Great South Bay the only significant predators were oyster drills and mud crabs. In Horseshoe Cove, off Sandy Hook Bay, clams were abundant where 6 predator species were abundant, probably because stones in the substrate provided cover from predation. Some observations on clam setting and survival also are included. Chemical control of predators led to increases in density of clams per unit area up to 8-fold. Mechanical control of predators might work, for oyster drills, mud crabs, and sea stars remain on the surface of the substrate, whereas moon snails, whelks and rock crabs, which often are buried in the bottom by day, frequently emerge at night. Principal predators of hard clam were gastropods and crabs, which take mostly small clams. Strength of clam year classes is determined by predation as well as by success of setting. Identity of predators could be determined from dead shells by the nature of damage, e.g., small, parallel-sided holes were made by drills; larger, sharply bevelled holes were by moon snails; whelks made small chips along shell margins; and fragmented shells were caused by mud crab, rock crab, blue crab, and other crab species. - J.L.M.

1193
MacKenzie, Clyde L., Jr. 1979.

Relation of biological and environmental factors to soft-shell and hard-shell clam management. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass. and MIT Sea Grant Program, SP-112: 67-78.

Managing objectives for hard clam *(Mercenaria mercenaria)* include increasing: 1) abundance and production of clams to improve economic prosperity of the fishing community; and 2) supplies of quality clams at moderate prices to consumers. At present, little is known about: 1) predators of larvae; 2) effect of bottom conditions, particularly associated biota, on setting density; 3) numerical aspects of setting; and 4) predators of seed clams during the first few weeks after setting. Percentages of larvae and seed which attain harvestable size have not been determined, but predators take most. Hard clams have large enough biotic potential to stock beds with dense clam populations, yet abundance is usually too low to support fisheries. Environmental factors usually are not optimal in terms of predator density and perhaps setting surfaces. Hard clam occurs in salinities from about 15 to 35°/₀₀, at depths from low tide mark to more than 7 meters, in sand, sand-gravel-stone, mud, and their combinations. Summer temps must rise above 15°C but remain below 33°C. They require a bed containing few predators, or some cover if predators are abundant. Hard clam larvae do not set as densely in mud as in sand. Effects of presence of macroscopic plants and animals on setting density has not been studied. Identified predators include moon snails, oyster drills, whelks, blue crab, green, rock, and mud crabs, starfish, and fishes, including rays, summer flounder, tautog, and puffers. As a rule, new generations of predators appear simultaneously with new generations of prey. Most adult predators also select small-sized prey. Hard clam is scarce where predators are abundant and little cover is available. Most predators remain on the surface of the bottom and therefore can be removed without destroying clams. The abundance of clams can probably be increased several times on most beds by developing a predator removal machine and taking other measures not specified. - J.L.M.

1194
MacKenzie, Clyde L., Jr. 1979.

Management for increasing clam abundance. Mar. Fish. Rev. 41(10): 10-22.

Low clam abundance does not stem from limited biotic potential, but from environmental constraints, such as predation. General awareness that clam *(Mercenaria mercenaria* and *Mya arenaria)* abundance can be increased by environmental improvement has been absent. Clam setting is favored by the fact that predators do not consume all young clams and cannot kill clams above certain lengths; fishermen do not take undersized clams, many of which are already mature; fishermen also do not take all legal-sized clams on a bed; the spawning season lasts a few months, and in some part of the season environmental factors are suitable; fishermen do not degrade the bottom, so that setting is not affected. A major opportunity to increase clam abundance is to control predation of clam spat and juveniles. This has been clearly demonstrated by previous research. A mechanical device for removing predators is suggested. It will require experimentation to make sure it functions efficiently. Cost and benefit studies must also be done to be certain that benefits will ensue. The method must be demonstrated and must clearly be beneficial. Political support will need to be stimulated, and clam production specialists must guide the program. With proper attention, such a program should be successful, when accompanied by other necessary regulations such as protection of small clams. - J.L.M.

1195
MacMillan, R. B. 1975.

Public health significance of shellfish management. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 16-24.

In 1974 N.Y. State issued 8,000 individual shellfish digger permits as well as permits to large shellfish farming operations. The industry reported landing 14.8 million pounds of shellfish (meats) with landed value of $19 million. In the early 1920s an outbreak of typhoid fever was traced to shellfish distributed from West Sayville, N.Y. Industry appeals to the federal government for help led to development of the present National Shellfish Sanitation Program (NSSP). Hard clams in Great South Bay, N.Y. accumulated fecal coliform levels from a norm of 50 MPN/100 g to a level of 9,200 MPN/100 g in dry weather in an area where boating and human population density increased on summer weekends. Cooking does not provide complete sterilization of infected clams, and harmful organisms may survive. NSSP, formerly administered by the U.S. Public Health Service, now comes under the Food and Drug Administration (FDA), in its Shellfish Sanitation Branch. FDA evaluates each State program for compliance with the NSSP Manual of Operations. It also issues monthly a certified list of shellfish shippers. The Shellfish Sanitation Program in N.Y. studies water quality, inspects shellfish, provides microbiology and chemistry laboratory support, and issues permits. The region under surveillance includes about 1.2 million acres of underwater lands, of which 575,000 acres are actually or potentially productive. At the time of writing 139,000 acres were closed to shellfish harvesting. Major sources of pollution are sanitary wastes from sewage treatment plants, urban stormwater runoff, and effluents from Long Island duck farms. All shellfish storage and processing facilities must be inspected before issuance of a license. Market samples of shellfish, and samples from growing grounds, are subjected to bacteriological analysis, and vessels are inspected periodically. Water and shellfish meats are analyzed for total and fecal coliform organisms, fecal streptococcus, and standard plate count. The laboratory also participates in collaborative studies to improve on current methodology. This work is supported by a mobile laboratory. The chemistry laboratory supports the shellfish program and other units in analyses of pesticide and heavy metal residues. Samples of shellfish, water, sediments and air, among other things, are examined. Pesticides in New York are not of public health significance. The 8,000 shellfish digger permits issued in 1974 represented an increase of 1,500 over 1973. At the time of writing FDA was promulgating regulations for NSSP which would require some changes in the N.Y. program. These were being viewed with reservations by the shellfish industry. - J.L.M.

1196
McMillian (should be MacMillan), Bruce. 1978.

Problems in classifying the Great South Bay. In Proc. Interstate Seafood Seminar, Oct. 4 to 7, 1977. William R. Hess, Jr. (ed). Va. Polytechnic Inst. and State Univ. Extension Div. and Dept. Food Sci. Technol., Seafood Processing Research and Extension Unit, Hampton, Va.: 265-278.

In 1976 landings of 9 million pounds of hard clam *(Mercenaria mercenaria)* meats with a dockside value of over $18 million were reported from New York. About 93% of total hard clam production in New York came from Great South Bay. The paper discusses in considerable detail the problems that faced the state when in June 1975 it was determined from a comprehensive sanitary survey that additional areas in the Bay had to be closed. Not until May 20, 1977 was the area closed, and a large-scale riot almost ensued. As a result the judge issued a temporary restraining order against the state. On July 20, 1977 the area was closed again but again the Attorney General's office issued another restraining order. Then the States of Connecticut and New Jersey sent telegrams requesting the City of New York or the State to take some action to protect its citizens. As a result, shellfish shipments were returned by out-of-state dealers. Finally on August 4, 1977 the area was closed. The judge's decision upheld the validity of the total coliform standard, and it also upheld the view that the standard is constitutional, or if it is not, that the agency was doing things right. They did not write an Environmental Impact Statement, and that was a possible weakness, but it was upheld. In other words, the State had done everything within its power to ensure that sanitary requirements had been met. - J.L.M.

1197

MacMillan, Robert B., and James H. Redman. 1971.

Hard clam cleansing in New York. Comm. Fish. Rev. 33(5): 25-33.

New York has about 400,000 acres of bottom suitable for shellfish, 13% of which was closed by pollution. Many closed areas, most of which are in the western part of Long Island, have abundant stocks of *M. mercenaria*. The resource can not be used legally, but it is a public health menace. The State began transplanting in 1964 to certified waters for 30-day depuration. In 1965 funds were obtained for a pilot-plant study of commercial depuration. The plant had controlled dry storage for untreated and treated shellfish, depuration tanks, and seawater treatment. Location was at West Sayville on Great South Bay. Landings of hard clam from the Bay in 1969 were 6.3 million pounds of meats with landed value of $6.85 million. Recommended water temperature for depuration was 59°F. Hard clams cease feeding at 45°F. Thus, a water heating system was installed to warm Bay water in winter. Three tanks, about 9 by 10 feet and 1.4 feet deep, received Bay water at 20 gal/min. Two settling tanks were provided to remove silt. For supplementary water supply four experimental wells were driven. At well point depth range of 20-50 ft below tidal water level pumping rate was 30 gal/min, water temperature 54.5-55.5°F, salinity 24-25.5°/°°, and no detectable bacteria/ml. Consequently, a larger well was driven and use of Bay water was discontinued. The advantages were: constant salinity and temperature, no need to heat water, minimum ultra-violet sterilization, elimination of fouling, elimination of settling tanks. Then 42 experiments were conducted with clams from several areas. After washing, clams were loaded in plastic coated wire baskets, placed in holding tanks, and treated for 48 hours. The most heavily contaminated sample contained 5,100 fecal coliform colony forming units (CFU) per 100 g of clam meats at the beginning of the experiment to 100 CFU at 24 hours, and to less than 20 CFU at the end of 48 hours. The usual method for determining fecal coliforms in shellfish takes 3 days. The authors developed a pour-plate procedure which gave results in 24 hours. When seawater temperatures fall below about 45°F clams cease feeding and no longer accumulate bacteria. Hard clam harvested in December to March inclusive are virtually free of coliforms, whatever the water quality. The crystalline style also is absent in winter, but experiments showed that when depurated in winter in water sufficiently warm, 50-92% of the clams developed a style in 24 to 48 hours, demonstrating that the clams were active. Depuration is used only to remove bacterial or viral contamination. The process does not remove contaminants like heavy metals, pesticides or radionuclides. The program was terminated in 1969. Its success led the State to announce that use of the process would be authorized by private concerns under appropriate conditions, and that laboratory support would be provided to ensure proper operation. - J.L.M.

1198
MacPhail, J. S., E. I. Lord, and L. M. Dickie. 1956.

The green crab--a new clam enemy. Prog. Repts. Atlantic Coast Stas. 63: 3-12.

The green crab (*Carcinides maenas*) has only recently appeared in Canadian waters. It has spread into the Bay of Fundy and towards the outer coast of Nova Scotia, and there is no sign that it has reached the limits of its spread. The northward extension of the range undoubtedly was fostered by the increasing temperatures along the coast. Experiments showed that soft clams, *Macoma*, and mussels were the favorite food. Quahogs (*Mercenaria mercenaria*) were taken occasionally. It was concluded that the green crab is one of the worst, if not the worst, clam predators known. - J.L.M.

1199
McCall, Peter L. 1977.

Community patterns and adaptive strategies of the infaunal benthos of Long Island Sound. J. Mar. Res. 35(2): 221-266.

Mercenaria mercenaria is not mentioned. - M.W.S.

1200
McCubbin, W. D., and C. M. Kay. 1968.

The subunit structure of fibrous muscle proteins as determined by osmometry. Biochim. Biophys. Acta 154(1): 239-241.

Paramyosin was prepared from adductor muscles of *Venus mercenaria*. Molecular weight of native *V. mercenaria* paramyosin was 212,000 by osmometry, in good agreement with the value of 220,000 measured by light scattering and Archibald ultracentrifugation. The solvent was 0.6 M KCl, 0.01 M potassium phosphate buffer (pH 7.4). Most striking was the reduction in estimated molecular weight (by a factor of 2) undergone by paramyosin in a denaturing rather than a benign medium. The study confirmed the hypothesis that paramyosin and light meromyosin fraction I are very similar to each other, and to tropomyosin, architecturally in that their molecules each contain 2 polypeptide chains. - J.L.M.

1201
McDermott, John J. 1964.

Food habits of the toadfish, *Opsanus tau* (L.), in New Jersey waters. Proc. Pa. Acad. Sci. 38: 64-71.

Mercenaria mercenaria and some other mollusks were found occasionally in toadfish stomachs but their incidence and numbers were insignificant in comparison with crustaceans. It was concluded that ingestion of mollusks is only by chance, i.e. they are taken up incidentally in the quest for other foods. - J.L.M.

1202
McDougall, K. D. 1943.

Sessile marine invertebrates of Beaufort, North Carolina. Ecol. Monogr. 13: 321-374.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1203
McErlean, A. J., and Jack Howard. 1971.

Photographic method for surveying clam populations. Proc. Natl. Shellf. Assn. 61: 91-94.

The method was used to survey *Mya arenaria* beds. It is possible that *Mercenaria mercenaria* might also be evaluated by this method. - J.L.M.

1204
McFarren, E. F., J. E. Campbell, and J. B. Engle. 1962.

The occurrence of copper and zinc in shellfish. In Proc. 1961 Shellf. Sanit. Workshop. Eugene T. Jensen (ed.). U.S. Dept. H.E.W., Pub. Health Serv.: 229-234.

In comparison with most other foods, marine organisms contain large amounts of Cu and Zn. Oysters contained about 10 to 20 times as much Cu and 30 to 40 times as much Zn as clams from the same or nearby areas. Species names are not given, but from the locality of collection (Kent shore, upper Chesapeake Bay, and New Hampshire waters) it is assumed that soft clam, *Mya arenaria*, was analyzed. It is concluded that *Mercenaria mercenaria* was not examined. - J.L.M.

1205
McFarren, E. F., H. Tanabe, F. J. Silva, W. B. Wilson, J. E. Campbell, and K. H. Lewis. 1965.

The occurrence of a ciguatera-like poison in oysters, clams, and *Gymnodinium breve* cultures. Toxicon 3: 111-123.

A toxin was found in *Crassostrea virginica* and *Venus mercenaria campechiensis* in spring 1962 from certain areas of Charlotte Harbor, Lemon Bay, Sarasota Bay and Tampa Bay, Fla. On the bases of symptoms in humans, solubility in organic solvents, and reactions of experimental animals fed or injected with the poison, the toxin appeared to be identical to the toxin responsible for ciguatera poisoning. Epidemiological investigation of several cases of human illness from eating these shellfishes showed that as little as 50 to 80 mouse units of toxin may produce some symptoms, and 400 to 500 mouse units produced a mild form of illness in humans. Cultures of *Gymnodinium breve*, and a sample of seawater from an area in which people had experienced respiratory irritation similar to that caused by "red tide", extracted with organic solvents, also were toxic to mice. It was not certain, however, that poisons from shellfishes and from red tide organism and water were identical. - J.L.M.

1206
McGrath, Richard A. (undated-1972 or later).

Benthic macrofaunal census of Raritan Bay - Preliminary results. Benthos of Raritan Bay. U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Middle Atl. Fish. Center, Sandy Hook Lab., Highlands, N.J., 40 p. (unnumbered).

Mercenaria mercenaria included in species list, but not discussed in text. - J.L.M.

1207
McGrath, Richard A. 1974.

Benthic macrofaunal census of Raritan Bay - Preliminary results. Benthos of Raritan Bay. In Hudson River Ecology. Proc. 3rd Symposium on Hudson River Ecology, Hudson R. Environ. Soc., 27 p. not numbered, 4 figs., 3 tables.

Mercenaria mercenaria is given in the species list, but detailed data are not given on abundance or distribution. The species was a minor constituent of "sand" community samples, and was a major constituent of 6.3% of the samples from "mud" community. The Raritan Bay system is grossly polluted. The most striking characteristic of the benthic fauna was its impoverishment. - J.L.M.

1208
McHargue, J. S. 1924.

The significance of the occurrence of copper, manganese and zinc in shellfish. Science 60: 530.

Data cited by Vinogradov (1953), abstracted elsewhere in this bibliography. - J.L.M.

1209
McHargue, J. S. 1927.

The proportion and significance of copper, iron, manganese, zinc in some mollusks and crustaceans. Trans. Ky. Acad. Sci. 2: 46.

Data cited by Vinogradov (1953), abstracted elsewhere in this bibliography. - J.L.M.

1210
McHugh, J. L. 1972.

Marine fisheries of New York State. U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Fish. Bull. 70(3): 585-610.

Landings of hard clam in New York State reached a maximum in 1947 of about 11 million pounds of meats, dropped to about 2.5 million pounds in 1954, and climbed to almost 8 million pounds in 1970. Production in Great South Bay rose from about 1.5 million pounds in 1959 to over 6 million pounds in 1969. The average price of hard clam has risen steadily over the past two decades. The rise in production and price was largely attributed to collapse of oyster and soft clam industries and a series of excellent sets in some of the bays of Long Island's south shore. Hard clam were apparently able to spawn successfully in some badly polluted areas. - D.L.

1211
McHugh, J. L. 1975.

Management of New York's hard clam fishery. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 44-47.

Most people in the industry believe that reported landings of hard clam in the State are underestimates. Substantial residential and recreational catches must be added to the underestimated commercial catch. This major industry makes important contributions to the economy of local communities. If any major fishery resource can be managed by the State unilaterally, the hard clam resource is an important place to begin, but no serious attempts have been made until recently. Now the State and some towns are developing management programs. Principal problems are water quality, inadequate law enforcement, inadequate information for management, and public ignorance of the issues and lack of cooperation. - J.L.M.

1212
McHugh, J. L. 1976.

Does fishing have a future? Search, State Univ. N.Y., Albany 1(2): 20-27.

Hard clam, *Mercenaria mercenaria*, is the most valuable commercial fishery resource in N.Y. It is partly responsible for the fact that, although the State ranks 17th among the 23 U.S. coastal states in weight of fish and shellfish landed, it is second to Texas in price paid to fishermen per lb. In 1974 shellfish made up about one-third of all N.Y. landings by weight, and this did not include shells of mollusks. Management, in the sense of maintaining maximum yields, is virtually non-existent. Extension of national jurisdiction will not solve the problem, for the major commercial fishery resources of N.Y. never have been subject to foreign fishing. Nine points that need to be considered for successful management are discussed. - J.L.M.

1213
McHugh, J. L. 1976.

Estuarine fisheries: Are they doomed? In Estuarine Processes. Vol. 1. Uses, Stresses, and Adaptation to the Estuary. Martin Wiley (ed). Academic Press, New York: 15-27.

In 1974 New York State was the major producer of *Mercenaria mercenaria:* 68% of the total Middle Atlantic Bight catch. Peak production in the Bight was in 1947 at about 7,710 metric tons of meats. Since 1947 landings in individual states have varied widely, but total production in the Middle Atlantic Bight has remained fairly stable. Hard clam is vulnerable to effects of water pollution and overfishing and also natural environmental change. Recreational and subsistence catches are not known, but they must be large. For example, a single town on Great South Bay, N.Y. issued 2,459 permits in 1974 for non-commercial clam harvesting, as compared to about 1,700 for commercial harvesting. Considerable quantities are also taken illegally. - J.L.M.

1214
McHugh, J. L. 1977.

Fisheries and fishery resources of New York Bight. U.S. Dept. Commerce, NOAA Tech. Rept. NMFS Circ. 401, v + 50 p.

Trends in hard clam landings in N.J. have been similar in their major features to those in N.Y. Reported landings were relatively high in the last 2 decades of the 19th century, dropped sharply and stayed relatively low until the 1930s, rose to maxima in the late 1940s and early 1950s, dropped sharply again, and subsequently rose in the 1960s. In N.J. the recent rise reached a peak in 1967 and catches have been dropping since. In N.Y. landings dropped after 1971, but 1975 was a record year. Clammers believe that the resource is overharvested, and this seems to be supported by the fact that in N.Y. the harvest has levelled off while numbers of clammers have increased. In R.I. once a major producer of hard clam, landings are about 20% of the historic peak in 1955. The sharp decline in N.J. landings in the 1950s was in part caused by closing of polluted areas. An outbreak of hepatitis in 1961 affected the industry seriously. The subsequent rise has been caused by improvement in consumer confidence, increased abundance of clams in some areas, depuration, and opening of some closed grounds. Most hard clam production in N.J. comes from bays of the outer coast. Raritan and Sandy Hook Bays once were important clamming areas, but grounds there are almost all closed. In 1975 N.J. produced 735 metric tons of hard clam meats, N.Y. 3,932 tons. Management in both states has largely been negative, monitoring water quality and closing grounds where necessary. Commercial landings probably are underestimated and there are substantial unrecorded recreational and residential catches. Management information is badly needed. The resource should be considered important because management does not require cooperation from adjacent states or other nations. Some local management programs are underway, but much more needs to be done. Recent increases in abundance of blue crab *(Callinectes sapidus)*, a serious predator, may have been responsible for declining abundance of hard clam. - J.L.M.

1215
McHugh, J. L. 1977.

Conference summary and comment. In Proc. Bi-State Conf. on Chesapeake Bay. L. Eugene Cronin (Chm. Ed. & Planning Comm.). Chesapeake Research Consortium, Inc., CRC Pub. 61: 275-283.

In New York, baymen see disappearance of eelgrass *(Zostera)* as a threat to the hard clam industry, but the relationship is not well understood. - J.L.M.

1216
McHugh, J. L. 1977.

Limiting factors affecting commercial fisheries in the Middle Atlantic estuarine area. In Estuarine Pollution Control and Assessment. Proceedings of a Conference, Vol. 1. U.S. Envir. Prot. Agency, Off. Water Planning and Standards, Washington, D.C: 149-169.

From 1969 to 1973 in the coastal states R.I. to Del. inclusive, hard clam landings remained relatively steady at an average annual weight of about 11.6 million pounds of meats. In the Chesapeake Bay states for the same period average annual landings were about 1.9 million pounds of meats. In the first region hard clam ranked 4th by weight of all species of fish and shellfish in 1969, 5th in 1973. In the Chesapeake region rank by weight was 11th in 1969, 14th in 1973. By total value of landings hard clam ranked higher, first place in the R.I. to Del. region in all 5 yrs from 1969 to 1973, and averaging 6th in the Chesapeake region. N.Y. is by far the largest producer of hard clam. From 1929 to 1957 N.Y. and R.I. vied for first place in volume of clam meats. Since 1957 production has been rising in N.Y., falling in R.I. The decline in R.I. probably has been caused by overharvesting and water pollution. The rise in N.Y. was caused by an increase in abundance in N.Y. since the 1950s, especially in Great South Bay, which now produces most of the hard clam harvest in N.Y. But despite a steady increase in clamming effort in N.Y., total catch has remained fairly steady for several years, and the resource may be overharvested. Water pollution is a problem on N.Y. clam beds also. Some towns on Great South Bay are developing management programs. Attempts are being made to improve law enforcement, gain an understanding of the dynamics of the resource, and transplants are being made from closed waters to clean areas. These efforts deserve encouragement and support. Almost 1/4 of shellfish bottoms in N.Y. waters are closed to shellfishing, and water pollution is a problem for the industry and a threat to public health in all states. Undoubtedly many factors affect distribution, abundance and availability of hard clam, but the only ones identifiable with certainty are: transfer of human pathogens, closure of certain beds, and occasional catastrophic events, the effects of which are obvious. - J.L.M.

1217
McHugh, J. L. 1978.

Historic fish and shellfish landings and trends. In Fisheries. By J. L. McHugh and Jay J. C. Ginter. MESA New York Bight Monograph 16, New York Sea Grant Inst., Albany: 3-79.

Illustrates commercial landings of hard clam meats in N.Y. and N.J. combined since 1880, and compares individual landings in the two states with total landings in the region Me. to N.Y. inclusive and N.J. to N.C. inclusive since 1960. This is the most valuable single fishery resource in the New York Bight area in price paid to clammers. Landings in the two states combined reached a low in the late 1920s, an all-time peak in 1947, another low in the late 1950s and early 1960s, and have now apparently stabilized. Concern about the future of the resource has been expressed because commercial permits in N.Y., the major producer, have about doubled since 1970, with no apparent increase in total catch. Life history of hard clam is reviewed briefly. - J.L.M.

1218
McHugh, John L. 1979.

United States clam industry: Where is it going? In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass. and MIT Sea Grant Program, SP-112: 7-24.

Hard clam *(Mercenaria mercenaria)* reached maximum production in New England in 1953 at about 7.2 million pounds of meats, and has continued to drop since then. The mid-Atlantic region has dominated hard clam production, with maximum landings of 13.6 million pounds of meats in 1950. Chesapeake

Bay peaked at 2.9 million in 1938. In the south, North Carolina was the greatest producer, and the maximum from N.C. to the east coast of Fla. was 1.4 million pounds of meats in 1902. The potential for clam production in New England is considerable. Prices are high for the two major species, and investment in aquaculture might be justified if certain things are favorable. Law enforcement is the outstanding problem. We have the knowledge and technology to succeed, but it is not certain that it can be done economically. Various partial aquacultural methods are widely used, but many are taken on faith rather than from proven techniques. Plants of spawners may be infinitesimal compared to natural reproduction, and unlikely to have much, if any, effect. Predators are particularly destructive of young clams when they have set but are still small. This is usually the size at which they are planted, because it is too costly to hold and feed large numbers. Application of ecological principles to practical shellfish management has been tried in various places, but few have become standard procedure. The paper ends with a list of 9 questions that the symposium might well consider and try to answer. - J.L.M.

1219
McNulty, J. Kneeland, William N. Lindall, Jr., and James E. Sykes. 1972.

Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase I, Area description. NOAA Tech. Rept. NMFS Circ. 368, vii+126 p.

Information on *Mercenaria campechiensis* is cited from papers abstracted elsewhere in this bibliography. Commercial production began about 1880 and increased in 1900 when vast beds were discovered near the Ten Thousand Islands. Commercial production reached a peak in 1932 and remained high until 1945. A sharp decline from 1945 to 1950 was attributed to overfishing. In 1962 to 1964 intensive harvesting of beds in Charlotte County provided a short-lived spurt in production. Clams were now widespread along the west coast of Fla. in salinities 20°/₀₀ to 35°/₀₀ and from mean high tide to over 50 ft depth, but the authors were unaware of commercial concentrations anywhere. Research had been active for 10 yrs, but few surveys of distribution and abundance were available. About 43% of the area of Fla. west coast estuaries, excluding Florida Bay, is affected adversely by pollution. - J.L.M.

1220
McNulty, J. Kneeland, Robert C. Work, and Hilary B. Moore. 1962.

Level sea bottom communities in Biscayne Bay and neighboring areas. Bull. Mar. Sci. Gulf Caribb. 12(2): 204-233.

Sampling was limited to areas relatively free from *Thalassia* and other "grasses" so that accurate sampling could be done with a grab. *Mercenaria mercenaria* and *M. campechiensis* were referred to the *Venus* community for consistency with other studies. At Gasparilla Island, in depths 1 to 2 meters, was a typical *Venus* community, in which *Mercenaria campechiensis* made up over 95% by tissue weight of the whole population, but considerably less by numbers. Median grain size of bottom materials was 0.5 mm, and sorting coefficient 1.21. In this community *M. campechiensis* density was 7 clams/m^2 and dry tissue weight 22,648 mgm/m^2. The community identified as *Laevicardium-Codakia* might be a type of *Venus* community according to Thorson's criteria because it prefers a similar type of sediment. - J.L.M.

1221
McNulty, J. K., R. C. Work, and H. B. Moore. 1962.

Some relationships between the infauna of the level bottom and the sediment in South Florida. Bull. Mar. Sci. Gulf Caribb. 12(3): 322-332.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1222
Magalhaes, Hulda. 1948.

An ecological study of snails of the genus *Busycon* at Beaufort, North Carolina. Ecol. Monogr. 18(3): 377-409.

Next to *Tagelus gibbus*, the favorite food of *Busycon* in laboratory tanks, *Chione cancellata* and *Venus mercenaria* tie for 2nd place as food. Max and min lengths of *Venus* eaten were 90.2 and 11.6 mm, heights 77.8 and 10.1 mm, and widths 54.7 and 5.6 mm. *Busycon* consumes hard clams by 2 methods: 1) the snail waits until the shell opens slightly, then inserts the edge of the outer lip of its own shell, forces the valves apart until the proboscis of the snail can reach the soft parts of the clam; 2) the prey is grasped by the foot muscle of *Busycon* and held so that the columellar muscle can contract and bring the outer lip of the snail shell against the ventral edges of the clam shell, often with such force that the clam shell, the snail shell, or both, are broken. This hammering of the edge of the clam shell can occur as often as 6 times/min. When the hole is large enough, *Busycon* inserts its sharp shell lip between the valves of *Venus* and pries it open. All 3 species of *Busycon* may feed on clams this way. Photographs of *Venus* shells showing chipped edges made by *Busycon* are reproduced. Shells of clams recently eaten by *Busycon*, or in process of being eaten, are always covered with a thick, sticky material, probably saliva. This contains a proteolytic enzyme. - J.L.M. and M.W.S.

1223
Mahoney, John B., and John J. A. McLaughlin. 1977.

The association of phytoflagellate blooms in Lower New York Bay with hypertrophication. J. Exper. Mar. Biol. Ecol. 28(1): 53-65.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1224
Mahoney, Paul, Gerald Fleischner, Irving Millman, W. Thomas London, Baruch S. Blumberg, and Irwin M. Arias. 1974.

Australia antigen: Detection and transmission in shellfish. Science 183 (4120): 80-81.

Australia antigen was found in clams contaminated by drainage of untreated sewage from a coastal hospital on the Atlantic coast of Maine. In closed-system aquariums, the antigen was ingested by clams *(Mercenaria mercenaria)* and transmitted to previously uninfected clams. In open-system aquariums, the titer of Australia antigen decreased with time, suggesting viral concentration rather than replication. - modified authors abstract. - J.L.M.

1225
Maier, F. J. 1947.

Present status of shellfish cleansing and conditioning processes. Natl. Shellf. Assn., Convention Address 1941, from selected addresses 1941-1946, 4 p.

At present the only commercial shellfish cleansing plant in operation in the United States is in Massachusetts. Yearly volume of clams treated varies from 19,000 to 58,000 bu. Cost of treatment averages 27¢ per bu. On the whole, the plant has accomplished the results for which it was designed. - J.L.M.

1226
Malek, Emile A., and Thomas C. Cheng. 1974.

Medical and Economic Malacology. Academic Press, New York, x+398 p.

Mercenaria mercenaria belongs to 1 of 6 classes of mollusk, Class bivalvia, also known as Pelecypoda or Lamellibranchiata. They are bilaterally symmetrical, have a shell of two valves with corresponding lobes of the mantle, and have no tentacles, eyes, "head", or radula. A dorsal ligament, together with teeth formed from the valves, form a hinge. Most are marine. All have a hatchetlike foot and lamellate gills. The Subclass Lamellibranchia has large gills relative to labial palps, forming feeding organs; filaments greatly elongated and reflected, forming 2-sided lamellae, the arms of which usually are united by lamellar junctions. Adjacent filaments are attached by ciliary junctions (filibranch) or united by tissue (eulamellibranch). Six orders are recognized, differentiated mainly by gill structure and arrangement. Chapter subjects in which *M. mercenaria* is mentioned are: pathogens of mollusks; hematology; internal defense mechanisms; and aquaculture. Early life history of clams is illustrated briefly by a discussion of embryonic development, induced spawning, artificial rearing of veligers, and pond culture. (Abstracter's note: the statement on p. 277: "Unlike oysters, clams are dioecious." is misleading. Hard clam undergoes sex reversal also.) - J.L.M.

1227
Malouf, Robert, Richard Keck, Don Maurer, and Charles Epifanio. 1972.

Occurrence of gas-bubble disease in three species of bivalve molluscs. J. Fish. Res. Bd. Canada 29(5): 588-589.

Hard clams held in heated running seawater in winter developed gas bubble disease. Heating cold seawater in closed heat exchangers causes supersaturation with atmospheric gases. The only gross symptom in hard clam was an obvious lightening of gill color, caused by presence of numerous trapped gas bubbles that prevented free flow of blood. Adult hard clams were much less affected than oysters. Clam mortalities were rare. - J.L.M.

1228
Manchester, Winnifred B. 1980.

Quahog dredging is latest career for old dragger. Natl. Fisherman 61(4): 54.

The Stanley B. Butler, a 90 ft dragger built in Maine in 1938 is making a comeback as a quahog dredger out of Point Judith, R.I. The Butler has been equipped with a jet dredge and brought in a record 90,000 bu of quahogs from waters off Block Island last year. - J.L.M.

1229
Mann, R., and T. M. Losordo. 1976.

The growth of six species of bivalve molluscs in a waste-recycling aquaculture system. In Marine polyculture based on natural food chains and recycled wastes. John H. Ryther. Woods Hole Oceanogr. Inst., Woods Hole, Mass., Tech. Rept. WHOI-76-92. U.S. Dept. Commerce, Natl. Tech. Inf. Serv. PB-261 939: 137-168.

Only small increments in live weight of *Mercenaria mercenaria* were observed from Nov. 1975 to May 1976. Some meat growth was evident at 15° and 20°C. Condition index increased consistently from beginning to end of period. Mortality varied between 15% and 42% in different lots. Results obtained with *M. mercenaria* and *Crassostrea virginica* were termed disappointing. - J.L.M.

1230
Mann, Roger, and John H. Ryther. 1977.

Growth of six species of bivalve molluscs in a waste recycling-aquaculture system. Aquaculture 11: 231-245.

Growth of 6 species of bivalve mollusks, including *Mercenaria mercenaria*, was compared in a waste recycling-aquacultural system. Food was algae, predominantly *Phaeodactylum tricornutum*. Experimental temperatures were 15° and 20°C, over the period November 1975 to May 1976. *M. mercenaria* was obtained from Long Island Oyster Farms. Although dry meat weight more than doubled at some positions, and growth was greater than previously reported, it was considerably less than that of *Tapes japonica* under identical conditions. It was suggested that hard clam has little potential for culture in the present system. - J.L.M.

1231
Manning, J. R. 1935.

Fish and shellfish for food. U.S. Bu. Fish., Spec. Memo 2256B.

Cited in Tressler and Lemon (1951) with data on vitamin content, protein and fat in clams (species not named). - J.L.M.

1232
Mansour, K. 1946.

Food and digestive organs of lamellibranchs. Nature 158(4011): 378.

The author takes issue with certain conclusions of C. M. Yonge, about the fate of chlorophyll in blood and lumen of the gut, about the function of the crystalline style, about identity of phagocytes, and about animal matter in the gut. *Mercenaria (Venus) mercenaria* is not mentioned. There follows a comment by J. J. Mansour-Bek, entitled "Extracellular proteolytic and lipolytic enzymes of some lamellibranchs" which also has been cited separately in this bibliography. - J.L.M.

1233
Mansour-Bek, J. J. 1946.

Extra-cellular proteolytic and lipolytic enzymes of some lamellibranchs. Nature 158: 378-379.

Follows a short paper by K. Mansour, abstracted also in this bibliography, and comments on observations by C. M. Yonge on the origin of extracellular proteolytic and lipolytic enzymes in stomachs of lamellibranchs. - J.L.M.

1234
Manwell, Clyde. 1963.

The chemistry and biology of hemoglobin in some marine clams - I. Distribution of the pigment and properties of the oxygen equilibrium. Comp. Biochem. Physiol. 8(3): 209-218.

Most lamellibranch mollusks lack respiratory pigments. Hemocyanin is not found in clams, but adductor muscles of *Mercenaria mercenaria* are pale pink with low concentrations of muscle hemoglobin (myoglobin). The oxygen affinity of hard clam myoglobin is very high (P_{50}=0.55 mm Hg). Clam hemoglobin lacks the sigmoid oxygen equilibrium curve typical of many vertebrate and a few annelin hemoglobins. This means there are no strong positive interactions between oxygen-combining centers. Hard clam myoglobin has n=1.00, which is to be expected of a hemoglobin with a molecular weight corresponding to only one heme per molecule. If one considers tissue hemoglobins to function simply as stores of oxygen it is difficult to understand the significance of most clam tissue hemoglobins, for only those of *Tivela* and shipworms are present in high enough concentration to give more than a light color to tissues. However, the very high affinity of *M. mercenaria* muscle hemoglobin for oxygen may serve to facilitate diffusion of oxygen into that thick, non-vascular structure. In small clams, muscles are almost colorless, but in clams over 8-10 cm long muscles are a deep pink. *M. mercenaria* has higher concentrations of hemoglobin in adductor muscles than *M. campechiensis*, even when identical clams of the two species are raised side by side. Myoglobins of the two are identical in solubility and electrophoretic properties. All except a few large *M. mercenaria* have no readily detectable hemoglobin in heart muscle, but heart of *M. campechiensis* has a higher concentration of hemoglobin than adductor muscles. Heart and adductor muscle soluble proteins in starch gel electrophoresis show zones in identical position, as do digestive gland (hepatopancreas), serum, nerve, or crystalline style. At least 30 soluble proteins have identical electrophoretic mobilities in the two "species". Aside from the external morphology of the shell, the only readily discernible difference between northern and southern quahog is the tissue localization of myoglobin. The question then arises whether differences in myoglobin levels between hearts and adductor muscles of the two species is a response to unknown differences in internal respiratory physiology, persisting even when animals are raised for years under identical conditions, or do different "control" genes exist? - J.L.M.

1235
Manwell, Clyde. 1964.

Chemistry, genetics, and function of invertebrate respiratory pigments - Configurational changes and allosteric effects. In Oxygen in the Animal Organism. Frank Dickens and Eric Neil (eds.). I.U.B. Symposium Series 31, MacMillan Co. (Pergamon), New York: 49-119.

The only reference to *Mercenaria mercenaria* in this chapter is to unpublished work by the author which showed that the variable heart hemoglobin of hard clams appeared to be biochemically and genetically different from its adductor muscle hemoglobin. - J.L.M.

1236
Manzi, John J., and Kathleen A. Donnelly. 1971.

Staining large populations of bivalve larvae. Trans. Am. Fish. Soc. 100(3): 588-590.

Eleven stains and dyes, in 5 concentrations, were tested on American oyster and *Mercenaria mercenaria* larvae. Five did not color the animals, one was toxic at all concentrations. Neutral red gave the best results. No substantial differences were noted between the two bivalves, except that hard clam larvae appeared to be less affected by toxic stains and dyes and had lower mortality and abnormality. Best staining was obtained with long exposure (24 to 48 hrs) to very low dye concentrations (2.5 to 5 ppm). - J.L.M.

1237
Manzi, John J., Victor G. Burrell, Jr., and W. Z. Carson. 1980.

A mariculture demonstration project for an alternative hard clam fishery in South Carolina: Preliminary results. 11th Ann. Meeting, World Maric. Soc., New Orleans, La., March 1980, 9 typed pages, 1 table, 6 figs.

Growth of seed *Mercenaria mercenaria* averaged 2 mm/month over a 13 month period (Oct 78 to Nov 79). Aggregate cover provides sufficient protection against predation during early grow-out. Combination of crushed gravel substrate and covers on trays provided sufficient protection for seed clams throughout the experiment. Survival of young seed clams (about 4 mm) in densitites as high as 5000/m^2 was exceptionally high for a 3-month trial period. Preliminary results show that high density cage clam culture is feasible for initial seed clam growth, and may be feasible for commercial production of large seed and market size clams. - J.L.M.

1238
Marak, Robert R. 1953.

Variations in sizes and rate of growth of lamellibranch larvae of the same parents. Natl. Shellf. Assn., Convention addresses 1951: 45 (abstract).

Larvae from eggs of a single female *Venus mercenaria* fertilized with sperm of a single male were grown to metamorphosis. Larvae from the same parents, kept under identical conditions, varied widely in growth rate, size, and time to setting. - modified author's abstract. - J.L.M.

1239 Marceau, F. 1909.

Recherches sur la morphologie, l'histologie et la physiologie comparees des muscles adducteurs des mollusques acephales. Arch. Zool. Exper. Gen., Ser. 5, Tome 2: 295-469, 4 pl.

This comprehensive monograph deals with a variety of bivalves, including *Venus verrucosa*, and mentions *V. decussata*. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M.

Marderosian, Ara H. Der.

See Der Marderosian, Ara H.

1240 Marinucci, A. C. 1975.

Interrelationships among growth, growth physiology, and external algal metabolites in the larvae of the quahog clam, *Mercenaria mercenaria* L. Ph.D. Thesis, Univ. Del., Newark, 92 p.

Not available in Dissert. Abstr. Internatl. - M.W.S.

1241 Marrat, F. P. 1883.

The naturalization in the estuary of the Mersey, of the *Venus mercenaria*, Linn., the wampum clam of the North American Indians. Privately printed.

Referring to this paper Heppell (1961) said that Marrat mentioned "the extensive shallow sandy shores of Lancashire and Cheshire" and concluded that substrates in the Liverpool Bay area were tolerable. It is inferred that some other factor (probably water temp) must have been responsible for failure of this introduction. - J.L.M.

1242 Marshall, J. T. 1897.

Additions to "British Conchology". J. Conch. 8: 366-367.

According to Heppell (1961) Marshall quoted the Manchester City News as describing the quahog as "bidding fair to compete with the familiar cockle." Living specimens from the Humber estuary were exhibited at the Manchester meeting of the Conchological Society. - J.L.M.

1243 Marshall, N. 1955.

Measurement of plankton feeders in relation to gross production. Ecology 36: 360-362.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1244 Marshall, Nelson. 1956.

Observations of mortality and growth in plantings of small soft-shell clams, *Mya arenaria*, and small quahogs, *Venus* hybrids, in the Niantic River. Suppl. Rept. to the Waterford-East Lyme Escallop Commission, April 30, 1956. (Issued concurrently with the report titled: "Studies of the Niantic River, Connecticut, with special reference to the bay scallop, *Pecten irradians*.)

The clams used in this experiment were a cross between *Venus mercenaria* and *Venus campechiensis*, about half female *mercenaria* crossed with male *campechiensis* and half the reverse. Three plantings were made: one off Camp Ribicoff; one off Saunders Point; and one up-river at the houseboat "Walrus". All were intertidal, but so close to extreme low tide that they were submerged most of the time. At each a strip 3 ft wide and extending at right angles to the tide line was dug clean and planted as follows from low tide shoreward: 4 ft planted with *Venus* seed at 25/sq ft; 1 ft left unplanted; 4 ft *Mya*. The offshore half of the *Venus* plants were covered with 3/8" galvanized hardware cloth weighted around the edges. Density of *Venus* was (clams/ft^2):

	Camp Ribicoff	Saunders Point	"Walrus" site
Protected	24 1/2	27 1/2	13 1/2
Unprotected	26 1/2	16 1/2	8 1/2

Time elapsed was about 2 months. Data are given also on initial number, final number, mean length and range. *Venus* was less vulnerable than *Mya*, but placement may have been the reason. - J.L.M.

1245

Marshall, Nelson, and Karen Lukas. 1970.

Preliminary observations on the properties of bottom sediments with and without eelgrass, *Zostera marina*, cover. Proc. Natl. Shellf. Assn. 60: 107-111.

Effects of the eelgrass blight in the early 1930s were not as drastic as had been anticipated. An eelgrass bed, an area cleared of eelgrass, and an open area were compared. Clam diggers were active in the open area, so the open-plot control area probably was turned over about as much as the raked area. At the sediment surface *Zostera* areas had higher levels of organic C, higher silt-clay content, and more interstitial water than open areas. Differences between open and *Zostera*-covered areas were seen only in the top cm layer. In a one-month period no consistent changes were observed from removing eelgrass or raking plots. Differences in hard clam abundance or ecology between areas were not mentioned. - J.L.M.

1246

Marteil, L. 1956.

Acclimatation du clam *(Venus mercenaria,* L.*)* en Bretagne. Rev. Trav. Inst. Pêches Marit. 20: 157-160.

According to Heppell (1961) Marteil recorded large hard clams about 20 yrs old in the River Etel, and some as large as 14 cm and up to 500 g in claires of the Gulf of Morbihan and River Penerf, all of which had been laid down in those places before 1940. From ages of clams at Sainte-Avoye, Marteil calculated that years of spawning were years in which mean water temps in July and Aug were above average and at the minimum temp for hard clam breeding. This was taken as possible evidence of local breeding. The substrate at Sainte-Avoye was firm, with oyster shell debris in the mud. -J.L.M.

1247

Martin, Arthur W., and Florence M. Harrison. 1966.

Excretion. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.) Academic Press, New York, Vol. II: 353-386.

Contains reference to a paper by Kowalevsky (1889) cited elsewhere in this bibliography. - J.L.M.

1248
Maschke, A. Purcell. 1976.

Production, trade and consumption of gastropods and bivalve molluscs. FAO Fish. Circ. 345 (FIPP/C345), iii+70 p.

In the northwest Atlantic at least 6 clam species are produced commercially, of which the most important are *Spisula solidissima* and *Mercenaria mercenaria*. Production of hard clam (the paper calls it soft clam but gives the scientific name *M. mercenaria*, and the production figure cited is compatible with hard clam production in that year) has declined somewhat recently, and there is evidence that the species is in need of better management. *M. mercenaria* is listed among other clam species produced in the northeast Pacific, but this may be misleading. Official U.S. statistics group several Pacific species under the name hard clam, including *Saxidomus* and *Protothaca*, which probably make up the bulk of west coast landings. Next to Japan, the United States is the world's second largest market for clams. Apparent annual per capita consumption of clams in the U.S. has increased from 0.7 kg live weight in 1960 to 1.4 kg in 1974. This has just about compensated for the decline in oyster consumption. Combined production of clams by U.S. and Japan is about 75% of world output. In the northwest Atlantic *Mercenaria mercenaria* is 2nd in importance among clams to *Spisula solidissima* by weight. Pollution and poor management are problems. In the Mediterranean and Black Seas *Venus gallina* is taken. *M. mercenaria* is taken also in the northeast Pacific, but nowhere is *Mercenaria* or *Venus* a major commercial species except along the North American Atlantic coast. Prices in the U.S. are much below those in Japan. Supply would seem to be the dominant consideration affecting future growth of consumption in the U.S. World catches of *M. mercenaria* are given for 1964-1974 incl. and average prices of hard clam in the U.S. and Japan for 1970-1975 incl. (Abstracter's note: these figures should be used with caution. The price of hard clams in the U.S. varies widely with grade, and with season, and an average gives only a general guide to prices. For example, on 30 December 1976, littlenecks were selling wholesale at Fulton Market in New York City for $60-65/bushel, cherrystones $25, and chowders $10-12. Price time-series also are relatively meaningless unless they are adjusted for changes in buying power of the dollar). - J.L.M.

1249
Mason, Phillip. 1974.

Shellfish Cookbook. Drake Publishers, Inc., New York, x+186 p.

In addition to recipes for molluscan and crustacean dishes this book contains information on life histories, anatomy, identification, and harvesting methods. The information is for the most part superficial and not always accurate. - J.L.M.

1250
Matthews, Samuel A. 1928.

The palps of lamellibranchs as autonomous organs. J. Exper. Zool. 51(3): 209-258.

Venus (Mercenaria) mercenaria has medium sized palps, thicker than those of *Mya* or *Anodonta*, but more active than those of any marine form studied except *Mya*. The high degree of autonomy which the palp exhibits is due to its intrinsic nervous mechanism, a nerve-net. - J.L.M.

1251
Matthiessen, G. C., and R. C. Toner. 1963.

A study of the marine resources of Barnstable County, Massachusetts. Marine Research Found., Inc., Edgartown, Mass., 31 p. + figs.

In the past decade (1950s), *Mercenaria mercenaria* was second by value among shellfish resources of the County, accounting for 38% of total landed value of shellfishes. Production in pounds of meats dropped from about 1.0 million pounds in 1907 to about 0.78 million in 1960, a 26% decrease. An increase in "casual" fishermen and natural fluctuations in abundance may account for the decrease. Principal problems of the shellfish industry were: 1) minimal attention to resource management and improvement; 2) resistance to private planting; 3) effects of dredging and filling; 4) water pollution; and 5) large and increasing harvest by summer visitors. It was recommended that the State establish a shellfish propagation center for mass production of important species, including hard clam; an adequate research facility; and conduct studies of estuarine circulation. - J.L.M.

1252
Matthiessen, G. C., and R. C. Toner. 1966.

Possible methods for improving the shellfish industry of Martha's Vineyard, Duke's County, Massachusetts. Marine Research Foundation Inc., Edgartown, Mass., 138 p.

Section 1 treats in some detail the techniques of plankton culture and problems. Most desirable food species for *Mercenaria mercenaria* are 2 flagellates, *Monochrysis lutheri* and *Isochrysis galbana*. Section 2 deals with conditioning adults for spawning. It is not uncommon to find mature sperm and eggs in quahogs at any time of year. They do not absorb undischarged gametes. In early spring they can be brought directly from the natural environment and induced to spawn without prior conditioning. In the laboratory, temp for normal development of larvae ranges from 17.5 to 32.5°C. Growth is fastest at higher temps. Use of *M. lutheri* and *I. galbana* as food precludes higher temps, for these species will not tolerate temps much above 27°C. Optimum density of these food organisms is 10^5 cells/ml at larval concentrations of 10/ml. Seawater was filtered, warmed, and stored in a tank for gravity flow to the culture room. Larvae were reared in 24 gal (90 l) plastic refuse containers with lids. Water temp was maintained at 27°C by holding containers in a constant temp bath. Water was changed daily; larvae were siphoned onto a stainless steel screen. Larvae were not disturbed until 2 days after fertilization, when they were capable of feeding and had fully formed shells. Only batches with 50% survival from fertilized egg were retained for culture. In addition to the 2 flagellates mentioned, quahog larvae lived and grew on a diet of the diatom *Cyclotella nana*, which was the chief component of blooms in Great South Bay and Moriches Bay, N.Y. in 1958. Optimum density for culturing quahog larvae to metamorphosis is 2.5 to 5 larvae/ml. Quahog larvae are easier to culture than oyster because they are less selective of food and larval life is shorter. Quahog larvae are not hindered in feeding when food is 10 to 12 times as concentrated as in nature. For juveniles a density of 24 clams/in^2 was not excessive for culturing up to a length of 5 mm; survival was 87% but growth was slow at temps used (16-20°C). At higher temps (22-29°C) rate of growth nearly doubled but survival was poor because large numbers of *Vorticella* interfered. Growth of *Vorticella* might be reduced by eliminating direct sunlight, and forceful spraying of quahogs. Culturing large numbers of quahogs, approximately 2 mm long, at a density of 41/in^2 is feasible. Improvements in size and shape of culture vessels are worth investigation. In summer 1963 quahogs 1/4 to 1/2 mm long were transferred from the hatchery at Brush pond, where salinity was variable (ca 25-30°/₀₀). They were protected in the natural environment by a fence, but no clams were found at end of summer. In 1964 hatchery-spawned clams averaging 6.5 mm long were held from late Aug to end of Oct in floating trays. Length at end of experiment was an average of 8.7 mm. In 1965 quahogs averaging 3 mm long were placed in sediment-filled buckets, in floating trays, on 1 Apr. By mid-June average length was 5 mm, by Sept 10 mm, when growth stopped. Practicality of artificial shellfish production is still questionable. A hatchery is expensive to build and operate, trained personnel are needed, and rewards are uncertain. A hatchery that could hold over $40x10^6$ oyster or quahog eggs and larvae would cost $40,000, equipment another $20,000, and annual cost of operation would be about $40,000. Personnel would cost an additional $17,500. (Abstracter's note: at today's inflated prices and wages, costs will be considerably higher). Only fragmentary information was available on anticipated survival of hatchery-reared quahogs in nature. It is extremely difficult to maintain juveniles under natural conditions that permit accurate evaluation of survival. In the area of study the authors concluded that oysters are best suited to hatchery operations because 1) they attach to a substrate and can be observed, and, if necessary, moved; 2) may be grown in heavy concentrations off the bottom; 3) if suspended, they mature more rapidly to marketable size than quahog; 4) price of oysters has been climbing steadily whereas hard clam prices vary widely; 5) oysters can be cultivated in tidal ponds with wide range of salinity, quahogs only in high salinity. For oysters, one year's production might return $120,000 for an annual investment of $36,700 (1966 dollars). The rest of the discussion deals with prospects for oyster culture. - J.L.M.

1253
Maurer, Don, and Les Watling. 1973.

The biology of the oyster community and its associated fauna in Delaware Bay. Del. Bay Rept. Ser. 6. Dennis F. Polis (ed.) Coll. Mar. Stud., Univ. Del. Newark, 97 p.

Mercenaria mercenaria is listed as one of 154 species associated with oyster beds, but it was not among the top 23 species. Hard clam was commonly collected in fine sands with clay, near and in oyster beds. The belief of local oystermen that old, noncultivated oyster beds were productive sites for hard clam was confirmed. Apparently, shell fragments afford protection to juveniles against predation, and clams survive predation better in certain shell fragment sizes (unspecified) than in others. Additional information on hard clam biology was being collected at the time of writing. - J.L.M.

1254
Maurer, Don, and Les Watling. 1973.

Studies on the oyster community in Delaware: the effects of the estuarine environment on the associated fauna. Int. Revue Ges. Hydrobiol. 58(2): 161-201.

Mercenaria mercenaria was found in fine sand and clay sediments underlying oysters and shells in 5 of 8 areas sampled, in and near oyster bars. Local oystermen considered old, noncultivated oyster beds as productive sites for harvesting hard clams. Shell fragments, especially of certain sizes, protect young clams against predation, especially from crabs. *Mercenaria mercenaria* occurred in less than 20% of all river samples. - J.L.M.

1255
Maurer, D., L. Watling, and G. Aprill. 1974.

The distribution and ecology of common marine and estuarine pelecypods in the Delaware Bay area. Nautilus 88(2): 38-45.

Mercenaria mercenaria is classified as a true estuarine species. It is commonly collected in fine sand with some clay. In Delaware Bay it ranges from Woodland Beach to the ocean, although it is most abundant in the lower Bay from south of Port Mahon to Broadkill Beach. It is present in commercial quantities in Rehoboth and Indian River Bays. Coincident with hard clam in smaller bays is *Pitar morrhuana*, which is commonly collected but less abundant. Both species are on the borderline between true estuarine and euryhaline marine species because they occur frequently near high salinity inlets or in the ocean. The salinity range of *M. mercenaria*, according to the literature, is 10-35°/∘∘. In the Delaware Bay area it was found between 15 and 30°/∘∘. It spawns May through October, is found in substrates of silt-clay through medium sand with some shell, is an infaunal suspension feeder, and a moderately rapid burrower. - J.L.M.

1256
Maurer, D., L. Watling, P. Kinner, W. Leathem, and C. Wethe. 1978.

Benthic invertebrate assemblages of Delaware Bay. Mar. Biol. 45(1): 65-78.

Bay-wide surveys of benthic invertebrates were made in Delaware Bay in summers, 1972 and 1973, at 105 and 102 stations respectively. Sediment distributions were mapped. Predators of hard clam *(Mercenaria mercenaria)* include blue crab and horseshoe crab. Unpublished laboratory studies showed that blue crabs can destroy up to 25 juvenile hard clams/day each, and that in tanks with several cm of sand casual movements of large horseshoe crabs crushed large numbers of juvenile hard clams. *M. mercenaria* was not among the 30 most frequently occurring species in samples. - J.L.M.

1257
Maury, C. J. 1920.

Recent Mollusca of the Gulf of Mexico and Pleistocene and Pliocene species from the Gulf States. Part I. Pelecypods. Bull. Am. Paleon. 8: 1-116, 1 pl.

This paper was not seen. - J.L.M.

1258
Medcof, J. C. 1947.

Clam farming in the Maritimes - preliminary information. Oyster Inst. N. Am., Trade Rept. 84, 3 p.

Could not locate. Search terminated. - J.L.M.

1259
Medcof, J. C. 1959.

Stock-taking shows that seven species are marketed; prospects for improvement. Dept. Fisheries of Canada, Trade News.

Could not locate. Search terminated. - J.L.M.

1260
Medcof, J. C., and C. J. Kerswill. 1965.

Effects of light on growth of oysters, mussels, and quahaugs. J. Fish. Res. Bd. Canada 22(2): 281-288.

Three species, *Crassostrea virginica, Mytilus edulis*, and *Mercenaria mercenaria*, were held in floating trays, in paired lots in light and dark compartments. Linear shell growth of oysters and mussels was greater in the dark, but thickness: length ratio (cupping) was reduced. No differences between the two lots of quahog were noted, except that meats were plumper (fatter) in light-exposed compartments, as were those of the other two species. - J.L.M.

1261
Medcof, J. C., and J. S. MacPhail. 1952.

The winter flounder - a clam enemy. Fish. Res. Bd. Canada, Prog. Rept. Atl. Coast Stas. 52(118): 3-8.

Winter flounder is frequently gorged with small soft clams, which they swallow whole. The flounder also feeds on siphons of *Mya*, and may destroy living clams by so doing or interfere with their ability to feed. No mention is made of predation on young hard clams, but the possibility should be recognized. - J.L.M.

1262
Medcof, J. C., Arthur H. Clarke, Jr., and John S. Erskine. 1965.

Ancient Canadian east-coast oyster and quahaug shells. J. Fish. Res. Bd. Canada 22(2): 631-634.

In a pond near St. Andrews, N.B. a native population of quahaugs was discovered in 1951. A barrier beach prevents flooding by cold waters of Passamaquoddy Bay except at high spring tides. A break in the barrier beach could destroy these clams and leave the shells to puzzle future geologists. At times and places along the coasts of Quebec and Nova Scotia conditions have favored quahaugs for at least short periods, although the species does not live in the vicinity today. This explains the large quantities of shells in Indian middens in such areas. Quahaugs taken in an Indian midden at St. Margaret's Bay, N.S. at about 44°39' N. Lat. were aged by radiocarbon dating as 500 ± 60 yrs. - J.L.M.

1263
Medcof, J. C., A. H. Leim, Alfreda B. Needler, A. W. H. Needler, J. Gibbard, and J. Naubert. 1947.

Paralytic shellfish poisoning on the Canadian Atlantic coast. Fish. Res. Bd. Canada, Bull. 75, 32 p.

Although the authors found that the problem of shellfish poisoning was broader than had been supposed, and that many species were involved, they did not examine *Mercenaria (Venus) mercenaria*. Six species were examined for toxicity according to geographic and local variations, distribution of toxin in the body, seasonal and annual differences, source of poison, effects of processing, and epidemiology. - J.L.M.

1264
Meers, Karren F. 1972.

A survey and investigation of the shallow water invertebrates of South Oyster Bay. A thesis presented to the faculty of Hofstra University in partial fulfillment of the Master of Arts degree in biology (sic). June 1972, iii+99 p.

Mercenaria mercenaria was found at 2 of 4 stations. Station 2, a salt marsh on the eastern side of Wantagh Parkway, Long Island, N.Y., with a soft and mucky bottom, "was littered with clams, both mercenaria and ensis" (sic). No *Zostera* was present. All organisms collected were figured and described very briefly. The drawing of hard clam is very inaccurate, and the common name is given incorrectly as cherry stone clam. The paper contains a summary of disappearance and reappearance of *Zostera*, but does not mention possible relationships with hard clam. - J.L.M.

1265 Meigs, E. B. 1915.

The ash of clam muscle in relation to its osmotic properties. J. Biol. Chem. 22: 493.

Data cited by Vinogradov (1953), abstracted elsewhere in this bibliography. - J.L.M.

1266 Melson, Gail L., and Robert W. Cowgill. 1976.

Comparison of the muscle protein paramyosin from different molluscan species. Comp. Biochem. Physiol. 55B(4): 503-510.

Paramyosin is a contractile protein consisting of 2 intertwined α-helical chains. It was isolated and purified from *Mercenaria mercenaria* and 3 other mollusks. Yields of 14 to 22.5 mg of purified paramyosin/g wet weight whole adductor muscle were obtained from hard clam by 3 different extraction methods. Estimated molecular weights ranged from 200,000 to 207,000 Daltons. Paramyosin appeared to be partially degraded unless proteolytic attack during the isolation procedure was prevented. Fluorescence was characteristic of emission from tyrosyl residues. Apparently the other fluorescent amino acid tryptophan is absent. Relative quantum yield of fluorescence (R_{tyr}) and absorbance at 276 nm for tyrosyl residues on paramyosins were: pH 2, 0.67; pH 7, 0.40, pH 2/pH 7, 1.67; A_{276}, 0.30. This shows that paramyosin is helical and displays fluorescence quenching at neutral pH. Amino acids, expressed as mole percent, were: glutamic acid 21.4, leucine 12.4, aspartic acid 13.3, alanine 12.0, arginine 10.7, lysine 7.0, serine 4.8, and lesser amounts of 8 others. Solubility of paramyosin from hard clam decreases markedly at low ionic strength at neutral pH. It was denatured by guanidine-HCl in multiple stages. When exposed to proteolysis by pepsin and trypsin, paramyosin from *Mercenaria* accumulated a resistant segment of 132,000 Daltons, suggesting that regions of paramyosin vary in stability, and that these variations may be of physiological significance in function of the molecule. - J.L.M.

1267 Menzel, R. Winston (ed.). 1956.

Annotated check-list of the marine fauna and flora of the St. George's Sound - Apalachee Bay region, Florida Gulf coast. Fla. State Univ., Oceanogr. Inst., Contrib. 61, 78 p.

Compiled primarily for student use in a course. *Mercenaria campechiensis* is included, but not *M. mercenaria*. Representative area is sand bars, grass flats, shell, and mud areas. Substrate is sand-mud. Occurs throughout the year. Salinity range 25 to 37°/₀₀. Abundance: common. - J.L.M.

1268 Menzel, R. W. 1960.

Growth and mortality of northern hard clam in Florida waters. Assoc. SE Biol., Bull. 7(2): 34-35 (abstract).

Growth of laboratory-reared *Mercenaria mercenaria* from Milford, Conn. was excellent, some reaching commercial size in 18 months. Growth was best in fall and spring, less in winter, and almost ceased in summer, especially during 2nd year. Mortality was very low when clams were protected from predators, but soon reached 100% without protection. - J.L.M.

1269
Menzel, R. W. 1962.

Shellfish mariculture. Proc. Gulf. Caribb. Fish. Inst., 14th Ann. Sess. Nov. 1961: 195-199.

Pilot operations to determine whether *Mercenaria mercenaria* can be raised profitably in Florida waters have shown that, unless clams can be protected from predators, mortality is very high. Experiments underway for 6 months showed encouraging survival and growth. Growth was much more rapid than in northern waters. In a year, growth rate varies several hundred percent among individual clams, and this offers promise for relatively uniform and rapid growth by selection. Hybrids of northern and southern quahaug grow better than the northern parent. It is concluded that, with refined techniques, costs may be offset by the return from such high-valued seafoods. - J.L.M.

1270
Menzel, R. Winston. 1962.

Seasonal growth of northern and southern quahogs, *Mercenaria mercenaria* and *M. campechiensis*, and their hybrids in Florida. Proc. Natl. Shellf. Assn. 53: 111-119.

Growth was measured for 19 months at Alligator Harbor, Fla. Fastest growth was in spring and fall. Northern quahog had the least overall growth (8 mm clams growing to 41 mm average length) and showed least growth during the hottest period. Southern quahog had the best (growing from 8 mm to 57 mm) and had least growth during the coldest period. Growth of hybrids was intermediate but closer to the southern parent (growing from 8 mm to 52 and 55 mm). Growth of hybrids was better than that of either parent in late spring and early fall. - modified author's abstract - J.L.M.

1271
Menzel, R. Winston. 1962.

Seasonal growth of northern and southern quahaugs and their hybrids. Assoc. SE Biol. Bull. 9(2): 34 (abstract).

Monthly measurements of growth have been made of the northern quahaug, *Mercenaria mercenaria*, the southern quahaug, *M. campechiensis*, and their reciprocal hybrids for 15 months in Alligator Harbor, Florida. Fastest growth for the 4 groups is in spring and fall. Northern quahaug has the least overall growth and shows least growth during the hottest period of the year. Southern quahaug shows the best overall growth and has the least growth during the coldest period. Growth of hybrids is between the two parents but closer to the southern than to the northern. Growth rate of hybrids is better than either parent in late spring and early fall. - J.L.M.

1272
Menzel, R. W. 1963.

Seasonal growth of the northern quahog, *Mercenaria mercenaria* and the southern quahog, *M. campechiensis*, in Alligator Harbor, Florida. Proc. Natl. Shellf. Assn. 52: 37-46.

Laboratory-reared *Mercenaria mercenaria*, mostly under 5 mm shell length, were obtained from Milford, Conn. and planted in boxes of sand covered with wire. *M. campechiensis* set in the boxes in spring. Clams were later transplanted and covered with 1/2-inch mesh wire. Measurements were made monthly. The northern species increased from 3 mm to 32.6 mm long in the 1st yr, to 49.6 mm the 2nd yr, and to 61.5 mm the 3rd yr. Southern clams increased from 16.5 to 54.3 mm the first yr measured, to 74.2 mm the 2nd yr. Although periods of measurement were not the same, *M. campechiensis* obviously grew faster. *M. mercenaria* grew fastest in spring and fall at temps between 15 and 25°C. Growth was less in cold weather and least in summer. *M. campechiensis* grew best in spring and fall, was fairly rapid in summer, and slow in winter. Both species grew relatively faster when young. The northern species grew faster than in the area from Me. to N.C., largely because it continued to grow in winter. High turbidity in summer in Alligator Harbor may also have affected growth of *M. mercenaria*. - J.L.M.

1273
Menzel, R. Winston. 1964.

Checklist of the marine fauna and flora of the St. George's Sound area. Fla. State Univ., Oceanogr. Inst., Tallahassee, Contrib. 61, 134 p.

Mercenaria campechiensis is included, but not *M. mercenaria*. Representative area is sand bars, grass flats, shell, and mud areas. Substrate is sand (mud). Present throughout the year. Salinity range 25 to 37°/oo. Abundance: common. - J.L.M.

1274
Menzel, R. W. 1964.

Observations of quahog clams and their hybrids. Am. Zool. 4(3): 292.

Northern quahog, *Mercenaria mercenaria*, from Conn., N.Y., Del., Va., N.C., S.C., and Fla. were crossed with southern quahog, *M. campechiensis*, from N.C. and 3 localities in Fla. Various backcrosses were made, as well as an F_2 of the F_1 of *M. campechiensis* Fla. female x *M. mercenaria* Conn. male. Meiotic and mitotic chromosomes have been studied. - J.L.M.

1275
Menzel, R. Winston. 1964.

Seasonal growth of northern and southern quahogs, *Mercenaria mercenaria* and *M. campechiensis*, and their hybrids in Florida. Proc. Natl. Shellf. Assn. 53: 111-119.

Growth of northern quahog, *Mercenaria mercenaria*, southern quahog, *M. campechiensis*, and their reciprocal hybrids were measured monthly for 19 months in Alligator Harbor, Florida. Fastest growth for the four groups occurred in spring and fall. Northern quahog had the least overall growth (8 mm clams growing to 41 mm average length) and showed least growth during the hottest period of the year. Southern quahog had the best overall growth (growing from 8 mm to 57 mm in average length) and grew least in the coldest period. Growth of hybrids was intermediate between that of parents but closer to the southern than to the northern parent, 8 mm clams growing to average lengths of 52 and 55 mm in 19 months. Growth rate of hybrids was better than that of either parent in late spring and early fall. - modified author's abstract - D.L.

1276
Menzel, R. W. 1966.

Studies of the F_1 and F_2 hybrids of the northern and southern quahog clams. Assoc. SE Biol. Bull. 13(2): 41 (abstract).

During the first half of five years' observations of northern and southern parents (*Mercenaria mercenaria* and *M. campechiensis*) and reciprocal hybrids, the southern species grew fastest, the northern slowest, and the hybrids intermediate but close to the southern parent. During the latter half hybrids surpassed both parents. The F_1 hybrid of the cross, female *M. campechiensis* x male *M. mercenaria*, grew larger than those of the reciprocal cross, and their F_2s were the most successful. The F_2 of the reciprocal cross all died within one month. A limited number of F_2s from reciprocal crosses between F_1s and the first mentioned F_2 are still growing. Although still too small for final characterization, they so far resemble the southern parent in shell morphology. - J.L.M.

1277
Menzel, R. W. 1967.

Studies of the F_1 and F_2 hybrids of the northern and southern quahog clams. Proc. Natl. Shellf. Assn. 57: 2 (abstract).

During the first half of five years' observation of northern and southern parents and reciprocal hybrids, southern species grew fastest and northern slowest. Growth of hybrids was intermediate, but closer to the southern parent. During the latter half of the observation period growth rates of hybrids surpassed both parents. The F_1 hybrid of the cross, female *Mercenaria campechiensis* x male *Mercenaria mercenaria*, grew larger than those of a reciprocal cross. All 4 possible F_2 crosses have been made. Although still too small for final characterization, they so far resemble the southern parent in shell morphology. - D.L.

1278
Menzel, R. W. 1968.

The species and the distribution of quohog clams *(Mercenaria)*. ASB Bull. 15(2): 46 (abstract).

Two species of quohog, *M. mercenaria* and *M. campechiensis*, and several recognized subspecies inhabit the Atlantic and Gulf of Mexico coasts of the United States. The northern quohog extends northward to Canada. In the Gulf it is represented by the subspecies *M. m. texana*. This species is confined to inshore waters of bays, inlets, and estuaries of proper salinity. The southern species occurs only offshore in the more northern part of its range (up to N. J.) but occurs inshore south of Cape Canaveral and in the Gulf of Mexico as well as offshore. *M. m. texana* is found inshore south of Cape Canaveral along with typical northern and southern forms. The two species hybridize readily in the laboratory and the F_2s have been reared. Morphology of F_2s is very similar to *M. m. texana* and it is surmised that the subspecies is a naturally occurring hybrid. - J.L.M.

1279
Menzel, R. W. 1968.

Chromosome number in nine families of marine pelecypod mollusks. Nautilus 82(2): 45-50, 53-58.

Acetocarmine squashes of eggs and zygotes which have been fixed in acetic acid-ethanol are reliable for rapid chromosome analysis. *Mercenaria mercenaria* and *M. campechiensis* have 19 chromosomes (2N=38). It is suggested that chromosome numbers are constant within a family, thus may be important in systematic studies. - J.L.M.

1280
Menzel, R. W. 1968.

Cytotaxonomy of species of clams *(Mercenaria)* and oysters *(Crassostrea)*. Proc. Symposium on Mollusca, Pt. 1 (Mar. Biol. Assn., India): 75-84, 3 pls.

Ranges of the quahogs *Mercenaria mercenaria* and *M. campechiensis* overlap from central coast of N.J. to central east coast of Fla. For most of this distance, and farther north where it has no close relative, *M. mercenaria* is usually confined to more saline bays and inlets. *M. campechiensis* is found in outer coastal waters north of central east coast of Fla. but also in coastal bays farther south and in Gulf of Mexico. A subspecies, *M. m. texana*, is found from about Cape Kennedy south, and also in Gulf of Mexico, but this subspecies apparently has not been taken south of the vicinity of Miami on the east coast, or on the west coast of Fla. West and south of the west coast of Fla. *M. campechiensis* and *M. m. texana* occur together. Northern and southern quahog hybridize readily in the laboratory. Thus, co-occurrence of the two species along the lower east coast of Fla. presents ample opportunity for interbreeding. Laboratory-reared hybrids resemble *M. m. texana*, suggesting that the subspecies may be of hybrid origin. Subspecies *M. m. notata* is not valid. *M. mercenaria* has a smoothish, glossy area on the center outer surface of the valves. Interiors of valves are white, commonly with purple stains. The lunule is 3/4 as wide as long. The species will remain tightly closed out of water up to 2 weeks, especially if kept cool. *M. campechiensis* lacks the smooth area on the outer surface of the valves, has persistent raised growth ridges, and more obese shells. Valve interiors have no purple stains, and the lunule is about as wide as long. This species, even under refrigeration, will gape, lose its shell liquor, and spoil in a few days. Reciprocal F_1 hybrids between the two species are fertile and the 4 types of F_2 hybrid have been reared in the laboratory. Studies of chromosomes of species and hybrids at meiosis and mitosis show that chromosomal behavior of hybrids is normal. - J.L.M.

1281
Menzel, R. W. 1970.

The species and distribution of quahog clams *Mercenaria*. Proc. Natl. Shellf. Assn. 60: 8 (abstract).

Northern quahog *(Mercenaria mercenaria)* and southern quahog *(M. campechiensis)* with several subspecies occur along the Atlantic coast of North America. Northern ranges from Canada to Florida and the northern Gulf of Mexico, the southern from New Jersey to Florida, the Gulf of Mexico, and is reported from the West Indies. Northern is confined to inshore waters of bays, inlets and estuaries, except specimens taken offshore on the northwest coast of Florida. Southern occurs only offshore in the northern part of its range, although one was seen from the mouth of Chesapeake Bay, but occurs inshore south of Cape Canaveral, Florida and in both habitats in the Gulf of Mexico. *M. mercenaria notata* has no validity based on breeding studies and occurrence of the subspecific trait in northern or southern forms. Museum specimens labelled *M. mercenaria alba* seem to be bleached *M. mercenaria*. The northern species is mostly represented by *M. mercenaria texana* below Cape Canaveral and in the Gulf of Mexico. Northern and southern species hybridize readily in the laboratory and F_2 hybrids have been reared. Shell morphology of about 3/4 of the F_2s is very similar to the subspecies *M. mercenaria texana* and it suggests this subspecies is a naturally occurring hybrid between the two forms. - J.L.M.

1282
Menzel, R. W. 1971.

Possibilities of molluscan cultivation in the Caribbean. In Symp. on Investig. and Resources of the Caribbean Sea and Adjacent Regions. FAO Fish. Rept. 71.2(4.27): 183-200.

The commercial quahog fishery in the U.S. is based largely on *M. mercenaria* and on small clams 50-75 mm long. Large clams are used in chowders, but must compete with more efficiently harvested and abundant *Spisula solidissima* and *Arctica islandica*. The relatively small fishery for *M. campechiensis* is related to gaping and spoilage soon after it is removed from the water, but also because some areas where it occurs in abundance are polluted, lack of fishery knowledge by local fishermen, lack of markets, and competition from well established and more profitable fisheries for shrimps, crabs, spiny lobster, and mullets. Northern quahogs 10-25 mm long were planted at various concentrations in fenced plots of 125 to 250 m^2. Mortality usually was less than 10%. Unprotected control plantings had 100% mortality, usually within 2 weeks, from crab and gastropod *(Busycon)* predation. On protected grounds, over 250 clams per m^2 would reach market size for half-shell trade in slightly over a year. Observations on laboratory-spawned northern and southern quahog and their F_1 and F_2 hybrids showed that all showed greatest shell growth in spring and fall. Northern species grew better in winter than southern. In summer, shell growth in northern quahog slowed, but southern grew almost as rapidly as in spring and fall. Southern species had greater annual growth. Shell growth of hybrids resembled southern parent more than northern. The F_1 hybrid surpassed the southern parent in shell growth in the third year. The two species are separated ecologically in the northern part of the range on the Atlantic coast, but half way down the east coast of Fla. opportunities for hybridization should be plentiful. The subspecies of *M. mercenaria*, which is common where the two species grow together, closely resembles laboratory-spawned F_2 hybrids. In laboratory experiments the southern species gaped within 24 hrs under refrigeration and in 60 hrs all were gaping or dead. All northern species were alive and most in good condition after 350 hrs. Less than 20% of F_1 hybrids were gaping at end of 350 hrs. Storage time depends on physiological condition of clams. Experiments suggest that hatchery-reared hybrids might be best for planting in clam farms. Satisfactory techniques for large-scale rearing of commercial quantities of clams from metamorphosis to the size at which they can be planted safely under protection have not yet been developed. Success of clam mariculture in the Caribbean is speculative. In tropical waters spawning will be more or less continuous, mitigating against successful controlled spawning in hatcheries. (Abstracter's note: this paper has an extensive list of literature cited.) - J.L.M.

1283
Menzel, Winston. 1971.

Selection and hybridization in oysters and clams. Mollusk Chaser, South Florida Shell Club, Inc., Miami, Fla. 9(10), 2 p.

Selection is that process in which certain alternative traits inherent in a species are transmitted to the progeny. Hybridization is one way to develop those traits. Two species of quahog clams occur on the east coast, *Mercenaria mercenaria* from Canada to Florida, and *M. campechiensis* from New Jersey to Florida, the Gulf of Mexico and the West Indies. The northern quahog can be held out of water under suitable conditions for considerable periods. Annual growth of the southern quahog is about twice as fast as the northern. F_1 hybrids have the keeping quality of the northern parent and the fast growth of the southern. They must be produced in a hatchery. Various characteristics could be selected for ideal clams, and certified seed could be produced. - J.L.M.

1284
Menzel, Winston. 1971.

The mariculture potential of clam farming. Am. Fish Farmer World Maric. News 2(8): 8-14.

Clams of genus *Mercenaria* appear to be suitable subjects for mariculture. Clam farming was advocated in Massachusetts about 50 years ago, but it was not until Dr. Loosanoff and colleagues at Milford, Conn. developed techniques for rearing shellfish larvae that molluscan mariculture could become a reality. Laboratory-spawned quahogs from that source have been grown in Florida for some years. Growth was faster in these semitropical waters. Northern quahog, *M. mercenaria*, occurs from the Gulf of St. Lawrence to Florida, and sparsely in some places in northern Gulf of Mexico. Southern quahog, *M. campechiensis*, ranges from New Jersey to Gulf of Mexico and West Indies. Northern species is found in mouths of estuaries, bays and inlets, in salinities above 20°/₀₀. In the northern part of its range, and south to about Cape Kennedy (Canaveral) southern species is found in shallow waters off the coast. Below C. Kennedy southern quahog is found inshore also, sometimes on same grounds as northern species. The two have differences in morphology and physiology. Shells of southern quahog are more obese and growth ridges are persistent on exterior of valves, even in old clams. The exterior central portion of valves in northern quahog are smoothish, especially in larger clams. Purplish-blue pigment characteristic of northern quahog is rarely found in the southern form. Especially in larger clams, the lunule of the southern species is about as wide as long, longer than wide in the northern, although this difference overlaps. The southern species quickly gapes and spoils when removed from the water, which restricts its marketability. Northern species will remain tightly closed out of water for 2 weeks or more, especially under refrigeration. In both species, ability to remain closed depends upon physiological condition, temp and humidity. In the several commercial hatcheries now operating, clams and their larvae are fed living food. Growth experiments in Fla. were conducted in natural environment by covering with wire to prevent predation. Growth of individual clams varied greatly. Best shell growth was in spring and fall for both species. Northern species grew all winter, but shell growth virtually stopped when water temp rose above 86°F. Southern species grew all summer but growth ceased when temp dropped below about 55°F. Annual growth of southern quahog was almost double that of northern. The 2 species hybridize readily in the laboratory and the hybrid is fertile. F_1, F_2 and F_3 hybrids are growing in Fla. F_1 and F_2 hybrids grew as well as southern parent or better. F_1 hybrids have intermediate shell characteristics, F_2 and F_3 hybrids have segregated shell characteristics. F_1 hybrids were able to remain closed out of water almost as long as northern parent. It takes about 2 yrs for northern quahog to reach halfshell market size in Fla. waters. Fifty clams/ft^2 was about maximum density for satisfactory growth. Southern quahog and hybrids reach market size in 1 to 1 1/2 yrs. One advantage of hard clam for mariculture is that small clams bring a higher price than older clams, which allows maximum turnover rate for crops. Quahogs have no known epidemic diseases, but disease might be expected when they are grown under mariculture conditions. Some hazards need to be solved. Several animals are voracious predators, especially blue crab (*Callinectes sapidus*). In cages, blue crabs can destroy 2-inch clams. Other predators are other crabs, whelks and moon shells. Smaller clams are most vulnerable. A small pilot quahog farm of 3,500 ft^2 had a maximum of over 100,000 clams at densities of 10 to 75/ft^2. Protection from predators was given by a 6 foot high fence of 1/4 to 1/2 inch mesh fencing of wire or nylon webbing. A few predators entered and had to be removed at times. Seed clams less than 1/2 inch long were not satisfactory because small predators could enter the screen. Smaller mesh screen would interfere with water circulation and be more vulnerable to storm damage. Fouling on meshes increased storm damage. Larger clams had less than 10% mortality from predators. Rearing clams to 1/2 inch size or larger requires large quantities of food and space and tremendous labor. Clams as small as 1/25 inch have been planted successfully in the field, but they were given protection that would not be practical commercially. Experimental results suggest that clams could be grown at a density of at least a million clams/acre. Northern quahog would reach half-shell size in about 2 yrs, F_1 hybrids in 1 yr. At a market price of 3¢ each, gross return/acre would be $30,000 provided that minimal densities could be maintained and prices remained firm. Unexpected mortalities or poor growth from environmental variations could be problems. An area with adequate currents would be necessary for food supply and removal of wastes. Salinity must remain above minimum levels. Other costs were estimated: fences cost about $2,000/acre installed; wire lasted about 3 yrs, and netting about 2 yrs, with minor repair; beds of crushed shell or stones, like those developed in Va. to reduce predation, if they worked in Fla., would add to costs. A hatchery would be essential. Costs were not estimated, but some logistic problems and needs are discussed. Labor would be another significant cost. One man with a helper probably could operate a small hatchery to supply enough seed clams for several acres, and take care of some other needs, like surveillance, minor repairs, sampling for growth, and preventing poaching. Additional labor would be needed for preparing beds for planting and for harvesting the crop. Mariculture of clams offers as much potential as any other organism now being considered, but it is still largely experimental. The principal problem probably is in rearing young clams to a size relatively resistant to predation. One interesting and challenging problem is further domestication through selection and breeding for desirable traits. Recommended facilities and conditions are: 1) a well equipped hatchery; 2) use F_1 hybrids for seed clams; 3) supply and maintain adequate predator control; 4) planting densities not over 50 clams/ft^2; 5) preliminary trial plantings for evaluations; and 6) proper site selection: a) salinity above 25°/₀₀, b) no extremes in salinity and temp, c) substrate of mud/sand, d) areas protected from continual wave action, and e) no pollution. - J.L.M.

1285
Menzel, R. W. 1971.

Quahog clams and their possible mariculture. Proc. 2nd Ann. Wkshp. World Maricul. Soc. 2: 23-36.

Quahog clams, genus *Mercenaria*, have a life history conducive to domestication. Most techniques have been established, and await commercial application. At present state of knowledge it is more practical to grow clams under natural conditions. Specific recommendations for clam mariculture are: 1) a hatchery for reliable seed supply; 2) use hybrid seed, *M. mercenaria* x *M. campechiensis*; 3) protect against predation; 4) plant at densities of 250 to 500 clams/m^2; 5) procure proper environmental conditions; and 6) make preliminary trial plantings for evaluation. - J.L.M.

1286
Menzel, R. W. 1972.

The role of genetics in molluscan mariculture. Bull. Am. Malacol. Un. for 1971, AMU, 37th Ann. Meeting: 13-15.

Most of the commercial fishery for hard clam in the United States is for northern quahog, *Mercenaria mercenaria*. The southern quahog, *M. campechiensis*, is relatively unimportant because it quickly gapes and dies when removed from the water. Hard clams can be grown commercially in aquaculture if predation can be prevented. Natural recruitment is too erratic, and seed clams for mariculture should be supplied from a hatchery. The two species hybridize readily in the laboratory, and F_2 and F_3 hybrids have been grown. In Florida it is possible to produce commercial-size northern quahog for the half-shell trade in about 2 years and southern quahog in about 1 year. Growth of hybrids about equals that of southern parent, but keeping quality out of water almost equals that of northern parent. Thus, hybrid clams should be used in mariculture. Concentrated effort is needed by government and industry to apply present knowledge and to intensify research, as has been done with commercial animals and plants on land. - J.L.M.

1287
Menzel, Winston. 1972.

Selection and hybridization in the mariculture of oysters and clams. Proc. 3rd. Ann. Workshop - World Mariculture Soc.: 309-317.

Next to oysters, quahogs are the most valuable mollusk in the United States. Most are sold in the shell. Northern species, *Mercenaria mercenaria*, is ideally suited to such use because it has excellent keeping qualities out of water. Southern species, *M. campechiensis*, quickly gapes and spoils. Native southern species grows almost twice as fast as northern. F_1 hybrids grow almost as rapidly, and keeping quality is almost as good as that of northern parent. In Gulf of Mexico waters the northern species, from New York, stops growing in summer. Plans for future experiments are described. - J.L.M.

1288
Menzel, R. W. 1972.

Effects of Man's activities on estuarine fisheries. Underwater Nat. 7(2): 19-31.

Mercenaria mercenaria is not mentioned, but many of the hazards to oysters described could apply equally to hard clam. - J.L.M.

1289
Menzel, Winston. 1974.

Clams and oysters as animals for mariculture in the United States. Proc. 10th Ann. Conf., Mar. Technol. Soc.: 611-617.

Mercenaria is relatively easy to rear under artificial conditions and brings a high price, thus is a suitable candidate for mariculture. Small clams, which are eaten raw, bring the highest prices, which is another advantage. *M. mercenaria* ranges from Gulf of St. Lawrence to Gulf of Mexico and includes a subspecies in the south. *M. campechiensis* ranges from New Jersey to Gulf of Mexico and Caribbean, only offshore in the north. The 2 species have several morphological and physiological differences. Northern quahog keeps the shell closed for a considerable period when out of water, southern species quickly gapes and dies. Northern species grows faster in warmer waters of northwest Fla. than in its native habitat, but not as well as native southern species. F_1 hybrids have the fast growth rate of southern parent and keeping qualities of northern. Thus, in southern waters, the hybrid should be used in mariculture. Growth under laboratory conditions is less than in the natural environment. Space requirements and costs work against holding juveniles for long in the hatchery. They can be planted in natural environment when as small as 1 mm, but must be protected against predators. Clams have been grown to market size in plots covered with wire. Below 15 mm mortality was heavy, probably from predators that entered through meshes of wire. When planted at over 15 mm mortality was 10 to 25%. In Fla. waters northern quahog will reach market size in about 2 1/2 yrs after spawning. About 500 clams/m^2 was maximum density for good growth. Clams 15 mm or larger, planted in fenced areas at 250 clams/m^2, and allowing for 25% mortality, will yield about $2x10^6$ clams/ha. At a wholesale price of 3¢/clam 1 ha would yield $60,000 gross. The method used would not be practical commercially. In Virginia, survival rates of 1 mm clams have been excellent when planted on bottom prepared with crushed shell, gravel, or slag to reduce predation. Experiments in Fla. using crushed oyster shell and pea gravel, and planting 2,500 small hatchery-reared clams on each of 8 plots, each 4.55 m^2, were not so successful. Half the control plots were covered with 12 mm mesh plastic coated wire. In these, survival was better than 50% in 9 months. In all other plots, including experimental, mortality was 80 to 100%. No explanation was given for failure. Various combinations of F_1 and F2 hybrids and backcrosses have been tested for growth. Clams from parents selected for rapid growth were larger than controls, and some reached market size of over 50 mm within 14 to 15 months. Commercial possibilities for clam mariculture are good if all presently known techniques are used. New techniques and refinements of present methods are needed. Filter-feeding mollusks are superior to other mariculture organisms because, being primary consumers, they waste less energy than animals at higher trophic levels. - J.L.M.

1290
Menzel, Winston. 1976,

Mariculture: Hybridization and selection in clams, *Mercenaria* spp. ASB Bull. 23(2): 81.

F_1 hybrids between *Mercenaria mercenaria* and *M. campechiensis* had desirable traits of both parents, faster growth rates of the southern and good keeping qualities in the shell of the northern. Considerable variation in growth occurred between individuals, presumably under genetic control. Hybrids and backcrosses were made from original wild parents secured from Atlantic and Gulf of Mexico coasts. Certain selected crosses showed about 40% faster growth rates than obtained previously - to commercial size within 15 months of spawning. Only limited progeny testing has been done. - J.L.M.

1291

Menzel, Winston. 1977.

Selection and hybridization in quahog clams (*Mercenaria* spp.). In Proc. 8th Ann. Meeting, World Mariculture Soc., La. State Univ., Div. Continuing Educ: 507-521.

From 1972 to 1975 northern *(Mercenaria mercenaria)* and southern *(M. campechiensis)* clams, original parents from Maine to Louisiana, including F_1 and F_2 hybrids and backcrosses, were reared to determine which crosses gave the best growth rates. Forty-six crosses were reared to 50 mm long. The following conclusions and recommendations were made. 1. Genetic manipulations and hybridization, along with selection, will establish superior commercial traits for growing in tropical and semitropical areas. 2. Hybrids should have at least half of the northern species in the pedigree for satisfactory keeping quality. 3. Best growth rates were obtained in tropical and semitropical areas. 4. If clams are to be grown in colder areas, selected clams from Delaware Bay should be used for best growth. 5. Clams from Delaware Bay should be used in hybridization with southern species for culture in tropical and semitropical areas. - J.L.M.

1292

Menzel, R. Winston, and Margaret Y. Menzel. 1965.

Chromosomes of two species of quahog clams and their hybrids. Biol. Bull. 129(1): 181-188.

Although the two American species of *Mercenaria* usually are thought to be easy to recognize, diagnostic characteristics are sufficiently variable to cause uncertainty at times. The two species hybridize readily in the laboratory and may also do so in nature. Live specimens of both species were obtained from several localities within their range, from Conn. to west coast of Fla. Both species have 19 pairs of chromosomes at metaphase I and 38 at embryonic mitoses. At metaphase I, chromosome pairs are small and slender and the chromatid split can often be seen. The metaphase I bivalents of *M. mercenaria* are similar to those of *M. campechiensis* but tended to be more compact and less easily analyzed for chiasma frequency and position. The F_1 hybrid was intermediate in this regard, and all chromosomes were paired regularly as 19 homomorphic bivalents at metaphase I. At anaphase I in both species the hybrid chromosomes at one spindle pole were commonly more compact and darkly stained than at the other. Mitotic chromosomes of first and second cleavage divisions were rather long and slender but tended to get shorter and more compact in later divisions, at least at metaphase. High chromosome number and small cells made it impractical to count chromosomes of individual nuclei after second cleavage metaphase. Individual chromosomes ranged widely in relative lengths and arm-length ratios. The ease with which hybrids can be made experimentally, and existence in nature of forms which appear to be intermediate suggest that some gene flow may occur. There appears to be no gross chromosomal barrier to such interchange. This, of course, does not mean that such interchange actually does occur in nature, but whether or not it does happen, hybrids could be an important source of variation for selection of improved strains for commercial production. - J.L.M.

1293

Menzel, R. W., and H. W. Sims. 1964.

Experimental farming of hard clams, *Mercenaria mercenaria*, in Florida. Proc. Natl. Shellf. Assn. 53: 103-109.

Hard clams 33-44 mm long were planted in fenced plots in Alligator Harbor, Florida. At concentrations of 75 clams/ft^2 clams grew 0.6-0.7 mm/month, but at concentrations ranging from 10-50 clams/ft^2 growth was uniformly good, 1.4-1.7 mm/month. Mortality was 5-18% in fenced plots and 100% in unfenced. Blue crab was the major predator. Planted clams less than 10 mm had 100% mortality even in fenced plots, probably caused by shipping from Connecticut. About 80% of the 37-44 mm clams reached market size (50 mm) in 8-10 months. Average length at harvest was 52-56 mm. - D.L.

1294
Menzel, R. W., E. W. Cake, M. L. Haines, R. E. Martin, and L. A. Olsen. 1976.

Clam mariculture in northwest Florida: Field study on predation. Proc. Natl. Shellf. Assn. 65: 59-62.

For 2 important reasons it is preferable to plant hatchery-reared clams in natural environment as soon as possible after setting: 1) costs of holding in a closed system may be prohibitive; and 2) growth rates in the laboratory have never been as good as in the field. In Va. tiny hard clams were protected successfully against predators by planting in a bottom protected with gravel, slag or shell. Various hybrids of *Mercenaria mercenaria* and *M. campechiensis* were planted at Alligator Harbor, Fla. in areas protected with a wire cage, with a substrate of pea gravel, and with crushed oyster shell. Two unprotected plots served as controls. Survival was better than 50% in the wire-covered plot, 10% in gravel, slightly more than 2% in shell, less than 1% in controls. It was concluded that in this area of Fla. gravel or crushed shell substrates do not give satisfactory protection. - J.L.M.

1295
Menzel, R. W., E. C. Cake, M. L. Haines, R. E. Martin, and L. A. Olsen. 1976.

Clam mariculture in northwest Florida: Observations on selection and hybridization. Proc. Natl. Shellf. Assn. 66: 103 (abstract).

Attempts have been made to breed faster-growing quahogs by crossing *Mercenaria mercenaria* with *M. campechiensis* and selecting for fast growth. Parents were obtained from areas from Me. to Tex. Eighty-eight successful rearings and plantings have been made from 1972 to 1975 inclusive. Replicates of each cross, on reaching 2 to 3 mm in the laboratory, were selected for size and were planted and compared with unselected controls. Some crosses reached over 50 mm long in 14 to 15 months. The most rapidly growing lots were selected groups of backcrosses of F_1 hybrids to southern quahog. Recent emphasis has been to backcross these with northern quahog, which has much better keeping quality when removed from the water. - J.L.M.

1296
Mercer, H. 1963.

Comment on L. I. commercial shellfish hatcheries. The Bluepoints Co., West Sayville, L. I., N. Y. Unpublished mimeo leaflet, 3 p.

Could not locate. Search terminated. - J.L.M.

1297
Merrick, Jacqueline P., and William H. Johnson. 1974.

Alpha paramyosin: Solubility and aggregation characteristics. Fed. Proc. 33(5), Pt. 2: 1521 (abstract 1684).

Alpha paramyosin, extracted from molluscan adductor muscle in presence of 0.01 M EDTA, differs from the classical ethanol preparation in size and solubility. Other differences are described. In present studies of aggregation, Ca, suspected as a controlling factor in "catch-muscle" action, affects nucleation time and growth rate. It is proposed that approximately 2/3 of the paramyosin molecule, a protease-resistant core, is involved in aggregation of monomers into thick filaments of adductor muscle, similar to light meromyosin. The C-terminal third is analogous to myosin subfragment-2. The 5% end is "sticky" and involved in interaction between large filaments. The molluscan species is not identified, but it probably was *Mercenaria mercenaria*. - J.L.M.

1298
Merrick, Jacqueline P., and William H. Johnson. 1975.

Further characterization of alpha paramyosin: reduced vs. oxidized forms. Biophys. J. 15(2) Pt 2: 158a (abstract).

Alpha paramyosin, a molecule which appears to be about 5% larger than the classical ethanol preparation extracted from *Mercenaria mercenaria*, is believed to be the native paramyosin species. Alpha-reduced R-paramyosin differs from the oxidized form in several respects. It is generally more soluble than alpha-oxidized, over an ionic strength range from 0.2 to 0.45M. Its phase change from monomer to aggregate is more abrupt and occurs between 0.35-0.25M at pH 7. When ionic strength is held constant at 0.35M, and pH is decreased from 7.0 to 6.7, alpha-R-paramyosin solubility falls off at a more rapid rate than that of the oxidized form. Certain mollusks accumulate lactate as a metabolic end product of the glycolytic scheme. In presence of 50nM lactate at pH 7.0, alpha-R-paramyosin begins to aggregate at a higher ionic strength than the control without lactate, forming large birefringent needles, as seen in phase contrast microscopy. These studies suggest that alpha-R-paramyosin is a physiologically poised system. Conformational changes in the thick filament paramyosin core, possibly leading to the catch state, could occur from very small changes in pH, ionic strength, and presence of certain metabolites such as lactate. - J.L.M.

1299
Merrill, Arthur S. 1971.

Symposium on commercial marine mollusks summary. In Symposium on Commercial Marine Mollusks of the United States. Am. Malacol. Un., Inc., Ann. Repts. for 1970: 38-40.

Mercenaria mercenaria is compared with other commercial mollusks in volume and landed value of production. Oyster was the most valuable, surf clam the largest offshore fishery. Hard clam produced only 1/3 the volume of the surf clam fishery, but exceeded it in value. Water pollution is an outstanding problem. Many problems of the molluscan shellfish industry could be solved, and the industry will continue to be an important part of the fishery economy. - J.L.M.

1300
Merrill, Arthur S., and Robert W. Hanks. 1969.

The Bureau of Commercial Fisheries Biological Laboratory at Oxford, Maryland, meeting the problems of the shellfisheries. Bull. Assn. Southeastern Biol. 16(4): 103-106.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1301
Merrill, Arthur S., and Helen S. Lang. 1971.

Pollution and commercial marine mollusks. In Symposium on Commercial Marine Mollusks of the United States. Am. Malacol. Un., Inc., Ann. Repts. for 1970: 36-38.

This brief general review mentions a few species but not hard clam, although it is applicable in general. Water pollution affects commercial mollusks in 2 ways, by altering environment so that they cannot survive, or by contaminating them so that they are unfit for human consumption. They are particularly susceptible because most species live in areas where pollution is most likely, and cannot move to more favorable waters. Kinds of pollution are fresh water, pesticides, domestic sewage, wastes from agriculture and animal husbandry, heavy metals, petrochemicals, pulp mill wastes, radioactivity, detergents, and waste heat. Mollusks can concentrate trace substances to levels much greater than in natural environment, which can not only cause physiological upsets to the animals, but also to man. Thermal pollution is perhaps the only type that might be used to advantage by the shellfish industry. - J.L.M.

1302
Merrill, Arthur S., and John W. Ropes. 1967.

Distribution of southern quahogs off the Middle Atlantic coast. Comm. Fish. Rev. 29(4): 62-64.

Little was known of the distribution of *Mercenaria campechiensis* north of Cape Hatteras. Surveys with hydraulic dredge in 1965 and 1966 extended the range northward to Point Pleasant, N.J. Most southern quahog collected were large because the dredge used was selective. They were larger and more numerous in sand and shell bottom (av. length 105 mm, 9.2 clams/tow) than in sand and silt (av. length 97 mm, 2.8 clams/tow). They were taken from Point Pleasant, N.J. to Oregon Pt., N.C. and were most numerous offshore southeast of Chincoteague Inlet, Va. Fossil records suggest that the species may once have lived farther north, e.g., the Boston Basin. - J.L.M.

1303
Merrill, Arthur S., and Haskell S. Tubiash. 1970.

Molluscan resources of the Atlantic and Gulf coast of the United States. Proc. Symp. on Mollusca, Pt. 3 (Mar. Biol. Assn., India): 925-948.

About 15 molluscan species are harvested commercially on the east coast of the United States and in Gulf of Mexico, but 5 make up most of the weight and value. *Mercenaria mercenaria* was third in order of economic importance. Generalized anatomy and physiology of clams is described. Hard clam is distributed from Gulf of St. Lawrence to Gulf of Mexico in relatively sheltered bays, coves, and inlets. Most of the catch was from N.Y. and Va. Great South Bay, Long Island, is an especially prolific source. The southern species, *M. campechiensis*, ranges from southern N.J. to Texas, and is almost entirely oceanic. Sexual maturity is attained at one yr of age. Almost all are male. By the 2nd yr half change to female and sex does not change thereafter. Spawning is from mid-June to mid-Aug, when water temp rises above 20°C. Females may release up to 24×10^6 eggs at one spawning and 250×10^6 in one spawning season. Larvae are about 200 μ at setting. Optimal larval development in the laboratory is at 25° to 30°C and salinity 27°/₀₀. Under these conditions larvae have set in 7 days, but in nature the average time is about 10 to 14 days. Growth is most rapid in warm periods, and clams enter the fishery at 2 to 3 yrs old. Larvae, juveniles, and young adults are affected by environmental conditions, are susceptible to bacterial and fungal infections, and are preyed upon by many predators. Older clams are relatively immune to predation except by man. Clams are dug by hoes, rakes, tongs, and dredges. An average day's catch is three 80-lb bushels in 8 to 9 hrs with manual gear. Patent tongs are used in some areas. Hydraulic dredges can take 25 bu/hr on productive grounds. Smaller sizes, 1 1/2 to 3 inches in diameter, bring the highest prices. - J.L.M.

1304
Messier, Arthur A., and Frances C. Garb. 1966.

Summary of the use of some relaxants on bivalve mollusks. U.S. Pub. Health Serv., Shellfish Sanitation Tech. Rept., Dec. 1966.

Paper not seen.

1305
Metcalf, Theodore G., and William C. Stiles. 1967.

Survival of enteric viruses in estuary waters and shellfish. In Transmission of Viruses by the Water Route. Gerald Berg (ed.) Interscience Publishers Div., John Wiley & Sons, New York: 439-447.

Experiments with bivalves were done with oysters, presumably *Crassostrea virginica*, but the findings probably are indicative for *Mercenaria mercenaria*. Enteric viruses have been demonstrated in shellfishes and in estuarine waters as far as 4 mi from the nearest sewage outlet. Virus survival in oysters appeared to be indefinite until water temp rose above 4°C, then cleansing was directly related to mollusk activity, which in turn is a function of temp. Elimination was most rapid in summer. Enteric viruses survived in estuarine water for 56 days in winter, 32 days in summer. Coxsackievirus B3 was most persistent, echovirus 6 intermediate, poliovirus 1 shortest-lived. Conditions for virus transmission would be optimal when high pollution levels coincide with maximum survival times. Viruses tend to be greatest in estuarine waters from July through October. Increased probability of virus transmission from consumption of raw shellfish thus would begin in midsummer, peak in fall, and possibly continue through winter. The seasonal pattern of infectious hepatitis in man, attributable to shellfish consumption, is similar. - J.L.M.

1306
Metcalf, T. G., Vaughn, J. M., and W. C. Stiles. 1972.

Occurrence of human viruses and coliphage in marine waters and shellfish. In M. Ruivo (ed.) Marine Pollution and Sea Life, Fishing News (Books) Ltd., London: 570-574.

No study was made of coliphage in hard clams, although hard clams may be found with oysters in such estuaries. Study of oysters led to the conclusion that a coliphage indicator system for enteric viruses has inherent short-comings. Its capacity to satisfactorily resolve the virus detection problem in marine waters is subject to question. - J.L.M.

1307
Meyers, T. R. 1979.

Preliminary studies on a chlamydial agent in the digestive diverticular epithelium of hard clams *Mercenaria mercenaria* (L.) from Great South Bay, New York. J. Fish Diseases 2: 179-189.

Prevalence of a chlamydial infection in hatchery-reared adult hard clams *Mercenaria mercenaria* from Great South Bay was relatively high and seasonally stable. Infection occurred early in life while juvenile clams were in the hatchery. Fluorescent antibody tests suggested that the clam agent shares the group antigen specific for chlamydia, but to a lesser degree than a known chlamydial strain used as a positive control. The method of Gimenez failed to stain elementary bodies in clam cell inclusion bodies. The inclusion body agent in hard clam differs from known strains of chlamydia. Characterization of the chlamydia must await successful propagation of the agent. - from abstract in Sea Grant notice of new publication. - J.L.M.

1308
Mihursky, J. A., V. S. Kennedy, A. J. McErlean, W. H. Roosenburg, A. J. Gatz, M. Castagna, S. G. O'Connor, J. M. O'Connor, C. I. Gibson, H. H. Zion, and L. Amende. 1974.

The thermal requirements and tolerances of key estuarine organisms. Univ. Maryland, Center for Environmental and Estuarine Research, Hallowing Point Field Station, Prince Frederick, Md. Completion Rept. A-011-Md, 14-31-0001-3020, July 1969 - June 1972. N.R.I. Ref. No. 74-132: vi+146. (U.S. Dept. Commerce, Natl. Tech. Inf. Serv. PB-239 073).

This report contains 9 sections, each separately authored. All have been released as journal publications or were in press at the time the report was released. Some are included in this report as manuscript copies or as re-prints. Papers dealing with *Mercenaria mercenaria* are abstracted separately under authors' names. - J.L.M.

1309
Mileikovsky, S. A. 1973.

Speed of active movement of pelagic larvae of marine bottom invertebrates and their ability to regulate their vertical position. Mar. Biol. 23(1): 11-17.

Some investigators concluded that *Mercenaria mercenaria* do not merely drift with the currents, but are able to some degree to control their vertical position in the water column. *M. mercenaria* straight hinged veligers moved upward 7 to 8 cm/min in boreal waters of the Atlantic coast. - J.L.M.

1310
Miller, Arthur P. 1936.

A study of the pollution of a shellfish producing area. J. Water Poll. Control Fed. 8(4): 634-646.

Health authorities in New York City recognized the danger to public health in taking clams from polluted waters of Raritan Bay, defined as Raritan Bay proper, Sandy Hook Bay, and Lower Bay, as early as Dec 1924, by closing their markets to all shellfishes from the area unless marked "for cooking purposes only". Restrictive actions by N.Y. State followed in 1925, and in N.J. in 1934. A chart showing clam growing grounds in the Bay and closed areas is included. The paper describes a survey of the area which considered quantities of sewage discharged, available diluting water, effects of channels, tidal currents, winds, and sampled for *B. coli*. In 1925, all of the N.Y. side of the Bay was closed and in 1934 a 1/4-mile strip along the N.J. shore. As a result of the survey a triangular area was added, beginning at Sandy Hook Point and running along the channel leading to Seguine Point near Princess Bay in N.Y., thence along the State boundary line which passes through Romer Shoal light. Planned extension of sewage treatment facilities was expected to alleviate the situation and lead to opening of some closed grounds. - J.L.M.

1311
Miller, A. P. 1937.

Waste disposal as related to shellfish. Sewage Works J. 9: 482-492.

We have this under another author's name. Search terminated. - J.L.M.

1312
Miller, Gardner B. 1978.

Corps' Santee project has McClellanvillers worried. Natl. Fisherman 59(5): 41, 78.

Beginning 4 yrs ago the local hard clam industry in the vicinity of McClellanville, S.C., began to grow into what is now described as a $400,000/yr business. The article describes diversion of the waters of the Santee River into the Cooper River, which led to increased salinity in the Santee estuary and development of a commercially valuable stock of *Mercenaria mercenaria* in the area. Harvesting is controlled by the S.C. Dept. of Wildlife and Marine Resources. Only 7 vessels are allowed permits, which must be renewed monthly. Weekly reports are required, and samples of the catch must be provided. For marketing reasons, harvesting is restricted to 2 days/week, Mondays and Thursdays, selected by the clammers. Three harvesting areas have been designated, and they are rotated annually, to allow the stocks to replenish themselves. Harvesting is by standard Maryland hydraulic dredges on vessels 32 to 55 ft long. The water diversion created shoaling problems in Charleston Harbor, which has required frequent and costly dredging. Plans to redivert the flow back into the Santee River are viewed as a threat to the clam industry, but this is difficult to prove, because records of water conditions and abundance of clams prior to development of the fishery are scanty. - J.L.M.

1313
Miller, Morton M., and Darrel A. Nash. 1971.

Regional and other related aspects of shellfish consumption: Some preliminary findings from the 1969 consumer panel survey. U.S. Dept. Commerce, NOAA, NMFS Circ. 361, 18 p.

Marked regional preferences exist for individual shellfish products. Clam markets are highly concentrated in 3 regions, New England, Middle Atlantic, and Pacific. About 37% of the U.S. population consumes about 85% of the national total. Per capita consumption in New England is close to 9 times the national average, but New England was no longer a leading clam-producing area and was importing over 80% of its supply. The middle Atlantic and Pacific regions accounted for 18% and 16% respectively of total U.S. clam consumption. The mid-Atlantic region received over 75% of U.S. clam landings at the time of the study and 3 of every 4 pounds landed there were shipped out, mostly to New England and the west coast. It was concluded that the central regions of the nation are extremely low in consumption of clams because producers have ample outlets for their production in traditional clam-eating areas. Over 60% of the clam harvest was surf clams, which are further processed into frozen or canned products. Thus, the nature of the product did not appear to be the reason for geographical market limits. It was concluded that if larger catches were made, marketing potential is high. Consumption of clams varies widely with season, which complements to a degree seasonal changes in oyster consumption, which are influenced by the myth of the "R" months. Clam consumption was steady in early summer, although lower than in winter, then rose sharply in August. From September onward clam consumption dropped as oyster consumption rose. Clams were more likely to be eaten away from home than most other shellfish species, and were eaten primarily by higher income groups. Young people consumed substantially less clams than those over 45. Species are not given, but these observations obviously apply in general to *Mercenaria mercenaria*. - J.L.M.

1314
Miller, William S., and Pieter Van Volkenburgh. 1972.

Chowder pot of the world: Great South Bay. The Conservationist, August-September, 1972, 2 p.

Describes *Mercenaria mercenaria* from Great South Bay, where most of the hard clams in the United States are harvested. It has just the right combination of environmental characteristics for large and continued production. Various types of harvesting are described, used by local citizens for their own use, by commercial clammers who harvest the natural beds, and by private owners or leasers of land. Size categories are described, and places to which clams are shipped are named. Two recipes are included. - J.L.M.

1315
Miller, William S., Elizabeth M. Wallace, Carl N. Shuster, Jr., and Robert E. Hillman. 1970.

Hard clam ... The gourmet's delight. Marine Resources of the Atlantic coast, Atl. States Marine Fish. Comm., Leaflet 14, 8 p.

Distributed along Atlantic coast from Florida to Gulf of St. Lawrence wherever climate permits reproduction. Also in Gulf of Mexico to Yucatan. In sheltered bays and coves, in shallow water, in bottoms ranging from gravel to soft mud. Usually most abundant in mud-sand. Optimum salinity is 18-26°/°°. Peak production is in the Middle Atlantic States. Usually graded by size from largest chowders at lowest price, to medium cherrystones at intermediate price, and smallest littlenecks at highest price. State regulations vary, and should be standardized. Harvesting is done by hand or by treading, with rakes or tongs, and with various types of dredge. Spawning is from late spring through midsummer, controlled by temperature. As many as 24 million eggs may be produced at a single spawning by one female. Eggs, fertilized in the water, develop through several free-swimming larval stages, then settle to the bottom in 1 to 2 weeks, attaching by a byssus thread to a firm surface. Sediment soon covers the young clam, but the mantle fuses to form a siphon which projects to the water above. Very early stages have a smooth shell. Later the shell develops pronounced ridges, which hold the young clam in the sediment after the byssus is discarded. Completion of burial occurs 2 to 4 weeks after spawning. Sexual maturity is reached in 2 to 4 years, depending on water temperature. Food comes in through the siphon with pumped water, and is carried to the mouth trapped on a mucus sheet which is moved by cilia on the gills. Sand and other irritable particles are carried to the edge of the gills, collect near the base of the siphon, and are flushed out by periodic contractions of the adductor muscles. On Cape Cod and Long Island clams are spawned artificially and reared in hatcheries, then transplanted to growing areas. Predation is a major problem. Fast-growing hybrid strains can be developed. Pollution is also a major problem of the hard clam industry. In New York about 35% of potential shellfish-producing areas are closed to harvesting, yet many have large clam populations. Costs of policing to deter poachers are substantial. The problem has been solved partially by transplanting clams to clean waters, where they cleanse themselves, or by artificial cleansing methods or "depuration". Hard clam is low in calories but rich in protein and certain minerals. Half a dozen clams on the half shell contain 3 to 4 ounces of meats, with about 70 calories, iron content about equal to beef liver, and an excellent supply of protein. - J.L.M.

1316
Milne, P. H. 1972.

Fish and Shellfish Farming in Coastal Waters. Fishing News (Books) Ltd., London, 208 p.

Clams, including *Mercenaria mercenaria*, replace mussels in the United States as suitable sessile species for sea farming. In 1962 about 22% of hard clams sold on the east coast of the U.S. were farmed on private grounds. Most procedures and techniques described for oyster culture are also applicable to clams. Main requirements in the growing area are firm bottom in which the clam can burrow, and a regular flow of water to provide planktonic food. Collectors are not required because clams settle directly on the bottom. Predators are a serious problem. Methods for protection against predation are expensive and require extensive maintenance. The method developed in Virginia by Castagna (1970), (described elsewhere in this bibliography), appears promising. - J.L.M.

1317
Mirchel, Andrew Christian Francis. 1980.

Enforcement of hard clam laws on Great South Bay, New York. A thesis presented to the Graduate School in partial fulfillment of the requirements for the degree of Master of Science in the Marine Environmental Sciences Program, State Univ. of New York at Stony Brook, May 1980, xi + 135 p.

Towns of Babylon, Islip, and Brookhaven, Suffolk County, and New York State participate in enforcement of hard clam laws on Great South Bay. Responsibilities, jurisdictions, and authorities differ, but enforcement activities overlap a good deal. Lack of coordination and cooperation among participating agencies weakens the overall enforcement effort. Shortcomings worth correcting are ineffective justification for and insufficient rationalization of laws and improper communication with clammers and courts. Courts are typically sympathetic with violators if there is no demonstration of willful intent to harm, no clear evidence of potential harm to the fishery, or no imminent risk to public health. Enforcement manpower is below the calculated lowest optimal level necessary for continuous coverage. This is decreased further by lack of coordination. Improved coordination and emphasis on routine patrol in uncertified areas, particularly at night and in fog, will improve enforcement. Overall, equipment is satisfactory, although the State and the Towns are not well equipped for patrol at night and in bad weather. Laws and regulations are sufficient to conserve the resource and protect public health if respected and enforced. Prosecution of violators can be more effective by improving communications between courts and enforcers. Legal assistance is needed to help prepare cases and act as liaison to courts. Better waste control also would help. A significant problem concerns the authority and image of town enforcers. They enforce the same laws as others and should be given the same authority. Substantial poaching of undersized and clams from uncertified areas continues. The best way to reduce poaching is by physical presence as a deterrent. Forfeiture of gear and equipment should be mandatory for poaching. Federal and state laws should be improved to prohibit traffic in undersized clams. License revenues, fees, and fines should revert into funds for enforcement, management, and research. - J.L.M.

1318
Mirolli, M. 1964.

The effect of reserpine on molluscs. Ph.D. Thesis, Harvard Univ.

Not available in Dissert. Abstr. Internatl. Not certain whether original information on *Mercenaria mercenaria* is included. - M.W.S. and J.L.M.

1319
Mirolli, Maurizio,and John H. Welsh. 1964.

The effects of reserpine and LSD on molluscs. In Comparative Neuro-chemistry. Proc. 5th Internatl. Neurochem. Symp. Derek Richter (ed.) Macmillan Co. (Pergamon), New York: 433-443.

Mercenaria (Venus) mercenaria is not mentioned. Reserpine and LSD affect postural behavior of all species studied. Reserpine lowered the level of 5-hydroxytryptamine (5-HT, enteramine, serotonin) in central ganglia, and induced tonic contraction of the muscular meshwork of the haemoskeleton and abolished tonus of shell muscles. LSD had no evident effect on shell muscle and had the opposite effect to reserpine on haemoskeletal muscles. - J.L.M.

1320
MIT Sea Grant Program. 1977.

Closed-cycle aquaculture. Revised ed., May 31, 1977. MIT Sea Grant Program, Marine Industry Adv. Serv., Cambridge, Mass., Rept. No. 77-15, Index No. 77-715-Zvl: 15-30.

Total annual production of clam meats in the U.S. is 110 to 115 million pounds, valued at $40 million to $42 million. Fifty percent of the value ($20 million) were hard clams. Data suggest that total dollar market for hard clams is as big or bigger than the market for oysters. The price of hard clams has gone up half again as fast as oysters, doubling over the past decade. Clams are increasing in popularity and have entered fast food chains, suggesting that market size and unit price will continue to rise. Hatchery operation and prototype production operations appear less capital and labor intensive. Clams are hardier and can be fast growing. Relative profitability of clams vs oysters should be scrutinized. - J.L.M.

1321
Mitchell, J. D. 1894.

List of Texas Mollusca. Times Steam Print., Victoria, Tex. 22.

This publication was not seen. - J.L.M.

1322
Mitchell, Philip H. 1914.

Oxygen requirements of shellfish. Bull. Bu. Fish, Washington (1912) 32: 207-222.

Most quahogs failed to remain open for any length of time in these experiments, thus only a few reliable measurements of oxygen consumption could be made. These showed a rather low oxygen intake. At 24°C the following data were obtained from quahogs of different sizes: 91 g, 1.01 mg/hr, 1.08 mg/hr, and 0.64 mg/hr; 150 g, 0.78 mg/hr; 470 g, 2.24 mg/hr. Oxygen used per hour per gram dried weight was: 91 g clam, 0.41 mg; 150 g, 0.221 mg. This is less than half the amount of O_2 used by oysters of comparable weight at 24°C. Closed quahogs used no O_2. Voluntarily closed clams did use O_2, which was interpreted as meaning that even when apparently closed they take in water by opening very slightly. At 24°C apparently closed clams of medium to large size took up 0.29, 0.61, 0.46, and 0.43 mg O_2 per hr. The smooth shell apparently takes up little, if any, O_2, but empty shells, considerably broken in opening, used a distinctly larger amount of O_2 than the clams that were clamped shut. - J.L.M.

1323
Mitchell, Roger. 1974.

Studies on the population dynamics and some aspects of the biology of *Mercenaria mercenaria* (Linné). Ph.D. dissertation, Faculty of Science, Department of Oceanography, University of Southampton, England, 2 p. (abstract).

Hard clam has become established in parts of Southampton Water and the Solent on the south coast of England, probably from deliberate introduction in 1925. Absence of the species along the west shore of Southampton Water and its exclusive distribution to the east in the Solent is explained partly by hydrographic conditions which control larval transport. Young clams were concentrated in shell gravel ridges. High clam density at some sites may have been caused by elimination of competing native species by extremely cold winters. Distribution of dominant year classes appeared to be correlated with summers of above average water temp and certain conditions of river flow. Good growth at sites where conditions were below optimum was attributed to utilization of metabolic reserves normally required for gametogenesis and spawning. Planktonic larvae were found from May to Sept in Southampton Water. There was evidence that this population has become adapted to spawn at lower temp than the ancestral stock. Warming of upper Southampton Water by power station effluent may have contributed to establishment of the species. Seasonal biochemical composition and condition index of sexually mature and immature clams were very similar. It was concluded that this cycle probably was linked more closely to water temp and availability of food than to state of gonads. Distribution and growth in relation to sediment type, and differences in biochemical content of early postlarvae and older clams are mentioned, but not described. - J.L.M.

1324
Mitchell, Roger. 1974.

Aspects of the ecology of the lamellibranch *Mercenaria mercenaria* in British waters. Hydrobiol. Bull. 8: 124-138.

Hard clams have been introduced into British waters several times. The first live specimen was taken in the Humber River in 1884. Stocks in Southampton Water and the Solent probably were derived from a small planting in the River Test in 1925. It is found in sediments ranging from almost pure shell gravel to sand-gravel-mud mixtures of up to 75% mud, but not in soft mud or clay, and in salinities from 24 to 35°/₀₀. Densities per unit area are much higher than those reported from the United States, up to 160 clams of commercial size per m^2. This may be due in part to elimination of competing native species by severe winters. Its absence in some parts of the area may be caused by toxic effects of industrial wastes and to easterly bias of tidal currents flowing down the estuary. It is suggested that the present distribution in the estuary is caused by recruitment from spawning in the River Test, and that the population will not expand unless another spawning colony is established to the east. The Southampton Water stock appears to be physiologically adapted to spawning at lower temperatures than in the U.S. (18 to 20°C). It is suggested that greatest recruitment occurs when summer river flows are low, which reduces flushing of larvae down the estuary and produces optimal temperatures and salinity. Recent reclamation work in the area, and increased commercial harvesting, probably will alter the distribution, density, and population structure. The major commercial fishery began in 1965. The 1971 catch was about 100 tonnes (over a million clams greater than 50 mm long). - modified author's summary - J.L.M.

1325
Mitra, S. B. 1901.

The crystalline style of Lamellibranchia. Quart. J. Micro. Sci. 44: 591-602.

This is a general discussion of the nature and functions of the crystalline style. At the time it apparently had not been observed in *Venus* but the author predicts that it will be shown to be present in all lamellibranchs. He concludes that it is an active amylolytic ferment; stored up as a flexible solid in the caecum or in a compartment of the alimentary canal; the end that projects into the stomach is dissolved slowly there and mixed with particles of food material, the starchy portion of which is transformed by it into a reducible sugar. The paper is illustrated with drawings. - J.L.M.

1326
Mix, M. C., et al. 1973.

The use of high specific activity tritiated thymidine and autoradiography for studying molluscan cells. J. Invertebr. Pathol. 21: 318-320.

Mercenaria mercenaria not mentioned. - J.L.M.

1327
Mizukami, Hiroshi. 1964.

Studies on structure and polymerization of *Venus mercenaria* paramyosin in solution. Dissert. Abstr. 24(9): 3813.

Paramyosin from adductor muscles of *V. mercenaria* was homogeneous in ionic strength 0.6 at pH 7.2 and above, and s_{20}^{w} was 3.1 S. Molecular weights determined by the Archibald method and light-scattering were 206,000 and 190,000 respectively. Axial ratio was 71, using Simha's factor, and length determined by light-scattering was 1400A. - J.L.M.

1328
Moeller, Henry W., and Steven Giordano. 1975.

A method for cultivating molluscs. Aquaculture 5: 215-218.

In 1965, Long Island, N.Y., the most important hard clam (*Mercenaria mercenaria*) producing area in the world, had closed 22.3% of its total shellfish acreage in Nassau County because of pollution. By 1 Jan 1974 about 62% of the total shellfish areas in Nassau County were closed. By enclosing mollusks in the interior of a tube of netting material, and floating from a raft, or buried in a suitable benthic sediment, clams can be harvested, retained in the netting for depuration, and shipped directly to market. - J.L.M.

1329
Mohlenberg, F., and H. U. Riisgard. 1979.

Filtration rate, using a new indirect technique, in thirteen species of suspension-feeding bivalves. Mar. Biol. 54: 143-147.

Mercenaria mercenaria is not mentioned. - J.L.M.

1330
Moore, Carol A. 1972.

The cytology and cytochemistry of the amebocytes of the hard clam *Mercenaria mercenaria*. M. A. Thesis, Montclair State College, v + 57 p.

Amoebocytes of *Mercenaria mercenaria* were of 3 types, a small granulocyte, a large granulocyte and a lymphocyte-like cell. Similarity of the nucleus in all 3 cell types suggests that these cells represent different stages of maturity. This was also suggested by the gradation of cytochemical reactions. Blunt granules were identified as mitochondria. They also exhibited unidentified material which was PAS-positive, diastase resistant, and metachromatic. Dot-like granules were identified as lysosome. These granules probably serve as centers of digestion for phagocytized materials. Refractile granules were demonstrated to be membrane bound, lipid-filled structures that reacted positively with Sudan Black B and Oil Red O respectively. These granules may act as storage centers. - J.L.M.

1331
Moore, Carol A. 1980.

Phagocytosis and degradation of a unicellular algae (sic) by hemocytes of the hard clam *Mercenaria mercenaria*. Natl. Shellf. Assn., Abstracts, Technical Sessions: 7 (abstract).

Hemocytes of the hard clam were observed to phagocytize *Isochrysis galbana* and several other species of unicellular algae, as well as congo red stained yeast. "Blunt" cytoplasmic granules received degraded materials from the phagosomes containing algae but not those enclosing a yeast cell. Blunt granules also participated in the hemocyte's intracellular processing of vital dyes and endotoxin. It is suggested that the blunt granules represent a mechanism whereby hemocytes can contain or further degrade foreign material. - J.L.M.

1332
Moore, Carol, and Albert F. Eble. 1973.

Cytology and cytochemistry of amebocytes of *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 63: 4 (abstract).

Three different amebocyte types of the hard clam were identified. A small (28 micron) motile granulocyte comprised 61% of total cell population, it had 4 distinct types of granules in the cytoplasm. A large (45 micron) non-motile granulocyte made up 37% of cell population, and had same 4 types of granules but only 1/3 as many as the granulocyte. The four types of granules were: 1.5 μ blunt type; 0.7 μ dot-like type; a 1 μ spherical refractile type; and a 2 micron rod-shaped granule. The agranulocyte (5 μ) contained no visible granules and had only a thin peripheral rim of cytoplasm surrounding the nucleus. Nuclei of all amebocytes appeared morphologically similar having uniformly dispersed chromatin and a rim of chromatin lining the nuclear membrane. Supravital studies with Janus Green B showed preferential uptake by blunt granules which within 10 minutes converted the dye to the red-reduction product diethyl safranin. Blunt and dot-like granules took up neutral red applied supravitally, which turned yellow in about 1/2-hour. Esterase studies indicated a strong nonspecific esterase in the small granulocyte. Acid phosphatase and NADH hydrogenase cytochemical studies are under investigation. - D.L.

1333
Moore, Carol A., and Albert F. Eble. 1977.

Cytochemical aspects of *Mercenaria mercenaria* hemocytes. Biol. Bull. 152(1): 105-119.

Hemocytes of *Mercenaria mercenaria* were of 3 types: an agranulocyte, and a small and a large granulocyte. The agranulocyte had only a thin periphery of cytoplasm surrounding the nucleus, and had no visible cytoplasmic granules in living preparations, but did show a few centers of nonspecific esterase activity. This cell type was 2% of the hemocyte population. Small granulocytes made up 61% of the total. They had 4 distinct granule types. The remaining 37% were large granulocytes. They contained the same 4 granule types, but only in one-third the abundance. Nuclei of all 3 types appeared morphologically similar. The 4 granule types were a blunt, a dot-like, a refractile, and a filamentous granule. Blunt granules were identified as mitochondria, dot-like granules as lysosomes. Refractile granules were membrane-bound, lipid-filled structures which act as lipid storage centers. The function of the filamentous granules was not clear, because they were not seen to react with any cytochemical technique. Nuclear similarity suggested that all 3 cell types might represent different stages of maturity, rather than 3 distinct cell lines. - modified authors' summary - J.L.M.

1334

Moore, Carol A., Nancy D., Drake and Albert F. Eble. 1972.

Cytology and cytochemistry of blood cells of *Mercenaria mercenaria* (Bivalva). Bull. N.J. Acad. Sci. 17(2): 44 (abstract).

Blood taken by cardiac puncture had 3 types of blood cell: 1) a large granulocyte with eosinophilic coarse granules; 2) a large granulocyte with fine granules; and 3) a small round amebocyte with fine granules. Flagellated cells appeared less commonly. It had not been determined whether these were blood cells or an invading protozoan. Long, branching pseudopodia emanated from large granulocytes, but no pseudopodia were seen in spherical amebocytes. Distribution of acid phosphatase and esterases in blood cells have been studied, but are not described. - J.L.M.

1335

Moore, Charles J. (ed.) date?

A recreational guide to oystering, clamming, shrimping and crabbing in South Carolina. Recr. Fisheries, Off. Conservation, Management and Marketing, S. C. Wildl. Mar. Resources Dept., Charleston, S.C., 58 p.

Over 95% of commercial clam production is shipped out of state in the shell. Local clams are predominantly hard clam, *Mercenaria mercenaria*, and several small populations of southern clam, *Mercenaria campechiensis*. Distribution is contagious, that is if one clam is found the chances of finding others in the same neighborhood are good. Highest densities occur in a mixture of shell and sand substrate, lowest densities in mud. Optimum salinity ranges from 18 to 26°/₀₀, although populations will be found at higher and lower salinities. Growth occurs throughout the year in S.C. Spawning begins in spring and continues through midsummer. Larval stage lasts from 1 to 2 weeks. Depending upon water temp it takes 2 to 4 weeks from spawning until the juvenile buries in the substrate. Clams are heavily preyed upon by several species of crab if not protected by overlying shell or gravel. Siphons serve 3 purposes: breathing, obtaining food, and eliminating wastes. Water is pumped through the siphon, passes over the gills and is strained to remove food. After receiving CO_2 from gills and other waste products from the digestive tract, water is expelled through the outgoing siphon. Cilia inside the tube and in gill chamber beat constantly to maintain circulation. Clams usually are sold under 3 market categories. Largest and cheapest are "chowder" clams, which are made into chowder or minced, diced or ground for other food uses. "Cherrystones" are medium sized and medium priced, and to some extent sold in the half shell. "Littlenecks" are smallest and most expensive. Clam season begins Sept 1 and ends May 30. No license is required for recreational harvesting for personal use. The head of any household is allowed a half-bushel per day for not more than 2 days/week. Clams may be harvested from public oyster grounds and state shellfish grounds. Taking clams from leased grounds must have permission from the leaseholder. Clam rakes with long tines are probably the best collecting apparatus. Low tide is the ideal time. SCUBA diving in deeper waters is a good way to pick up smaller sizes. - J.L.M.

1336
Moore, C. R. 1885.

144. - Introduction of clams into Delaware Bay (From letters to Prof. S. F. Baird). Bull. U.S. Fish Comm. 5 for 1885, Washington, D.C.: 426.

The writer of this letter to Prof. S. F. Baird was informed by a Thomas Beesley, of Beesley's Point, N.J., that originally there were no clams in Delaware Bay. Early settlers on the Bay side of N.J. took 50,000 quahogs from the sea side and planted them in front of their farms on the Bay. Thereafter, they had enough for their own use. The writer stated that Beesley was careful and reliable, but confirmation was not possible because all the people concerned were dead. - J.L.M.

1337
Moore, Donald R. 1961.

The marine and brackish water Mollusca of the State of Mississippi. Gulf Res. Rept. 1(1): 1-58.

Nine species, belonging to 7 genera, and including *Mercenaria mercenaria*, have been reported from Mississippi waters. Hard clam is rare in Mississippi. A few live clams have been collected on the north side of Horn and Ship Islands in sand. Spaulding (1906), abstracted elsewhere in this bibliography, reported several beds from the Chandeleur Islands, but it was not known in 1961 whether these beds still existed. - J.L.M.

1338
Moore, Hilary B., Leon T. Davies, Thomas H. Fraser, Robert H. Gore, and Nelia R. Lopez. 1968.

Some biomass figures from a tidal flat in Biscayne Bay, Florida. Bull. Mar. Sci. Gulf Caribb. 18: 261-279.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1339
Moore, H. F. 1898.

Oysters and methods of oyster-culture (with notes on clam culture). In Manual of Fish Culture. Rept. U.S. Commr. Fish. for 1897: 263-340, pls. V-XVIII. (Manual of Fish Culture revised and separately published 1900.)

Use of clam shells as cultch is mentioned, the species are not identified, but undoubtedly *Mercenaria (Venus) mercenaria* was included. This is a detailed account of methods in use at the time for all aspects of oyster culture, including artificial propagation. It is well illustrated with drawings and photographs of oysters, oyster larvae, pests and predators. Pages 339-340 contain a brief account of clam culture. *Mya arenaria* was the only species with which culture had been attempted at the time, but quahog (*Mercenaria mercenaria* - sic) was considered as equally favorable. Quahog was the "clam" of markets in New York, Philadelphia and southward, and it also was used to some extent in New England. Soft clam was the principal species in markets north of New York. Quahog was somewhat more important to the south. - J.L.M.

1340
Moore, J. K., and N. Marshall. 1967.

The retention of lamellibranch larvae in the Niantic estuary. Veliger 10(1): 10-12.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1341
Moore, S. F., and R. L. Dwyer. 1974.

Effects of oil on marine organisms: a critical assessment of published data. Water Research 8: 819-827.

Oil has been reported as lethal to *Mercenaria mercenaria*. This should not be taken to imply that extensive, valid data have been reported, but only that some data may exist. Toxicity to bivalves generally is at the level of about 5 to 50 ppm of soluble aromatic fractions. Effects of several specific spills on marine organisms generally are discussed. Significant levels of uncertainty exist in all aspects of oil spill effects, but it is useful to classify effects as lethal, sublethal, coating, habitat alteration, and incorporation. Larval stages are more sensitive than adults. Additional toxicity data, and more experimental and field studies of oil degradation processes and ecological interactions are needed. Continuous discharges of low concentrations of hydrocarbons should be regulated according to soluble aromatic content, not total hydrocarbons. - J.L.M.

1342
Moore, T. J. 1884.

Note on a further local attempt to naturalize the American clam *(Venus mercenaria)*. Proc. Lit. Phil. Soc. Liverpool 38: xc.

According to Heppell (1961) Moore received a barrel of live hard clams from New York. They were planted in several areas in the Humber estuary and the River Dee and elsewhere. No evidence of survival was found later, but the clams apparently were in good condition, for a few held in the Liverpool Museum were alive at least 16 months later. - J.L.M.

1343
Moore, T. J. 1886.

Note on the possible naturalization of the American clam *Venus mercenaria* on the coasts of Lancashire and Cheshire. 1st Rept. on fauna of Liverpool Bay (Appendix to Proc. Lit. Phil. Soc. Liverpool 40): 368-370.

According to Heppell (1961) an attempt was made by Moore in 1869 to naturalize the hard clam. The only result was the rumored finding later of a doubtful valve. - J.L.M.

1344
Morgenroth, Victor H., III, Margaret C. Boadle-Biber, and Robert H. Roth. 1976.

Dopaminergic neurons: Activation of tyrosine hydroxylase by a calcium chelator. Molec. Pharmacol. 12(1): 41-48.

Addition of the calcium-chelating agent ethylene glycol bis(β-aminoethyl ether)-N,N'-tetraacetic acid (EGTA) to a high-speed supernatant preparation from rat striatum produced a dramatic increase in activity of tyrosine hydroxylase assayed in presence of subsaturating concentrations of tyrosine and reduced pterin cofactor. This activation appeared to be mediated by changes in kinetic properties of tyrosine hydroxylase. This and other kinetic alterations could be reversed by adding calcium to the assay medium, but magnesium, even in high concentrations, was ineffective. Similar activation was observed with tyrosine hydroxylase isolated from the dopamine-rich pedal ganglion of *Mercenaria mercenaria*. - J.L.M.

1345
Morris, Percy A. 1973.

A field guide to the shells of the Atlantic and Gulf Coasts and the West Indies. 3rd ed. William J. Clench (ed.) Houghton Mifflin Co., Boston, xxviii+330 p.

Range of *Mercenaria (=Venus) mercenaria* is Gulf of St. Lawrence to Fla. in shallow water. Length 5 to 6 in fully grown. External morphology described. Popular names include round clam, hard-shelled clam, cherrystone clam, and little-necked clam. This is the chief commercial clam of east coast, second to oyster in value. Many ancient shell heaps from Me. to Fla. attest to extensive use by Indians. Quahog is the Indian name. *Mercenaria* probably comes from Indian use of colored edge of shell as wampum. Pearls are not uncommon, but of no commercial value. Some recognize a subspecies *notata*, smaller, usually lacking purple border, and with brownish, zigzag marks on outer surface. A very closely related species, *M. campechiensis*, is larger and is found from Va. to Tex. A useful glossary is included. - J.L.M.

1346
Morrison, Carol M., and Paul H. Odense. 1973.

Gross structure of the adductor muscles of some pelecypods. J. Fish. Res. Bd. Canada 30(10): 1583-1585.

A study of gross structure of adductor muscles showed that pelecypods conform to the following grouping: a) "Protobranchia" b) shallow-burrowing (including *Venus mercenaria*); c) surface-attached; and d) deep-burrowing and immobile. The adductor muscle has 2 portions, translucent and opaque, except in the deep-burrowing group, which have opaque muscles only. In *Venus mercenaria* and some other species in the shallow-burrowing group the translucent portion usually is tinted pink. Translucent muscle is usually striated or obliquely striated, whereas opaque muscle is usually smooth and slower. Both parts of the muscle probably are used in burrowing. Fast muscle can contract briefly to clear the mantle cavity of detritus. It also can close the valves rapidly in adverse conditions and can keep them closed if necessary. Opaque muscle contains more paramyosin than translucent muscle. The method of isolating paramyosin shows that it is resistant to dehydration and to changes in pH and temp. The actomyosin system of translucent muscle may be more labile and susceptible to post-mortem changes than the paramyosin in opaque muscle. Anterior and posterior adductors of *Venus mercenaria* are fairly symmetrical. The anterior is divided into translucent and opaque portions almost equal in size; the posterior appears to have 3 portions, opaque, translucent, and intermediate in translucency. - J.L.M.

1347
Morrison, George. 1971.

Dissolved oxygen requirements for embryonic and larval development of the hardshell clam, *Mercenaria mercenaria*. J. Fish. Res. Bd. Canada 28(3): 379-381.

At water temperatures of about 25°C embryological development was normal at oxygen concentrations of 0.5 mg/liter and above. At 0.2 mg/liter mortality was 100%.. In a single separate experiment eggs held at 0.34 mg/liter did not develop beyond trochophore stage and no shells formed. Growth of larvae is much better at 4.2 mg/liter and above than at 2.4 mg/liter and below. At the lower level of dissolved oxygen, growth was virtually zero. Growth rate returns to normal when larvae are transferred from low concentrations of dissolved oxygen (short-term stress) to higher concentrations. Larval growth rates were lower in flowing than in static water, probably because phytoplankton cells were being lost through the overflow screen. Short-term stress from low oxygen levels has no permanent effect on larval growth. - J.L.M.

1348
Morrison, G., E. Jackim, and K. Bonatti. 1977.

Use of an inert radioactive particle for measuring particle accumulation by filter-feeding bivalve molluscs. Mar. Biol. 40(1): 51-55.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1349
Morse, Edward S. 1881.

The gradual dispersion of certain mollusks in New England. Bull. Essex Inst. 12: 171-176.

The author traces the rapid diffusion of *Littorina litorea* (sic) from Kennebunk, Maine in 1870 to New Haven, Conn. by 1880. No mention is made of *Mercenaria (Venus) mercenaria*. - J.L.M.

1350
Morse, Edward S. 1919.

Observations on living lamellibranchs of New England. Proc. Boston Soc. Nat. Hist. 35(5): 139-196.

The mantle of *Venus mercenaria* is fringed, but with more uniformity than *Cytherea convexa*. It is light salmon color. At its junction with the branchial siphon it shows rather large digitations; viewed from below, the folds of the mantle appear very close together and interlock. Foot short and broad, occupying nearly entire length of ventral margin of shell. Siphons are united, very short, and of nearly equal diameter, the branchial siphon larger. The margins of the openings are fringed with very small papillae crowded together; these vary slightly in length, a few are bifurcated. Anal papillae alternate long and short, branchial papillae not so alternating. Siphonal walls are thin and mottled, with minute black blotches. The siphonal valve in young is quite conspicuous, but the author had never observed it in adults. When the shell rests on its side the siphons turn upward at right angles to the long diameter. In the very young shell the hinge margin posterior to the beak is straight. The shell is marked with high concentric ribs. Siphons of young are long and narrow, with a conspicuous valve which is light yellow with black mottlings. Adult and young are illustrated, with details of siphonal openings. - J.L.M.

1351
Morton, Brian. 1973.

A new theory of feeding and digestion in the filter feeding lamellibranchia. Malacologia 14(1-2): 63-79.

This comprehensive review paper concludes that although it had previously been believed that filter-feeding lamellibranchs feed and digest their food continuously and simultaneously, this is not so. These processes are rhythmic and related to environmental rhythms. In time and space, feeding is dynamic. Food is first collected, filtered, selected, and passed to the stomach. Then food collection ceases and accumulated food is digested. The evidence is traced from rhythmic adduction of shell valves, to changes in constituents of stomach fluids over a tidal cycle, to intermittent secretion of style material and dissolution of the crystalline style, to the fact that the gastric shield is enzymatically active and not simply protective, and to rhythmic sorting or storage in stomach, appendix, and digestive diverticula. A number of misinterpretations and misunderstandings are cleared up. Many lamellibranch species are discussed. Evidence is included that daily rhythms have been detected in *Venus mercenaria*, as well as monthly and 27-day cycles. The extensive list of literature contains 110 citations. - J.L.M.

1352
Morton, J. E., and C. M. Yonge. 1964.

Classification and structure of the Mollusca. In Physiology of Mollusca. Vol. 1. Karl M. Wilbur and C. M. Yonge (eds.) Academic Press, New York: 1-58.

No specific mention of *Mercenaria (Venus) mercenaria*, but the paper has general application. Class Bivalvia, Subclass Lamellibranchia, Order Heterodonta. Gills eulamellibranch, and shell less modified than in Anisomyaria, with adductors similar. Hinge dentition is of the "heterodont" type. Mantle edges usually united at one or more points ventrally, and often produced posteriorly into siphons. Shallow or deep-burrowing, or occasionally surface-living. - description verbatim from text - J.L.M.

1353
Morton, Rose Ann, and Mary Ann Burklew. 1969.

Florida shellfish toxicity following blooms of the dinoflagellate, *Gymnodinium breve*. Fla. Dept. Nat. Res., Div. Marine Resources, Mar. Research Lab., St. Petersburg, Tech. Ser. 60, ix+26 p.

Shellfish toxicity was detected twice, in August and November 1967, and January 1968, following outbreaks of red tide caused by *G. breve*. Toxicity determinations were made on *Crassostrea virginica* at all stations except TX2, near Sarasota. At that station, clams were sampled, but the species is not given. Toxicity at station TX2 was moderate, and lasted a relatively short time. - J.L.M.

1354
Mosley, James W. 1959.

Water-borne infectious hepatitis. New England J. Med. 261(14): 703-708.

Jaundice epidemics have been attributed at times to water-borne transmission since the 19th century, but this mode of spread of infectious hepatitis was not definitely recognized as an epidemiologic entity until recently. Infectious hepatitis is the first viral disease for which a water-borne route of infection has been generally accepted. Such a route also has been postulated for poliomyelitis but no conclusive evidence was available at time of writing. The paper does implicate some foods, including oysters, as vehicles, but hard clam is not mentioned. The paper ends with a note that it was to be concluded, presumably in a later issue of the same journal. - J.L.M.

1355
Mosley, James W. 1959.

Water-borne infectious hepatitis (concluded). New England J. Med. 261(15): 748-753.

This paper considers only cases in which epidemics were transmitted by drinking water, either proven or suspected. Shellfish-related infections are not discussed. - J.L.M.

1356
Mosley, J. W. 1964.

IV. Clam associated epidemics of infectious hepatitis. Hepatitis Surveill. Rept. 18: 14-17.

The copy of this paper as received contained no information on journal and date. Pagination is 14-17. Title and subtitles are: IV. *Clam associated epidemics of infectious hepatitis*. A. *New Jersey and Pennsylvania*. B. *Connecticut*. Tables 5 to 9 and figures III to V are mentioned in the text, but not included with the copy. Between 29 Sept 1963 and 22 Feb 1964, 164 persons who had eaten raw clams, probably harvested along the south-central coast of New Jersey, developed infectious hepatitis. In N.J. and eastern Pennsylvania, among counties reporting 10 or more cases during the period, 8 counties had a history of raw clam ingestion 10 to 60 days prior to onset in more than 20% of reported cases. These were Atlantic, Burlington, and Camden Counties in N.J. and Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties, Pa. Previous surveys in coastal areas showed that no more than 20% of people ate raw clams in a 2-month period. Thus, this concentration of cases suggested that raw clams were a vehicle of infection. In 115 cases one or more restaurants or fish markets were identified as place of purchase of raw clams. Suppliers were known in 110 of these cases. The source in many cases was the Pleasantville, N.J. area. Other clams implicated came from shippers from R.I. to Va. In New Haven, Conn., in January 1964, infectious hepatitis cases increased, and so did the proportion of cases with a history of raw clam ingestion. An investigation gave the following preliminary results: from 1 Nov 1963 to 1 March 1964, Connecticut had 245 cases of viral hepatitis and Rhode Island 68. About half the cases in New Haven and Fairfield Counties, Conn. had eaten raw clams during the period. In other Connecticut counties no more than 15% of hepatitis cases had eaten raw clams, which is about "normal". Only 13% of New Haven and Fairfield County cases had a history of personal contact with a known hepatitis case during 2 months prior to onset; 31% of the balance of Conn. cases had known contacts. Onset of hepatitis cases in patients who had eaten raw clams corresponded with the known incubation period (median number of days 30-34). Most clams had come from Narragansett Bay, R.I. from a single shipper, or at most from this and a second shipper. - J.L.M.

1357
Mosley, J. W. 1964.

IV. Shellfish-associated infectious hepatitis. A. Clam-associated infectious hepatitis - New Jersey and Pennsylvania: Follow-up report. Center for Disease Control, Hepatitis Surveillance Rept. 19: 30-32, with tables and figs.

Author's name, date, and journal do not appear in the xerox copy supplied through interlibrary loan. These were taken from the literature reference which brought the paper to our attention and the computer memo attached to the copy. The epidemic of infectious hepatitis in Southern N.J. and eastern Pa. associated with ingestion of raw clams from Atlantic County appeared to have stopped. Between 29 Sept 1963 and 25 Apr 1964 surveillance information was collected on 1,039 cases of hepatitis in the area. Raw clam ingestion 10 to 60 days prior to onset of symptoms was reported for 252 cases. Of these 252 cases, 194 were traced directly or indirectly to shippers in Atlantic County. Many purchases were made in restaurants, and repeated shipments of contaminated clams were suggested. Cases of infectious hepatitis from Kansas, Michigan, Nebraska, District of Columbia, and Missouri were linked with the same sources.

B. Clam-associated infectious hepatitis - Connecticut: Follow-up report: 32-34.

From 1 Nov 1963 to 15 June 1964 the State of Connecticut had at least 489 cases of viral hepatitis. Surveillance data were available on 455. Raw clam ingestion 10 to 60 days prior to onset of symptoms was reported in 119 cases. All but 8 had obtained clams from restaurants and markets in Conn. The epidemic came in 2 waves, Jan to Mar, and late Apr to May. Both waves reflected real increases in proportion of clam-associated cases. Only 8% of well persons 20 years and older who lived in the same block as the hepatitis cases had consumed raw clams, whereas 26% of hepatitis cases had. Clams associated with most cases were traced directly or indirectly to 2 dealers. The clams presumably came from Narragansett Bay, R.I. It was very unlikely that the clams had been harvested illegally. The length of the epidemic suggested that several shipments of contaminated clams had been made. It was concluded that shellfish-associated epidemics of infectious hepatitis may be relatively common, but rarely produce enough cases to attract attention of health authorities. - J.L.M.

1358
Motley, H. L. 1934.

Physiological studies concerning the regulation of heart beat in fresh water mussels. Physiol. Zool. 7: 62-84.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

1359
Moulton, James M. 1953.

Gustafson's growth experiment on *Venus* in Casco Bay. 4th Conf. on Clam Research 1 p. (mimeo).

A study was started in June 1952 by planting quahogs of various sizes in localities between West Bath and Freeport, Maine. Preliminary data showed that quahogs in one area grew 3 times as fast as in another, and that growth leveled off in Sept in both places. (Abstracter's note: This is not an adequate citation. This is believed to be the series of conferences sponsored informally by Bureau of Commercial Fisheries, never formally published as such.) - J.L.M.

1360
Moulton, James M., and Gareth W. Coffin. 1954.

The distribution of *Venus* larvae in Orr's Cove plankton over the tide cycle and during the summer and early fall of 1953. Me. Dept. Sea Shore Fish., Research Bull. 17, 51 p.

In individual tidal cycles there was apparently little consistency between tide stage and peak of *Venus* larval distribution. Summation of all observations, however, appeared to show that on the average, greatest numbers of larvae were present in the period 3 hrs after high tide to 1 hr before low tide, and smallest numbers from 1 hr before to 1 hr after low tide. Larvae were present at least from beginning of July to nearly end of Sept, with peaks early in July and at end of Aug. Dense sets of *Venus* which have occurred in Orr's Cove appear to have been the result of postlarval redistribution rather than of concentrated setting. It is emphasized that results of one summer's work cannot be considered conclusive. Weather fluctuations and other variables can affect results substantially. Detailed tables of observations are included. - J.L.M.

1361
Moulton, J. M., and A. H. Gustafson. 1956.

Green crabs and the redistribution of quahogs. Science 123(3205): 992.

Green crab, *Carcinides maenas*, is an important predator of quahog, *Venus mercenaria*, as well as a minor factor in redistributing quahog populations. A green crab was observed moving about with a one-inch quahog pinched onto the tip of one of its walking legs. When disturbed, the quahog amputated the tip of the crabs leg, which nicked the edge of each valve of the quahog shell. Of 26 quahogs found resting on top of the substrate at Sebascodegan Island, Maine, 24 had shell margins marked as described above. It is assumed that these quahogs were redistributed by attaching themselves to a crab's leg when a crab inadvertently placed a leg tip between open valves of a quahog. Of 1000 quahogs between 1.5 to 5.0 cm sampled, 2.9 percent had circular nicks at shell margins. Green crab may therefore benefit quahogs to a small degree by thinning crowded populations. There may also be correlation between quahog density and frequency of missing leg tips of crabs, or quahog shell nicks and green crab abundance. - W.J.B.

1362
Murchelano, Robert A., and Carolyn Brown. 1969.

Bacterial flora of some algal foods used for rearing bivalve larvae. J. Fish. Res. Bd. Canada 26: 2760-2764.

Heterotrophic bacteria in 15 mass cultures of 6 genera of algae used for feeding larvae of *Crassostrea virginica* and *Mercenaria mercenaria* were isolated, identified, and their physiology studied. Of 120 isolates, 118 were asporogenous gram-negative rods, types commonly found in the sea. Most isolates, 98 or 81.6%, belonged to the genus *Pseudomonas*. A nutritionally acceptable algal food for bivalve larvae can become unacceptable because certain bacterial flora develop. Some bacteria produce soluble toxins or invade cells, which lead to significant or total larval mortality. Physiologically, isolates were more lipolytic than proteolytic or amylolytic. Those that reduced nitrate to nitrite and produced ammonia from peptone broth were more numerous than those that produced H_2S from sodium thiosulphate and indole from tryptophan. About 92% of isolates were sensitive to chloramphenicol, 37% to penicillin, 65% to streptomycin, and 75% to tetracycline. Most effective use of antibacterials can be made only after composition of bacterial flora is determined , but many initially unacceptable algal foods can be made acceptable by supplementing them with appropriate antibacterials. - J.L.M.

1363
Nagabhushanam, R. 1968.

Studies on neurosecretion in mollusca. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 572-579.

This review paper does not mention *Mercenaria mercenaria.* - J.L.M.

1364
Nagai, T., R. A. Nystrom, and C. L. Prosser. 1961.

Mechanical and electrical properties of some invertebrate visceral muscles. Biol. Bull. 121(2): 401-402.

Non-striated muscles of invertebrates in which conduction has been examined conduct mainly by intrinsic nerves, rarely by stretch. Average velocity of conduction in *Venus* intestine in moist air was 1.1 cm/sec. Intestinal conduction was not blocked by procaine or tetracaine. To some degree intestines showed phasic and tonic contractions, spontaneously and in response to shocks. Phasic contraction time was 2 to 3 sec, time for half-relaxation 15 to 40 sec. Tonic contractions persisted for many minutes. Conduction appeared to be from muscle fiber to fiber, much as in vertebrate smooth muscle. - J.L.M.

1365
Nash, Darrel A. 1970.

Preliminary analyses of a survey of buying patterns for fresh and frozen fish and shellfish by household characteristics. U.S.A. Working Paper 46, Bu. Comm. Fish., U.S. Dept. Interior, Washington, D.C., 43 p. (marked *draft manuscript - for review only*).

A complete record was obtained for a full year of fish purchases of a representative panel of 1,500 participants. *Per capita,* negro households purchased more than twice the amount of fresh and frozen seafoods as white households. Jewish households used about twice the amounts used by Catholic and Protestant households. Usage of most products, except shrimp was localized. When head of household was over 45 yrs old, purchases of fish and shellfish were distinctly greater than for younger households. Purchases of fish meals in restaurants were related to income level. Clams were consumed in much greater quantities *per capita* in New England than in any other part of the country. Clams, like lobsters, were purchased more frequently away from home (e.g., in restaurants), and were more frequently purchased by persons with higher incomes. Clams are not identified by species. - J.L.M.

1366
Nassau-Suffolk Regional Planning Board. 1974.

Guidelines for the management of Long Island hard clam resources. Regional Marine Resources Council, Hauppauge, New York, 13 p.+ 3 app.

Hard clams are, by value, the most important commercial fishery resource in New York State, yet there is no adequate information base or mechanisms for managing the resource. Landings of hard clam peaked in 1947 at nearly 11 million pounds of meats, declined to a low of 2.5 million pounds in 1954, and was 7.3 million pounds in 1973. Great South Bay is the most important producer of hard clam in the world. The Regional Marine Resources Council identified the problems of the resource and available knowledge, and has developed guidelines and goals. Problems include inadequate knowledge of life history, biology, and population dynamics, including effects of harvesting, on hard clam. There is only fair knowledge of the quantitative contributions of pollution from various sources which result in closings of shellfish areas, and the effect of these pollutants on hard clam survival. There is inadequate enforcement of existing laws, and a lack of cooperation among groups within the hard clam industry. Scientific research guidelines are presented which attempt to expand the knowledge base of the life history and fishery of the hard clam. Administrative guidelines describe programs that must be evaluated for their effects on the hard clam resource, such as dredging, seeding, and sewage treatment. - D.L.

1367
National Academy of Sciences. 1957.

The effects of atomic radiation on oceanography and fisheries. NAS-NRC Pub. 651, Washington, D.C., ix+137 p.

Many of the papers in this report are of general application to molluscan shellfishes. Chapter 8, the only chapter which mentions *Mercenaria (Venus) mercenaria* specifically (Boroughs et al), is abstracted elsewhere in this bibliography. - J.L.M.

1368
National Academy of Sciences. 1975.

Petroleum in the marine environment. Workshop on inputs, fates, and the effects of petroleum in the marine environment. Washington, D.C., xi+107 p.

References to *Mercenaria mercenaria* are citations from papers by Farrington and Quinn (1973) and Yevich and Barry (1970), abstracted elsewhere in this bibliography. - J.L.M.

1369
National Marine Fisheries Service. 1977.

The molluscan shellfish industries and water quality: Problems and opportunities. U.S. Dept. Commerce, NOAA, Natl. Mar. Fish. Serv., Off. Fish. Devel., Supt. Docs., Washington, D.C., v+46 p.

The report was submitted in fulfillment of the requirements of Sect. 16(a) of the Coastal Zone Management Act Amendments of 1976, PL 94-370 (16 USC 1462). It discusses 8 segments of the national molluscan shellfish industry, including the hard clam industry. The background is contained in a publication by Ritchie (1977) abstracted elsewhere in this bibliography. Findings and conclusions include: 1) the shellfish industry is composed of small entities widely scattered along the coastline of the U.S; 2) competition for use of the coastal zone is a major cause of problems; 3) 18.5% of the grounds are closed by pollution and the annual rate of increase is about 0.6%; 4) the industry is regulated by many authorities with overlapping jurisdiction -- these functions should be consolidated; 5) FDA requirements for approved growing areas are regarded as sufficient for consumer protection, but the prescribed microbiological criteria may be too strict; 6) better information on contaminants is needed; 7) the industry needs revision, and help in financing and technological research; 8) sound management programs are needed; 9) research is needed on paralytic shellfish poisoning; 10) depuration programs should be expanded in the natural environment and onshore; 11) more extensive use should be made of aquaculture; and 12) increased effort is needed in mission-oriented biological and public-health-related research. - J.L.M.

1370
Natural Resources Institute. 1970.

Assateague ecological studies. Final Report. I. Environmental information. Univ. Md., Nat. Res. Inst.

Unable to locate. Search terminated. - M.W.S.

1371
Natural Resources Institute. 1970.

Assateague ecological studies. Final Report. III. Assateague study, suggestions for land use and park management. Univ. Md., Nat. Res. Inst.

Unable to locate. Search terminated. - M.W.S.

1372
Navez, A. E., J. D. Crawford, D. Benedict, and A. B. DuBois. 1941.

On metabolism of the heart of *Venus mercenaria*. Biol. Bull. 81(2): 289-290.

Excised heart of hard clam will keep its characteristic contractions for a long period in a small quantity of aerated seawater. This is so when the heart is whole, cut into a few pieces, or chopped into many small pieces. In any form, heart tissue will respire at a uniform rate for long periods. "Cut" heart exceeds whole heart in O_2 consumption by about 10%; "chopped" heart is lower by about 10%; "minced" heart about 50% lower; but all seem to fix O_2 with an RQ around 1.0. This applies to heart unwashed with sea water. Washing with sea water lowers the rate of the reaction, but addition of the washings usually restores the rate to normal. "Minced" pulp can be centrifuged into 2 components: supernatant fluid, which respires at about 30-35% of the rate of the original "minced" pulp; and granular part 65-70%. Acetonic extracts and residues reunited in water are inactive or inactivated. The cytochrome-cytochrome oxidase-dehydrogenase system was used as a working hypothesis of functioning of the respiratory system, because cytochrome C and succinic dehydrogenase were present in *Mercenaria* heart. Addition of p-phenylenediamine determines a large increase in QO_2 depending on concentration, which persists for long periods. Poisoning of heart by KCN determines an inhibition of 40% at most, whether p-phenylenediamine is present or absent. Addition of succinate alone raises QO_2 by 10%; succinate+methylene blue increases it to 150% max, but methylene blue alone does the same. Inhibition of this reaction by KCN is 30-40%. Na fluoride, azide, iodoacetate and selenite had small or no effects. Ethyl urethane alone enhanced. A strong lumiflavin reaction points to presence of a flavoprotein. A weak glutathione reaction is given also. It was concluded that the observations did not fit the working hypothesis, and other unreported experiments confirmed the rejection. Additional work was planned. - J.L.M.

1373
Neff, Jerry M. 1971.

Electron microscope histochemistry and biochemical characterization of alkaline phosphatase in the mantle of the clam *Mercenaria mercenaria*. Am. Zool. 11: 661-662 (abstract 224).

Alkaline phosphatase activity was associated with the microvilli of the columnar epithelial cells of the outer surface of the outer mantle fold and with the microvilli of the cells of the general outer surface of the mantle above the pallial line. It was also associated with the apical zonulae adhaerens of these cells. No activity could be detected in the cells lining the periostracal groove. Calcium but not magnesium enhanced alkaline phosphatase activity. In the presence of 10mM calcium, magnesium was slightly inhibitory. - J.L.M.

1374
Neff, Jerry M. 1972.

Ultrastructural studies of *periostracum* formation in the hard shelled clam *Mercenaria mercenaria* (L). Tissue Cell 4(2): 311-326.

The inner surface of the outer fold of the mantle of hard clam contains 5 cell types. The outer surface of the second fold contains only flattened cells, all of similar morphology. Intermediate cells lie between the cells of the 2 folds. Periostracum has 2 layers, an outer mineral-rich pellicle and an inner homogeneous protein layer. The pellicle arises at the base of the periostracal groove between the basal cell and the 1st intermediate cell. It has a membrane-like layer and a granular layer. Periostracum is secreted by columnar epithelium lining the inner surface of the outer mantle fold. Cells of the outer surface of the 2nd fold support the periostracal sheet and move it out of the groove as it is synthesized. All phases of formation of periostracum are going on simultaneously, but each phase is the result of activities of particular groups of cells at different positions in the groove. Those components which appear at the base of the groove are secreted first and subsequent layers are added in the sequence in which they first appear moving from the base toward the mouth of the groove. In *Mercenaria* the 1st component formed is the membrane-like layer of the pellicle. Then electron-dense granules are secreted onto the outer surface of the pellicle membrane. Finally, the homogeneous periostracum proper is added to the inner surface of the pellicle as it moves distally in the periostracal groove. The 2nd cell of the outer fold probably has 2 functions: to guide the pellicle out of the base of the periostracal groove, and to protect the pellicle from being torn when the mantle contracts upon closure of the valves. The function of the mineral-rich granule-filled cells of the outer fold is obscure. The remaining cells of the outer fold are typical of cells engaged in protein synthesis and excretion. The variable number of lysosome-like bodies probably are capable of resorbing components of the periostracum. The gland cells underlying the epithelial cells of the inner surface of the outer fold contain proteins rich in phenolic groups. The rounded vacuoles contained in these cells probably contain phenolic precursors of the tanning agent for the periostracum. Fine fibrous material between the inner surface of the periostracal protein and the apex of the columnar cells of the inner surface of the outer fold is probably an uncondensed precursor of the homogeneous protein layer of the periostracum. The low epithelial cells of the outer surface of the 2nd fold support the periostracum and are probably responsible for moving it out of the periostracal groove as it is formed. The periostracum appears to be tightly bonded to the microvilli. Vacuoles in these cells may contain the bonding substance that attaches the periostracum to these cells. The slender outer plica of the 2nd fold undoubtedly manipulates the fully formed periostracum and applies it to the growing edge of the shell. (Abstracter's note: this paper contains a brief discussion of the functions of the periostracum. It provides a waterproof covering for the shell, protecting it from dissolution by acids in the environment. It provides the original substrate for mineral deposition at the edge of the shell. In some mollusks, elements or derivatives of the periostracum may actually be incorporated into the outer part of the prismatic layer of the shell. It encloses the extrapallial space ventrally and isolates it from the external environment.) - J.L.M.

1375
Neff, Jerry M. 1972.

Ultrastructure of the outer epithelium of the mantle in the clam *Mercenaria mercenaria* in relation to calcification of the shell. Tissue Cell 4(4): 591-600.

The general outer epithelium of the mantle of hard clam is composed of tall narrow columnar cells with densely packed apical microvilli, convoluted lateral and basal cell membranes, and abundant mitochondria in the apical and basal cytoplasm. Cells are joined apically by a zonula adherens followed by a septate desmosome. Small calcium-rich granules fill intercellular spaces and are present in small vesicles in apical cytoplasm and microvilli. Amoebocytes in subepithelial connective tissue also contain granule-filled vacuoles. Soluble Ca was detected histochemically in intercellular spaces but not intracellularly. These characteristics, and paucity of rough endoplasmic reticulum and Golgi complexes are characteristic of cells in ion or water transporting epithelia. Cells of the outer epithelium of the mantle were almost devoid of mineral ash. Most ash in the mantle was associated with granules in the subepithelial connective tissue and intercellular spaces. It is assumed that the main pathway of Ca permeation through mantle epithelium is via intercellular spaces. The outer epithelium of the mantle has little or no transepithelial ionic and osmotic gradient and relatively small electrical potential. In *Mercenaria* Ca appears to move across the outer epithelium of the mantle in 2 forms. Mineral-rich granules react with sodium fluoride and probably represent a complex between an organic substrate and Ca. A soluble sulphated acid glycoprotein in the shell matrix binds Ca selectively and tightly. The mineral-rich granules may represent this Ca-glycoprotein complex. If so they probably represent less than 10% of the Ca traversing the mantle. The granules appear to originate in close association with amoebocytes in subepithelial connective tissue, and to move up the intercellular spaces to the level of the septate desmosomes, eventually to be extruded through the microvilli into the extrapallial cavity. Much of the Ca moves through the epithelium in soluble ionized form. The main route of Ca permeation through the outer epithelium of the mantle is via intercellular spaces. The paracellular route does not preclude some role for epithelial cells themselves in generation or control of Ca fluxes. Some component of outward Ca flux could be coupled with inward K transport or outward movement of CO_2. - J.L.M.

1376
Nelson, Julius. 1910.

Report of the biologist. In Annual Report N.J. Agric. Coll., Exper. Sta., New Brunswick: 225-266, 5 pls.

Some clam larvae are noted in table 2 (presumably hard clam larvae, but not identified) which lists oyster larvae obtained by water filtration. - J.L.M.

1377
Nelson, Julius. 1911.

Report of the biologist. In Annual Report, N.J. Agric. Exper. Sta., New Brunswick: 185-217.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1378
Nelson, Julius. 1913.

Report of the biologist. In Annual Report, N.J. Agric. Coll., Exper. Sta., New Brunswick: 281-345.

In the Mullica River in 1912 large numbers of clam "fry" were observed in the plankton on 4 August. These were particularly abundant at the surface in a "tide slick". A Connecticut oysterman told the author that such slicks were the place to look for oyster "fry". This and other reports in this series contain detailed observations on weather, temp, tides, salinity, and abundance of oyster larvae. - J.L.M.

1379

Nelson, Julius. 1914.

Report of the biologist. In Ann. Rept. N.J. Agric. Coll. Expt. Sta.: 489-535.

Plankton samples for oyster larvae also contained clam larvae, presumably hard clam. These were almost always present, but it was noted that they look so much like oyster larvae at some stages that identification was difficult. Table IV records samples taken from 13 June 1913 to 21 August at Barnegat Station and from 26 June to 10 Sept at Edge Cove Station. Clam larvae were present until July 7 at Barnegat, and present only intermittently thereafter. At Edge Cove clam larvae apparently were less abundant, and appeared mainly for short periods in mid-July to the end of July. - J.L.M.

1380

Nelson, Julius. 1916.

Report of the Department of Biology. In Ann. Rept., N.J. Agric. Coll., Expt. Sta.: 239-260.

In July 1915 the newly organized State Board of Shell Fisheries began its work, succeeding the Bureau of Shell Fisheries and several oyster commissions. This report makes passing reference to a study of green clams (species not identified) in 1892. It is suggested that this might be associated with oxygen deficiency. An annelid larva which is rather abundant in the plankton in June and July (and apparently suspected as a predator of bivalve larvae) could not feed on oyster or quahog larvae because they are larger than the worm. - J.L.M.

1381

Nelson, Thurlow C. 1918.

On the origin, nature, and function of the crystalline style of lamellibranchs. J. Morph. 31(1): 53-111.

Studies were made on American oyster, ribbed mussel, and *Venus mercenaria*. The paper also reviews the literature on the crystalline style of lamellibranchs and corrects some misapprehensions. Previous workers had surmised from its structure that the style rotates, but the author believed that he was the first to observe the rotation directly. Food material in the stomach of the veliger larva of *Venus* is in constant rotation. This is caused largely by the action of 2 groups of large cilia. It is always clockwise viewed from the anterior end of the larva. In position and direction of stroke these correspond to those of the adult. The period of rotation of the crystalline style in the adult is quite rapid. It also is clockwise from the anterior end. Food material in the stomach, entangled in mucus, becomes wound around the head of the style, and is whirled around in the lumen just posterior to the gastric shield. Strings of mucus from any part of the body, if led to the stomach cavity, are at once drawn in and wound up in the food mass. The cilia of the style sac push it anteriorly against the gastric shield with force enough to cause the style to bow out when the stomach walls are drawn apart. The style arises as a thin core of bubbly mucus, upon which are deposited co-axial layers of a gelatinous protein, containing enzymes. Movement of the style is important in separating food from foreign particles and in serving as a substitute for peristalsis. The gastric shield protects the gastric mucosa against the abrasive action of the head of the revolving style. The style contains strong amylolytic ferments held in a stiff gelatinous matrix of a globulin-like substance. - J.L.M.

1382
Nelson, Thurlow C. 1921.

Aids to successful oyster culture. I. Procuring the seed. N. J. Agric. Experim. Stas., Bull. 351: 1-59.

Other than a reference in the foreword, to the effect that Dr. Julius Nelson was brought to Tuckerton in 1892 to investigate the "greening" of clams, there is no other reference to clams in this bulletin. - J.L.M.

1383
Nelson, Thurlow C. 1925.

Recent contributions to the knowledge of the crystalline style of lamellibranchs. Biol. Bull. 49(2): 86-99.

Venus is mentioned only by reference to work of other authors. Reformation of the style can be very rapid. Approximately 15 min to a few hrs at summer temp is sufficient in some bivalves. The style contains strong amylolytic ferments. One function of the style is to separate food materials from sand and other waste. The powerful cilia of the style sac spin the style on its long axis and push it anteriorly into the stomach. The head of the style gathers food strings coming from the oesophagus. As the mass is whirled around in the stomach most sand and other non-digestible matter is sorted out mechanically by the ciliary tracts of the stomach wall and passed on to the intestine. Where the head of the style comes in contact with the stomach wall is a tough resistant covering, the gastric shield. The sorting and stirring mechanism is important in animals in which ciliary activity is substituted for muscular peristalsis. Food particles escaping from the stomach may be passed across the faces of the typhlosoles from the intestine and be incorporated in the style. This recovers part of the food materials rejected from the stomach during separation of inert materials. Styles of some bivalves, but not *Venus*, contain a large active spirochaete, *Cristispira*. The conclusion of Berkeley that the style plays a part in anaerobic respiration is not supported. Secretion of a crystalline style may be a direct response to siphoning, whether the water contains food organisms or not. - J.L.M.

1384
Nelson, Thurlow C. 1928.

On the distribution of critical temperatures for spawning and for ciliary activity in bivalve molluscs: Science 67(1730): 220-221.

Lamellibranch mollusks breed at a specific water temperature, constant for species throughout their range. Spawning occurs during a period of rising temperature and is started by a "trigger" temperature slightly below that of the water in which spawning first occurs. *Venus mercenaria* spawns at 24-25 degrees Celsius. Lamellibranchs also have a critical temperature below which ciliary activity is inhibited or abolished. Critical temperatures, especially those for spawning, are of prime importance in determining distribution of mollusks. *Venus mercenaria* is limited to a relatively few sheltered areas where spawning temperatures of 25°C occur during summer. Mollusk species with lower spawning temperatures, such as *Mytilus edulis* (10-12°C), are more widely distributed. - W.J.B.

1385
Nelson, Thurlow. 1947.

Some contributions from the land in determining conditions of life in the sea. Ecol. Monogr. 17(3): 337-346.

Natica, the predatory snail, penetrates into the bottom to destroy many *Venus*. From Delaware Bay southward giant sting rays excavate deep pits with their wings, washing out hard and soft clams and other mollusks for food. Rays, chimeras, and bottom-feeding sharks have teeth adapted to crushing hard-shelled mollusks. In Great South Bay, Long Island, in 1924 and in Barnegat Bay, N.J. in 1925 the entire oyster set was killed in a few hours on the bottom where temporary low oxygen conditions prevailed. - J.L.M.

1386
Nelson, Thurlow C. 1960.

Some aspects of pollution, parasitism and inlet restriction in three New Jersey Estuaries. In Trans. 2nd Seminar on Biological Problems in Water Pollution, 20-24 Apr 1959. C. M. Tarzwell (ed.) U.S. Dept. HEW, Pub. Health Serv., Robt. A. Taft Sanitary Eng. Center, Cincinnati: 203-211.

In 1919 a heavy storm cut through a second inlet into Little Egg Harbor, N.J. Salinities rose, and oysters were eliminated rapidly except for scattered groups in tidal creeks entering the Bay. Production of *Mercenaria mercenaria* rose correspondingly, and Little Egg Harbor at the time of writing supported one of the most productive clamming areas on the N.J. coast. The oyster industry of Raritan Bay was driven to extinction by about 1917 by the effects of water pollution, but at the time of writing a substantial quahog fishery persisted. Extinction of oyster stocks was attributed to industrial pollution by copper. Persistence of hard clam resources was believed to be related to their preference to higher salinities. Recently, increase in petroleum pollution of bottom deposits had interfered with sale of clams. Most of the report traces the history of the bays of the N.J. coast and the effects of natural and man-made variables on the environment and upon the shellfish industry, especially oysters. - M.W.S. and J.L.M.

1387
Nelson, T. C., and J. B. Allison. 1937.

On the nature and effects of stimulation of the sperm on the oyster. Anat. Rec. 70, suppl. 124: (Paper not seen).

No effect by sperm of *Venus mercenaria* on pumping of oyster. - J.L.M.

1388
Nelson, Thurlow C., and H. H. Haskin. 1949.

On the spawning behaviour of oysters and of *Venus mercenaria* with especial reference to the effects of spermatic hormones. Anat. Rec. 105(3): 484-485.

Spawning of *Venus mercenaria* and some oyster species is a group reaction stimulated by a hormone carried on the sperm. This hormone is soluble in alcohol and benzene. Oyster sperm carry a second hormone, named diantlin, a conjugated protein which relaxes the ostia of the gills. *Venus* sperm do not carry diantlin. Eggs of *Venus* pass out through the excurrent siphon, not through ostia. So far the authors had been unable to induce spawning in *Venus* in absence of sperm. Spawning had occurred in the laboratory at temps from 22.4 to 30°C. The observations of Loosanoff and Davis that quahaugs can be induced to spawn and produce viable larvae in midwinter if warmed gradually over several weeks were confirmed. - J.L.M.

1389
Neuman, L. D. (ed.). 1976.

Review of harmful substances. United Nations. IMCO/FAO/UNESCO/WMO/WHO/IAEA/UN Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). Reports and Studies 2, iv+80 p.

The report contains notes on major categories of marine pollution, inorganic wastes, radioactive materials, oil and oil dispersants, organic chemicals, organic industrial wastes, military wastes, heat, detergents, solid objects, dredge spoil, and inert wastes. Reference to species is sparse. *Mercenaria (Venus)* is mentioned only twice: average values for Mn in *M. mercenaria* are reported as 3 to 7 mg/kg dry weight; *Venus* (species not given) rapidly accumulated 30 to 40 mg/kg Hg from 0.3 mg/kg mercuric chloride but 70 mg/kg from methyl mercury. The bibliography contains references only to major source materials. - J.L.M.

1390 New York Conservation Department. 1928.

Seventeenth Annual Report for the year 1927. Legislative Doc. (1928) 38, J. B. Lyon Co., Albany, 371 p.

Discussion of the shellfisheries reflects the overwhelming importance of the oyster industry in the 1920s. Hard clam is mentioned, but not in any detail, but discussion of grounds open and closed to shellfishing is equally applicable to hard clam. Jamaica Bay had been closed for about 15 years. Raritan Bay had been condemned for about 4 years. Areas near New York City, in Long Island Sound, and in bays and estuaries around the shores of Long Island, open and closed, are described in detail. Residents were issued 903 permits to take shellfish for market from public shellfish grounds. Private planters held 383 perpetual franchise leases and 85 fifteen-year leases. - J.L.M.

1391 New York Ocean Science Laboratory. 1971.

The problems of Long Island waters. Summary report. NYOSL, Montauk, N.Y., Tech. Rept. 0010, 27 p. not numbered.

This paper is the proceedings of a workshop held 9-11 Feb 1971. *Mercenaria mercenaria* is not mentioned. - M.W.S.

1392 New York Ocean Science Laboratory Staff. 1970.

The state of knowledge with regard to the effects of physical and chemical environmental conditions on marine biota with emphasis on the Long Island situation. NYOSL Tech. Rept. 0004, 67 p.

The report contains 3 pages (not numbered) on *Mercenaria (Venus) mercenaria*. Average spawning size is 1 1/2 inches long; average spawning age 3 yrs, maximum age 25 yrs; it takes 3 yrs to reach 1 1/2 inches long; older clams grow more slowly. Normal temp range is 18-30°C; growth rate increases with temp and is negligible at low temps; 85% mortality occurs at temps above 30°C and below 15°C (abstracter's note: the statement about mortality below 15°C is incorrect); increasing temp to 20 to 22°C for 2 to 3 wks in the laboratory will induce spawning; temp also affects size, shape and setting of clam larvae. Egg and larval development of hard clams from Long Island Sound occurs at salinity 27.5°/°°; development will not occur below 17.5°/°°; decreased salinity increases oxygen consumption of muscles of adults. Normally, 80 to 100% saturation with oxygen is needed for average growth; at low concentrations the shell closes and the clam can live anaerobically for several days. Adult hard clams feed on plankton and detritus; the more diatoms in the environment, the greater the growth rate; hard clams have been reared in the laboratory on several species of algae; hard clam also filters bacteria, and *E. coli* content of clams is a reflection of *E. coli* content of overlying waters several hrs before; dissolved substances also affect larval development. Less than 2 g silt/liter of seawater is needed for normal feeding and growth. Optimum larval development is at pH 7.8 to 8.2 but development will occur at pH 6.75 to 8.5. Metabolic rate fluctuates with changes in barometric pressure. Pesticides affect development of eggs and larvae; adults accumulate DDT, DDE, and DDD. Currents are required for feeding and respiration; the required substrate is sand or gravel; hard clams usually are found on flat bottom. Parasites and diseases include *Malacobdella*, *Vibrio*, *Pseudomonas*, and trematodes. Papers cited are abstracted elsewhere in this bibliography. (Abstracter's note: the section on hard clam obviously was prepared in a hurry and was carelessly done. Much of the information included is incomplete or vague, and much of it is inaccurate. Authors' names are misspelled and some papers cited in the text are not listed under literature cited.) - J.L.M.

1393
New York Ocean Science Laboratory Staff. 1970.

The state of knowledge with regard to the effects of physical, chemical and biological conditions on the uses of the coastal resources. NYOSL Tech. Rept. 0006, 25 p.

This review treats finfishes and shellfishes. The text is very general and does not get down to specific cases. For example, under Water Quality Characteristics. A. Salinity and Temperature it is merely stated that "a large amount of information is available, and the relationship of these two parameters to shellfish is rather well understood." The literature cited contains only about a dozen references to *Mercenaria mercenaria*, all of which are abstracted elsewhere in this bibliography. - J.L.M.

1394
New York Sea Grant Institute. 1975.

Hard clam recipes from around the U.S. Sea Grant Advisory Service, State Univ. of N.Y. at Stony Brook, 8 p.

Twelve recipes taken from various sources. - J.L.M.

1395
New York State. 1975.

Proceedings of a workshop on the shellfish management program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany, 59 p.

Individual papers in this volume are abstracted elsewhere in this bibliography. Pages 51 to 59 contain useful appendices on historic shellfish landings, numbers of people participating in recreational fisheries, scientific and common names of shellfishes, form of certification of shellfish grounds, numbers of shellfish permits issued, and organization of the Division of Marine and Coastal Resources, Bureau of Shellfisheries and Algae, Dept. of Environmental Conservation. A chart showing areas closed to shellfishing on 1 April 1975 is included. - J.L.M.

1396
New York State Supreme Court. 1932.

People vs Miller (Municipal title to clams in land-locked bay). 235 App. Div. 226: 257, 300-308.

This case upholds the right of the Town of Southampton to manage the production of Mecox Bay, pointing out that two royal charters apply. The first was dated 1 November 1676, known as the Andros Charter. The second, dated 6 December 1686, is known as the Dongan Charter. These clearly stand today. - J.L.M.

1397
Newcombe, Curtis L. 1930.

Animal communities in the intertidal belt of the St. Andrews region. <u>In</u> Ann. Rept. Atl. Biol. Sta. to Biol. Bd. Canada, 2 p. (not numbered).

Preliminary report of investigations in summer 1929. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1398
Newcombe, Curtis L. 1935.

Certain environmental factors of a sand beach in the St. Andrews region, New Brunswick, with a preliminary designation of the intertidal communities. J. Ecology 23: 334-355.

The major infaunal community in the area was dominated by *Mya arenaria* and *Nereis virens*, with *Cerebratulus marginatus* as a subdominant, *Macoma baltica* as an influent, and *Lineus ruber* and a small unidentified annelid as subinfluents. The author comments that this biome extends widely in the Gulf of Maine, as an intertidal community of greatest economic value to the fisheries of the region. South of Cape Cod, he says, different associations exist, and the influence of *Venus mercenaria* becomes dominant south of New York State. - J.L.M.

1399
Newcombe, Curtis L., Sarah J. Thompson, and Herman Kessler. 1938.

Variations in growth indices of *Venus mercenaria* L. from widely separated environments of the Atlantic coast. Cdn. J. Research, D.16: 1-5.

Variations in linear indices of length, width, and thickness, and differences in shell weights of *V. mercenaria* from Gulf of St. Lawrence, Chesapeake Bay, and North Carolina were studied. Living clams were dried to constant weight, and shells weighed after removal of body parts. Constants of the equations W=a+bL and T=d+eL were determined, where W=width (greatest radius with umbo as center), T=thickness (greatest distance across valves), and L=length (greatest anterior-posterior dimension). Within the length range studied the relation between logL and logW was a straight line, so that $Wt=cL^k$, where c is a constant denoting the value of Wt when L=1 (the fractional coefficient), and k is the ratio of relative growth rate of shell weight to relative growth rate of length. Relative growth rate means rate of growth per unit dimension. Results were as follows:

Dimensional ratios	Constants	Gulf of St. Lawrence	Chesapeake Bay	North Carolina
L to W	b	0.931	0.772	0.852
	a	-2.876	2.274	1.395
L to T	e	0.560	0.583	0.570
	d	0.378	-0.634	-0.631
L to Wt	k	3.003	3.032	3.151
	c	0.00000214	0.00000171	0.00000108

The "b" values for linear dimensions showed the greatest differences between regions, whereas differences in actual widths and thicknesses at corresponding lengths were not considered significant. Shells from Gulf of St. Lawrence were heavier than those from warmer waters of Chesapeake Bay and N.C. The only obvious environmental relationship appeared to be an inverse relationship between shell weight and water temp. - J.L.M.

1400
Newell, B. S. 1953.

Cellulolytic activity in the lamellibranch crystalline style. J. Mar. Biol. Assn. U.K. 32(2): 491-495.

Crystalline styles of *Ostrea edulis* and *Mytilus edulis* appeared to contain a cellulolytic factor as yet unidentified. *Venus (Mercenaria) mercenaria* is not mentioned. - J.L.M.

1401
Newell, G. E. 1964.

Physiological aspects of the ecology of intertidal molluscs. Chapter 2 in Physiology of Mollusca. Vol. 1. K. M. Wilbur and C. M. Yonge (eds.) Academic Press, New York: 59-81.

V. mercenaria can respire anaerobically. Oxygen consumption of tissues of populations of *V. mercenaria* acclimated to cold water is higher at any given temperature than that of those from warm-acclimated temps. - J.L.M.

1402
Newell, Norman D. 1965.

Classification of the Bivalvia. Am. Mus. Nov. 2206: 1-25.

The name to be applied to bivalve mollusks has been a source of widespread disagreement. World malacologists have been about equally divided between Pelecypoda and Lamellibranchiata, and there seems to be no possibility of winning universal adoption of either. There is now a strong swing toward compromise on Bivalvia Linnaeus 1758, which is not only the oldest name applied to the Class, but has the merit of possessing a familiar English cognate, "bivalve", which is meaningful to a layman. *Mercenaria (Venus) mercenaria* belongs to the Subclass Heterodonta Neumayr 1884, Order Veneroida Adams and Adams 1858 (as Veneracea) Suborder Arcticina Newell (new suborder), Superfamily Veneracea Rafinesque 1815, Family Veneridae Rafinesque 1815. History of bivalve classification is covered in detail. - J.L.M.

1403
Newell, R. C. 1970.

Biology of Intertidal Animals. Am. Elsevier Pub. Co., Inc., New York, viii + 555 p.

This is primarily an account of British forms, but *Venus (Mercenaria) mercenaria* is mentioned in several places. High level animals continue to respire even when the tide is low, using anaerobic respiration as in *Venus mercenaria* (Dugal, 1939). The differing experimental methods used by various investigators makes strict comparisons between pumping rates difficult. Thus the great difference in level between the values of weight-specific pumping rates in *Venus mercenaria* (Rice and Smith, 1958) compared with other bivalves may be partly attributable to the experimental conditions under which feeding was measured. The temperature conditions under which feeding was measured would also adequately account for such differences. Animals living high on the shore might reduce water loss by closure of the shell valves, as in *Venus mercenaria* (Dugal, 1939). Elsewhere, haemoglobin is confined mainly to muscles and nervous system, for example, in heart and adductor muscles of the bivalve *Mercenaria* sp. Anaerobiosis occurs in *Venus mercenaria* (Dugal, 1939). - J.L.M.

1404
Newell, R. C., and H. R. Northcroft. 1967.

A re-interpretation of the effect of temperature on the metabolism of certain marine invertebrates. J. Zool., London 151(3): 277-298.

At least 2 rates of oxygen consumption can be distinguished in intact animals of a wide variety of common intertidal invertebrates. When the animal is active, oxygen is taken up rapidly at a rate that increases with temp in approximate agreement with the Arrhenius law. A slower rate, corresponding with quiescence, alternates with the rapid rate and does not vary with temp over much of the range 7° to 22.5°C. It is concluded that, contrary to common belief, the intertidal invertebrates studied (which did not include *Mercenaria mercenaria*) had a "basal metabolic rate" with a Q_{10} of approximately 1 over much of the normal environmental temp range and in this respect are well suited to life in a habitat in which temp fluctuates rapidly. - modified authors' abstract - J.L.M.

1405

Noguchi, Hideyo. 1921.

Cristispira in North American shellfish. A note on a spirillum found in oysters. J. Exper. Med. 34: 295-315, 4 pls.

Ten molluscan species collected in the Woods Hole, Mass. area were examined for presence of the parasitic spiral organism *Cristispira*. The parasite was found in the crystalline style of 3 species, including *Venus mercenaria*. In 110 hard clams examined, styles were present in 70. Only 8 styles contained the parasite. Efforts to culture the organism failed. - J.L.M.

1406

North, Dan. 1963.

Oysters from Europe for S.F. San Francisco Examiner, Sec. 1, p. 23, June 16.

Refers to plantings of 800 European oysters in Tomales and Drakes Bays in summer 1962, and 2,000 quahogs in Tomales Bay in May 1963, by Victor L. Loosanoff and Walter Dahlstrom. - J.L.M.

1407

Nystrom, Richard A. 1967.

Spontaneous activity of clam intestinal muscle. Comp. Biochem. Physiol. 21(3): 601-610.

Longitudinal non-striated muscle of *Mercenaria mercenaria* intestine gives an unusual variety of contraction patterns when excited spontaneously, neurally, electrically and pharmacologically. Experiments were conducted with isolated preparations of the cardiac segment of hard clam gut in a sea water bath at 21 to 23°C. Isolated segments of hard clam intestine are frequently, although not always, spontaneously active. Normally this activity consists of a series of slow, rhythmic waves which are not very strong. Often, also, a preparation will show trains of fast contractions. Trains of 10 or so contractions occur about once every 5 min. 5-Hydroxytryptamine (5-HT) produces variable reactions in hard clam intestine. Three successive applications of 10^{-5}M 5-HT produced first a large, long contraction followed by slow relaxation, second a large but faster contraction followed by beating (3 contractions/min) and a small increase in tone, third, delayed beating (4.5 contractions/min) and tone, but no initial tonic contraction. 10^{-5} acetylcholine (ACh) elicited a phasic and a tonic response, confirming Greenberg's data. These experiments suggested that the spontaneous activity of *Mercenaria* intestine is normally caused by spontaneous activity of nerve cells embedded within the musculature. - J.L.M.

1408

O'Connor, J. S. 1972.

The benthic macrofauna of Moriches Bay, New York. Biol. Bull. 142(1): 84-102.

Samples were taken with a Ponar grab which sampled an area of 0.05 m^2. The grab penetrated relatively deeply except in sandy sediments. All sampling stations were selected at random, except for 14 purposely selected, mostly in dredged channels. Five substrate types were recognized: sandy sediments (37% of total area of Bay bottom), clayey silt and silt (33%), transitional (sand with 25-80% clay and silt 20%), and dredged channels (10%). The fifth was identified by subdividing the sandy biotope into bottoms with dense vegetation and those with sparse or no growth. Major taxa identified were 13, with 24 dominant and 12 less dominant species. In the Bay as a whole polychaetes (41%) and bivalves (36%) predominated in ash-free dry weight. The small area sampled per grab and the relative rarity of *Mercenaria mercenaria* as individuals caused great variability in biomass estimates. Nevertheless, hard clam was by far the dominant organism in wet weight biomass. Although it was not stated, it is assumed that biomass of bivalves was reported with valves removed. Suspension feeders dominated in sandy sediments, deposit feeders in soft clayey silt bottoms. The standing crop of macrobenthic organisms was less than expected, probably because oxygen concentrations are low in summer. - J.L.M. and W.J.B.

1409
O'Gower, A. K., and Patricia I. Nicol. 1968.

A latitudinal cline of haemoglobins in a bivalve mollusc. Heredity 23, Pt. 4: 485-492.

Mercenaria mercenaria is not mentioned. - M.W.S.

1410
Okubo, K., and T. Okubo. 1962.

Study on the bio-assay method for the evaluation of water pollution - II. Use of the fertilized eggs of sea urchins and bivalves. Tokai Reg. Fish. Research Lab., Bull. 32: 131-140.

In Japanese with English synopsis. Effects of pollutants on fertilized eggs of bivalves are easily recognizable in disturbed metamorphosis. The bivalves were *Crassostrea gigas* and *Mytilus edulis*. - J.L.M.

1411
Olander, Jitka. 1971.

Substructure of the paramyosin molecule. Biochem. 10(4): 601-609.

The only material in this paper pertinent to *Mercenaria mercenaria* is that the protein preparation was prepared from whole adductor muscles of hard clam. The extraction procedure was described in a paper by Johnson et al. (1959) abstracted elsewhere in this bibliography. - J.L.M.

1412
Olsen, Stephen B., and David K. Stevenson. 1975.

Commercial marine fish and fisheries of Rhode Island. Coastal Resources Center, Univ. R.I., Kingston, Mar. Tech. Rept. 34, 117 p.

Mercenaria mercenaria, bay quahaug, is the most abundant animal of its size living in the bottom of Narragansett Bay. Habitat, spawning, growth, and distribution in Rhode Island waters are described by reference to published papers abstracted elsewhere in this bibliography. It is stated that the stocks in Narragansett Bay could sustain a much larger harvest. Quahaugs in dense, underharvested beds may be buried several layers deep in sediments, and only a fraction of those present will be taken with a single pass of a dredge. It is assumed that productive areas can produce a sustainable annual yield of about 25% of the standing crop. The most productive beds in the Providence River are polluted, and closed to harvesting. Reported commercial landings rose irregularly to a peak of about 5 million pounds of meats in 1955, then declined rapidly. Landings have been below one million pounds since 1972, and it was predicted that the decline would continue if no action were taken. - J.L.M.

1413
Ono, Joyce K., and Daryl C. Sweeney. 1970.

The accumulation of dopamine-^{3}H by *Mercenaria* ganglia. Am. Zool. 10(4): 503-504 (abstract).

Ganglia of quahog contain high concentrations of dopamine which can be synthesized locally from exogenous DOPA. Isolated pedal ganglia incubated in 0.1 μM dopamine-^{3}H solutions (S.A. 10.6 mC/μ mole, 10 min, 21.5°C) accumulated a dopamine concentration 2.4 times higher than the external medium. (Abstracter's note: authors commonly confuse the terms *higher* and *as high*; 2.4 times higher means 3.4 times as high. The basic data are not given, so it was not possible to determine whether the statement as given is correct.) Ganglia concentrated dopamine-^{3}H at levels higher than those in ganglionic extracellular spaces, but other tissues (digestive gland, heart, gills, kidney, mantle, foot, siphon, adductor muscles, and visceral mass) did not accumulate the substance above extracellular concentrations. Thus, ganglia are the only significant sites of dopamine accumulation in *M. mercenaria*, and a blood-brain barrier to dopamine is lacking in this animal. - J.L.M.

1414
Opsata, Margaret. 1977.

Delaware experiments offer exciting mariculture prospects. Natl. Fisherman 58(8), Dec. 1977: 6B-7B.

Oysters, clams, and other bivalves were grown in a closed, recirculating system. Costs in a laboratory system were about 9¢ each, or $20 to $22/bu to produce a crop. It was believed that mass production techniques should reduce costs significantly. - J.L.M.

1415
Orton, J. H. 1937.

Oyster breeding and oyster culture. Edward Arnold Co., London.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

1416
Osburn, H. L. 1887.

Notes on Mollusca observed at Beaufort, N.C. Stud. Biol. Lab. Johns Hopkins Univ. 4: 64-81.

According to Jacot (1921), abstracted elsewhere in this bibliography, Osburn recorded *Venus mercenaria* from this area. - J.L.M.

1417
Osterhaug, Kathryn L., and Rose G. Kerr. 1953.

How to cook clams. U.S. Fish Wildl. Serv., Test Kitchen Ser. 8, 13 p.

Contains information on buying and shucking clams of various species, including *Mercenaria mercenaria*. Twenty-eight recipes are included. - J.L.M.

1418
Othmer, Donald F., and Oswald A. Roels. 1974.

Power, fresh water, and food from cold, deep seawater. J. Mar. Tech. Soc. 8: 39-43.

Reprinted by permission from Science 182(4108): 121-125 (1973). Principles underlying use of cold nutrient-rich water from below the thermocline in the tropics are discussed and their applications to mariculture described. Hard clams from Long Island, N.Y. grew very rapidly in this artificial "upwelling" system, reaching market size more rapidly than in the natural environment. Hybrid clams weighing 8 g on introduction reached 38.5 g in 6 months, which was commercial littleneck size. - J.L.M.

1419
Otto, Sara V. 1971.

Manokin River project: An ending and a beginning. Comm. Fish. News, Md. Fish Wildl. Admin. 4(3): 2, 4.

A new project, Molluscan Mortality Studies, has as its major objective a study of parasite distribution in several species, including *Mercenaria mercenaria*. - J.L.M.

1420
Otto, Sara V. 1973.

Hermaphroditism in two species of pelecypod mollusks. Proc. Natl. Shellf. Assn. 63: 96-98.

One bilaterally hermaphroditic hard clam was found in Chincoteague Bay from 546 clams examined. Phagocytic infiltration was heavy throughout the clam indicating physiological stress. Of 520 clams examined from Chesapeake Bay, no hermaphrodites were found. - D.L.

1421
Otto, Sara V. 1975.

D.N.R. readies new facility for shellfish studies. Comm. Fish. News, Md. Dept. Natural Resources 8(6): 1.

A trailer was being modified for use as a field office and laboratory. The facility was expected to assist in providing further information on shellfish diseases, such as the Amorphous Blue Bodies condition in hard clam, caused by the parasite *Chlamydia*, which infests one or several cells in the lining of digestive gland tubules, then reproduces in tremendous numbers. - J.L.M.

1422
Otto, S. V., J. C. Harshbarger, and S. C. Chang. 1975.

Clamydia infections in clams. 1. Incidence, distribution and histopathology. Soc. Invertebr. Pathol., Ann. Meeting (8th). Corvallis, Oregon: 29 (abstract).

We were not able to find the volume that contained this abstract. - J.L.M.

1423
Owen, G. 1953.

The shell in the Lamellibranchia. Quart. J. Microscop. Sci. 94: 57-70.

Venus is mentioned, but the species is not identified. In lamellibranchs generally, direction of growth at any region of the valve margins may be resolved into: a) a radial component radiating from the umbo and acting in the plane of the generating curve; b) a transverse component acting at right angles to the plane of the generating curve; and c) a tangential component acting tangential to, and in the plane of, the generating curve. The radial component is always present and affects the form of both valves; the transverse component may be reduced or absent in one valve. The mantle and shell are oriented with reference to the normal axis, which follows that sector of the shell secreted by the normal zone of the mantle edge (where the effect of the transverse component is greatest) and passes through the umbo, the normal zone and the point at which the greatest transverse diameter of the shell intersects the surface of the valves. The form of shell valves should be considered in reference to the outline of the generating curve, spiral angle of the normal axis, and form (planospiral) of the normal axis. "Deflection" anteriorly of the umbones and splitting of the ligament in many bivalves is a consequence of a tangential component affecting the form of both valves. The turbinate spiral shell in gastropods and lamellibranchs is the resultant of two differential growth ratios, which in lamellibranchs act respectively perpendicularly to the plane of the generating curve, and *in* the plane of the generating curve. - modified author's summary - J.L.M. and M.W.S.

1424
Owen, G. 1955.

Observations on the stomach and digestive diverticula of the Lamellibranchia. I. The Anisomyaria and Eulamellibranchia. Quart. J. Microsc. Sci. 96(4): 517-537.

Mercenaria mercenaria is not mentioned, but on p. 533 is a beautiful diagram of the probable pathway of material within the stomach and digestive diverticula of a generalized lamellibranch. The crystalline style also is shown. - M.W.S. and J.L.M.

1425
Owen, G. 1958.

Shell form, pallial attachment and the ligament in Bivalvia. Proc. Zool. Soc. London 131: 637-648.

This paper describes the adductor muscles and ligament of bivalves in some detail, but contains no specific discussion of *Mercenaria (Venus) mercenaria*. - J.L.M. and M.W.S.

1426
Owen, Gareth. 1966.

Feeding. Digestion. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.) Academic Press, New York, Vol. II: 1-51, 53-96.

Contains references to *Mercenaria (Venus) mercenaria* abstracted elsewhere in this bibliography. - J.L.M.

1427
Owen, Gareth. 1974.

Feeding and digestion in the bivalvia. In Advances in Comparative Physiology and Biochemistry 5: 1-35. (O. Lowenstein, ed.). Academic Press, N.Y.

Venus striatula 21-28 mm long, at 17°C, pumped 40 ml/hr per animal (Allen 1970). This is low compared to other bivalves listed, but size is a factor, and these were relatively small. *M. mercenaria* has a high pumping rate per unit gill area (6.05 ml/hr/unit gill area). It lives in situations where water contains relatively little suspended material (Hughes 1969). But Owen notes that calculation of gill area did not seem to have taken into account whether or not the gills were plicate, which they are in *M. mercenaria* and *Cardium edule* but not in *Mytilus*, *Mya*, and *Scrobicularia*, which have flat gills. Rate of water movement over the animal has an effect on pumping rate. *M. mercenaria* at a flow rate of 200 ml/min had a specific filtration rate of 55.5, at flow rate of 300 ml/min 75.5 per gram of dry meat weight. Sensitivity of *M. mercenaria* to different food concentrations (Walne 1972) was: *Dunaliella tertiolecta*, at maximum ration 16.6×10^4 filtered 4.98×10^7 μ^3/animal/hr; *Isochrysis galbana*, max. ration 38×10^4 filtered 2.17×10^7 μ^3 per animal/hr; and *Phaeodactylum tricornutum*, max. ration 90×10^4 filtered 4.50×10^7 μ^3/animal/hr. Food value of different algae to *M. mercenaria* was expressed in terms of the ratio of rate of growth on experimental food to rate of growth on *Isochrysis* or *Tetraselmis*, calculated by dividing mean size at 21 days from commencement of test by mean size of control on same day. Results: *Monochrysis lutherii* 0.59, *Tetraselmis calcitrans* 1.11, *Skeletonema costatum* 3.30, *Isochrysis galbana* 1.00, *Dicrateria inornata* 0.67, *Cricosphaera carterae* 0.70, *Chlorella stigmatophora* 0.31, *Phaeodactylum tricornutum* 0.44, *Olisthodiscus* sp. 0.75, *Nanochloris* (sic) *atomus* 0.92, *Micromonas pusilla* 0.74, *Dunaliella tertiolecta* 0.14, and *Chlamydomonas coccoides* 0.19. *Chlorella* and *Chlamydomonas* have rigid cell walls, but *Dunaliella* does not, so the conclusion by Jorgensen (1966) is suspect: "Evidence for rhythmic pattern of feeding in bivalves, other than that imposed by environmental factors, is equivocal." But it is clear that a rhythm is imposed on intertidal bivalves. (In *O. edulis* total protein in the crystalline style is correlated with tidal cycle.) - J.L.M.

1428
Owen, G., E. R. Trueman, and C. M. Yonge. 1953.

The ligament in the Lamellibranchia. Nature 171(4341): 73-75.

This is a general discussion of the origin and structure of the ligament. Few species are mentioned, and *Mercenaria (Venus) mercenaria* is not included. In each group of Lamellibranchia the ligament has a characteristic formation, "internal" or "external", elongated or condensed, with primary and secondary constituents variously developed. No general description will cover all cases. The ligament primarily consists of a superficial periostracum and an "outer" and an inner layer, corresponding to the three layers of the shell. The 3 layers have different origins. Periostracum is secreted by a groove between outer and middle lobes of mantle edge. Mantle edge secretes largely uncalcified organic matter to produce the "outer layer", and the bulky inner layer of the ligament is secreted by epithelium of the *isthmus*, the connecting neck of tissue between the 2 lobes of the mantle, which has been called erroneously *pallial suture*. - J.L.M.

1429
Palincsar, Joan Shriner. 1959.

Periodisms in amount of spontaneous activity in the quahog, *Venus mercenaria*. Ph.D. dissertation, Northwestern Univ. (1958). Dissert. Abstr. 19(3): 2640.

Activity of *V. mercenaria* was recorded continuously for ten 29-day periods during four years from 1954-1957. Single-day cycles showed some characteristics of overt activity cycles with major maximum usually in daylight, but highly variable. Diurnal cycles of 29 days were quite similar, usually unimodal, and the major maximum of the day tended to shift from morning to afternoon in alternate yrs. Average range was about 45%. Calculated 29-day lunar-day cycles had a range of only about 20%, and points on the same curve of individual cycles were not significantly different. A mean cycle for the 4 yrs, however, showed a significant maximum 3 to 6 hrs after lunar zenith and a minimum about lunar nadir. An hypothesis was suggested which combines endogenous and exogenous rhythmic control mechanisms. (Abstracter's note: the abstract was not very carefully written, and the meaning was not always entirely clear. The hypothesis mentioned was not further explained. The original thesis was not examined.) - J.L.M.

1430
Palmer, Katherine van Winkle. 1927.

The Veneridae of eastern America, Cenozoic and Recent. Paleont. Amer. 1(5): 209-522, pls. 32-76.

Genus VENUS (Linnaeus) Lamarck

Venus Linnaeus, 1758, Systema Naturae, ed. X, p. 684; Linnaeus, 1767, ed. XII, p. 1128; Gmelin, 1792, Systema Naturae, Tome VI, p. 3266; Lamarck, 1799, Prodome, p. 84.
Mercenaria Schumacher, 1817, Essai d'une Meth., p. 135; Gray, 1847, Proc. Zool. Soc. Lond., p. 183; Deshayes, 1853, Cat. Conch. Biv. Sh. Brit. Mus., pt. I, p. 113; H. and A. Adams, 1857, Gen. Rec. Moll., vol. II, p. 418; Stoliczka, 1871, Pal. Indica, vol. III, p. 153; Tryon, 1884, Struct. and Syst. Conch., vol. III, p. 176 not Cossmann, 1887, Cat. Illus.
Venus Fischer, 1887, Man. de Conch., p. 1083 not *Venus* H. and A. Adams, 1857.
Crassivenus Perkins, 1869, Proc. Bost. Soc. Nat. Hist., vol. XIII, p. 147.
Venus Dall, 1902, Proc. U.S. Nat. Mus., vol. 26, No. 1312, p. 360; Dall, 1903, Trans. Wag. Inst. Sci., vol. III, pt. 6, p. 1307; Cossmann and Peyrot, 1911, Actes Soc. Linn. Bordeaux, Tome LXIV, p. 322; Jukes-Browne, 1914, Proc. Mal. Soc. Lond., vol. 11, p. 79.

Animal Tethys.
Testa bivalvis, labiis margine antico incumbentibus.
Cardo dentibus 3: omnibus approximatis: lateralibus apice divergentibus.
Vulva & Anus Distincta. - /Linnaeus, 1758./
Shell large, inequilateral and thick; lunule is large, cordate and bounded by an incised line; escutcheon defined by a high ridge which varies in sharpness; inner margin crenulate; pallial sinus medium in size, pointed; three cardinals in each valve; anterior cardinals of both valves simple; left, middle cardinal bifid; left, anterior cardinal high and pointed, right middle and posterior cardinal bifid; left, posterior cardinal very thin and hardly differentiated from the nymph plate; no laterals in either valve; the nymphs of both valves very coarsely rugose; exterior usually smooth or with concentric ribs or striations. Gives also complete synonymies for *V. mercenaria* and *V. campechiensis*. Describes also 78 other species and subspecies of *Venus*. - J.L.M.

1431
Pannella, Giorgio. 1972.

Palaeontological evidence on the Earth's rotational history since early Precambrian. Astrophys. Space Sci. 16(2): 212-237.

Daily growth layers in calcified structures of modern and fossil organisms, especially bivalve mollusks, are arranged in seasonal and tidal patterns and provide evidence on length of lunar month and year in the geological past. Growth patterns in shells of *Mercenaria mercenaria* are clearly developed and are among the most complex, so that they provide maximum information. Data from Miocene *M. campechiensis ochlockoneensis* and Recent *M. mercenaria* and *M. campechiensis* and other calcareous remains demonstrate that the number of days/lunar month and days/yr has decreased significantly since Ordovician time, but not necessarily at a uniform rate. - J.L.M.

1432
Pannella, Giorgio. 1975.

Palaeontological clocks and the history of the earth's rotation. In Growth Rhythms and the History of the Earth's Rotation. G. D. Rosenberg and S. K. Runcorn (eds.). John Wiley & Sons, London: 253-284.

J. W. Wells was the first to propose use of fossils as "geochronometers". In intertidal *Mercenaria mercenaria*, organic lines are formed during periods of shell closing at low tide. The periodicity of line formation is lunar, 12 hr 25 min in semi-daily tides or 24 hr 50 min in daily tides. Because the lunar-day rhythm is bimodal, a lunar increment may consist of 2 growth layers and 2 organic lines, when 2 low tides interfere with internal calcification rhythms. The growth layer is deposited rapidly in 2 to 3 hrs during rising tides, as calcification is accelerated after a period of enforced retardation. Most rapid deposition was observed during evening rising tides. The propitious time for calcification each 24-hr period is dictated by internal circadian rhythms and external factors such as light and temp. Intertidal growth patterns are not caused entirely by tidal rhythms, but by interplay of solar, circadian, and lunar rhythms. Growth patterns of *M. mercenaria* in New England are different from those in Florida because these conditions are different. Animals in intertidal areas show a "switch zone" in shell structure, which is caused by the tidal phase 50-min shift with respect to sidereal day. The shift compresses the time of calcium carbonate deposition in one direction until it "snaps back", missing a day every fortnight, consisting of 13 1/2 lunar days (14.8 sidereal days). Different types of switch zone have in common the fact that one growth line used as a reference to measure the "daily" spacing suddenly repeats at half the previous or subsequent distance. When this happens the sequence of symmetrical increments changes to sequences of asymmetrical increments. In earlier studies, e.g., Pannella and MacClintock (1968), the coincidence between number of counted bands and number of days was fortuitous, caused by the particular natural conditions prevailing at the time of the experiment. For some purposes the loose definition that increments are daily is acceptable, but for precise geophysical interpretation a strict separation of solar and lunar increments is necessary. Conclusions from earlier work must be reassessed. - J.L.M.

1433
Pannella, Giorgio, and Copeland MacClintock. 1968.

Biological and environmental rhythms reflected in molluscan shell growth. In Paleobiological aspects of growth and development, A symposium. Donald B. Macurda, Jr. (ed.). Paleont. Soc. Mem. 2, J. Paleontology 42 (suppl. to no. 5), Pt. 2 of 2: 64-80.

Living *Mercenaria mercenaria* were notched at growing edge of shell and planted in the intertidal zone in Barnstable Har., Mass. Shells from 2 lots, killed 368 and 723 days after planting, had as many small growth increments as the numbers of days from notching to killing. Superimposed on daily growth records were thin daily increments of winter, and 14-day cycles of thick and thin daily increments caused by tides. Comparison with tidal records showed that, for each 14-day cycle, thin daily increments formed during neap tides and thicker increments during spring tides. Such patterns also are present in hard clams from the subtidal zone, but rarely as pronounced. Spawning patterns differ from winter patterns. Spawning induces an interruption of regular deposition followed by a series of thin daily increments. Continuous sequences of bidaily patterns also are common in *M. mercenaria*, one thick daily increment followed by a relatively thin one. Clearest 14-day cycles were seen in shells of *Tridacna squamosa*. Temp, tides, reproductive activity, substrate, depth of water, and age affect molluscan growth. Preliminary data from *Mercenaria* and other fossil bivalves suggest a decreasing trend in mean number of days per lunar month from 30.07 in the Pennsylvanian, 29.96 in the Cretaceous, 29.82 in the Eocene, 29.38 in the Miocene, to 29.13 Recent. - J.L.M.

1434
Pannella, Giorgio, Copeland MacClintock, and Maxwell N. Thompson. 1968.

Paleontological evidence of variations in length of synodic month since late Cambrian. Science 162: 792-796.

Circadian rhythms regulate almost universally the world of living matter. They often leave records in skeletons of continuously growing organisms. The question arises: do daily bandings record solar or synodical time? Experiments on bivalve mollusks have led to the conclusion that solar time is the basic unit, and that synodical time is expressed in thickness of increment. Most of the data reported were from bivalves. For control and comparison counts from the recent bivalve *Mercenaria mercenaria* from New England were recorded. Number of increments/month in 6 hard clams varied from 28.98 to 29.58 for an average of 29.17. In general, growth patterns record fewer increments than actual days, and this average value is 1% less than the actual value for the synodic month. The change in length of synodic month for the Miocene, based on a count from one specimen of *Mercenaria campechiensis ochlockoneensis* (18 million yrs BP) that showed the same shell structures and growth patterns as recent *M. mercenaria*, was higher than the one predicted by astronomical calculations. Values for Eocene and Upper Cretaceous also were higher than predicted. Analysis of fossils dating back to Upper Cambrian (510 million yrs BP) suggested that slowing of the earth's rotation has not been uniform. These observations and speculations show that by using growth patterns of organisms it will be possible to shed light on events that affected the general distribution of oceans and continents in the past. Two breaks in slope of the curve describing length of synodic month through 510 million yrs of geologic time, in the Pennsylvanian and Cretaceous, may be related to changes in distribution of continents, ocean, and adjacent shallow seas, and their effects on rotation of the earth. - J.L.M.

1435
Parker, C. 1881.

Poisonous qualities of the starfish. The Zoologist 5: 214.

Postulates that a toxic secretion, liberated by the sea star and introduced between the valves of a clam, is responsible for opening the valves. - from Burnett, Ecology 41(3), 1960 - J.L.M.

1436
Parker, G. H. 1932.

An unusual living inclusion in the shell of a clam. Ecology 13(1): 102-103.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1437
Parker, P. S. 1967.

Clam survey Ocean City, Maryland to Cape Charles, Virginia. Comm. Fish. Rev. 29(5): 56-64.

This was primarily a surf clam *(Spisula solidissima)* survey, but ocean quahogs *(Arctica islandica)* were taken, especially at water depths between 20 and 25 fath. In sections where ocean quahogs were most abundant it was estimated that commercial catches of about 15 bu/20 min tow would be possible. - J.L.M.

1438
Parker, Phillip S. 1967.

A clam measuring board. Comm. Fish. Rev. 29(4): 65-66.

A simple measuring board to make clam measurements rapidly and accurately even under rough sea conditions is described, and materials listed. The board was designed for *Spisula solidissima,* but it would be equally useful for *Mercenaria mercenaria.* - J.L.M.

1439
Parker, Phillip S., and Lars A. Fahlen. 1968.

Clam survey off Virginia (Cape Charles to False Cape). Comm. Fish. Rev. 30(1): 25-34, appendix.

From 1961 to 1965 inclusive, total surf clam production was greater than total landings of *Mercenaria mercenaria* and soft clam combined. - J.L.M.

1440
Parker, Phillip S., and Ernest D. McRae, Jr. 1970.

The ocean quahog, *Arctica islandica,* resource of the northwestern Atlantic. Fish. Industr. Research 6(4): 185-195.

Contains a paragraph and 2 illustrations describing the distinguishing features of ocean quahog and *Mercenaria mercenaria.* Ocean quahog has one posterior lateral tooth in each valve, lacking in hard clam. Hard clam has a pallial sinus on inner surface of shell, ocean quahaug does not. Presence of a pallial sinus shows that the clam has a retractile siphon. Hard clam has a distinct purple border around edge of shell on inner surface, ocean quahog does not. Periostracum of ocean quahog is black or dark brown. Periostracum of hard clam is straw colored. (Abstracter's note: the purple coloration on the inside of hard clam valves is highly variable, and sometimes absent, not invariably present as the authors imply.) - J.L.M.

1441
Parker, Robert H. 1955.

Changes in invertebrate fauna, apparently attributable to salinity changes in the bays of central Texas. J. Paleon. 29(2): 193-211, 8 fig.

Previous studies in the area were made during periods of very low or highly variable salinity. From 1948 to 1953 an extended drought with low river runoffs brought salinities to record highs, with little variation. Many marine and open-gulf species invaded the bays, growth and appearance of oyster reefs changed, and low-salinity mollusks like *Rangia cuneata* virtually disappeared. *Mercenaria campechiensis texana* is listed as having been found alive in bays and dead in the Gulf of Mexico. - J.L.M.

1442
Parker, Robert H. 1956.

Macro-invertebrate assemblages as indicators of sedimentary environments in East Mississippi Delta region. Bull. Am. Assn. Petrol. Geol. 40(2): 295-376, 32 fig., 8 pl.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1443
Parker, Robert H. 1959.

Macro-invertebrate assemblages of central Texas coastal bays and Laguna Madre. Am. Assn. Petrol. Geol., Bull. 43(9): 2100-2166.

Coastal waters are classified as: 1) river-influenced, low-salinity bays; 2) enclosed bays of low to variable salinity; 3) open high-salinity bays; 4) inlet areas (e.g., connections between bays and ocean); and 5) hypersaline bays and lagoons. Subcategories are shallow grassy bays, and salt marshes. Loosely compacted sediments of high-salinity bay margins, which are sandy, ranging from sand-silt-clay to almost pure fine sand, may be "ideal" for penetration just below surface sediments by large filter-feeding pelecypods like *Mercenaria*. *M. mercenaria campechiensis* and *Tagelus divisus* best characterize this environment. Scallops, *Aequipecten irradians amplicostatus*, also are abundant. Two faunal assemblages are characteristic of open high-salinity bays: the one just described, and small pelecypods and gastropods of the predominantly clayey sediments of bay centers, which are capable of remaining at the surface of such soupy sediments. Salinity appears to be the controlling factor for gross high-salinity bay fauna, but substrate and circulation seem to be responsible for separation of the fauna into the 2 assemblages described. - J.L.M. and M.W.S.

1444
Parker, Robert H. 1960.

Ecology and distributional patterns of marine macro-invertebrates, northern Gulf of Mexico. In Recent Sediments, Northwest Gulf of Mexico. Francis P. Shepard, Fred B. Phleger, and Tjeerd H. Van Andel (eds.). Am. Assn. Petrol. Geol., Tulsa, Okla.: 302-381.

Mercenaria mercenaria campechiensis is described as abundant in dense beds at inlet end of lagoons; large (1 to 5 1/2 inches). The paper contains an extensive bibliography. - M.W.S. and J.L.M.

1445
Patterson, C. M. 1968.

Chromosomes of molluscs. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 635-686.

This comprehensive review paper refers to work on *Mercenaria mercenaria* contained in papers abstracted elsewhere in this bibliography. - J.L.M.

1446
Pauley, Gilbert B. 1969.

A critical review of neoplasia and tumor-like lesions in mollusks. In Neoplasms and Related Disorders of Invertebrate and Lower Vertebrate Animals. C. J. Dawe and J. C. Harshbarger (eds.) Natl. Cancer Inst. Monogr. 31, Govt. Print. Off., Washington, D.C.: 509-539.

Mercenaria mercenaria is not mentioned. - J.L.M.

1447
Pearce, John B. 1972.

Invertebrate resources: Available forms and potentials. In Resources of the World's Oceans. Henry R. Frey (ed.). N.Y. Institute of Ocean Resources Inc.: 75-90.

Beds of hard clam *(Mercenaria mercenaria)* presently exist in parts of Raritan Bay, but there is indication that they are not reproducing. The standing crop is almost solely large clams. Apparently no recruitment is occurring off Staten Island and in the western part of Raritan Bay. Harvesting has been prohibited for the last decade because clams are grossly contaminated. Many parts of Great South Bay, L.I. are open to clamming but new areas are closed each year. Navesink and Shrewsbury Rivers, connected to Sandy Hook Bay, N.J., are essentially closed to clamming, as is Sandy Hook Bay, for public health reasons. (Abstracter's note: the author's conclusion, that hard clams were not reproducing, is unlikely. Recruitment is not obvious in a mature stock. This chapter discusses many species, but only references to hard clam are cited here.) - J.L.M.

1448
Pearce, John B. 1974.

Invertebrates of the Hudson River estuary. Ann. N.Y. Acad. Sci. 250: 137-143.

Shellfish that remain, largely beds of hard clam, *Mercenaria mercenaria*, are unsuitable for human consumption because they are contaminated by human wastes. Similar conditions prevail in Jamaica Bay, New York, the Navesink and Shrewsbury Rivers of New Jersey. Hard clams are still found in certain parts of Raritan Bay, but the Bay is closed to harvesting shellfish. - J.L.M.

1449
Pearse, A. S. 1928.

On the ability of certain marine invertebrates to live in diluted sea water. Biol. Bull. 54: 405-409.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1450
Pearse, A. S. 1936.

Estuarine animals at Beaufort, North Carolina. J. Elisha Mitchell Sci. Soc. 52(2): 174-222.

Venus m. mercenaria and *V. c. campechiensis* were found at Piver's Island, Beaufort, N.C. *Venus ziczac* also was taken. *V. mercenaria* (20 clams used in experiment) was alive and in good condition after 114 hrs in fresh water, 102 to 120 hrs in mixtures of fresh and seawater, and 120 hrs in seawater. Exposed to desiccation in air in summer *V. mercenaria* lived an average of 255.8 hrs and a max of 310.1 hrs. The most resistant animals of a number of invertebrate species to these treatments were those, like *Littorina*, accustomed to spend much time out of water, and those, like *Venus*, with heavy protective shells. (Abstracter's note: *V. campechiensis* was not included in these experiments. According to the literature the southern quahog does not survive well exposed to air. Thus, the generalization about heavy shells does not always apply.) - J.L.M. and M.W.S.

1451
Pearse, A. S. 1947.

Parasitic copepods from Beaufort, North Carolina. J. Elisha Mitchell Sci. Soc. 63(1): 1-16.

In 1946, 2,350 animals, including 445 mollusks, were examined for parasites. This paper reports on 30 copepod species found in 39 host species. *Myicola spinosa* n. sp. was found on gills and mantle of *Venus mercenaria* in May and June. - J.L.M.

1452
Pearse, A. S. 1949.

Observations on flatworms and nemerteans collected at Beaufort, N.C. Proc. U.S. Natl. Mus. 100(3255): 25-38.

Venus mercenaria was often infested with *Malacobdella grossa*, Order Bdellonemertea, Class Nemertea. On June 1, eight hosts yielded three; on June 17, nine hosts six (three in one host); and on July 25, five hosts one; an average of 0.45/host. - J.L.M.

1453
Pearse, A. S., H. J. Humm, and G. W. Wharton. 1942.

Ecology of sand beaches at Beaufort, N.C. Ecol. Monogr. 12(2): 135-190.

Venus mercenaria was quite common on mud and sand flats on Bird, Sheepshead, and Guthrie Shoals and also on the beach inside Fort Macon. The species is mentioned in several places in the text in connection with resistance to wave action, digging and depth of burrowing, length of siphons, feeding, predation by birds, and breeding, but these are general observations and not new contributions to knowledge. - J.L.M. and M.W.S.

1454
Penn, Edwin (Erwin ?) S. 1974.

Price spreads and cost analyses for finfish and shellfish products at different marketing levels. NOAA Tech. Rept. NMFS SSRF 676, 74 p.

The paper does not mention hard clam specifically, but the data and conclusions would apply generally to this species. The margin between selling and purchasing prices for each of 13 fishery products and the share of the consumer's dollar by each level and each cost component are calculated. Costs and profits are analyzed by each marketing function and major influences on margin differences are described. The study was made to provide a guide to fish firms to determine whether there was room for improvement in performance. - modified author's abstract - J.L.M.

1455
Percy, George. 1973.

A preliminary review of evidence for prehistoric Indian use of animals in northwest Florida. 25th Ann. Meeting, Fla. Anthrop. Soc., unpub. rep. distrib. at meeting, 51 p.

According to Cake (1977), abstracted elsewhere in this bibliography, Percy reported larval cestodes of the genus *Tylocephalum* in *Mercenaria (Venus) campechiensis* and *M. (Venus) mercenaria texana*. - J.L.M.

1456
Perkins, E. J. 1974.

The Biology of Estuaries and Coastal Waters. Academic Press Inc. (London) Ltd., ix + 678 p.

Mercenaria mercenaria is referred to occasionally throughout the work. The work deals primarily with British estuaries, but references are given frequently to other parts of the world. - J.L.M.

1457
Perkins, George H. 1869.

Molluscan fauna of New Haven. A critical review of all the marine, fresh-water, and land Mollusca of the region, with descriptions of many of the living animals and of two new species. Proc. Boston Soc. Nat. Hist. 13: Part II. Lamellibranchiata: 139-164.

Veneridae; *Crassivenus* nov. gen. *Crassivenus mercenaria* nobis. *Venus mercenaria* Linn., Syst. Nat., 1131; Lam., An. sans Vert., Vol. VI, p. 346; Gould, Invert. Mass., p. 85, fig. 67; De Kay, Moll. N.Y., p. 217, pl. xxvii, fig. 276. Common round clam. Occurs abundantly in sand just below low tide level. Animal with mantle open freely, except behind, where it is united to form two very short siphons, which are blackish, fringed at the ends, bright yellow inside; the mantle is thickened and ruffled at the edge, yellowish white; gills, two pairs, greenish white, oblong-ovate, somewhat pointed behind, hanging obliquely, inner a little larger; foot rather large, when contracted broad and short, strongly striated, somewhat crenulate on lower edge, which is sharp, broadest before and obtusely rounded behind, pointed bluntly, color buff yellow; palpi lanceolate, smooth without, striated within; muscles pink on inner side, white on outer, anterior pear-shaped, posterior ovate. Measurements: length of shell 77 mm, breadth 71 mm, height 54 mm; length of foot 37 mm, breadth 15 mm anteriorly; length of gills 28 and 29 mm, breadth 15 and 16.4 mm; length of palpi 12.6 mm, breadth 7 mm; length of siphon tube 14 mm, breadth 8 mm. As, according to British Association rules, no specific name can be made generic, those formerly given to this and the next species *(Totteniana gemma)* do not hold. I therefore propose the names here given. - verbatim quotation from original, except for slight changes in punctuation and abbreviations, where necessary to change format. - J.L.M.

1458
Perry, C. A. 1940.

Comments on Mr. Bidwell's paper: A review of bacteriological shellfish scoring. Conv. addresses, Natl. Shellf. Assn., 5 p., not numbered.

Bidwell concludes that coliform densities in sea water represent a "fair measure of pollution". The author believes that *E. coli* offers a sounder measure. His data show that a coliform score of 50 (MPN 2400) would allow about 1/4 of polluted hard clams to go to market. There is little doubt that crude coliform scores represent temperature effect and do not necessarily bear any relation to pollution. It might be concluded that a limiting score of 5 would be reasonable for hard clams in the low score period. A limiting score of 50 for shucked hard clams seems satisfactory. - J.L.M.

1459
Perry, Louise M., and Jeanne S. Schwengel. 1955.

Marine shells of the western coast of Florida. Paleontol. Research Inst., Ithaca, N.Y., 318 p.

Mercenaria lives on sandy bottoms buried beneath the surface with siphons extended upward into the water. *Natica, Polinices, Terebra, Conus, Nassarius, Cantharus,* and *Urosalpinx* move freely about, preying largely on these bivalves. *Busycon* and *Fasciolaria* are found wherever *Mercenaria campechiensis* is present. Phylum Mollusca, Class Pelecypoda, Order Teleodesmacea, Family Veneridae is the largest pelecypod family in numbers of genera and species, and of widest distribution in depth and range. They are native to all seas, and wherever man has found them he has used them for food and the shells for use and ornament. They are burrowers but do not dig deeply and move about freely with a flattened tongue-shaped foot. *Mercenaria campechiensis* (Gmelin) [*Venus campechiensis* Gmelin]: Alt 100 mm, length 110 mm, is size of average adult shell, but some are much larger and heavier; shell grayish white, heavy, thick, solid and porcelanous; inequivalve; umbos far forward; strong external ligament; lunule and escutcheon well defined; margins rounded; sculpture of close lamellar concentric ridges; hinge margin thick, with strong cardinal teeth and a rugose area in each valve; interior smooth, white, often violet color at anterior and posterior margins; pallial sinus small, angular; inner margins crenulate. (Abstracter's note: this description sounds more like *M. mercenaria*, and the adult illustrated in plate 14, fig. 89 appears to have the smooth area in the middle of the outer surface of the valve, characteristic of the northern quahog.) - J.L.M.

1460
Pesch, Gerald. 1972.

Isozymes of lactate dehydrogenase in the hard clam, *Mercenaria mercenaria*. Comp. Biochem. Physiol. 43B(1): 33-38.

M. mercenaria samples were obtained from 4 localities from Prince Edward Island, Canada, to Wadmalaw Island, S.C. For comparison, *M. campechiensis* from Beaufort, N.C. and Tampa Bay, Fla., were examined. Lactate dehydrogenase occurred as isozymic patterns of 1 or 2 bands, with no phenotypic differences between sexes. The simplest genetic mechanism to explain the observed phenotypes is single-locus autosomal inheritance. Up to 7 different alleles may be found at this locus. Each band was equated with an allele. Homozygotes had one band, heterozygotes had 2. All Canadian clams were of a common phenotype composed of 2 bands. Presence of this double band in the entire population was explained either by duplication of the locus controlling structure of the enzyme, or by complete selection for heterozygotes. The other populations had a variety of single- and double-banded phenotypes showing that gene duplication had not occurred in these populations. The number of different lactate dehydrogenase bands showed a gradual increase from 2 in the Canadian population of *M. mercenaria* to 7 in the Fla. population of *M. campechiensis*. Observed and expected phenotypic frequencies fitted poorly. More double-banded patterns were observed than expected in 5 of the 6 populations, and in the other, from N.C., observed numbers were significantly less than expected. *M. mercenaria* closes its valves at temps below 4°C and is relatively inactive. The Canadian population undoubtedly experiences long periods of anaerobiosis in winter. The single phenotype with 2 bands probably represents an adaptive "optimum" for the rigorous northern environment, in which isozymes necessary for aerobic and anaerobic metabolism are necessary for survival. Florida and N.C. clams respire year-round. Continuous growth attests to their continuous respiration. Under such conditions various phenotypes, including homozygotes, survive well. Homozygotes are favored in the N.C. population, which came from the deepest water sampled (15 m), which probably has the narrowest range of temp fluctuation. Where shifts from aerobic to long periods of anaerobic metabolism are not necessary, it probably is more efficient metabolically to have only one form of lactate dehydrogenase. Logically, selection favoring homozygotes should lead to predominance of a single allele best suited to that environment. Although homozygotes were most frequent in the N.C. population, they were not exclusive. It is suggested that genetic variability is maintained in that area by transport of larvae of varied genetic background into the Beaufort area. - J.L.M.

1461
Pesch, Gerald George. 1972.

Protein polymorphisms and population genetics of the hard clam, *Mercenaria mercenaria* (L.). Ph.D. Thesis, Univ. Rhode Island, 59 p.

Four populations of *M. mercenaria* were sampled, from the Bideford River, P.E.I., Canada, Boothbay Harbor, Maine, Narragansett Bay, R.I., and Wadmalaw Island, S.C. Samples of *M. campechiensis* from Beaufort, N.C. and Tampa Bay, Fla. were obtained for comparison. Electropherograms of tissue proteins were assayed with medium specific for lactate dehydrogenase, NAD-malate dehydrogenase, and 2 enzymes of unknown substrate, tetrazolium oxidase and an esterase. From phenotypic differences in these enzymes it was inferred that genetic differences existed at the loci controlling their primary structure. Three of the 4 enzymes were polymorphic, with an average of 3.5 alleles per locus for 4 loci in *M. campechiensis* and 2.6 alleles per locus for 4 loci in *M. mercenaria*. Selection favoring heterozygotes was found at the lactate dehydrogenase locus, particularly in the Canadian sample. Heterozygotes have 2 forms of lactate dehydrogenase. This presumably aids metabolism in an environment requiring alternating aerobic and anaerobic metabolism. - modified from Dissert. Abstr. Internatl. 33(2), 1972: 840B. - J.L.M.

1462
Pesch, Gerald. 1974.

Protein polymorphisms in the hard clams *Mercenaria mercenaria* and *Mercenaria campechiensis*. Biol. Bull. 146(3): 393-403.

The northern hard clam is intertidal and in shallow waters from the Gulf of St. Lawrence to the Gulf of Mexico. The southern species ranges from N.J. to the Gulf of Mexico and West Indies. It is found offshore in the northern half of its range, and offshore and inshore to the south. Adults of both species are non-mobile and long-lived (up to 20 yrs). They lie slightly buried in sandy or muddy bottoms. During larval life they may be dispersed widely by currents. Ample opportunity exists for genetic exchange between adjacent populations. Electrophoretic mobility of an enzyme is determined by its primary structure. Enzyme variants detected by electrophoresis are equated with alleles at the locus controlling the primary structure of that enzyme. With this technique, phenotypic differences reflect genotypic differences at single loci. Such techniques were used to answer the questions: 1) how much variation exists within the gene pool of northern and southern hard clam populations? 2) what genetic differences exist among widely separated populations of the 2 species? and 3) does the gene pool of the northern species differ greatly from that of its southern congener? *M. mercenaria* was sampled in the Bideford River, P.E.I., Canada; Boothbay Harbor, Me; Narragansett Bay, R.I; and Wadmalaw Island, S.C. The southern species was taken at Beaufort, N.C. and Tampa Bay, Fla. Electrophoretic patterns were obtained for enzymes in gill, mantle, muscle, and whole animal homogenates. Three enzymes were polymorphic in all 6 populations. An average of 2.6 alleles/locus was found in 4 populations of *M. mercenaria*, 3.5 alleles/locus for 2 populations of *M. campechiensis*. Malate dehydrogenase-NAD form had a single allele which predominated in all populations. A 2nd rare allele appeared in the Me. and S.C. populations of northern clam. Polymorphism was pronounced at an esterase locus, but no regular shift was seen with latitude. North to south clines were observed at tetrazolium oxidase and lactate dehydrogenase loci. Different patterns observed for each locus suggested a complex of selective processes probably of differing adaptive significance. In a portion of the gene pools the 2 species had many alleles in common (12 of 16). Commonality of alleles, homology of chromosomes, ease of hybridization, and intergrades in the field suggested that these species have not yet reached reproductive isolation. (Abstracter's note: one possibility not recognized in this study was the influence of frequent and uncontrolled introductions of hard clam from one locality to another. In some areas such introductions have been made for a long time, either deliberately, in the common practice of bringing in spawners from colder waters on the assumption that this will increase the chances of obtaining a successful set, or inadvertently, mixed with oyster transplants. The potential effects of such activities, which have not been inconsiderable, should be recognized and examined.) - modified author's summary - J.L.M.

1463
Petch, T. 1907.

The marine fauna of the Humber district and the Holderness coast. Trans. Hull Sci. Field Nat. Club 3: 40.

According to Heppell (1961) Petch observed that live quahogs were being taken in the Humber estuary by the Cleethorpes oyster dredgers. The colony originated from accidental introduction with American oysters. - J.L.M.

1464
Petersen, C. G. Joh. 1918.

The sea bottom and its production of fish food. A survey of the work done in connection with valuation of the Danish waters from 1883-1917. Rept. Danish Biol. Sta. 25, 82 p.

The *Venus* community and other communities are described and discussed. - J.L.M.

1465
Pfitzenmeyer, Hayes T. 1972.

Molluscs of the Chesapeake Bay. In Biota of the Chesapeake Bay. Andrew J. McErlean, Catherine Kerby and Marvin L. Wass (eds.). Chesapeake Sci. 13 (Suppl.): S107-S115.

Most Bay research on mollusks has centered on American oyster, soft clam, and *Mercenaria mercenaria*. Hard clam is limited in distribution to high salinity areas of the lower Bay, but extends into Maryland waters with populations dense enough to support a modest commercial fishery. Biology of hard clam has received less attention than that of the other 2 major commercial species. Information on growth and survival, economic importance, and general biology is contained in other papers abstracted in this bibliography. The center of the hard clam industry is not in the Bay itself, but in the Chincoteague Bay area of Virginia and Maryland on the seaside of the Eastern Shore. - J.L.M.

1466
Pfitzenmeyer, H. T. 1972.

Tentative outline for inventory of molluscs: *Mya arenaria* (soft-shell clam). In Biota of the Chesapeake Bay. Andrew J. McErlean, Catherine Kerby and Marvin L. Wass (eds.). Chesapeake Sci. 13 (suppl.): S182-S184.

The outline applies generally to all mollusks, and could be useful as an outline for a synopsis of knowledge of *Mercenaria mercenaria*. Major headings are: Description of Species, which includes taxonomic, distributional, and life history information; and Ecological Information, including habitat, feeding, predation, fisheries, and influence of toxic substances. - J.L.M.

1467
Phelps, Donald K. 1964.

Distribution of benthic invertebrates in relationship to the environment of Charlestown Pond. Univ. R.I., Narragansett Marine Lab., Rept. 64-3: 18-54. Portions of a Doctoral Dissertation. Functional relationships of benthos in a coastal lagoon. Univ. R.I. Library (As received, this was the cover page, numbered 18, of a xerox copy). Next page is page 1, entitled: Progress Report - Environmental relationships of benthos in salt ponds, covering the period January 1, 1962 to October 1, 1964. H. Perry Jeffries, Coordinator. Grad. School Oceanogr., Univ. R.I., Kingston, Ref. 64-3, October 15, 1964: 19-54.

The only specific reference to hard clam *(Mercenaria mercenaria)* is the statement that an understanding of why certain salt ponds gain and lose climax communities of commercially important forms, and why some are continuously producing oysters, quahaugs, or scallops must be preceded by an awareness of overall conditions. To recognize that the pond is a functioning system, and that all of its parts are interdependent, is to recognize that this system works toward an immutable succession, the ultimate resolution of which is its transition from a marine to a terrestrial environment. Through intelligent manipulation a climax community of oysters, clams, quahaugs, or scallops could be encouraged or preserved. Conclusions re management were: 1) in sediments finer than sand there is a complete lack of structural stability over time; 2) in very fine sands diversity is high, redundancy low, and stability is characteristic of faunal and sediment populations - here a population would not reach commercial density; 3) in medium fine sands climax communities produce great abundance, and commercially important species could be reared for economic exploitation. Charlestown Pond is not a good place for planktonic larval stages, but it is a good growing area for postlarval bivalves. - J.L.M.

1468
Phillips, F. X. 1971.

The ecology of the benthic macroinvertebrates of Barnegat Bay, N.J. Ph.D. thesis, Rutgers Univ., New Brunswick, N.J., 178 p.

Major taxa in samples included bivalves. Observed distribution was irregular. Several of the more common species were associated with specific substrates, others were more widespread. - modified from Dissert. Abstr. Internatl. 32(9), 1972: 5148B; species were not mentioned in the abstract. - J.L.M.

1469
Phillips, Ronald C. 1960.

Observations on the ecology and distribution of the Florida seagrasses. Fla. State Bd. Conserv., Mar. Lab., St. Petersburg, Prof. Pap. 2, 72 p.

Mercenaria mercenaria and other biota are not discussed. - J.L.M.

1470
Philpott, D. E., Margit Kahlbrock, and A. G. Szent-Gyorgyi. 1960.

Filamentous organization of molluscan muscles. J. Ultrastruct. Res. 3: 254-269.

Adductor muscles (or anterior byssus retractor of *Mytilus edulis*) of 7 bivalve species were made to relax by adding magnesium sulphate to the seawater. It is interesting that this method did not work with *Mercenaria mercenaria*. Examination was made on fixed and stained material. Two types of filamentous structure were found: thick filaments with diameters 250 to 1500 A, and thin filaments with diameters about 50 A. Thick filaments had the 145 A periodicity characteristic of paramyosin. It is proposed that thick filaments of quahog are mostly paramyosin, thin filaments actomyosin. The two types of filament were found in tinted and white adductor muscle of *Mercenaria*. It is reasonable to assign the contractile properties of "catch muscle" to its actomyosin content. (Abstracter's note: some of the 27 literature citations are abstracted elsewhere in this bibliography. They were located from other references. We made no attempt to locate and read others because titles are not given). - J.L.M.

1471
Pierce, Madelene E. 1950.

Venus mercenaria. In Selected Invertebrate Types. Frank A. Brown, Jr. (ed). John Wiley and Sons, Inc., New York: 324-334.

This is a valuable guide to the anatomy and functional morphology of hard clam. It leads the student to detailed structure of the shell, muscle attachments, mantle, visceral mass and foot, respiratory system, circulatory system, excretory system, digestive system, and reproductive system. Details are illustrated with clear labelled diagrams. (Abstracters' note: the chapter on certain sponges (Cliona, Halichondria, Chalina) by W. D. Burbanck (p. 78 ff) mentions that clam shells, particularly *Venus*, are often completely riddled by the boring sponge *Cliona*.) - J.L.M. and M.W.S.

1472
Pietsch, Helen G., and Reuben M. Cares. 1964.

Histologic technique for larvae of bivalve molluscs. Turtox News 42(9): 234-235.

Describes a technique for paraffin embedding, microtome sectioning, and staining of lamellibranch larvae for studying infectious bacterial necrosis in hard clam and other species. Refers to a paper on the pathogen by Tubiash and Chanley (1963), abstracted elsewhere in this bibliography, and a manuscript by Cares and Tubiash on histopathology of bacillary necrosis of larval *M. mercenaria*, to be published in a journal not identified. We have been unable to locate this second paper. - J.L.M.

1473
Pilgrim, R. L. C. 1954.

The action of acetylcholine on the hearts of lamellibranch molluscs. J. Physiol. 125(1): 208-214.

Some mechanism exists, intimately linked with the rhythmically contractile system of the lamellibranch ventricle, which is influenced by acetylcholine (ACh). Results to date did not show overall behavioral patterns, and no attempt apparently had been made to draw them together. The author reports results of studies on 8 New Zealand lamellibranchs, with data on *Venus mercenaria* and *Gryphaea angulata* for comparison. Effective concentration of the drug in producing reduction in amplitude or systolic arrest or reduced frequency varied between species. *Dosinia* and *Amphidesma* were comparable to *Venus* in their high sensitivity, and should be equally suitable for bioassay. - J.L.M.

1474
Pluhowski, Edward J. 1970.

Urbanization and its effect on the temperature of the streams on Long Island, New York. U.S. Geol. Surv., Prof. Pap. 627-D: 1-60.

Human modifications of the natural environment have increased average stream temp in summer by as much as 5° to 8°C. Winter stream temp in man-affected reaches of the streams averaged about 1.5° to 3°C lower than in unaffected reaches. *Mercenaria mercenaria* is not mentioned, but it is possible that these alterations might affect the ecology of coastal bays into which these streams empty, and in some of which *M. mercenaria* is abundant. - J.L.M. and M.W.S.

1475
Poillon, C., and L. Clarke. 1965.

Report on critical needs of the commercial fishing industry of Long Island, New York. L.I. Fisherman's (sic) Assn., Atl. Process. Co., Westhampton Beach, N.Y. (unpub).

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Experiments to re-establish historical oyster seed grounds and to control the southern oyster drill. La. Wild Life Fish. Comm., Tech. Bull. 6, 82 p.

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1477
Poole, J. C. 1975.

Notes on investigations pertaining to molluscan shellfish. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 28-31.

The paper describes pond culture of oyster seed, studies of *Cladophora* to investigate the possibility of controlling blooms, studies relating to control of *Codium*, activities related to surf-clam management, and management of bay scallop resources. *Mercenaria mercenaria* is not mentioned, but control of algae might have benefits for the hard clam industry. - J.L.M.

1478
Porter, Hugh J. 1964.

Incidence of *Malacobdella* in *Mercenaria campechiensis* off Beaufort Inlet, North Carolina. Proc. Natl Shellf. Assn. 53: 133-145.

The nemertean, *Malacobdella grossa*, has been found in the mantle cavity of several bivalve species, including *Mercenaria mercenaria*, in Europe and North America. The nemertean was found in 83.3% of *M. campechiensis* from commercial beds on the ocean side of the barrier islands on both sides of Beaufort Inlet. Incidence was the same in both sexes. Incidence varied from 26 to 100% in individual samples. Most clams had only one worm. The number of clams with 2 or more was greatest in summer, least in winter. Usually, when more than one worm was present each was small or medium-sized. The highly variable frequencies of occurrence are attributed to seasonal, annual and local differences. Some workers had believed that when more than one *Malacobdella* was present in a clam, the largest would kill the smaller, so that eventually only one large animal would remain. Experiments did not confirm that such attacks occur. Recruitment of a new year class of worms begins in Feb or Mar, continues through summer and fall, but does not occur after Oct. *Malacobdella* an inquiline commensal, does not appear to harm the host. - J.L.M.

1479
Porter, H. J. 1967.

Seasonal gonadal changes of adult clams, *Mercenaria mercenaria* (L.), in North Carolina. Proc. Natl. Shellf. Assn. 55: 35-52.

Major spawning was in June when water temp rose above 20°C, was followed by light spawning, and a minor peak in Sept-Oct. Spawning was followed by rebuilding of follicles. Most unspawned ovocytes were gradually lost in the period Dec-early March. Major build-up of follicles occurred in March, and by April-May many mature ovocytes and spermatozoa were present. - J.L.M.

1480
Porter, Hugh J. 1972.

Recent advances in clam aquaculture. Bull. Am. Malacol. Un., Inc.: 16-17.

Larval culture in North Carolina consisted of placing about 140,000 larvae in plastic dishpans in a dark, temperature-controlled room without changing the water or adding antibiotics. Food was mass cultures of *Nannochloris*. About 50% of larvae survived to setting. In Virginia, larvae were raised in a greenhouse in pails at initial concentrations of 1 million larvae/50 l which is reduced to 200,000/50 l by setting time. Clarified water rich in natural phytoplankton was used for food. Experiments are being performed to determine the value of various species of alga as food for juvenile clams. Use of heat from generators to stimulate growth of phytoplankton and clams, was precluded by use of toxins to clean discharge pipes. Juvenile clams have been reared in outdoor troughs with running seawater. A sand substrate in the troughs increased growth fourfold. Clams grew to a size of 1.7-3.0 mm in 2 months and 10 mm in 4 months. An area protected from wind with a slow current was covered with an aggregate of oyster shells or stone several inches deep to protect seed clams (1.7-3.0 mm) from predators. Clams planted at densities of 25/ft^2 had survival ranging from 35-95%, but in areas without aggregate survival was less than 16%. Hydraulic dredging harvested clams and replaced the aggregate. - D.L.

1481
Porter, Hugh J. 1974.

The North Carolina marine and estuarine Mollusca, an atlas of occurrence. Univ. N.C., Inst. Mar. Sci., vi + 351 p.

Class Pelecypoda = Bivalvia, Order Veneroida, Family Veneridae, *Mercenaria campechiensis, M. c. subcampechiensis, Mercenaria mercenaria,* and *M. m. notata,* together with synonyms are listed on p. 80 and 81. - J.L.M.

1482
Porter, H. J., and A. F. Chestnut. 1962.

The offshore clam fishery of North Carolina. Proc. Natl. Shellf. Assn. 51: 67-73.

Mercenaria campechiensis generally has a larger, thicker, and rougher shell than *M. mercenaria* without a smooth central area on the outside. Its lunule is usually the same length and width. The shell interior is white without the purple markings found on *M. mercenaria.* The teeth on the inner margin are finer, the posterior angle of the pallial sinus is more acute, and the meat generally darker than *M. mercenaria.* The range of *M. campechiensis* is from Chesapeake Bay to Cuba and Mexico. Little mixing between the northern and southern species was observed in North Carolina. A commercial offshore dredge fishery has developed in North Carolina in 1960, but it can only operate in colder weather due to the large number of clams that spoil before processing. Active fishing by 12 boats from January to March 1960 yielded a total catch of about 1.2 million lbs, or 4,831 lbs/boat/day. The principal clam bed fishery lies between Cape Lookout and Beaufort Inlet in 30 to 40 feet of water. Dredging records show a density of one clam/40 to 60 square feet. Clams were mostly 3.5 to 4 inches long. - J.L.M.

1483
Porter, Hugh J., and Jim Tyler. 1971.

Sea shells common to North Carolina. N.C. Dept. Nat. Econ. Resources, Div. Marine Fish., Inf. Ser., 2nd printing 1972, 3rd 1974, 4th 1976, reprinted by Univ. N.C. Sea Grant Coll. Progr. and N.C. Dept. Admin. Off. Mar. Affairs, UNC-SG-72-09, 36 p.

Mercenaria mercenaria: concentric sculpture of fine ridges, shell not a flat disk. Length 4 1/2 in; range Canada-Texas; lower edge of shell toothed, exterior central area smooth, interior frequently with some purple; heavy shell. Common, beaches and sounds and mouths of estuaries near ocean. Basis of large commercial fishery in N.C. waters; large marine farming potential. *M. campechiensis:* length 4 3/4 in; range Virginia to Texas; closely related to *M. mercenaria.* Exterior central area of shell not smooth but sharply ridged; interior all white. Common, offshore beaches; living 40 to 50 ft depth offshore near inlets; bed between Cape Lookout and Beaufort Inlet once was fished commercially. Appears to hybridize with *M. mercenaria* in N.C. inlets; hybrids may reach 6 in long. Included is *Pitar morrhuana,* morrhua venus, 1 1/2 in long, which looks like a small quahog and is sometimes confused with hard clam. Lower edge of shell is not toothed (crenulate); shell thin and fat; dull gray; common on offshore beaches in N.C; range Canada to N.C. - J.L.M.

1484
Pottinger, S. R., and W. H. Baldwin. 1946.

The content of certain amino acids in seafoods. Comm. Fish. Rev. 8(8): 5-9.

Could not locate. Search terminated. - J.L.M.

1485
Prakash, A., J. C. Medcof, and A. D. Tennant. 1971.

Paralytic shellfish poisoning in Eastern Canada. Bull. Fish. Res. Bd. Canada 177, 87 p.

Outbreaks of paralytic shellfish poisoning are common in eastern Canada. Over 200 illnesses and 23 deaths have been reported since 1880. Affected areas are middle and lower reaches of Bay of Fundy and lower estuary of St. Lawrence River. Poisonings occur mainly in summer and are associated with abundance of the dinoflagellate *Gonyaulax tamarensis*. Soft clams and blue mussels have accounted for about 90% of the cases, but 14 shellfish species have shown toxicity, including *Mercenaria (Venus) mercenaria*. Hard clam has not been implicated in poisonings and is not rated as a paralytic shellfish poisoning hazard. The report brings together all pertinent information then available on the subject and includes an extensive reference list. - J.L.M.

1486
Pratt, David M. 1953.

Abundance and growth of *Venus mercenaria* and *Callocardia morrhuana* in relation to the character of bottom sediments. Sears Found., J. Mar. Res. 12(1): 60-74.

A survey of Narragansett Bay showed that hard clams were most abundant in mud bottoms, but this was related to the presence of large particles such as shell and rock as minor constituents. Since current velocity is related to sediment particle size, it was thought that current velocity determined abundance of clams. Clams were planted in the bottom of the bay in adjacent boxes containing sand or sandy-mud. Clams living in sand grew 24% faster than clams in an adjacent box of sandy-mud. - D.L.

1487
Pratt, D. M. 1974.

Attraction to prey and stimulus to attack in the predatory gastropod *Urosalpinx cinerea*. Mar. Biol. 27(1): 37-45.

In running water *Mercenaria mercenaria* was not very attractive to *Urosalpinx*. Of 9 species tested, 6 were considerably more attractive. In standing water more drills were attracted to *M. mercenaria* than to any other experimental animal, although more holes were drilled in 3 other species. Effluents from living prey, as well as tactile stimuli, are important stimuli to predators. - J.L.M.

1488
Pratt, D. M., and Donald A. Campbell. 1955.

Benthonic productivity project, summary. Ref. No. 55-10, ONR, Biol. Branch.

List only.

1489
Pratt, D. M., and D. Campbell. 1956.

Environmental factors affecting growth in *Venus mercenaria*. Limnol. Oceanogr. 1(1): 2-17.

Growth of hard clam in Narragansett Bay, expressed as shell length increments, was inversely related to initial length. Different parts of the bay showed up to threefold variations in growth during a year. Growth varied little from year to year at the same location. Most growth occurred before mid-July. Growth in Narragansett Bay was greater than at Prince Edward Island and comparable to growth reported in New Jersey and Cape Cod's south side. Differences in current velocity, dissolved oxygen and salinity had little effect on growth. Growth was negligible below 10°C and increased with rising temperature to 23°C.

Growth was correlated with diatom abundance. Growth was slower in sediments of high silt-clay content than in sediment with low silt-clay. Silt-clay inhibits growth possibly by interfering with feeding by reducing sediment permeability, producing growth inhibitory substances or requiring energy expenditure to clear filtering apparatus. - D.L.

1490
Pratt, Henry Sherring. 1935.

A manual of the common invertebrate animals exclusive of insects (2nd ed). P. Blakiston's Son & Co., Inc., Philadelphia, xviii+854 p.

Phylum Mollusca, Class Pelecypoda (Lamellibranchiata), Order Teleodesmacea, Family Veneridae: *Venus mercenaria* L. Mollusca: bilaterally symmetrical, unsegmented animals in which the body is usually encased in a calcareous shell, and is made up of 4 parts, visceral mass, head, mantle and foot. Pelecypoda: Symmetrical mollusks with a double or bivalve shell and mantle, and without a head. Teleodesmacea: gills reticulate, right and left lobes of mantle more or less connected on ventral and hinder margins, siphons usually well developed, 2 adductors about equal in size, shell porcellaneous or obscurely prismatic, never nacreous, ligament behind umbo, hinge teeth separated into distinct cardinals and laterals, usually with a hinge plate and a pallial sinus, sexes usually separate, many families. Veneridae: shell regular, heavy; ligament external; hinge usually with 3 diverging teeth in each valve; laterals not constant; pallial sinus usually small; mantle open below; several hundred species, in all seas, in tropics often very brightly colored. *Venus:* shell thick and round or ovate, inner lower margin minutely crenulated; cardinal teeth 3 in each valve; laterals absent; lunule distinct; ligament prominent; siphons short, unequal, and more or less separated; mantle margins fringed; numerous species, in all seas. *V. mercenaria* L. - hard-shell clam, little-neck clam, quahog. Shell ovate or heart-shaped; anterior end short; posterior end rounded; umbo directed forwards; surface a dirty white, with prominent, sharp, concentric ridges; inner surface smooth, dull white, lower margin violet or purple; length 11 cm; width 6 cm; height 9 cm. Gulf of St. Lawrence to Texas, on sandy and muddy bottoms in shallow water; very common south of Cape Cod; used extensively for food; shells were used by Indians for manufacture of wampum, the violet portion forming the most valuable pieces. - J.L.M.

1491
Pratt, S. D. 1973.

Benthic fauna. In Coastal and Offshore Environmental Inventory - Cape Hatteras to Nantucket Shoals. Univ. R.I., Grad. School Oceanogr., Mar. Expt. Sta., Kingston, Mar. Pub. Ser. 2: 5-1 to 5-70.

Since the decline of oyster stocks in Great South Bay and Moriches Bay, Long Island, N.Y., *Mercenaria mercenaria* and *Mytilus edulis* make up a large part of wet-weight biomass in sandy and transitional sediments. *M. mercenaria* can tolerate freezing, but succumbs at -6°C. At any temp hard clam dies when 64% of its tissue water has been removed as ice. It is sometimes infested by the polychaete *Polydora*. *Busycon carica* and *B. canaliculatum* are voracious predators on hard clam and other bivalves. Infrequent references to hard clam in this chapter are cited from published papers abstracted elsewhere in this bibliography. - J.L.M.

1492
Prescott, Benjamin, and George Caldes. 1967.

Chemical studies of an antitumor substance from clams. Fed. Proc. 26(2): 314 (abstract 336).

The antitumor principle of clam liver extract (species not named, but presumably *Mercenaria mercenaria*) is a greenish to white amorphous powder, non-dialyzable, forming a colloidal solution in water. Activity is destroyed when solutions are heated to 70° or higher (presumably C) for 30 min. Antitumor activity of aqueous solutions is not destroyed at pH 8.0.

Isoelectric point is at pH 4.1. It is precipitated by the usual protein-precipitating agents such as trichloracetic acid, ammonium sulphate, alcohol, and sulphosalicylic acid. Average value of elements was: N 12%, P 0.25%, S 1.6%, C 42.5%, and H 7%. Hydrolysate contained 18 amino acids. - J.L.M.

1493
Prescott, B., and C. P. Li. 1966.

Antimicrobial agents from sea food. Malacologia 5(1): 45-46.

An antibacterial and an antiviral substance termed paolin 1 and paolin 2 respectively have been isolated from *Mercenaria mercenaria*. Paolin means abalone extract in Chinese. The paolins seem to be relatively non-toxic in a limited number of animal experiments. Antibacterial activity was tested against *Staphylococcus aureus*, *Streptococcus pyogenes*, and *Salmonella typhi*. Gram positive and gram negative organisms were inhibited by 20 μg/ml of paolin 1. Paolin 2 inhibited the early phase of multiplication of poliovirus, influenza B virus, or herpes simplex virus in tissue culture, reducing the virus yield by more than 90%. - J.L.M.

1494
Prescott, B., C. P. Li, E. C. Martino, and G. Caldes. 1964.

Isolation and characterization of antiviral substance from marine animals. Federation Proc. 23: 508 (abstract 2441).

Antiviral substance has been extracted from *Venus mercenaria* and 5 other marine mollusks. Acetic acid extract of oysters had antiviral activity. The same extract purified by fractional precipitation with various concentrations of alcohol also reduced viral activity in mice. The product was a white powder, water soluble, heat stable, resistant to digestion by pepsin and trypsin, and precipitated by all protein precipitants. It has a sedimentation constant of 1.6 S and a molecular weight tentatively estimated at 30,000. No pyrimidines or purines were detected, and no significant quantity of P was present, showing that antiviral activity is not caused by any adhering nucleic acid. - J.L.M.

1495
Prescott, B., M. L. King, G. Caldes, C. P. Li, and A. M. Young. 1974.

Characterization of an antitumor substance from clam *(Mercenaria mercenaria)* liver. Internatl. J. Clin. Pharmacol. Ther. Toxicol. 9(1): 1-5.

Schmeer (1964), abstracted elsewhere in this bibliography, was the first to show that a substance which she named mercenene, extracted from *Mercenaria mercenaria*, could prevent development of tumors in mice. Antimicrobial substances isolated from mollusks had been designated as paolins. Paolin I was the antibacterial fraction, Paolin II the antiviral component. The study reported here found that the antitumor substance may consist of polypeptides, carbohydrates and unidentified components which may be the active principle. It is suggested that the active material includes several distinct components. If the unknown component is the active principle, the protein molecules combined with an unidentified prosthetic group may be a carrier or an inhibitor so that conversion of bound active material to the free form is necessary for greater antitumor activity. The greater activity of some batches may have been caused by splitting-off of active component from the protein carrier during fractionation, or by removal of inhibitors. (Abstracter's note: our records show that Schmeer published a paper in 1963 which referred to antitumor properties of hard clam extract.) - J.L.M.

1496

Price, D. A., and M. J. Greenberg. 1975.

Isolation of a cardioexcitatory oligopeptide from molluscan ganglia. Fed. Proc. 34: 776 (abstract 3154).

Extracts of molluscan ganglia, including those of *Mercenaria mercenaria*, contain a substance that increases amplitude of molluscan heart beat or induces rhythmicity. The authors conclude from various experiments that the active substance is an oligopeptide (ca 500 MW) containing at least an arginyl and a phenylalanyl residue. - J.L.M.

1497

Price, David A., and Michael J. Greenberg. 1977.

Structure of a molluscan cardioexcitatory neuropeptide. Science 197(4304): 670-671.

Neurohumors characteristic of mollusks are acetylcholine, 5-hydroxytryptamine, and dopamine. Other substances in aqueous extracts of molluscan ganglia have cardioexcitatory activity. These can be separated chromatographically, but so far are unidentified. One, up to now called peak C, is of particular interest because it not only can augment the contractile force of molluscan cardiac muscle and induce prolonged contractions of other muscles, but also can restore regular beating of arrhythmic hearts or induce beating in quiescent hearts. Peak C has been found in all major classes of mollusk, concentrated particularly in nervous tissue. Using heart preparations of *Mercenaria mercenaria* and radula protractor of *Busycon* as parallel bioassay systems, the authors isolated peak C from ganglion extracts of *Macrocallista nimbosa* and purified the extract. Peak C was identified as a tetrapeptide amide having the sequence: Phe-Met-Arg-Phe-NH_2 (Phe=phenylalanine; Met=methionine; Arg=arginine). This appeared to be the correct sequence of 4 possible structures. Another abbreviation, approved by the IUPAC-IUB Commission on Biochemical Nomenclature, is FMRFamide (F, M, and R are one-letter abbreviations for the amino acids Phe, Met, and Arg, and the designation FMRFamide conveys the amino acid sequence of the peptide and the fact that the carboxyl terminal is substituted with an amide group). Assuming that FMRFamide is a neurosecretory product, its physiological role in mollusks might be as a long-term regulator of muscular rhythmicity and tone. - J.L.M.

1498

Price, Kent S. 1978.

Advances in closed (recirculated) system mariculture. Rev. Biol. Trop. 26 (Suppl. 1): 23-43.

The long-range collective objective of Delaware's maricultural research is to produce successfully, on algal or prepared foods, or both, desirable, fast growing, palatable, nutritious oysters and clams, free of toxins and pathogens, in a controlled environment seawater system, at reasonable cost, unhampered by legal constraints, using natural sources of energy, and recycling organic wastes. Research began in September 1968. During the 7th year (1974-75) clams and oysters were grown to seed size in recirculating seawater systems, and clams *(Mercenaria mercenaria)* and oysters *(Crassostrea virginica)* were raised to edible market size, with growth about three times that of the fastest reported growth in Delaware Bay. Details of other investigations are given. Economic aspects and research needs still to be determined are listed and discussed. Outstanding progress during the past year (1975-76) and the strong interest expressed by industry in the closed system process, cause them to expect to enter into a cooperative industry-University pilot effort to demonstrate the commercial feasibility of closed system bivalve mollusk culture before the end of the 1978-79 grant year. - J.L.M.

1499
Price, K. S., M. R. Carriker, C. E. Epifanio, R. F. Srna, G. D. Pruder, E. T. Bolton, and K. P. Smith. 1976.

Mariculture in controlled environment seawater systems - A review of research at the University of Delaware (1968-75). FAO Tech. Conf. on Aquaculture, Kyoto, Japan, 26 May-2 June 1976. FAO Fish. Rept. 188: 89.

A progress report on research accomplished. The paper by Price (Advances in closed (recirculated) system mariculture - 1978) brings this up-to-date and includes new information. - J.L.M.

1500
Price, T. J. 1963.

Accumulation of radionuclides and the effects of radiation on molluscs. In Ann. Rept. Bu. Comm. Fish. Biol. Lab., Beaufort, N.C. for fiscal year ending June 30, 1961. U.S. Dept. Interior, Fish Wildl. Serv., Bu. Comm. Fish. Circ. 148: 31-32.

Mercenaria mercenaria concentrated radioactive cobalt 43 times over amounts in water in 47 days. Rate of loss of cobalt-60 was influenced by water temp. Shells concentrated iron-59 and cerium-144 to higher levels than did meats. Accumulation of cerium-144 was influenced by physical state of the isotope in seawater. Most radioactivity was associated with particles on body surfaces and their presence in organs and structures of the digestive system. - J.L.M.

1501
Price, Thomas J. 1964.

Accumulation of radionuclides and the effect of radiation on mollusks. In Ann. Rept. Bu. Comm. Fish. Biol. Lab., Beaufort, N.C. for fiscal year ending June 30, 1962. U.S. Dept. Interior, Fish Wildl. Serv., Bu. Comm. Fish. Circ. 184: 25.

Estuarine mollusks are extremely susceptible to contamination from radioactive material because they feed by filtering suspended matter from large volumes of water passing over their gills. *Mercenaria mercenaria* lost cerium-144 rapidly for the 1st 45 days, much more slowly thereafter. After 105 days, 20% of the original radioactivity remained. Uptake of gold-199 by clams and separated shells was rapid for the 1st 8 days, then diminished. At the end of the experiment clams contained 3.6 times the amount of activity found on shells. Clams in montmorillonite clay contained 38% less gold after 23 days than clams in radioactive seawater. Clams accumulated zinc-65 more slowly per unit weight than oysters. At 21 days the concentration factor in clams was 40.3, in oysters 336.6. At that time, maximum uptake of zinc-65 had not been reached. - J.L.M.

1502
Price, Thomas J. 1965.

Accumulation and retention of radionuclides and the effects of external radiation on mollusks. FWS Circ. 204: 10-14.

Tanks were prepared with 10 µg Zn/liter and 6 µg Zn_{65}, 100 µg Zn/liter and 60 µg Zn_{65}, and 500 µg Zn/liter and 300 µg of Zn_{65}. Uptake by *Mercenaria mercenaria* was rapid initially, then fell off. The apparent steady state of the radioactive content was reached much earlier in the tank with least concentration of Zn and Zn_{65}. Another series of tanks held the same amount of stable Zn but varied amounts of Zn_{65}, namely the same amounts as before, but with 14.5 µg/liter of Zn. The uptake was essentially the same. Retention was lost at roughly the same rate in all three groups, about half being lost in 32 days. Zinc retention at high and low temps varied considerably. At 8° to 10° there was an initial loss of over 50% in the first 3 days, then virtually none, even though the clams had extended siphons which indicated they were still active. At 21 to 25° loss was less rapid, but lasted for at least 45 days, and was 27% of the original. Clams were exposed to doses of radiation ranging from 186,656 to 5,833 roentgens. LD_{50} was reached in 5.5 days at the highest dose, 4.5 days at 163,324, 6.5 days at 139,992, 25.5 days at 116,600, and 38.5 days at 93,328. At 46,664 to 5,833 roentgens there was less than 50% mortality in 60 days. - J.L.M.

1503
Price, Thomas J. 1965.

Accumulation of radionuclides by marine invertebrates. In Ann. Rept. Bu. Comm. Fish. Radiobiol. Lab., Beaufort, N.C. for fiscal year ending June 30, 1964. U.S. Dept. Interior, Fish Wildl. Serv., Bu. Comm. Fish. Circ. 217: 16-18.

Mercenaria mercenaria was among several marine invertebrates exposed to radionuclides. Iodine-131 was accumulated rapidly at first, more slowly after 10 days. After 28 days radioactivity was 10 times as great in clams than in the surrounding water, and was still accumulating. Levels in oysters, scallops and mussels were 10 times to 2 1/2 times as great in the same period. Clams in a tank without substratum accumulated more radioactivity than clams in a substratum, probably because sediments adsorbed some radioisotopes. Hard clams were held in a zinc-65 solution for 5 days, then held in the natural environment or in a laboratory tank of running seawater. After 177 days larger clams in both experiments had retained more of the original activity than smaller clams. Retention was lower in laboratory tanks, probably because the clams were unable to burrow, and thus had more body surface exposed. More than one rate of retention of zinc-65 was observed. - J.L.M.

1504
Price, Thomas J. 1965.

Accumulation of radionuclides and the effects of radiation on molluscs. In Biological Problems in Water Pollution, Third Seminar, Cincinnati, 13-17 Aug. 1962. Envir. Health Ser., Water Supply and Poll. Contr., FS 2.300:WP-25: 202-210.

Accumulation and retention of cesium-137, cerium-144, zinc-65, and gold-199, and effects of radiation were followed on *Mercenaria mercenaria* and 2 other bivalves. Over 20 days, uptake of Cs-137 by hard clams was fairly constant, with little evidence of reaching a steady-state condition. Clams accumulated more isotope than oysters. Loss rates also were studied. After 28 days 12% of the isotope remained in hard clams. Ce-144 was taken up rapidly by clams, with a strong inflection point before 4 days and maximum level of accumulation after 20 days. Clam shells accumulated Ce-144 most rapidly and reached the highest maximum; meats accumulated much smaller amounts, and liquor least. Initial loss of Ce-144 was rapid during the 1st 45 days. After 195 days 20% of original activity remained. Clams accumulated much less Zn-65 than oysters. After about 22 days both species were still accumulating Zn-65 but at a lower rate. Accumulation of Au-199 by hard clam was rapid for 14 days, much slower thereafter. Live clams took up more activity than separated shells. Under irradiation with cobalt-60 at various dosage rates up to a maximum of 350,000 roentgens/hr, controls showed no mortality. LD_{50} rates for hard clam were: 186,656 r - 5.5 days; 163,324 r - 4.5 days; 139,992 r - 6.5 days; 116,600 r - 25.5 days; 93,328 r - 38.5 days; at lower rates, 50% mortality was not reached after 60 days. Accumulation of radionuclide was little affected whether the activity was in the ionic or particulate state. - J.L.M.

1505
Price, T. J., G. W. Thayer, and G. B. Montgomery. 1974.

Analysis of the invertebrates and sediments along shore-to-shore transects in the Newport River estuary. Atl. Estuar. Fish. Ctr., NMFS, Ann. Rept. to AEC: 183-198.

Mercenaria mercenaria was not taken in all transects. In density it ranged from 0.1 to 2.1 animals/m^2 where found. Ash-free dry weight ranged from 0.5 to 3.4 g/m^2. - J.L.M.

1506
Price, T. J., G. W. Thayer, M. W. LaCroix, and G. P. Montgomery. 1976.

The organic content of shells and soft tissues of selected estuarine gastropods and pelecypods. Proc. Natl. Shellf. Assn. 65: 26-31.

Mercenaria mercenaria from Cape Lookout, N.C. had 1.90%$\pm$0.18 ash-free dry weight for shell, 79.79%$\pm$4.32 for meats, and 26.81%$\pm$10.47 for pallial fluid. Total organic material in % was 38.60$\pm$3.83 for shell, 54.29$\pm$5.27 for meats, and 7.41$\pm$2.99 for pallial fluid. - J.L.M.

1507
Pringle, Benjamin H., Dale E. Hissong, Edward L. Katz, and Stefan T. Mulawka. 1968.

Trace metal accumulation by estuarine mollusks. J. Sanit. Eng. Div., Proc. Am. Soc. Civil Eng. Proced. Pap. 5970 (SA 3): 455-475.

Average trace metal levels in *M. mercenaria* from about 100 stations from Me. to N.C. in the natural environment were: Zn 20.6 ppm wet weight, Cu 2.6, Mn 5.8, Fe 30, Pb 0.52, Co 0.20, Ni 0.24, Cr 0.31, and Cd 0.19. In a simulated natural environmental system quahaugs accumulated Cu from an environmental level of 0.5 ppm at a rate of 0.06 g/kg/day and Pb from an environmental level of 0.2 ppm at 0.63 g/kg/day at water temperatures of 10° and 20°C respectively. Hard clams from Boston Harbor, at experimental temperatures ranging from 4 to 12°C, and over a depletion time of 84 days lost Cu at a rate of 0.05 g/kg/day, Mn at 0.095 g/kg/day, Zn at 0.12 g/kg/day, and Fe no depletion. Along the Atlantic coast in the natural environment Zn levels varied from about 10 to 40 ppm in hard clams, Cu from about 1-16 ppm, Mn from about 1-30, Fe from 9-83, Pb from 0.1-7.5, Cr from about 0.2-5.8, Ni 0.1-2.4, Co 0.1-0.2, and Cd about 0.1-0.7. Levels of Zn, Cu, and Cd were moderately to considerably higher in American oyster. It was concluded that: species differ in uptake and concentration of a given metal; uptake rates and concentration levels attained depend on the environmental concentration level; temperature, salinity, dissolved oxygen, and physiological condition all affect uptake rate and concentration; for Cd, Cu, Pb, and Zn the apparent toxicity determines uptake and concentration and the duration of the experiment. Hard clams deplete themselves of heavy metals at lower rates than soft clam. For any given metal and set of experimental conditions hard clams had the lowest uptake rates and concentrations among soft clam, American oyster, and hard clam. - J.L.M.

1508
Prosser, C. Ladd. 1940.

Acetylcholine and nervous inhibition in the heart of *Venus mercenaria*. Biol. Bull. 78(1): 92-102.

Venus mercenaria heart is extremely sensitive to acetylcholine (ACh). Atropine does not antagonize this inhibition. The preparation from *Venus* is so stable that it has some advantage over the commonly used leech muscle as a test material. Clam heart can be tested in situ, it can be mounted in a tube of seawater which can be replaced by test fluid, or heart can be mounted in a chamber through which test fluid is perfused. In situ the threshold is many times higher than by other methods. Normally a heart mounted in the morning retains high sensitivity through the day. Sensitivity is greatest if clams are freshly dug rather than held in running seawater or in a refrigerator. Sensitivity varies seasonally, highest in spring and low from late summer to early winter. Atropine is extremely toxic to *Venus* heart. In low concentrations it makes beat irregular and frequently stops beat. When non-toxic concentrations of atropine are used with or before ACh there is no consistent antagonism of ACh inhibition. Adrenaline increases frequency of the heart beat and tonus slightly. In high concentrations it may stop heart in systole. Nicotine acts much like ACh in reduction of amplitude and arrest in systole. Histological preparations show nerve endings but no nerve cells in *Venus* heart. ACh appears to leave the contracting mechanism intact and to act on the pacemaker and conducting mechanisms of this myogenic heart. Stimulation of visceral ganglion causes inhibition in diastole resembling the effect of ACh. Fluid from a clam heart inhibited by visceral ganglion stimulation often depresses beat of an eserinized test heart. Eserine prolongs inhibition caused by ACh or by nerve stimulation. ACh probably is liberated as the normal cardiac inhibitory agent in *Venus*. - J.L.M.

1509
Prosser, C. Ladd. 1942.

An analysis of the action of acetylcholine on hearts, particularly in arthropods. Biol. Bull. 83(2): 145-164.

Hearts of higher arthropods and some annelids and tunicates which are accelerated by acetylcholine (ACh) are neurogenic. Hearts of adult vertebrates, mollusks, and probably *Daphnia*, which are inhibited by ACh, are myogenic but innervated. Embryonic hearts of vertebrates, *Limulus*, and hearts of *Artemia* and *Eubranchipus* are unaffected by ACh and are probably non-innervated. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S. and J.L.M.

1510
Prosser, C. Ladd, and Hazel B. Prosser. 1937.

The action of acetylcholine and of inhibitory nerves upon the heart of *Venus*. Anat. Rec. 70(1), suppl. 1: 112.

The heart of *Venus* is extremely sensitive to acetylcholine (ACh). Sensitivity is greater early in summer than later. Threshold concentration in June is 1 in 10^{12}, in Sept 1 in 10^{9}. Action of ACh is mainly negatively intropic but rate of beat also slows slightly. Eserine increases sensitivity to ACh. Ventricles inhibited by ACh contract in response to mechanical stimulation, and conduction is not stopped. There is no localized pacemaker, the beat can start at any point on the surface of the ventricle. Stimulation of visceral ganglion inhibits heart as much as does ACh, but a much more marked fall in tonus is set up by nervous inhibition than by ACh. Reflex inhibition can be caused by stimulation of mantle and other regions. This natural inhibition is not increased nor is its threshold lowered by application of eserine or ACh to heart. But transfer of sea water from heart and pericardium of an inhibited preparation to a normally beating heart inhibits beat of the second heart. It is concluded that normal inhibition of clam heart is mediated by a substance similar to but not identical with ACh. - J.L.M.

1511
Prosser, C. L., R. A. Nystrom, and T. Nagai. 1965.

Electrical and mechanical activity in intestinal muscles of several invertebrate animals. Comp. Biochem. Physiol. 14: 53-70.

Sections of the hindgut of *Mercenaria (Venus) mercenaria* showed phasic (fast) contractions (0.25-2 sec contraction time) and tonic (slow) contractions (3-15 sec for contraction, 10-45 sec for half-relaxation). Strength-duration curves of the 2 responses intersect, so that brief pulses elicit phasic contractions, long pulses elicit tonic contractions. Similar experiments with other animals led to the conclusion that conduction in echinoderm intestine may be from muscle fiber to muscle fiber, as in vertebrate visceral smooth muscle, while conduction in molluscan and crustacean intestines appears to be by nerves. Intestinal muscle of bivalve mollusks has multiple innervation. - from authors' summary - J.L.M.

1512
Pruder, Gary D., Ellis T. Bolton, and Stuart F. Faunce. 1977.

System configuration and performance bivalve molluscan mariculture. College of Marine Studies, Univ. Delaware, Newark, Sea Grant Tech. Rept. DEL-SG-1-77, 21 p. (U.S. Dept. Commerce, Natl. Tech. Inf. Serv. PB-265 423.)

The report deals with oyster culture. Section headings include: 1) quantity of algae cleared by oysters; 2) recycle system configuration; 3) prototype system; and 4) mass outdoor cultivation of algae. - J.L.M.

1513
Pruder, Gary D., Ellis T. Bolton, and Paul H. Sammelwitz. 1976.

Controlled-environment bivalve molluscan mariculture. Coll. Mar. Stud., Univ. Del., Newark, DEL-SG-23-76, 14 p.

The closed-cycle controlled system was developed to experiment with commercially applicable methods for growing *Crassostrea virginica* and *Mercenaria mercenaria*. The report emphasizes accomplishments in designing, constructing and operating the laboratory; development and improvement of techniques; and results to date with oysters. No specific data are given on hard clam. Major remaining problems were: gaps in knowledge of mass algal culture, and rapid growth and premature spawning of oysters. - J.L.M.

1514
Pruder, Gary D., Ellis T. Bolton, Earl E. Greenhaugh, and Robert E. Baggaley. 1976.

Oyster growth and nutrient nitrogen cost in bivalve molluscan mariculture. Coll. Mar. Stud., Univ. Del., Sea Grant. Tech. Rept. DEL-SG-11-76: 3-20. (U.S. Dept. Commerce, Natl. Tech. Inf. Serv. PB-257 991.)

The Delaware Mariculture Project has the objective of developing an efficient, reliable, and economical process and hardware system to raise *Crassostrea virginica*, *Mercenaria mercenaria*, and other commercially desirable bivalves from egg to marketable size. Procedures and results are discussed under the following headings: 1) improved oyster growth rate; 2) reduction in make-up nutrient cost; and 3) application of foam fractionation. Potential to recycle and reduce cost of nitrogen, when the supply is obtained from commercially available chemicals, is made evident by the small percentage of N that is utilized by oysters. An 85 g oyster will yield 2.7 g dry tissue weight of which 10% or 0.27 g is nitrogen. The shell contains 1/2% organic material (0.35 g), of which 0.03 g is N. Intake is 380 g N/bu, of which 90 g N/bu is utilized, a conversion efficiency of 24%. With recycling, it is difficult to envision a nitrogen cost exceeding 10¢/bu. - J.L.M.

1515
Prusch, Robert D., and Carol Hall. 1978.

Diffusional water permeability in selected marine bivalves. Biol. Bull. 154(2): 292-301.

The water permeability of mantle tissue from several marine, and one fresh-water, species of mollusc, including *Mercenaria mercenaria*, was determined. Water permeability was generally correlated with habitat, permeability decreasing with increasing height above the sublittoral zone. The observed differences are not caused by a change in physical dimensions of tissue, but may be caused by changes in chemical composition. - authors' summary - J.L.M.

1516
Prytherch, Herbert F. 1937.

The cultivation of lamellibranch larvae. In: Culture Methods for Invertebrate Animals. Paul S. Galtsoff et al. (eds.). Dover Pubs., New York: 539-543.

A general discussion of culture methods. *Venus* is mentioned. - J.L.M.

1517
Pulley, Thomas E. 1952.

An illustrated check list of the marine mollusks of Texas. Tex. J. Sci. 4: 167-199, 13 pl.

This publication was not seen. - J.L.M.

1518
Pulley, Thomas E. 1953.

A zoogeographic study based on the bivalves of the Gulf of Mexico. Ph.D. dissertation, Harvard Univ. (abstract in Ann. Rept. Am. Malacol. Un., 1952: 2-3).

It is assumed that an abstract by the same author entitled: Distribution of mollusks in the Gulf of Mexico. Am. Malacol. Un. Ann. Rept. 1952 (1953), contains the gist of this dissertation. The abstract is summarized below. - J.L.M. and M.W.S.

1519
Pulley, Thomas E. 1953.

Distribution of mollusks in the Gulf of Mexico. Pacific Div. A.M.U.P., 5th Ann. Meeting. _In_ Am. Malacol. Un., Ann. Rept. 1952, 18th Ann. Meeting: 2-3.

Study of identity and ranges of 238 species and subspecies in shallow water in the Gulf of Mexico showed that most species were not scattered indiscriminately along the coastline, but were concentrated in a relatively few narrow regions of faunal transition. These zones are also zones of temperature transition, in which mean min winter temp or mean max summer temp changes by 8° to 12°F/100 miles. In regions of faunal uniformity, however, temp varies about 1°F/100 miles. Where temp change is about 4° to 5°F/100 miles, ranges of many species are terminated at scattered intermediate points between the more pronounced faunal and temp discontinuities on either side. The following faunal provinces were recognized: 1) Nova Scotian, south coast of Newfoundland to Cape Cod; 2) Virginian, Cape Cod to Cape Hatteras; 3) Carolinian, Cape Hatteras to Cape Canaveral; 4) South Florida, Cape Canaveral to Key West and Cape Romano; 5) Southwest Florida, Cape Romano to Anclote Keys; 6) Northeast Gulf, Anclote Keys to Mississippi River; 7) Northwest Gulf, Mississippi River to Matagorda Island; 8) Texas Transitional, Matagorda Island to Cabo Rojo; 9) Mexican, Cabo Rojo to Cabo Catoche; 10) West Indian, West Indies, Central and South America to Brazil; and 11) Offshore West Indian, 25 to 100 fathoms in Caribbean Sea and Gulf of Mexico. Range limits determined by temp north of Cape Hatteras must be caused by summer temps, south of Cape Hatteras by winter temps. Adults have upper and lower temp limits for survival, but for most species reproduction is limited to a narrower range. Where range limits are determined by summer temp, northern range limits are in localities where temp is not high enough for reproduction; southern range limits must be in regions too warm for adult survival. Inability to reproduce at peak summer temp is not important, because spawning can occur in spring or fall. The reverse is true where range limits are determined by winter temps, so that north of Cape Hatteras the northern limit is controlled by temps too low in summer for reproduction, and the southern limit by temps too high in summer for adults, and south of Cape Hatteras the northern limit is where it is too cold in winter for adults, and the southern limit where it is not cold enough in winter for reproduction. It is possible to predict with reasonable accuracy the temp extremes of regions for which no data are available, if temp requirements of species are known from their range limits elsewhere. This also applies to late Tertiary or Quaternary horizons in which recent species were present. The area from Cape Hatteras to Cape Henry is particularly depauperate because the area has a sharp winter temp break, with an annual temp range of 50°F. Other factors also are important in determining distributional ranges. - J.L.M.

1520
Purchon, R. D. 1977.

The Biology of the Mollusca. Pergamon Press, Oxford, xxv+560 p.

Mercenaria (Venus) mercenaria is referred to in relation to predation by *Polinices duplicata, Melongena coronata, Murex fulvescens,* and *Busycon;* byssal attachment; lipase in extracts of digestive diverticula and crystalline style; passage through a juvenile male phase in the first yr, then about a 50:50 sex ratio; spawning temp about 24° to 25°C; and commercial importance of an introduced stock in southern England. The chapters are organized by form and function in Mollusca, and the book contains no comprehensive accounting of biology of hard clam. References to the species are by citation of papers abstracted elsewhere in this bibliography. - J.L.M.

1521
Rainer, S. F., A. M. Ivanovici, and V. A. Wadley. 1979.

Effect of reduced salinity on adenylate energy charge in three estuarine molluscs. Mar. Biol. 54: 91-99.

Mercenaria mercenaria is not mentioned. - J.L.M.

1522
Rains, Harry H. 1965.

A report on shellfish farming in Long Island waters - Critical needs. L.I. Shellf. Farmers Assn. Inc., 11 p., 1 fig., app. A 5 p.

It take 5 to 8 years to grow a marketable crop of oysters and clams. New York is presently the leader in hard clam production. In the last 50 years oyster production in N.Y. has dropped 99%, hence the urgency of the problem. Four elements are necessary for successful shellfish farming: adequate seed supply, clean waters, ownership or control of underwater and shore-front property, and predator control. Techniques have been developed to produce seed clams artificially. Four small hatcheries operate on Long Island. These installations need grants for research and development and funds are needed to build large hatcheries to supply enough seed for all shellfish farmers in the State. The importance of clean waters is emphasized by the hepatitis epidemic in the Raritan Bay area about 4 years ago. Collapse of the shellfish industry in Great South Bay in the 1940s was attributed to enrichment by duck farm wastes which caused blooms of an alga *(Nannochloris)* inimical to shellfish. Flow of these wastes from Moriches to Great South Bay was corrected by dredging Moriches Inlet, which allowed Moriches Bay to flush directly into the ocean. Long Island has over 900,000 acres of bottom suitable for shellfish farming. Only 40,000 acres is presently leasable and only a small part of that is being farmed. One good acre of bottom can hold 500 bushels of marketable shellfish. The towns of Islip, Huntington, and Brookhaven have started a balanced farming program. Successful shellfish farming requires assurance that suitable areas are available in the long term. Major shellfish predators are sea stars (starfish), drills, and flat worms. Barnacles are also harmful because they smother seed oysters. The industry needs scientific advice and research on pest control. Transplants of shellfish from polluted to clean waters by the Town of Huntington is a promising development. Recommended are: 1) a permanent Natural Resources Commission be established; 2) research, training, demonstration projects by industry, government and universities; 3) a clean water program; 4) provide and preserve underwater and shore-front property for shellfish farming; 5) dredge Moriches Inlet; 6) a N.Y.-Conn. study of ways and means to restore conditions for natural seed oyster production; 7) adequate marine police protection; and 8) preservation of wetlands. (Abstracter's note: Most of this document was prepared in the interest of private oyster planters, but the general principles and problems discussed apply to hard clam also.) - J.L.M.

1523
Ramus, J. 1971.

Codium: the invader. Discovery 6(2):

Could not locate. Search terminated.

1524
Rapport, Maurice M. 1968.

Discussion of the possible mechanism of action of serotinin on molluscan muscle. Adv. Pharmacol. 6, B: 16-17.

The paper relates to Dr. Twarog's work on intracellular Ca levels as the most probable site for explaining how 5-HT (5-hydroxytryptamine) causes relaxation of catch in retractor muscle of *Mytilus*. The author refers to work by Woolley and Gommi (1965, 1966) cited elsewhere in this bibliography, and speculates on participation of lipids other than gangliosides as 5-HT receptors. - J.L.M.

1525
Raven, C. P. 1964.

Development. Chapter 5 in Physiology of Mollusca. Vol. 1. K. M. Wilbur and C. M. Yonge (eds.). Academic Press, New York: 165-195.

In all molluscs, except cephalopods, cleavage is spiral. - J.L.M.

1526
Ravera, O. 1968.

Molluscs in radiobiology. In Proc. Symp. Mollusca, Pt. II. Mar. Biol. Assn. India, Mandapam Camp: 456-462.

This review paper mentions work of others, abstracted elsewhere in this bibliography, on influence of dose on reduction of survival time. Mollusks are much more radioresistant than mammals. - J.L.M.

1527
Raymont, J. E. G. 1972.

Some aspects of pollution in Southampton Water. Proc. Royal Soc. London B180(1061): 451-468.

Mercenaria mercenaria from 4 parts of Southampton water had residues of 0.18 to 0.57 μg/g dry tissue Hg, 3.2 to 7.12 μg/g As, and 0.007 to 0.015 μg/g Sb. Gills had highest Hg concentration. Concentrations of Zn, Cu, and Fe are given from a paper by Romeril (1971) abstracted elsewhere in this bibliography. It was concluded that, although *M. mercenaria* can concentrate some heavy metals to an extraordinary degree, Southampton Water could not be regarded as a dangerously polluted area. Thermal effects from a power plant have apparently favored spawning of hard clam in a limited area. To the west, beyond the effects of waste heat, no records of *Mercenaria* existed. In the general area 100 clams of all sizes have been recorded per yd^2. In the outfall the highest density of commercial sizes was $160/m^2$. Highest density of young clams (10 mm mean) was $4{,}750/m^2$. The author notes that Carriker (1961), abstracted elsewhere in this bibliography, gave 3 $clams/yd^2$ as a reasonable commercial density, and regarded "several per sq. ft." as "dense". Bottom mud, which is rich in total Hg, may be a major source of Hg for clams. Spawning of *Mercenaria mercenaria* in the area appeared to occur at temps 18 to 19°C and above. - J.L.M.

1528

Raymont, J. E. G. 1976.

The introduction of new species in habitats of heated effluents. In Harvesting Polluted Waters. O. Devik (ed.). Plenum Press, New York: 185-199.

The most remarkable accidental introduction to Southampton Water in southern England was *Mercenaria mercenaria*. The species has undoubtedly responded to locally warmer conditions in heated effluents of power stations. A single specimen was first recovered in 1957 by the author, and it has been recorded in the area since 1956. Hard clam has so extensively colonized Southampton Water that it is the dominant bivalve in many places and supports a commercial fishery. American authorities say that spawning seldom occurs below 24°C. Although in the U.S. gonads begin to grow again in fall immediately after spawning, in Southampton no major growth of gonads recurs until spring. Another difference is that in the Southampton area the critical temp for spawning is about 18°C. At first in the area only certain years appeared to be favorable for spawning. Such yrs were the warm yrs 1955 and 1959. Now some spawning occurs every year, although only some yrs are really successful. It is not known when the species was introduced into Southampton Water. Clams taken from 1957 onward appeared to be relatively old, perhaps dating from the 1930s. Some evidence has been found that a few clams were introduced about 1926. Warm effluent appears to have facilitated survival and reproduction. Density of clams is high. In one area 100 clams/m^2 have been counted. In the Marchwood power plant outfall up to 160 clams/m^2 are reported. Densities of young have been as high as 4,750/m^2. Carriker (1961) cited 3 clams/m^2 as reasonable for commercial harvest. *M. mercenaria* occurs in stone and shell gravel with mud, soft mud, and hard gravel and sand in Southampton Water, and is described as remarkably unselective of substrate. Growth differs in different locations, and in general is less than in the U.S. They do best in the warm outfall. Most growth is in June-August. First spawning may be as early as May in the warmer water. Successful setting depends on adequate temp. Two peaks of larvae usually are observed, in May-June and July-August. The first probably comes from warm effluent, the second from summer spawning elsewhere, when temps are high enough. - J.L.M.

1529

Raytheon Company. 1972.

An ecological survey of the Arthur Kill. Raytheon Co., Environmental System Center, Environmental Research Lab. (unpublished? - or does n.p. mean no pagination?)

Interlibrary loan could not trace this. Raytheon Company denies existence of an environmental laboratory within their system. Search terminated. - J.L.M.

1530

Read, Kenneth R. H. 1966.

Molluscan hemoglobin and myoglobin. In Physiology of Mollusca. Karl M. Wilbur and C. M. Yonge (eds.), Academic Press, New York, Vol. II: 209-232.

Contains references to *Mercenaria (Venus) mercenaria* abstracted elsewhere in this bibliography. - J.L.M.

1531

Reese, A. M. 1942.

The old star-fish clam question. Science, N.S. 96: 513-515.

Assumed that a toxic secretion, liberated by sea star and introduced between valves of the clam, is responsible for opening the clam. - from Burnett, Ecology 41(3), 1960 - J.L.M.

1532
Renkavinsky, J. L. 1975.

The noncommercial value of shellfish. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 37-38.

N.Y. waters contain 37 gastropod and 31 bivalve species, of which only 8 are eaten regularly. As a group, shellfishes provide food for lobsters, crabs, and several species of fish, as well as waterfowl. Waterfowl predators can be classified as divers or dabblers. Both groups feed on clams, although mussels, soft clam, and oyster drills are more frequently found than hard clam in waterfowl stomachs. - J.L.M.

1533
Reynolds, N., and P. C. Wood. 1956.

Improved techniques for the bacteriological examination of molluscan shellfish. J. Appl. Bact. 19(1): 20-23.

No mention of *Mercenaria mercenaria*. - J.L.M.

1534
Rhoads, Donald C. 1967.

Biogenic reworking of intertidal and subtidal sediments in Barnstable Harbor and Buzzards Bay, Massachusetts. J. Geol. 75(4): 461-476.

Mercenaria mercenaria is not mentioned. - M.W.S.

1535
Rhoads, Donald C. 1973.

The influence of deposit-feeding benthos on water turbidity and nutrient recycling. Am. J. Sci. 273: 1-22.

References to *Mercenaria mercenaria* are citations of other papers, abstracted elsewhere in this bibliography. - J.L.M.

1536
Rhoads, Donald C. 1974.

Organism-sediment relations on the muddy sea floor. Oceanogr. Mar. Biol. Ann. Rev. Harold Barnes (ed.). George Allen & Unwin Ltd., London: 285-300.

Mercenaria mercenaria has been grown successfully on racks a few cm above unstable bottom in the turbidity zone. Growth rates were higher than in natural bottom nearer shore. The muddy sea floor is a nutrient reservoir. References to hard clam in this paper are from papers abstracted elsewhere in this bibliography. - J.L.M.

1537
Rhoads, D. C. 1971.

Near-bottom turbidity related to biogenic reworking of bottom muds. D. S. Gorsline (ed.) Abstract volume, Second National Coastal and Shallow Water Conf. Sponsored by Geography Programs. Office of Naval Research. University Press, Univ. Southern Calif.: 189.

Tidal current scour resuspends the reworked surface several meters into the water column, generating a near-bottom turbidity layer. The presence of this turbidity zone has potential importance for the nutrition of grazing zooplankton. The suspended fecal pellets of benthic invertebrates may provide an organic-rich food source for planktonic copepods, and may also be utilized by commercially important suspension-feeding bivalves like *Mercenaria mercenaria*. Transplantation of these bivalves into this turbid zone on bottom rafts has given favorable growth. - J.L.M.

1538
Rhoads, Donald C., and Giorgio Pannella. 1970.

The use of molluscan shell growth patterns in ecology and paleoecology. Lethaia 3(3): 143-161.

In *Mercenaria mercenaria*, winter rings on the shell can be distinguished from disturbance or spawning rings because they occur after a gradual decrease in shell concavity. Juvenile hard clams grown in holding tanks were notched and transplanted to the intertidal zone in Milford, Conn., and then to subtidal of Buzzards Bay, Mass. Microgrowth patterns of clam shells recorded the transplant sequence. Growth decreased after transplant to intertidal and from intertidal to surface of turbid mud subtidal bottom. Growth increased from intertidal to subtidal in clams elevated above turbid mud bottom. Growth was greater in sand than mud in all areas. Hard clams deprived of substratum exhibited change in microgrowth patterns such as: large varices; periostracal extensions; and sharply delimited daily growth bandings. - D.L.

1539
Rhoads, Donald C., and David K. Young. 1970.

The influence of deposit-feeding organisms on sediment stability and community trophic structure. J. Mar. Res. 28(2): 150-178.

Juvenile *Mercenaria mercenaria* one summer old from Milford, Conn., were marked and planted in mud and sand in plastic trays. One tray was held in the intertidal zone, 3 were planted in water 20 m deep on a 3-tiered platform. The bottom of the deepest tray was 10 cm above, the others were 45 cm and 75 cm above bottom in Buzzards Bay, Mass. The control tray was held at Milford, Conn. Control and the deep tray clams grew at the same rates, adding about 0.6 mm in 64 days. Clams in the middle tray added about 1.1 mm, and in the upper tray about 1.3 mm. The 3 experimental trays were above a mud bottom burrowed by deposit feeders. Differential growth was measured by shell growth. Hard clams feed only when valves are open and shell deposition takes place only during periods of valve separation. Therefore, hard-tissue growth reflects metabolic activity. During extended periods of starvation soft-tissue growth may be negative, while net hard-tissue growth, although small, is positive. Intensive reworking of the upper few cm of a mud bottom by deposit feeders produces a fluid fecal-rich surface easily resuspended by low-velocity tidal currents. It is suggested that the physical instability of this surface tends to clog the filtering structures of suspension-feeders like hard clam, bury newly settled larvae or discourage settling of suspension-feeding larvae, and prevent sessile epifauna from attaching. This could explain the marked spatial separation of suspension-feeders (which are largely confined to sandy or firm mud) and deposit-feeders (which attain high density on soft, muddy bottom). - J.L.M.

1540
Rhoads, Donald C., Kenneth Tenore, and Mason Browne. 1975.

The role of resuspended bottom mud in nutrient cycles of shallow embayments. In Estuarine Research. Vol. 1. Chemistry, Biology, and the Estuarine System. L. Eugene Cronin (ed.). Academic Press, Inc., New York: 563-579.

The bottom of Buzzards Bay, Mass. below a depth of about 13 m is dominated by silt-clay sediment. A turbid-water layer, created by tidal-current scour, extends about 3 m above the bottom, and sometimes higher. Trays of *Mercenaria mercenaria* were placed on the bottom in 20 m of water within the turbidity layer. Clams had higher growth rates than populations grown nearshore. Details are contained in other papers by the senior author abstracted elsewhere in this bibliography. - J.L.M.

1541
Rhodes, Raymond J., Willis J. Keith, and V. G. Burrell, Jr. 1977.

South Carolina's hydraulic escalator harvester fishery. Proc. Natl. Shellf. Assn. 67: 122 (abstract).

Nine hydraulic escalator clam dredges harvested 31,538 bags (250clams/bag) of *Mercenaria mercenaria* from North and South Santee Rivers in the 1974-75 clamming season. In the 1975-76 season 25,948 bags were taken by 7 vessels from North Santee Bay. Estimated mean hourly catches were 10.1, 10.8, and 19.8 bags/hr. in South Santee River, North Santee River, and North Santee Bay, respectively. - J.L.M.

1542
Rhodes, Raymond J., Willis J. Keith, Peter J. Eldridge, and Victor G. Burrell, Jr. 1977.

An empirical evaluation of the Leslie-DeLury method applied to estimating hard clam, *Mercenaria mercenaria*, abundance in the Santee River estuary, South Carolina. Proc. Natl. Shellf. Assn. 67: 44-52.

Estimates were made from catch and effort data for hydraulic escalator harvesters, 1974-1976. Legal harvesting areas in South and North Santee Rivers and North Santee Bay had estimated populations of 6.4 million, 5 million, and 10.7 million clams, respectively. Density of clams in preferred harvesting areas varied from 18 to 24 clams/m^2. The Leslie-DeLury method had 2 limitations. Effort estimates were not available for specific locations, and gear competition made abundance estimates questionable. - J.L.M.

1543
Rice, T. R., and J. P. Baptist. 1974.

Ecologic effects of radioactive emissions from nuclear power plants. Chap. 10 in Human and Ecologic Effects of Nuclear Power Plants. Leonard A. Sagan (ed.). Charles C. Thomas, Publisher, Springfield, Illinois: 373-439.

Price (1965) found that about 93,000 r killed 50% of the oysters *(Crassostrea virginica)* in 34 days, and 50% of the clams *(Mercenaria mercenaria)* in 38.5 days. If LD-50s are calculated earlier or later than 30 days after irradiation, the tolerances of the two species are not similar (White and Angelovic 1966). Oysters have an LD-50 almost twice that of clams 20 days after irradiation and only one-fourth that of clams 40 days after irradiation. - J.L.M.

1544
Rice, Theodore R., and Rebecca J. Smith. 1958.

Filtering rates of the hard clam *(Venus mercenaria)* determined with radioactive phytoplankton. U.S. Fish Wildl. Serv., Fish. Bull. 58(129): 73-82.

Radioactive phosphorus was used to label four species of phytoplankton for measuring filtering rates of hard clam. There was no relation between initial concentration of *Nannochloris* and its rate of removal by an individual clam. The ratio of water filtered per gram of meat was higher for small clams than larger ones. *Nannochloris* and *Chlorella* were filtered at a lower rate than the larger diatoms (2 *Nitzschia* species). Intermediate populations of diatoms (5-75 million/l) were filtered more rapidly than larger or smaller populations. Filtering rate of clams in *Nannochloris* was higher when it was in mixed suspensions of diatoms than in unialgal suspensions of *Nannochloris*, but filtering of *Nitzschia closterium* was lower when it was mixed with *Chlorella* than in unialgal suspensions of *Nitzschia*. Filtering rates are higher for clams in natural phytoplankton than in unialgal green algae suspensions, but lower in unialgal diatom suspension. Adding silt to algal suspensions instantaneously lowered the filtering rate. - D.L.

1545
Richards, Gary. 1978.

Evaluation of coli-count samplers for monitoring the sanitary quality of seafoods. In Proc. Interstate Seafood Seminar, Oct. 4 to 7, 1977. William R. Hess, Jr. (ed.). Va. Polytech. Inst. and State Univ. Extension Div. and Dept. Food Sci. Technol., Seafood Processing Research and Extension Unit, Hampton, Va: 127-132.

This paper presents a promising alternative method to determine total and fecal coliform counts in homogenates of fishery products using Millipore Coli-count Samplers. Samples tested included *Mercenaria mercenaria*, oyster, and Gulf shrimp. Some of the hard clam samples were suspected of contamination and did not give reasonable results. The others, however, gave readings that were not very different from MPN determinations. The cost is much less with the Coli-count samplers, and they can be performed by production workers with no previous microbiological background. Further evaluation is necessary. - J.L.M.

1546
Richards, Horace G. 1936.

Some shells from the North Carolina "Banks". Nautilus 49(4): 130-134.

In collecting shells from beaches from Virginia Beach, Va. to Myrtle Beach, S.C. and elsewhere in the south the author has been impressed with the large numbers of shells that appeared to be fossil. Many were very worn, others black. At the tip of Cape Hatteras unusually large shells of *Fulgur perversum* (11" long) and *Venus campechiensis* (5" by 6") were collected. Today they rarely, if ever, reach those sizes. Fragments of coquina (fossil) deposits found along N.C. outer beaches (Banks) contained *V. mercenaria* and other bivalve remains. *V. campechiensis* probably is Pleistocene. A great many southern species have their recorded northern limit in N.C. It is undoubtedly true that many warmwater species do occur near Cape Hatteras, but some of the records probably are based upon Pleistocene fossils found on beaches. Pleistocene seas were warmer than present. It is therefore desirable that a new northern or southern limit be based upon living specimens. - J.L.M.

1547
Riddiford, Lynn M., and Harold A. Scheraga. 1962.

Structural studies of paramyosin. I. Hydrogen ion equilibria. Biochemistry 1(1): 95-107.

Hydrodynamic measurements on paramyosin prepared from adductor muscle of *Venus mercenaria* showed that the protein was homogeneous in various solvents. Molecular weight estimates depended on ionic strength and pH of medium, varying from 228,000 to 618,000. In 0.3 M KCl at pH 7.4, molecular weight determined by the sedimentation equilibrium method was 330,000. Nine tyrosyl groups are masked in native paramyosin and ionize normally in a mixed solvent of 5 M guanidine HCl and 1.2 M urea (GU). Carboxyl and imidazole groups ionized normally in 0.3 M KCl and GU. All groups titrating in the alkaline range of KCl solution (tyrosyl, lysyl, arginyl) have slightly low pK_{int} values which become normal in GU, thus local electrostatic interactions in KCl may occur. Apparent absence of electrostatic effects was noted in alkaline GU solutions. Otherwise the electrostatic interaction parameter w in both solvents agreed with the theoretical w based on a cylindrical model. It was concluded that the extreme stability of the native paramyosin molecule arises mainly from nonpolar interactions. The hydrodynamic properties of *Venus* paramyosin are consistent with models of stable asymmetric rodlike aggregates. Even in GU the rodlike character is apparently retained. Electrostatic and hydrophobic interactions must be responsible for most of the stabilization of the native molecule (possibly a coiled coil). Some of the 77 literature citations are abstracted elsewhere in this bibliography. Because the listing in this paper contains no titles, we made no attempt to locate and read the others. - modified authors' abstract - J.L.M.

1548
Ridewood, W. G. 1903.

On the structure of the gills of the Lamellibranchia. Phil. Trans. Royal Soc. London B195: 147-284.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

1549
Rindge, Mila E. 1962.

Infectious hepatitis in Connecticut. Conn. Health Bull. 76: 125-130.

Historical records since 1950 and available annually to 1961 inclusive show that the rates/100,000 population in Conn. and in the U.S. as a whole were low in 1950, relatively high in the mid-1950s, low in the late 1950s, and high in 1961. No attempt was made to differentiate between infectious hepatitis and the clinically similar serum hepatitis. In only one year prior to 1961 was the reported incidence higher in Conn., namely 1955. Trends were similar in the State as compared with the U.S., except that a maximum was reached in the country as a whole in 1954 rather than 1955, and the 1961 national peak was much higher than in Conn., and higher than the 1954 peak. Conn. has lagged one year behind the U.S. in peaks and lows, which suggested that incidence in the State might be almost double the 1961 rate in 1962. In 1961 New Haven, Conn., with about 6% of the population of the State, had 27% of all cases reported. The New Haven peak was in Feb. New Haven cases differed in several respects from those in the rest of the State. Fifty-six persons with hepatitis had a history of recent consumption of raw shellfish and there was epidemiological evidence that 15 had eaten raw clams from a polluted area at Greenwich, Conn. In 1961 outbreaks of infectious hepatitis related to consumption of raw shellfish from polluted waters also were reported from other parts of the country. - J.L.M.

1550
Rindge, M. E., J. D. Clem, R. E. Linkner, and L. K. Sherman. 1965.

A case study on the transmission of infectious hepatitis by raw clams. U.S. Dept. Health, Educ. Welfare, Pub. Health Serv., Washington, D.C., 36 p.

Could not locate. Search terminated. - J.L.M.

1551
Ritchie, Theodore P. 1976.

The U.S. Clam Industry. Del. Sea Grant College Program, Coll. Mar. Stud., Univ. Delaware, Newark and Lewes, DEL-SG-26-76, 119 p.

With some minor alterations, this is essentially the same publication as "A comprehensive review of the commercial clam industries in the United States", published by the U.S. Dept. of Commerce, and abstracted following this. - J.L.M.

1552
Ritchie, Theodore P. 1977.

A comprehensive review of the commercial clam industries in the United States. U.S. Dept. Commerce, NOAA, Natl. Mar. Fish. Serv. (Delaware Sea Grant Program, Coll. Mar. Stud., Univ. Del., Newark and Lewes, Del., DEL-SG-26-76), ix+106 p.

Mercenaria has the most extensive distribution of commercial clam resources in the U.S. and the industry associated with hard clam harvesting has the highest employment and total exvessel value. *Mercenaria* species occur close to shore and water pollution is a major problem in their continued utilization. Hard clams are often consumed raw, and public health incidents threatened the viability of the industry. A canning industry based on *Mercenaria campechiensis* was established on the west coast of Fla. in 1913. Peak landings were in 1932. Subsequent landings decreased, and the canneries closed in 1947. Meat shortages during and immediately after the 2nd world war created increased demand for clams. Greatest landings of *Mercenaria* were in 1947. Effects of domestic and industrial pollution are largely to deny major segments of the resource to the industry rather than to affect the resource itself. Larger populations of clams in closed areas are a temptation to poachers and a threat to public health. Storm runoff is a particularly difficult aspect of pollution. Biotoxins such as that caused by dinoflagellates are not a major problem to the hard clam industry except indirectly through erosion of consumer confidence in shellfish generally. Fluctuations in hard clam landings have economic causes, related to seasonal demand and competition, as well as to fluctuations in bioliogical production. Areas harvested regularly tend to have poor recruitment, although occasional large sets, which support harvesting for several years, occur infrequently. Hatchery techniques for rearing young or "seed" clams are well developed. Juveniles must be protected from predation if hatchery seed is to contribute to the commercial supply. Smallest clams are most susceptible to predation. Management is difficult because points of landing are numerous, and jurisdiction over the resource and the harvest often is divided among levels of government, as in New York, where towns, counties, State, and several federal agencies share responsibility. Maximum sustainable yields are not known for any hard clam resource. Recreational harvesting is increasing, and the catch is not known. Mechanical harvesting is allowed in some places and under certain conditions, but much of the catch is taken by hand, with tongs, rakes and by treading. The smallest legal sizes, littlenecks, bring the highest price. Regulations primarily relate to minimum size limits, licensing, legal harvesting methods, closure of polluted areas, and sanitary requirements. Buyers must have shippers permits and shipments must be packaged and identified as to source. In dry storage at reduced temp hard clams will live 1 to 3 weeks. Most hard clams are sold in the shell, so storage and waste disposal problems are minimal. Marketing of smaller sizes is not considered a problem. Marketing of largest sizes, "chowder clams", has always been a problem. Prices of all sizes vary seasonally. Markets are influenced by events such as the kepone incident in Virginia. Harvesting pressure has increased in most areas and the resource shows signs of declining. Most states lack adequate information for management, and public attitudes are not sympathetic. Principal needs are: 1) pollution abatement; 2) reduction of illegal harvesting; 3) stock assessments; 4) increased aquacultural effort and full use of proven techniques; 5) evaluation and improvement of management regulations; 6) public policy that encourages leasing of marginal or barren grounds for aquaculture; 7) depuration and transplantation of polluted clams; and 8) study of clam population dynamics to develop strategy for stock utilization. - J.L.M.

1553
Roberts, B. S., G. E. Henderson, and R. A. Medlyn. 1979.

The effect of *Gymnodinium breve* toxin(s) on selected mollusks and crustaceans. In Toxic Dinoflagellate Blooms. Dennis L. Taylor and Howard H. Seliger (eds.). Elsevier/North-Holland, New York: 419-424.

Two groups of clams, *Mercenaria campechiensis*, were collected locally and exposed to live *G. breve* cultures or to NH-15. The clam meat was stored frozen in small packages and thawed as needed during feeding experiments with adult *Callinectes sapidus* and *Menippe mercenaria*. The first group collectively filtered an estimated 2.4 x 10^9 cells in 10 days after which toxicity was assayed as 41 mouse units. The second group filtered about 3.3 x 10^9 cells in 15 days and toxicity was assayed as 60 mouse units. No tests were made on *Mercenaria campechiensis*. - J.L.M.

1554
Roberts, Morris H., Jr., Robert J. Diaz, Michael E. Bender, and Robert J. Huggett. 1975.

Acute toxicity of chlorine to selected estuarine species. J. Fish. Res. Bd. Canada 32(12): 2525-2528.

Larvae of *Mercenaria mercenaria* were among various life-history stages of several species tested. Hard clam larvae were among the most sensitive forms tested. EC50 value at 48 hr was 0.006 mg/l of total residual chlorine, and TL50 value estimated at 0.001 mg/l. Thus, it is not necessarily true that small residues in sewage plant effluents are harmless. - J.L.M.

1555
Robertson, James D. 1964.

Osmotic and ionic regulation. Chapter 9 in Physiology of Mollusca. Vol. 1. K. M. Wilbur and C. M. Yonge (eds.). Academic Press, New York: 283-311.

Blood plasma of *M. mercenaria* is in osmotic equilibrium with seawater across permeable membranes such as gills, where isosmoticity is within 1%. Cole (1940) found blood 1.76Δ°C and seawater 1.76Δ°C. In slightly diluted seawater it was blood 1.39Δ°C and seawater 1.34Δ°C. This slight hypertonicity in dilute seawater was possibly only apparent, because no details were given about the equilibration period. *V. mercenaria* tissues show anomalous reactions to decreased salinity: gills and mantle increase and muscles decrease in oxygen consumption (Hopkins 1949). *Mytilus* is the same. - J.L.M.

1556
Robinson, Peg. 1973.

Clam dredges too effective for Fla. beds. Natl. Fisherman 54(4): 2C.

From the late 30s to mid-40s, the state's clam industry was in full swing, but otherwise the clam fishery has been small. At its height, these beds were possibly the largest known. The reasons for the disappearance of the major beds are not known. Recent surveys have shown that mechanical harvesting equipment should be prohibited in grass covered and vegetated areas. - J.L.M.

1557
Robinson, W. E. 1980.

Statistical analysis of digestive gland tubule variability in *Mercenaria mercenaria* (L.), *Ostrea edulis* L. and *Mytilus edulis* L. Natl. Shellf. Assn., Abstracts, Technical Sessions 19 (abstract).

Recent investigations show that bivalves apparently demonstrate rhythms of intracellular digestion, often correlated with the tidal cycle. Evidence is based primarily, and often solely, on the diverse histological appearances of the digestive gland tubules from different individuals over a period of time. Four main tubule types, signifying various stages of intracellular digestion, can be recognized: 1) holding; 2) absorptive; 3) fragmenting; and 4) reconstituting. Digestive tubules and similar tubule types are not randomly distributed within the digestive gland, but are grouped together around common secondary ducts. This necessitates use of a cluster sampling technique for proper statistical analysis. In all three species, variability of tubule types is high within individual digestive glands as well as between individuals sampled at the same time. Based on calculations to minimize total variance, it is better to sample a small area from numerous individuals rather than a large area from a few animals. Intra-animal variability is similar in all three species. Similarly, inter-animal variability is the same in the subtidal quahog and mid-intertidal mussel, but much less in the low intertidal oyster. Problems imposed by variability and tubule clustering have not adequately been considered in previous investigations of bivalve digestion. - J.L.M.

1558
Robinson, W., and R. Langton. 1979.

Digestion in a subtidal population of *Mercenaria mercenaria* (Linn.) (Bivalvia). Mar. Biol.

Publication not seen. - J.L.M.

1559
Rodrick, Gary E., and Thomas C. Cheng. 1974.

Biochemistry of molluscan phagocytosis. Am. Zool. 14(4): 1263 (abstract).

Phagocytosis is considered to be one of the 3 major types of internal defense mechanism in mollusks. Phagocytosis is not accompanied by an increase in respiration in *Mercenaria* and *Crassostrea*, as it is in mammals. (Abstracter's note: or the increase is lower in pelecypods; the text is not clear on this point.) In hard clam and oyster the glycolytic pathway provides energy necessary for particle engulfment, as it does in mammals. Nitro-blue tetrazolium reduction does not occur in the 2 pelecypod species, as it does in mammalian phagocytes. Hard clam and oyster may utilize antimicrobial systems other than the myeloperoxidase-H_2O_2-halide system which occurs in mammalian cells. - J.L.M.

1560
Roels, Oswald A. 1969.

Marine proteins. Nutr. Rev. 27(2): 35-39.

Various methods of capturing nutrients of the sea to make foods for man are discussed, from use of guano as fertilizer to produce corn, which is in turn fed to pigs, to manufacture of fish protein concentrate for direct consumption by man. In the first method it takes about a million pounds of fish to produce one pound of human protein, in the second, about 1,000 pounds of fish are required. Other techniques attempt to use a shorter food chain. One method is to use cold, nutrient-rich seawater from the depths as a basis for culture of fishes and shellfishes. In Japan, yellowtail are produced at the rate of 280 metric tons/hectare/year. Particular shellfish species are not discussed in this paper, but it is known that Dr. Roels has grown hard clams in the Caribbean. - J.L.M.

1561
Roels, Oswald A. 1973.

Final report on Sea Grant #1-35354 (Suppl. to GH-87) Artificial upwelling. To Natl. Oceanic Atmos. Admin., Office of Sea Grant Programs from Columbia Univ., Palisades, N.Y., 12 p.

After introducing a one-mile long, 3" pipe, to a depth of 830 meters, ponds were built for phytoplankton. When blooms of *Cyclotella nana* had been obtained using the deep-water nutrients, 200,000 juvenile oysters and clams *Mercenaria mercenaria*) were introduced. After a heavy storm the nutrient content of the water changed suddenly, indicating that the water was coming from 200 meters. This forced addition of nutrients to the water. The rest of the paper deals with rectification of the situation. - J.L.M.

1562
Roels, Oswald A., Kenneth C. Haines, and Judith B. Sunderlin. 1975.

The potential yield of artificial upwelling mariculture. Biol. Lab., Lamont-Doherty Geological Observatory, Columbia Univ., Palisades, N.Y., Rept. of Progress for work supported by Sea Grant Project No. 04-5-158-59, 18 p.

Mercenaria mercenaria survived but grew very slowly. *M. campechiensis* and the F_1 cross grew from 1 mm spat to market size in 6.5 to 13 months, faster than any other animal. - J.L.M.

1563
Roels, O. A., K. C. Haines, and J. B. Sunderlin. 1976.

The potential yield of artificial upwelling mariculture. 10th European Symposium on Marine Biology, Ostend, Belgium. Vol. I: 381-390.

At St. Croix antarctic intermediate water is pumped continuously from 870 m depth into 45,000 liter concrete pools in which unialgal cultures of planktonic diatoms are grown. The diatom clones used are: *Thalassiosira pseudonana, Chaetoceros simplex, Bellerochea polymorpha,* and *Chaetoceros curvisetus. Mercenaria campechiensis* and the F_1 cross with *M. mercenaria* grew from 1 mm spat to market size in 6.5 to 13 months in the artificial upwelling system, but no animals had reached market size in any of the other environments after 13 months. - J.L.M.

1564
Roels, O. A., S. Laurence, M. W. Farmer, and L. Van Hemelryck. 1976.

Organic production potential of artificial upwelling marine culture. In Microbial energy conversion. H. G. Schlegel and J. Barnea (eds.). Erich Goltze KG, Gottingen, 1976: 69-81.

Among 8 species which grew well and reached market size quickly was *Mercenaria campechiensis* and F_1 of *M. campechiensis* and *M. mercenaria.* Protein production/m^2/yr in the St. Croix experimental system for 330 days operation/yr was 0.52 kg or 5.2 tons protein/ha/yr. - J.L.M.

1565
Roessler, Martin A., and Joseph C. Zieman, Jr. 1969.

The effects of thermal additions on the biota of Southern Biscayne Bay, Florida. Proc. Gulf Caribb. Fish. Inst., 22nd Ann. Sess.: 136-145.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1566
Romeril, M. G. 1971.

Preliminary observations on trace metal accumulation in the hard shell clam *Mercenaria mercenaria.* Centr. Electr. Research Labs., Lab. Note RD/L/N 31/71 (Job. no. VJ 355), 8 p., 1 fig.

Clams collected in winter 1969/70 and summer 70 from several sites in Southampton Water usually contained higher concentrations of Zn, Fe, and Cu in soft tissues than in samples taken along American coasts. Greatest concentrations were in clams taken farthest up the estuary. Total amount of metal increased with age of clam. Higher levels as compared with most North American samples was attributed to relatively high turbidity of the water, which made considerable amounts of metal available in particulate form. At a station in the lower estuary concentrations were:

Metal	Total quantity of trace metal (μg)		
	Age 3+	Age 4+	Age 5+
Zn	50.2	90.7	131.3
Cu	12.87	25.92	32.03
Fe	107.2	194.9	240.8

- J.L.M.

1567
Romeril, M. G. 1974.

Trace metals in sediments and bivalve mollusca in Southampton Water and the Solent. Rev. Internatl. d'Oceanographie Medicale 33: 31-47.

Significant variations occurred in tissue content of Zn, Cu, and Fe with locality, season, and age in *Mercenaria mercenaria* and *Cerastoderma edule*. In general, metal content was correlated with metal content of sediments. Results emphasized the need for extensive and comprehensive background data to assess accurately the significance of observed fluctuations. - J.L.M.

1568
Romeril, M. G. 1979.

The occurrence of copper, iron and zinc in the hard shell clam, *Mercenaria mercenaria*, and sediments of Southampton Water. Estuarine Coastal Mar. Sci. 9(4): 423-434.

Concentrations of Cu, Fe, and Zn were measured in *M. mercenaria* from several locations along Southampton Water to provide background data for accurate assessment of the significance of observed fluctuations. Studies showed considerable seasonal, age, and geographical fluctuations in tissue metal concentration. All metal concentrations in clam tissue were lower at the seaward end of the estuary, but although sediment metal levels generally followed a similar trend, tissue and sediment values appeared to correlate with each other only for Fe. Trace metal accumulation by clams is obviously affected by many factors. A change in concentration with age was the most easily recognized relationship. Seasonal trends are evident, but they lack satisfactory explanation. There is little evidence of any significant effect on metal uptake which could be attributable to operation of the Marchwood Power Station. - J.L.M.

1569
Roop, Tom, and Michael J. Greenberg. 1967.

Acetylcholinesterase activity in *Crassostrea virginica* and *Mercenaria mercenaria*. Am. Zool. 7(4): 737-738 (abstract 112).

Isolated venerid hearts are about 10,000 times "more sensitive" to acetylcholine (ACh) depression than are ostreid hearts. But eserine augmentation of ACh effect in venerids is about 30-fold "smaller" than potentiation in ostreids. In *Crassostrea virginica*, rhythmical activity of gills is increased by ACh. The threshold drops in presence of eserine. Eserine alone augments rhythmical activity. Action of ACh on *Mercenaria mercenaria* gills is scarcely affected by eserine. Cholinesterase activity recovered from oyster heart and gill was at least 100 times "greater" than that of *Mercenaria* organs under the same analytical conditions. Ganglia of the 2 species had a similar high activity. Differences in cholinergic pharmacology of oysters and clams are attributable to comparatively high cholinesterase activity of oyster tissues. - J.L.M.

1570
Ropes, John W. 1963.

The incidence of *Malacobdella grossa* in hard clams from Nantucket Sound, Massachusetts. Limnol. Oceanogr. 8(3): 353-355.

The commensal nemertean *M. grossa* is widely distributed along the Atlantic coast of the U.S., in *Mercenaria mercenaria*, *M. campechiensis*, and *Mya arenaria*. Incidence of worms varied from 5.3% to 23.5% in samples of clams from different localities. Water currents and velocities may be responsible for this variation. No clam contained more than one nemertean. - J.L.M.

1571
Ropes, John W. 1971.

Maryland's hard clam studied at Oxford Laboratory. Comm. Fish News, Md. Fish Wildl. Admin. 4(6): 2-3.

Bays and estuaries of the Atlantic Ocean side of the Delmarva Peninsula have averaged 1.5 million pounds of meat production per year from *Mercenaria mercenaria* in the decade 1960-69; Chesapeake Bay only about 800,000 pounds. The hard clam industry was presented with two alternatives: to increase selective fishing pressure on smaller, more valuable, clams, or to grow young clams artificially in hatcheries under controlled conditions. It was feared that present markets for small clams might destroy brood stocks needed for natural replenishment. To identify sex of a hard clam, thin sections of tissue must be examined under a microscope. During spawning, sex cells are carried to the surrounding water through the siphon. Sex products are forced out rhythmically by the powerful adductor muscles. A few clams ripened by mid-June, but spawning was delayed until late June-early July after water temp had dropped to 25°C, then rose to 29°C. Spawning probably continued through July. Threshold temp for spawning in Chincoteague Bay is 25° to 30°C. Spawning temps are lower farther north, suggesting the Chincoteague Bay quahogs are different phsiologically. This could add to the cost of artificial propagation. - J.L.M.

1572
Ropes, John. 1976.

NMFS studies new offshore clam resource: The ocean quahog. Comm. Fish. News, Md. Dept. Natural Resources 9(6): 1, 4.

Describes in some detail what is known about *Arctica islandica*, the ocean quahog, including spawning, temp requirements, distribution, and history of the fishery. *Mercenaria mercenaria* is mentioned. - J.L.M.

1573
Ropes, John W., and Charles E. Martin. 1960.

The abundance and distribution of hard clams in Nantucket Sound, Massachusetts, 1958. U.S. Dept. Interior, Fish Wildl. Serv., Spec. Sci. Rept. - Fish. 354, 12 p.

At the request of the Atlantic States Marine Fisheries Commission, a survey was made of *Venus (Mercenaria) mercenaria* stocks in Nantucket Sound. The gear was a hydraulic dredge such as was used in the surf clam fishery. Population densities were very low. No hard clam less than 60 mm long was taken, even with a fine lining in the dredge, or with a clam-shell bucket. No new hard clam beds of commercial importance were found. Sizes were very uniform and large, average length 111 mm (4 3/8 inches), and 95% were between 94 and 127 mm. Average population densities for the 3 major areas were 0.7, 0.6, and 0.5 clams/100 ft^2. Greatest density in any single tow was 11 clams/11 ft^2. Estimated ages were 15 to 30 yrs. Growth was slow. It was concluded that this stock was an accumulation of a few offspring that survive each year. A commercial fishery was possible only because the hydraulic dredge is so efficient. Densities of hard clam stocks reported in the literature (abstracted elsewhere in this bibliography) for Chincoteague Bay, Md. and Narragansett Bay, R.I. were much higher. Bottom water temps in Nantucket Sound seldom reach 69°F, which has been reported as the minimum temp for spawning. Thus, spawning in the Sound may occur only in those rare years when water temp rises above this level. Sampling showed that the following hard clam predators were present: *Busycon canaliculatum* and *B. carica*, *Lunatia (Polinices) heros* and *P. duplicatus*, *Asterias* sp. and *Limulus polyphemus*. The future of the hard clam fishery in Nantucket Sound was judged uncertain. - J.L.M.

1574
Ropes, John W., and Arthur S. Merrill. 1967.

Malacobdella grossa in *Pitar morrhuana* and *Mercenaria campechiensis.* Nautilus 81(2): 37-40.

The commensal nemertean *M. grossa* was found in 91 of 104 *M. campechiensis* from 13 locations off Cape May, N.J. to off Cape Charles, Va. Most hosts had one nemertean; one had 2, another 4. The nemertean has also been reported from *M. mercenaria* on the Atlantic coast of North America and *Venus mercenaria* on the coast of Europe by Coe (1943), abstracted elsewhere in this bibliography. - J.L.M.

1575
Rosen, Albert, and Richard K. Robinson. 1961.

Summary of Florida commercial marine landings, 1960, and an analysis of the catch and effort of certain species. Univ. Miami, Inst. Mar. Sci., Mar. Fisheries Research Rept. to Fla. State Bd. Conserv., 32 p.

The list of common and scientific names of species landed in Fla. on p. 31 and 32 identifies hard clams as *Mercenaria mercenaria* and *M. campechiensis*. Presumably they are not listed separately in catch statistics. - J.L.M.

1576
Rosenberg, G. D., and S. K. Runcorn (eds.). 1975.

Growth Rhythms and the History of the Earth's Rotation. Conclusions. John Wiley & Sons, London: 535-538.

This volume contains many important references to *Mercenaria mercenaria* which are abstracted elsewhere in this bibliography under names of chapter authors. The concluding section contains the following comment on hard clam research: "Thompson's laboratory studies of *Mercenaria* confirm *Mercenaria* growth periodicities described by the Yale group of Rhoads, Pannella and MacClintock. Moreover, they further establish a link between a behavioral process (gaping) and increment production. Thompson also believes that her work establishes the existence of an internal biological clock in *Mercenaria*, independent of the environment. This conclusion should be the subject of interesting discussion between the endogenous and exogenous schools of biorhythm workers." - J.L.M.

1577
Rosenfield, Aaron. 1976.

Infectious diseases in commercial shellfish on the middle Atlantic coast. Am. Soc. Limnol. Oceanogr., Spec. Symp. 2: 414-423.

In some *Mercenaria mercenaria* from Chincoteague Bay were amorphous blue bodies consisting of Feulgen positive organisms belonging to the Chlamydiaceae. Some of these *Chlamydia* sp. were in turn infected with a virus. This was the first report in the United States (attributed to Otto et al. 1975 and Harshbarger et al. 1975) of phagelike particles in rickettsia-like organisms of aquatic invertebrates. - J.L.M.

1578
Ross, V. 1974.

Major clam farmer shifts emphasis to frozen products. Quick Frozen Foods 37: 62-64.

Interlibrary loan was unable to obtain without information on month of publication. Search terminated. - J.L.M.

1579
Ruckebusche, H. 1949.

Le clam. Note sur *Venus mercenaria* L. Son introduction et son élevage dans le bassin de la Seudre. Rev. Trav. Off. Pêches Marit. 15: 99-117.

According to Heppell (1961) a successful naturalization of hard clam was reported by Ruckebusche, from a planting made about 1910. Apparently the clams multiplied prolifically. This led to establishment of a flourishing clam industry centered around Mornac and Marennes. Tolerance of hard clam to environmental stress was illustrated by finding live clams in bottoms of claires which had been dried up for a month. It was not known why prolific reproduction occurred in channels and streams of the Seudre, but in the claires, which are served by saltwater streams flowing into the main channels, reproduction did not occur or larvae did not survive. - J.L.M.

1580
Ruddy, Shaun J., Ronald F. Johnson, James W. Mosley, John B. Atwater, Michael A. Rossetti, and James C. Hart. 1969.

An epidemic of clam-associated hepatitis. J. Am. Med. Assn. 208(4): 649-655.

According to these authors the first epidemic of infectious hepatitis attributable to ingestion of raw shellfish was in Sweden in 1956. Little apprehension was aroused in the United States that a similar epidemic might occur. Two cases in 1961, one in the Gulf of Mexico and one in N.J., alerted officials in this country. From late fall 1963 through spring 1964, 123 clam-associated cases attributed to consumption of raw *Mercenaria mercenaria* occurred among 468 cases of infectious hepatitis recorded in Connecticut in the same 32-week period. The evidence was convincing. Among other things, the proportion of patients with a history of clam consumption was very much higher than in the preceding 2-year period and "sixfold greater" than for a comparable population without hepatitis. The frequency of clam-associated cases waxed and waned independent of the pattern of non-associated cases, and also independent of the known pattern of clam consumption. No other hypothesis could account for these and other findings. It was concluded that the clams responsible were shipped through commercial channels, not a bootleg operation. The shellfish may well have come from open waters, because contaminated clams were still being distributed when intensive policing was in effect. It has been demonstrated that oysters in estuarine waters will retain coxsackievirus B3 until spring, and will not begin to free themselves of virus until water temperatures rise. If clams are similar in this respect, coliform counts are an inadequate index of viral contamination. Waters from which the clams responsible for the epidemic came could not be identified, but it was concluded that the clams came from harvesters and dealers in Rhode Island. - J.L.M.

1581
Ruegg, J. C. 1961.

The proteins associated with contraction in lamellibranch "catch" muscle. Proc. Royal Soc. London B154(955): 209-223.

Mercenaria (Venus) mercenaria is not mentioned. Some of the 43 papers cited are abstracted elsewhere in this bibliography. Because the list does not contain titles we made no attempt to locate and read any others. - M.W.S. and J.L.M.

1582
Ruegg, J. C. 1961.

On the tropomyosin-paramyosin system in relation to the viscous tone of lamellibranch "catch" muscle. Proc. Royal Soc. London B154: 224-249.

Mercenaria (Venus) mercenaria is not mentioned. Some of the 65 papers cited are abstracted elsewhere in this bibliography. Because the list does not contain titles we made no attempt to locate and read any of the others. - M.W.S. and J.L.M.

1583
Ruggieri, George D. 1972.

The search for anti-cancer agents from marine organisms: biological aspects. In Food-Drugs from the Sea, Proceedings 1972. Leonard R. Worthen (ed.). Mar. Tech. Soc., Washington, D.C.: 354-358.

Cites studies of *Mercenaria mercenaria* by Schmeer (1964) and Hegyeli (1964), abstracted elsewhere in this bibliography. Level of anti-cancerous activity varies with season and may be temperature-dependent. Clams brought into the laboratory in winter show progressive increases in amount of active substance as clams are acclimated to higher temp. - J.L.M.

1584
Russell, Howard J., Jr. 1972.

Use of a commercial dredge to estimate a hardshell clam population by stratified random sampling. J. Fish. Res. Bd. Canada 29(12): 1731-1735.

Mercenaria mercenaria occurs naturally in contagious distributions that fit the negative binomial. If surveys designed to estimate clam abundance do not take this into account they can be seriously in error. The sampling design in this study was based on a preliminary survey which produced a contour plan of abundance. The final survey attempted to sample equal fractions of areas of bottom between contours. The rocking-chair dredge was calibrated in action to determine the area of bottom covered by a 10-minute standard tow. Estimates of abundance on the same ground were made from catch and effort data supplied by the commercial clam fleet. Population estimates at the beginning and end of the commercial dredge season, by stratified sampling were $18{,}148 \pm 5{,}704$ bu and $7{,}235 \pm 2{,}167$ bu respectively. By the DeLury method applied to commercial catch and effort data the initial population was estimated to be 21,880 bu, with limits of 18,170 and 28,510 bu. Good agreement between these estimates demonstrated that the rocking-chair dredge provides estimates well within the range of accuracy required for management of commercial fisheries. - J.L.M.

1585
Rutherford, Donald. 1975.

Oysters in hot water. Sea Frontiers 21(5): 273-280.

International Shellfish Enterprises, Inc., of Moss Landing, Calif., raises quantities of young *Crassostrea virginica* and *Mercenaria mercenaria* (not identified by scientific name in the article, but known from other sources). Local upwelling provides nutrients for growing planktonic algal foods, and stimulation of spawning and growth is provided by waste heat from a power plant. Oysters, which require 3 to 4 yrs to reach maturity in their native habitat, mature within 15 months at Moss Landing. Similar results have been obtained with clams and scallops. Growth rates of individuals from the same brood vary greatly, and runts are selected out, to provide a supply of uniform size. One problem encountered in starting the operation was to obtain approval from regulatory agencies. It was necessary to deal with 15 agencies. The attitude of representatives of many agencies was to restrict rather than to encourage. - J.L.M.

1586
Ryder, John A. 1889.

The byssus of the young of the common clam (*Mya arenaria* L.). Am. Nat. 23(265): 65-67.

This apparently was the first published observation that *Mya* originally attaches by a single byssal thread. *Mercenaria (Venus) mercenaria* is not mentioned, but it is suggested that other bivalves may attach by the same method. (Abstracter's note: if the title had been cited correctly, we probably would not have been put to the trouble of searching out this paper.) - J.L.M.

1587
Ryther, J. H. 1954.

The ecology of phytoplankton blooms in Moriches Bay and Great South Bay, Long Island, N.Y. Biol. Bull. 106: 198-209.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1588
Ryther, John H. 1969.

The potential of the estuary for shellfish production. Proc. Natl. Shellf. Assn. 59: 18-22.

Hard clam is not mentioned specifically in this paper, but the principles discussed are pertinent. If shellfish were dependent on the organic matter produced in the volume of water in which they live, an annual yield of about 150 kg of meat per hectare would be possible. But because water containing food moves back and forth across shellfish beds or suspended cultures, yields can be much higher. Successful bottom culture utilizes organic production from nearly 50 times the growing area, Japanese raft culture from 500 times, and Spanish mussel culture 5,000 times the area. Intensive and extensive culture cannot be carried out in the same estuary. - J.L.M.

1589
Ryther, John H. 1971.

Recycling human wastes to enhance food production from the sea. Envir. Letters 1(2): 79-87.

An algal farm of 50 acres, operated in conjunction with a shellfish farm of one acre, would be capable of providing tertiary sewage treatment for a population of 11,000 people and could produce a by-product of one million pounds of meats of commercial shellfishes. - J.L.M.

1590
Ryther, J. H. 1974.

Fish and shellfish pathology. Smithson. Sci. Info. Exch., Inc., Washington, D.C.

Smithsonian Sci. Info. Exchange quoted price of $90. Search terminated. - J.L.M.

1591
Ryther, J. H. 1975.

Preliminary results with a pilot plant waste recycling marine aquaculture system. Woods Hole Ocean. Inst., NOAA Office of Sea Grant, WHOI 75-41, NOAA 04-4-158-5, 61 p.

Bivalve mollusk culture was unsuccessful in the 1st yr of operation. - from ADP abstract received through interlibrary loan. - J.L.M.

1592
Ryther, John H. 1975.

Mariculture: How much protein and for whom? Oceanus, Winter 1975, 18(2): 10-22.

This is a general discussion of the problems associated with mariculture. The principal difficulty, according to the author, is how to cut the cost of food, which accounts for 25-50% of total operating costs. There is hope for success, but it has not yet been achieved in the United States. - J.L.M.

1593
Ryther, John H. 1976.

Marine polyculture based upon natural food chains and recycled wastes. In Marine Resources Development and Management. A Report on the Woods Hole Oceanographic Institution Sea Grant Program for July 1975-June 1976. NOAA Sea Grant 04-6-158-44016. Dean F. Bumpus (coordinator): 2-5.

Emphasis was on phytoplankton-bivalve-seaweed culture. Control of phytoplankton species that appeared was not possible. *Phaeodactlyum tricornutum* dominated cultures most of the time. Temp is the single most important controlling factor determining species. Mean ash-free dry weight yields ranged from 3 g/m^2/day in winter to 9 g/m^2/day in summer. *Mercenaria mercenaria* did not grow significantly in 18 months, although some other bivalves grew well. - J.L.M.

1594
Ryther, John H. 1976.

Marine polyculture based on natural food chains and recycled wastes. Woods Hole Oceanogr. Inst., Woods Hole, Mass., Tech. Rept. WHOI-76-92. U.S. Dept. Commerce, Natl. Tech. Inf. Serv. PB-261 939: 1-18.

Concept of the system is to grow unicellular marine algae in mixtures of seawater and effluent from a secondary sewage treatment plant. Algae grown in continuous flow-through culture are fed to oysters, clams, scallops, or mussels. Winter flounder and lobster are stocked as postlarvae or juveniles to feed on feces and pseudofeces produced by bivalves, and on small invertebrates supported by the wastes. Seaweeds provide a final polishing stage, removing nutrients regenerated by excretion and metabolism of animals, and remaining nutrients not initially removed from wastewater by phytoplankton. In 1st year of operation shellfish culture raceways were stocked with large numbers of juvenile or seed American oysters and hard clams *(Mercenaria mercenaria)*. These failed to grow significantly and most died during the following 18 months. It was concluded that the phytoplankton, predominantly *Phaeodactylum tricornutum*, was inferior and unsuitable as food. The problem was solved indirectly by using exotic bivalve species which did well in the system. - J.L.M.

1595
Ryther, John H., and John E. Bardach. 1968.

The status and potential of aquaculture, particularly invertebrate and algae culture. Vol. 1, Pt. I. The status and potential of aquaculture, by John H. Ryther and John E. Bardach. Pt. II. Invertebrate and algae culture, by John H. Ryther. U.S. Dept. Commerce, Natl. Tech. Info. Serv., PB 177 767, 261 p.

The report does not deal specifically with culture of *Mercenaria mercenaria*. Part II, Chap. 1. Culture of the American oyster on Long Island, New York, describes hatchery techniques for raising seed oysters, and mentions that in the winter of 1966 10 million seed clams were produced experimentally in the G. Vanderborgh and Son hatchery (now Long Island Oyster Farms Inc). - J.L.M.

1596
Ryther, J. H., and W. M. Dunstan. 1971.

Nitrogen phosphorus and eutrophication in the coastal marine environment. Science 171: 1008-1013.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1597
Ryther, John H., and Kenneth R. Tenore. 1976.

Integrated system of mollusk culture. In Harvesting Polluted Waters. O. Devik (ed). Plenum Press, New York: 153-167.

Discusses in general the environmental requirements of mollusks with respect to their potential for mariculture in heated effluents. Considerations relating to type of power plant and its future level of operation also are discussed. Food supply is equally as important as temperature if the project is to succeed. References to *Mercenaria mercenaria* are contained in papers abstracted elsewhere in this bibliography. - J.L.M.

1598
Ryther, J. H., W. M. Dunstan, K. R. Tenore, and J. E. Huguenin. 1972.

Controlled eutrophication, increasing food production from the sea by recycling human wastes. BioScience 22: 144-152.

Mercenaria mercenaria is not mentioned. - M.W.S.

1599
Ryther, John H., Joel C. Goldman, Cameron E. Gifford, John E. Huguenin, Asa S. Wing, J. Philip Clarner, Lavergne D. Williams, and Brian E. Lapointe. 1975.

Physical models of integrated waste recycling-marine polyculture systems. Aquaculture 5: 163-177.

The system is described in detail, and some preliminary experimental results described. Mollusks held in the system were seed clams *(Mercenaria mercenaria)* approximately 1.25 cm long, and seed oysters. Juvenile bait worms *(Nereis virens)* were introduced to feed on clam biodeposits. Performance was to be reported separately. - J.L.M.

1600
Saddler, James B., and Frieda B. Taub. 1972.

Chemical variability of algal shellfish feeds. Proc. Natl. Shellf. Assn. 62: 6-7 (abstract).

Controlling the levels of NO_3 and PO_4 in nutrient medium used for algal culture controls protein level, total lipid level, and composition of algal fatty acids. *Chlamydomonas reinhardtii* were grown in defined inorganic media with initial concentrations 5 mM NO_3, 0.04 mM PO_4 to 0.025 mM NO_3, 0.002 mM PO_4. Decreased NO_3 and PO_4 concentrations reduced cell yield, but total lipid content/algal cell was greatest at 0.5 mM NO_3 and 0.04 mM PO_4. High and moderate levels of these two nutrients gave similar fatty acid compositions, but when these amounts were reduced major changes were seen in algal fatty acid composition. Saturated fatty acids 16:0 decreased from 31 to 23%, and 20:0 decreased from 4 to 2%, stearic acid increased from trace amounts to a max of 12% at lowest NO_3 and PO_4 concentrations. Fatty acid 16:3 decreased from 4 to less than 1% and 18:4 decreased from 20 to 3%, while C-20 and C-22 polyunsaturates increased from trace amounts to a max of 21%. The result was an increase in percentage of long chain fatty acids, especially polyunsaturates. In continuous culture *Monochrysis lutheri* has considerably larger amounts of polyunsaturates than *C. reinhardtii*. Responses of different algal species to growth conditions are similar. Therefore, it can be expected that the increase in C-20 and C-22 PUFA observed for *C. reinhardtii* at low NO_3-PO_4 concentrations will also be true for *M. lutheri*. No mention is made of individual species of bivalve, but this knowledge will be useful to shellfish hatchery operators. - modified authors' abstract - J.L.M.

1601
Saila, Saul B., and Thomas A. Gaucher. 1966.

Estimation of the sampling distribution and numerical abundance of some molluscs in a Rhode Island salt pond. Proc. Natl. Shellfish Assoc. 56: 73-80.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1602
Saila, S. B., and S. D. Pratt. 1973.

Mid-Atlantic Bight Fisheries. In Coastal and offshore environmental inventory, Cape Hatteras to Nantucket Shoals. Mar. Exp. Sta., Grad. School of Oceanogr., Univ. Rhode Island, Mar. Pub. Ser. 2: 6-1 to 6-125.

(Abstract of hard clam section only: 6-30 to 6-34) Range is from Gulf of St. Lawrence to Gulf of Mexico in shallow bays and coves. Southern quahog, *M. campechiensis*, extends north to Point Pleasant, N.J., and is almost completely oceanic. Second most valuable mollusk fishery in Middle Atlantic Bight in 1960s. At age one year and length one cm almost all have mature male gonads. By end of second year approximately 50% become sexually mature females. Spawn from late spring to mid-August at temperatures above 20°C. In salinity 27°/°° and water temperature 25-30°C larvae set by end of 7 days. Under natural conditions setting probably takes longer. Hard clams are filter feeders. Maximum growth is in summer. Clams enter the fishery at age 2 to 3 years and about 3.5 cm long. After setting, clams burrow into bottom, usually sand or sand-clay. Juveniles and young adults are prey to crabs, lobster, and snails. Adults are more resistant. Hard clam can resist high levels of water pollution and can survive low oxygen. Large numbers may be found in polluted waters, where competitors, predators, and man may offer little threat. In New York by 1970 about 157,000 acres of clam beds were closed to shellfishing. Research on management strategies is needed now. - J.L.M.

1603
Saila, S. B., J. M. Flowers, and R. Campbell. 1965.

Applications of sequential sampling to marine resource surveys. Ocean. Sci. Ocean Eng. 2: 782-802.

Decisions on sample sizes traditionally have been predetermined, based on characteristics of a single sample. Sequential analysis, developed during second world war, relies upon information gathered during a survey to determine optimum sample size on basis of numbers of organisms taken and their variability. The method is here illustrated from data gathered in surveys of distribution and abundance of *Mercenaria mercenaria*, presumably in Rhode Island waters, with a construction bucket and a Fall River dredge. The negative binomial distribution fitted data gathered with the bucket; standard towed dredge data followed the normal distribution. In marine resource surveys, areas of interest are large and heterogeneous with respect to environmental variables. Even in relatively uniform areas hard clams tend to cluster. A large area must be subdivided into as many uniform subareas as required, if this sampling plan is to be effective. The sequential plan is then applied to each subarea. Data may be combined or averaged as necessary. Greatest advantage of the method is to save time. - J.L.M.

1604
Saila, S. B., J. M. Flowers, and M. R. Cannario. 1967.

Factors affecting the relative abundance of *Mercenaria mercenaria* in the Providence River, Rhode Island. Proc. Natl. Shellf. Assn. 57: 83-89.

In the Providence River, R.I., hard clam was more abundant in areas in which average sediment grain size was greater than 2 mm diameter and carbon content of sediment relatively high. Clam distribution was contagious. Other factors measured: pH, cation exchange capacity, total N, available P, and water depth (max. 30 ft), were not highly associated with clam abundance. Much of the observed difference in abundance may have been caused by predation or other variables not measured. Sediment properties alone did not predict clam abundance with high precision. Stringer found 588,000 bu of hard clams in 3,534 acres in 1956. A later survey (1965) estimated 1.3 million bu. - D.L. and J.L.M.

1605
Saila, S. B., T. T. Polgar, and A. B. Rogers. 1968.

Results of studies related to dredged sediment dumping in Rhode Island Sound. Proc. Annual NE Reg. Antipoll. Conf.: 71-78.

This paper could not be obtained either through interlibrary loan or from Dr. Saila's office. - J.L.M.

1606
Salchak, Anthony, and Jeff Haas. 1971.

Occurrence of the northern quahog, *Mercenaria mercenaria*, in Colorado Lagoon, Long Beach, California. Calif. Fish Game 57(2): 126-128.

The only recorded introduction of *Mercenaria* in southern Calif. was at Newport Bay in 1940, but there is no evidence that it was successful. Introductions into northern and central Calif. waters have had varying degrees of success. There are no records of introductions into Colorado Lagoon. Its presence was first recognized in 1967, and a survey was made in 1969. Of 267 specimens taken, the dominant size range was 20 to 40 mm max dimension, with extremes of 8 to 101 mm. Specimens 60 mm and larger were found at 1/3 of 31 stations, suggesting that the colony was well established. - J.L.M.

1607
Saloman, Carl H., and John L. Taylor. 1969.

Age and growth of large southern quahogs from a Florida estuary. Proc. Natl. Shellf. Assn. 59: 46-51.

Age and growth of *Mercenaria campechiensis* from Boca Ciega Bay, Fla. were estimated from external growth lines and from transverse shell sections. The largest clam was 172 mm (6.8 in) long and weighed 2,110 g (4.6 lb), the second largest 169 mm and 2,485 g. Two large dead clams measured 179 and 173 mm. The oldest live clam was estimated to be 20 yrs old, but the largest shell was only 14 yrs. Growth is rapid, but very old clams decrease in shell length and height with increasing age as shell margins recurve and become thick or blunt. A clam exceeds 50% of its expected height at 22 yrs in its 3rd yr and over 70% by the time it reaches age 5. An average length of 38-67 mm is reached early in the 2nd yr (littleneck), 68-77 mm by end of 2nd yr (cherrystone), and above 77 mm in 3rd yr (chowder). - J.L.M.

1608
Sanders, H. L. 1956.

The biology of marine bottom communities. Chapter X in Oceanography of Long Island Sound, 1952-1954. Bull. Bingham Ocean. Coll. 15: 346-414.

Mercenaria mercenaria is mentioned as present (46 individuals weighing 0.036 g/m^2) west of Charles Island, but not discussed in text. - J.L.M.

1609
Sanders, Howard L. 1958.

Benthic studies in Buzzards Bay. I. Animal-sediment relationships. Limnol. Oceanogr. 3: 245-258.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B.

1610
Sanders, H. L. 1960.

Benthic studies in Buzzards Bay. III. The structure of the soft-bottom community. Limnol. Oceanogr. 5(2): 138-153.

Mercenaria mercenaria is not mentioned. - J.L.M.

1611
Sanders, Howard L., J. Frederick Grassle, and George R. Hampson. 1972.

The West Falmouth oil spill. I. Biology. Woods Hole Oceanogr. Inst., Tech. Rept. 70-20, 23 p., tables.

Bivalves were essentially missing from samples taken in fall, winter, and spring of 1969-70. Shells of recently killed clams *(Mya arenaria ?)* were present in fall samples. Two *Gemma gemma* were the only living clams in a sample taken on 21 Sept 1969, 5 days after the oil spill. The last sample analyzed, on 1 March 1971, contained a single quahog *(Mercenaria mercenaria)* less than a year old. This was an intertidal station. At station 9, farther seaward, a sample on 18 Dec 1969 contained a single living *Callocardia morrhuana*. The 8 April 1970 sample had none. On 13 July 1970, 28 bivalves of 5 species, but no *M. mercenaria*, were present. By 11 Aug 1970 the sample contained 2,467 members of 16 species, including 4 *M. mercenaria*. - J.L.M.

1612
Sanders, H. L., P. C. Mangelsdorf, Jr., and G. R. Hampson. 1965.

Salinity and faunal distribution in the Pocasset River, Massachusetts. Limnol. Oceanogr. 10 (suppl.): R216-R229.

Only one specimen of *Mercenaria mercenaria* was taken. - J.L.M.

1613
Sanders, H. L., E. M. Goudsmit, E. L. Mills, and G. E. Hampson. 1962.

A study of the intertidal fauna of Barnstable Harbor, Massachusetts. Limnol. Oceanogr. 7(1): 63-79.

Mercenaria (Venus) mercenaria was present, but was not a major element in the biological economy of the area. The only discussion of the species was in the authors' concluding remarks: "... the average fisheries biologist is hardly aware that species other than the commercial clams *Venus mercenaria* and *Mya arenaria* exist in Barnstable Harbor where neither is a major element ... Evidence has been presented which shows that the abundance of *Mya* in Barnstable Harbor may largely be determined by biological competition with other species. The naive practice in applied fisheries biology of studying a commercial species in complete isolation from its biological environment can never lead to an understanding or even an insight of the problem. No species in nature lives in a biological vacuum. Broad, detailed, and many-dimensional community investigations represent the only practical approach to a proper understanding of applied fisheries problems." (Abstracter's note: I cannot disagree with the wisdom of this statement. Experienced fishery biologists are not so naive as to believe that fishery problems are that simple. However, fishery research and management do not exist in a socio-political vacuum, either. Socio-political forces are also a part of the fishery-ecological environment and they introduce constraints equally as important and difficult as biological, physical, and chemical factors.) - J.L.M.

1614
Savage, N. B. 1976.

Burrowing activity in *Mercenaria mercenaria* (L.) and *Spisula solidissima* (Dillwyn) as a function of temperature and dissolved oxygen. Mar. Behav. Physiol. 3(4): 221-234.

Burrowing activity was utilized as a measure of ability of *Mercenaria mercenaria* and *Spisula solidissima* to cope with extremes of temperature and dissolved oxygen. A zone of optimum activity was seen, above and below which burrowing declined with changing temp. Optimum for *Mercenaria mercenaria* was 21°-31°C. Optimum for *Spisula* was 16°-26°C. Ability of *Mercenaria* to burrow, when exposed to oxygen impoverished conditions (less than 1 mg O_2/l of seawater) for up to 3 wks, was not severely or permanently impaired. *Spisula* was much less tolerant of low oxygen. - J.L.M.

1615
Sawyer, David B. 1950.

II. Feeding activities of the boring snail, *Polynices duplicata*. Third Rept. on Investig. of Methods of Improving the Shellfish Resources of Mass.: 16-17.

This paper deals only with soft clams. At 70°F ten snails destroyed 202 of 300 clams available in 30 days, or 0.67 clams per day. At 50°F the rate of consumption dropped to one-fifth. One pound of snails had to consume 20 to 25 lbs of clams or other food. - J.L.M.

1616
Scarpelli, Dante G., and Aaron Rosenfield (eds.). 1976.

Molluscan pathology. Mar. Fish. Rev. 38(10): 1-50.

This preface, and the brief papers that follow it are the proceedings of a workshop held 3-5 Sept. 1975 at Wye Institute, Md. Papers that contain specific information on *Mercenaria mercenaria* are abstracted elsewhere in this bibliography. It was concluded, among other things, that lesions resembling neoplasms occur in bivalves in nature, but that their identity has not always been interpreted correctly. Careful laboratory experimentation is needed. - J.L.M.

1617
Schapiro, Harriette C., James F. Steenberger, and Zoe A. Fitzgerald. 1977.

Hemocytes and phagocytosis in the American lobster, *Homarus americanus*. In Comparative Pathobiology. Vol. 3. Invertebrate Immune Responses. Lee A. Bulla, Jr. and Thomas C. Cheng (eds.). Plenum Press, New York: 127-133.

Using suspensions of hemocytes in hemolymph from the clam *Mercenaria mercenaria* Foley and Cheng (1975) found that all hemocyte types interact with bacteria. They concluded that one cell type, the granulocyte, was of greater importance in phagocytosis. Bacteria were found adhering to hemocyte surfaces and in phagosomes. *In vitro* phagocytosis of bacteria by hemocytes of *Mercenaria mercenaria* was accompanied by "degranulation" of hemocytes, with concomitant release of lysozyme (Cheng et al. 1975).- J.L.M.

1618
Schecter, V. 1941.

Experimental studies on the eggs of the clam, *Mactra solidissima*. J. Exp. Zool. 86: 461-480.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

1619
Schelske, C. L. 1964.

Ecological implications of radioactivity accumulated by molluscs. Ecology 45: 149.

Search terminated - incorrect reference. - J.L.M.

1620
Scher, Stanley. 1955.

A review of the nutritional biochemistry of marine pelecypods. In 7th Rept. Investig. Shellf. Mass., Mass. Dept. Natural Resources, Div. Mar. Fish: 21-35.

This comprehensive review paper deals with bivalve mollusks generally, under the headings: inorganic nutrition; organic nutrition; metabolism of carbon compounds; enzymatic degradation of dietary carbohydrates; the tricarboxylic acid cycle; terminal oxidation; enzymatic degradation of dietary nitrogen compounds; decomposition of metabolic nitrogen compounds; metabolism of lipids; and growth factors. Eighty references are given; those which cite *Venus mercenaria* specifically are abstracted elsewhere in this bibliography. - J.L.M.

1621
Schiemenz, P. 1895.

Wie offen die Seestern Austern? Mittheil. Deutsch. Seefisch. 12(6): 102-118.

According to Lavoie (1956) Schiemenz demonstrated experimentally that valves of *Venus verrucosa* could be separated by a pull of 900 g, but a clam held by tube feet of *Asterias* could be released only if the pull were more than 1,000 g. He concluded that a sea star could exert a pull greater than that which could be sustained by *Venus*. Lavoie pointed out that Schiemenz had measured only the adhesive capacity of the tube feet, and did not show that the sea star could also open bivalves by muscular force alone. - J.L.M.

1622
Schiemenz, P. 1895.

How do starfish open oysters? J. Mar. Biol. Assn. U.K. 4: 266.

Postulates that the sea star opens clams by sheer force. - from Burnett, Ecology 41(3), 1960 - J.L.M.

1623
Schlieper, C. 1968.

High pressure effects on marine invertebrates and fishes. Mar. Biol. 2: 5-12.

Mercenaria mercenaria is not mentioned. - J.L.M.

1624
Schmeer, Sister M. Rosarii, O.P. 1963.

Chemical and biological characteristics of growth-inhibiting agents from *Mercenaria mercenaria* extracts. Biol. Bull. 125(2): 390-391 (abstract).

Of a series of mollusks tested, *Mercenaria* yielded the most promising results in antitumor activity on Sarcoma 180 (Sa 180) and Krebs 2 ascites tumor, propagated in the form of ascites and implanted as solid tumor in Swiss albino mice. In early experiments *Mercenaria* extracts inhibited growth of Sa 180 in dilutions in which extracts had no toxic effect. All controls died within 10 days; treated animals all survived for 6 months, when they were sacrificed. The mice produced normal litters and showed no tumor recurrence. In recent studies *Mercenaria* extracts also were active against Krebs 2 tumor. Extracts in higher concentrations were toxic, perhaps from presence of K, which could be eliminated by dialysis. One "unit" of antitumor activity can be extracted from 80-100 mg wet weight of *Mercenaria* tissue, and approximately 10,000 units from 1 kg wet weight. The active agent or agents can be extracted with water. Saturation (20%) with ammonium sulphate did not precipitate antitumor agent, but most of it was precipitated between 25% and 70% saturation with ammonium sulphate. The active principle was thermostable, and antitumor properties were not destroyed by lyophilization at -65°F. Partial purification on Sephadex G-100 columns suggested a molecular weight less than 100,000 g. - J.L.M.

1625
Schmeer, M. Rosarii. 1964.

Growth-inhibiting agents from *Mercenaria* extracts: chemical and biological properties. Science 144: 413.

Aqueous extracts of *Mercenaria mercenaria* have a regressive and inhibiting effect on sarcoma 180 and on Krebs 2 carcinoma in Swiss albino mice. The active agent is not precipitated by 20 to 25% saturation with $(NH_4)_2(SO_4)$, but greater concentrations decrease the yield of active agent. When extract is treated with 4 volumes of methyl alcohol chilled to -20°C, and extract chilled to +2°C, 70% of activity can be extracted. At room temp 15 to 20% of activity is in the supernatant. The agent is destroyed by boiling at 100°C for 25 min. Activity is decreased by heating at various temps above 50°C for 25 min, but 100% of activity is retained at 37°C. It is non-dialyzable and lyophilization at -20°C does not destroy antitumor activity. Lipids do not appear to be responsible for the activity. Dilutions effective against sarcoma 180 were not toxic. Controls died within 10 days after implantation of tumor, treated animals were still healthy and normal in 6 months. Treated animals showed no recurrence of tumors and produced normal litters. In treatment of Krebs-2 ascites tumor, extracts in concentrations higher than those used (one unit in total volume of 0.25 ml) were toxic. Toxicity was probably caused by K and could be eliminated by dialysis. Methods of preparation and partial purification of crude extract are described. Partial purification appeared to give almost pure inhibitor. In summer the agent was 8 to 9 times as concentrated in *Mercenaria* than during the rest of the year. - J.L.M.

1626
Schmeer, M. R. 1964.

Mercenene: Growth-inhibitor extracted from molluscs. Effects on Sarcoma-180 and Krebs-2 carcinoma. Seminar Natl. Inst. Health, D.B.S. 24 Sept 1964.

Could not locate. Search terminated. - J.L.M.

1627
Schmeer, M. Rosarii. 1966.

Mercenene: Growth-inhibiting agent of *Mercenaria* extracts. Further chemical and biological characterization. Ann. N.Y. Acad. Sci. 136(9): 213-218.

A more purified extract of *Mercenaria mercenaria* containing the active agent mercenene had a regressive and inhibiting effect on Krebs-2 solid carcinoma in Swiss mice. Histological examination of tumors treated for 7 days (1 unit of activity administered/day) showed healing tissue as compared with necrotic tissue of controls. The data suggest that mercenene has a low molecular weight. An earlier suggestion that the tumor-inhibitory principle is a volatile derivative of methylglyoxal would appear improbable. - modified author's summary - J.L.M.

1628
Schmeer, M. R. 1966.

Mercenene: Cytopathologic effects on Krebs-2 carcinoma in CF 1 mice, HeLa (Atl) and human amnion (FL) cell lines. Cancer Chemother. Rept. 50(9): 655-658.

Krebs-2 tumors, implanted as a solid carcinoma in CF 1 inbred mice, were treated with a water extract of fresh, raw *Mercenaria* including fluid inside the valve. Injections of mercenene were made subcutaneously (sc) once a day for 7 days. Eight days after initial treatment, antitumor agent caused 3- to 4-fold regression of tumor in treated animals as compared with controls. At least 80% of treated mice taken at random for longevity studies had no observable tumor at the implantation site by the 21st to 28th day, while all control animals were dead by 28 days. Six months later, cytologic study of treated animals confirmed the absence of tumor cells. In vitro studies with HeLa (Atl) and human amnion (FL) cells showed cytotoxicity in HeLa cell cultures but no toxicity in the amnion line. - modified author's abstract - J.L.M.

1629
Schmeer, Sister Arline Catherine (formerly published as M. R. Schmeer). 1968.

Mercenene clam extract: effects on the population kinetics of an experimental carcinoma and a non-neoplastic tissue. Biol. Bull. 135(2): 434-435.

Mice with 4-day-old Krebs-2 solid carcinoma were given 7 daily injections of mercenene. Experimental and control animals were sacrificed 24 hrs after each daily injection of clam extract, so that the last groups killed had received 7 doses and had 11-day-old tumors. Examination led to the conclusion that mercenene, under the conditions of the experiment, has no effect on kinetics of the progenitor compartment of duodenum (a non-neoplastic tissue) of tumor-bearing mice. Clam extract does act as an oncolytic agent against cells of Krebs-2 carcinoma by preventing cells from entering the DNA synthetic period. The extract was non-toxic to amnion cells. It is extremely significant to have an anticancer agent that is selective in killing only neoplastic cells *in vitro* and *in vivo.* - J.L.M.

1630
Schmeer, Sister Arline C. 1969.

Mercenene: an antineoplastic agent extracted from the marine clam *Mercenaria mercenaria.* In Neoplasms and Related Disorders of Invertebrate and Lower Vertebrate Animals. Natl. Cancer Inst., Monog. 31. Govt. Print. Off., Washington, D.C.: 581-591.

An anti-cancer agent, mercenene, is present in mollusks, especially in *Mercenaria mercenaria.* Mercenene may be ingested by the clam and then may be extracted readily through the extraction process. Another possibility is that some food material undergoes a change *in vivo*, giving an active anti-cancer principle. The source is not known. Crude aqueous extracts of mercenene were administered to cancerous mice for 7 days. Six months later the mice were killed and examined for tumors and tumor cells. Mercenene was never toxic. Young scar tissue was seen, but no tumor cells persisted. These mice had produced normal offspring, while controls died in 21-28 days. Clam tissues with most promising tumor-inhibiting activity were the crystal body (crystalline style ?) and liver. Chemical composition of mercenene has not been determined. - J.L.M.

1631
Schmeer, M. Rosarii, and Grace Beery. 1965.

Mercenene: A preliminary investigation of the cytological effects of this anti-tumor agent extracted from *Mercenaria mercenaria* on the Krebs-2 carcinoma. Biol. Bull. 129(2): 420.

Mercenene, a growth-inhibitor extracted from edible molluscs, and in particular the quahog, *Mercenaria mercenaria,* has been studied *in vivo* and *in vitro* for the cytological effects it produces on the solid Krebs-2 carcinoma tumor (K-2) in CF1 mice and monolayer cultures of HeLa and normal human amnion lines grown on sterile glass. An extract was prepared as reported earlier, and injected subcutaneously into mice that had previously received 25-30 million ascites K-2 cells. Control or untreated animals received 0.25 ml. physiological saline in the same dosage schedule as the treated groups. On the eighth day after initial treatment was begun, tumors from all treated and untreated mice were excised and prepared for light microscopy investigation. Many tumors from repeated experiments were studied. Among the observations made, it was noted that the treated mice had smaller tumors, and that sections of these tumors showed a great infiltration of fibroblasts, fewer mitotic cells, less necrosis, small numbers of white blood cells as compared with control or untreated tumors, little polyploidy, normal nuclear-cytoplasmic ratio, and few cells with enlarged nuclei usually predominant in the K-2 tumor. HeLa cell cultures showed a 4+ degeneration in 48-72 hours after initial treatment with Mercenene, while normal human amnion cells showed little to no degeneration for the same period of time. - Entire article, as published, except for acknowledgments. - J.L.M.

1632
Schmeer, M. Rosarii, and Grace Beery. 1965.

Mercenene: Growth-inhibitor extracted from *Mercenaria campechiensis*. *In vivo* and *in vitro* activity. Biol. Bull. 129(2): 420-421.

It has been previously reported that a growth-inhibitor called Mercenene was extracted from a species of edible clam, *Mercenaria mercenaria*. This clam is very abundant in Rhode Island and Cape Cod marine waters. Testing our theory that the growth-inhibitor may be due to some special feeding habit of the animal, we tested another species of *Mercenaria*, *Mercenaria campechiensis*, that is relatively abundant south of the Chesapeake Bay area. Water extracts of the fresh, raw clam were prepared in an identical procedure used for the preparation of extracts of *M. mercenaria*. Previously implanted CF1 mice received 0.25 ml of various concentrations of the extract, each day for seven full days. Control, untreated animals had an identical dosage schedule, but received, in place of the extract, 0.25 ml physiological saline. On the eighth day after initial treatment with Mercenene, the Krebs-2 carcinoma tumors were excised and weighed. Control animal tumors were also weighed at the same time. It was observed that a 25% concentration of the water extract induced the greatest regression and inhibition of tumor. *In vitro* investigations using the HeLa and normal human amnion cell lines suggest a toxic effect on the HeLa lines, with very little or no degeneration of the human amnion cell line. The presence of Mercenene in an additional species of edible clam may indicate a selective feeding habit, or it may suggest that the clam ingests some agent or agents in the marine environment, changes it *in vivo*, and produces a chemically modified principle that possesses anticancer activity. - Entire article as published. - J.L.M.

1633
Schmeer, M. Rosarii, and Grace Beery. 1965.

Mercenene: Growth-inhibitor extracted from the clam *Mercenaria campechiensis*. A preliminary investigation of *in vivo* and *in vitro* activity. Life Sci. 4: 2157-2163.

Mercenaria mercenaria had the greatest concentration of antitumor material of all mollusks studied to date. Availability of clams, low cost, ease in handling extract, and stability under usual conditions, make hard clam an attractive potential source of antitumor material. However, the known capacity of hard clams to concentrate materials present in the environment suggested that clams used in previous experiments might have been ingesting something from Massachusetts waters that was the source of the antitumor principle. Consequently, it was decided to investigate the closely related southern species of *Mercenaria* from waters south of the Chesapeake Bay area. (Abstracter's note: although it is not stated, it might have been in the minds of the researchers that substances derived from water pollution might have been responsible for the antiviral properties of *M. mercenaria* and that such substances would be less likely to be present in clams from less-polluted southern waters.) Extracts from *M. campechiensis* showed antitumor activity similar to that produced by extracts of the northern species. Treated mice showed evidence of inhibition and regression of carcinoma. There was no evidence of toxicity, such as weight loss, appetites appeared normal, eyes were clear, and coats of hair healthy. Control mice with implanted tumors showed all symptoms characteristic of controls in previous experiments with *M. mercenaria*. HeLa cells were completely degenerated by clam extract in 72 hrs. (Abstracter's note: some of the 10 papers cited are abstracted elsewhere in this bibliography. Because titles are not included in the list, we made no attempt to locate and read the others.) - J.L.M.

1634
Schmeer, M. R., and G. Beery. 1966.

Mercenene: Some observations of cytological effects *in vivo* and *in vitro*. (Cited as in preparation in 1966.)

Could not locate. Search terminated. - J.L.M.

1635
Schmeer, Sister M. Rosarii, O.P., and Rev. J. D. Cassidy, O.P. 1966.

Mercenene: Preliminary analysis of induced focal changes in the Krebs-2 carcinoma fine structure. Biol. Bull. 131(2): 405-406.

Mercenene was extracted from *Mercenaria*, purified, and administered to 4-5 week old female CF1 mice implanted with Krebs-2 carcinoma. After 7 days, autopsy and tumor biopsy were performed on half the treated mice and all untreated animals. The remaining 45 treated mice were held for 6-month longevity study. Examination of nuclei, nucleolar apparatus, membranes, Golgi zone, mitochondria, endoplasmic reticulum, and RNP particles of untreated cells showed no changes. In mercenene-treated tumor cells changes were observed in polysomes, free ribosomes, nuclear envelope, and nucleolar apparatus. Quantitative alteration by mercenene at these sites suggested possible antagonism of protein metabolism in cancer cells. Induced oncolysis, reflected in fine-structure changes, could further elucidate the antitumor activity of mercenene. Cytochemical studies were underway to test this hypothesis. - J.L.M.

1636
Schmeer, M. Rosarii, and Cecilia V. Huala. 1965.

Mercenene: *In vivo* effects of mollusk extracts on the Sarcoma 180. Ann. N.Y. Acad. Sci. 118(15): 603-610.

Mercenaria mercenaria, *Ostrea virginica*, *Busycon canaliculatum*, *Loligo* sp., and a land snail (*Helix* sp.) were tested as possible sources of antitumor agents on Sarcoma 180 in Swiss albino mice. Extract was prepared from ground mollusk meats, with sterile water. Test animals receiving *M. mercenaria* extract had greatest increase in body weight but smallest tumor size. Mice receiving mollusk extracts were less irritable than controls. Tumor growth in controls produced marked increase in weight, and these animals had poor appetites. *Mercenaria* extract had greatest antitumor activity. By 10th day all control animals were dead. Preliminary tests suggested that mollusk extracts were non-toxic. Between 80 and 100% of all experimental lots treated with *Mercenaria* extract survived until sacrificed 6 months later. All produced normal litters of offspring. - J.L.M.

1637
Schmeer, M. Rosarii, and Charles G. Wilber. 1965.

Mercenene: Growth-inhibitor extracted from natural products. Federation Proc. 24: 403 (abstract 1514).

Extracts from edible mollusks inhibit development and cause regression of sarcoma 180 and Krebs-2 carcinoma tumor in Swiss mice. Of all mollusks studied, *Mercenaria* was the most promising source of mercenene. The active agent, in crude form, can be extracted with water, ammonium sulphate, and organic solvents. Additional purification produces an effective active principle which inhibits growth of Krebs-2 carcinoma in 3-4 week old female CF1 mice. Typical mean control tumor weight was about 2,200 mg. Mice receiving mercenene for 7 days had a mean tumor weight of 750 mg. Molecular weight of active principle was less than 1000. - J.L.M.

1638
Schmeer, M. Rosarii, Derek Horton, and Akio Tanimura. 1966.

Mercenene, a tumor inhibitor from *Mercenaria:* Purification and characterization studies. Life Sci. 5(13): 1169-1178.

Preparations from tissue of *Mercenaria mercenaria* possess demonstrated *in vivo* antitumor activity, ascribed to presence of a biologically active principle named mercenene. In purified preparations mercenene is slowly dialyzable, heat stable, and highly active in tissue culture against human HeLa cancer cells. Samples from 10 independent preparations had these percentage elemental compositions: C 5.9-6.9; H 4.8-5.8; N 10.1-13.2; P 0.1-0.15; S 15.7-16.7; ash (as sulphate) 41.7-42.6%. X-ray powder diffraction patterns of solid samples revealed lines of moderate intensity corresponding to ammonium sulphate and sodium chloride, with a complex pattern of sharp lines indicating a crystalline, organic substance. Tentative estimates of molecular weight were in the range 280-550. Desalted, exhaustively dialyzed mercenene probably has a glycopeptide-type structure, possibly associated with a small proportion of protein. An earlier proposal that the tumor-inhibitory principle of mercenene is a volatile derivative of methylglyoxal appears improbable. - J.L.M.

1639
Schmitt, F. O., R. S. Bear, C. E. Hall, and M. A. Jakus. 1947.

Electron microscope and X-ray diffraction studies of muscle structure. Ann. N.Y. Acad. Sci. 47(6): 799-813.

When molluscan adductor muscles, including those of *Venus*, are macerated with KCl a viscous mass is obtained from which may be prepared a suspension of needle-shaped fibrils readily observed with a dark field microscope. This fibrous protein forms a considerable portion of the muscle substance. Solubility properties of this protein differ from those of myosin. To distinguish this protein from myosin it has been given the name *paramyosin*. Unstained paramyosin fibrils appear mottled under the electron microscope, but when they are stained appropriately a structure of great regularity is observed. The whole structure presents a lattice containing an axial periodicity 5 times that of the band separation of transverse bands, or 5x145=725A. If a line is drawn through any spot representing a transverse band, parallel to the axis, other spots on this line will be separated by 5 bands. If clam adductor muscles are macerated in Edsall's solution (in which paramyosin fibrils dissolve), fibrous bundles of another type may be obtained by centrifugation. These bundles are composed of fine filaments closely resembling myosin filaments of skeletal muscle. Closely adhering to the filaments are dense particles which are frequently aligned to give a cross-striated appearance to the bundles. Axial distance between striations is about 1,100A. It seems probable that myosin components are contractile in these muscles, as they are in striated vertebrate skeletal muscle, although there is no morphological evidence that paramyosin fibrils actually shorten. They may have a role in the clutch mechanism (ability to remain shortened for a long time with minimal expenditure of energy). Except for those features characteristic of paramyosin and collagen, when present, X-ray diffraction patterns of a wide variety of striated and smooth muscles are essentially the same and therefore have been attributed to the myosin filaments. Differences in structure at the light microscope level of resolution are not reflected in X-ray structure of myosin components. Further advances in understanding the contractile mechanism from the structural approach requires more information about internal organization of myosin filaments. - J.L.M.

1640

Scholander, P. F. 1960.

Oxygen transport through hemoglobin solutions. Science 131(3400): 585-590.

In studies of steady-state diffusion of air at various pressures through hemoglobin solutions nitrogen diffused in proportion to pressure, but rate of oxygen transport was greatly enhanced and apparently proceeded by 2 additive processes. One was regular diffusion through the solvent (water), which was proportional to pressure; the other was specific transport mediated by hemoglobin molecules at a rate constant over a wide pressure range. At low tensions the process may transport "over eight times more oxygen" than does straight diffusion. Myoglobin and a few other pigments *in vitro* have the same property. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1641

Schreiber, Robert A. 1973.

The fishes of Great South Bay. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N. Y., 199 p.

The Bay produces important amounts of shellfishes, especially hard clam *(Mercenaria mercenaria)*. Hard clam production has been rising steadily since the mid-1950s (latest year 1970), and most has come from Great South Bay. This species accounts for more than 50% of the total value of all fishes and shellfishes landed in New York. - J.L.M.

1642

Schroeder, William C. 1920.

Clam resources of the Ten Thousand Islands, Fla. U.S. Bu. Fish., Econ. Circ. 46, 5 p.

This paper was not examined, on the assumption that the gist of it was contained in Schroeder (1924), which is abstracted in this bibliography. - J.L.M.

1643

Schroeder, William C. 1924.

Fisheries of Key West and the clam industry of southern Florida. Rept. U.S. Commr. Fish. for 1923, Appendix 12, Doc. 962, 74 p.

Key West was settled in 1822, and fishing has been one of its principal industries. Hard clam, *Venus mercenaria mortoni*, does not occur at Key West, but the clam industry of southwest Fla. is of great importance. The largest bed of clams in the U.S. was in the region of the Ten Thousand Islands off the southwest coast of Fla. The bed was about 40 mi long and 5 mi wide and contained nearly 150 mi^2 of clam-producing grounds. The southern part of the bed was about 70 mi from Key West and could be reached from there in less than 24 hr in a small sailboat. Small landings of quahog at Key West are caused by lack of local demand. From 1889 to 1915 annual landings of clams at Key West varied from 10 to 25 thousand clams. In 1918 two fishermen with a single boat were the only clam fishermen. They landed 38,000 clams. Fla. hard clam *(V. mercenaria mortoni)* resembles New England quahaug *(V. mercenaria)* closely. Adults of southern clam are larger and have a heavier shell; a weight of 2 lbs is not unusual. The species has 3 types: thick-lipped, thin-lipped, and intermediate. Dead clamshells were very abundant in some parts of the ground, and mortality has been attributed to dredging. The author concluded that the mortality was natural, possibly caused by sudden salinity changes. Estimates of abundance on various beds are given. Clams were harvested by hand-digging in the intertidal zone, or in shallow water, by the method known as treading. The clam dredge used had teeth at intervals on a moving belt, mounted on a large, houseboat-like vessel 90 ft long by 20 ft wide. The dredge and method of operation are described in detail. Except for small amounts landed at Key West, most clams were canned in 2 canneries, at Marco and Caxambas, Lee County. Packs were little-neck clams, steamed clams, minced clams, clam chowder, and clam juice. Processing is described in detail. It was concluded that the clam resource of southern Fla. could withstand a larger harvest. Principal constraints were inaccessibility of the resource and remoteness from northern markets. - J.L.M.

1644
Schubel, J. R., and D. J. Hirschberg. 1978.

Estuarine graveyards, climatic change, and the importance of the estuarine environment. Estuarine Interactions. Academic Press, Inc.: 285-303.

Perhaps the most diagnostic indicators of ancient estuarine deposits are the remains of "estuarine" organisms like *Mercenaria mercenaria*, which are not living, and which may be misleading. McHugh has recently questioned the basis from which he and others had inferred estuarine-dependence, noting that at least one author had questioned the merits of spending large sums on management of hard clam, which is fated eventually to diminish greatly in abundance, if not to diminish entirely, in the normal course of events. Some well-intentioned but overzealous environmentalists have laid great stress on the importance of estuaries for survival of many important species. It would appear that such evaluations cannot be justified; which is not to say that estuaries are unimportant. - J.L.M.

1645
Schwartz, N., H. E. Gaffney, M. S. Schmutzer, and F. D. Stefano. 1963.

A method for the analysis of chlorinated benzenes in clams *(Mercenaria mercenaria)* and oysters *(Crassostrea virginica)*. J. Assn. Official Agric. Chem. 46(5): 893-898.

Polystream, a mixture of chlorinated benzenes, has been shown to be effective in controlling predators on shellfish grounds. It was desirable to determine residues of Polystream present in *Mercenaria mercenaria* and *Crassostrea virginica* after treatment. The compound was extracted with n-hexane-isopropanol followed by gas chromatographic separation. The method can detect quantities as small as 10^{-10} g. Average recovery of added Polvstream was 99% for clam samples and 104% (sic) for oysters. Recoveries were estimated by reading the 1,2,3,4-tetrachlorobenzene peak. Relative precision for triplicate chromatograms was $\pm$ 5%. Extraction recoveries under these experimental conditions, in which chlorinated benzenes were added to the macerated sample, do not necessarily represent conditions in exposed mollusks, where the compounds may be present in tissues. - J.L.M.

1646
Schwind, Phil. 1977.

Practical Shellfish Farming. Internatl. Mar. Pub. Co., Camden, Me., 112 p. (2. Quahogs: 18-34).

This is a rather general account, describing growth rate, importance of currents, substrate, predation, and planting methods with mature stock, seed clams, and raft culture. The value of this brief account to someone beginning with limited knowledge is questionable. - J.L.M.

1647
Seapy, R. R., and C. L. Kitting. 1978.

Spatial structure of an intertidal molluscan assemblage on a sheltered sandy beach. Mar. Biol. 46(2): 137-145.

No mention of *Mercenaria mercenaria*. - J.L.M. and M.W.S.

1648
Segal, Earl. 1961.

Acclimation in molluscs. Am. Zool. 1: 235-244.

Poikilotherms, including *Venus mercenaria*, do not regulate their body temp, yet show varying degrees of homeostasis of rate functions and shifts in tolerance levels in response to seasonal and latitudinal temp changes, in different parts of a microgeographic range, and in laboratory experiments. This compensatory response or acclimation has been demonstrated in various gastropods and pelecypods from land, sea and fresh water. All mollusks have a similar order-of-magnitude response. Most of this knowledge has come from eurythermal species, but insufficient data are available to deny that stenothermal species do not or are less able to acclimate. The compensatory adaptation might be pheno- or genotypic, but only a few species appear to be genotypic in this respect. The limit to which an animal may be acclimated is not necessarily the temp at which it will show its greatest ability to acclimate. In some animals there is much evidence that nervous and hormonal factors play a decided role. But acclimation of isolated tissues and certain enzyme systems points to the cell as the site of the mechanism. The nature of the mechanism is not known. - J.L.M.

1649
Segar, D. A., J. D. Collins, and J. P. Riley. 1971.

The distribution of the major and some minor elements in marine animals. Part II. Molluscs. J. Mar. Biol. Assn. U.K. 51(1): 131-136.

Specimens of *Mercenaria mercenaria* examined were from the northern side of the Solent, close to Lee-on-Solent, in southern England. Elemental composition of shells, expressed as ppm dried at 60°C, was: Fe 1,600; Mn 1.5; Co 1.2; Ni 2.4; Cd 0.80; Cu 1.7; Pb 0.43; Zn 3.4; Ag 0.21; Cr 0.37; Al 71; Na 5,700; K 230; Ca 330,000; Mg 48; Sr 170; and P 28. Composition of entire soft parts was: dry weight 20.0%; Fe 5,400; Mn 18; Co 4.3; Ni 11; Cd 2.1; Cu 25; Pb 18; Zn 94; Ag 1.3; Cr 0.79; Al 615; Na 17,000; K 11,000; Ca 3,200; Mg 2,700; Sr 13; and P 4,200. Concentration of major elements in soft parts of the 12 species examined was relatively constant, except for low Na in *M. mercenaria* and 2 others, and Ca in 2 species. - J.L.M.

1650
Selby, Cecily Cannan, and Richard S. Bear. 1956.

The structure of actin-rich filaments of muscles according to X-ray diffraction. J. Biophys. Biochem. Cytol. 2(1): 71-85.

A second type of fibrous muscle component, which is possibly of greater significance than paramyosin, was found in smooth and striated muscle from vertebrates and invertebrates. This was originally designated type II, but subsequent studies showed that it was an actin-rich fibrous system, if not composed of actin alone. Actin component was extracted from the "tinted" (red) portion of *Venus mercenaria* adductor muscle, which is richer than the "white" part in actin. From analysis of moderate- to small-angle X-ray diffraction patterns the structure and configuration of actin-rich filaments were deduced. - J.L.M.

1651
Seraichekas, H. R., D. A. Brashear, J. A. Barnick, P. F. Carey, and O. C. Liu. 1968.

Viral depuration by assaying individual shellfish. Appl. Microbiol. 16(12): 1865-1871.

Using *Mercenaria mercenaria* as experimental animals, individual clams were polluted with LSc 2ab strain of type 1 poliovirus by introducing virus in controlled amounts into the aquarium. Under controlled hydrographic conditions, uptake of virus by individual clams varied 10 to 100 fold. This explains the wide variability of viral contents of pooled samples. Although most clams were free of virus in relatively short time of depuration, some still harbored minimal amounts of contaminant. Presence of virus in some clams could be obscured by pooling samples. To simulate naturally polluted clams as closely as possible, some were exposed to minimal amounts of virus. These were cleansed more rapidly by the depuration process than clams polluted with more virus. Naturally polluted clams contained less virus than those studied in the laboratory; thus it was anticipated that naturally contaminated clams may be cleansed more rapidly. Infectious hepatitis virus was not available for laboratory study. It was suggested that field studies be made of the merits of depuration, to be accompanied by epidemiological studies of consumers. - J.L.M.

1652
Shah, H. C., C. M. Fontneau, and G. P. Carlson. 1971.

Drug metabolism in *Mercenaria mercenaria*. Pharmacologist 13(2): 268 (Abstract 431).

Drug metabolizing activity was investigated in the common quahaug, *Mercenaria mercenaria*. Whole homogenates of hepatopancreas were unable to carry out the detoxification of O-ethyl O-p-nitrophenyl phenylphosphonothioate (EPN), O-demethylation of p-nitroanisole, N-demethylation of aminopyrene or oxidation of hexobarbital. Nitroreductase activity was shown by the conversion of p-nitrobenzoic acid to p-aminobenzoic acid. A higher concentration of NADP than normally used for rat liver homogenates was necessary. The system was stimulated 4-fold by 10^{-4}M flavin mononucleotide but not by the addition of $MgCl_2$. The reaction was inhibited 47 per cent by 10^{-2}M KCN. Neither 10^{-3}M SKF-525A nor carbon monoxide inhibited the activity of the system. Over 90 per cent of the activity was found to be associated with the soluble fraction of the hepatopancreas. - entire abstract as published - J.L.M.

1653
Shaw, E., and D. W. Woolley. 1956.

Some serotoninlike activities of lysergic acid diethylamide. Science 124: 121-122.

Experiments were done on isolated heart of *Venus mercenaria* and on anesthetized dog. The authors attempted to repeat experiments by Welsh (1954), abstracted elsewhere in this bibliography, which reported that serotonin stimulated *V. mercenaria* heart and increased amplitude of beat, and that this action of the hormone was antagonized by LSD-25. Results were contradictory: instead of acting as an antiserotonin, LSD-25 acted like serotonin. Discussion with Welsh resolved the problem. The earlier experiment had been done with *V. mercenaria* from European waters. The U.S. species acted differently. On isolated hard clam heart from U.S. waters, LSD-25 acted like serotonin, and was more potent, weight for weight, than the hormone itself. Possession of a serotoninlike and an antiserotonin action need not be perplexing. Serotonin can be viewed as acting on tissues in combination with a receptor specifically designed to react with it. These receptors may vary slightly from tissue to tissue. In *V. mercenaria* heart LSD-25 not only combines with receptors, but is able to produce a serotonin-like effect presumably because the "fit" is good enough. Antiserotonin action of serotonin itself then may be pictured merely as combination of 2 or more molecules of serotonin with one receptor site, which is thus blocked because it has not combined with a single molecule. This is the classical picture of inhibition of an enzyme by an excess of its substrate. - J.L.M.

1654
Shaw, W. N. 1971.

Off-bottom growing techniques. Am. Fish Farmer and World Aquac. News 2(9): 16-21.

This article describes oyster culture. *Mercenaria mercenaria* is not mentioned. - J.L.M. and M.W.S.

1655
Shaw, William N. 1972.

Aquaculture of mollusks along the west coast of the United States. Bull. Am. Malacol. Union, Inc. 37: 23-24.

Commercial clam culture is very limited on the Pacific coast. Most clam landings are by recreational fishermen. Possibilities are recognized for culture of soft clam, razor clam, common littleneck and Japanese littleneck. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1656
Shaw, William N. 1974.

Aquaculture of molluscs along the United States Atlantic and Gulf coasts. NOAA Tech. Rept. NMFS Circ 388: 57-65.

American oyster, hard clam and bay scallop are discussed. *Mercenaria mercenaria* is distributed along the Atlantic coast and Gulf of Mexico. Peak production was 21 million lbs (of meats) in 1950, dropped to 14.2 million in 1955, and since has remained fairly stable at between 13.3 and 15.8 million. N.Y. is the leading producer. Va., N.J., N.Y., Mass., and R.I. together accounted for 91% of U.S. hard clam landings in 1970. In N.Y. the center of the resource is the south shore of Long Island in sheltered bays like Great South Bay. Gears include tongs, rakes, dredges, hoes, grabs, and by hand. In 1967 in N.Y. dredges, tongs, and rakes made the catch. The hydraulic escalator dredge was recently introduced (on private grounds only) and does little damage to clams or beds. This gear is also used in Chincoteague Bay, Md. The fishery appears to be in excellent condition although there is concern about water pollution. Of 450,000 acres of potential shellfish producing bottoms in N.Y. 156,892 acres are closed. Depuration is feasible and would cost about $1.76/bu. The most intensive efforts at propagation have been made on Cape Cod and Long Island. Clams are artificially spawned and reared in hatcheries to the seed stage, then transplanted to growing areas. Heavy losses from predation are a problem. In Va. a method has been developed to protect young clams from predation by spreading crushed oyster shell, crushed stone, or pea gravel on the bed and planting clams of match-head size at 25 to 50 clams/ft^2. Survival as high as 80% has been obtained by this method. One of the largest clam hatcheries is in N.C. Approximately 4 million larvae are produced per week, and reared to metamorphosis in about 2 wks, then placed in shallow trays mounted vertically in banks of 10 trays. The set is held in trays for 8 wks, then transferred to running seawater in concrete raceways. Seed clams measure 1 to 2 cm at 14 wks. When they reach 2.5 cm they are sold as seed clams or planted. In the U.S. many companies have tried molluscan aquaculture and failed. Coastal waters are used primarily for navigation and recreation, and access for aquaculture is limited. Costs are high, and profits will be possible only with high-priced species. In most states legal regimes favorable to development of aquaculture do not exist. Pollution, or the threat of it, also is a problem. It is hoped that these problems can be solved. - J.L.M.

1657
Sheldon, R. W. 1967.

Relationship between shell-weight and age in certain molluscs. J. Fish. Res. Bd. Canada 24(5): 1165-1171.

Mercenaria mercenaria was among seven species examined. It was assumed that annual growth is detectable by rings or annuli on the external surface of the valves, and age was determined in this way. A linear relationship of shell weight to age appeared to exist between ages of 2 and 8 years. Annual increments (estimated from fig. 2) were approximately 15 grams. Older clams were not available. The samples were obtained from Southampton Water on the south coast of England. - J.L.M.

1658

Shelton, R. G. J. 1971.

Two recent problems in oil pollution research. Internat. Council Expl. Sea, Fish. Improvement Comm., Copenhagen, 9 p.

Mercenaria mercenaria collected from an area of chronic oil and organic waste pollution and transferred to an unpolluted area showed the following amounts of contamination: as collected 16.0 μg/kg benzo (a) pyrene content; 7 weeks after transfer to an unpolluted area 8.2 μg/kg; 16 weeks after transfer 0.9 μg/kg, and >60 weeks after transfer 1.1 μg/kg. These results show that BP is not retained indefinitely, but is either metabolized or lost by solution in the water. Present results show that from the fisheries point of view sinking is not an ideal way of dealing with floating oil. - J.L.M.

1659

Shiber, John G., and Bryan Ramsay. 1972.

Lead concentrations in Beirut waters. Mar. Pollut. Bull. 1972: 169-171.

Venus mercenaria is mentioned onlv in citing Craig (1967) abstracted elsewhere in this bibliography. - J.L.M.

1660

Shimizu, Toshi, and Yohko Ohta. 1968.

Carotenoids in bivalves-III. Carotenoids in corb shell. Bull. Japan. Soc. Sci. Fish. 34(3): 210-213.

The lutein content of corb shell, *Corbicula japonica*, is 10 to 20 times more than hard clam. - from authors' English summary - (Abstracter's note: The text is in Japanese, and nowhere does the scientific name of the hard clam appear. The reference may be to a Japanese species.) - J.L.M.

1661

Shrubsole, G. W. 1885.

On the occurrence of *Venus mercenaria* (Linn.) in the estuary of the Dee. Proc. Chester Soc. Nat. Sci. 3: 111-112.

Heppell (1961) reported that Shrubsole found on the beach more than 100 single or double valves of *Venus mercenaria*. The shells were so fresh that the ligaments were perfect. It was estimated that they had not been dead more than a week or so. This finding in 1882 confirmed survival of clams stored in the area in 1879. From the size of some shells it was estimated that they were only a few months old. However, Heppell cited a letter from Shrubsole to Marrat (1883) which stated that the shells were 1 to 3 inches, and over. Thus, they did not prove that successful spawning had occurred. Shrubsole described the growing areas in the Mersey as sandbanks. - J.L.M.

1662

Shultz, Fred T. 1970.

Genetic potentials in aqua-culture. In Heber W. Youngken, Jr. (ed.). Food-drugs From the Sea, Proceedings 1969. Mar. Tech. Soc., Washington, D.C.: 119-134.

Papers dealing with *Mercenaria mercenaria*, abstracted elsewhere in this bibliography, are cited, but no specific mention is made of hard clam. - J.L.M.

1663
Shumway, S. E. 1977.

Effect of salinity fluctuation on the osmotic pressure and Na^+, Ca^{2+} and Mg^{2+} ion concentrations in the hemolymph of bivalve molluscs. Mar. Biol. 41(2): 153-177.

Mercenaria mercenaria was not investigated. All species studied were osmoconformers. Responses of some species were different when valves were closed than when open. Reference is made to work on *M. mercenaria* by Hoyeaux et al. (1976), abstracted elsewhere in this bibliography. - J.L.M.

1664
Shumway, Sandra E., Peter A. Gabbott, and Arthur Youngson. 1977.

The effect of fluctuating salinity on the concentrations of free amino acids and ninhydrin-positive substances in the adductor muscles of eight species of bivalve molluscs. J. Exper. Mar. Biol. Ecol. 29(2): 131-150.

Eight bivalve molluscan species, including *Mercenaria mercenaria*, were used as test animals, normal and wedged open. Hard clam showed an initial increase in concentration of ninhydrin-positive substance (NPS) in adductor muscle during exposure to decreasing salinity, then a fall in NPS level. These changes were repeated during the second cycle. Increased NPS concentration always occurred as salinity declined, but the subsequent fall in NPS took place immediately following the initial rise in hard clam and some other species, later in the cycle in others. Hard clam was capable of sustained tonic closure, and in normal animals the NPS increase was measured after shell closure had occurred. Wedged-open clams also showed an increase in NPS, at the same time as closed animals. Normal hard clams showed an increase in total free amino-acid (FAA) especially glycine content of adductor muscle tissue after 3 hrs in a sinusoidal salinity profile, but no significant change in NH_3. Species like hard clam, oyster, and mussels tend to close their valves when external osmotic concentration reaches a critical level and remain closed until the concentration rises. These species also are less strongly euryhaline than *Scrobicularia plana* and *Mya arenaria*. Valve closure will produce tissue hypoxia, and this could account, partly at least, for observed increases in the FAA pool. At the same time, reductive amination of keto-acid intermediates will prevent accumulation of ammonia. It is suggested that NPS and FAAs are used as osmotic effectors in marine bivalves exposed to constantly lowered salinities, but are not used for the same purpose under cyclic salinity changes. - J.L.M.

1665
Shuster, Carl N., Jr. 1954.

A method for recording measurements of certain molluscs, arthropods, and fishes. Prog. Fish-Culturist 16(1): 39-40.

The method includes enclosure of graph paper within a protective jacket of aluminum foil. - J.L.M.

1666
Shuster, Carl N., Jr. 1957.

On the shell of bivalve mollusks. Proc. Natl. Shellf. Assn. 47: 34-42.

Shells usually were prepared for sectioning by embedding in gypsum and cutting with a hacksaw or carborundum circular saw. Cut edges were smoothed on a glass plate covered with water and carborundum powder and polished with cleansing powder. Some shells were treated with diluted HCl or CH_3COOH. The laminated structure of *Mercenaria mercenaria* shell is clearly visible. Prominent laminae of translucent material in the inner portion of the shell pass to the outer surface through two regions of opaque shell of different color and texture. The outer opaque region is cream-colored and not as hard as the inner. Purple pigment, when present, is prevalent in the translucent part. Within the outer edge of the translucent shell, conchiolin and periostracum seemed to be joined, or the periostracum is deeply imbedded in the translucent material. Translucent laminae are deposited in periods of slow growth, opaque layers when growth is rapid. - J.L.M.

1667
Shuster, C. N. 1959.

Biological evaluation of the Delaware River estuary. In State of Delaware Intrastate Water Resources Survey. J. G. Smith et al. (eds.). William N. Cann, Wilmington, Del. vol. 21: 1-73.

A paper with similar title and approximately the same number of pages appeared as Info. Ser., Pub. 3, Univ. Del. Mar. Lab. - J.L.M.

1668
Shuster, Carl N., Jr. 1959.

A biological evaluation of the Delaware River estuary. Univ. Del. Mar. Lab., Info. Ser. 3, 77 p.

Mercenaria mercenaria is dredged in winter in Delaware Bay. In Rehoboth and Indian River Bays hard clams are taken with tongs year-round. From 1950 to 1956 the harvest averaged 629,143 lbs of meats/yr for which clammers received an average of $207,616. Average landed values were about $3/bu. Most grounds were in Kent County, where average harvest was 1.66 bu/acre. (Abstracter's note: this is a very small yield; it is not clear whether this is an average for the entire area of bottom or for producing clam grounds only.) In Sussex County (Rehoboth and Indian River Bays) large volumes of Delaware River-diluted ocean water enter on every flood tide, causing large changes in the environment. Clam beds cover about 17,000 acres. Rakes are used as well as tongs, all year. Average yields were 17.3 lbs of clam meats/acre/yr as compared with 15 lbs/acre in Delaware Bay. One bu of live clams produces about 9 lbs of meats. Recreational clammers took an estimated 614,600 hard clams in two 12-week periods in summer, 1952 and 1953. The estimated numbers of recreational clammers was 11,325/yr. They spent 43,000 hrs clamming and took an average of 7 clams/hr. Out-of-State residents took about 70% of this harvest. A spot check in Rehoboth and Indian River Bays by fishery wardens showed that about 250 people clammed/day on weekdays, 400 on holidays and weekends. Average harvest was 100 clams/person, and it was estimated that over one million clams could have been taken in 1957 by sport clammers. This was about 3 times the catch estimated in 1952-53. It was not certain whether this difference was caused by an increase in sport-clamming effort, or whether survey methods were not comparable. - J.L.M.

1669
Shuster, Carl N., Jr. 1966.

A uniquely shaped quahog. Maritimes, Univ. R.I., 10(2): 14.

A three-inch long *Mercenaria mercenaria* had asymmetrical and unequal valves. The only scientific paper describing such a clam dealt with southern quahog, *M. campechiensis*. A few such specimens are in museums, but none seen by the author had such extreme asymmetry as this Narragansett Bay clam. - J.L.M.

1670
Shuster, Carl N., Jr. 1967.

Resume of the Natl. Conf. on Depuration, U.S. Dept. Health, Educ., Welfare, Northeast Research Center, Narragansett, R.I.: 1-11.

Contains numerous references to *Mercenaria mercenaria* without great detail. - J.L.M.

1671
Shuster, Carl N., Jr. 1969.

A three-ply representation of the major organ systems of a quahaug. Atl. States Mar. Fish. Comm., Marine Resources of the Atlantic Coast, Suppl. to Leaflet 14 (Miller et al.- Hard Clam), 8 p.

Relative positions of major organ systems of hard clam are printed on heavy stock, back to back, so that three sections can be cut out, folded, arranged in sequence, and stapled in the hinge area. The result is a sequence of visualisations from exterior to interior of the clam, with all major structures labelled. Drawings are of professional caliber. This is a useful guide to hard clam morphology. - J.L.M.

1672
Shuster, Carl N., Jr. 1971.

The hard clam and soft clam of the western Atlantic coast. Ann. Repts. (1970) Am. Malacol. Union: 13-15.

Mercenaria mercenaria and *M. campechiensis* were important foods and artifacts to Indians. Quahaug valves were broken and the pieces ground into cylindrical beads. This strung wampum or shell-money had different values. Dark, purple-colored beads were worth twice as much as white beads. Sections of crenulate shell margin were pressed against moist clay to form designs on pottery. Hard-clam production averaged 14.3 million lbs of meats/yr in the period 1959-1968. New York was first with 5.4 million lbs, followed in order by N.J., R.I., Va., and Mass. Other states produced minor amounts. Intertidal populations provided popular sport fisheries. Hand gears for hard clam include hoes, rakes, bullrakes, and tongs. Power dredging is more efficient. (Abstracter's note: it is not mentioned that in most areas power dredging is permitted only on leased grounds.) Hard and soft clams sometimes coexist, but not with each in abundance. Their ecologies obviously are somewhat different. Soft clam ranges from the Canadian maritimes to N.C., northern hard clam principally from Maine southward, and southern quahaug, which has commercial offshore populations, from N.J. to Gulf of Mexico. Spawning is in early summer when critical temp thresholds are reached, and as temp drops in fall a second spawning may occur. The 2 *Mercenaria* species easily hybridize in the laboratory. Spawning can be induced easily in conditioned quahaugs. Eggs of hard clam have a gelatinous envelope. Fertilization is in the surrounding water. Within 2 hrs, depending on temp, the 2-celled stage is reached. Food, turbidity and salinity also affect rate of development. In about 12 hrs at room temp a microscopic ciliated trochophore larva hatches. Soon shell secretion begins and a straight-hinged, shelled larva is formed. As the veliger enlarges, the shell changes shape and an umboned larval stage is reached. The next stage is transitional, alternatively swimming or creeping over the substrate. Metamorphosis is most common at 200-215 μ shell length, the velum is lost and the byssus gland becomes active. Byssus production stops when the young clam is about 9 mm long. The juvenile mantle secretes shell material over its entire surface, forming a laminated structure in which most deposition is at the shell edges. A prominent growth ring on the surface of the shell is associated internally with a prominent layer of translucent material in cross-section, which marks a time of abrupt cessation of shell growth. This can be a hibernation mark, or a record of a shorter term disturbance such as a heavy storm. The oxygen-isotope method allows determination of water temp at the time shell material was deposited. Clams, especially young, are active burrowers. Shell, water jets, and synergistic-antagonistic relations between hinge, muscles and hemocoel all take part in burrowing. A special mucus-secreting region of the mantle allows hard clam to expel mud, even when out of water. Largest clams reported were: northern quahaug 6 1/8 in long, 2.5 lbs live weight; southern species 6 5/8 in and 6.5 lbs. *Mercenaria* occasionally has asymmetrical shell anomalies or a bifurcated siphon. - J.L.M.

1673
Shuster, Carl N., Jr. 1975.

The thermal component of Atlantic coast estuarine environments. Proc. 10th Ann. Conf., Mar. Tech. Soc. (1974): 629-638.

Mentions a report by Sung Y. Feng in 1967 at the 1st Natl. Conf. on Depuration (apparently unpublished) which demonstrated a 3-dimensional pattern of behavior of *Mercenaria mercenaria* within a matrix of salinity and temp. Salinity and temp were plotted on x and y coordinates and clam responses on the z axis. The diagram showed a mound of activity, in which all activity stopped beyond the broad outline of the base of the mound, and maximum activity formed a plateau at the peak of the mound. Such multidimensional analyses provide a more realistic view of ecological interactions than single-factor analyses. - J.L.M.

1674
Shuster, Carl N., Jr., and Albert F. Eble. 1962.

Techniques in visualization of organ systems in bivalve mollusks. Proc. Natl. Shellf. Assn. 52: 13-24.

Three-dimensional representation of organ systems greatly increases the ability of the observer to visualize ramifications and relationships to other parts. Details are given of tested methods for embedding and sectioning of shell and entire specimens, rubber molds of shell cavity, and vinyl acetate injections of vascular and digestive systems, with subsequent plastic embedding and sectioning of corrosion and cleared preparations. - modified authors' abstract - J.L.M.

1675
Shuster, Carl N., Jr., and Benjamin H. Pringle. 1968.

Effects of trace metals on estuarine mollusks. Proc. 1st Mid-Atlantic Industrial Waste Conf., Univ. Delaware, CE-5: 285-304.

Magnitudes of present trace metal levels were measured by atomic absorption spectrophotometer in 100 samples of *Crassostrea virginica*, *Mercenaria mercenaria* and *Mya arenaria* from Maine to N.C. Uptake of trace metals by these bivalves was measured for up to 20 weeks in the laboratory by exposure to controlled flows of seawater containing specific concentrations of trace metals. Trace metal levels in the oyster have increased slightly over the last 35 years. No earlier data for comparison were available for clams. The general pattern of toxicity to hard clam, from greater to lesser effects, was copper, cadmium, chromium,and zinc. At environmental levels of 0.025 to 0.5 ppm copper for periods up to 15 weeks the concentration in quahaug tissues increased moderately. At 0.1 and 0.2 ppm cadmium, concentration in quahaug tissues increased as much as 21-fold in 5 weeks. At 0.1 ppm lead, concentration in quahaug tissues increased 86-fold, and at 0.2 ppm lead 171-fold in 5 weeks. At 0.01 ppm chromium, concentration in quahaug tissues rose about 2.4-fold in 10 weeks. Trace metal levels in quahaug from natural environments ranged from 11.5 to 40.2 ppm per kg of wet tissue weight for zinc, 1.0-16.5 for copper, 9.0-83.0 for iron, 0.7-29.7 for manganese, 0.10-0.73 for cadmium, 0.1-7.5 for lead, 0.19-5.8 for chromium, 0.1-2.4 for nickel,and 0.1-0.2 for cobalt. Levels in oysters were higher than in clams for zinc, copper, iron,and cadmium, but about the same order of magnitude for manganese, lead, chromium, nickel,and cobalt. Accumulation studies led to the following conclusions: 1) species differ in uptake and concentration of a given metal; 2) duration of exposure affects uptake rate and tissue level; 3) temperature and physiological condition are related to uptake and concentration; and 4) apparent toxicity of a metal for a species may determine uptake, concentration, and duration of the experiment. Limited data suggested that zinc-exposed quahaugs produced more purple-shell than controls or those exposed to cadmium. Mortalities of 8 quahaug populations exposed to 2 concentrations of 4 metals differed from oyster experiments in several ways. Extreme mortalities (62 and 74%) occurred in 0.025 and 0.05 ppm copper within 15 weeks. Only one clam died in controls. No quahaug exposed to zinc died. Cadmium-exposed quahaugs died in substantial numbers, 23% in the 0.2 ppm experiment. Uptake is a function of water temperature. - J.L.M.

1676
Sidwell, Virginia D., James C. Bonnet,and Elizabeth G. Zook. 1973.

Chemical and nutritive values of several fresh and canned finfish, crustaceans, and mollusks. Part I. Proximate composition, calcium, and phosphorus. Mar. Fish. Rev. 35(12): 16-19.

Proximate composition of hard clams *(Mercenaria mercenaria)* was as follows: mean ± standard error, range, and number of analyses; 91.8 ± 0.1, 90.8-92.5, 20 for moisture in g%; 4.41 ± 0.17, 3.20-6.24, 19 for crude protein in g%; 1.97 ± 0.02, 1.79-2.16, 20 for ash in g%; 0.21 ± 0.02, 0.10-0.42, 20 for ether fat in g%; 65 ± 3, 20-91, 31 for Ca in mg%; and 69 ± 3, 50-130, 26 for P in mg%. - J.L.M.

1677
Sidwell, Virginia D., Audrey L. Loomis, Pauline R. Foncannon,and David H. Buzzell. 1978.

Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. IV. Vitamins. Mar. Fish. Review 40(12): 1-16.

Clams of the family Veneridae contained the following vitamins, (averages, range, number of averages used): A 1,124±237, 887-1,360, 2 I.U: Ascorbic acid 14.2±1.1, 13.1-15.2, 2 mg; Thiamin 100±33, 10-240, 7μg; Riboflavin 381±147, 20-940, 7 μg; Niacin 2.9±0.6, 1.1-5.0, 6 mg; B_{12} 3.9±1.7, 2.2-5.6, 2 μg. - J.L.M.

1678
Sidwell, Virginia D., Audrey L. Loomis, Karen J. Loomis, Pauline R. Foncannon, and David H. Buzzell. 1978.

Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and molluscs. III. Microelements. Mar. Fish. Rev. 40(9): 1-20.

Clams *(Venus)* contained 4.3 (0.0-19.2) 10 averages Cu, 59.6 (16.0-130.0) 12 averages Fe, 27.5 (5.1-77.0) 11 averages Zn, 0.8 (0.2-1.4) 5 averages I, 0.1 (0.0-0.3) 18 averages Hg, 0.8 (0.2-2.6) 6 averages Pb, 2.0 (0.9-5.6) 8 averages As, 0.2 (0.0-0.6) 11 averages Cd, 0.3 Co, 0.6 Se, 0.3 (0.2-0.4) 5 averages Ch, 254.7 Al, and 0.6 Ni. The first figure is an average, figures in parentheses the range of averages, and third figure the number of averages. Where only one number is given there was only one determination. Sometimes the range is large because wide variations occur with season. - J.L.M.

1679
Sieling, F. W. 1956.

The hardshell clam fishery of Maryland waters. Md. Tidewater News 12(10), suppl. 9, 2 p.

Venus mercenaria supports a considerable commercial and recreational fishery along the seaside of Maryland (ocean side of the Delmarva Peninsula). Annual production is about 25 million clams, from Chincoteague and Sinepuxent Bays and adjoining waters. Md.ranked 7th in hard clam production on the Atlantic coast in 1948. Hard clams are found in muddy, sandy, or clay mixture bottoms from high tide to 50 or 60 ft deep in suitable salinity. They do not thrive in water less than 15°/°° salinity. They are absent in the Md.part of Chesapeake Bay except near the Virginia line and in the Pocomoke and Tangier Sound areas. Spawning in Md.usually begins about the first of June and lasts through Aug. Average length at the end of the first year is about 3/4". New

England hard clams reach only 1/4" in the same period of time. Growth remains more rapid in Md. waters. Growth stops when water temp drops below about 40°F, and begins again when temp rises above 50°F. Growth slows in the spawning season. Some important predators are blue crab, mud crab, cownose ray, moon snail, and conch. Clamming regulations are described, market sizes and prices are discussed, and methods of clamming discussed and illustrated. Life history and anatomy are described and illustrated. Research requirements are outlined. This is an informational bulletin for public education. - J.L.M.

1680
Simpson, Bob. 1964.

Artificial cultivation of clams, oysters, proved practical in N. C. laboratory. Natl. Fisherman 45(Aug. 1964): 13.

In the University's fisheries laboratory mature clams *(Mercenaria mercenaria)* are kept in tanks for about a month in controlled temperature water, near the normal spawning temperature. At the end of this conditioning period the temp is raised slightly for several hours and sperm is deposited in the tanks. This causes the clam to spawn. Eggs are held at fixed temp for two days until they become larvae. Algal cultivation is done in sterile water to reduce disease, and fed to the larvae in concentrated doses. As they grow they are transferred to larger trays, and at about 1/2 inch are placed in screened trays in the Sound. At about 3/4 inch they are placed in gardens to reach maturity. Survival after artificial rearing depends upon the care exercised. Silting, disease, severe temperature changes, excessive salinity change and predators will determine survival. - J.L.M.

1681
Simpson, John W., and J. Awapara. 1968.

The pathway of glucose degradation in some invertebrates. Comp. Biochem. Physiol. 18(3): 537-548.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1682
Simpson, John W., Kenneth Allen, and Jorge Awapara. 1959.

Free amino acids in some aquatic invertebrates. Biol. Bull. 117(2): 371-381.

Taurine was absent in every freshwater and terrestrial mollusk studied, but was present in detectable and measurable amounts in every invertebrate living in salt or brackish water, including *Venus mercenaria*. It was not possible to assign a definite role to taurine, but it was suggested that it plays a very important role as an osmoregulator. - J.L.M.

1683
Sims, Harold W., Jr. 1965.

Large quahog clams from Boca Ciega Bay. Quart J. Fla. Acad. Sci. 27(4): 348.

Live *Mercenaria campechiensis* 168 mm long and weighing 6 1/2 lbs, and 3 others 149.5, 155.5, and 160 mm long were taken at a point where water depth is 2 to 3 ft at normal low tides. Three of the 4 were new size records. - J.L.M.

1684
Sims, Harold W. Jr., and Randall J. Stokes. 1967.

A survey of the hard shell clam *(Mercenaria campechiensis)* (Gmelin) population in Tampa Bay, Florida. Fla. State Bd. Conserv. Mar. Lab., Spec. Sci. Rept. 17, 8 p.

Hard clam is widely distributed along the west coast of Florida and was very abundant in the early 1900s, but has since declined. One hundred stations were sampled one or more times along the entire shoreline by taking random samples with a commercial clam rake within an area of 1/4 mile diameter. Numbers of clams per man-hour varied from 1.0 to 276.0, sizes from 22.8 to 160.5 mm. Delineation of the extent and boundaries of larger beds was attempted by replicate sampling. One and three-inch-deep core samples were taken from the center of each station and sediments graded into eight standard particle sizes. Temperature, salinity, water depth, tidal condition, and bottom type data are given. Clam populations are located primarily in the lower portions of the Bay. Absence of significant numbers of clams from shallow areas of the upper bay are attributed to industrial pollution. The largest and most productive area appears to be lower Boca Ciega Bay south to Mullet Key, which is an area of good water flow and rich grass beds. Some yearly recruitment takes place in this region, for more than one year class was present in samples. No hard clams were found in Tampa Bay Inlet at Passage Key, but surf clams, *Spisula solidissima similis*, were abundant. Sediment texture varies with depth, but is uniform within a given depth range. Shallow water sediments in Tampa Bay had a dominant particle size of 0.25 to 0.10 mm (fine sand). There was no correlation of substrate particle size with clam population density. Large populations were associated with seagrass or coarse-grained sediment. Lower Boca Ciega Bay has the largest population of brood clams and must be preserved in its present state if large clam populations are to be sustained. Tampa Bay also could be an important producer if properly managed. - W.J.B.

1685
Sims, L. J., and T. Dirnberger. 1971.

A quantitative study of heavy metals in clams. Proc. Pa. Acad. Sci. 45: 20-23.

Could not locate. Search terminated. - J.L.M.

1686
Sindermann, Carl J. 1964.

The Bureau of Commercial Fisheries Biological Laboratory at Oxford: Present and future. U.S. Dept. Interior, Fish Wildl. Serv., Circ. 200: 8-17. In The Bureau of Commercial Fisheries Biological Laboratory-Oxford, Maryland: Programs and Perspectives.

Molluscan shellfishes of commercial importance in Chesapeake Bay include American oyster, soft clam, and *Mercenaria mercenaria*. Research at Oxford has included oyster, soft clam, and surf clam. No studies of hard clam are mentioned. - J.L.M.

1687
Sindermann, Carl J. 1971.

Predators and diseases of commercial marine mollusca of the United States. In Symposium on Commercial Marine Mollusks of the United States. Am. Malacol. Un., Inc., Ann. Repts. for 1970: 35-36.

This brief general summary mentions only oysters specifically. Predation and disease are among important impediments to full expression of biotic potential. These factors are partially density-dependent, and at times may be dominant influences on abundance or population size of commercial mollusks. Major predators are sea stars, flatworms, predaceous and parasitic snails, crabs, fishes, and cephalopods. Problems with drills have been intensified by promiscuous transfers and introductions of mollusks. Competitors like mud blister worms, barnacles, tube worms, and corals can affect growth and survival. Diseases have received most attention in oysters. Neoplasms are known in some bivalves, and nematode parasites have been found. Few mollusk diseases are transmissible to humans, but human disease may be caused by passive transfer of pathogens and chemicals from mollusks used as food, especially when eaten raw. Included are hepatitis, typhoid fever, paralytic shellfish poisoning, and insecticide and heavy metal poisoning. Development of cultural practices for certain commercial mollusks will require techniques for control of these and other environmental factors. - J.L.M.

1688
Sindermann, Carl J., and Aaron Rosenfield. 1967.

Principal diseases of commercially important bivalve Mollusca and Crustacea. U.S. Dept. Interior, Fish Wildl. Serv., Fish. Bull. 66: 335-385.

Mass mortalities of clams comparable to those of oysters and mussels have not been reported. Mass deaths may pass unnoticed in sediment-hidden clams, and this may be why information is scarce. Diseases and parasites known in clams are several protistan organisms, larval trematodes, larval cestodes, parasitic copepods, and tumors. The only record of infestation of *Mercenaria mercenaria* reported in this paper is of the parasitic copepod *Myticola porrecta* in a single hard clam from the Gulf of Mexico, described by Humes (1954), abstracted elsewhere in this bibliography. Commercial mollusks are known to suffer mass mortalities of epic proportions. More attention should be paid to such events and their causes, especially in bivalves other than oysters. - J.L.M.

1689
Sinitsin, D. F. 1911.

The parthenogenetic generation of the trematodes and their descendents (sic) in the Black Sea mollusks. Mem. Acad. Imp. Sci., St. Petersburg, Cl. Phys. Math., 8 ser. 30(5), 127 p. (Russian text.)

According to Stunkard and Uzmann (1958), abstracted elsewhere in this bibliography, Sinitsin described the digenetic trematode *Adolescaria perla*, mostly from near the gill plates of an unidentified species of *Venus*. - J.L.M.

1690
Smith, A. C., and M. C. Mix. 1978.

The effects of sodium chloride concentration on electrophoretic patterns of adductor muscle proteins from bivalve molluscs. Comp. Biochem. Physiol. 61B(1): 169-171.

Protein patterns obtained by electrophoresis showed that muscle extracted and dialyzed in 0.030 g% NaCl solution produced superior patterns. *Mercenaria mercenaria* was not used. - J.L.M.

1691
Smith, Carl C., and David Glick. 1939.

Some observations on cholinesterase in invertebrates. Biol. Bull. 77(2): 321-322 (abstract).

Of 6 marine invertebrate species examined, *Venus mercenaria* gave the lowest production of CO_2: hard clam heart 5.5 mm^3 CO_2 per 50 mg tissue in 30 min; *Modiolus demissus* highest with 304. Concentration of cholinesterase apparently follows roughly the amount of nervous tissue present. The insensitivity of clam heart to eserinization can be explained on the basis of the low eserase content found. - J.L.M.

1692
Smith, Carl C., and Louis Levin. 1938.

The use of the clam heart as a test object for acetylcholine. Biol. Bull. 75(2): 365 (abstract).

Details of the method are not given. The smallest concentration of choline to give a demonstrable inhibition of *Venus mercenaria* heart was 1:50,000. Acetylcholine (ACh) in a concentration of 1:1,000,000,000 produced a 50% reduction in amplitude of beat, from which the heart recovered quickly. In solutions of choline and ACh, in which choline was present in subminimal quantity, no effect on normal inhibition produced by ACh was observed. Sensitization by eserine was not needed. In the apparatus used, the least amount of choline which could be detected was 0.2 mg; the smallest amount of ACh which could be assayed was 0.00001 mg or 0.01 gamma. Hard clams are easily available and can be kept for long periods, which makes them suitable as a simple tool for bioassay of choline derivatives. - J.L.M.

1693
Smith, Christopher Field. 1979.

Aspects of hard clam management in Great South Bay, New York. Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Marine Environmental Sciences, Marine Sciences Research Center, State University of New York, Stony Brook, N.Y., viii+96 p.

The study considers standing stock, growth, mortality, fishing and natural, and recruitment in stocks of hard clam from Maine to Georgia, and derives estimates of low, medium, and high values for each. These are combined to produce a conceptual model of the probable status of the stocks of hard clam in Great South Bay, New York. The conclusion is that the stocks cannot stand an increase in exploitation rate, and that probably a reduction in fishing effort is warranted. The minimum size limit of one inch in thickness is examined and it is concluded that it is not too low to affect the success of reproduction. A larger biomass might be harvested if the limit were raised, but since the most valuable clams are the smallest ones, and since these are marketed by count rather than by volume, the lowest safe size limit would be best. There is not sufficient knowledge at present to say what this is, and it probably changes with time. There is also not adequate knowledge to determine at present whether hatchery techniques are feasible for large scale operation. - J.L.M.

1694
Smith, F. A., L. Ortolano, R. M. Davis, and R. O. Brush. 1970.

Fourteen selected marine resource problems of Long Island, New York: Descriptive evaluations. Traveler's Research Corp., Hartford, Conn., v+128 p.

Shellfishing is one of Long Island's oldest and most important marine industries. *Venus mercenaria* is the principal species. Hard clam is for the most part non-migratory, which is an advantage and a disadvantage. Intensive cultivation and management is possible, and this can be done under control of local jurisdictions. But the stock is critically dependent on maintenance of favorable habitat over the entire life cycle. Even temporary adverse conditions cannot be escaped. Hard clam landings in N.Y. about tripled from 1954 to 1968. The clam industry is a mixed operation engaged in by large companies with advanced harvesting equipment, by small-scale baymen, part-time and full-time using traditional methods, and as a family quasi-recreational pursuit. Some beds are privately owned or leased, others are public. Good natural sets have been the rule since the early 1960s, after severe hurricane damage in the 1960s. There is evidence of overharvesting in Huntington Bay public grounds on the north shore of L.I. Reduced productivity was not noted on leased grounds in Huntington Bay, nor on public grounds of south shore bays. Need for management, and perhaps limits on entry, is evident. About 10% of shellfish growing areas are closed for public health reasons. A limited, largely experimental program of transplanting clams to open areas was underway, but transplanting was estimated to add more than $2 per bu to total cost of product. The State has been operating a depuration plant, and improved domestic waste treatment and changes in methods of handling duck farm wastes were expected to improve the situation. L.I. shellfish production is capable of improvement, especially if aquacultural methods are adopted. Principal governmental agencies with developmental or regulatory interests are the State Bureau of Marine Fisheries, which can issue leases to State-owned bottom, issue permits for shellfishing, license processors and shippers, enforce regulations on seasons and size limits, close areas for sanitary reasons, and enforce regulations on harvesting, transplanting, and shipping of contaminated clams. The State does not have power to restrict commercial entry to public clam grounds or to directly regulate total harvest. Various town governments also may lease bottoms under their jurisdiction to private planters, and issue permits for harvesting in town waters. In interstate commerce, regulations are controlled by the National Shellfish

Sanitation Program of the U.S. Public Health Service, which determines water quality standards and sanitary quality of product. The Bureau of Commercial Fisheries of U.S. Dept. of the Interior is the primary research and development agency and collector of statistics. Knowledge of local environmental conditions as they relate to shellfish production is far from satisfactory. Standing crops and potential yield have never been measured satisfactorily. An inventory would be useful. Information on present scientific and technological knowledge should be compiled for application to solving problems of the Long Island shellfish industry. Some subjects requiring analysis are: 1) legal status of private and public rights to shellfish bottom and resources; 2) economic structure, organization and performance of the private shellfish industry; and 3) role and function of public agencies in regulating and managing the resource. - J.L.M.

1695
Smith, Hugh M. 1893.

Report on the fisheries of the south Atlantic states. Bull. U.S. Fish Comm. for 1891, Vol. XI: 271-356, pls. XLIII-LXXIV.

The only mollusk of commercial prominence was American oyster. *Venus mercenaria* was abundant in some areas, and small quantities were taken in N.C., Ga., and Fla. Reported landings of hard clam in 1890 were: N.C. 226,152 lbs, $12,090; Ga. 4,000 lbs, $300; Fla. 5,600 lbs, $350. Total landings were 29,469 bu. Landed values of the hard clam catch in 1880 were: N.C. $15,575, S.C. $3,300, Ga. $1,650, and Fla. $20,855. Clam landings are given also by counties. Figures for Fla. are for the east coast only; west coast landings were reported by Collins and Smith 1892 (1893), abstracted elsewhere in this bibliography. - J.L.M.

1696
Smith, J. E. (ed.). 1968.

"Torrey Canyon" pollution and marine life. A report of the Plymouth Laboratory. Cambridge Univ. Press, Cambridge, U.K., xiv+196 p.

In a sandy area at Marazion, in the vicinity of the contaminated area, several *Venus striatula* were found at mid-tide level. They were apparently healthy and not affected by oil or detergent. At St. Michael's Mount, 250 m offshore in water 2 m deep in coarse sand, dead and dying *Venus striatula* and several other species were found by divers. - J.L.M.

1697
Smith, M. 1937.

East Coast Marine Shells. Edwards Bros., Ann Arbor, Mich., 308 p.

The section on *Venus* appears to be identical with the 4th edition (1951), which is abstracted here. We have not seen the title page of this edition, which is probably the first. - J.L.M.

1698
Smith, Maxwell. 1951.

East coast marine shells. Edwards Brothers, Inc., Ann Arbor, Mich., 4th ed., revised, vii+314 p.

Class Pelecypoda, Order Teleodesmacea, Family Veneridae, *Venus mercenaria* Linne. Shell solid; umbones far forward and projecting nearly to front of shell, also elevated and curved; lunule rough and heart-shaped; blunt point at posterior end of shell; ridges crowded and most conspicuous at ends; interior white, often deep violet outside the muscular impressions; basal and interior margin crenulated. Length 3 inches or more. Many mutations, some hardly deserving separate names. These are produced by temp, food, kind of bottom, and salinity, and other environmental factors. In Pleistocene fossil beds of Sankoty Head, Nantucket Island, are shells remarkable for their variety, some without parallel among the recent species. Nova Scotia to Yucatan. *Venus mercenaria notata* Say has zigzag brown painting and usually lacks purple coloring. *Venus mercenaria subradiata* Palmer: the smooth middle portion of the disk shows fine and even radial lines between the concentric ones. *Venus mercenaria alba* Dall lacks purple coloration and has no brown markings. *Venus campechiensis* Gmelin: larger, rounder, much thicker shell than *V. mercenaria*, usually white inside and out; lower posterior angle of pallial line more acute, scalloping of inner margin finer, arrangement of cardinal teeth less fanlike; length 4 inches. Juvenile shell less convex than in other species, lunule and escutcheon brown with fine pale zigzag lines. Occasionally in the umbones cavity a pale purple tinge, which is lacking in *V. mercenaria*. Mutations are similar to those of *V. mercenaria* except that the center of the disk is never entirely smooth. Sometimes a trace of purple at margin. This is the persistent type beyond the Mississippi delta, especially in Texas. Abundant in Yucatan. Chesapeake Bay to Cuba. *V. campechiensis alboradiata* Sowerby has brown rays on a pale ground; Gulf of Mexico. *V. campechiensis quadrata* Dall has a thin shell, small, subquadrate, and uncolored. *Venus campechiensis texana* Dall has the concentric lines toward center of disk coalescent, ribs flat-topped with polished tops, valves usually extremely convex; Texas. - J.L.M.

1699
Smith, Osgood R. 1952.

Small clams move into a flat, see the sights, and move on. Maine Coast Fisherman 7(3): 20.

The species is not identified, but it is probably *Mya arenaria* rather than *Mercenaria (Venus) mercenaria*. The conclusions might apply to either species, however. The gist of the article is that abundance and distribution of newly metamorphosed clams do not necessarily provide a forecast of future abundance or distribution. During the stage in which they are attaching and reattaching by a byssus thread clams may move considerable distances and be resorted by attaching to loose marsh grass and other drifting debris. Many questions about distribution, abundance, and survival remain to be answered. - J.L.M.

1700
Smith, Osgood R. 1954.

The wanderings of small clams. Ann. Meeting Natl. Shellf. Assn., 12-14 Aug. 1952: 105-107 (date of publication estimated).

Large scale movements of recently set or juvenile *Mya arenaria* take place by rafting of newly set clams attached to algae or debris. Older juveniles are active and move laterally for considerable distances. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M.

1701
Smith, Rebecca Joyce. 1958.

Filtering efficiency of hard clams in mixed suspensions of radioactive phytoplankton. Proc. Natl. Shellf. Assn. 48: 115-124.

Removal of phytoplankton from suspension by *Mercenaria* was measured by labeling a species of *Carteria* with Ca^{45} and other types of phytoplankton with P^{32}. Clams varied from 80 to 88 mm long. Algal cells 2-3 microns in diameter are not removed as efficiently as larger cells in the same suspension. Algal cells 4 microns and larger are retained by the clam with the same efficiency. *Gymnodinium* sp. caused most clams to close soon after filtering began. Density of algal cells in suspension did not affect filtering efficiency of clams. - D.L.

1702
Smith, Sanderson. 1862.

On the Mollusca of Peconic and Gardiner's Bays, Long Island, New York. Ann. Lyc. Nat. Hist. N.Y. 7(20): 147-168.

Ninety-six molluscan species are reported from these two bays at the eastern end of Long Island. *Venus mercenaria* was moderately abundant, *Venus (Gemma) gemma* very abundant. - J.L.M.

1703
Smith, S. 1886-1887.

Catalogue of the Mollusca of Staten Island. Proc. Nat. Sci. Assn. Staten Island 1: 35, 50.

According to Jacot (1920), abstracted elsewhere in this bibliography, Smith listed 78 species. Inclusion of *Mercenaria (Venus) mercenaria* is not mentioned, but it is likely that it was collected. - J.L.M.

1704
Sowerby, G. B. 1842-1887.

Thesaurus conchyliorum, or monograph of genera of shells. 5 vols., illustr. London, Sowerby.

Listed for information only. - J.L.M.

1705
Spaulding, M. H. 1906.

A preliminary report on the distribution of the scallops and clams in the Chandeleur Island regions, Louisiana. Bull. Gulf Biol. Sta. 6: 29-43, chart.

The clam of the area is identified as *Venus mercenaria*. Largest specimens were about 6" long. The siphon is very short and clams are buried partially in the bottom, or with the posterior end of the shell barely showing at the surface. The hinge is always uppermost. They are found on almost any type of bottom which is not too soft or shifting. Slightly soft and tenaceous bottom with limited growth of vegetation apparently is best. No very small clams were found. On any particular bed clams were of nearly uniform size. Conchs and storms may be the greatest sources of mortality. The beds are described in some detail. They covered about 3 mi^2 and the author concluded that abundance could be increased and beds extended by artificial propagation. - J.L.M.

1706
Spinner, George P. 1969.

The wildlife wetlands and shellfish areas of the Atlantic coastal zone. Serial Atlas of the Marine Environment. Folio 18. Am. Geogr. Soc., New York, 4 p., 12 charts.

These show in a general way the distribution of *Mercenaria mercenaria* from Maine to Florida. Total estimated acreage of hard clam grounds is 1,123,000 acres. Distributions are very generalized and not sufficiently accurate to show abundance. - J.L.M.

1707
Spotte, S. H. 1970.

Fish and invertebrate culture, water management in closed systems. Wiley Interscience, New York, 160 p.

Mollusks are mentioned, but no specific references are made to any species. - J.L.M.

1708
Sprague, J. B., and J. R. Duffy. 1971.

DDT residues in Canadian Atlantic fishes and shellfishes in 1967. J. Fish. Res. Bd. Canada 28(1): 59-64.

Residues of DDT in whole meats of *Venus mercenaria* of average size 6.1 cm averaged 0.04 ppm (range 0 to 0.21), much lower than in some fishes. Residues of DDE averaged 0.01 (0.01 to 0.02). Differences between 4 sampling locations in Prince Edward Island and New Brunswick were not significant. There appeared to be no threat to the clam stocks, although the possibility of reproductive damage at some level of contamination should not be dismissed. No threat to human health from consumption of clams was recognized. - J.L.M.

1709
Sprague, Victor. 1970.

Some protozoan parasites and hyperparasites in marine bivalve molluscs. In A Symposium on Diseases of Fishes and Shellfishes. Stanislas F. Snieszko (ed.). Am. Fish. Soc., Washington, D.C. Spec. Pub. 5: 511-526.

Nematopsis veneriis has been found in gills of *Venus fasciata* in France. *N. ostrearum* has been found in *Venus ziczac* in North America. Unidentified haplosporidian ciliates of the Order Thigmotrichida have been found in *Mercenaria*. - J.L.M.

1710
Srna, R. F., and A. Baggaley. 1976.

Rate of excretion of ammonia by the hard clam *Mercenaria mercenaria* and the American oyster *Crassostrea virginica*. Mar. Biol. 36(3): 251-258.

The 2 bivalve species were maintained in identical laboratory environments and fed the same diet for one month prior to measuring ammonia excretion. Juveniles and adults were measured. *M. mercenaria* excreted more ammonia per gram body weight, and data for *Mercenaria* were more scattered. Neither temp fluctuation nor decomposition of organic nitrogen in test water accounted for the scatter. Behavioral differences between the 2 species may explain the differences. - modified authors' abstract - J.L.M.

1711
Srna, Richard F., Anne Baggaley, and Walter Page. 1976.

Physical-chemical methods for the control of algal species and composition in algal culturing facilities. Proc. 7th Annual Meeting World Maric. Soc., Univ. Delaware Sea Grant DEL-SG-8-76, iii + 28 p.

Mercenaria mercenaria requires certain species of algae in adequate amounts for satisfactory growth. *Thallassiosira pseudonana* is suitable, but when contaminated with *Phaeodactylum tricornutum* growth is unsatisfactory. In fact *M. mercenaria*, when fed *P. tricornutum* alone, does not survive. Three methods were tried to provide optimum food conditions, ultrasonic waves, manipulation of nutrient concentrations, and continuous seeding to compensate for slow growth of one alga over another. A two-loop algal culturing process was the result. One loop consists of a seed culture utilizing a small percentage of influent water and a larger mass algae culture. The mass algae loop is inoculated continuously with new seed so that desirable species outcompete undesirable species. Water entering the seed loop is purified by ultrasonic treatment so that undesirable species may be eliminated from the seed cultures. - J.L.M.

1712
Srna, Richard F., Charles Epifanio, Michael Hartman, Gary Pruder, and Ann Stubbs. 1973.

The use of ion specific electrodes for chemical monitoring of marine systems. Part I. The ammonia electrode as a sensitive water quality indicator probe for recirculating mariculture systems. DEL-SG-14-73, June 1973, work sponsored by NOAA, Office of Sea Grant under grant no. 2-35223.

The ammonia (Orion 95-10 ammonia ion specific) electrode was tested and characterized for use in monitoring water quality and biological activity in a closed cycle system. Its precision and ease of use make it possible to monitor the ammonia level in a system. - M.C.

1713
St. Amant, Lyle S. 1972.

Biological effects of petroleum exploration and production in coastal Louisiana. In Santa Barbara Oil Symposium, Santa Barbara, 16-18 Dec. 1970, R. W. Holmes and F. A. DeWitt (eds.). Univ. Calif.: 335-354. (Citation not contained on copy received from Univ. Nebraska Lincoln Libraries.)

The only mention of clams (species not specified) is the following: 4. Direct loss of oyster or clam producing areas to industrial competition for the same water bottoms or physical damages to beds by the construction of nearby facilities. This is a good discussion of the effects of petroleum exploration and production on oysters and other important animals. During early production and throughout the second world war there was no regulation of industry with respect to pollution. After 1950 the impact of the petroleum industry on oyster growing became evident, and this led to a pollution control system and administrative procedures to protect the coastal environment. The cumulative results of introduction of sublethal amounts of oil or other pollutants into the environment for long periods of time and the additive effect of apparently innocuous ecological changes are unknown. These two factors may in the long run result in disastrous management of the environment if we continue to make decisions based only on obvious short-term effects. - J.L.M.

1714
St. Amant, L. S. 1973.

Shellfish and crustacean productivity in marshes and estuaries. Proc. Coastal Marsh and Estuary Mgmt. Symp., Baton Rouge, La.: 151-161.

SUNY - Stony Brook library reported that after considerable searching they were unable to locate or verify this title. Because it does not necessarily relate to *Mercenaria mercenaria* search was terminated. - J.L.M.

1715
Staff of Sandy Hook Laboratory, NMFS, NOAA. 1971.

Review of aquatic resources and hydrographic characteristics of Raritan, Lower New York and Sandy Hook Bays. Rept. prepared for Batelle Inst. Appendix III. Special Report on Benthic Communities and Shellfish Population in Lower and Raritan Bay: 62-86.

Adult *M. mercenaria* are not uniformly distributed in Upper New York or Raritan Bays. At 7 stations 12-15 ft deep densities ranged from one clam per 6 ft^2 to one per 170 ft^2. At 23-25 ft deep density was one clam per 9 ft^2. Standing crop and species diversity were impoverished. Larger numbers of commercial-size hard clams were found in New York waters of the Bay and larger number of smaller clams in N.J. It is suggested that normal reproduction and recruitment may not occur in relatively heavily polluted waters off Staten Is. Standing crops of hard clam in Raritan Bay are similar to or greater than those reported in Narragansett Bay. Dates of sampling are not given, but the year was presumably 1971. - J.L.M.

1716
Stafford, J. 1901.

The clam fishery of Passamaquoddy Bay. Contrib. Canadian Biol. (1901): 19-40, 4 pls.

South of New York the common species is *Venus mercenaria*, but this report deals in great detail with *Mya arenaria*, which is the commonest north of Boston. - J.L.M.

1717
Stafford, J. 1912.

On the recognition of bivalve larvae in plankton collections. Contr. Canad. Biol. 1906-10(6) Rept. 14: 221-242.

This wordy and somewhat rambling paper mentions in the introduction some conflicts between quohog (sic) and oyster industries. The quohog fishery opened in Sept, a month before opening of the oyster season, and stirred up sediment which, according to the author, interfered with oyster setting. At the close of the spring season an extension of time was allowed to dispose of clams on hand. This led to nightly poaching of oysters as well as hard clams. *Venus mercenaria* was distributed geographically in approximately the same places as *Ostrea virginica*, from Bay Chaleur to the southern coast of Nova Scotia, restricted to favorable areas. A considerable hard clam industry had developed. Clams were stored for weeks in large wooden trays anchored below low-tide mark, and were shipped in barrels or more frequently in bushel or 1 1/2 bu sacks to New York and Chicago. Quohog larvae were recognized by comparison with known larvae of other species, and by their presence in areas populated by adult hard clams and absence in areas not populated by adults. In 1909 the first quohog larva appeared in plankton collections near Bay du Vin. A week later quohog larvae were abundant. The early stages remain in the straight-hinge form when other bivalves are recognizable by their umbos. Umbos begin to show at a length of about 25 units on the stage micrometer (1 unit=6.9 mikra). After the umbo is formed it is easy to distinguish quohog larvae from those of other species. Drawings of various stages are given in figures 25-30 of plate XXIII. - J.L.M.

1718
Stafford, Walter F., III,and David A. Yphantis. 1972.

Existence and inhibition of hydrolytic enzymes attacking paramyosin in myofibrillar extracts of *Mercenaria mercenaria*. Biochem. Biophys. Res. Commun. 49(3): 848-854.

Paramyosin is attacked by at least 2 hydrolytic enzymes in extracts of adductor muscle of *M. mercenaria* under usual isolation conditions. EDTA-inhibited and phenylmethane sulphonyl fluoride-inhibited hydrolase activities have been identified. When paramyosin is extracted into high salt at pH 7.5 in presence of 0.01 M EDTA, a new molecular species of paramyosin is isolated, with molecular weight about 5,000 daltons higher than material isolated by previous procedures. A high resolution acrylamide gel electrophoresis technique, using split gels, detected small differences in apparent sub-unit molecular weight. - modified authors' summary - J.L.M.

1719
Stanley, Steven M. 1970.

Relation of shell form to life habits of the bivalvia (Mollusca). Geol. Soc. Am., Mem. 125, 296 p.

Mercenaria mercenaria (Linné)

The shell is very large (maximum length 12 to 13 cm) and elliptical in lateral view, with a somewhat pointed posterior. It is strongly prosogyre, elongate posteriorly, and moderately inflated. Valves are thick and slightly rugose. Ornamentation consists of sharp, fine concentric ridges present only anteriorly and reduced by abrasion in adults, but covering entire valves of first-year spat. Interior ventral valve margins are denticulate. L/H 1.25, H/W 1.52, AL/L 0.25, T.I. 0.60. L= length; H= height; W= width; AL= anterior length T.I.= Thickness Index, which is the ratio of volume of shell material to internal volume. Such a design provides stability in the substrate by having a great density and low center-of-gravity at the expense of burrowing speed. This is a typical shell structure for suspension feeders, found in stable, firm substrates, which do not frequently change location or reburrow. *M. mercenaria* is tolerant of an unusually wide range of environmental conditions. It is common in intertidal and shallow subtidal environments. It is found in clean sand and muddy sand, but most commonly in sediments containing a moderate amount of pebble or coarse shell debris, which is required for larval settlement. It prefers bare, rather than grass-covered bottoms. This species is a moderately rapid burrower. The foot emerges opposite the hinge and flows slowly into the substratum during a prolonged probing period. Five or 6 burrowing sequences are normally required to erect the shell. The erect probing orientation is with dorsal area just posterior to the hinge horizontal. Angle of rotation is about 25°. Direction of movement into the sediment is slightly forward (about 25°) from vertical. Life position varies with substratum type. Animals in clean sand live more deeply buried (average depth about 2 cm) than those living in muddy sediments (average depth about 1 cm in 30 percent mud). Individuals living in clean sand sometimes strain water through the overlying sediment layer. Sand-dwellers also eject pseudofeces less often and grow more rapidly than mud-dwellers. Animals in compact sand normally live with the long axis of the shell oriented approximately 45° from vertical, those in muddy substrata tend to live with long axis nearly vertical. In intertidal sand, small animals commonly live more deeply buried than large animals, apparently for protection against disinterrment, to which they are more vulnerable. - W.J.B.

1720
Stanley, Steven M. 1972.

Functional morphology and evolution of bysally attached bivalve mollusks. J. Paleontol. 46(2): 165-212.

Evidence is strong in favor of the hypothesis (attributed to C. M. Yonge) that adult byssal attachment has arisen in the Bivalvia through neoteny. Stabilizing adaptations of *Mercenaria mercenaria* change during growth. A byssus is used for juvenile fixation until size confers greater stability by permitting deeper burial and by increasing ratio of weight to shell surface area. Four stages in development of *M. mercenaria* are illustrated in figure 7: byssal plantigrade stage; first-year clam with sharp, concentric costae for physical stabilization; young clam with relatively long siphons for protection in a deep life position; and large clam with short siphons in a shallow life position. If positions of life stages and lengths of siphons are drawn correctly, which must be presumed because a 5 cm scale is included, the relatively deep young stage is farther below the surface of the substrate than the large clam, although their centers of gravity appear to be about equally deep. The deep stage appears to be about 4 cm long and the hinge is about 4 cm below the surface. The large clam is about 9 cm long and the upper edge of the shell about 1 1/2 cm below the surface of the substrate. As shown, ratios of siphon length to shell length are about 1:1 and 1:5. - J.L.M.

1721
Stanley, Steven M. 1975.

Why clams have the shape they have: an experimental analysis of burrowing. Paleobiology 1(1): 48-58.

Analysis of movies has shown that each rocking motion of a morphologically typical clam, *Mercenaria mercenaria*, involves typically rotational movement, with no translational component. The clam is able to burrow by "walking" its way downward only because the axis of backward rotation lies to the anterior of the axis of forward rotation. The blunt anterior serves to shift the axis of backward rotation anteriorly, thus aiding in downward progress. - modified author's abstract - J.L.M.

1722
Stasek, Charles R. 1963.

Orientation and form in the bivalved mollusca. J. Morphol. 112(3): 195-214.

Largely because early conchologists ignored the body, and developed a system of orientational terms based on features of the valves, the dorsal, ventral, anterior, and posterior regions of the shell do not necessarily lie adjacent to similarly named regions of the body. However, it is recommended that the directional terminology be retained in *Venus*. - J.L.M.

1723
Stasek, C. R. 1963.

Geometrical form and gnomonic growth in the bivalved Mollusca. J. Morphol. 112(3): 215-231.

Mentions a paper by Clench (1948) in Review of the Society of Malacology which described an aberrant specimen of *Venus campechiensis* which had a protuberant right valve. - J.L.M.

1724
Stauber, Leslie A. 1961.

Immunity in invertebrates, with special reference to the oyster. Proc. Natl. Shellf. Assn. 50: 7-20.

Mercenaria (Venus) mercenaria is not discussed, but the processes and principles described are generally applicable. - J.L.M.

1725
Stauffer, Robert C. 1937.

Changes in the invertebrate community of a lagoon after disappearance of the eel grass. Ecology 18(3): 427-431.

Venus mercenaria was considered common before and after eel grass disappeared. The species was present in 33 to 50% of collections reported by Allee (1923) and formed 2 to 5% of the total population in 1936. - J.L.M.

1726
Steimle, Frank W., Jr., and Richard B. Stone. 1973.

Abundance and distribution of inshore benthic fauna off southwestern Long Island, N.Y. U.S. Dept. Commerce, NOAA Tech. Rept. NMFS SSRF-673, iii+50 p.

Mercenaria mercenaria is listed in Appendix Table 3, species collected on survey, but the detailed subsequent tables containing benthic grab collection records contain no record of hard clam. - J.L.M.

1727
Stephens, Grover C. 1967.

Dissolved organic material as a nutritional source for marine and estuarine invertebrates. In Estuaries. G. H. Lauff (ed.). Am. Assn. Adv. Sci., Washington, D.C., Pub. 83: 367-373.

Carbohydrates other than glucose are not available to *Mercenaria mercenaria* from solution. - J.L.M.

1728
Stephens, Grover C., and Robert A. Schinske. 1961.

Uptake of amino acids by marine invertebrates. Limnol. Oceanogr. 6(2): 175-181.

Removal of amino acids from solution by 35 genera in 11 phyla was studied by following the concentration of an acid added to the ambient seawater. Beginning with a concentration of 2.0 mM glycine, *Mercenaria mercenaria* removed 20% of the amino acid in 17 hrs. Bacterial utilization, and adsorption on the walls of the containers or on surfaces of animals were ruled out as improbable on the basis of control experiments. Adsorption on inorganic particles in the water was possible, but not considered likely. The possible nutritive significance of amino acid uptake was considered speculative. - J.L.M.

1729
Stephens, K., R. W. Sheldon, and T. R. Parsons. 1967.

Seasonal variations in the availability of food for benthos in a coastal environment. Ecology 48(5): 852-855.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1730
Stevenson, Charles H. 1899.

The preservation of fishery products for food. U.S. Fish Comm., Bull. 1898: 335-563, illus.

Burnham and Morrill established the first clam cannery in the United States in 1878 at Pine Point, Maine. The pack was small for some years, as considerable difficulty was experienced with discoloration, but production slowly increased when this difficulty was overcome. Inclusion of minced clam, broth, and clam chowder increased the value of canned clam products until they are now (1938) fifth in order of importance of canned fishery products. - from Jarvis (1943) - J.L.M.

1731
Stevenson, William H. 1952.

Fisheries statistical program. Univ. Del. Mar. Lab., Ann. Rept. 1: 21-32.

The Marine Laboratory of the University of Delaware began an inventory of marine natural resources of the State in Jan. 1952. Among other sources, information was obtained from commercial and sport fishermen. Information on commercial and recreational shellfishing was included. Keeping of catch records was voluntary. Clamming in Indian River and Rehoboth Bays for sport was recorded for 89 days between 14 June and 12 Sept 1952. Total number of participants was 15,100, who spent 45,500 hrs clamming. Thirty percent were Delaware residents. Total take was 300,800 clams or 6.6 clams/man-hour. Species of clam is not given, but presumably most were *Mercenaria mercenaria*. - J.L.M.

1732
Stewart, James E. 1974.

Potential for culture of invertebrates in Canada. In Aquaculture in Canada. The practice and the promise. H. R. MacCrimmon, J. E. Stewart and J. R. Brett. Bull. Fish. Res. Bd. Canada 188: 35-52.

Life history of *M. mercenaria* is known and can be manipulated. It is similar to oyster life history except that after a certain size the clam burrows into the substrate. This effectively limits culture to bottom rearing. A good market exists, and grounds where substantial fisheries once existed are or should be good for managed production. Constraints include a growth period of 4 to 5 yrs to market size, relatively low market value (Abstracter's note: this may no longer be a constraint if prices of littleneck clams are comparable to those in the United States), confinement to bottom rearing, and disease. Virtual elimination of the Canadian Atlantic clam fishery in the early 1960s has been attributed to disease, possibly the same disease that eliminated the oyster fishery of the same area earlier. The prime requirement would be to develop disease-resistant seed stock. Disease and nutrition often do not receive the attention they deserve. It is recommended that prior to actual investment in production facilities the following information should be assembled and analysed searchingly: 1) general biology; 2) site surveys and selection; 3) markets and their potential; 4) environmental considerations 5) diseases, infectious and parasitic; 6) predation; 7) nutritional requirements and food sources; 8) genetics; 9) bioenergetics; 10) engineering; 11) processing and product development; 12) property and rights; and 13) economics. Each is discussed briefly. - J.L.M.

1733
Stewart, James E., and H. E. Power. 1963.

A sea water aquarium for marine animal experiments. J. Fish. Res. Bd. Canada 20(4): 1081-1084.

The aquarium is suitable for holding shellfishes. - J.L.M.

1734
Stickney, Alden P., and Louis D. Stringer. 1957.

A study of the invertebrate bottom fauna of Greenwich Bay, Rhode Island. Ecology 38(1): 111-122.

Clam investigations of U.S. Fish and Wildlife Service were established by Congress in 1948 under legislation sponsored by Atlantic States Marine Fisheries Commission to study populations of *Mya arenaria* and *Venus mercenaria*. Water depth in Greenwich Bay is almost uniform at 10 to 14 ft, except for the channel. Bottom is silt to sandy-silt to sand, with shell in some places. Water conditions are typically uniform top to bottom. Max water temp was 26°C. Salinity varied from 27 to 30°/₀₀. Tidal currents were relatively slow. The Bay proper was relatively unpolluted. Samples were taken with a "clamshell" construction bucket. *Venus mercenaria* was present in each sector sampled. Abundance varied from 2 to 22 clams/m^2 in 1951 and 1 to 24 clams per m^2 in 1952. Hard clam was present in the *Ampelisca* community, but was present almost everywhere in the Bay. It was less abundant in mud than elsewhere. *V. mercenaria* also was present in the *Crepidula-Nereis-Neopanope* community and was more abundant in sand-silt-shell type sediment favored by this community than in any other type of bottom. Mean numbers of *Venus*/sample (clams over 20 mm) in 1951 were: silty sand plus shell 12 clams; silty sand 6; pure sand 2; and mud 2. A chart shows the distribution and density of *Venus* in the areas sampled. In the sand bottom community numerous juveniles of *Venus* and other bivalves settled in certain places in 1952, forming substantial temporary populations. The drill *Eupleura caudata* was reducing these populations at the time of sampling. *Venus* also was present in the intertidal zone. It was among the predominant species on stony beaches. A substantial spatfall of *Venus* was found on most parts of the shore each year. *Eupleura caudata*, *Urosalpinx cinerea*, and *Neopanope texana* are very destructive of young. *Eupleura* is broadly distributed and does not necessarily congregate where young *Venus* are numerous, but in 1951 and 1952 the greatest numbers appeared in sector 10, where newly set bivalves of several species were abundant. In 1951 34% of all juvenile *Venus* taken had been drilled, and in 1952 all had been drilled. Drilling is most destructive to the 2 to 7 mm size group of *Venus*. Those above 15 mm are seldom attacked. Other important predators of *Venus* were *Limulus polyphemus*, *Callinectes sapidus*, *Ovalipes ocellatus*, *Libinia emarginata*, *Polynices duplicata*, and *Busycon canaliculatum*. Young *Venus* do not set uniformly over all parts of the bottom ostensibly suitable for them. They may colonize different areas of the Bay each year. This may be caused by concentration of larvae by currents, but to some extent also may be influenced by voluntary movement of newly set juveniles. The muddy central part of the Bay is relatively barren of *Venus*. No association was observed between distribution of *Venus* and other species. Some similarity in distribution was noted between *Venus* and *Nereis*, but the centers of population of the two did not coincide exactly. *Venus* and 7 other species, by reason of their abundance and broad distribution, were termed characteristic of Greenwich Bay. *Venus mercenaria*, like *Pectinaria gouldii*, is distributed intermittently along the New England coast, although the 2 species showed no particular similarities in distribution in Greenwich Bay. In 13 localities between Portland, Me. and Milford, Conn. the 2 species were present in 6 and absent in 6. One locality had *Venus* but no *Pectinaria*. At Salem, Mass. lives the only recent population of *Venus mercenaria* between Boston and Portland, Me. This is also the location of the only population of *Pectinaria gouldii* known to the authors along the same section of coast. - J.L.M.

1735
Stimpson, W. 1860.

Mollusca of Beaufort, N.C. Am. J. Sci., ser. II, 29: 442.

According to Jacot (1921), abstracted elsewhere in this bibliography, Stimpson recorded *Venus mercenaria* and *V. campechiensis* from this area. He also points out that Stimpson confused Cape Lookout with Cape Hatteras. - J.L.M.

1736
Stolting, Walter H., and Morton J. Garfield. 1952.

Fish and shellfish preferences of household consumers-1951. Part I - National summary, Part II - Regional summary. U.S. Dept. Interior, Fish Wildl. Serv., Washington, D.C. Fishery Leaflets 407 and 408, 46 and 66 p.

Clams are treated as a generic group, species not identified. Fresh, frozen, and canned shellfish was used in less than half as many households in the United States as fresh, frozen, and canned fish. - J.L.M.

1737
Strand, Ivar E., Jr. 1979.

Economic research on clams: A review and assessment. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass., and MIT Sea Grant Program, SP-112: 131-138.

This review of the literature suggests some future directions for research. For those clams that come within FCMA control, economic research should improve. It is presumed also that biologists will have better data to do growth and recruitment studies. Research on demand for clams is appropriate, because it is still not possible to say whether demand is elastic or inelastic. It appears that additional clams appear to be more important than additional markets, at present. Exploratory work on private and public economics of the development of hatcheries is in order. There is no current fisheries literature that adequately deals with joint production systems, and once the steady-state or zero recruitment assumptions are denied, disequilibrium models and estimating techniques have not been tested. But the most critical failure of past economic research has been its failure to demonstrate convincingly that management will assist the industry in obtaining reasonable profits. Until this is accomplished, the usefulness of past research will not be appreciated. - J.L.M.

1738
Stringer, L. D. 1950.

Greenwich Bay survey. Ann. Conf., Clam Investigations, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 17-18.

Area of Greenwich Bay is about 111.3 million ft^2 or 2,560 acres. Number of quahogs/ft^2 was 1.34, and total estimated population 149 million. Differences between mud and sand, and eastern and western parts were: mud, 0.93 clams/ft^2; sand, 1.77 clams/ft^2; eastern, 1.45 clams/ft^2; western, 1.19 clams/ft^2. - J.L.M.

1739
Stringer, Louis D. 1952.

The hard clam (quahaug) program. Proc. Natl. Shellf. Assn. for 1950: 34-37.

Objectives of the federal program were to: 1) determine the physical and biological conditions needed to maintain an area at maximum production, or restore a depleted area; 2) determine if an understanding of these conditions can be used to maintain production or overcome depletion; and 3) develop methods to attack problems in other areas. R.I. was chosen because it has an intensive and highly productive hard clam fishery, the productive areas were small enough for easy intensive study, a marine laboratory was available, and other clam studies were going on in neighboring states, which would facilitate frequent consultation. A survey of Greenwich Bay, R.I. showed that the bottom in the western half was mostly sticky mud, the eastern half mostly sand with small areas of shell. Most sub-legal clams were in the western part. Large clams predominated in the eastern. Distribution was very irregular, and centers of heavy concentration small and scattered. Studies of currents had been started. Plankton samples were taken 3 times/week. An interview system had been set up to get catch statistics. Expected results were: 1) estimate of expected annual yield at present harvesting rate; 2) best rate of removal for maximum sustainable yield; 3) conditions of life history and ecology that influence production; and 4) basic knowledge of clam farming methods. The federal laboratory at Milford, Conn. was cooperating on laboratory culture and scientists at Rutgers university on food organisms, obtaining seed from natural production, growth, predation, and larval stages. The Narragansett laboratory was doing ecological surveys of Narranganset Bay with emphasis on hard clam. The federal laboratory at Beaufort, N.C. was studying basic food materials of hard clam using radioactive tracers. The State of Maryland was studying clam growth and survival, and the University of N.C. growth and survival in N.C. waters. - J.L.M.

1740
Stringer, Louis D. 1952.

Quahaug productivity studies in Greenwich Bay. 3rd Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 21-23.

Total estimated population in 1950 was 300 million clams. Only 30 million were available to commercial fishermen, the rest were below legal size. Two areas of high abundance were shown. Over 30 clams/ft^2 at mouths of Apponang and Greenwich Coves. The western third of the Bay showed highest overall concentration, but this was primarily quahogs below 48 mm. Catch per unit of effort has fluctuated but averages about 893 necks and 334 large clams/boat/day. Number of boats fishing is between 30 and 50/day for 9 months. Fishing is intermittent in winter. Total estimated removal from Aug 1950 to Aug 1951 was 13 million clams, or about 45% of those legally available. Greatest effort is during the latter part of August. Bullrakes take mostly necks, tongs about half and half. This is probably a matter of choice. - J.L.M.

1741
Stringer, Louis D. 1953.

Hard clam productivity studies, Greenwich Bay, Rhode Island. 4th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 32-35.

Population estimates:	Total population	Over legal size (48 mm)
1950	142,000,000	36,000,000
1951	357,000,000	41,000,000
1952	661,000,000	37,000,000

The outstanding feature was the patchiness of *Venus*.

Total removals:	Removals		Catch/man/day		
1950	5,000,000	necks	1.24	1.13	large
1951	8,000,000	"	1.16	1.38	"
1952	8,000,000	"	1.22	1.34	"

- J.L.M.

1742
Stringer, Louis D. 1955.

Greenwich Bay hard clam productivity studies. In 5th Conf. on clam research, Boothbay Har., Me. U.S. Dept. Interior, Fish Wildl. Serv.: 1-9.

Year	Sublegals 15-47 mm	Legals over 47 mm
1950	0.26	0.30
1951	0.47	0.41
1952	0.33	0.39
1953	0.13	0.44
1954	0.17	0.33

Number of legal size has remained nearly the same, but the number of sublegals has dropped sharply. A predicted shortage of "necks" in 1954 was borne out. Geographical distribution has remained nearly the same. The 3 areas of high abundance, at the mouth of Apponaug Cove, entrance to Greenwich Cove, and middle of eastern section, have occurred in all years from 1950 to 1953. The area at the mouth of Apponaug Cove has almost disappeared, as expected. A new area appeared from Cedar Tree Point to Buttonwoods Point, and is one of the most dense in the Bay. Average is 5.3/ ft^2 with maximum densities over $20/ft^2$. These were spawned in 1952. The cause of these high and low abundance areas is unknown, except for bottom type. When large quantities of shell are present, abundance of hard clams is high (mud, sand and shell $1.54/ft^2$, sand and shell 0.98, mud and shell 0.60, mud and sand 0.60, sand 0.54, mud 0.27). Three principal subtidal communities were recognized, the *Ampelisca* community, with relatively few hard clams; the *Crepidula* community, with relatively abundant hard clams; and the sand-bottom community, with some hard clams present. Boats vary from less than 10/day in January to about 60/day in August. Mean number of hours fished/day is just over 5 and mean number of days/week about 4. Mean number of boats/day was 1950-38; 1951-34; 1952-34; 1953-32; and 1954-29. Areas of high abundance are found and receive the heaviest effort. Removals are about equal to recruitment. Removals: 1950-59 total, 32 legal, 9 removed; 1951 - 93, 44, and 7; 1952 - 76, 41, 8; 1953 - 60, 46, 7; and 1954 - 53, 35, and 5. Total catch has remained almost constant, but a smaller proportion of "necks" is taken; 1.2 bu necks, 1.3 bu large in 1950; 0.7 bu necks, 1.8 bu large in 1954. When necks drop, some boats move to other portions of Narragansett Bay. - J.L.M.

1743
Stringer, Louis D. (undated).

The population abundance and effect of sediment on the hard clam. U.S. Fish Wildl. Serv., Appendix E, 17 p. (Note: exact reference was not clear.)

A clam shell bucket was used to sample the bottom of Narragansett Bay to survey the hard clam population in 1956 and 1957. Best clam beds are in the upper shallow areas of the bay. Hard clam abundance varies from year to year, but the location of areas of abundance remain constant. Successful settings occur at infrequent and variable intervals. By analyzing relative abundances of different size classes, relative success of spawning during the year when the given size class was spawned can be determined. The range of estimates for the rate of sedimentation in Narragansett Bay is 0.02-0.1 ft/year. All clams tested resumed pumping after having 1 1/2-2 1/2 inches of sediment dumped on them. It is thought that a hovering layer of sediment will have an adverse affect on clams. Surveys showed that hard clams were most abundant in sediment of mud, sand, and shell. Pure mud and sand bottoms had the lowest abundance. Hurricane barriers constructed in lower Narragansett Bay will not markedly affect the hard clam resource through changes in sedimentation. - D.L.

1744
Stringer, L. S. 1956.

Population characteristics of the hard clams in Greenwich Bay, Rhode Island. Trans. Am. Fish. Soc. 85.

Interlibrary loan could not identify as given. Search terminated. - J.L.M.

1745
Struve, K., and W. Kairies. 1930.

Die chemische Zusammensetzung einiger als Fischnahrung wichtigen wirbellosen Bodentiere der Nordsee. Wiss. Meeresunters. Abt. Helgoland, N.F. 17(6): 1-22.

Dry organic matter as % of living or wet weight of *Venus ovata* is 7%. - J.L.M.

1746
Stunkard, Horace W. 1938.

The morphology and life cycle of the trematode *Himasthla quissetensis* (Miller and Northup, 1926). Biol. Bull. 75(1): 145-164.

Vogel (1933), abstracted elsewhere in this bibliography, concluded that *Himasthla muehlensi*, a human parasite, is aquired by eating raw or insufficiently cooked mollusks. Examination of large numbers of *Venus mercenaria* purchased in the New York market, failed to detect metacercaria of this species. Thus, it could not be determined whether *H. muehlensi* is distinct from *H. quissetensis*, which was found in *Nassa obsoleta* at Woods Hole, Mass. - J.L.M.

1747
Stunkard, Horace W., and Joseph R. Uzmann. 1958.

Studies on digenetic trematodes of the genera *Gymnophallus* and *Parvatrema*. Biol. Bull. 115(2): 276-302.

Sinitsin (1911) described *Adolescaria perla* from near the gill plates of an unidentified species of *Venus*. - M.W.S. and J.L.M.

1748
Subrahmanyam, C. B., and C. H. Oppenheimer. 1970.

Food preference and growth of grooved penaeid shrimp. In Food and Drugs from the Sea, Proceedings 1969. H. W. Youngken, Jr. (ed.). Mar. Tech. Soc., Washington, D.C.: 65-75.

Laboratory experiments were conducted to determine growth in length and weight, conversion efficiency, and mortality on different diets. *Mercenaria* was not an ingredient. - J.L.M.

1749
Sullivan, Charlotte M. 1948.

Bivalve larvae of Malpeque Bay, P. E. I. Bull. Fish. Res. Bd. Canada 77, 36 p., 22 pl.

Venus mercenaria is placed in the *Ensis* group of larvae, with high, rounded, long slopes; wide umbones; and long bases. (Abstracter's note: there is some confusion here. Table 1 lists *V. mercenaria* with *Ensis directus*, *Mytilus edulis*, *Rochefortia planulata* as *Ensis* group, but the text contains the same species under the heading *Rochefortia* group.) Except in *Venus*, umbones are low with wide bases. Large *Venus* larvae are distinctive, but small stages may be confused with corresponding sizes of *Ensis* and *Rochefortia*. *V. mercenaria* larvae are found in Malpeque Bay from early July to mid-August. Size ranges from 105x120 μ to 310x320 μ. Small larvae are colorless and silvery. With growth they change to creamy yellow, then to muddy yellow-brown. The "liver" is gray. At 105 to 140 μ the umbones begin to project above the hinge line but remain small, low, rounded, and knoblike with narrow bases. Until half-grown, length exceeds height. Thereafter, the difference is reduced until at setting the larva is almost circular. The postero-dorsal angle is higher than the antero-dorsal. Large *Venus* larvae differ from most others in that the anterior margin is longer and more gently curved than the posterior. The slopes are about equally long. In large larvae the statocyst is often conspicuous in the foot. The transparent, silvery color of small larvae differentiates them from similar stages of other species. Later stages are distinctive for their creamy-yellow color, rounded bottom-heavy shape, and particularly the relatively small, knob-like umbones, with dimpled surfaces. Compared with *Rochefortia planulata*, early stages of *Venus* have a slightly shorter hinge line, umbones which show as heavy bars under the hinge line in straight-hinge stages, contrasting with the hardly distinguishable umbones of *Rochefortia*, smaller more rounded umbones with narrower bases, silver color turning to creamy yellow, contrasting with yellow-banded *Rochefortia* which turns bright yellow. Compared with *Ensis directus* early stages of *V. mercenaria* has a smaller straight-hinge stage, umbones apparent from the beginning as bars under the hinge line, contrasting with the inconspicuous umbones of straight-hinge *Ensis* larvae, narrower based heavier umbones which project above the hinge line earlier in development, a bolder shell outline, silvery color which turns creamy-yellow, differing from the pale delicate yellow of *Ensis*. Differences between *Venus* and *Mytilus* are obvious. Very young spat of *Venus* were not described because none was collected. The author found a close resemblance between small *Pitar morrhuana* spat and *Venus*. The smallest *Venus* spat seen differed from *Pitar* of the same size in having a larger number of concentric ridges, prodissoconch not clearly delineated, umbones heavier with broader bases, and dissoconch heavier. The discussion is illustrated with photomicrographs of 5 stages of *Venus* larva and a spat. - J.L.M.

1750
Sumner, Francis B. 1910.

An intensive study of the fauna and flora of a restricted area of sea bottom. Bull. U.S. Bu. Fish. 28 (Pt. 2): 1225-1236.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1751
Sumner, Francis B., Raymond C. Osburn, and Leon J. Cole. 1913.

A Biological Survey of the Waters of Woods Hole and Vicinity. Pt. I. Sect. I. Physical and zoological. U.S. Dept. Commerce and Labor, Bu. Fish., Bull. 31(1911): 1-200.

Venus mercenaria is included in a group of species restricted wholly or chiefly to Buzzards Bay, not the Sound, and as a predominantly southern species. - J.L.M.

1752
Sumner, Francis B., Raymond C. Osburn, and Leon J. Cole. 1913.

A Biological Survey of the Waters of Woods Hole and Vicinity. Pt. II. Sect. III. A catalogue of the marine fauna. U.S. Dept. Commerce and Labor, Bu. Fish., Bull. 31(1911): 547-794.

Family Veneridae, *Venus mercenaria* Linnaeus. Quahog, round clam, hard clam, little neck clam. A partial synonymy is included. Littoral distribution general throughout the region. Abundant in sand or mud, just below low-tide level, especially in harbors, estuaries or other sheltered places, where it is also taken at depths of several fathoms. Shells, and occasionally living specimens, dredged by the Survey throughout the length of Buzzards Bay; much less frequent in Vineyard Sound. Shells recorded from depths of 2 to 13 fath, most frequently in mixtures of mud and sand; living specimens taken in depths as great as 6 fath. A long list of stations is given, with details of collections made. The extensive bibliography contains a number of papers which may contain references to hard clam, although none does specifically in the title. - J.L.M.

1753
Sunderlin, J. B., M. Brenner, M. Castagna, J. Hirota, R. W. Menzel, and O. A. Roels. 1976.

Comparative growth of hard shell clams (*Mercenaria mercenaria* Linne and *Mercenaria campechiensis* Gmelin) and their F1 cross in temperate, subtropical, and tropical natural waters and in a tropical artificial upwelling mariculture system. World Maricult. Soc., Proc. 7th. Ann. Workshop: 171-183.

Growth of quahogs (*Mercenaria mercenaria* and *M. campechiensis*) and their F_1 cross in a controlled experimental environment was compared to growth in uncontrolled natural environments. Clams were spawned by Paul Chanley of Greenport, N.Y. The controlled environment at St. Croix, U.S. Virgin Islands had no pollutants or predators and fouling was minimal. Salinity was 34.75 to 34.95°/₀₀ and water temp 22 to 30°. Clams from each of the 3 populations were planted at Southold, N.Y. and at both St. Croix sites. *M. campechiensis* and F_1 clams were sent to Wachapreague, Virginia and Alligator Harbor, Fla. and *M. mercenaria* and F_1 to Hawaii. *M. campechiensis* and F_1 clams reached market size in 6.5 to 13 months in the St. Croix artificial site. Clams did not reach market size by 13 months in Southold, Wachapreague, or Salt River Inlet, St. Croix. F_1 clams in Hawaii, and Florida were close to market size when the experiment was terminated after 13 months. Survival and growth of *M. mercenaria* was poor in the artificial upwelling area, in Salt River Inlet, and in Hawaii. - modified authors' abstract - J.L.M.

1754
Suomela, Arnie J. 1956.

The Fish and Wildlife Service and the shellfish industry. Proc. Natl. Shellf. Assn. 46: 15-19.

A population census of hard clam (*Mercenaria mercenaria*) in Greenwich Bay, R.I. late in 1954 showed the lowest density in 5 yrs of sampling. The decline in abundance was accompanied by a drop in average number of boats clamming. - J.L.M.

1755
Suszkowski, Dennis J. 1973.

Sewage pollution in New York Harbor: A historical perspective. Thesis presented in partial fulfillment of the requirements for the Degree of Master of Science, State Univ. of N.Y., vi + 68 p.

In 1908 the Bureau of Marine Fisheries of New York State said that no oysters were being harvested from the New York Bay area, although in 1908 and 1909 oysters were being taken from the vicinity of Robbins Reef, Kill Van Kull, and the Rahway River. Value of shellfish produced in Harbor waters in 1908 amounted to $1.3 million and it was thought that the waters in Lower Bay could be maintained for shellfish culture. In 1925 Lower New York Bay was closed to shellfishing by authorities. N.J. opened Raritan Bay beds in 1934 because treatment facilities were improved. A portion of New York's beds were reopened in 1941. The value of the industry at that time was about $1.0 million. In 1961 after a hepatitis outbreak the Bay was once again closed to shellfishing. Subsequently, N.J. reopened the Sandy Hook beds. - J.L.M.

1756
Swan, J. H. 1971.

Significance of the distribution of 5-hydroxytryptamine in molluscs. Master's thesis, Fla. State Univ.

Not available in Dissert. Abstr. Internatl. Not certain whether original information on *Mercenaria mercenaria* is included. - M.W.S. and J.L.M.

1757
Swansburg, K. B., and M. W. Mullan. 1957.

Studies in the self-cleansing of quahaugs *(Venus mercenaria,* L.). Canada Dept. Fish., manuscript rept. 57-2.

Could not locate. Search terminated. - J.L.M.

1758
Swedmark, M., B. Braaton, E. Emanuelsson, and A. Granmo. 1971.

Biological effects of surface active agents on marine animals. Mar. Biol. 9(3): 183-201.

Effects of 3 anionic and 2 nonionic surface active agents were different on fishes, bivalves, and crustaceans. Fishes were most susceptible, bivalves more tolerant, and decapods most resistant. Anionic surfactants were more toxic to fishes and decapods than nonionic, and soft anionic more toxic than hard. Nonionic surfactants were more toxic to bivalves and barnacles than anionic, and hard nonionic more toxic than soft. Active species were more susceptible than less active. *Mercenaria mercenaria* was not used. - M.W.S. and J.L.M.

1759
Sweeney, Daryl. 1963.

Dopamine: Its occurrence in molluscan ganglia. Science 139(3559): 1051.

Cerebropleural, pedal, and visceral ganglia of *Mercenaria mercenaria* each contained high levels of dopamine. Gill, mantle, heart, and intestinal tissues showed no appreciable dopamine content. Dopamine is the principal catecholamine in molluscan ganglia, and it has a function independent of its role as the precursor to norepinephrine, probably as a regulator of *Mercenaria (Venus)* heart. The range of concentration in *M. mercenaria* ganglia was 137 to 405 μg/g, considerably higher than in the other 9 bivalves and gastropods examined. - J.L.M.

1760
Sweeney, Daryl. 1969.

Absence of monoamine (sic) oxidase activity in several invertebrate nervous systems. Am. Zool. 9(3): 582 (abstract 213).

Among other species, *Mercenaria mercenaria* ganglia, heart, gill, digestive gland, kidney, and intestine were assayed. Weak monamine (sic) oxidase activity was noted in hard clam digestive gland (0.07 μM/g/hr for 5-hydroxytryptamine=5-HT and 0.17 for dopamine) and gill (0.06 for 5-HT and 0.21 for dopamine). In all other tissues MAO activity was less than 0.05 at 22°C for both substrates. It was concluded that monamine oxidase is not involved in metabolism of monoamines in these invertebrate nervous systems. - J.L.M.

1761
Sweeney, Daryl C. 1969.

The synthesis of dopamine from DOPA in the ganglia of *Mercenaria mercenaria* (Mollusca, Pelecypoda). Comp. Biochem. Physiol. 30(5): 903-907.

It has been suggested that dopamine may be a transmitter agent in molluscan nervous systems. Ganglia of *Mercenaria mercenaria* contain the highest concentration of dopamine yet reported for mollusks. Dopamine-^{3}H appeared in ganglia of all experimental clams within 1 hr of injection of DOPA-^{3}H into pedal sinus. Levels of dopamine-^{3}H were highly variable during the 6 hr period of measurement, suggesting an irregular circulation of tracer in the pelecypod hemocoel, but ganglia were consistently the most concentrated site of newly synthesized dopamine as compared with visceral mass, foot, heart, kidney, gill, siphons, mantle, and adductor muscles. Isolated ganglia also were capable of converting DOPA-^{3}H to dopamine-^{3}H, and higher concentrations of dopamine-^3H were converted in pedal than in cerebral or visceral ganglia. Measurements of dopamine turnover in isolated pedal ganglia, and the time course of ganglionic dopamine synthesized in the clam, suggest that dopamine is not actively metabolized in *Mercenaria* ganglia. - J.L.M.

1762
Sykes, James E., and John R. Hall. 1971.

Comparative distribution of molluscs in dredged and undredged portions of an estuary, with a systematic list of species. U.S. Dept. Interior, Bu. Comm. Fish., Fish. Bull. 68(2): 299-306. (Also issued as a separate, dated 1970.)

Mollusk species and numbers of organisms were much less numerous in soft sediments of canals than in sandy sediments in undredged parts of Boca Ciega Bay, Fla. Living specimens of 5 species, including *Mercenaria campechiensis*, were found in 14 samples from canals, which had sediments with 85% silt and clay. In 93 samples from undredged areas 156 species were taken, also including *M. campechiensis*. Natural bottom averaged 91% sand and shell and yielded 5,631 live mollusks. Channel stations yielded only 16 living mollusks. Soft sediment was the principal factor limiting abundance and diversity of mollusks in bayfill canals. Such sediments were as thick as 4 m in waterways dredged 15 yrs earlier. - J.L.M.

1763
Syverton, J., W. S. Scherer, and T. M. Elwood. 1954.

Studies on the propagation in vitro of poliomyelitis viruses. V. The application of strain HeLa human epithelial cells for isolation and typing. J. Lab. Clin. Med. 43(2): 286-302.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1764
Szent-Gyorgyi, Albert. 1958.

Motion, energy transmission, and the cellular matrix. In Perspectives in Marine Biology. A. A. Buzzati-Traverso (ed.). Univ. Calif. Press, Berkeley: 233-238.

This chapter contains no direct reference to any species, but it does explain why the author chose to base his scientific research on motion and its organ muscle, which led him to work on mollusks, including *Venus (Mercenaria) mercenaria*. Many of his publications are abstracted in this bibliography. Motion is generated in muscle by a complex protein, actomyosin, composed of two single proteins, actin and myosin. This complex interacts with ATP, a nucleotide, and ions. Myosin is built of rod-shaped molecules, probably about 1,200 A long and 15-20 A wide. Actin is built of globular molecules which can associate to long strings. The relation of actin to myosin is decided by the ions present, which, with their charges, dominate electric attraction and repulsions between the 2 proteins. The nucleotide ATP has 3 parts: a heterocyclic purine base, a pentose, and a chain of 3 phosphate groups joined by P-O-P links. About 10,000 calories of free energy have to be invested to establish such a link. By splitting a link, an equal amount of energy is released. In muscle contraction the last of these P-O-P links is split, to give the energy that moves bodies of animals. Early work suggested that myosin molecules formed a rod, which contracted by folding. More recent studies showed that the myosin molecule is built of subunits, which were called "meromyosins". A myosin molecule of MW 420,000 has 3 such subunits, one thick, and with 2 slender units in line with it, one at each end. The work seemed to be done by the slender meromyosins, but the energy of ATP was released by the thicker ones, and somehow had to get from thick to slender subunits. Meromyosins are built of a large number of MW 4,500 gram subunits called "protomyosins" held together by weak secondary forces. It is probable that contraction is not a folding, but some rearrangement of protomyosins. The P-O-P bond has only a potential, which has to be exchanged for energy when it goes into biological action. Muscular contraction is essentially the reversal of what happens in photosynthesis. - J.L.M.

1765
Szent-Gyorgyi, Albert. 1965.

Cell division and cancer. Science 149(3679): 34-37.

This is an important paper in that it traces the author's early interest and work with biologically active substances. It refers only indirectly to work on *Mercenaria mercenaria*. Reports discovery of 2 antagonistic substances, one of which retarded and one of which promoted growth. The retarder was named "retine" and the promoter "promine". Despite their opposing effects they were found to be very similar physically and chemically, almost the same substance. Variability in behavior was later explained by work with retine which showed that the substance has a very small molecule and is bound *in vivo* to a hydrophilic colloid, from which it can be released fairly easily. Bound to its carrier retine is stable; released, it is unstable. The relation of the 2 substances to cancer offers some intriguing research possibilities. - J.L.M.

1766
Szent-Gyorgyi, Andrew G. 1953.

Meromyosins, the subunits of myosin. Arch. Biochem. Biophys. 42(2): 305-320.

Short digestion of myosin by trypsin produced 2 subunits L-meromyosin, with molecular weight 96,000 and 550A long and 16A wide; and H-meromyosin, with molecular weight 232,000 and 435A long and 29A wide. H-meromyosin has the total ATPase activity and the capacity to combine with actin of the intact myosin molecule. One myosin molecule consists of 4 L-meromyosins and 2 H-meromyosin molecules. It is proposed that the L-meromyosin molecules are linked in a chain and the H-meromyosins are attached to them. It is suggested that L-meromyosin is the contractile part of the myosin molecule. *Mercenaria (Venus) mercenaria* is not mentioned. - J.L.M. and M.W.S.

1767
Szent-Gyorgyi, Andrew G., Carolyn Cohen, and John Kendrick-Jones. 1971.

Paramyosin and the filaments of molluscan "catch" muscles. II. Native filaments: Isolation and characterization. J. Mol. Biol. 56(2): 239-258.

A new method for partial separation of the filaments of molluscan muscles produces 2 fractions, one mainly of actin filaments, many of which were attached to dense bodies, and one consisting of very long and thick filaments which contained essentially all the paramyosin and myosin in the muscle. Some actin filaments also were present in the 2nd fraction. When solution of myosin was prevented, myosin filaments similar to those of vertebrate striated muscle seldom were found in either fraction. Myosin could be extracted selectively from thick filaments without solution of paramyosin, but extraction of paramyosin was always accompanied by solution of myosin. Removal of myosin changed the surface appearance of thick filaments: a characteristic pattern of darkly staining nodes or gap regions in the paramyosin filament was visible in negatively stained preparations. Nodes were roughly triangular, defining polarity of the structure. Some filaments showed reversal of polarity along their length. It was concluded that thick filaments have a bipolar core of paramyosin covered with a surface layer of myosin. Molluscan myosin (including that of *Mercenaria mercenaria*) formed filaments resembling those of rabbit myosin when precipitated *in vitro*. Its assembly in the thick filament therefore is determined by the paramyosin core. Paramyosin greatly inhibited actin-activated ATPase of myosin selectively when these proteins were mixed about mole to mole. Long bipolar thick filaments with myosin on the surface can explain the development of tension in these molluscan muscles according to the sliding filament theory. This suggests also that paramyosin may have a specific regulatory role in tension maintenance: in the catch mechanism a phase change in paramyosin may be coupled to movement of cross-bridges formed between myosin and actin. - modified authors' abstract - J.L.M.

1768
Szent-Gyorgyi, A. G., W. Lehman, and J. Kendrick-Jones. 1971.

Actomyosin and regulation in molluscan muscles. Biophys. Soc., Progr. and Abstr., 15th. Ann. Meeting: 234a (Abstract ThAM-C10).

Ca-dependent regulatory functions in molluscan muscles are associated with myosin. Purified myosin preparations of *Mercenaria mercenaria* and *Aequipecten irradians* bind Ca at free Ca concentrations of 10^{-7} to 10^{-5} M, and their ATPase activity when mixed with purified actin is Ca-dependent. Tropomyosin is not required for regulation by Ca in molluscan muscles. SDS acrylamide electrophoresis of native thin filament preparations showed essentially 2 components, actin and tropomyosin. Components with chain weight smaller than tropomyosin were not found in native thin filaments. Myosins from muscles of *Mercenaria* doublet with a chain weight somewhat below 20,000. The only component found in significant quantity in washed whole muscle with a chain weight lower than that of tropomyosin was the light chain of myosin. - J.L.M.

1769
Tanaka, Yataroh. 1969.

Studies on propagation of a hard clam, *Meretrix lamarckii* - I. Artificial Breeding. Bull. Tokai Reg. Fish. Res. Lab. 58: 163-167. - II. Resistibility to hypotonic sea water: 169-171.

In Japanese with English abstracts. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1770
Taormina, A. S. 1975.

Overview of New York's shellfish resources. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 7-9.

The Indian name for Long Island was "Sewanhaka" - Island of Shells. Commercial landings of *Mercenaria mercenaria* in New York for 1973 and 1974 were 607,286 bu with landed value of $11,175,115 and 669,452 bu with landed value $13,434,190 respectively. These are minimal values because they do not include economic values in the supply, processing, shipping, and retailing segments, nor do they include recreational and "mess digging" values. Of nearly 3 million New Yorkers who participated in recreational saltwater fishing in 1973-74 about 1 in 4 were recreational shellfishermen. Shellfishes also are valuable foods for other marine animals. Much of the fish and wildlife management effort of the Department is devoted to acquisition of key wetlands with funds provided by the Environmental Bond Act of 1972. The Department also works closely with county, town and village governments and the Nature Conservancy in wetland protection. Under provisions of the Tidal Wetlands Act of 1973 a major effort goes to monitoring water quality to determine from which waters shellfish may be taken safely. Considerable effort also goes into reviewing and evaluating potential impacts of sewer projects, power plants, bridges, roads, marinas, airports, and housing on the marine environment. The shellfish resource is the foundation of an industry probably worth $100 million or more to New York. - J.L.M.

1771
Taormina, A. S. 1975.

Shellfish for the dinner table. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 39.

Shellfishes like hard clam and oyster are often eaten raw, but they also are delicious in many recipes. Cookbooks have been written on shellfish alone, including one with 300 recipes written by 2 Long Islanders. Some people have allergic reactions to shellfish, but to many they are important parts of the diet. - J.L.M.

1772

Taormina, A. S. 1975.

Role of public agencies other than NYSDEC in shellfish management. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 40-43.

Roles of the following agencies are described briefly: U.S. Dept. Commerce; U.S. Dept. Health, Educ. Welf., Food and Drug Admin; Atl. States Marine Fish. Comm; N.Y. Sea Grant Inst; Nassau-Suffolk Regional Marine Resources Council; Towns of Hempstead, Oyster Bay, Islip. - J.L.M.

1773

Tappel, A. L. 1960.

Cytochromes of muscles of marine invertebrates. J. Cell. Comp. Physiol. 55: 111-126.

Mercenaria mercenaria was more difficult to analyze than other bivalves because it has bright-pink pigmentation. Occurrence of cytochromes *c* and *b* can be inferred from the maxima of the α and γ peaks. Cytochrome *b* can be identified in the low temp spectrum with maximum at 562 mμ. There was no strong evidence for presence of cytochromes $a+a_3$ because there was no max absorption in the 600 mμ region in the difference spectrum or the low temp spectrum. Concentrations of respiratory pigments showed that cytochromes *b* and *c* were high, and calculated concentration of cytochromes $a+a_3$ was low. - J.L.M.

1774

Tarver, J. 1971.

Rehabilitation of natural oyster seed grounds destroyed or damaged by hurricane Camille. La. Wild Life Fish. Comm., New Orleans, 11 p.

This paper could not be located. A similar paper by a different author was found under the same agency and date: Ford, Ted B. 1971. Effects of Hurricane Camille on Louisiana's oyster growing areas east of Mississippi River-Lake Borgne to California Bay and other marine fisheries industries. La. Wildl. Fish. Comm., New Orleans: 79-86. This paper is abstracted under the author's name elsewhere in this bibliography. - J.L.M. and M.W.S.

1775

Taub, Frieda B. 1974.

A continuous algal culture system for feeding shellfish. Proc. Natl. Shellf. Assn. 64: 15 (abstract).

In an 8 ft x 6 ft floor space $2x10^{11}$ cells/day can be produced. This is equivalent to 1,000 liters of $2x10^5$ cells per ml, enough to feed 200 cases of oyster larvae. The space will accommodate another line of the same capacity. The unit requires replenishment of pasteurized seawater and sterilized enrichment solution, a 2% CO_2-air source, and removal of the yield if it is stored. It may remain functional for as long as 3 months or longer, but also may need cleaning monthly. A second culture line assures an uninterrupted supply of algae. Approximate cost is $1,000 to $2,500 depending on type of equipment. Major labor requirement is for pasteurization, which is done in batches. In-line pasteurization would reduce labor to a minimum. - modified author's abstract - J.L.M.

1776

Tauc, Ladislav. 1966.

Physiology of the nervous system. In Physiology of Mollusca. Karl L. Wilbur and C. M. Yonge (eds). Academic Press, New York, Vol. II: 387-454.

Contains references to *Mercenaria (Venus) mercenaria* abstracted elsewhere in this bibliography. - J.L.M.

1777
Tauc, L., and H. M. Gerschenfeld. 1962.

A cholinergic mechanism of inhibitory synaptic transmission in a molluscan nervous system. J. Neurophysiol. 25: 236-262.

This paper deals with *Aplysia depilans*. References to *Venus mercenaria* were from papers abstracted elsewhere in this bibliography. - J.L.M. and M.W.S.

1778
Taxiarchis, Louis N. 1955.

Observations concerning predation on *Venus* at Morgan's Bay, Surry, Maine, 1954. 5th Conf. on Clam Research, U.S. Dept. Interior, Bu. Comm. Fish., 1 p. (mimeo).

In 1950 the *Venus* population was evenly distributed throughout very soft mud (wattenschlick) and densely packed sand and pebble. In 1954 only a few clams survived in the hard packed gravel, and none elsewhere. The decrease in numbers was attributed primarily to gull predation. Another predator was green crab, *Carcinides maenas*. - J.L.M.

1779
Taylor, Clyde C., Henry B. Bigelow, and Herbert W. Graham. 1957.

Climatic trends and the distribution of marine animals in New England. U.S. Fish Wildl. Serv., Fish. Bull. 115 (Vol. 57): 293-345.

Venus mercenaria spawns successfully only in temperatures of about 68 to 70°F but winters successfully where water chills to 34 to 35°F. Potentiality to extend its range northward is limited more by summer than by winter temps, for successful reproduction is necessary if a stock is to be maintained. - J.L.M.

1780
Taylor, J. L., and C. H. Saloman. 1968.

Benthic project. In Rept. Bu. Comm. Fish. Biol. Lab., St. Petersburg Beach, Florida, fisc. yr. 1967. J. E. Sykes (ed.), U.S. Fish Wildl. Serv., Circ. 290: 3-5.

Absence of a commercial fishery for *Mercenaria campechiensis* in Tampa Bay, Fla. is attributed to undependable annual recruitment, possibly caused by disease and predation. Under favorable conditions, southern quahog sets well and grows rapidly in the estuary. Annual growth of quahogs in Boca Ciega Bay has been studied since 1964. Growth of northern quahog transplanted to Tampa Bay from N.Y. waters also has been measured. Hatchery clams from Oyster Bay, N.Y. grew from about 2.5 mm to over 5 mm in 6 months. Seed clams from Great South Bay, N.Y. grew from 48 mm to about 52 mm in the same period, and to 56 mm in 12 months. This was about 1/3 the growth rate of southern quahog in the same area. Marked southern quahogs were set out at 20 stations in Tampa Bay. After 12 months growth in upper Tampa Bay was 9 mm, in the central part of the Bay 11.5 mm, and in the lower Bay more than 12 mm. All plantings were on bottoms free of grass. - J.L.M.

1781
Taylor, John L., and Carl H. Saloman. 1968.

Some effects of hydraulic dredging and coastal development in Boca Ciega Bay, Florida. U.S. Fish Wildl. Serv., Fish. Bull. 67(2): 213-241.

Filling of 1,400 ha (3,500 acres) by hydraulic dredging has reduced the area of Boca Ciega Bay by about 20% since 1950. It was estimated that the annual standing crop destroyed was 1,133 metric tons (798 kg/ha dry whole weight) of sea grass and 1,812 metric tons of associated infauna. Loss of annual production of biological resources was 25,841 metric tons of sea grass, 73 metric tons of fishery products, and 1,091 metric tons of infauna exclusive of meiofauna. This was an annual loss of $1.4 million. *Mercenaria campechiensis* was abundant in lower Boca Ciega Bay, but since these were below the area of greatest alteration, and no damage was mentioned specifically, the hard clam resource presumably was not affected significantly, at least directly, by dredging, filling, and associated effects. Density of seagrass was correlated positively with abundance of infauna, and in Lower Boca Ciega Bay seagrass was about as abundant as in other places in the Gulf of Mexico. - J.L.M.

1782
Taylor, John L., and Carl H. Saloman. 1969.

Benthic project. In Rept. Bu. Comm. Fish. Biol. Lab., St. Petersburg Beach, Florida, fisc. yr. 1968. James E. Sykes (Director). U.S. Dept. Interior, Fish Wildl. Serv., Circ. 313: 3-10.

Study of benthic ecology in estuaries of the eastern Gulf of Mexico began in 1963. Particular attention was paid to organisms with actual or potential commercial value, including southern quahog, *Mercenaria campechiensis*. Growth of a clam population in lower Boca Ciega Bay was recorded for the 5th yr. Average length was 5 mm greater than in 1967 and nearly twice the mean length of those measured in 1964. Poor setting was illustrated by scarcity of small clams. Six large clams, including a record size for northern Boca Ciega Bay, ranged in length from 166 to 179 mm, and ages were estimated at 14 to 20 yrs. - J.L.M.

1783
Taylor, John L., and Carl H. Saloman. 1970.

Benthic project. In Rept. Bu. Comm. Fish. Biol. Lab., St. Petersburg Beach, Florida, fisc. yr. 1969. J. E. Sykes (ed). U.S. Fish Wildl. Serv., Circ. 342: 3-10.

Distribution of southern quahog in Tampa Bay, Fla. is wide. It is especially abundant in Boca Ciega Bay. Typical habitat was firm sandy sediment and salinity 24°/°° or higher. Other preferred conditions were: mean grain size, fine sand (0.165 to 0.125 mm); weight % $CaCO_3$ 1 to 30; weight % organic C less than 9; weight % organic N 2; and poorly sorted; current 0 to 1.3 m/sec; temp not limiting; pH less than 7; dissolved O_2 saturated; depth less than 10 m; vegetation, turtle grass. Scarcity of quahog in Hillsborough Bay was attributed mainly to pollution and its effect on bottom conditions. Relation of shell height and width to length and age, and length (and age) in relation to weight are well understood. Data are presented in graphic form, not in a table. Conditions were favorable for clam culture in Tampa Bay, but success will depend on predator control. - J.L.M.

1784
Taylor, John L., and Carl H. Saloman. 1972.

Nereid shell blisters in the southern quahog clam. Quart. J. Florida Acad. Sci. 35(1): 21-26.

The nereid polychaete *Neanthes arenaceodentata=Neanthes caudata* is the apparent cause of shell blisters in *Mercenaria campechiensis* in Boca Ciega Bay, Florida. Incidence of blisters averaged 37% and ranged from 30% to 51%. Among dead shells collected in the vicinity 44% incidence was observed. In most clams blisters were found on one valve only, at the posterior end. In some clams the posterior adductor and retractor muscles were partially destroyed. *N. arenaceodentata* was caught mainly in relatively high salinity, mostly above 25°/°°. The largest specimen collected was about 70 mm long by 4 mm wide, and the largest in a shell blister was 20 by 1 mm. Worms longer than 15 mm were sexually mature. Shell blisters consisted of a raised conchiolin membrane, which separates the worm from the mantle cavity. The worm accumulates fecal material and detritus which gives the blister a dark and unattractive appearance, and makes infested individuals unacceptable as half-shell or steamer clams. Blister formation probably impairs the vitality of the host, and in some cases causes damage to soft tissues. - J.L.M.

1785
Taylor, John L., John R. Hall, and Carl H. Saloman. 1971.

Mollusks and benthic environments in Hillsborough Bay, Florida. U.S. Dept. Commerce, Natl. Mar. Fish. Serv., Fish. Bull. 68(2): 191-202.

Stations were classified as healthy (8 of 45 stations) if live mollusks were abundant and diverse, marginal (18 of 45) if at least 50% belonged to one or more of 4 indicator species, and unhealthy (19 of 45) if no live mollusk was taken. *Mercenaria campechiensis* was collected at only 4 stations. Mean sediment grain size varied from 2.02 to 3.15 O with standard deviations of 0.7 to 1.8 O, sediment types were fine sand to very fine sand, bottom vegetation was absent or *Gracilaria* sp. present (1 sta), and bottom salinity 18.51 to 22.95. All but one of these stations were classified healthy. Most of the Bay is seriously polluted. - J.L.M.

1786
Taylor, Richard F., Miyoshi Ikawa, John J. Sasner, Jr., Frederick P. Thurberg, and Kenneth K. Andersen. 1974.

Occurrence of choline esters in the marine dinoflagellate *Amphidinium carteri*. J. Phycol. 10(3): 279-283.

Isolated hearts of *Mercenaria mercenaria* were used to assay occurrence of choline-like substances isolated from the dinoflagellate. These plankton organisms have been shown to be toxic to fishes and mice, and supernates from cultures of *A. carteri* have caused fish kills in 15 to 25 min. Natural and synthetic acrylylcholine had approximately 1/4,000 the activity of acetylcholine, and choline O-sulphate about 1/20,000 the activity, on isolated *Mercenaria* heart. - J.L.M.

1787
Teal, John M. 1962.

Energy flow in the salt marsh ecosystem of Georgia. Ecology 43(4): 614-624.

Among estuarine species limited in marsh to low water level is included *Mercenaria mercenaria*. Salinity varies from 20 to 30°/₀₀ with values as low as 12°/₀₀ in heads of creeks just after heavy rains. The limited number of animals which have adapted to these extremes are relatively free from competing species and enemies. - J.L.M.

1788
Teal, John M., and John W. Farrington. 1977.

A comparison of hydrocarbons in animals and their benthic habitats. In Petroleum hydrocarbons in the marine environment. Rapp. Proc.-Verb. Reunions, Cons. Internatl. Expl. Mer 171(Sect. 4): 79-83.

Mercenaria mercenaria is not mentioned in the text, but fig. 64 shows gas chromatographs of alkanes, cycloalkanes, alkenes, and cycloalkenes from sediments and quahog from a chronically polluted area. Distribution of these hydrocarbons is appreciably lower in retention time in clams than in sediments, showing that clams discriminated for lighter compounds in accumulating hydrocarbons from their surroundings. - J.L.M.

1789
Tebble, Norman. 1966.

British Bivalve Seashells. Trustees of the British Museum (Natural History), London. Alden Press Osney Mead, Oxford, 212 p.

Venus (Mercenaria) mercenaria Linnaeus — Quahog
Plate 12, Fig. a; Text-fig. 57 — Hard shell-clam

Shell solid, equivalve; inequilateral, beaks in the front half of the shell; rarely more than 5" (12·7 cms.) in length; broadly oval in outline; a dirty white, light varnish-brown, dull grey or grey-brown in colour occasionally with red-brown zigzag markings near the margins.* Periostracum grey-brown. Ligament a deeply inset, dark brown elliptical band, behind the beaks reaching half-way to the posterior margin. Lunule well defined, broad, heart-shaped. Escutcheon indistinct. Sculpture of concentric lines, raised here and there into ridges, and fine radiating lines. In young specimens the ridges are present all over the shell but in the adult they persist, after wear and tear, only near the anterior and posterior margins. Growth stages prominent. Both valves with three cardinal teeth; in addition there is present in each valve a rough tooth-like area behind the beaks and immediately below the ligament; this area has the appearance of a supplementary posterior cardinal tooth which has been broken off. No laterals. Inside of shell white, sometimes deep violet about the adductor muscle scars. Pallial sinus not deep, triangular. Margin crenulate.

Venus mercenaria lives in mud, with stones and shells, from between tide-marks to depths of a few fathoms, being most abundant a short distance above low water-mark. It is a native species of the coast of N. America from Nova Scotia to Yucatan where it is harvested in some places as a wild crop for sea food. The first living specimens in the United Kingdom were found in the Humber in 1860, but previously, in 1859, a dead shell, probably originating in a ship's ballast, was found in the Mersey. Since that time it has been reported from the Menai Straits, and unsuccessful attempts have been made to introduce it into the Dee (Cheshire) and Mersey estuaries, whilst large colonies have become permanently established in the Solent, Southampton Water and Portsmouth Harbour. These populations may have been introduced via the kitchens of Atlantic liners.

In recent years experimental colonies have been introduced into the R. Yealm, Devon, Poole Harbour, Dorset, the Rivers Crouch, Roach and Blackwater and at Walton, Essex. Some of these were removed on completion of the experimental period but specimens may still be found. The species has been successfully cultivated on a commercial scale in the Solent and has lately been available on the menus of some London hotels.

Venus mercenaria was introduced into various places in France in an attempt to breed it for commercial purposes but none of these was successful until 1910 when a population deposited in the basin of the R. Seudre became properly acclimatised. This was the basis for a now flourishing clam fishery. It has also been reported at various times from Brittany, where colonies still survive, in Zeeland, the Netherlands and in Ostend Harbour, Belgium. - verbatim copy from p. 118-119 of the original - J.L.M.

*Around the British Isles these zigzags occur only on populations imported in late years from N. America.

1790
Templeton, W. L., R. E. Nakatani, and E. E. Held. 1971

Radiation effects. In Radioactivity in the Marine Environment. Natl. Acad. Sci., Washington, D.C.: 223-239.

Cites work of White and Angelovic (1965, 1966), abstracted elsewhere in this bibliography, and reproduces a figure, showing that for the first 25 days *Crassostrea virginica* is much more resistant to radiation than *Mercenaria mercenaria*, but after 80 days LD_{50} for hard clam was greater than for oyster. Radiation tolerances must be expressed as time curves rather than the usual $LD_{50/30}$. - J.L.M.

1791
Tenore, Kenneth R. 1972.

Macrobenthos of the Pamlico River estuary, North Carolina. Ecol. Monogr. 42: 51-69.

No mention of *Mercenaria (Venus) mercenaria*. - W.J.B. and M.W.S.

1792
Tenore, K. R., and W. M. Dunstan. 1973.

Comparison of feeding and biodeposition of three bivalves at different food levels. Mar. Biol. 21: 190-195.

The 3 species were *Mercenaria mercenaria, Crassostrea virginica*, and *Mytilus edulis*. Actual amount of food removed by all 3 bivalves increased with increasing food concentration. At all food concentrations hard clam ingested least food, mussel most. Relative feeding rates (percent of available food removed) at lower food levels were depressed for all 3 species, but increased quickly to a maximum at food concentrations typical of natural environment. This max remained constant for mussel and oyster, but declined for hard clam with further increase in food concentration. Hard clam had lowest biodeposition rate, mussel highest. Biodeposition rates of all 3 increased logarithmically with increasing food concentration. Feeding and biodeposition data were used to calculate assimilation rates, which showed that oysters were most efficient (percent assimilation 87.9 to 77.4), hard clam (77.3 to 71.2) and mussel (75.5 to 71.1) about equal. These bivalves are definitely adapted to food levels found in their natural environments. Increases in these food levels would produce greater biodeposition that could shift the food web to deposit-feeding pathways. The findings also have implications for planning and interpreting studies of heavy metals and other pollutants. In aquaculture it would be advantageous to keep food concentrations within the most favorable assimilation efficiency range, to obtain optimum production. Food was an algal culture dominated by diatoms, especially *Skeletonema costatum*. - J.L.M.

1793
Tenore, Kenneth R., and U. K. Gopalan. 1974.

Feeding efficiencies of the polychaete *Nereis virens* cultured on hard-clam tissue and oyster detritus. J. Fish. Res. Board Can. 31(10): 1675-1678.

Ecological and assimilation efficiencies of *Nereis virens* cultured on minced meats of *Mercenaria mercenaria* were higher (18.0 and 77.3%) than worms fed on biodeposits from *Crassostrea virginica* fed on mixed phytoplankton dominated by *Phaeodactylum tricornutum* (5.7 and 28.8%). Amounts of clam tissue consumed (0.285 g tissue/g dry worms) were considerably less than amounts of oyster biodeposits (1.720 g/g dry worms). - J.L.M.

1794
Tenore, Kenneth R., Joel C. Goldman, and J. Phillip Clarner. 1973.

The food chain dynamics of the oyster, clam, and mussel in an aquaculture food chain. J. Exp. Mar. Biol. Ecol. 12: 157-165.

Secondary-treated sewage effluent was used as a nutrient source for culturing marine phytoplankton, which in turn was used as food for rearing *Mytilus edulis, Crassostrea virginica*, and *Mercenaria mercenaria*. Feeding rate of mussel (5.36 μg C removed/l/g C/animal) was higher than that of oyster (3.92) and clam (3.03), but ecological efficiencies (net production/ingested food) of clam were highest (23.69%), oyster somewhat lower (18.38%), and mussel poorest

(10.01%). Food chain efficiencies were lower than ecological efficiencies, suggesting under-utilization of available food. Hard clam, with lowest feeding rate, was more efficient at utilizing food it filtered and so had the highest net production (=ecological efficiency). In contrast, mussels had the highest feeding rate but lowest ecological efficiency. Rates of regeneration of nutrients, especially total inorganic N, and high biodeposition rates of bivalves suggest that multispecies aquaculture systems would be more efficient and productive than one-species systems. - modified authors' abstract - J.L.M.

1795
Thayer, Gordon W., S. Marshall Adams, and Michael W. LaCroix. 1975.

Structural and functional aspects of a recently established *Zostera marina* community. Proc. 2nd Internatl. Estuar. Res. Conf. 1: 518-540. In Estuarine Research. Vol. 1. Chemistry, Biology, and the Estuarine System. L. Eugene Cronin (ed.). Academic Press, Inc., New York: 518-540.

The study area was Phillips Island, near the mouth of the Newport River estuary, near Beaufort Inlet, N.C. *Mercenaria mercenaria* ranked 35th among 45 species of epifauna, making up 0.05% of the organisms by number. No other specific reference is made to hard clam. - J.L.M.

1796
Thilberg, G. W. 1975.

The role of law enforcement. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 34-36.

The main responsibility of the Division of Law Enforcement with respect to shellfish is to patrol noncertified shellfish areas. Not too long ago the total force was 6 officers and limited equipment. In 1975 the complement of officers was 34, and equipment included boats with radar, fast skiffs powered with outboard motors, radio-equipped cars, and walkie-talkies. It was believed that very few shellfish from closed areas were getting to market. Another problem is illegal harvesting and marketing of high-value undersized clams or "seed clams". On Long Island 90% of enforcement effort was concentrated on marine resources. Leniency in the courts also was a problem. Suffolk County has assigned an Assistant District Attorney to handle conservation cases only. Illegal shellfish harvesting also was being discouraged by suspension of permits and seizure of boat, motor and all equipment. - J.L.M.

1797
Thompson, Ida. 1975.

Biological clocks and shell growth in bivalves. In Growth Rhythms and the History of the Earth's Rotation. G. D. Rosenberg and S. K. Runcorn (eds.). John Wiley Inc., London: 149-162.

Mercenaria mercenaria, 40 to 55 mm shell height, was the experimental animal. Before experiments began the growing edge was rubbed to break the periostracal seal, leaving a notch in the shell. Experimental tanks were closed systems in which the liquid medium was instant ocean. Semidiurnal intertidal experiments simulated a 12.4 hr tidal cycle in which clams were exposed to air for half the period. The light cycle was 12 hr light, 12 hr darkness. Temp varied with light cycle from 20-26°C. In non-tidal experiments water level was constant, light cycle was 12 hr light, 12 hr dark, temp was 19±2°C. Constant-condition experiments had constant water level, constant light, and temp 19±2°C. Duration of experiments was 36 to 130 days. Clams were not fed. Valve movement was measured automatically with a lever which magnified movements 2.5 times, connected to a recorder. Valve movement was clearly rhythmic in all experiments. In the simulated intertidal experiment the pattern of rhythms was similar in individual clams. In the non-tidal regime patterns of rhythms varied among individuals. In the constant-conditions regime variation was even greater, but rhythms continued, demonstrating presence of a bioclock. Microscopic study of shell sections showed that the number of open intervals and number of daily growth increments corresponded closely. Shell growth maps shell movements, and is bioclock-controlled. In the intertidal experiment valves were open almost exclusively in high water and darkness. Several days of one opening per 24 hrs were followed by several days of 2 openings, controlled by interaction of light cycle and tidal cycle. In absence of a tidal cycle all clams had a 24 hr rhythm, sometimes in phase with valves open in darkness, sometimes with light. Opening at first appeared to be in phase with lights-on at 6 am, but rephasing occurred after a few days or weeks and may have been an artifact. Some clams in the non-tidal regime had a second rhythm of 22-23.2 hrs, some had a lunar-related second rhythm somewhat longer than 24 hrs. Shells grown intertidally record solar and lunar (tidal) cycles. Growth occurs mainly at night. Valves are closed in daylight, tissue pH drops, and conchiolin concentrates on the growing edge, forming the dark band of the increment; or concentration of conchiolin will come about from contact of the inner side of the accreting periostracum, where conchiolin has not yet entirely polymerized, with the growing shell edge, as the mantle is withdrawn. Night activity would appear to be adaptive in shallow water, where major predators like birds are light-active and locate prey visually. Addition of a tidal cycle to a solar-day rhythm of shell growth could account for formation of semi-monthly clusters of lines. Just as open intervals in experiments were interrupted periodically by low tides, growth of nightly increments should be interrupted at certain times of the semi-month, producing a narrower band, or leaving a dark band similar to the light-deposited dark band. If high tides occur when the moon is in upper and lower transit, then low tide will occur at midnight during first and third lunar quarters. Deposition of complex increments will occur around lunar quarters. In non-tidal experiments, which simulated some aspects of subtidal habitats, a general pattern of response was more difficult to find. But most clams showed two independent but interacting rhythms in which the number of open-intervals per 24 hr period alternated from 1 to 2. Failure to establish some permanent and consistent rhythmic pattern showed that light cycles alone were poor entrainers of bivalve rhythms. Under constant experimental conditions, light cycles, tidal cycles, and temp cycles were absent, but gravitational and electromagnetic cycles were still present. These are similar to abyssal conditions, where growth increments occur, but no tidal clustering. It is not certain at present whether these increments measure geophysical cycles, or if so, which. Even in a constant-conditions regime, bioclocks apparently are not completely independent variables, but interact with lunar and solar events. In *M. mercenaria* it was concluded that valve movement and increment deposition are under control of a biological clock, and valve opening under "constant conditions" appeared to be responsive to actual solar-day and lunar-day cycles. - J.L.M.

1798
Thompson, Ida L., and Franklin H. Barnwell. 1970.

Biological clock control and shell growth in the bivalve *Mercenaria mercenaria*. Geol. Soc. Am., Abstracts with Programs 2(1): 704.

Opening and closing of valves of hard clam were recorded continuously in artificial sea water aquariums for 8 weeks. Under constant illumination persistent overt rhythms of activity were measured, with periods deviating somewhat from 24 hr. Under cycles of 12 hr light and 12 hr darkness, distinct daily rhythms were noted, with large individual differences in pattern. Microscopic examination of shell growth patterns showed that both experimental lots laid down periodic layers. Comparison of detailed patterns with opening and closing activity was under way. - J.L.M.

1799
Thompson, Mary H. 1964.

Cholesterol content of various species of shellfish. I. Method of analysis and preliminary survey of variables. U.S. Dept. Interior, Bu. Comm. Fish., Fish. Industr. Res. 2: 11-15.

Mercenaria mercenaria taken in Nov 1962 from upper Chesapeake Bay contained about 77 to 86 mg/100 g total cholesterol. Oil content was 2%, moisture content 86.6%. Cholesterol content was somewhat higher than oysters, sea scallop, and Dungeness crab (35-65) but lower than blue crab and peneid shrimp (73-165). Samples were taken at various times of year, but seasonal variations were not measured. - J.L.M.

1800
Thompson, V. P., W. H. Johnson, and J. L. Katz. 1971.

The large filaments from catch muscles: pH and ionic strength dependence of aggregation. Biophys. Soc., Progr. and Abstr., 15th Ann. Meeting: 205a (Abstract WPM-L15).

Large filaments (500-1,500 A diam) can be isolated from white adductor muscle of *Mercenaria mercenaria*. These filaments form long (200-500 μ) longitudinally oriented aggregates as pH is lowered from 7.0 to 6.3. Preparations of purified large filaments were made by centrifugation at ionic strength 0.02-0.10. Actin, then myosin, were removed selectively by varying pH and ionic strength in presence of ATP-EGTA. Ionic strength requirements for aggregation follow in general the solubility curve for ethanol-extracted paramyosin. Native filaments (with myosin on the surface) showed a shift of pH of aggregation with ionic strength, which differs from that of paramyosin filaments (with myosin removed). When temp was raised from usual 2 to 4°C to 25°C, native and paramyosin filaments, as well as ethanol-extracted paramyosin solutions, aggregated in a narrow range of pH (7.0 to 6.8) as pH was lowered from 7.0, suggesting a strong similarity between behavior of pure paramyosin and filaments containing this protein. Presence of actin does not appear to alter aggregation properties of filaments. - modified authors' abstract - J.L.M.

1801
Thorson, Gunnar. 1956.

Marine level-bottom communities of recent seas, their temperature adaptation and their "balance" between predators and food animals. Trans. N.Y. Acad. Sci., Ser. II, 18(8): 693-700.

Animals that live on the bottom of the sea fall into 2 distinct ecological groups, epifauna and infauna. Epifauna are much more diverse, including more than 4/5 of all bottom-dwellers. For hundreds of millions of years the small numbers of genera that make up the infauna, and live in uniform level-bottom areas, must have covered much larger and more uniform areas than the epifaunas. These infauna will provide the "guide fossils" of our period. Whereas typical epifaunal groups show a marked increase in number of species from Arctic to tropical seas, pronounced infaunal groups seem not to increase from high to low latitudes. In sandy bottoms in shallow water are found "chains" of parallel *Venus* communities, different species replacing each other with latitude and temp. An Arctic community at 0°C shows roughly a similar metabolic rate, similar rate of growth, and similar feeding habits, as a boreal community at 8°C or a Mediterranean community at about 12°C, or a tropical community at a higher temp. Thus, observations on predation, mode of feeding, competition, or growth made at any specific coastal area may be of direct help in explaining similar phenomena in other similar communities. The author describes how modern experience with level-bottom communities might be used by paleoecologists to understand a prehistoric level-bottom community, for example by study of shells found in a fossil bed. Teamwork in conducting coordinated studies of level-bottom communities worldwide, or even around the coasts of the United States, would yield much valuable knowledge. - J.L.M.

1802
Thorson, Gunnar. 1958.

Parallel level-bottom communities, their temperature adaptation, and their "balance" between predators and food animals. In Perspectives in Marine Biology. A. A. Buzzati-Traverso (ed.). Univ. Calif. Press, Berkeley: 67-86.

Series of parallel *Venus* communities, dominated by *Venus* and *Spisula* or *Mactra*, are known from sandy bottoms in shallow water from East Greenland, western Atlantic coast, North Sea, Mediterranean, and Persian Gulf. Each shows uniform features qualitatively and quantitatively, irrespective of latitude. A sandy, muddy, or mixed bottom has roughly the same appearance and structure in cold or warm seas, and contains roughly the same number of invertebrate species per square unit in the Arctic or the tropics. The only fundamental difference is temp of water. Most marine invertebrates are totally adapted, or nearly so, to temps at which they normally occur. This applies especially to different species of the same genus that replace each other according to latitude and temp. Thus, an Arctic parallel level-bottom community will have about the same metabolic growth rates at 0°C as its boreal parallel at 8°C, its Mediterranean parallel at about 12°C, and its tropical parallels at even higher temps, and mutual competition within these communities will be about the same. Studies of species of each of the genera of level-bottom lamellibranchs will be of fundamental value to all students of communities dominated by these genera, at whatever latitude. Factors that influence survival and growth of the animals in such communities, such as larval distribution, food, predation, and others, are discussed for a variety of invertebrate and vertebrate species in some detail. References to *Venus (Mercenaria)* are cited from papers most of which are abstracted elsewhere in this bibliography. In the discussion, V. L. Loosanoff commented on Thorson's suggestion that teams of researchers in different regions be organized to study parallel level-bottom communities. He described existing studies of *V. mercenaria*, *V. campechiensis*, and hybrids in 6 locations from Maine to Florida. Lack of complete communication between such investigators might lead to erroneous conclusions. - J.L.M.

1803
Thorson, Gunnar. 1961.

Length of pelagic larval life in marine bottom invertebrates as related to larval transport by ocean currents. In Oceanography. Invited lectures presented at the International Oceanographic Congress held in New York, 31 Aug.- 12 Sept. 1959. Mary Sears (ed.). AAAS Pub. 67: 455-474.

Reports verbal communication from V. L. Loosanoff that *Venus mercenaria* may vary in larval life from 7 to 20 days depending on water temperature. - J.L.M.

1804
Thorson, Gunnar. 1966.

Some factors influencing the recruitment and establishment of marine benthic communities. Neth. J. Sea Res. 3(2): 267-293.

This important review paper does not deal with *Mercenaria (Venus) mercenaria* specifically, but does discuss *Venus* communities. Macrofaunal communities of marine sediment bottoms (or "level" bottoms) seem, roughly, to have parallels in many areas of the globe, whatever the latitude. Thus, there is an Arctic *Venus fluctuosa* community, a boreal *V. gallina (=striatula)* community, and a Mediterranean *V. verrucosa* community, all associated with sandy bottoms at roughly 10-40 m depth, and a deeper living boreal *V. fasciatum* community, associated with shelly sand. More recently, other such communities have been described: *Venus declivis* from shelly sand off Guinea and Senegal, *V. (Mercenaria) campechiensis* from Florida, *V. casina* from the Channel off Roscoff, and *V. (Austrovenus) stuchburgi* from New Zealand. The voracious sea star *Astropecten irregularis*, inhabiting a sandy-bottom *Venus* community in northern seas, may contain more than 400 lamellibranch spat in its stomach at one time. In the area of Helsingor, Denmark, this sea star feeds on *Spisula subtruncata*, a fast-growing, short-lived species with high metabolic rate, and on *Venus gallina*, a slow-growing, long-lived species with low metabolic rate. Each specimen of *Venus*, with a life span roughly 4 times that of *Spisula*, may be in danger of being eaten by *Astropecten* for a period 4 times longer. Despite these odds, *Venus* survives, because *Spisula* creates a much stronger water current, and thus can be scented and found more readily. Its high oxygen consumption also forces *Spisula* to open its valves even in the stomach of *Astropecten*, where it will be killed and digested rapidly, whereas *Venus* in the same situation can stand an oxygen deficit. *Venus* will close its valves and may be regurgitated from the stomach of the sea star up to 18 days later, fully ålive. Evaluation of the rate of feeding of such a predator by the proportions of prey found in stomachs could be entirely misleading. - J.L.M.

1805
Thurberg, Frederick P., Anthony Calabrese, and Margaret A. Dawson. 1974.

Effects of silver on oxygen consumption of bivalves at various salinities. In Pollution and Physiology of Marine Organisms. Academic Press Inc., New York: 67-78.

Silver content of parts of Long Island Sound is an order of magnitude higher than surrounding western North Atlantic waters. Oxygen consumption rate of hard clams increased with decreasing salinity and with increasing Ag concentration at 25 and 35°/₀₀. Ag had no effect on already elevated consumption values at 15°/₀₀. - J.L.M.

1806
Tiews, K. 1973.

Report on a survey of present research activities in the field of aquaculture in the EIFAC region. Food and Agric. Org. of the U.N., FI:EIFAC 72/SC II-1, Rev. 1, 29 March 1973, vii + 63 p.

The only research currently being done on *Venus (Mercenaria) mercenaria* is in the British White Fish Authority laboratory at Conway. - J.L.M.

1807
Tiffany, William J., III. 1972.

Aspects of excretory ultrafiltration in the bivalved molluscs. Comp. Biochem. Physiol. 43A(3): 527-536.

Comparative osmotic pressure measurements of blood and pericardial fluid of 5 bivalve species, including *Mercenaria mercenaria* and *M. campechiensis*, demonstrated an osmotic pressure gradient from pericardial fluid toward the blood. Systolic pressure in the ventricle of these species was smaller than the osmotic pressure gradient. Therefore, ultrafiltration cannot take place across ventricle into pericardial cavity. It is highly likely that auricular and ventricular filling in these species is aided by negative pressures in the pericardial cavity. - modified author's abstract - J.L.M.

1808
Tiffany, William J., III. 1974.

Ultrastructural evidence for reabsorption in the nephridium of the bivalved mollusc *Mercenaria campechiensis*. Trans. Am. Microsc. Soc. 93(1): 23-28.

The fine structure of the nephridium of *M. campechiensis* resembles that of a gastropod, goosefish, crayfish, and mammals. The basal region of the cells contains dense conglomerations of alpha-glycogen rosettes. It is suggested that the nephridium of this species may be a glycogen-storing organ, in addition to its function in reabsorption of filterable metabolites, ions, and water from the urine. - J.L.M.

1809
Tiller, R. E. 1950.

Greenwich Cove survey. Ann. Conf., Clam Investigations, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 18-19.

The Cove was divided into 4 approximately equal subareas. Total area 10.75 million ft^2 or 274 acres. Area 1 (upper cove); total area 2.555 million ft^2; area sampled 50 ft^2; number of clams 0.38 clams/ft^2; total estimated population 970.9 thousand clams. Area 2 (downstream): total area 2.888 ft^2; area sampled 150 ft^2; number of clams 0.31 clams/ft^2; total estimated population 895.4 thousand clams. Area 3 (downstream further): total area 2.177 million ft^2; area sampled 150 ft^2; number of clams 1.26 clams/ft^2; total estimated population 2.743 million clams. - J.L.M.

1810
Tiller, R. E. 1950.

The hard clam fishery of the Atlantic coast. Ann. Conf., Clam Investigations, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 21-22.

Coastal waters from Maine to Fla. Generally decrease in abundance in southern part of range. No other information. - J.L.M.

1811
Tiller, Richard E., John B. Glude, and Louis D. Stringer. 1952.

Hard-clam fishery of the Atlantic coast. Comm. Fish. Rev. 14(10): 1-25.

Information was obtained from personal interviews during 1949 to 1951 with clammers, dealers, and state conservation personnel in all Atlantic coast states and from official catch statistics. This was preliminary to planning and establishing a clam research program authorized by Congress in 1948. From 1931 to 1948 total landings of hard clam trended upward to a level above previous peak years, but annual production and value were small compared with other shellfish resources. Hard clams occur in nearly every sheltered bay, cove, or inlet along the entire coast, but the fishery is centered in southern New England and the middle Atlantic states. In 1944-48 N.Y., N.J., R.I., and Mass. produced 85% of the total catch. Gears used are short-handled hoes and rakes in very shallow water, forks and picks in southern states, long-handled rakes and tongs in deeper water. In very deep water sectional wooden handles or stales are fitted to rake heads, making the handles over 50 ft long at times, although 36 ft is usually the maximum. Dredges are more varied in design than other clam gears. Conservation laws in various states regulate the design of dredges and specify where and when they may operate. For the coast as a whole tongs take the largest part of the catch (65% in 1944-48). Some states specify a minimum size limit, others do not. Gear and season limits are tabulated by states. In some states the towns, rather than the states, make and enforce regulations. Hard clams are graded by size. The smallest group, littlenecks, commands the highest price. In Maine commercial clam fishing is limited to a small area in upper Casco Bay. Hoes were the principal gear. Nearly all digging was in the intertidal zone. The fishery was very small. It was concluded that the fishery was not likely to expand. In Mass. most of the hard-clam fishery was along the south shore of Cape Cod, and around Nantucket, Martha's Vineyard, and the Elizabeth Islands. Rakes were the most important gear, but dredges were permitted in deeper offshore waters. The fishery is regulated by individual townships. The resource was not in good condition, from overharvesting and setting failures. Historic fluctuations in the catch may have been caused by variations in recruitment and heavy pressure on littlenecks, the smallest and most valuable legal sizes. Some grounds were closed by pollution. Demand exceeded supply and some dealers were importing clams from R.I. It was concluded that the resource was being fully utilized. In R.I. hard clams were restricted to the upper part of Narragansett Bay, and were rarely found in commercial quantities deeper than 25 ft. Bull rakes and tongs were the most important gears. Dredging is permitted in only one area, from 1 Dec to 31 Mar. The resource was judged to be in good condition and the industry was prosperous. Work was under way in the Fish and Wildlife Service to measure the effects of harvesting on the resource and to estimate the allowable catch. No results were reported. There was concern about out-of-state shipment of undersize clams. The dredge fishery, which once supported a fleet of about 40 boats, now has only 5, because that segment of the resource has been overharvested. It was believed that this fishery would not survive unless more grounds were opened to dredging. Pollution was a problem in some areas, but was not considered serious. The industry did not report problems with predators. In Conn. there is almost no sheltered water, and hard-clam production is limited to Fairfield County, where shelter is provided by Long Island, and a few coves near New London and Mystic. Tongs and rakes are the most important gears. Clam digging is not a full-time occupation in Conn., and the industry is of minor importance. Commercial oyster growers sell the clams they bring up with oysters, but do not conduct a directed clam fishery. Clam farming might be possible, but the prevailing view was that scarcity of seed would be a problem. Most of the hard-clam fishery in New York is in the sheltered bays of the south shore of Long Island, but some bays of the north shore, which had not been closed by pollution, also produce hard clams. The 3 most important areas, in descending order of production, were: Great South Bay (western portion more productive than eastern), Port Jefferson to Cold Spring Harbor along the north shore of L.I., and Greenport to Peconic Bay at the eastern end. Tongs and rakes were the most important gears. Dredges are allowed only on private grounds. The fishery was in excellent condition, and except for some problems with duck farm pollution, the industry was relatively free of problems. Until about 15 years ago (e.g., about mid-1930s) Shinnecock and Great South Bays were the most consistent producing areas, but since then clams have been found in nearly every bay and cove on L.I. It is believed in the industry that opening of the intracoastal waterway in 1930-31, by increasing salinity, improved the environment for hard clams. Disappearance of eel grass, which began in 1931, also was believed to favor the hard clam resource by improving water circulation. Setting was not regular, but frequent enough to maintain the supply of clams. Heavy sets were reported on both shores of L.I. in 1941. The industry was more concerned about water pollution than overharvesting. Pollution from duck farms was a growing problem, although the effect on the hard clam resource was believed to be minor. Results of scientific studies conducted in 1949 were not yet available. Marketing was not a problem. Most clams were shipped to New York City, but shipments to places as distant as Md. and Ohio were reported. New York ranks first among the states in hard clam production, and it was concluded that the resource was in no immediate danger of overexploitation. Hard clams are taken along almost the entire coast of N.J. Best areas are Little Egg Harbor and Great Bay. The most important gears are tongs and rakes. Dredging is allowed on private grounds, or with sailing vessels on public grounds. Some people in the industry were concerned about overharvesting and setting failures, but others were optimistic, believing that recent declines in production were temporary. Demand is so great for small clams, especially in late summer, that quantities of undersize clams are taken illegally. Principal markets are N.Y., Pa., and Ohio. Many dealers maintain leased beds on which they store clams bought at low prices, to hold until markets improve. Except near Atlantic City and Wildwood water pollution was not a problem. It was concluded that the resource was in good condition and overharvesting unlikely. Delaware had few clam beds, and production was insignificant. Dredges are the only gear used in the Delaware Bay industry. In the sheltered waters of Rehoboth Bay and Indian River were small tonging fisheries. The dredge fishery began as a sideline of the oyster industry, but good markets for clams led to a directed clam fishery in the summers of 1949 and 1950. The catch is mostly large clams, which are canned. Clam production had been increasing in Delaware Bay, but the protected coastal bays were not as productive of hard clams as Chincoteague Bay to the south. The resource in Delaware was almost fully exploited, there were no marketing problems, and no evidence of overfishing. Pollution was not a serious problem. In Md. Pocomoke Sound in Chesapeake Bay produces small quantities of hard clams, but most production in the State comes from protected bays on the ocean side. These bays are very shallow, with soft sandy mud. Tongs and rakes are the important gears. A few hard clams are taken in the oyster dredge fishery. Total catches were trending upward but the resource was judged to be in good condition except in Pocomoke Sound, where some formerly productive grounds had been virtually denuded. Marketing is the major industry problem. In cold winters, when harvesting farther north is restricted by ice, some dealers have imported clams from N.Y., N.J., R.I., and N.C. to hold on their beds for higher prices. In recent warm winters, this practice proved risky, and some dealers abandoned it. The market is almost entirely out-of-State. Regular markets were in N.Y., Pa., Ohio, Fla., and Tex. Peaks of demand are late summer (for clambakes) and winter for large chowder clams. Two firms in Md. were producing canned chowder and another was freezing clams. Despite marketing problems the industry had been growing steadily. In Va. the industry also is centered along the seaside of the eastern shore, but hard clams also are taken in the lower parts of Chesapeake Bay. The broad shallow flats on the western side of the Bay where salinities are high enough are also quite productive, and make excellent holding grounds. Tongs and rakes are the most important gears. In some areas patent tongs are used. Catches in dredges are incidental to private oyster harvesting. Recent catches were less than formerly, but the problem apparently was not overharvesting, but overproduction and marketing.

Planting clams on private leased ground is one of the most important parts of the hard-clam industry in Va. The winter trade is the most profitable, when competition from the north is less keen. Pa., N.Y., Ohio, and Fla. are the best markets. Almost all are sold in the shell. Pollution is a problem only near Norfolk. The State permits transplantation for depuration. Predation is not a serious problem, except when skates invade Chincoteague Bay. At least one planter put up fences to protect his supply. Hard clams are found in nearly all sheltered waters in N.C. Almost all the catch was taken with rakes. Dredging began in 1949. The principal problem was market development, although there was some concern about the developing dredge fishery. The winter season is most profitable, and most clammers are part-timers. Bedding of cheap clams in summer is common, as it is in Va. Most clams are sold in the shell through dealers in Va. and Md. Freezing meats and liquor separately cuts cost of shipping. Pollution and predation are not problems. It is believed that supply greatly exceeds demand. It was concluded that the resource will not be fully utilized until markets are found or a more intensive dredge fishery develops. In S.C. it was believed that large unexploited stocks of hard clam existed. The catch is made mostly with rakes on exposed flats at low tide. Dredges in the oyster industry also take a few clams. Directed dredging for clams is prohibited in water less than 12 ft deep. Lack of markets has retarded development of the industry. Only in severe winters is the price high enough to warrant digging and shipping. Some S.C. laws, such as a closed season during the peak of the raw-bar and clam-bake market, and a ban on shipping clams out of state in the shell, also inhibit the industry. Clams are found in most coastal waters of Ga. but there was no commercial fishery at the time of writing. There is almost no local demand, and northern markets are too distant. There is some question as to whether the resource is large enough to support a commercial fishery. In Fla. hard clams are found along both coasts, but greatest numbers are on the west coast from Ten Thousand Islands to Tampa Bay. Total area of these grounds was at least 150 mi^2, off a shallow shelving shoreline where the water may be less than 12 ft deep 5 mi offshore. Clam digging is a part-time occupation, using rakes, hoes, and grabs. Reliable records of the fishery were not available. A conveyor-belt dredge was introduced about 1913. High costs caused this operation to discontinue in 1947. The regular "Fall River" dredge used in New England has been tried in Fla. but it was never used commercially. Results of early studies of this fishery were conflicting. Some concluded that the resource had been damaged by dredging, others thought the potential was almost unlimited. The history of the fishery shows that abundance varied widely, from great abundance to economic scarcity. Most people in industry believed that the causes were natural, not overfishing. The fishery in the Ten Thousand Islands area had ceased, and it was doubtful whether it would resume. Lower Tampa Bay produced a supply for local use and a few large clams were taken near Clearwater. Local demand for clams is small and seasonal, and outside markets were difficult to find. Further problems were sand in the meats and poor keeping quality. At the time of writing there was virtually no hard-clam fishery in the State. It was concluded that along the Atlantic coast as a whole hard-clam stocks were in good condition. Stocks in most places were adequate and dealers are more concerned about demand than supply. The only major exception was the unexplained disappearance of the very large bed on the west coast of Fla. Stocks in R.I. may not be able to withstand further increases in effort. Water pollution was a serious problem only in Mass., R.I., and N.Y. To some degree this had been alleviated by transplanting to clean areas. Clam production in these states could be increased by improved waste treatment. Marketing was an important problem for all states from Md. south. Severe winter weather restricts northern diggers, but southern clammers usually find winter digging profitable. Markets for southern clams are also affected by lower meat yields. Hard clams from Me. to N.Y. average about 11.5 lbs meats/bu, N.J. to Del. about 9, and Md. to Fla. only about 7.5 lbs/bu. - J.L.M.

1812
Towe, Kenneth M., and George R. Thompson. 1972.

The structure of some bivalve shell carbonates prepared by ion-beam thinning: A comparison study. Calcif. Tissue Res. 10(1): 38-48.

In cross-polarized light from an ion-beam thinned sample, the boundaries between prisms in *Mercenaria mercenaria* are well shown and growth lines running normal to the prisms can be seen. In the electron microscope the transmission images show that the prisms are not single crystals, as they appear to be in polarized light, but are constructed of numerous smaller crystalline units with their long axes parallel and subparallel to those of the larger prisms. The polycrystalline nature of the prisms has been confirmed by selected-area electron diffraction. - J.L.M.

1813
Tower, Donald B., and Donald McEachern. 1948.

Experiences with the 'Venus' heart method for determining acetylcholine. Canadian J. Research 26E(2): 183-187.

Existing methods for determination of acetylcholine (ACh) were not satisfactory because they lacked sensitivity to micro-amounts, the ACh molecule is unstable, and ACh is similar chemically and pharmacologically to other constituents of biological materials. Chemical analysis would not detect less than about 0.1 mg of pure substance. Sensitivity of *Venus* heart to ACh was reported originally by Prosser and Prosser (1937) and studied further by others (all abstracted elsewhere in this bibliography). Adaptation of the method for biological assay of ACh was described by Wait (1943) and Welsh (at that time in press). The method is described and illustrated. Isolated ventricle of *V. mercenaria* is stable for many hours. Its minimal sensitivity for ACh was between 0.005 and 0.01 μg %. The method is simple and highly specific and the preparation may be used repeatedly, as often as every 5 to 10 min. The effect of ACh on ventricular contractions is one of partial or complete inhibition of systolic contraction without significant effect on rate. Extent of inhibition is almost directly dependent on amount of ACh present. Isolated ventricle is highly specific. It is insensitive to most other constituents of biological tissues and fluids, particularly K, histamine, and adrenaline. It is not susceptible to pH over at least the range pH 5 to 8.5. It is also insensitive to anticholinesterases such as physostigmine (eserine), prostigmine, and di-isopropylfluorophosphate (DFP). In active biological samples the identity of ACh can be established through its destruction by alkali-heat hydrolysis. *Venus* ventricle shows seasonal variations in responsiveness to ACh. Poor preparations can be restored to normal by addition of ergot alkaloids to the medium to give a final concentration of 1:1,000,000. - J.L.M.

1814
Townes, H. K., Jr. 1939.

Ecological studies on the Long Island marine invertebrates of importance as fish food or bait. State N.Y. Conserv. Dept. 28th Ann. Rept. 1938, 14 (Suppl.): 163-176.

Venus mercenaria is common in rather shallow water on bottoms of gravel, sand or mud. Commonest on sand. Often used as bait. - J.L.M.

1815
Tressler, Donald K. 1923.

Marine Products of Commerce. Chapter 28 - The clam industry of the United States. New York: 532-547.

Revised edition, published in 1951 under names of Tressler and Lemon, is abstracted below. - J.L.M.

1816
Tressler, Donald K., and James McW. Lemon. 1951.

Marine Products of Commerce: Their acquisition, handling, biological aspects and the science and technology of their preparation and preservation. Reinhold Pub. Corp., New York, xiii+782 p.

Chapter 14. Fish and shellfish as food: 282-306. - *Venus mercenaria* in Sept. 1966 had the following amino acids in proteins of edible portions: Arginine 5.27%; histidine 1.45%; lysine 5.40%; tryptophane 1.19%. Clams (species not named) contained vitamins A, B, D and G, protein 9% and fat 1%. *Venus mercenaria* had 1.37 mg/kg iodine in fresh meats. Chapter 27. The clam industry of the United States: 576-589. - *Venus mercenaria* was one of 2 important species of clam on the Atlantic coast. It is common from Cape Cod to Texas. South of New York it is much more abundant than soft clam. Growth to commercial sizes is decidedly slower than soft clam. Approximate composition of quahogs: 1) removed from shell - moisture 80.8%; protein (Nx6.25) 10.6%; fat 1.1%; carbohydrates 5.2%; mineral matter 2.3%; total nutrients 19.2%; 2) in shell - shell 67.5%; moisture 28%; protein 2.1%; fat 0.1%; carbohydrate 1.4%; minerals 0.9%; 3) canned - moisture 82.9%; protein 10.5%; fat 0.8%; carbohydrates 3%; minerals 2.8%. Collection of seed quahogs or spat is much more difficult than for soft clams because small hard clams are never found in such vast quantities. As many as 75 young quahogs/ft^2 may be caught in box collectors, the method has not been profitable. Young quahogs (littlenecks) bring high prices, and farming to produce small clams has been suggested, using larger animals as spawners. Hard clam was considered inferior to soft clam, and little attention was given to quahog until beginning of 19th century. The industry did not become important until 20th century, when demand for "littlenecks" began. The industry is located chiefly in Mass., R.I., N.Y., N.C., and Fla. The species occurs from Mass. to Fla. and in Gulf of Mexico. In the Gulf states they are dug only on the west coast of Fla. Harvesting is by rakes and tongs, and by dredges on private grounds. In deep water a basket rake, with a handle 25 to 65 ft long, is used. It is essentially a summer fishery. The catch is washed, graded, and shipped in barrels or bags. Clams often are bedded on tidal flats to hold for favorable market conditions. Others are held in the water on floats. Chief New England markets are Boston and New York. Quahogs will live out of water much longer than soft clam, thus are better known in the Mississippi valley. Clam chowder for canning usually is prepared from quahogs. Processing techniques are described. Chapter 36. Some problems of the fisheries: 752-765. - Storage is a problem for the clam industries. Clams are seldom frozen for long storage because they become rubbery. - J.L.M.

1817
Tressler, D. K., and A. W. Wells. 1924.

Iodine content of sea foods. U.S. Bu. Fish., Doc. 967.

Data cited by Vinogradov 1953, abstracted elsewhere in this bibliography. - J.L.M.

1818
Triggle, D. J., and C. R. Triggle. 1976.

Chemical Pharmacology of the Synapse. Academic Press, New York, x+654 p.

The book will serve well as an advanced textbook of neuropharmacology for graduate students and as a reference book for workers in the field. It is pointed out that a variety of fascinating questions remain to be answered. Although the review does not say so specifically, it is probable that studies using preparations of *Mercenaria mercenaria* tissues and organs are covered. Each chapter has an extensive bibliography - from book review by Richard E. Zigmond, Science 197(4309): 1175-1176. - J.L.M.

1819
Tripp, M. R. 1963.

Cellular responses of mollusks. Ann. N.Y. Acad. Sci. 113(1): 467-474.

Most information on lamellibranch tissue responses has been obtained from histopathological studies of diseased oysters. The paper cites no specific information on *Mercenaria mercenaria* but the general principles would apply. Responses of mollusks to foreign materials fall into 3 categories: 1) no appreciable cellular response; 2) small particles in tissues and blood sinuses may be phagocytized and either carried through epithelia to the exterior or degraded intracellularly; and 3) foreign material in lesions may be infiltrated and surrounded by masses of amoebocytes, and the entire lesion is eventually walled off by an epithelial layer. These leave unanswered many questions about molluscan immunity. Stauber (1961), cited elsewhere in this bibliography, stated the problem clearly. Techniques of tissue culture, immunology, and axenic culture will be useful experimental tools. - J.L.M.

1820
Tripp, M. R. 1970.

Defense mechanisms of mollusks. J. Reticuloendothelial Soc. 7(2): 173-182.

This review paper discusses nonspecific humoral factors, cellular responses, encapsulation and antibody-like substances. The only specific reference to *Mercenaria mercenaria* is by citation of Schmeer (1966), abstracted elsewhere in this bibliography, on antitumor activity of mercenene, an aqueous extract of hard clam, and probably a glycopeptide. The author comments that the mode of action of paolins and mercenene has not been demonstrated, nor has it been shown that they are functional under natural conditions. A potential parasite that penetrates the outer epithelium of a vertebrate may be challenged by 3 types of defense: 1) naturally occurring nonspecific humoral factors; 2) phagocytes, fixed and motile, or other motile cells; and 3) specific antibody. In mollusks nonspecific humoral factors may act directly to destroy foreign material, or they may enhance phagocytosis. Particles usually are digested by phagocytes, but in some cases they survive and may even multiply. In these cases cells migrate to the exterior and contained particles are lost by attrition. Pinocytosed foreign material is carried across epithelia also; there is no evidence that it is digested intracellularly. Large particles are walled off by capsules of leucocytes and connective tissue. Antibodies are not known to be produced in mollusks, but there is some evidence that specific effective humoral factors may be induced by infection with, or injection of, appropriate foreign substances. - J.L.M.

1821
Trueman, E. R. 1966.

Bivalve mollusks: Fluid dynamics of burrowing. Science 152(3721): 523-525.

Bivalves that live in sand or mud, like *Mercenaria*, all use essentially similar steplike digging movements. Each step includes a cycle of activities including the following successive actions: 1) extension of foot; 2) closure of siphons; 3) adduction of the valves; 4) pedal dilation; 5) contraction of pedal retractor muscles, causing movement of shell into the sand; 6) followed by a short period of relaxation when the valves open. Between successive cycles is a static period of variable duration when the foot is extended, probing more deeply into the substrate, and the shell remains stationary or is slightly raised. Pedal retraction usually occurs in two phases, so that posterior retraction follows anterior, and a rocking motion is imparted to the shell, making for easier penetration. Protraction and probing of the foot is done by intrinsic pedal muscles. Contraction of transverse and protractor muscles causes extension of retractors, generating only low pressures in the pedal hemocoel. In the digging cycle, adduction of the shell causes a major increase of pressure in pedal hemocoel; pressure is sustained by retraction of foot, which occurs immediately after adduction. At adduction, hydrostatic pressure is increased not only in the foot but throughout the body. The effect of adduction is to put the hinge ligament under a strain that causes valves to reopen. Internal pressure ejects water from the mantle cavity and blood into the pedal hemocoel. Ejection of water liquifies sand adjacent to the shell immediately before retraction, allowing easier penetration. Increased pressure in the foot, and relaxation of transverse muscles distally, causes dilation. Dilation must precede retraction, to provide firm pedal anchorage so that the shell can be pulled down. An important part of the digging cycle is the recovery of the clam near the end of the cycle, in which valves are opened by the elasticity of the ligament. - J.L.M.

1822
Trueman, E. R. 1967.

Activity and heart rate of bivalve molluscs in their natural habitat. Nature 214(5090): 832-833.

Reports research on *Cardium edule* and *Donax vittatus*. The ability of *Mercenaria (Venus) mercenaria* to respire anaerobically is mentioned. - J.L.M.

1823
Trueman, E. R. 1968.

The burrowing activities of bivalves. In Studies in the Structure, Physiology and Ecology of Molluscs. Vera Fretter (ed.). Academic Press Inc. (London) Ltd. and Academic Press Inc., New York: 167-186.

Mercenaria mercenaria and other species have been studied. This is largely a review article, summarizing work of the author and others. Papers on *M. (Venus) mercenaria* are abstracted elsewhere in this bibliography. Bivalves dig by a series of steps, a "digging cycle", which continue until the animal is beneath the surface. The activity has 6 phases, which integrate pedal protraction and retraction with opening and closing of valves, much of the body musculature playing a part in each cycle. The hinged shell is the basis of a fluid-muscle system which allows the strength of adduction to be used in digging. Adduction generates high pressures in haemocoele and mantle cavity equally and simultaneously. In the haemocoele this pressure gives rise to the characteristic dilated form of the foot to give secure anchorage so that at retraction the shell is drawn down. Pressure in the mantle cavity produces powerful jets of water which loosen the adjacent sand. At each step the foot probes, using intrinsic pedal muscles at relatively low hydrostatic pressure, while the shell is held in place by the elastic ligament pressing valves open against the substrate. Hinge teeth maintain contact between the valves dorsally during digging, when valves are gaping ventrally. It is possible that tissues adjacent to and between the teeth contain tactile receptors. Little is known about nervous control of the digging cycle. Evolution of the bivalved shell seems to have been an adaptation for active burrowing. By the form of their shell, bivalves have been able to utilize the double fluid muscle system for burrowing and have become among the more successful inhabitants of soft substrates. Rate of probing varies widely between species, e.g., *Ensis arcuatus* 90 probes/min, *M. mercenaria* 16, and *Mya arenaria* 1. Diagrams of a generalized bivalve at various stages of the burrowing cycle probably were drawn from *M. mercenaria*. - J.L.M.

1824
Trueman, E. R., A. R. Brand, and P. Davis. 1966.

The dynamics of burrowing of some common littoral bivalves. J. Exper. Biol. 44(3): 469-492.

A detailed description of burrowing activities and mechanisms of 4 common littoral bivalves with very different shell shapes and habits. *Mercenaria mercenaria* was not included, but it appears that the general picture for *Ensis* holds good for other "normal" bivalves such as the Veneridae: a) protrusion of foot into substrate until fully extended (hakenform); b) dilation of distal end of foot to form an anchor (schwellform); and c) pull downwards by contraction of pedal retractor muscles (grabstufe). The paper is illustrated with clear line drawings. - J.L.M.

1825
Trueman, E. R., A. R. Brand, and P. Davis. 1966.

The effect of substrate and shell shape on the burrowing of some common bivalves. Proc. Malacol. Soc. London 37(2): 97-109.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1826
Tubiash, Haskell S. 1975.

Bacterial pathogens associated with cultured bivalve mollusk larvae. In Culture of Marine Invertebrate Animals. Walter L. Smith and Matoira H. Chanley (eds.). Plenum Press, New York: 61-71.

At times the laboratory at Milford, Conn. had catastrophic and inexplicable overnight losses of molluscan larvae. Affected live cultures often showed shimmering, vibrating particles around margins of many larvae, identified as active swarming of bacteria. Named bacillary necrosis, the disease takes a swift and dramatic course. Within 4 to 5 hrs early signs of infection are reduction of mobility and a tendency for many larvae to lie quiescent with foot and velum extended. Swarms of bacteria originating from discrete foci appear on margins of some larvae. Swarming becomes progressively more intense and diffuse, resembling swarming bees. In 8 hrs death is widespread and in a heavily seeded culture mortality may be complete in 18 hrs. Pathogenic strains obtained from oyster larvae were not as virulent or motile as those from *Mercenaria mercenaria*. All pathogens were gram-negative, motile, flagellated rods, of the Order Pseudomonadales. Five serological strains were typed and labelled. Type J consisted entirely of pathogens isolated from disease episodes of seed hard clams. The bacteria were identified as 3 species of *Vibrio*. Strict attention to sanitation is the primary preventative. - J.L.M.

1827
Tubiash, Haskell S., and Paul E. Chanley. 1963.

Bacterial necrosis of bivalve larvae. Bacteriological Proceedings, 1963: 164, RT16 (abstract).

A group of gram-negative marine bacterial isolates duplicate spontaneously occurring infections. Infection and death with necrosis proceeds rapidly, spreading from foci which demonstrate a characteristic "swarming" by the infecting bacteria. Isolates from *Mercenaria mercenaria* larvae and spat are equally infectious for larvae of European oyster and bay scallop. Experimentally induced epizootics have been controlled by prophylactic and therapeutic use of dihydrostreptomycin and chloramphenicol. - J.L.M.

1828
Tubiash, Haskell S., and Paul E. Chanley. 1965.

Bacterial epizootics in larval and juvenile pelecypods. Am. Malacol. Union, Ann. Repts. for 1965: 12.

This publication was not seen. - M.W.S.

1829
Tubiash, H. S., and P. E. Chanley. 1966.

Infectious necrosis: A disease of larval and juvenile bivalve mollusks. Proc. 55th meeting, Natl. Shellf. Assn., Washington, D.C. 21-25 July, 1963: page not numbered.

Listed by title only, under the heading "Other technical papers presented at the 1963 Convention." - M.W.S.

1830
Tubiash, Haskell S., and Alva E. Farrin. 1967.

Dichlorophene for control of tunicates in cultures of artificially reared bivalve mollusks. Progr. Fish. Cult. 29(4): 235-237.

Dichlorophene proved to be effective for control of the fouling ascidian tunicate *Molgula manhattensis* in experimental hatchery cultures of juvenile bivalve molluscs. Exposure to DCP at levels of 10 ppm for 4 to 6 hrs was lethal to tunicates but not to juvenile or adult *Mercenaria mercenaria*. Adult hard clams tolerated exposure to 10 ppm DCP for 6 hrs with no apparent ill effects. - J.L.M.

1831
Tubiash, Haskell S., Paul E. Chanley, and Einar Leifson. 1965.

Bacillary necrosis, a disease of larval and juvenile bivalve mollusks. I. Etiology and epizootiology. J. Bacteriol. 90(4): 1036-1044.

Four biotypes and 5 antigenic types of bacteria pathogenic to larvae of *Mercenaria mercenaria* and 4 other bivalves were isolated. All are gram-negative motile rods. Comparative studies of a fairly large number of similar bacteria isolated from presumably normal marine fauna showed that none of these was pathogenic for bivalve larvae nor did they have antigens common with the pathogenic group. The 4 biotypes had a number of common characteristics that rarely were present in other cultures from marine fauna. The pathogens were of the type commonly classified as *Aeromonas* sp. or *Vibrio* sp. Initial invasion probably is through larval alimentary tract. Adult clams and other species exposed to massive concentrations of all pathogenic serotypes showed no ill effects, although they ingested vast numbers of test bacteria. Antibiotic preparations apparently are effective in preventing and treating larvae infected in hatcheries. Some drugs were tolerated by larvae at concentrations which may be helpful therapeutically. - J.L.M.

1832
Tubiash, Haskell S., Rita R. Colwell, and Riichi Sakazaki. 1970.

Marine vibrios associated with bacillary necrosis, a disease of larval and juvenile bivalve mollusks. J. Bacteriol. 103(1): 271-272.

A group of bacteria, identified by numerical taxonomic analysis as *Vibrio* spp., can be isolated from overtly healthy, diseased, or moribund bivalve mollusks or their environments in productive commercial shellfish areas. *Mercenaria mercenaria*, among other bivalves, is subject to infection in laboratory cultures and in the natural environment. - J.L.M.

1833
Tubiash, Haskell S., Carl N. Shuster, Jr., and John A. Couch. 1968.

Anomalous siphons in two species of bivalve mollusks. Nautilus 81(4): 123-125.

Included was a specimen of *M. mercenaria* with a supernumerary structure on ventral outer wall of incurrent siphon. This anemone-like projection had a distal whorl of tentacles, similar to a normal siphon, but lacking a functional opening. - J.L.M.

1834
Tufts, Norman R. 1967.

Topical labeling of shellfish. Proc. Natl. Shellf. Assn. 57: 73-76.

A durable mark for shellfish could be used for detecting bootlegged clams, identification of growing areas and shellstock, and as a tool in research. Successful marking was accomplished with epoxy glue, Spectraglo green tracing powder coated with krylon, and krylon-sprayed acetone solutions of melamine sulphonamid formaldehyde resins. Marked shells can be detected by fluorescence under ultraviolet light. - J.L.M.

1835
Tulley, T. E. 1952.

A zoogeographic study based on the bivalves of the Gulf of Mexico. Ph.D. dissertation, Harvard Univ.

Not available in Dissert. Abstr. Internatl. Not certain whether original information on *Mercenaria* is included. - M.W.S. and J.L.M.

1836
Turekian, Karl K., and Richard L. Armstrong. 1960.

Magnesium, strontium, and barium concentrations and calcite-aragonite ratios of some recent molluscan shells. J. Mar. Research (Sears Found.) 18(3): 133-151.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

1837
Turekian, Karl K., J. Kirk Cochran, D. P. Kharkar, Robert M. Cerrato, J. Rimas Vaisnys, Howard L. Sanders, J. Frederick Grassle, and John A. Allen. 1975.

Slow growth rate of a deep-sea clam determined by ^{228}Ra chronology. Proc. Natl. Acad. Sci. 72(7): 2829-2832.

Sediment-water interactions in shallow coastal regions produce Radium-228 which in turn comes from decay of Thorium-232. The radionuclide is deposited in the shells of mollusks. *Mercenaria mercenaria* from Cape Cod area yielded 0.20 disintegrations per min, which is within a factor of 2 of the probable dpm ^{228}Ra/g of Ca ratio of the water in which it was taken. Material from which the count was recorded came from the growing edge of the shell. - J.L.M.

1838
Turner, Harry J. 1953.

Growth of molluscs in tanks. Sixth Rept. Investig. Shellf. Mass., Mass. Dept. Nat. Res., Div. Mar. Fish: 35-38.

Experiments were conducted in outdoor tanks to determine what bivalves would survive and grow in impounded salt water, optimum salinity for growth, and effects of feeding mass-produced phytoplankton. Conditions in the tanks were suitable for growth of quahaugs but not other species tested. Growth was best at 23 to 28°/₀₀ salinity. Growth took place in absence of appreciable current, provided that food supply was adequate. Weak convection currents from diurnal heating and cooling apparently were sufficient to keep phytoplankton suspended. *Chlorella* was the predominant form. Small amounts of potassium nitrate and sodium phosphate were added. Growth was not exceptional, but compared with average natural conditions. In large scale culture, calcium deficiency might be a problem. - J.L.M.

1839
Turner, Harry J., Jr. 1953.

A review of the biology of some commercial molluscs of the east coast of North America. Sixth Rept. Investig. Shellf. Mass., Mass. Dept. Natural Resources, Div. Mar. Fish: 39-74.

The most concise and useful account of the anatomy of the hard clam, *Venus mercenaria*, was that of Belding (1931). The species occurs from Cape Cod to Texas, with relict or new isolated populations at Salem, Mass., Casco Bay, Maine, St. Andrews, N.B., and in the Gulf of St. Lawrence. Setting is infrequent beyond the continuous range. Hard clams occur most frequently in the lower estuary. It is seldom found in the upper estuary, but there are exceptional ocean habitats. A large population has existed for a long time along certain shoals in Nantucket Sound, which is essentially an ocean environment. Young clams are completely absent, and the population consists entirely of large clams, blunted with age, uniform in size. Complete absence of young makes it appear that this population originated as a single year class. Productive populations of mixed year classes with continuous recruitment normally occur in the lower estuary. Factors that induce spawning are undoubtedly complex and numerous, but it is believed that temp is of greatest importance. At optimum temp hard clam larvae begin to set as early as 7 days after fertilization, but unfavorable temp may delay setting to as much as 30 days. Better understanding of larval behavior and physiology would have practical advantages for the industry. Part of the difficulty in studying setting behavior is that setting is seldom observed directly. Formation of assemblages or populations of commercial mollusks needs further study. The relationship between food and growth is important, but imperfectly understood. Hard clam differs from oyster in that it can utilize *Chlorella* and green flagellates even in concentrations that make the water soupy green. Water circulation is important, but only in its capacity to deliver an abundant food supply. Limits of the range of north-south distribution are determined by water temp, but the exact effect of temp upon growth within the species range has received little attention. Hard clam growth is slower in higher latitudes. Effects of salinity on growth are poorly known. Experiments by the author have shown that growth is favored by slight dilution of seawater to about 24 to 28°/₀₀. Little is known about oxygen requirements. Hard clams grow better in sand than in mud. Little has been published on the relation between water depth and growth. Hard clams can reestablish themselves in the substratum if disturbed. Young clams are more active than adults. Clams are vulnerable to predators, especially in juvenile and young stages, and their best defense is a high reproductive potential. Young of predatory species are much more abundant than adults, and they usually are present when clams are young, hence can be highly destructive. No direct evidence exists to show that exploitation has an influence on propagation of a commercial mollusk species. The view that exploitation affects propagation adversely is indirect and tenuous and needs study. Hard clam farms in existence at the time of writing were merely holding grounds, for marketing at times of higher prices. The author did not visualize a bright future for shellfish farming. Much of this review paper deals in general with mollusks without specific reference to species. Examples are drawn mostly from literature on oysters, mussels, and soft clam. This abstract has selected for the most part only specific references to hard clam. Since the time of writing, many existing gaps in knowledge of hard clam biology have been filled, at least partially, although much remains to be done. - J.L.M.

1840

Turner, Harry J., Jr. 1955.

Seventh report on investigations of the shellfisheries of Massachusetts. Mass. Dept. Natural Resources, Div. Mar. Fish: 3-4, 17-20.

Preliminary studies of feeding of *Venus mercenaria* showed that quahaugs will take almost any small particle into the digestive tract, but siliceous diatoms and armored flagellates passed through undigested. *Chlorella* and related forms, and naked flagellates, were digestible. Artificial propagation of seed shellfishes would benefit the shellfish industry by providing a reliable source of seed. Massachusetts has about 3,000 acres of intertidal and shallow waters, about half of which was suitable for quahaugs. A suggested management plan would be to rotate grounds every 3 yrs, which is the average time required to produce littlenecks. The plan would require seeding of 500 acres/yr. Each acre would support a million quahaugs, and with low mortality would yield 1,000 to 1,500 bu of littlenecks in 3 yrs. Thus, a hatchery would have to produce at least 500 million seed quahaugs/yr. According to available information, an installation of reasonable size could rear this many seed clams to metamorphosis. Techniques based on the work of Loosanoff (1954) abstracted elsewhere in this bibliography, are described. Mortality of natural sets of soft clam may be as great as 99% before legal length of 2 inches is reached.

Hard clam is presumed to be more resistant, but protection is needed for small hatchery-reared juveniles. Moreover, present methods of rearing larvae are not completely predictable. Batches of larvae may be killed by changes in water quality or by fungus. Financing artificial production will be costly, and the practicability of the method needs further consideration. - J.L.M.

1841
Turner, Harry J. 1956.

Eighth report on investigations of the shellfisheries of Massachusetts. Introduction. Mass. Dept. Natural Resources, Div. Mar. Fish: 3-4.

Studies of biology of quahaug larvae had 2 purposes: 1) to account for erratic and unpredictable occurrences of setting; and 2) to assess larvaculture as a means of providing a predictable and reliable source of seed to populate barren areas. Logistic problems and their solutions are mentioned. Production of seed was judged to have promise. - J.L.M.

1842
Turner, Harry J., Jr. 1957.

The effect of power dredging of (sic) the quahog populations of Nantucket Sound. In Rept. Investig. Shellf. Mass. for 1957, Commonw. Mass., Dept. Nat. Resources, Div. Mar. Fish: 9-14.

Several large sea scallop vessels were rerigged with jet dredges to harvest an old population of large quahaugs in sheltered waters in winter. The study was made to judge the validity of fears that this new fishery might be destroying the brood stock that perpetuated inshore hard clam stocks. Limited available temp records for Nantucket Sound showed that in August the waters are well mixed, with uniform temp of about 69°F. This was just at the critical level for spawning. It was concluded that spawning of quahaugs may not occur. Observations showed that hard clams did not spawn in Nantucket Sound in 1957, and even if they had, temps were too low for survival of many larvae. Non-tidal drift in the Sound is such that larvae originating in the region would be swept out to sea before metamorphosis. Only in 2 localized spots were currents slow enough to make local setting possible. It was concluded that complete removal of quahaug populations of Nantucket Sound beyond the 3-mile limit probably would not affect repopulation of stocks in shallow inshore waters, and that there was no biological reason to restrict power dredging in deeper waters of Nantucket Sound. (Abstracter's note: the xerox copy obtained through interlibrary loan shows no author's name. It is assumed that Turner was author.) - J.L.M.

1843
Turner, Harry J., Jr. 1960.

Clams. Oceanus 7(1): 2-4, 6-11.

This interesting report is entirely about soft clam farming. - J.L.M.

1844
Turner, Harry J., and Carl J. George. 1955.

Some aspects of the behavior of the quahaug, *Venus mercenaria*, during the early stages. Eighth Rept. Investig. Shellf. Mass., Mass. Dept. Nat. Res., Div. Mar. Fish: 5-14.

Survival of large sets is an exceptional occurrence, not a regular event, in any one locality. Laboratory studies of artificially spawned hard clams were made from fertilization to early juvenile stages. Observed behavior of eggs, larval stages, metamorphosis and setting, and juveniles, led to speculation that spawning just after low tide might be more successful than spawning on an ebbing tide; that water circulation might be important; that food supply when feeding begins might be of critical importance; that behavior patterns which tend to keep larvae within the estuary are obviously favorable; that the protracted period of swimming and crawling that follows setting is advantageous in increasing the probability that the right type of bottom will be found; and that newly set quahaugs probably are not adversely affected by minor disturbances of the substratum. The probability of a succession of events, all of which favor survival, may be so low as to explain the rare occurrence of dense sets. - J.L.M.

1845
Turner, Ruth Dixon. 1973.

Quahog. In Encyclopedia Britannica, William Benton, Publisher, Chicago. Vol. 18: 914.

A corruption of the word *paquahock* used by New England Indians. Has short siphons, so does not bury deeply. Often a portion of the valves is protruding, or the shell may lie on the surface. General information also appears under Bivalve, Mollusk. - J.L.M.

1846
Turner, Ruth D., and Arthur Christian Johnson. 1970.

Some problems and techniques in rearing bivalve larvae. Am. Malacol. Un., Bull. for 1969: 9-13.

Successful rearing of bivalve larvae is a relatively recent accomplishment, because eggs and larvae are small, free swimming period is relatively long, and larvae must be fed. Most early work developing algal cultures and controlling infestations was done by Loosanoff and colleagues at Milford, Conn. (abstracted elsewhere in this bibliography). This paper describes an inexpensive travelling laboratory developed for rearing boring and fouling bivalves. - J.L.M.

1847
Turney, W. Jack, and Bob F. Perkins. 1972.

Molluscan distribution in Florida Bay. Sedimenta III. Compar. Sedimentol. Lab., Div. Mar. Geol. Geophys., Univ. Miami, Rosenstiel School Mar. Atmosph. Sci., 37 p.

Mercenaria mercenaria was among the species identified. Many species, including hard clam, thrive in temperate climates, and some range as far north as Nova Scotia. The fauna of the Bay were predominantly molluscan, represented by about 100 genera and 140 recognized species. Sediment particles greater than 1/8 mm made up 58 to 95% of bottom deposits. It was believed that the disintegration process is caused by crabs, boring sponge, perforating algae, holothurians, worms, and *Thalassia* roots. - J.L.M. and M.W.S.

1848
Twarog, Betty M. 1954.

Responses of a molluscan smooth muscle to acetylcholine and 5-hydroxytryptamine. J. Cell. Comp. Physiol. 44: 141-163.

This paper deals primarily with experiments on *Mytilus edulis*, but *Venus* is mentioned on p. 146, 153, and 154. It is not clear from the context how much of the discussion actually applies to *Venus*, so this abstract touches only on the paragraphs in which specific reference is made, except for the section describing the nature of 5-hydroxytryptamine (5-HT). Acetone extracts of 5-HT (serotonin; enteramine) were assayed on *Venus* heart, which was soaked for at least 10 min in 10^{-5}M Mytolon before assay. The acetylcholine (ACh) block produced by this method is complete, and is not reversed when Mytolon solution is washed off. Activity of the extract was matched by known doses of 5-HT (serotonin creatinine sulfate) and from this the 5-HT content of the extract was calculated. (The section that follows, titled RESULTS, may describe studies of *Venus*, but no specific reference is made and figure legends to not identify species.) Two determinations on *Venus* heart showed an inhibitory effect equivalent respectively to 1.2 and 1.1 μg ACH/g wet weight of tissue.

A control assay, using homogenate in which muscle cholinesterase was still active, showed considerably less inhibition. The inhibitory effect could be abolished totally by adding active serum cholinesterase to the homogenate before the test, or by pretreating *Venus* heart with Mytolon, an ACh blocking agent. Activity of extracts assayed against known quantities of 5-HT on *Venus* heart proved equivalent to 1.0 µg 5-HT/g wet tissue. 5-HT and the extract proved excitatory. 5-HT is of widespread natural occurrence. It appears to be identical with enteramine, which has been detected in salivary glands of *Octopus* and *Eledone*, in mammalian gastrointestinal mucosa and spleen, intestine of *Ciona* and *Tethium*, and in skin of amphibia. The vasoconstrictor principle first isolated from beef serum is the creatinine sulfate salt of 5-HT. Serotonin or a very similar substance is possibly released from brain tissue. The mechanism of action of 5-HT was still unknown. - J.L.M.

1849
Twarog, Betty M. 1959.

The pharmacology of a molluscan smooth muscle. British J. Pharmacol. Chemother. 14(3): 404-407.

Venus mercenaria is mentioned, but only by reference to papers by Welsh and Taub (1953), Luduena and Brown (1952), and Welsh and McCoy (1957), abstracted elsewhere in this bibliography. - J.L.M.

1850
Twarog, Betty M. 1960.

Innervation and activity of a molluscan smooth muscle. J. Physiol. 152(2): 220-235.

The paper deals with *Mytilus edulis*. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S. and J.L.M.

1851
Twarog, Betty M. 1960.

Effects of acetylcholine and 5-hydroxytryptamine on the contraction of a molluscan smooth muscle. J. Physiol. 152(2): 236-242.

The paper deals with *Mytilus*. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S. and J.L.M.

1852
Twarog, Betty M. 1967.

The regulation of catch in molluscan muscle. J. Gen. Physiol. 50: 157-169.

The paper deals with *Mytilus*. *Mercenaria mercenaria* is not mentioned. - - M.W.S.

1853
Twarog, Betty M. 1968.

Possible mechanism of action of serotonin on molluscan muscle. Adv. Pharmacol. 6 B, Academic Press, New York: 5-15.

Serotonin (5-hydroxytryptamine or 5-HT) causes relaxation of catch, increased spiking, decreased membrane resistance, and stimulation of metabolism of *Mytilus* smooth muscle. It has been speculated that 5-HT controls translocation of intracellular Ca^{++}. The chapter describes experiments to test the validity of the proposed Ca^{++} - 5-HT interaction, and provide further knowledge of the site of action of 5-HT in *Mytilus edulis*. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1854
Twarog, Betty M. 1974.

"Immunity" to paralytic shellfish toxin in bivalve molluscs. In A. M. Cameron et al. (eds.), Proc. 2nd Internat. Symp. on Coral Reefs. Vol. 1. Illus. Map. Great Barrier Reef Committee, Brisbane, Australia: 505-512.

Nerves of *Mytilus edulis* and certain bivalves, including *Mercenaria mercenaria*, are resistant to blocking effects of saxitoxin (STX), an active principle of paralytic shellfish toxin, and tetrodotoxin (TTX), derived from puffers. Resistance to STX and TTX is a property of individual nerve fibers, and is not caused by a protective sheath around fibers. Na deficiency reduces and blocks the action potential, so resistance does not depend on development of a non-sodium spike-generating mechanism. Species resistant to STX can and do accumulate levels of paralytic shellfish toxin dangerous to man. *M. mercenaria*, among other bivalves, was relatively insensitive, although not fully resistant, to STX. The blocking effect was reversed after washing off STX or TTX. *M. mercenaria* was most resistant to STX of 4 species tested, but relatively less resistant to TTX. In September 1972, during a red tide along the northeast coast of Mass., quahogs and oysters accumulated no toxin at Eastham, Mass., whereas other species contained amounts as great as over 10,000 μg/100 g. *Mercenaria*, although resistant, possibly did not accumulate toxin because it may have escaped exposure to *Gonyaulax*, although *Mytilus* and *Mya* in the same area had high levels of toxin. Reasons should be explored. - J.L.M.

1855
Twarog, Betty M., and Irvine H. Page. 1953.

Serotonin content of some mammalian tissues and urine and a method for its determination. Am. J. Physiol. 175(1): 157-161.

Most extracts were assayed on isolated heart of *Venus mercenaria* supplied within 24 hrs of digging. Clams could be maintained for weeks at about 5°C in tanks of shallow aerated seawater. Inhibitory effects of acetylcholine (ACh) and analogous quaternary ammonium compounds on isolated hearts was eliminated by maintaining in the bath a concentration of 10^{-5}M (6μg/cc) of mytolon chloride. Threshold of *Venus* heart to serotonin lay between 10^{-9}M and 10^{-8} (0.00018 and 0.0018 μg/cc) bath concentration. Sensitivity appeared to increase with decreasing temp, as has been reported with ACh. When serotonin was added, to yield concentrations 0.0018 and 0.018 μg/cc in the bath, amplitude of beat was regularly increased by from 10% to 50%. In this range, excitation by serotonin varied linearly with logarithm of concentration. Excitation was complete within 2 minutes. Immediate recovery followed washing with fresh sea water, and within 10 minutes the test could be repeated with no change in magnitude of response. No after-effects were seen unless concentrations above 10^{-6}M (0.18 μg/cc) were applied. *Venus* heart was insensitive to Pitressin and angiotonin in all concentrations. It was excited by adrenaline and tyramine only at concentrations near 10^{-5}M and showed no response to histamine at this concentration. Responses to adrenaline and tyramine differed quantitatively from response to serotonin. Sensitivity to tryptamine and to cinobufotenine (N, N-dimethyl-5-hydroxytryptamine) was high. Threshold for these last substances lay at a concentration between 20 and 100 times greater (sic) than serotonin threshold. After experiments with tissues of dogs, and brains of rats and rabbits, it was concluded that isolated *Venus* heart provides a sensitive and selective measure of serotonin activity. Serotonin occurs in acetone extracts of dog, rat, and rabbit brain in amounts ranging from 0.1 to 0.3 μg/g tissue, and it is normally excreted in human and dog urine in amounts varying between 0.1 and 1.0 μg/cc. - J.L.M.

1856
Tyler, Jim. 1970.

Raising clams for money. N.C. Tar Heel Coast 6(12): 1.

Describes in popular terms the operations of the Coastal Zone Resources Corporation clam hatchery. The gist is that it is too soon to judge whether the project can succeed. Cost of production cannot yet be assessed, but the possibility is suggested that some day in the near future a clam farmer in North Carolina could raise a $32,000 clam crop on one acre. This pilot project has been supported by the Coastal Plains Regional Commission. - J.L.M.

1857
Uchida, R. N. 1972.

Review of recent progress in coastal aquaculture in the USA. In Coastal Aquaculture in the Indo-Pacific Region. T. V. R. Pillay (ed.). Fishing News (Books) Ltd., London: 84-104.

Reference to hard clam is very brief and cites Iversen (1968), abstracted elsewhere in this bibliography. - J.L.M.

1858
Udell, H. 1951.

Bacterial pollution of Raritan and Lower Bays and its relation to shellfish. Fed. Security Agency, U.S. Pub. Health Serv. (typewritten rept.).

According to Campbell (1964), abstracted elsewhere in this bibliography, this unpublished report was concerned with effects of pollution on shellfishes. - J.L.M.

1859
Udell, Harold F. 1956.

Sanitary surveys of shellfish areas. Proc. Natl. Shellf. Assn. 46: 27-31.

A general discussion of the relation of water pollution to propagation of oysters and clams, and effects on the harvest and distribution of these shellfishes. Species are not always named, but the principles and issues discussed apply generally to hard clam. Continual deficiencies of dissolved oxygen cause mortality of adults, and interfere with setting and growth of juveniles. In domestic wastes about 50% of the organic material is in suspension, and 65% of this amount will settle to the bottom, creating adverse conditions for shellfishes. Industrial wastes contain not only large amounts of organic materials, usually exceeding that in raw sewage, but also substances toxic to shellfishes and their food organisms. Presence of pathogenic bacteria is a threat to public health. Continued sanitary surveys of shellfish growing areas are necessary. Inadequate data may unduly penalize industry. Each area requires separate study because local conditions differ. All surveys have 4 major considerations: 1) reconnaissance of shore areas and tributaries; 2) bacteriological study of the waters; 3) chemical study of the waters; and 4) hydrographic study of the area. Depth of burrowing of clams depends on water temp. Stratification of the water, especially in summer, creates sampling problems. In an important hard clam producing area a detailed study, sampling twice a month for 14 months, showed that the same concentration of coliform organisms found in water directly over the shellfish grounds would be found in *Venus mercenaria* meats themselves, except at water temps below 8°C. Contamination of the clams was highly seasonal, and the survey demonstrated that closure was necessary only for 2 or 3 months each year. Chemical and hydrographic studies are needed in addition to bacteriological sampling because they provide information for evaluation of pollution conditions and for planning pollution abatement. Chemical studies give an indication of biological activity of pollutants. Information on circulation and flushing rates is critical. Consumer confidence in the shellfish industry is at stake. - J.L.M.

1860
Udell, H. F., J. Zarudsky, T. E. Doheny, and P. R. Burkholder. 1969.

Productivity and nutrient values of plants growing in the salt marshes of the Town of Hempstead, Long Island. Bull. Torrey Bot. Club 96(1): 42-51.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1861
Ukeles, Ravenna. 1961.

The effect of temperature on the growth and survival of several marine algal species. Biol. Bull. 120(2): 255-264.

A paper by Loosanoff (1959), abstracted elsewhere in this bibliography, on feeding *Venus mercenaria* larvae with mixed phytoplankton, is cited. - J.L.M. and M.W.S.

1862
Ukeles, R. 1971.

Nutritional requirements in shellfish culture. In Artificial Propagation of Commercially Valuable Shellfish -Oysters- (K. Price & D. Maurer, eds.) Univ. Delaware: 43-64.

References to *Mercenaria mercenaria* in this paper are citations from other papers abstracted elsewhere in this bibliography. - J.L.M.

1863
Ukeles, Ravenna. 1976.

Views on bivalve larvae nutrition. Proc. 1st Internatl. Conf. Aquacult. Nutr., Sea Grant Coll. Progr., Univ. Del: 127-162.

For culturing *Mercenaria mercenaria* and other bivalve larvae in the laboratory or in hatcheries the most important need is to provide optimum nutrition in efficient and economical ways. Better and more definitive methods are needed to evaluate the effects of various diets on larval growth and development. This review paper discusses work of authors abstracted elsewhere in this bibliography. Major topics are seawater supply and quality, soluble nutrients, particulate nutrients, and living foods of natural or cultured origin. - J.L.M.

1864
Urakubo, G., et al. 1972.

The method for determination of 59Fe in marine organisms by radiochemical analysis. Bull. Natl. Inst. Hyg. Sci. (Tokyo) 90: 4-11. (English abstract, Jap.)

Mercenaria mercenaria is not mentioned. - J.L.M.

1865
Urch, M. J., and M. Wood. 1972.

Opening up the shellfish market. Am. Fish Farmer 3(3): 7-8.

Obviously in error. It appears to be a popular article rather than a scientific paper. Not worth following up. - J.L.M.

1866
U.S. Army Corps of Engineers. 1962.

Distribution of shellfish resources - south shore - Suffolk County (unpublished).

Report not available. Some of the material may be included in U.S. Army Corps of Engineers (1975), especially the 4 plates, dated 1962, showing shellfish-producing grounds in Great South Bay, Shinnecock and Moriches bays, N.Y. - M.W.S. and J.L.M.

1867
U.S. Army Corps of Engineers. 1975.

Maintenance of Great South Bay channel and Patchogue River and Long Island Intracoastal Waterway, New York navigation projects. U.S. Army Engineer District, New York, N.Y., vi+72 p., 4 appendices, ill.

This is a final environment impact statement dealing with the general problem of maintenance of channels in the area, for the primary purpose of water delivery of petroleum products to the village of Patchogue. Specific projects will require additional environmental data. Twelve-year records of commodity traffic including petroleum, fishes and shellfishes, and other cargo are included for Great South Bay, Moriches and Shinnecock Bays. Hard clam is the principal fishery product. About 10% of the shellfish beds are closed because the water does not meet acceptable coliform standards. Included are 4 plates showing distribution of shellfish resources in 1962. Hard clam areas are classified as: 1) high production; 2) moderate production with potential for increased production; and 3) moderate to high production, formerly high oyster value for seed, future potential good to excellent for oyster growing. Fig. 6a shows the Bluepoints Co. holdings in Great South Bay and public lands leased to private planters in Town of Islip waters. In 1973 total shellfish production from the 3 bays was over 600,000 bu with a landed value of over $11 million. Recreational shellfish catches are unknown, but it was agreed that they must be substantial. Major damage to shellfish resources was not anticipated from dredging or deposition of spoil. - J.L.M.

1868
U.S. Department of Commerce. 1970-

Shellfish Market Review and Outlook. NOAA, Natl. Mar. Fish. Serv., Market Research and Services Div.

This monthly publication contains information on supply and prices of crustacean and molluscan shellfishes. - J.L.M.

1869
U.S. Department of the Interior. 1945.

Fishery resources of the United States. 79th Congress, 1st Sess., Senate Doc. 51, U.S. Govt. Printing Off., iv+135 p.

Hard clam lives from almost high-tide level to depths of over 50 feet, usually on flats several feet below low water. Fishery yields about 13 million pounds of meats annually, worth (landed value) about $2.2 million, mostly from uncultivated public grounds. Catch is made by treading, hoes, rakes, tongs, and dredging. Most of catch is sold fresh; the rest is canned minced, or as chowder or clam cocktail. Realizing the potential yield from the fishery is inhibited by water pollution and lack of cultivation. (Abstracter's note: this abstract contains only the section on hard clam: 94.) - J.L.M.

1870
U.S. Department of the Interior. 1956.

A preliminary report on fishery resources in relation to the hurricane damage control program for Narragansett Bay and vicinity, Rhode Island and Massachusetts. U.S. Fish Wildl. Serv., Off. River Basin Stud., Boston, Mass., 34 p., 2 append. (Unpubl. report signed by D. R. Gascoyne, Regional Director.)

In 1956 very little evidence existed on the relation of hard clam to temp, O_2 or salinity. With few exceptions research on hard clam has taken place only within the last 10 yrs (e.g., 1945-1955). Limited funds have slanted this research toward management studies. Studies of growth, population dynamics, reproduction, and predation have been thought much more important than studies of tolerance to environmental change. Surveys of standing stocks of hard clam in upper Narragansett Bay were planned as a preliminary to future studies, but funding was terminated in Sept 1956. In 1953 R.I. became the largest producer of hard clam of all Atlantic coast states. Since that time the catch has averaged more than 4 1/2 million lbs of shucked meats/yr, which is more than 1/4 of the Atlantic coast catch, with landed value of about $1.75 million/yr. In 1954 hard clam accounted for 43% of landed value of all fishery products landed in R.I. The harvest in R.I. is taken largely with hand-operated gear, mostly bullrakes and tongs. Rakes usually are used in soft bottom and deep water, tongs in hard bottom and shallow water. The other 5% of the catch is taken with mechanical dredges. Under State law mechanical dredges can be used only in certain areas of the Bay and only at certain seasons. In 1955, 2,837 shellfish licenses and 41 mechanical dredging licenses were issued. The catch was sold through 30 licensed dealers. In addition, non-commercial diggers take quahogs for their own use. Their numbers are not known. Commercial hand diggers worked about 5 hrs/day and 4 days/wk for a daily return of $10-12. Commercial clamming reached a peak in August and a low in January. Clamming was prohibited between sunset and sunrise. Legal size is a clam that will not pass through a 1 1/2 in diam ring. Clams were sold in 2 commercial size groups. Smaller quahogs were known as "necks" and brought the higher price (at that time about 10¢ per lb) and were usually eaten raw. "Large" clams brought about 3 1/2¢/lb and were used in chowder and for canning. Necks were in the size range 47 to 66 mm (1 3/4 to 2 1/2 in) long. Clams over 66 mm long were "large". "Sublegal" clams, less than 47 mm long, also were taken in surveys, but the gear did not take clams smaller than 15 mm, which are about 1 yr old. Clams 15 to 46 mm are 1 to 3 yrs old, those 47 to 66 mm (necks) are 3 to 6 yrs old, and those over 66 mm 6 to 20 yrs or more. Surveys were made of about 38,483 acres in that part of Narragansett Bay roughly north of 41°36'N Lat. Sampling was done with a small clam-shell construction bucket, which covered an area of about 5 ft^2 and dug deep enough to catch all quahogs. Sampling by this method was not possible in water shallower than 5 ft, which it was planned to sample later by other means. All quahogs taken were measured. Stations were on a grid 900 feet apart in lines oriented N-S and E-W. The survey occupied 1,960 stations from late 1955 to July 1956. It was found that hard clams are distributed fairly generally over upper Narragansett Bay. No area was completely barren. Most were in water 5 to 25 ft deep. But distribution was irregular, and setting seemed to occur in patches, which may be influenced by current patterns, bottom sediments or general hydrography. The Providence River, all of which is closed to clamming by pollution, had the most general distribution of all 3 size groups, probably because harvesting is forbidden. In the heavily industrialized area, however, clams were almost completely absent. In the rest of the Bay distribution ranged from dense to almost barren. Distributions of size grades are illustrated on charts. Densities ranged from 0.48 to 17.6 quahogs/ft^2. Large clams were most abundant, necks next most abundant, and sub-legals least. Density in the Providence River was more than 3 times the average for the entire upper Bay and nearly 7 times the least dense area. Relative numbers of the three size categories varied with area. No area other than Providence River had more than 1 clam/ft^2. No area had more sub-legals than either of the other 2 sizes, and only 2 had more necks than large. In general, hard clams were more closely associated with coarser sediments, but this does not include very coarse types like gravel, rubble, and rocks. More usually are found in sand than in mud. Over the whole area it was estimated that the standing crop was 847,324,000 hard clams of all sizes. (Abstracter's note: this was about 22,018 clams/acre.) Heavy densities of large clams probably are caused by the preference for small clams, which allows larger sizes to accumulate.

Tables 1 & 2 are reproduced here to give details:

	Number per ft^2 Sublegal	Necks	Large	Broken	Total	Estimated total no of clams
Providence River	0.18	0.90	0.47	0.02	1.57	325,593
Ohio Ledge	0.05	0.16	0.25	0.02	0.48	195,562
East Passage	0.05	0.09	0.08	0.01	0.23	56,217
Bristol Harbor	0.15	0.34	0.35	0.02	0.86	65,898
Mount Hope Bay	0.05	0.08	0.13	0.01	0.27	106,373
High Banks	0.02	0.05	0.25	0.03	0.35	67,619
Greenwich Bay	0.07	0.07	0.14	0.01	0.29	30,062
Upper Bay (av)	0.07	0.19	0.21	0.02	0.49	847,324*

*Total number. Numbers are in thousands. Totals and totals per unit area are not proportional because regions are not equal size.

- J.L.M.

1871
U.S. Public Health Service. 1954.

A report on the public health aspects of clamming in Raritan Bay.

Could not locate. See Campbell 1964, 1965. - J.L.M.

1872
U.S. Public Health Service. 1961.

Transcript of conference on pollution of the interstate waters of the Raritan Bay and adjacent waters, First Session. August 1961.

Could not locate. See Campbell 1964, 1965. - J.L.M.

1873
Uzmann, Joseph R. 1955.

Parasites of clams. 5th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 71.

The following parasites were found on *Venus*: the nemertean *Malacobdella obesa* and the trematode *Himasthla quissetensis*. - J.L.M.

1874
Valiela, Ivan, Mario D. Banus, and John M. Teal. 1974.

Response of salt marsh bivalves to enrichment with metal-containing sewage sludge and retention of lead, zinc and cadmium by marsh sediments. Environ. Pollut. 7(2): 149-157.

Growth of *Mercenaria mercenaria* and American oyster was not affected by experimental additions of sewage sludge containing Pb, Zn, and Cd, but *Modiolus demissus* grew better than controls. No increase of Pb or Zn content occurred in any of the 3 species, but Cd increased in all. Apparently Pb and Zn were largely trapped by marsh sediments. Cd was also retained by sediments but it was more labile. - J.L.M.

1875
Vallentyne, J. R. 1969.

Pyrolysis of amino acids in Pleistocene *Mercenaria* shells. Geochim. Cosmochim. Acta 33: 1453-1458.

The order of increasing stability of amino acids in pyrolysed shells of *Mercenaria mercenaria* from the Wailes Bluff formation in Virginia was serine, threonine, methionine, lysine, tyrosine, phenylalanine, isoleucine, leucine, proline, valine, glycine, alanine, and glutamic acid. Rates of decomposition were all greater than for the same amino acids in dilute aqueous solution. Water decreases decomposition probably by dilution, which reduces the frequency of interaction of amino acids among themselves and with other components of *Mercenaria* shell. The most significant general result was the striking similarity in amino acid composition of pyrolysed Pleistocene shells and untreated Miocene shell. Pyrolysis, in effect, transformed amino acid composition of Pleistocene shell into that of Miocene shell. - J.L.M.

1876
Van der Heyde, H. C. 1922.

On the physiology, digestion, respiration and excretion of echinoderms. C. De Boer Jr., Den Helder (Dissertation, Amsterdam).

Assumes that a toxic secretion, liberated by sea star and introduced between valves of the clam, is responsible for opening the clam. - from Burnett, Ecology 41(3), 1960 - J.L.M.

1877
Van Popering, M. J. 1947.

History of the shellfish industry in Great South Bay, New York. Part II. Shipping industry. Unpub.(?) ms., 20 p.

The beginnings of the oyster industry in Great South Bay are traced, the export trade described, the names of early shellfish companies given, and brief biographies of some of the leading pioneers included. The firm of G. Vanderborgh and Son (now Long Island Oyster Farms, Inc.), established in 1884, handled many clams, which they bought from baymen working the public grounds. Some of these clams were replanted (presumably to hold for favorable market conditions). Another firm, Still and Clock of Bay Shore, began a clam business about 1925, buying the catch of baymen from public grounds. Many residents of Islip Town tonged clams for 4 to 6 months each year, some working also in winter as weather permitted. Most grounds under lease were leased between 1874 and 1900, many of them in 1885. Before leasing, it was mandatory to tong clams on the ground in question, to determine whether a living could be made harvesting clams. The lease would be allowed if clams were sparse. Each plot was 4 acres, and no person was allowed more. Since this was not enough ground for profitable operation, planters evaded the law by taking out additional plots in the names of friends and relatives. This practice was eliminated when the Islip Town Board in 1931 began leasing larger plots for 10 yr periods at $2.50/acre. It was provided that leases could be renewed for another 10 yrs at a rental to be determined. In 1937 some new leases were issued for 15 yrs, with the option to renew for another 10 yrs. A copy of a lease issued in 1878 is included. There was no record of the amount of clams taken from the Bay. Many thousand bushels were taken each year. In addition to regular baymen, others turned to the Bay for a living in hard times. Before auxiliary power was in common use, clam boats carried sail, and diggers left home on Monday morning, lived on their boats near or on the grounds, and returned home Friday afternoons. When power was added clamming became a daily operation. On leased grounds tongers were hired to make the catch of oysters. Sometimes enough clams were taken to pay for the day's labor. - J.L.M.

1878
Van Weel, P. B. 1961.

The comparative physiology of digestion in molluscs. Am. Zool. 1(2): 245-252.

Not much is known about many aspects of digestion in mollusks, practically nothing of permeation through the intestinal wall. What is the correlation between "willingness" to phagocytize and true resorption? Does the midgut gland "take over" from the intestine, or vice versa? What are the causes of apparent changes in resorption and enzyme production from drastic changes in diet? Is there adaptation in the long run? Definite data are lacking on the relation between utilization and amount of food available. How does age affect enzyme production, resorption and utilization? These problems await solution. *Mercenaria (Venus) mercenaria* is not mentioned but these questions are applicable. - from author's conclusions - M.W.S. and J.L.M.

1879
Van Winkle, Webb. 1966.

Gill tissue respiration as a function of salinity and temperature in four species of pelecypods. Proc. Natl. Shellf. Assn. 56: 6 (abstract).

Oxygen consumption (Q_{O_2}) of excised gill tissue from *Mercenaria mercenaria* was measured at salinities ranging from 5-30°/°° and temperatures of 10°, 18°, and 26°C. The Q_{O_2} was significantly higher at the lower salinities, this increase being even greater at lower temperatures. - modified author's abstract - D.L.

1880
Van Winkle, Webb. 1967.

Ciliary activity and oxygen consumption in Pelecypod gill tissue. Proc. Natl. Shellf. Assn. 57: 5-6 (abstract).

Cilia of gill tissue from low-salinity as compared to high-salinity acclimated animals beat faster at low experimental salinities. With respect to the ability of cilia to tolerate reduced salinities the 4 species are ranked as follows: *Modiolus>Crassostrea>Mytilus>Mercenaria*. At low salinities isolated gill tissue utilized as much or more oxygen than at high salinities, yet at these low salinities ciliary activity was greatly reduced. If this is true also in the intact animal it means that there is a constant or increased expenditure of energy under conditions where the food gathering machinery is working less efficiently. - J.L.M.

1881
Van Winkle, Webster, Jr. 1967.

Ciliary activity and oxygen consumption of bivalve gill tissue. Ph.D. Thesis, Rutgers Univ., New Brunswick, N.J. Dissert. Abstr. 28(3): 1291-B.

Gill cilia of winter as compared to summer *Mercenaria mercenaria* were more active at low salinities at all temps. Salinities corresponding to 80% ciliary activity were 17°/°° for *Mercenaria*, 5°/°° for *Crassostrea virginica*, 5°/°° for *Mytilus edulis*, and less than 2.5°/°° for *Modiolus demissus plicatulus*. Gill oxygen consumption was the same for low- and high-salinity-acclimated *Mercenaria*, and was greater at low salinities. Effects of salinity on oxygen consumption did not appear to be correlated with the lower salinity boundaries of whole animals. Hydration and osmotic-ionic regulation theories did not provide an adequate explanation of interspecific differences in effects of low salinities on oxygen consumption. Effects of experimental salinity on ciliary activity and oxygen consumption appeared to be independent. Ciliary activity was always reduced at salinities in which oxygen consumption was greater or the same. - J.L.M.

1882
Van Winkle, Webb. 1968.

The effects of additives on the pumping rate of *Mercenaria mercenaria*. Proc. Natl. Shellf. Assn. 58: 9-10 (abstract).

Effects of additives on pumping of *Mercenaria mercenaria* were measured. Additives included: simple organic compounds (glucose and glycine); hormones (acetylcholine, adrenalin, and serotonin); and gonad extracts (male and female *Mercenaria* and *Mytilus*). The simple organic compounds, and adrenalin and serotonin occasionally, stimulated pumping. Acetylcholine inhibited pumping at 10^{-7}-10^{-3}M. *Mercenaria* gonad extracts stimulated pumping and spawning. - D.L.

1883
Van Winkle, Webster, Jr. 1968.

The effects of season, temperature, and salinity on the oxygen consumption of bivalve gill tissue. Comp. Biochem. Physiol. 26(1): 69-80.

Oxygen consumption of gill tissue from *Mercenaria mercenaria* and 3 other species was measured at salinities of 5, 10, 15, 20, 25, and 30°/₀₀ and temperatures of 10, 18, and 26°C, winter and summer. At any salinity level, oxygen consumption of hard clam tissue increased with temp. At any temp level oxygen consumption decreased with increasing salinity. Clams collected in summer consumed more oxygen at any particular temp level than those collected in winter. Summer clams also consumed more oxygen at any particular salinity level. - J.L.M.

1884
Van Winkle, Webster. 1972.

Ciliary activity and oxygen consumption of excised bivalve gill tissue. Comp. Biochem. Physiol. 42A(2): 473-485.

Ciliary activity of gill tissue from low- and high-salinity acclimated *Mercenaria mercenaria*, American oyster and 2 species of mussel was measured at various salinities. For each species there was initial inhibition of activity at experimental salinities differing appreciably from acclimation salinity. If the difference between experimental and acclimation salinity was not too great, inhibition was followed by recovery. Recovery time-experimental salinity response surfaces were shifted toward lower salinities for low-salinity acclimated oyster and mussels, but not for hard clam, compared to high-salinity acclimated groups. At low as compared to high salinities, ciliary activity decreases, whereas oxygen consumption increases or remains approximately constant. - modified author's abstract - J.L.M.

1885
Van Winkle, Webster. 1975.

Problems in establishing the relationship between pumping rate and oxygen consumption rate in the hard clam, *Mercenaria mercenaria*. Comp. Biochem. Physiol. 50A(4): 657-660.

The literature contains conflicting conclusions on the relationship. Some authors have concluded that oxygen removal by hard clam is a consistent function of water transport, and that water transport may be regulated at least partially by oxygen requirements. Another author suggested that the cause-effect relationship was the reverse, and that increased oxygen consumption rate followed from an increase in pumping rate, stating that pumping is work accomplished by energy supplied by respiratory processes. The author concluded that the question has not been settled, and that more direct physiological evidence is needed, such as simultaneous measurements of pumping rate, external oxygen levels, and blood oxygen levels, to determine whether pumping rate of hard clam is dependent upon oxygen requirements. - J.L.M.

1886
Van Winkle, W., S. Y. Feng, and H. H. Haskin. 1976.

Effect of temperature and salinity on extension of siphons by *Mercenaria mercenaria*. J. Fish. Res. Bd. Canada 33(7): 1540-1546.

Extension of siphons is only a crude index of activity, but it can be studied quickly, easily, and cheaply. Thus, the index is useful for initial definition of limits for temp, salinity, and some other variables in depuration of shellfishes. Results can provide guidelines for more detailed and sophisticated studies on activity and purification. The study showed considerable phenotypic plasticity. Temp limits shifted upward from April to May. Salinity limits shifted upward from late winter to late summer. Activity was relatively low in summer. Some results were unexpected, e.g., a pronounced decrease in upper temp limit associated with an increase in acclimation temp. This demonstrated the effects of other variables, and of the physiological state of clams, and is consistent with results of previous studies in N.J. which showed decreased growth rate in summer. *Mercenaria mercenaria* is only moderately euryhaline. Purification should not be considered at salinities below 20°/₀₀ and is likely to be most successful above 22°/₀₀ to 23°/₀₀. It is also suggested that temps below 10°C are not advisable. Heated water should be used in winter. Purification probably also should not be considered at temps above 30°C and is most likely to be successful at 25°C or below. It may be difficult to purify quahogs during June to August, regardless of temp or salinity. Depuration should not be attempted when activity levels drop below 50%. Extension or non-extension of siphons was the criterion of activity, not the distance extended. - J.L.M.

1887
Vanderborgh, G. 1966.

A report on shellfish farming in Long Island waters: Critical needs. Nassau-Suffolk Regional Planning Board, Oceanographic Committee.

The only report we could locate that appeared to be similar to the one cited above was: Stephan, E. C. (chairman). 1966. The status and potential of the marine environment. Rept. of the Oceanographic Committee to the Nassau-Suffolk Regional Planning Board, Hauppauge, N.Y., ix+92 p. in 3 parts plus an appendix, each numbered separately. The shellfish industry of New York State is discussed in various places. Among the conclusions and recommendations are: 1) unpolluted waters are essential to commercial shellfish production; 2) duck farm wastes have created a nutrient imbalance harmful to shellfish production; 3) Long Island (at the time of writing) had 400,000 acres of fully approved active shellfish areas; 4) L.I. was the leader in national hard clam production with landed value of $5.5 million, but this was only 60% of what it was 20 years earlier; 5) declines in shellfish production have been caused by sewage pollution, duck farm wastes, destruction of wetlands, spraying of DDT and other insecticides, and dredging. In addition to man-made factors, natural factors also add complications, such as: destruction of seed by adverse weather; predation; and silting of inlets. Legal and zoning problems have contributed: 1) inadequate and outmoded leasing practices for shellfish bottoms; and 2) lack of suitable shorefront property for land-based segments of industry. The most creative activity of industry was identified as development of shellfish hatcheries. Industry also had helped itself through research and adoption of good management techniques. Discussion of eelgrass problems is included. Detailed information is given on open and closed shellfish areas by locality. - J.L.M.

1888
Vanderborgh, George H., Jr. 1971.

Growing of marine animals (especially oysters and clams) on a commercial scale using heated seawater effluent. Long Island Oyster Farms Inc. Conf., Northport, N.Y., 31 Oct. 71: 186-192.

The selective breeding program of Long Island Oyster Farms Inc. with specially developed hatchery techniques and incubation in the warm water lagoon of the power plant has increased survival rate of oysters a million-fold and cut maturing time in half. Clams also are adaptable to this nursery life. Benefits of controlled cultivation are: 1) uniformity of quality; 2) marketing at prime condition; 3) reduction of varying conditions by cooperation between power company and shellfish grower. (Abstracter's note: the paper received was a manuscript copy of a speech to be given at the National Conference on Waste Heat Utilization to be held at Gatlinburg, Tennessee on 27-29 Oct 1971. Title: The growing of marine animals (especially oysters and clams) on a commercial scale using heated seawater effluent. It is assumed that the contents are essentially the same: 11 ms p.) - J.L.M.

1889
Vanderborgh, George H., Jr. 1972.

Commercial molluscan hatcheries and their problems. In Progress in Fishery and Food Science. Remedios W. Moore (ed.), Univ. Washington Pub. Fish., New Ser. 5, Seattle: 187-189.

Problems are discussed by a practical shellfish farmer. The paper deals principally with oysters, but hard clam is mentioned in passing. The author believed that the Vanderborgh-Radel Hatchery, operated in conjunction with the power plant at Northport, Long Island, N.Y., and using heated water effluents, was the first and only hatchery to produce a market crop of shellfish year-round, and make a profit. He recommends that research done in the past be examined to determine why more progress has not been made. - J.L.M.

1890
Vanderzant C., and C. A. Thompson, Jr. 1973.

Microbial flora and distribution of *Vibrio parahaemolyticus* in molluscan shellfish, water, and sediment. Abstr. Annu. Meet. Am. Soc. Microbiol. 73(E9): 2.

Mercenaria mercenaria and other bivalves, and water and sediment samples, from Galveston Bay, Tex. were examined. Bacterial counts of shellfishes ranged from 2.3×10^4 to 1.1×10^7/g. Counts in sediment samples were from less than 10^2 to 2.5×10^5/g, and in water samples usually less than 10^2/ml. Plates were incubated at 25°C for 48 hrs. In freshly harvested mollusks *Moraxella, Aeromonas, Vibrio, Pseudomonas, Acinetobacter, Achromobacter,* and *Flavobacterium* predominated. At retail level *Aeromonas, Moraxella,* and *Vibrio* predominated. - J.L.M.

1891
Vaughn, J. M., E. F. Landry, T. J. Vicale, and M. C. Dahl. 1979.

Isolation of naturally occurring enteroviruses from a variety of shellfish species residing in Long Island and New Jersey marine embayments. - J. Food Protection.

Could not locate. Search terminated. - M.W.S.

1892
Vaughn, J. M., E. F. Landry, T. Vicale, and P. Davis. 1979.

Viruses in a tertiary sewage treatment-aquaculture system: Shellfish and shellfish-growing waters. Informal report prepared for the Woods Hole Oceanographic Institution by the Land and Freshwater Environmental Sciences Group, Dept. Energy and Environment, Brookhaven National Laboratory Inc., BNL-25702 (limited distribution), 18 p.

This preliminary study used cultures of bacteriophage MS-2 obtained from Dr. Zsigray of the University of New Hampshire. *Mercenaria mercenaria* were allowed to accumulate virus for 18 to 24 hrs, then placed in raceways and samples collected at intervals. Temperature in raceways was maintained at 15°C. Elimination of MS-2 from quahogs required 17 days, as compared with about 26 days with oysters *(Crassostrea virginica)*. This appeared to be somewhat longer than predicted by Liu et al. (1967) for depuration of poliovirus types 1 and 3. It is recommended that a depuration period of 20 to 25 days be used for shellfishes in virus-free ESL raceway waters. - J.L.M.

1893
Verber, James L. 1976.

Safe shellfish from the sea. Am. Soc. Limnol. Oceanogr., Spec. Symp. 2: 433-441.

This report deals with the closing of areas in New York Bight and off Delaware Bay to surf clam harvesting. It also contains general information on the history of the National Shellfish Sanitation Program, and landings of *Mercenaria mercenaria*, oysters, surf clams, and soft clams from 1944 to 1974. - J.L.M.

1894
Verduin, Jacob. 1969.

Hard clam pumping rates: Energy requirement. Science 166(3910): 1309-1310.

This paper challenges conclusions drawn by Hamwi and Haskin (1969) on oxygen consumption and pumping rates of *Mercenaria mercenaria*. Using their data the author concludes that the regression of pumping rate on oxygen consumption is not linear, but curvilinear. The line drawn by Hamwi and Haskin predicts zero oxygen consumption when pumping rate is 0.84 l/hr, which is obviously not true. The curve gives a non-pumping rate of respiration of about 1.5 ml O_2/hr/clam. The author also concluded that there is nothing in the data to suggest that pumping rate is regulated by oxygen requirement; rather, the O_2 consumption required to power the pump at maximum rate is about 5 times "greater" than it is at the minimum rate. In aerobic respiration the caloric value of fuel consumed is about 0.112 calorie/micromole O_2 consumed. Thus, pumping of a liter of water at maximum rate burns about 7.5 calories of respiratory substrate. At minimum rates the pump is more efficient, requiring only about 1.5 calories of fuel per liter pumped. - J.L.M.

1895
Vernberg, F. John, C. Schlieper, and David E. Schneider. 1963.

The influence of temperature and salinity on ciliary activity of excised gill tissue of molluscs from North Carolina. Comp. Biochem. Physiol. 8(3): 271-285.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1896
Vernon, H. M. 1895.

The respiratory exchange of the lower marine invertebrates. J. Physiol. 19(1-2): 18-70.

Mercenaria (Venus) mercenaria is not mentioned, but mollusks are included under "lower marine animals". Respiration is very small compared with that of teleost fishes. Respiratory activity of different animals is affected very differently by temp. The less differentiated and lower forms show greatest effects. Small animals have higher respiration rates than larger animals of the same species. In captivity, respiration of mollusks remained either constant or diminished slowly with time. On asphyxiation, quotients greater than unity were obtained. - J.L.M.

1897
Verrico, Donald J. 1972.

The abundance of the hard clam, *Mercenaria (=Venus) mercenaria*, in relation to substrate character in South Oyster Bay, New York. A thesis presented to the faculty of Hofstra University in partial fulfillment of the requirements for the degree of Master of Arts, 27 p., some not numbered.

The author recognized 4 bottom types: very soft mud with little vegetation; firm bottom lacking vegetation; eelgrass beds; and edges of channels where sediments were relatively coarse. Average densities of clams were 0.58/yd^2 in soft mud, 1.21 in sand, 1.41 in eelgrass beds, and 0.63 at edges of channels. All the mean values for particle size fell within the range for fine sand, thus the survey was not very sensitive to the relationship of clam abundance to particle size. The bottom in the soft mud area was a reducing environment, not favorable for clams. The firm sandy bottom contained the smallest clams, which is consistent with its intensive use as a clamming area. Eelgrass beds and channel edges had the largest clams, and these are not heavily harvested. The author concluded that clam density was inversely related to particle size, but that presence of H_2S disturbed the relationship, and that presence of eelgrass is important to hard clam because it provides a substrate for setting, recycles nutrients, prevents production of H_2S, reduces current velocity thus favoring setting, and inhibits harvesting by humans. (Abstracter's note: the author's conclusions are not well supported by his data, and appear to be taken mostly from the literature. Alternative conclusions might be drawn, and more conclusions might be possible if detailed data were included. For example, only average sizes of clams per sample are given and numbers of clams are not included. Information on particle sizes is much more detailed.) - J.L.M.

1898
Verrill, A. E. 1873.

VIII. - Report upon the invertebrate animals of Vineyard Sound and the adjacent waters, with an account of the physical characters of the region. In Report on the condition of the sea fisheries of the south coast of New England in 1871 and 1872. Spencer F. Baird, Commissioner. U.S. Comm. Fish Fisheries, Washington, Govt. Printing Off.: 295-522.

Venus mercenaria is common on sandy shores, living chiefly on sandy and muddy flats just below low water, but often found on the portion laid bare at low water of spring tides. It most abounds in estuaries. It burrows a short distance below the surface, but is often found crawling at the surface, with the shell partly exposed. It has short siphon-tubes, united from base to near the ends, and a large muscular foot with a broad thin edge. Mantle lobes are separate all around the front and ventral edge of the shell, and their edges are thin, white, and folded into delicate frills, some of which, near siphons, are elongated. The broad opening in the mantle allows the foot to be protuded from any part of the ventral side, with an extensive sweep forward and backward. Foot and mantle edges are white, tubes are yellowish or brownish-orange toward the end, more or less mottled and streaked with dark brown, and sometimes with opaque white. It is important as food. Small or moderate-sized clams are preferred. Tongs and rakes are the principal gears. Estuarine clams have rough, thick, dull-white or mud-stained shells, those from sandy shores outside have thinner and more delicate shells, often with high, thin ribs, especially when young. Some have angular or zig-zag lines or streaks of red or brown (var. *notata*). Hard clam is very abundant from Cape Cod to Fla. North of Cape Cod it is comparatively rare and local. On the coast of Maine and Bay of Fundy it occurs only in a few special localities, in small sheltered bays where the water is shallow and warm. In southern parts of the Gulf of St. Lawrence, where water is warmer and shallower than on the Maine coast, it occurs in some abundance. *V. mercenaria* are found on muddy shores and sheltered sandy shores. Hard clam is abundant where mud is somewhat firm and mixed with sand. It is especially abundant in estuaries and harbors of Long Island Sound. Statistics of catch are unreliable because they are mostly taken and sold by individual fishermen and marketed along the coast from Fla. to Boston. It is probable that more than 1.5 million bu are consumed annually. In New Haven the retail price was $2 to $3 per bu for small clams, $1 to $2 for large. - J.L.M.

1899
Verrill, A. E. 1892.

The marine nemerteans of New England and adjacent waters. Trans. Conn. Acad. Arts Sci. 8: 382-456.

List only.

1900
Verrill, A. E., S. I. Smith, and Oscar Harger. 1873.

D. - Catalogue of the marine invertebrate animals of the southern coast of New England, and adjacent waters. In Report on the condition of the sea fisheries of the south coast of New England in 1871 and 1872. Spencer F. Baird, Commissioner. U.S. Comm. Fish Fisheries, Washington, Govt. Print. Off.: 537-747.

Venus fragilis O. Fabricius is listed in the synonymy of *Macoma fragilis* Adams. In the synonymy of *Venus mercenaria* Linne are listed *Mercenaria violacea* Schumacher, *M. mercenaria* Chenu, *Crassivenus mercenaria* Perkins, *V. notata* Say, and *V. praeparca* Say. *Venus gemma* Totten is listed in the synonymy of *Tottenia gemma* Perkins *(Gemma gemma)*. *V. manhattensis* Prime is listed in the synonymy of *Tottenia manhattensis* Verrill. *Venus islandica* Linne is listed in the synonymy of *Cyprina islandica* Lamarck. *V. castanea* Say is listed in the synonymy of *Astarte castanea* Say. *V. minuta* Fabricius is listed in the synonymy of *Turtonia minuta* Stimpson. *Venus mercenaria* was found from Florida to Massachusetts Bay; more rare and local north, at Quahog Bay, Me: Nova Scotia; and southern part of Gulf of St. Lawrence to Bay of Chaleur. Not found on coast of Me. east of Kennebeck River nor in Bay of Fundy. Very common in Vineyard Sound, Buzzards Bay, Long Island Sound, and southward. Fort Macon; South Carolina; Georgia; and Texas. Fossil in Post-Pliocene of Point Shirley, Nantucket Is., Gardiners Is., Virginia and South Carolina. In Pliocene of S.C. and in Miocene of Md., Va., N.C., and S.C. - J.L.M.

1901
Verrill, A. Hyatt. 1950.

Shell Collector's Handbook. G. P. Putnam's Sons, New York, ix+228 p.

Quahog is mentioned on the first page of Chapter 8, but only in general terms. - M.W.S. and J.L.M.

1902
Vincent, D., and A. Jullien. 1938.

La teneur en acetylcholine du coeur des mollusques. Compt.-Rend. Seances Soc. Biol. 127(1): 334-336.

Hearts of cephalopods, lamellibranchs (including *Venus verrucosa*), and opisthobranch gastropods have relatively low content of acetylcholine. Pulmonate gastropods have considerably higher levels, and hearts of certain prosobranch gastropods are even higher. The only levels higher than this observed in invertebrates were about 3 times the level of *Murex trunculus* noted in ganglia of *Octopus*. - J.L.M.

1903
Vinogradov, A. P. 1953.

The elementary chemical composition of marine organisms. Sears Found. Mar. Research, Mem. 2, xiv+647 p.

The following analyses have been made on *Venus mercenaria:* water 84.56% of living matter, 74.4% of muscular tissue; ash 3.20% living matter, 1.46% muscle; nitrogen 2.67% of living matter; Na 0.205% of muscle; K 0.311% of muscle; Ca 0.038 of muscle; Mg 0.048% of muscle; P 0.153% of muscle; S 0.225% of muscle; Fe 0.0% of muscle; Cl 0.322% of muscle. *Venus* sp: CaO 0.7819% of dry matter; MgO 0.3988% of dry matter. *Venus mercenaria:* P 0.1720% of living matter, 0.7998% of dry matter; S 0.3560% of living matter, 1.6440 of dry matter. *Venus virginea:* shells $CaCO_3$ 99.49% of ash residue; Al_2O_3+Fe_2O_3 0.41% of ash residue; $CaSO_4$ 0.31% of ash residue. *Venus mercenaria:* Mn 0.0043% of dry matter, 0.00026 in living matter, 0.00190% of dry matter, 0.00803% of ash. *Venus verrucosa:* Mn 0.00038% of living matter, 0.00166 of dry matter, 0.00917% of ash. *Venus mercenaria:* Fe 0.0711% of dry matter, 0.001% of living matter, 0.006% of dry matter, 0.028% of ash, 0.0% of living muscular tissue. *Venus verrucosa:* Fe 0.009% of living matter, 0.045% of dry matter, 0.248% of ash. *Venus mercenaria:* Cu 0.0016% of dry matter, 0.00083% of living matter, 0.00625% of dry matter, 0.02841% of ash. *Venus verrucosa:* Cu 0.000875% of living matter, 0.00449% of dry matter, 0.024635% of ash. *Venus kennicotti:* Cu 0.00% of living matter. *Venus mercenaria:* Cu in % of living matter 0.00104 in mantle, 0.00236 in liver. *Venus verrucosa:* Cu in % of living matter 0.00023 in mantle, 0 in muscle, 0 in gills, 0.00075 in liver, 0.00035 in sex organs, 0.00463 in precordial glands. *Venus mercenaria:* Zn 0.00451% in living matter, 0.033450% in dry matter, 0.14870% in ash. *Venus verrucosa:* Zn 0.0033% and 0.00470% in living matter, 0.0127% and 0.02447% in dry matter, 0.13234% in ash. *Venus kennicotti:* Zn 0.00051% in living matter. *Venus mercenaria:* Zn 0.1359% in fresh matter; I 0.137% in living matter, 0.620% in dry matter. *Venus verrucosa:* I 0.4 mg/100 g ash residue of shells. *V. gallina:* I 0.13 mg/100 g in ash residue of shells. Blood of lamellibranchs contains Cu and haemocyanin. Calcite and aragonite are found in the shells. - J.L.M.

1904
Virnstein, Robert William. 1976.

The effects of predation by epibenthic crabs and fish on benthic infauna in Chesapeake Bay. Ph.D. dissertation, Coll. William & Mary, 87 p. (Dissert. Abstr. Internatl. says 96 p.)

Predators studied were blue crab, spot, and hogchoker. Species in the infauna are not identified in the abstract. Decreased predation caused large increases in density and diversity of infauna within 2 months. Largest population increases were by opportunistic species, which are considered to be most subject to predation. Species which avoid predation by living deeply or retracting quickly into the substrate were least affected, and were usually the dominant species in the community. All species increased in enclosures, which suggested that their population densities are not controlled by competitive interactions. Infaunal population sizes were limited by predation and not by food or space. Severe predation pressure and physical disturbances keep population levels far below the carrying capacity of the environment. Severe predation, rapid growth, short generation times, and rapid turnover rates of infaunal communities, despite a low standing crop, suggest that such communities are an important food source for predator species important to man. - from Dissert. Abstr. Internatl. 37(2): 597-B - J.L.M.

1905
Virnstein, Robert W. 1977.

The importance of predation by crabs and fishes on benthic infauna in Chesapeake Bay. Ecology 58(6): 1199-1217.

No mention of *Mercenaria mercenaria*. In summary, however, the point is made that shallow water infaunal communities are highly stressed; species populations are not resource limited, but rather are predator controlled; and these communities are an important food source for predatory species important to man. - J.L.M.

1906
Vishniac, Helen S. 1955.

The morphology and nutrition of a new species of *Sirolpidium*. Mycologia 47(5): 633-645.

Sirolpidium zoophthorum (n.sp.), a marine fungus parasitic on larvae of American oyster and *Mercenaria mercenaria*, makes good growth at temps ranging from 20 to 30°C in defined media containing appropriate inorganic salts, glucose or soluble starch, NaH-glutamate, thiamine, and small amounts of agar, if initial pH is between 6.7 and 7.5. The morphology is described in detail. This was the first marine phycomycete to be described in pure culture. - J.L.M.

1907
Vogel, H. 1933.

Himasthla muehlensi n. sp., ein neuer menschlicher Trematode der Familie Echinostomidae. Zentbl. Bakt. ParasitKde 127: 385-391.

According to Cheng et al. (1966) and Cheng (1967), abstracted elsewhere in this bibliography, Vogel reported a human infected with this intestinal trematode after eating raw *Mercenaria mercenaria* in New York. This was a German citizen, who later, on arrival in Germany, complained of gastrointestinal disturbances. The worms were passed after treatment with an antihelmintic. It can be assumed that metacercaria of *H. muehlensi* occur in hard clams from the east coast of the U.S. although it has yet to be found. - J.L.M.

1908
Vokes, Harold E. 1967.

Genera of the Bivalvia: A systematic and bibliographic catalogue. Bull. Am. Paleontol. 51(232): 103-394.

Class Bivalvia, Subclass Heterodonta, Order Veneroida, Suborder Venerina, Superfamily Veneracea, Family Veneridae, Subfamily Venerinae: *Venus* Linnaeus, 1758, Syst. Nat. (ed 10): 684. *Venusarius* (emend. pro *Venus* Linnaeus, 1758) Dumeril, 1806, Zool. Anal., 168. *Venusarius* Froriep, 1806, Dumeril's Anal. Zool., 189 [*Venus* Linnaeus, 1758]. - J.L.M.

1909
Wainwright, Stephen A. 1969.

Stress and design in bivalved mollusc shells. Nature 224(5220): 776-779.

Mercenaria mercenaria is not mentioned. - J.L.M.

1910
Wait, R. B. 1943.

The action of acetylcholine on the isolated heart of *Venus mercenaria*. Biol. Bull. 85(1): 79-85.

Purpose of the study was to test the idea of using *Venus* heart to determine the acetylcholine (ACh) content of tissues, when only small amounts were available. Heart of *Venus* was already known to be extraordinarily sensitive to ACh. The concentration-action curve is a hyperbola, and it is difficult to record beats of small amplitude, therefore ACh values can be determined most accurately when concentrations are such as to produce between 20 and 80% decrease in amplitude. Temp control is important. A heart relatively insensitive to ACh at 25 to 30°C becomes 100 times as sensitive at 5 to 10°C. Midway in this range of temp heart will beat with satisfactory amplitude and frequency for 12 to 24 hrs. - J.L.M.

1911
Waite, J. Herbert. 1977.

Evidence for the mode of sclerotization in a molluscan periostracum. Comp. Biochem. Physiol. 58B(2): 157-162.

Describes the process in *Geukensia (Modiolus) demissa*. *Mercenaria mercenaria* is not mentioned. - J.L.M. and M.W.S.

1912
Wakefield, Harold F. 1964.

Adhesives, technology and marine organisms. In Symposium on Experimental Marine Ecology. Grad. School Oceanogr., Univ. R.I., Narragansett Mar. Lab., Occ. Pub. 2: 51-58.

The work started with questions about the mechanism of adhesion of adductor muscle to the shell of *Mercenaria mercenaria*. Study of adhesive joints in living animals must use a different set of rules and standards than in industrial adhesive technology. Substrates are a composite made up of inorganic crystals cemented together mainly by an organic adhesive, which seems to be a precursor of collagen laid down as a liquid with subsequent hardening. Exact compositions should be determined and curing mechanisms should be investigated, for industrial applications. The concept of a suction-cup mechanism by which some mollusks may attach to solid surfaces is not necessary. The author believed that attachment to the substrate could be explained by the adhesive technologist's concepts of "tack". The paper contains a useful review of adhesion in bivalve shells, composition of shell, shell repair, composition and strength of adductor muscle, the "catch" or "clutch" mechanism, biochemical mechanics of muscle structure and activity, characteristics of hinge and ligament, and byssus attachment. - J.L.M.

1913
Walford, Lionel A. (Director). 1971.

Review of aquatic resources and hydrographic characteristics of Raritan, Lower New York and Sandy Hook Bays. Rept. prepared for Battelle Inst. by staff of Sandy Hook Sport Fish. Mar Lab., U.S. Dept. Commerce, NOAA, NMFS, Highlands, N.J., manuscript rept., 67 p. (Another version, same date, has 86 pages.)

Dredge samples taken in western Raritan Bay had impoverished faunas, with the exception of *Mercenaria mercenaria*. Adult hard clams were not uniformly distributed in Lower and Raritan Bays. Density ranged from one clam/6 ft^2 to one clam/170 ft^2. N.Y. waters had greater numbers of commercial-size clams and Raritan Bay greater numbers of smaller clams. It was suggested that normal reproduction and recruitment may not occur in more heavily polluted waters, even though adults may continue to survive in such places. Less than 1% of clams taken were of sublegal size. Standing crops of adult quahogs in Raritan Bay were similar to or exceeded those reported for Narragansett Bay by Pratt (1953), abstracted elsewhere in this bibliography. Standing crops much larger than those in Raritan Bay are possible, for Belding (1912), abstracted elsewhere in this bibliography, found 20 clams/ft^2 on some beds in Mass. - J.L.M.

1914
Walker, A. O. 1894.

Venus mercenaria Linn. American clam. Proc. Chester Soc. Nat. Sci. 4: 210.

According to Heppell (1961) Walker stated that the flushing pool of the Dee River at Bagillt Wharf was cleaned out to a depth of 2 ft of mud in 1888 but no trace was found of hard clams planted in 1883. - J.L.M.

1915
Wallace, Dana E. 1952.

State and town shellfish planting programs in Maine. 3rd. Conf. on Clam Research, 2 p. (mimeo).

Cooperative projects with towns and clam diggers to transplant seed quahogs from areas of heavy set to commercial beds, and to close certain areas to rehabilitate the stocks, are described. Some plantings also were done with private planters. Final results were not reported. - J.L.M.

1916
Wallace, Dana. 1952.

Age determination and growth rate of soft clams and quahogs in Maine. 3rd Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 89-91.

The samples were rather small. Growth ranged from 11-16 mm for 20-35 mm clams to 5 to 17 mm for 36-58 mm clams. - J.L.M.

1917
Wallace, Dana E. 1953.

Setting of *Venus* and *Mya* in Maine as indicated by 1952 surveys. 4th Conf. on Clam Research, 4 p. (mimeo).

In mid-August 1952 substantial natural sets of both species were observed in Maquoit Bay, Maine. *Venus* were 2-4 mm long and varied between 40 and 208 clams/ft^2. The most recent large set of *Venus* was in 1947. One area, roughly 1,000 by 600 ft, had about 1,000 *Venus*/ft^2. In another area *Venus* was 400 to 500 clams/ft^2. In discussion it was brought out that *Venus* sets had survived much better than *Mya* in the previous few years. It was suggested that this was caused by recent rises in water temp. - J.L.M.

1918
Wallace, Dana E. 1953.

The commercial scale transplanting of *Venus* in Harpswell and West Bath. 4th Conf. on Clam Research 3 p. (mimeo).

Cooperation between towns, clam diggers, and the State of Maine in transplanting quahogs and rotating digging areas are described. Production records were not yet available. - J.L.M.

1919
Wallace, Dana E. 1955.

The use of equipment and techniques in applied shellfish management. Proc. Natl. Shellf. Assn. 45: 209.

Maine's hard clam industry depends on natural sets, and survival and growth to commercial size. It is feasible to transplant quahogs. When they are over 1/2 in long they are relatively immune to crab damage. They establish in flats readily and growth is good. Seed is gathered with a portable pump and 2-in suction hose. Catches up to 256 bu/day of clams slightly over 1 in were made with a larger pump. Plantings were 200 to 400 clams/ft^2. Approximately 2,800 seed clams/min were harvested with a 6 in hose. Damage was negligible. - J.L.M.

1920
Wallace, Dana E. 1979.

State and local management institutions. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass. and MIT Sea Grant Program, SP-112: 25-29.

Traces the philosophy of ownership and jurisdiction over clam resources of coastal waters as far south as New Jersey. Local communities have tended to control the harvest, in the interest of the towns and their residents. In the late 1800s research began, to deal with many unknowns. Whether for public or private use, various laws were passed to control the harvest, by local and by state governments. Much of the success and lack of success of these laws has depended on whether the fishermen understood and accepted them. Fishery agencies have failed to act, at times, because deficiencies existed in communication, or because there were not sufficient manpower, time, or funds to do the job. The hope is expressed that the conference will help to fulfill that need. - J.L.M.

1921
Wallace, David H. 1967.

Statement at Conf. on Pollution of Raritan Bay and adjacent Interstate Waters. 3rd Sess., Vol. 3. Fed. Water Pollution Control Admin., U.S. Dept. Interior. Paul DeFalco (ed.): 1046-1054.

In the late 19th century the center of New York's oyster industry was located in Princess Bay, a part of Raritan Bay. It was forced to vacate the area as pollution increased. A map shows the part of Raritan Bay set aside for dredging of fill materials, and other areas with high values for fishes, shellfishes, and wildlife. Millions of bushels of clams, (presumably mostly hard clam) were present in N.Y. and N.J. waters of Raritan Bay. Estimated market value was about $40 million, but this was a potential value because the clams were a dangerous public health hazard. All N.Y. waters in the Bay were currently restricted for harvesting shellfishes. Economic loss caused by this closure was estimated at $500,000 annually, and with increased value since 1961 the annual loss for N.Y. alone probably was nearer $1 million. Poaching of shellfishes from closed waters was a continuing threat to public health. In 1966 New York began a program to transplant shellfishes from polluted Jamaica Bay, Long Island to clean waters. - J.L.M.

1922
Wallace, David H. 1971.

The biological effects of estuaries on shellfish of the Middle Atlantic. In A Symposium on the Biological Significance of Estuaries. P. A. Douglas and R. H. Stroud (eds.), Sport Fish. Inst., Washington, D.C.: 76-85.

Hard clam, living in lower parts of estuaries, are far more adjustable than oyster to environmental deterioration. In heavily contaminated Raritan Bay hard clam still spawn and reproduce successfully, although oyster is long since gone. The standing hard clam population is several million bushels, but these are unsafe for eating raw. Intensive policing is necessary to prevent marketing. Conditions are similar in various places in the Mid-Atlantic states. The recent rise in production of hard clam in New York was made possible by a series of excellent sets in several bays on the south shore of Long Island. - J.L.M.

1923
Walls, R. A., Paul C. Ragland, and Edward L. Crisp. 1977.

Experimental and natural early diagenetic mobility of Sr and Mg in biogenic carbonates. Geochim. Cosmochim. Acta 41(12): 1731-1737.

Ammonium acetate dissolution experiments on shell material of *Crassostrea virginica* (calcite) and *Mercenaria mercenaria* (aragonite) suggested the following relative order of abundance for readily exchangeable Sr and Mg: Mg(arag)>Mg(calc)>Sr(calc)>Sr(arag). Preferential dissolution of Mg and Sr with respect to Ca can be explained by the presence of loosely bound ions in a multi-phase shell structure. - J.L.M.

1924
Walne, P. R. 1958.

The importance of bacteria in laboratory experiments on rearing the larvae of *Ostrea edulis* (L.). J. Mar. Biol. Assn. U.K. 37(2): 415-425.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

1925
Walne, P. R. 1964.

The culture of marine bivalve larvae. Chapter 6 in Physiology of Mollusca. Vol. 1. Karl M. Wilbur and C. M. Yonge (eds.). Academic Press, New York: 197-210.

Carriker (1959) studied for 3 yrs a pond in Long Island Sound. *Venus* grew well but rate of exchange with the sea was so high that few larvae were retained. Author stresses the importance of controlling bacteria in larval cultures. Not all batches of eggs from one *Venus* had the same vitality. There is no greater variation in survival and growth of larvae of young or old parents than between different members of the same age group. Chanley (1955) found that *Venus* larvae from same female crossed with 2 different males, and from 2 females crossed with the same male, showed significant differences in growth rate, suggesting that inherited factors from either parent were responsible. This needs further investigation. Annual cycle of activity of hard clam gonads is: 1) resting phase - resorption of unspawned material may take place; 2) phase of active gametogenesis, giving ripe oocytes and spermatozoa; and 3) liberation of sex products, which requires a stimulus. Resting period is often a period of rapid growth and replenishment of food reserves, and it is useless to attempt to condition for spawning at this time. Once sufficient reserves have accumulated, the period required for maturation of gametocytes is a function of temp. Raising water temp. to 20-22°C over 2-3 wks is sufficient for *V. mercenaria*, although behavior is less predictable than that of *Crassostrea virginica*. *V. mercenaria* is more resistant than *Crassostrea* to stimulation by presence of egg or sperm. It is best to use gametes which have been shed by the parent. Teasing out gonadal tissue usually gives material which is not fully ripe. Gonad extract also can be used to stimulate spawning. *Venus mercenaria* is more resistant than oyster to this method of stimulation. Chemical and electrical stimulation also are possible. Although bivalve larvae can be reared in standing water, stirring is necessary. It is best to change the water frequently. Most bivalve larvae, including quahog, are able to withstand shocks associated with screening and water change. Changing the water is beneficial in controlling bacterial growth and development of toxic metabolites, but water from some sources, such as those containing dinoflagellate blooms, affects development and growth adversely. Larvae thrive on a diet of unicellular algae small enough to be swallowed (less than 10 μ). Provision of an adequate food supply is imperative. *Chlorella* is adequate. Mixed cultures are unstable and not necessarily reproducible. Algal species differ widely in their food value to bivalve larvae, and some are probably toxic or produce toxic metabolites. *Venus mercenaria* can develop and grow on a wider variety of foods than can *Crassostrea*, including Chlorophyceae, Chrysophyceae, and some Cryptophyceae. The relation between amount of food and density of larvae in the culture is important. During dinoflagellate blooms at Milford bivalve cultures failed to grow normally. This may imply presence of toxic metabolites or absence of required substances in seawater; it is extremely difficult to investigate. Larvae of *Venus* have been reared on mixed algal cultures obtained by adding nutrient salts or commercial agricultural fertilizers to seawater. The organisms were mostly *Chlorella*, but such mixed cultures are unstable and not necessarily reproducible. Erdschreiber is best ($NaNO_3$ 0.1g, Na_2HPO_4 0.02g, soil extract 50 ml, seawater 1,000 ml. Soil extract: autoclave rich loam and distilled water in proportions of 1 liter water to 1 kg soil). *V. mercenaria* is tolerant of many foods provided the cells are small enough. Chlorophyceae: not all species of *Chlorella* are good. *Chlorella* cultures are liable to contain toxic metabolites and overfeeding of larvae will cause death. Chrysophyceae: *Isochrysis galbana*, *Monochrysis lutheri*, and *Chromulina pleiades* give excellent growth, they rarely become toxic, and culture methods are well known. Bacillarophyceae and Cryptophyceae are not so satisfactory. Detritus has been tried with *Venus* without success. *Venus* fed a mixture of 4 species gave rather better growth than with single foods. Feeding rates necessary for maximum larval growth: *V. mercenaria* 10 larvae/ml, *Isochrysis galbana* 200 cells/mm^3/day, *Monochrysis lutheri* 250 cells/mm^3/day. Epizootic fungus (*Sirolpidium zoophthorum*) in larval cultures of *V. mercenaria* can kill most larvae in 2 to 4 days. Despite careful attention to details, some larvae die before metamorphosis, and most mortality is unexplained. Among suspected pathogens are bacteria, colorless flagellates, and ciliates. - J.L.M.

1926
Walne, P. R. 1964.

Sea-water supply system in a shellfish-culture laboratory. U.S. Dept. Interior, Fish Wildl. Serv., Research Rept. 63: 155-159.

The system would be suitable for culture of *Mercenaria mercenaria*. Water is distributed from roof tanks to a tank room where it is heated and enriched with phytoplankton, and to the hatchery where it is filtered and sterilized. Equipment is described. - modified author's abstract - J.L.M.

1927
Walne, P. R. 1970.

Studies on the food value of nineteen genera of algae to juvenile bivalves of the genera *Ostrea*, *Crassostrea*, *Mercenaria* and *Mytilus*. Ministry Agric. Fish. Food, Fish. Investig. Series II, 26(5), 62 p.

The food value of algal species was determined by repetitive experiments at various times on bivalves of different parentage. Samples of *Mercenaria mercenaria* from a few weeks to one year old, ranging in size from 0.6 to 7.0 mm, were selected. Samples for each experiment were selected within a narrow size range from the same batch of siblings. Origin of breeding stock was Southampton, England. Growth was measured as an increase in shell size or live weight at various concentrations (usually five) of unialgal cultures in filtered seawater over a span of 3 weeks. In some cases unfiltered seawater was also used. Relationship between length and live weight was constant.

A control group was fed *Isochrysis* or *Tetraselmis*. In all cases algae were fed to bivalves on the basis of cell numbers, yet estimates of cell volume for most species were obtained by a Coulter counter or measurement of centrifuged packed cell volume. Differences in growth between *Chlamydomonas* and *Tetraselmis* were not due to amino-acid composition, as no substantial differences in amino-acid composition were noted. *Skeletonema costatum* and *Pyramimonas grossii* (less than 100 cells/μl) showed better growth than control, but based only on one experiment each. Clams fed *Tetraselmis* sp. showed maximum growth at 15-20 cells/μl, while growth rate was not very sensitive to different cell concentrations of *Isochrysis galbana*. Substantial growth was noted with *Olisthodiscus* sp. (1.0-7.0 cells/μl), *Cryptomonas* sp. (75 cells/μl), *Cricosphaera carterae* (5.0-7.5 cells/μl), *Dicrateria inornata* (200 cells/μl), and *Monochrysis lutherii* (100 cells/μl). - W.J.B.

1928

Walne, P. R. 1970.

The growth of relaid American hard clams (quahogs) in England and Wales. Min. Agric. Fish. Food, Fish. Exp. Sta., Conway, N. Wales, Shellf. Inf. Leaflet 16, 8 p., 5 figs.

Venus (Mercenaria) mercenaria is not native to Europe, but attempts have been made to introduce it into Britain, France, Holland, and Belgium. All soon died out, with the exception of 1 or 2 in France, presumably because the areas were unsuitable or water temps were not high enough for reproduction. The origin of the reproducing population in Southampton Water in southern England is not known. The standing stock is presently several hundred tons of market-sized clams. In the Shellfish Culture Unit at Conway about 42% of fertilized eggs have been reared to spat stage and about 25% to 10 mm shell length. Thereafter, when planted in the natural environment, small clams are vulnerable to predation by shore crabs *(Carcinus maenas)*. When quahogs reach 20 to 25 mm long they are resistant to even the biggest crabs, but they do not reach this size until 2 yrs, and it is costly and inconvenient to protect them for so long. For growth experiments in the natural environment each clam was numbered. From March to September 1964, a standard clam 40 mm long grew by 6 to about 17 mm (final length 46 to 57 mm). At 5 sites, growth was above average and clams reached an average length of 54.2 mm by fall. At 4 sites, average length in fall was only 45.9 mm. Muddy shores in quiet creeks and estuaries were preferable to exposed areas or bottoms in which the substrate was too hard. Growth experiments in 1966-1968 showed that the relationship between length in year n and in year n+1 could be described by a straight line. The relationship was: 10 mm at planting = 23.2 mm after 1 yr; 2 yrs 35.6 mm; 3 yrs 47.2 mm; and 4 yrs 58.0 mm. If favorable sites were selected, better growth than this average relationship could be obtained. Annual survival, expressed as a percentage, fell into 2 clear groups: clams 9 to 13 mm long at planting had an average mortality of 12.1%, clams 17 to 21 mm at planting died at the rate of only 3.3% per yr. Seed 10 mm long at planting will be 50 to 60 mm long at harvesting, 3 to 4 growing seasons later. If clams are protected by netting, about 80% will survive to market size. To allow for accidents and other eventualities, 50% mortality from planting to harvest probably is more realistic. Experimental densities of clams were 2 million/ acre. If growth and mortality under commercial operation were the same as in experiments, the harvest would be one million clams, 55 to 60 mm long per acre. These would weigh about 60 g. Thus, a million would weigh 30 metric tons. The natural population in Southampton Water contains 25 to 30 tons/acre. - J.L.M.

1929

Walne, P. R. 1972.

The influence of current speed, body size and water temperature on the filtration rate of five species of bivalves. J. Mar. Biol. Assn. U.K. 52(2): 345-374.

Experiments were based on removal of particulate matter by clams. It was assumed that filtering was 100% efficient. In a closed system *Mercenaria mercenaria* of shell length 4-5 mm were fed different concentrations of *Isochrysis galbana, Phaeodactylum tricornutum,* and *Dunaliella tertiolecta.*

Clams regulated filtration rate according to quantity of food present, filtering less water at highest cell densities. Numbers of cells filtered per unit time increased with concentration of cells, approaching an asymptote at higher cell densities. The asymptote was about 34×10^4 cells/hr of *Isochrysis* and 98×10^4 cells/hr of *Phaeodactylum*. No clear asymptote was reached with *Dunaliella*. Mean number of *Dunaliella* cells eaten/hr was 16.6×10^4. Lowest cell density tested was 17 cells/µl, which apparently was sufficient for clams to get their maximum ration. Median cell volume of *Dunaliella* was 300 μ^3, about 5 times the cell volume of the other two species. The relatively small size of the *Isochrysis* ration as compared to *Phaeodactylum* probably was related to its high nutritive value. *Isochrysis* is a much better food for hard clam than the others. In flowing water, filtration rate is directly related to flow rate. Hard clams of mean shell length 0.8 cm and dry meat weight 4.8 mg filtered about 10 ml/min at a flow rate of 300 ml/min. Filtration rates were highly correlated with size of clam, especially if calculated on the basis of dry meat weight. Filtration rate was inversely correlated with water temp. Hard clams were particularly sensitive to reduction in temp. Results of these experiments emphasize the importance of standardizing rate of water movement in such studies. Experiments with different concentrations of food suggest that adult bivalves can be as sensitive to small changes in food concentration as larvae are. Siphonate forms like *Mercenaria* had lower filtration rates than oysters. - J.L.M.

1930
Walne, P. R. 1972.

The importance of estuaries to commercial fisheries. In The Estuarine Environment. R.S.K. Barnes and J. Green (eds.). Applied Science Publishers, Ltd., London: 107-118.

Mercenaria mercenaria was found over 3 ha at a density of 206 g/m^2 in Southampton Water, England. Establishment of *Mercenaria mercenaria* in Southampton Water is due to warmer temperatures in shallow waters, reinforced by the warm-water effluent of a nearby power station. - J.L.M.

1931
Walne, P. R. 1974.

Culture of Bivalve Molluscs. 50 years experience at Conwy. Fishing News (Books) Ltd., West Byfleet, Surrey, England, 173 p.

Most of this book deals with the European flat oyster, *Ostrea edulis*. Many techniques and methods, and accumulated experience, however, could be applied to *Mercenaria mercenaria*. Chapter 6, "Other species of bivalves", contains most information on hard clam. In the U.S., larger populations of quahog are below low-water mark in soils varying from soft mud to shell and mud. Various attempts have been made to establish the species in Britain and Europe, but most were unsuccessful. Most seed placed in Essex rivers were severely reduced by crab predation. At Conwy they grew very slowly. Later a substantial population was found in Southampton Water in the upper part of the estuary. Some beaches had 50 to 150 clams/m^2 in a broad band from mid-tide level to low-water mark of spring tides. This was traced to heavy spatfalls in 1959-61, but older clams also were present. This demonstrated that quahogs could thrive in Britain in a highly polluted and not very promising area. In the laboratory larvae are reared in late winter and early spring to gain max. advantage of summer growing period. Spat reared in July and August will reach only 1-2 mm by end of fall and renewal of growth is delayed until well into the following summer, and these spat may remain permanently stunted. Quahogs of 4-7 cm are brought to the hatchery in December and January and kept in 20-22°C running seawater. Over three years the number of days to spawning varied from 29 to 52 days. Spawning is induced by raising water temperature to 26°C and adding a suspension of male gonad. After 24 hrs at 22°C embryos are swimming. On 2nd or 3rd day shell is well enough developed to protect the larva, so that larvae can be collected on a screen to change the water. Up to 1/2 million larvae can be reared in 75 liters of water. On the average about 42% metamorphosed. Average time to metamorphosis was 21 days, at a shell length of about 250 µ. At this stage the ciliated foot is prominent and larvae crawl on bottom. When water is changed many larvae remain attached by byssus and must be washed off with a strong jet of water. At this stage a stagnant culture is no longer suitable because larvae clump and smother. Spat are transferred to trays with nylon mesh base in running seawater. Coarsely strained water enriched with 50 cells of *Isochrysis* and 5 of *Tetraselmis* (presumably per µl). If trays are being used at capacity, algal culture must be added continuously. The system is closed, water is renewed twice a week, and spat are washed to remove detritus and break up clumps. As they grow, spat are moved to progressively larger mesh. Growth of individuals varies widely, and it is best to sort selectively and grow size groups separately. At about 1 mm shell length spat are removed and placed in running seawater at ambient temp outside the lab. At this stage a 450-liter unit needs 5 liters of algal culture/day. In about 63 days about 28% of fertilized eggs survived to mean size of 1.2 mm. Trays and pipes require constant maintenance. A million quahogs 2.5 mm long require 2,058 l of seawater/hr; a million at 15 mm require 144,000 l/hr. After planting in the natural environment predation becomes a serious problem. *Carcinus maenas* was the principal predator. Size of crab determines size of clam that can be eaten. One method of protection is to cover clams with mesh of suitable size. Clams of about 10 mm length at the beginning of the growing season were over 20 mm at end of growing season, clams about 40 mm at beginning of season were somewhat less than 55 mm at end of season. Mortality during growing season varied from about 25% to 2%. Survival of larger clams was on the average higher and much less variable. In Conwy the growing season is May to September. Best growth is obtained in warmer waters on the south and southeast coasts of England. Seed planted in the natural environment at 10 mm long increases in length in the following 4 yrs by 10-23.2, 23.2-35.6, 35.6-47.2, and 47.2-58 mm, respectively. Mortalities were 12.1%, 15, 17.8, and 20.5%, respectively (cumulative). Quahogs were planted at a density of $2x10^6$/acre. Estimated survival on a commercial scale probably would be lower, perhaps 50%. A million quahogs of 55-60 mm would weigh 30 metric tons. Quahogs are excellent material for hatchery culture. They thrive in soft muddy bottom unsuitable for culture of other shellfish. The major problem is protection of seed against predation. Miscellaneous references to hard clam in other chapters were: filtering rates of quahog are more affected by low temp than oysters and mussels; quahog requires higher temp for spawning than does *O. edulis*; growth of *M. mercenaria* for 28 days after metamorphosis is somewhat less than 1.5 mm at about 17°C, and about 2.5 mm at about 25.5°C; meat weight, expressed as ratio of dry meat weight/dry shell weight x 100, declined from about 7 at 11°C to about 6 at 24°C. Chapter 4 contains information on value of various phytoplankton organisms as food for *O. edulis* larvae, but much of this discussion will be of interest in connection with clam culture, as will most other chapters. - J.L.M.

1932

Walne, P. R. 1974.

Shellfish culture. Chapter 19 in Sea Fisheries Research. F. R. Harden Jones (ed.). John Wiley and Sons, New York: 379-398.

At Conwy Fisheries Experiment Station, adult *Mercenaria mercenaria* are ripened in running seawater at 21°C for about 40 days in winter and less in spring and summer. A standard 75-liter bin is stocked with about 400,000 larvae 24 hr after fertilization. About 40% will metamorphose 21 days later at 22°C at a mean size of about 0.25 mm. Quahog larvae do not attach permanently at end of the free-swimming period. When most larvae have metamorphosed they are transferred to trays with plastic mesh base, immersed in seawater. The water is enriched with 50 cells of *Isochrysis* or 5 cells of *Tetraselmis* per microliter and circulated continually through the trays. With 750,000 quahaugs distributed among 8 trays, each with area of 400 cm^2, growth and survival are good in a closed system with total volume 450 l. Clams reach 1 mm after about 40 days at 22° and are transferred to trays in running water at ambient temperature outside the laboratory. About 28% of original eggs survive to 1 mm. Standard trays have a base area 900 cm^2 and a flow of 1.2 l/min. A million quahaugs at 10 mm require in summer about 36,000 l/hr from which they extract about 75% of the particulate matter. Thus, they should be transferred to the natural environment as soon as possible. Unless protected in some way they are then subject to predation by the crab *Carcinus maenas.* Experiments showed that unless protected until at least 2 cm, survival of clams was poor. Estimates of growth and survival were obtained by holding groups of 200 clams in a wooden frame 61 cm square by 9 cm deep, sunk flush with the beach surface. The top was closed with plastic mesh against predators. Samples of various sizes of clam were planted at 16 sites. Clams were measured at beginning and end of successive growing seasons. Average shell lengths each year, of clams 10 mm when planted, were: 1 yr, 23.2 mm; 2 yrs, 35.6 mm; 3 yrs, 47.2 mm; 4 yrs, 58 mm. Mortality was about 12%/yr among clams 9-13 mm at planting, falling to 3% when 17-21 mm at planting. Growth is limited by water temperature. At Conwy, May to September is the growing period. Quahaugs thrive in soft muddy areas unsuitable for other shellfish culture. If the New England grading system were used, clams would reach "littleneck" size about 4 years after planting. A yield of a million clams 55-60 mm long from 0.4 ha can be expected (littleneck size is 50-60 mm). This yield would weigh 30 tons. (Abstracter's note: 30 tons is roughly 750 bushels = about 750 bu/acre.) - J.L.M.

1933
Walne, P. R. 1976.

Factors affecting the relation between feeding and growth in bivalves. In Harvesting Polluted Waters. O. Devik (ed.). Plenum Press, New York: 169-183.

Experiments on *Mercenaria mercenaria* in June-September showed that in absence of additional food, some growth took place in natural seawater, but proportion of dry meat expressed as condition index (dry meat/dry shell) declined. When extra food was added, growth was enhanced, and condition index also improved. In 21 days in natural seawater, hard clams grew from shell weight of 36.8 mg to 53.4 mg with no added food, to 92.1 mg with 20 cells/µl *Tetraselmis*, and to 97.1 mg with 100 cells/µl *Isochrysis*. Percent meat went from 4.7 initially to 3.5, 5.8, and 5.2, respectively. In filtered seawater shell weight was 41.9 mg with no food, 81.6 mg with *Tetraselmis* and 94.6 mg with *Isochrysis*; meanwhile percent meats were 3.2, 4.8, and 5.2, respectively. Different species of algae show wide differences in food value. Species used in the laboratory may not be representative of those in natural environment. No good non-living diet has yet been developed. The small particles required are attacked readily by bacteria, which foul the water. Given an adequate diet, too much food leads to waste through production of pseudofeces, low conversion efficiency, and poor growth. Suitable water currents are necessary to stimulate feeding and carry away feces. Increased temp may hasten growth but divert energy from somatic to gonadal growth. Increased temp also appears to hasten shell growth more than meat growth. This may explain the observation that shellfishes at low latitudes tend to be in poorer condition than those at high latitudes. - J.L.M.

1934
Walne, P. R., and G. J. Dean. 1967.

Studies on the introduction of the American clam *(Venus (Mercenaria) mercenaria)* (L.) into British waters. Internatl. Counc. Explor. Mer, Fish. Improvement Comm. 1967/E.6, 12 p. (mimeo).

Breeding stock from Southampton Water was the origin of most animals. Clams have been raised in late winter or early spring to obtain maximum advantage of the summer growing season. Length of conditioning season for 3 successive winters was 29 to 52 days. Larvae were reared in polyethylene bins of 75 l capacity at 5,000 to 10,000 per liter. Average results for 3 yrs were: av no of larvae 436,000, 42% metamorphosed, 21 days. Satisfactory results have been obtained by rearing larvae in 12 liter glass tubes at a density of 40,000 to 60,000 larvae per liter but at this density food must be added continuously. When about 75% of the larvae have metamorphosed spat are transferred to trays with nylon base immersed in seawater. *Isochrysis galbana* or *Tetraselmis suecica* (or a mixture of the two) are added. A closed circulation system is used which holds 450 liters. Good growth and survival can be obtained with up to 750,000 to 1,000,000 clams provided algal culture is added continuously to maintain 50 to 100 cells of *Isochrysis* or 5 to 10 cells of *Tetraselmis* per µl. Growth of competing species of invertebrates can be controlled by a thorough wash with fresh water. Size and numbers per batch at about 1 mm were 267.5 μ at planting, 216,750 in a batch, size 1,219.5 μ when moved outside, 42.5 days of growth, and 66.9% survival. Over about 1 mm in size spat were held outside. Animals are sorted from time to time to maintain individuals of about the same size together. Flow is about 1.2 l/min in a tray with base area 900 cm^2. The number of clams per tray is related to size of animals, 2.5 mm or 0.005 g about 40,000 clams per tray, 10 mm or 3.5 g about 2,500 per tray. Growth at Conway starts about early May and continues until the end of August. Clams 5 mm long at the beginning of the growing season have reached about 30 mm at end of growing season. Survival in the first two yrs was 70 to 90%. Clams grown in Menai Straits and at Conway grew about the same, from a mean size of about 16 mm in January 1965, to about 45 mm in May 1967. Coverage was necessary to avoid predation. Major problems were, mesh could be blocked by growth of weed and Ascidians, or the frame could be covered by a layer of silt. These investigations have demonstrated that larvae of *Mercenaria mercenaria* can be reared in substantial numbers and spat can be cultured with only moderate losses. Satisfactory growth and survival can be obtained in a number of places in England and Wales. Expected growth and survival of 1,000,000 clams after 3 yrs are 20 to 34 mm and 80,000 animals. - J.L.M.

1935
Walne, P. R., and G. J. Dean. 1972.

Experiments on predation by the shore crab, *Carcinus maenas* L., on *Mytilus* and *Mercenaria*. J. Cons. 34(2): 190-199.

Unprotected plantings of hatchery-reared quahogs suffer heavy mortality. Rates of destruction were measured in the laboratory by placing one crab each in a series of boxes, each box containing 15 clams, 5 of each of 3 size groups, held in running seawater. Numbers of clams eaten per unit time were affected by a number of factors, illustrating the difficulty of measuring predation rates in laboratory studies. Clams allowed to burrow in sand or mud were less vulnerable than unprotected clams. A substrate of mud offered better protection than sand. Competition may be important, as suggested by one experiment in which 10 crabs in one container ate far more clams each than 5 crabs in separate containers, although ratios of crabs to prey were the same. By inference from more extensive experiments with mussels, other things may be assumed for quahog: rate of predation is a function of water temperature, crabs from some areas are more voracious than those from others, numbers of prey of a certain size eaten by crabs was a measure of ease of attack and not of size structure of clams available, crabs tend to select the smaller prey, larger crabs can open larger bivalves, rates of consumption varied from zero to more than 4 clams/day. Quahogs used in these experiments varied in length from 2 to 26 mm, crabs from 15 to 79 mm in carapace width. Highest rate of predation was by the smallest crabs on the smallest clams. - J.L.M.

1936
Walsh, Dennis. 1974.

The responses of the bivalve *Mercenaria mercenaria* to declining oxygen tensions. Thesis presented to School of Marine Science, College of William and Mary.

Oxygen consumption, pumping rate, and filtration efficiency of *Mercenaria mercenaria* were measured and compared at low and high oxygen tensions. Results indicated *Mercenaria* could maintain a constant O_2 consumption in declining oxygen tension, but critical oxygen tension (P_c) at which this respiratory regulation ceased appeared to depend on the clam's size and sex. Three modes of respiratory regulation were observed and described. The efficiency with which the cilia of the gill were able to remove particles was found to be independent of pumping rate, oxygen consumption and the oxygen tensions. - M.C. (Confirmed by examination of original thesis. - J.L.M.)

1937
Walsh, Dennis T. 1979.

The Wampanoag fisheries project: Shellfish production improvement at Gay Head, Marthas Vineyard, Massachusetts. Second Ann. Rept. to Economic Development Admin., U.S. Dept. Commerce, Tech. Assistance Grant no. 01-6-01369-1.

Hatchery reared *Mercenaria mercenaria* seed were grown under plastic mesh on intertidal flats. Growth averaged 0.005 cm/day from March to July. This slow growth was probably due to fouling of the plastic mesh. Eventually most of the seed died from smothering. Seed growth in rafts had greater than 90% survival. - M.C.

1938
Walters, W. S. 1975.

Introduction. In Proceedings of a Workshop on the Shellfish Management Program in New York State. N.Y.S. Dept. Envir. Conserv. and N.Y. Sea Grant Inst., Albany: 5-6.

Intent of the Workshop was to explore management roles and responsibilities to broaden the base of cooperation underlying state and local management agencies. - J.L.M.

1939
Walzl, E. M. 1937.

Actions of ions on the heart of the oyster *(Ostrea virginica)*. Physiol. Zool. 10: 125-140.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

1940
Walzl, E. M. 1938.

Response of the oyster heart to electrical stimulation and effect of calcium and potassium on its threshold of inhibition. J. Cell. Comp. Physiol. 12: 237-246.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

1941
Wang-Tai-Si. 1928.

Recherches sur le cuivre, le fer, le manganèse et le zinc chez les mollusques. Thèse, Paris.

Data cited by Vinogradov 1953, abstracted elsewhere in this bibliography. - J.L.M.

1942
Warburton, Frederick E. 1958.

The manner in which the sponge *Cliona* bores in calcareous objects. Cdn. J. Zool. 36: 555-562.

The boring sponge attacks hard clam as well as oysters and other mollusks. Apparently cytoplasmic filaments penetrate calcite by secreting minute amounts of acid. Fragments of shell are carried through sponge parenchyma to excurrent canals. (Abstracter's note: Large hard clams in Great South Bay, N.Y. are sometimes attacked by boring sponge. External evidence is confined to the dorsal portion of the shell, between umbones and siphons, but when infestation is well developed the sponge ramifies entirely over the inner surfaces of the valves in a reticulated pattern, covered by a layer of calcareous material. The material was brought in by Gregory T. Greene.) - J.L.M.

1943
Wardle, William J. 1979.

A new marine cercaria (Digenea: Aporocotylidae) from the southern quahog *Mercenaria campechiensis*. Contrib. Mar. Sci. 22: 53-56.

A new larval trematode, *Cercaria mercenariae* n. sp., is described from gonadal tissue of southern quahog *M. campechiensis* from Galveston, Texas. It most resembles *Cercaria loossi*. This is the first report of a cercaria from clams of the genus *Mercenaria*. - J.L.M.

1944
Warinner, J. E., and M. L. Brehmer. 1966.

The effects of thermal effluents on marine organisms. Internatl. J. Air Water Pollution 10(4): 277-289.

Mercenaria mercenaria was not taken during the study, possibly because samples of benthos were taken with a 1/20 m^2 Petersen grab. The authors comment that a sparsely distributed organism like hard clam might contribute greatly to biomass of a sample, but little numerically. Nineteen molluscan species were taken. Community composition and abundance of marine benthic invertebrates were affected by thermal discharge from a plant in the York River, Virginia, over a distance of 300 to 400 m. The affected area was small because the less dense heated water rises above the bottom as it flows offshore. Diversity indices indicated stress. In winter, diversity was higher. Stress was noted at times of high normal river temp. - J.L.M.

1945
Warren, Shields. 1916.

Feeding habits of *Busycon*. Nautilus 30: 66-68.

Busycon canaliculata will not attack quahogs as early in life as *B. carica* because the lip of its shell is almost paper-like until the snail is well grown. A quahog is grasped by the foot of the snail so that the hinge is toward the columella. The edges of the clam are left free. Usually *Busycon* rests on its foot and the canal points upward at an angle of about 30°. The foot slowly contracts, about 6 times/min, and the edge of the clam is brought against the inner edge of the lip with considerable pressure, then is drawn inward and toward the canal. A small piece is chipped from the edge of the clam, and the process is repeated until the gap is large enough to admit the radula, which then tears out the flesh. This chips the lip of the snail, also. The whelk does not always succeed, for occasionally clams are found alive with the edge much chipped. - J.L.M.

1946
Warwick, R. M., C. L. George, and J. R. Davies. 1978.

Annual macrofauna production in a *Venus* community. Estuarine Coastal Mar. Sci. 7(3): 215-241.

Total annual production was 25.815 $g/m^2/yr$, mean biomass 45.793 $g/m^2/yr$, giving an overall P/B for the community of 0.56. Annual production of *Venus striatula* was 0.616 $g/m^2/yr$ and mean biomass 1.496 $g/m^2/yr$, giving a P/B ratio of 0.41. Spawning success is variable from year to year; 1969 set was 2.3 $clams/m^2$, 1972 set only 0.8 $clams/m^2$. *Mercenaria mercenaria* is not mentioned. - J.L.M.

1947
Wass, Marvin L. 1965.

Check list of the marine invertebrates of Virginia. Va. Inst. Mar. Sci., Spec. Sci. Rept. 24, 3rd rev., 58 p.

Phylum Mollusca, Class Pelecypoda, Order Eulamellibranchia, Family Veneridae, *Mercenaria mercenaria* (L., 1758). Abundant above 10°/₀₀. - J.L.M.

1948
Wass, M. L. 1967.

Biological and physiological basis of indicator organisms and communities. Section II - Indicators of pollution. In Pollution and Marine Ecology. Theodore A. Olson and Fredrick J. Burgess (eds.). Interscience Pub., New York: 271-283.

Mercenaria (Venus) mercenaria is not mentioned in this chapter nor elsewhere in the book. - J.L.M.

1949
Waters, John F. 1970.

The Sea Farmers. Hastings House, Publishers, New York, 120 p.

This popular account describes aquaculture of fishes, mollusks, and other invertebrates and plants, including hard clam (not mentioned by scientific name, but obviously *Mercenaria mercenaria*). Information was obtained from papers reviewed elsewhere in this bibliography, and from correspondence and discussions with well-known shellfish biologists and administrators. The discussion of hard clam life history is brief, but clear and reasonably accurate. - J.L.M.

1950
Watling, Les, and Don Maurer. 1973.

Guide to the macroscopic estuarine and marine invertebrates of the Delaware Bay region. Del. Bay Rept. Ser. 5. Dennis F. Polis (ed.). Coll. Mar. Stud., Univ. Del., 178 p.

Phylum Mollusca, Class Pelecypoda, Order Eulamellibranchia, Family Veneridae, *Mercenaria mercenaria*. - J.L.M.

1951
Weatherley, A. H., and B. M. G. Cogger. 1977.

Fish culture: Problems and prospects. Science 197(4302): 427-430.

Deals with fishes, not mollusks. Discussion of problems such as lack of an organized summation of the field of knowledge, high operating costs, and others are generally pertinent to shellfish culture. - J.L.M.

1952
Webber, Harold H. 1972.

Invertebrate aquaculture. In Progress in Fishery and Food Science. Remedios W. Moore (ed.). Univ. Washington Pub. Fish., New Ser. 5, Seattle: 191-201.

Except in Japan and the United States little effort has been devoted to culture of clams. *Mercenaria mercenaria* grows well in British waters but apparently does not breed there regularly except in Southampton Harbor. If hard clam is to become a significant crop in England hatchery production of seed is essential. Hard clam culture is much like that developed for oysters, up to the time of metamorphosis and settlement of spat. Thereafter, behavior and substrate preferences are different. Juveniles must be protected up to about 7 to 8 mm diameter from predation by *Carcinus maenas*, which abounds in

British waters. Clams may be grown in submerged, mesh-bottom trays, then transplanted to open bottoms after 1 to 1 1/2 years. They are often harvested after 4 yrs, but may be held longer. What is needed to advance molluscan aquaculture generally is attention from informed generalists, who can pull together isolated bits of information from diverse sources and disciplines to create a productive human enterprise. Because others in the Symposium were to discuss work in Japan and the United States, this author chose to deal primarily with Europe and the far east. - J.L.M.

1953
Webber, Harold H., and Pauline F. Riordan. 1969.

Molluscan mariculture. Proc. Gulf Caribb. Fish. Inst., 21st Ann. Sess.: 177-185.

A general discussion of the subject, with no detailed treatment of any species. - J.L.M.

1954
Weiner, Stephen, and Leroy Hood. 1975.

Soluble protein of the organic matrix of mollusk shells: A potential template for shell formation. Science 190(4218): 987-989.

Much of the soluble protein of the organic matrix of *Mercenaria mercenaria* shell, and that of *Crassostrea* and *Nautilus*, is made up of a repeating sequence of aspartic acid separated by glycine or serine. In *M. mercenaria*, amino acid composition of soluble fraction was 25.60 (mole %) aspartic acid + asparagine, 11.06% serine, and 12.28% glycine, and 83.6% of the protein was in the soluble fraction. Proportions of free amino acids released from the aragonite shell of *M. mercenaria* after 48 hrs of hydrolysis with 0.25M acetic acid at 108°C were: aspartic acid 65.0%, glycine 26.5%, and serine 18.3%. The regularly spaced, negatively charged aspartic acid may function as a template upon which mineralization occurs. - J.L.M.

1955
Weiner, S., H. A. Lowenstam, and L. Hood. 1977.

Discrete molecular weight components of the organic matrices of mollusc shells. J. Exper. Mar. Biol. Ecol. 30(1): 45-51.

Six bivalve species, including *Mercenaria mercenaria*, 3 gastropods, and 1 cephalopod, were used. Protein and polysaccharide are the 2 major constituents of the organic matrix of the shell. Numbers of components, relative migration distances of soluble fractions in gel electrophoresis, and concentrations varied greatly. Discrete molecular weight bands of the soluble fraction of *M. mercenaria*, on amino-acid analysis, accounted for about 10% of total protein. The remaining protein fraction was composed of very high molecular weight components which did not enter the 5% polyacrylamide at the top, and lower molecular weight components which entered the gel and formed a dense background of nondiscrete molecular weight material. - J.L.M.

1956
Weisel, John W. 1975.

Paramyosin segments: Molecular orientation and interactions in invertebrate muscle thick filaments. J. Molec. Biol. 98(4): 675-681.

If paramyosin from red or white adductor muscle of *Mercenaria mercenaria* is digested with carboxypeptidase, chain weight is reduced by about 5,000 daltons. Instead of predominantly PI paracrystals formed by untreated paramyosin, only DIII paracrystals are formed. Compared to DIII paracrystals formed from native *Mercenaria* paramyosin, the lightest bands, regions with the largest number of overlapping molecules, here are reduced in length by 60 A at each end. A 60 A reduction in molecular length agrees well with a 5,000 reduction in molecular weight. These structures are dihedral, thus no conclusions could be made about location of the C-terminus. The molecular arrangement in a DIII paracrystal is too complex to allow further conclusions. The pattern of peptides from CNBr cleavage of carboxypeptidase-treated *Mercenaria* paramyosin differs from the usual pattern in complete loss of 9,000 molecular weight peptide, one of the 7 final products of CNBr digestion, suggesting that this peptide is C-terminal. - J.L.M.

1957
Weisel, John W., and Andrew G. Szent-Gyorgyi. 1975.

The coiled-coil structure: Identity of the two chains of *Mercenaria* paramyosin. J. Molec. Biol. 98(4): 665-673.

The main conclusion is that the two chains of paramyosin from red portion of *Mercenaria mercenaria* adductor muscle are very similar, if not identical. Close similarity or identity of the two chains, and polar paracrystal structures observed by electron microscope, suggest that the two chains of paramyosin are parallel. - J.L.M.

1958
Weller, Christopher, and Kenneth Chew. 1973.

Production of shellfish feed by continuous algal culture. Proc. Natl. Shellf. Assn. 63: 10-11 (abstract).

An apparatus was developed which can produce a sustained daily yield of $2x10^{11}$ cells consisting of 2 to 5 g ash-free dry weight of *Monochrysis lutheri*. This is considerably greater than what could be produced with the same space and effort with traditional batch cultures. This 32-l apparatus produced algal cells with protein content that varied from 7 to 45% of dry weight, which was less orderly than the product of a one-liter continuous culture experiment. The large unit produces enough food for millions of clam larvae, thousands of seed animals, or a few adults. - J.L.M.

1959
Wells, Harry W. 1957.

Abundance of the hard clam *Mercenaria mercenaria* in relation to environmental factors. Ecology 38(1): 123-128.

Chincoteague Bay in Maryland is shallow. Much of the area has a depth of only 2 to 4 feet. Maximum in the channels is 8 feet, except where strong tidal currents have scoured troughs 20 to 40 feet deep. The high evaporation rate produces high salinities in summer, up to 39°/₀₀. Increased rainfall in winter and spring, and a lower evaporation rate, reduce salinities. In June to August 1953, 93 stations were sampled, distributed through 100 square miles in the Maryland region of the Bay. Distribution correlated well with bottom types, with shell, sand, sand-mud, and mud in decreasing order of abundance. Higher densities of clams were also correlated with stronger currents. Numbers of clams were apparently excluded from certain parts by unfavorable low spring salinities and low summer ocean temps. Clams were more abundant in deeper water. Raking is most often used in summer. Areas sampled in 1952 showed a 33% decrease in abundance. An area on the eastern margin is subjected to intense fishing pressures. Here, the clam population declines rapidly when reduced setting reduces replacement of young clams. For the first time, clams were dredged on a large scale in the central part of the Bay during the winter of 1952-53. Here also this reduced the population by about 33%. - J.L.M.

1960
Wells, Harry W. 1957.

Status of the name *Venus*. Ecology 38(1): 160-161.

Two groups once included in the genus *Venus* were sufficiently distinct to have been recognized as subgenera. One has a reduced anterior lateral hinge tooth and contains mostly eastern Atlantic species. The other has no such tooth, and contains the American species. Each group has had a separate path in recent evolution. Reduction of the anterior lateral hinge tooth is a case of convergent evolution, not the last point of an evolutionary line before complete loss of the tooth. The number and position of hinge teeth has been of primary importance in generic classification in the Veneridae. Therefore, this difference calls for generic separation. *Venus verrucosa*, an eastern Atlantic form, is type species for the genus. Therefore, the American species must be given another generic name. The northern quahog was first named *Mercenaria violacea*, but that generic name has been considered only as a generic synonym for *Venus*. Now *Mercenaria* becomes the valid name for the American group. - J.L.M.

1961
Wells, H. W. 1961.

The fauna of oyster beds with special reference to the salinity factor. Ecol. Monogr. 31: 239-266.

The study was made in the Newport River and environs, a North Carolina coastal estuary near Beaufort. *Mercenaria mercenaria* is found in the substrate between oysters or under them. It was found in less than 20% of collections made in this study. Hard clams were found as far upstream as Cross Rock, where mean salinity of 20 observations was 18.98°/₀₀ and individual observations ranged from 0.6 to 35.4°/₀₀. They burrow into the substrate, often in shelly bottoms near oyster beds. Wells comments that this abundance is probably due to the utility of shell as a substrate for setting of larvae. (Abstracter's note: other authors have suggested that presence of shell inhibits predation.) Experiments with *M. mercenaria* 55 to 120 mm long failed to establish a low salinity death point at temps of 25.3-27.5°C. The animal must rely on its store of glycogen for anaerobic respiration while the valves are closed, and the amount in storage determines the length of time that the clam can remain closed. Smaller, young animals usually die first. *Mercenaria* is considered to be among the most tolerant of all estuarine animals to low salinities. But during the low salinity period caused by two hurricanes that passed over the area on 12 and 17 August 1955, many hard clams died, and the death rate, as might be expected, was higher than for oysters. - J.L.M.

1962
Wells, William Firth. 1933.

Method of shellfish culture. Patent no. 1,933,950, Nov. 14, 1933: 139. U.S. Patent Office official Gazette.

In the artificial culture of shellfish, the step which removes bodies substantially larger than the shellfish by centrifuging the culture water before supplying it to the shellfish. In the artificial cultivation of shellfish, the process which introduces the larvae into a confined and isolated body of culture water, from which bodies inimical to larval development have been removed, removing larvae in a mass from the culture water when it has become deficient in developing value, and transferring the mass of larvae to another confined and isolated body of culture water from which bodies inimical to development of larvae have been removed. - J.L.M.

1963
Wells, William Firth. 1969.

Early oyster culture investigations by the New York State Conservation Commission (1920-1926). State of N.Y. Conserv. Dept., Div. Mar. Coastal Resources, 119 p.

This volume contains reprints of 7 articles by W. F. Wells from annual reports of the Commission. They deal with techniques for shellfish culture in hatcheries, purification techniques, artificial collection of seed in nature, and successful propagation of other mollusks, including quahog. Figures of various stages of quahog development are included. Discussion of culture of *Mercenaria mercenaria* is confined to a few brief and general remarks, leaving the impression that routine rearing of hard clam was not yet assured. - J.L.M.

1964
Welsh, John H. 1943.

Acetylcholine level of rat cerebral cortex under conditions of anoxia and hypoglycemia. J. Neurophysiol. 6(5-6): 329-336.

Among several assay methods used was isolated heart preparation of *Venus mercenaria*. *Venus* heart apparently is unaffected by substances other than ACh in tissue suspensions at the great dilutions used. (Abstracter's note: because it is so extremely sensitive to acetylcholine (ACh) *Venus* heart can be used to assay ACh with very dilute extracts and thus reduce to a minimum the possibility of interference by other substances.) - J.L.M.

1965
Welsh, John H. 1948.

IV. Concerning the mode of action of acetylcholine. Bull. Johns Hopkins Hosp. 83: 568-579.

Isolated heart of *Venus mercenaria*, like some other biological preparations, is sometimes excited, sometimes inhibited, by acetylcholine (ACh). Complete stoppage of heart occurs at concentrations about 50 times the threshold concentration for inhibition. This suggests that an enzyme system is involved directly in the action of ACh. *Venus* heart has very little cholinesterase, which accounts for the very slight potentiation of ACh action by anti-cholinesterases. When ethyl radicals are substituted for methyl in the onium group of choline or ACh, activity is lost, and relatively high concentrations are without effect. This directs attention to this portion of the molecule, and the action of quaternary ammonium compounds on *Venus* heart becomes of interest. The pentavalent nitrogen with its 3 methyl groups becomes, in certain respects, the most significant part of the ACh molecule. The rapidity with which ACh in small amounts acts on *Venus* heart suggests that it is acting as a "trigger" to set off a reaction or chain of reactions. The specificity of the $(CH_3)_3N$ group suggests that size and configuration are important. Rapid recovery of heart after washing and rapid blocking action of quaternary ammonium ions other than tetra methyl ammonium, when present with ACh in the medium surrounding the heart, suggest that ACh is acting at or near the surface of the smooth muscle membrane. It is suggested that ACh may play a role in regulation of cellular metabolism and growth. This more general role of ACh could account for its wide distribution in plants and animals. ACh may act as a coenzyme to regulate activity of an enzyme or receptive substance in or near the cell membrane, which alters excitability of the cell. The instability of ACh makes it a possible regulator of a process that must be started and stopped quickly. - J.L.M.

1966
Welsh, John H. 1953.

The occurrence of an excitor amine in the nervous system of *Buccinium* and its action on the heart. Anat. Rec. 117(3): 637-638 (abstract 232).

Regulatory nerves of molluscan hearts, including *Venus mercenaria*, appear to produce opposing mediators. Evidence thus far obtained identified the excitor agent as 5-hydroxytryptamine. - J.L.M.

1967
Welsh, John H. 1953.

Excitation of the heart of *Venus mercenaria*. Arch. Exper. Pathol. Pharmakol. 219: 23-29.

Isolated heart of *Venus mercenaria* is excited by compounds known to be acetylcholine (ACh) antagonists, probably by blocking endogenous ACh. Certain ergot alkaloids excite *Venus* heart in low concentrations and strongly resist washing out. They may be removed from heart tissue with alkaline wash fluid. Adrenalin, noradrenalin, tyramine, and histamine excite at relatively high concentrations. 5-Hydroxytryptamine (5-HT), also known as enteramine or serotonin, excites *Venus* heart at concentrations as low as 10^{-10}M. Electrical stimulation of regulatory nerves to the heart has an effect similar to that produced by applied 5-HT. This suggests that 5-HT may be a normal mediator for excitatory nerves of the heart. - modified author's summary - J.L.M.

1968
Welsh, John H. 1954.

Hydroxytryptamine: A neurohormone in the invertebrates. Fed. Proc., Fed. Am. Socs. Exp. Biol. 13: 162-163 (abstract 539).

5-Hydroxytryptamine (5-HT), also known as serotonin or enteramine, mediates nerve action in certain invertebrates. It excites heart of *Venus mercenaria*, as does stimulation of visceral ganglion following block of cholinergic inhibitor nerves. Agents that block 5-HT also abolish nervous excitation. Paper chromatography and bioassay have identified and measured quantitatively the acetylcholine (ACh) and 5-HT of pooled cerebro-pleural, visceral, and pedal ganglia of *V. mercenaria* and *Busycon*. In *Venus* ganglia the ratio of 5-HT to ACh is about 4:1, in *Busycon canaliculatum* about 1:1. When the neuromuscular blocking agent mytolon is used to block ACh inhibition of *Venus* heart, sensitivity to 5-HT is unaltered. When lysergic acid diethylamide or ergot alkaloids are used to block 5-HT they do not affect the response to ACh. Thus, the antagonistic action of these 2 neurohormones on *Venus* heart is not caused by competition for the same receptor substance. It would appear proper to add 5-HT to the list of chemically known substances produced by nerve cells which act on effectors or other neurons. - J.L.M.

1969
Welsh, John H. 1954.

Marine invertebrate preparations useful in the bioassay of acetylcholine and 5-hydroxytryptamine. Nature 173(4411): 955-956.

It was apparent from a brief survey that hearts of several British marine mollusks may be useful in determining and estimating small amounts of acetylcholine (ACh) and 5-hydroxytryptamine (5-HT), as was already known for *Venus mercenaria*, which is highly sensitive to small amounts of both these substances. More recently it was shown that ganglia of *V. mercenaria* contain 5-HT and ACh, and it is likely that these were the substances present in tissue studied in England. - J.L.M.

1970
Welsh, John H. 1955.

Neurohormones. In The Hormones - Physiology, Chemistry and Applications. Gregory Pincus and Kenneth V. Thimann (eds.). Vol. 3. Academic Press, Inc., New York: 97-151.

This chapter reviews the status of knowledge of regulator substances under the headings: diversity of neurohormones and their distribution; production, transport, storage, and release of neurohormones; and recent advances in understanding modes of action. Observations on isolated heart of *Venus mercenaria* are summarized from the literature. No acetylcholine (ACh) analogue has been found that has a greater physiological activity than ACh itself. The smallest molecular alteration caused a loss of activity, which was not so with other test animals or organs because cholinesterase hydrolysis interfered. *Venus* heart has a very low level of cholinesterase activity, which confers an advantage related to the precise fit between ACh and receptor, which more than offsets the disadvantage of instability. Depending on concentrations present, ACh may be excitatory or inhibitory on *Venus* heart. 5-Hydroxytryptamine (5-HT) has a powerful excitor action on *Venus* heart. At the time of writing few biologists were convinced that 5-HT should be classed as a neurohormone. On *Venus* heart, LSD (lysergic acid diethylamide) acts as an essentially irreversible analogue of 5-HT. It is suggested that the most characteristic physiological feature of neurons is their production and release of substances of high biological activity that integrate bodily functions. The chapter identifies a number of terms and compounds mentioned frequently in papers on physiology and pharmacology of *Mercenaria (Venus) mercenaria*. - J.L.M.

1971
Welsh, John H. 1955.

On the nature and action of coelenterate toxins. Deep Sea Research, Suppl. to vol. 3: 287-297.

The well-known sensitivity of the heart of *Venus mercenaria* to a variety of quaternary ammonium compounds led to exploratory tests of hearts of mollusks native to the area of Friday Harbor, Wash. It was found that heart of *Schizothaerus nuttallii*, horse clam, was sensitive to crude extracts of tentacles of *Metridium* and *Cyanea*. Extracts of *Metridium* and *Physalia* tentacles inhibited the beat of *Venus* heart. - J.L.M.

1972
Welsh, John H. 1956.

Neurohormones of invertebrates. I. Cardio-regulators of *Cyprina* and *Buccinum.* J. Mar. Biol. Assn. U.K. 35(1): 193-201.

Most references to *Venus mercenaria* are citations from papers abstracted elsewhere in this bibliography. Unpublished data include a statement that *V. mercenaria* heart contains 0.1 μg of acetylcholine (ACh) per gram of heart tissue. Inhibition of *Venus* heart by electrical stimulation is caused by release of ACh from endings of cardio-inhibitor neurons which have their cell bodies in the visceral ganglia. *Venus* heart is doubly innervated, the inhibiter nerves releasing an ACh-like substance and excitor nerves a 5-hydroxytryptamine-like (5-HT) substance. - J.L.M.

1973
Welsh, John H. 1957.

Serotonin as a possible neurohumoral agent: Evidence obtained in lower animals. Ann. N.Y. Acad. Sci. 66(3): 618-630.

If acetylcholine (ACh) has 5-hydroxytryptamine (5-HT) as its opposing neurohumor in *Venus mercenaria* it should be possible to find these substances in *Venus* ganglia. There is evidence that 5-HT is a product of cardioregulator nerves in mollusks, where it is an excitor agent. 5-HT also occurs in a variety of non-nervous tissues in lower vertebrates and invertebrates. In mollusks 5-HT relaxes certain noncardiac muscles and appears to be a product of some inhibitor nerves. Heart of *Venus mercenaria* has a pattern of drug action which supports the view that it is normally regulated by 5-HT or a closely related compound. - J.L.M.

1974
Welsh, John H. 1958.

Evidence for 5-HT granules in molluscan ganglia. Anat. Rec. 132: 516 (abstract).

5-Hydroxytryptamine (5-HT, serotonin) appears to be a mediator of nerve impulses in mollusks. It is contained in granules or vesicles in nerve tissue. These compartments are surrounded by a membrane which has properties similar to those of mitochondria. Homogenates of ganglia of *Venus mercenaria* made in 1 molar sucrose (approximately isotonic with the tissue) have low activity when assayed with *Venus* heart. Addition of 10 volumes distilled water to an aliquot of such homogenate increases its activity 4 to 10 times. Freezing and thawing, or treatment with digitonin, increases the activity of a sucrose homogenate. When low-speed supernatant of a molar sucrose homogenate of *Venus* ganglia is again centrifuged at high speed, over 1/2 the 5-HT is found in the small amount of sediment. Further study was planned. - J.L.M.

1975
Welsh, John H. 1961.

Neurohormones of *Mollusca*. Am. Zoologist 1: 267-272.

Neurohormones are substances of high physiological activity produced by nerve cells and released at their axon terminations to act as short-range, brief-duration transmitter agents, or as long-range, long-duration circulatory hormones. The short-range transmitters can be called neurohumors, and the more characteristic hormones neurosecretory substances. Mollusks have neurosecretory systems comparable with those of arthropods and vertebrates, but less is known about their physiological roles. Isolated *Venus* heart can be inhibited by direct electrical stimulation and it recovers soon after the stimulus is stopped. Duration of inhibition is greatly prolonged after heart is treated with an anti-cholinesterase like eserine. Inhibition is quickly abolished when heart is bathed by an appropriate acetylcholine (ACh) antagonist like tetraethylammonium. Mytolon is even more effective. When ACh reacts with acceptor substance in *V. mercenaria* heart the cationic head of the ACh molecule is important. Compounds with carbonyl group in the same relative position to that in ACh are the most active. Sometimes *Venus* heart is excited after inhibition produced by electrical stimulation of visceral ganglion. After an ACh-blocking agent (Mytolon) was applied to heart, only excitation was seen. Synthetic 5-HT excited *Venus* heart in low concentrations in a way that parallelled closely that produced by nerve stimulation after ACh blockade. It was important to know if 5-HT was present in the molluscan nervous system. *Venus* ganglia by chance turned out to be highly favorable material, and it was shown by various methods that 5-HT is present in *Venus* and other molluscan nervous systems. LSD, a derivative of lysergic acid, in trace amounts, excited *Venus* heart in a way similar to that produced by 5-HT. As little as 10^{-16} M LSD will produce a maximal increase in amplitude of beat, which is only partially reversed after prolonged washing. Some closely related lysergic acid derivatives have little or no exciter action but instead are effective 5-HT antagonists. This important review paper describes the status, at time of publication, of work in the U.S. and Europe on molluscan neurohormones. - J.L.M.

1976
Welsh, John H. 1968.

Distribution of serotonin in the nervous system of various animal species. Adv. Pharmacol. 6A(Pt.2): 171-188.

Serotonin has a strange distribution in nature. In plants it occurs in fruits such as bananas and the urticant fluid of stinging nettle. In animals it is present in unusually high concentrations in venoms of social wasps, some spiders and scorpions, and terrestrial and semiterrestrial toads and frogs. It is found in enterochromaffin cells of the intestine in all vertebrate classes and in blood platelets and mast cells of mammals. Presence of 5-HT (5-hydroxytryptamine, serotonin) in nervous systems was unsuspected until the early 1950s. 5-HT-containing neurons in vertebrates and invertebrates can be recognized by their characteristic yellow fluorescence after freeze-drying and reacting with formaldehyde vapor, and can be distinguished from green-fluorescing catecholamine-containing neurons. Ganglia of bivalve mollusks contain the highest levels of 5-HT found so far in any nervous system. It was fortunate coincidence that the first attempt to isolate 5-HT from an invertebrate system used ganglia from *Mercenaria (Venus) mercenaria*. Molluscan ganglia contain enzymes required for synthesis of 5-HT. The 5-HT is stored in membrane-bound vesicles. Many drugs that act on the 5-HT system in mammals have similar action on mollusks. For example, D-lysergic acid diethylamide mimics action of 5-HT on *Mercenaria* heart; methysergide is a highly effective blocking agent; and reserpine releases 5-HT. 5-HT has been found in many other invertebrates, from protozoa to echinoderms and protochordates. - J.L.M.

1977
Welsh, John H. 1971.

Neurohumoral regulation and the pharmacology of a molluscan heart. Comp. Gen. Pharmacol. 2(8): 423-432.

This most interesting paper reviews some major developments during 30 years of research on neurohumoral regulation of heart of *Mercenaria (Venus) mercenaria*. It should be read as an introduction to the relatively voluminous literature on the subject, including research on other mollusks. The intent was to show how complex the regulation of the heart of a relatively primitive animal can be, and also to point out how studies on such a heart may reveal new facts and principles that have application elsewhere. Among these were:

early discovery of 5-hydroxytryptamine (5-HT) in central nervous system of *Venus*; excitatory action of LSD and the extraordinary sensitivity of the heart to this substance; presence of dopamine in primitive nervous systems; innervation of a heart by neurosecretory neurons; and resemblance of the action of neuropeptides that they presumably release to action of 5-HT on heart. - modified author's conclusions - J.L.M.

1978
Welsh, John H. 1972.

Catecholamines in the invertebrates. Chapter 4 in Catecholamines. H. Blaschko and E. Muscholl (eds.), Handbk. Exper. Pharmacol, New Series 33, Springer-Verlag Berlin, Heidelberg, New York: 79-109.

This review chapter cites the work of Sweeney and Greenberg on *Mercenaria mercenaria*. These papers are abstracted elsewhere in this bibliography. *M. mercenaria* contains 22 to 261 µg/g wet tissue of dopamine. Noradrenaline and adrenaline were not detected. Determination was by spectrofluorometry. - J.L.M.

1979
Welsh, John H., and Lois D. W. Arnold. 1973.

The serotonin-like actions of some hallucinogens on a molluscan heart. Bol. Zool. Biol. Mar., Sao Paulo (Nova Ser) 30: 81-86.

Several psychedelic substances representing different classes of hallucinogens mimic the action of serotonin (5-hydroxytryptamine), rather than catecholamines, on isolated hearts of *Mercenaria mercenaria*. Included in this or earlier studies were indole derivatives, indole-containing substances, and phenylethylamine derivatives. - J.L.M.

1980
Welsh, John H., and Jane E. Hyde. 1944.

The distribution of acetylcholine in brains of rats of different ages. J. Neurophysiol. 7(1): 41-49.

Regional distribution of acetylcholine (ACh) in rat brain is related to that of cholinesterase. Resistance of different parts of the mammalian nervous system to anoxia and hypoglycemia may be related to the quantitative distribution of ACh. Extracts were assayed on isolated hearts of *Venus mercenaria* because it is extremely sensitive to small amounts of ACh. Except for the pallium, changes in ACh level of parts of rat brain with age are fairly closely paralleled by changes in respiration, glucose utilization, and glycogen storage. - J.L.M.

1981
Welsh, John H., and Anne C. McCoy. 1957.

Action of d-lysergic acid diethylamide and its 2-bromo derivative on the heart of *Venus mercenaria*. Science 125(3243): 348.

Serotonin (5-hydroxytryptamine) appears to be a normal regulatory neurohumor of *Venus* heart. This heart is extremely sensitive to LSD, which has an excitor action resembling that of serotonin. Unlike serotonin, however, action of LSD is very slowly reversed by washing. Bromo-LSD antagonizes the actions of serotonin and LSD on *Venus* heart. These several actions and interactions appear to parallel rather closely those observed in mammalian nervous systems. - J.L.M.

1982
Welsh, John H., and Merilyn Moorhead. 1959.

The *in vitro* synthesis of 5-hydroxytryptamine from 5-hydroxytryptophan by nervous tissues of two species of mollusks. Gunma J. Med. Sci. 8(3): 211-218.

Ganglia of *Venus mercenaria* contain much more 5-hydroxytryptamine (5-HT) than *Busycon* ganglia. In fact *Venus* ganglia are among the highest in 5-HT of any invertebrate examined. *Venus* ganglia synthesized from added 5-hydroxytryptophan (5-HTP) from 50 to over 250 μg 5-HT/g of tissue in 3 hrs. Evidence was found for a seasonal variation in 5-HTP decarboxylase levels. With blood as an incubation medium, addition of marsilid (1-isonicotinyl-2-isopropyl hydrazide), which was used as an inhibitor of amine oxidase, usually increased slightly the amount of 5-HT found. Pyridoxal phosphate was used in some experiments because it had been shown to be a cofactor for 5-HTP decarboxylase. This compound, for some unknown reason, sometimes increased the amount of 5-HT, but sometimes reduced it. (Abstracter's note: the bibliography to this paper, containing 20 references, was not searched because titles were not given. It is probable that all pertinent papers were located by other means.) - J.L.M.

1983
Welsh, John H., and Merilyn Moorhead. 1959.

Identification and assay of 5-hydroxytryptamine in molluscan tissues by fluorescence method. Science 129(3361): 1491-1492.

Earlier identification of 5-hydroxytryptamine (5-HT, serotonin, enteramine) in nerve tissue of *Venus mercenaria* and *Busycon* has been confirmed. Content of 5-HT in various tissues of *V. mercenaria* ranged from 30 μg/g in pooled ganglia to less than 0.004 μg/g in blood. No tissues other than ganglia had a value as high as 1 μg/g. The rather large spread of values (12-52 μg/g in ganglia) reflected seasonal and individual variations in 5-HT content, and difficulty of freeing the small, fragile *Venus* ganglia of surrounding tissue. Low levels of 5-HT in non-nervous tissues may be derived from nerve endings. Ganglia of *Busycon canaliculatum* contained less than 1/3 as much 5-HT as those of *Venus*. - J.L.M.

1984
Welsh, John H., and Merilyn Moorhead. 1960.

The quantitative distribution of 5-hydroxytryptamine in the invertebrates, especially in their nervous systems. J. Neurochem. 6(2): 146-169.

5-Hydroxytryptamine (5-HT), also known as serotonin or enteramine, is distributed in a variety of cells and tissues of plants and animals. Its unusual distribution, and the probable multiple role of 5-HT, have diverted attention from what may be its most important single function, that of a neurohumor. 5-HT has been found in tissues of many invertebrates, including ganglia of *Venus mercenaria*, in fresh tissue of which the average concentration is 40.0 μg/g. No consistent differences in 5-HT levels of different ganglia of *Venus* were found. Earlier estimates of 5-HT values in *Venus* ganglia were too low, probably because remnants of other tissues were present. The present value of 40 μg/g is one of the highest for any nervous tissue. Equivalent amounts of 5-HT of nervous origin are found only in other bivalves. No organ or part of *Venus* outside the nervous system contained more than 0.75 μg/g (mantle edge), and none was detected in blood. Lower amounts of 5-HT occur in *Venus* nerve than in ganglia, which suggests that it is concentrated in cell bodies or nerve terminals. The 5-HT found in *Venus* heart, mantle, and other non-nervous tissues may derive from nerve endings. More primitive and less specialized invertebrates appear to have more 5-HT in their nervous systems than do more specialized forms. - J.L.M.

1985
Welsh, John H., and Alan G. Slocombe. 1952.

The mechanism of action of acetylcholine on the *Venus* heart. Biol. Bull. 102(1): 48-57.

Large *Venus mercenaria* from Narragansett Bay were used. When heart was stimulated with a train of impulses at 10/sec for 30 sec an inhibition similar to that produced by acetylcholine (ACh) was observed. Stimulation with direct current produced negative intropic, chronotropic, and tonotropic effects when anodal, and positive chronotropic and tonotropic effects when cathodal. This reversibility with changing polarity was interpreted to mean that the step in the regulatory process influenced by electrical stimulation is fundamentally electrical. Chemical response to electrical stimulation was demonstrated by the effect on a receptor heart of fluid which had been perfused from a stimulated donor heart. An electrical response to ACh is shown by changes in the electrocardiograph. These changes were interpreted as changes in conduction velocity of 2 propagated monophasic components of opposite sign. The ACh-blocking agent tetraethylammonium bromide was shown to antagonize anodal effects and augment cathodal effects in clam heart. These interactions between electrical and chemical aspects of beating of *Venus* heart suggested that the ACh system is intimately associated with electrical aspects of excitation. - J.L.M.

1986
Welsh, John H., and Rae Taub. 1948.

The action of choline and related compounds on the heart of *Venus mercenaria*. Biol. Bull. 95(3): 346-353.

Isolated heart of *V. mercenaria* is unusually sensitive to acetylcholine (ACh), in certain respects superior to dorsal muscle of leech, rectus abdominis of frog, isolated frog heart, and blood pressure of cat. Hard clam is usually available in the market. Under refrigeration it remains edible for some weeks, but after 1 to 2 wks the heart beats irregularly. Experimental material, therefore, should be fresh. Shell length of 8 to 12 cm is the most convenient size. The heart is exposed by removing umbo and hinge of shells and cutting away mantle and precardium dorsal to the heart. Threads for attaching to a support in the bath and to a writing lever are passed under the atria and tied close to the ventricle. The ventricle is isolated by cutting atria distal to the threads and cutting blood vessels and intestine. Although only the outer surface of the heart is directly exposed to materials introduced to the batch, cannulation and introduction of ACh into the ventricle does not increase sensitivity. Fluids in the bath must be changed without draining the bath. A bath capacity of 10 ml is appropriate. Seawater is an adequate perfusion fluid, which maintains a regular beat for 2 to 3 days. Artificial seawater made from 30 g NaCl, 0.9 g KCl, 1.1 g $CaCl_2$, and 3.5 g $MgSO_4.3H_2O$ in 1 liter of water, buffered to pH 7-7.5 with phosphate or bicarbonate is satisfactory. Oxygen supply should be gentle to avoid disturbance. Although treatment with an anti-cholinesterase potentiates the action of ACh 2 to 5 times, this is normally undesirable because hard clam heart is so sensitive to ACh and recovery after ACh treatment is slowed by anti-cholinesterase. Hearts which fail to beat or beat with low amplitude can be excited with adrenaline or tyramine, but the effect is abolished quickly by washing. Ergot alkaloids, like ergotoxine, ergotamine, and ergonovine have remarkably persistent excitatory action. *Venus* heart is smooth muscle, with pharmacology not unlike that of some vertebrate smooth muscles. Sensitivity of *Venus* heart is greatest in late winter and spring, but the seasonal change is not great. In late summer the beat tends to be irregular. ACh sometimes, at low concentrations (10^{-11} to 10^{-10} M), induces a small increase in amplitude. At 10^{-9} to 10^{-8} the effect is negative, and at a concentration of about 50 times that which just gives a measurable decrease in amplitude the heart stops in diastole. The log-concentration-response curve is sigmoid. Ten compounds related to choline or ACh were much less effective in inhibiting hard clam heart action than Ach. Triethylcholine chloride and triethylacetyl choline iodide caused no inhibition. - J.L.M.

1987
Welsh, J. H., and R. Taub. 1948.

The action of choline and related compounds on the heart of *Venus mercenaria*. Biol. Bull. 95: 618-630.

Volume 95 of Biol. Bull. has no pages 618-630. A paper of the same title, by the same authors, appears on pages 346-353 of Biol. Bull. Vo. 95. The two were cited in the same paper, but the second reference was either an error, or appeared in another journal. (See p. 220 of Vergleichende Pharmakologie von Ubertragersubstanzen in tierssystematischer Darstellung, by Hans Fischer. <u>In</u> Handbuch der experimentellen Pharmakologie, Band 26, Springer-Verlag Berlin, Heidelberg, New York, 1971.) - J.L.M.

1988
Welsh, J. H., and R. Taub. 1950.

Molecular configuration and biological activity of substances resembling acetylcholine. Science 112(2912): 467-469.

Using isolated heart of *Venus mercenaria* as a test object, it was concluded that an ether oxygen and carbonyl group, spatially disposed as in acetylcholine (ACh), is of special significance in determining the activity of ACh analogues. The exactness of "fit" or "dovetailing" between all parts of the drug molecule and structures in the receptor molecule are important. ACh may play a role as a coenzyme for an enzyme that regulates membrane polarity and permeability. This further evidence of the significance of molecular configuration in the interaction of ACh analogues and receptor substance is not inconsistent with that hypothesis. - J.L.M.

1989
Welsh, John H., and Rae Taub. 1950.

Structure-activity relationships of acetylcholine and quaternary ammonium ions. J. Pharmacol. Exp. Therap. 99(3): 334-342.

The test preparation was isolated heart of *Venus mercenaria*, which has an automatic rhythmicity of beat and an extraordinary sensitivity to acetylcholine (ACh). Threshold sensitivity usually is between 10^{-9} and 10^{-8} M ACh. At 10 to 50 times the threshold dose the heart is stopped in diastole. It was concluded from studies of the actions of quaternary ammonium ions that: 1) at least 2 methyl groups are required for ACh-like activity of such ions on *Venus* heart; 2) quaternary ammonium ions with 3 or 4 alkyl groups other than methyl have an excitatory action, apparently caused by blocking of residual ACh - these ions also reduce the effect of added ACh; 3) at equimolar concentrations, quaternary ammonium ions with the asymmetry of ACh are more active than symmetrical ions; 4) in the alkyltrimethylammonium series the member with a 5-carbon chain most closely approaches the activity of ACh on *Venus* heart; and quaternary ammonium ions with 3 or 4 alkyl groups other than methyl (also triethylacetylcholine) have a reversed ACh-like activity on *Venus* heart and reduce the activity of applied ACh. In the alkyltriethylammonium series, members with an alkyl chain made up of fewer, or more, than 5 carbon atoms had greater blocking activity than amyltriethylammonium ions or triethylacetylcholine. This was not anticipated and is not readily explained. It appears that the shape and size of quaternary ammonium ions, rather than physico-chemical differences such as solubility, determine how closely they approach ACh in their activity. - J.L.M.

1990
Welsh, John H., and Rae Taub. 1951.

The significance of the carbonyl group and ether oxygen in the reaction of acetylcholine with receptor substance. J. Pharmacol. Exp. Ther. 103(1): 62-73.

Many acetylcholine (ACh) analogues have been synthesized and studied pharmacologically, but their relative activities usually have been determined on intact animals or isolated organs rich in cholinesterase. It was thought that an extended series of studies on a single isolated organ with low cholinesterase activity might lead to a better understanding of structure-activity relationships of ACh and at least one type of receptor molecule. Consequently, isolated ventricle of *Venus mercenaria* was selected as an appropriate test object. Preliminary tests by Welsh and Taub (1948), abstracted elsewhere in this bibliography, showed that *Venus* heart was indeed a very sensitive indicator of structural changes in the ACh molecule. In the simplest related substances, quaternary ammonium ions, it was found that a minimum of 2 methyl groups was required for ACh-like activity, and other activities were observed for related compounds. Tests were made with quaternary ammonium derivatives of pentanones, 4-ketoamyltrimethyl ammonium ions, quaternary ammonium derivatives of pentanols, substitution of a methyl or acetoxy group for the ketone oxygen of 4-ketoamyltrimethylammonium halide, reversal of position of the carbonyl group and adjacent oxygen and their distance from the quaternary nitrogen, ethoxycholine bromide, and 3-ketoamyltrimethylammonium iodide. Certain substitutions and changes in position of the carbonyl group produced marked losses in biological activity. It was concluded that a carbonyl group at a maximum distance of 7 A from a quaternary nitrogen is an important linking group with the receptor protein of *Venus* heart. It was suggested that a bond forms between the carbonyl carbon or ketone oxygen and an appropriate group in the protein molecule. - J.L.M.

1991
Welsh, John H., and Rae Taub. 1953.

The action of acetylcholine antagonists on the heart of *Venus mercenaria*. Br. J. Pharmacol. Chemother. 8(3): 327-333.

This paper reports attempts to gain better understanding of structure-activity relationships of acetylcholine (ACh) and one type of "receptor substance" by restricting attention to one suitable, isolated organ, *Venus mercenaria* heart. The hypothesis was that ACh receptor substances may be a family of enzymes for which ACh serves as a coenzyme. Pharmacology of *Venus* heart resembles that of vertebrate autonomic ganglia in many ways, but it differs in some important respects, such as failure of pentamethonium to block ACh on *Venus* heart, whereas mytolon, which has little action at synapses in autonomic ganglia, is the most effective ACh antagonist yet found for this organ. The ACh blocking action of certain substances having 2 carbonyl groups, such as barbiturates and mytolon, suggests that these groups may attach simultaneously to the ACh receptor molecule. This could account for the action of the large group of substances having 2 or more carbonyl groups that are useful as analgesics, hypnotics, and anticonvulsants. - J.L.M.

1992
Welsh, John H., and Betty Twarog. 1960.

Chapter III in Measurement of smooth muscle activity in invertebrate animals. In Methods in Medical Research. H. D. Bruner (ed.). Yearbook Pub., Inc. Chicago, 8: 187-199.

Techniques and methods for using isolated hearts of *Venus mercenaria* as sensitive and selective test objects for bioassay of acetylcholine (ACh) and 5-hydroxytryptamine (5-HT) are given. Techniques for storing and dissecting clams, and details of the assay preparation are described and methods of assay discussed. - J.L.M.

1993
Welsh, J. H., M. Mirolli, and G. A. Cottrell. 1965.

5-Hydroxytryptamine and the action of reserpine on molluscs. XXIII Internatl. Physiol. Congr., Tokyo.

Interlibrary loan reported that the volume requested did not contain the article described. Search terminated. - J.L.M.

1994
Westman, James R., Sr., and Milton H. Bidwell. 1948.

Waste disposal and the fisheries of the salt waters adjacent to the Greater New York Metropolitan area. N.Y. State Conserv. Dept., Bu. Mar. Fish. (unpub.), 6 p., 6 tables, 2 figs.

At the time of writing, water pollution had been responsible for loss of about 1/3 of N.Y. shellfish grounds for food production. At the wholesale level this loss was estimated at $4 million. Only a small portion of the waters of Raritan Bay, Sandy Hook Bay, and Lower New York Bay remain certified for shellfish harvesting. New York waters of this area were very productive of hard clams. For example, a small certified area off Staten Island (illustrated in fig. 1, which was not included in the copy available to us) produced more than 13,000 bushels of clams in 1947. Total hard clam production from N.Y. waters of the Lower New York Bay complex was 985,440 lbs of meats in 1946, 1,056,000 lbs in 1947. Recommendations are made for changes in methods of waste disposal in the area. - J.L.M.

1995
Wheat, Maxwell C., Jr. 1962.

Eelgrass - A controversial link in the chain of life in our marine waters. The Conservationist, N.Y. State Conserv. Dept., Feb.-Mar. 1962: 28-30.

A review of the catastrophic decline of eelgrass beds in the Long Island area in the early 1930s and its gradual return, including some of the efforts to rehabilitate the resource and some problems and beneficial effects of eelgrass to man. Eelgrass as a substrate for setting of clams (species not identified, but certainly including *Mercenaria mercenaria*) is mentioned. Clams are able to move a little on the eelgrass blades, but this consists of climbing up or dropping a short distance on the leaves, later to dig into the bottom. - J.L.M.

1996
Wheeler, Charles L. 1952.

Massachusetts hard and soft clam planting program. 3rd Ann. Conf. on clam research, Boothbay Harbor, Me. U.S. Dept. Interior, Fish Wildl. Serv.: 41-44.

Hard clam plantings have been generally successful. Most of the work is done by the Towns, but the State contributes. - J.L.M.

1997
Wheeler, Charles L. 1955.

Shellfish management in Massachusetts. 5th Ann. Conf. on Clam Research, Boothbay Harbor, Me. U.S. Fish Wildl. Serv.: 30-31.

Assistance is rendered in 2 ways: financial, to the amount of $20,000/yr to aid in elimination of predators and aid municipal propagation projects; and advisory, on request. Approximately 4,000 bu are transplanted each year, closed for fishing for various periods, then opened. - J.L.M.

1998
Whetstone, Jack M., and Arnold G. Eversole. 1978.

Predation on hard clams, *Mercenaria mercenaria*, by mud crabs, *Panopeus herbstii*. Proc. Natl. Shellf. Assn. 68: 42-48.

Decapod crustaceans made up 88.5% of the predators collected. Clam shell bits were in stomachs in 4 species *Panopeus herbstii*, *Callinectes sapidus*, *Menippe mercenari* , and *Eurypanopeus depressus*. Shell bits were found in 15.8% of the 279 *P. herbstii* examined. Shell bits were more often found in larger crabs. Clam mortalities decreased with increasing clam size and with decreasing water temp. Frequency of shell bits in stomachs of *P. herbstii* parallelled clam mortality. Some size selection process appeared to be operating. - J.L.M.

1999
White, J. C., Jr., and J. W. Angelovic. 1965.

Acute radiation LD_{50} values at different times after irradiation for several marine organisms. In Ann. Rept. Bu. Comm. Fish. Radiobiol. Lab., Beaufort, N.C. BCF Circ. 244: 40-42.

According to Templeton et al. (1971), abstracted elsewhere in this bibliography, these authors stated that radiation tolerances must be described as time curves for mean lethal dose rather than the usual $LD_{50/30}$. - J.L.M.

2000
White, John C., Jr., and Joseph W. Angelovic. 1966.

Tolerances of several marine species to Co^{60} irradiation. Chesapeake Sci. 7(1): 36-39.

No original research on *Mercenaria mercenaria* is reported. References to this species are by citation of a paper by Price (1965), abstracted elsewhere in this bibliography. Some reanalysis of Price's data is included, showing that although mean lethal doses (LD_{50}) for *Crassostrea virginica* and *M. mercenaria* were similar at about 30 days, overall radiation tolerances were quite different. For the first 25 days after exposure oyster was much more resistant to radiation than hard clam, but from 25 to 50 days oyster has a much higher mortality. - J.L.M.

2001
White, James T. 1968.

The destruction of clams by sea lettuce. Underwater Nat. 5(1): 27.

The Shrewsbury and Navesink Rivers in N.J. have rich clam beds of *Mya arenaria* and *Mercenaria mercenaria* which have supported a clam industry for a long time. Many acres of clam beds are destroyed in summer by *Ulva lactuca*, which breaks loose and collects in areas where currents are slight. Clams which normally live buried in the bottom were found in summer lying on the surface of the bottom, dead. It was concluded that mats of sea lettuce on the bottom suffocate clams underneath. After sea lettuce dies off in late fall, beds are reseeded by setting of larvae from adjacent beds. The mortality described was soft clams. The inference is that hard clams may also be killed. - J.L.M.

2002
White, K. M. 1937.

Mytilus. Liverpool Mar. Biol. Comm. Mem. 31, 177 p.

Listed in Brown (1950) in bibliography for *Venus mercenaria* with reference to chapter by Pierce, abstracted elsewhere in this bibliography. - J.L.M.

2003
Whitlatch, Robert B. 1977.

Seasonal changes in the community structure of the macrobenthos inhabiting the intertidal sand and mud flats of Barnstable Harbor, Massachusetts. Biol. Bull. 152(2): 275-294.

Although *Mercenaria mercenaria* would be expected to occur in the area, it was not included in the community studied, probably because emphasis was on intertidal benthos and on a sedimentary environment. Deposit-feeders made up over 90% of the organisms sampled. - J.L.M. and M.W.S.

2004
Whitman, Barbara. 1978.

Shellfish survey a success story. Taffrail 3(3): page no. not included in xerox copy supplied by interlibrary loan.

Greenwich Cove, Conn., which has been closed to shellfishing since 1961, was surveyed in 1977. Large numbers of hard clams were found in mud and clay bottom types. Of these, 66% were chowder size, 28% cherrystones, and only 1% littlenecks. The remaining 5% were seed (less than legal size). It is suggested that if the Cove is reopened to shellfishing it should be for recreational use only. The complete report is available for study at the Marine Center. - J.L.M.

2005
Whittaker, Robert H. 1970.

Communities and Ecosystems. MacMillan Co., New York, xi+158 p.

No mention of *Mercenaria (Venus) mercenaria*. - J.L.M.

2006
Whyte, Martin A. 1975.

Time, tide and the cockle. In Growth Rhythms and the History of the Earth's Rotation. G. D. Rosenberg and S. K. Runcorn (eds.). John Wiley & Sons, London: 177-189.

Cerastoderma edule and *C. glaucum*, like *Mercenaria mercenaria*, calcify at night. References to hard clam are by citation of papers abstracted elsewhere in this bibliography. - J.L.M.

2007
Wiederhold, Michael L., and Edward F. MacNichol, Jr. 1970.

Only decreases in illumination elicit spike responses in the siphonal photoreceptor system of the hard-shell clam, *Mercenaria mercenaria*. Biol. Bull. 139(2): 442-443 (abstract).

M. mercenaria responds to dimming of light by retracting the siphon and closing the shell. Presumably this is a protective reflex used to withdraw the siphon when the shadow of a predator passes over. Spike responses were recorded from axons in the siphonal nerve which could bring about this reflex. Only off-responses to light were observed, never responses to onset of illumination. It is suggested that receptor cells probably lie near the surface of the inner siphon wall, which is yellow-pigmented. - J.L.M.

2008
Wiederhold, Michael L., Edward F. MacNichol, Jr., and Allen L. Bell. 1973.

Photoreceptor spike responses in the hardshell clam, *Mercenaria mercenaria*. J. Gen. Physiol. 61(1): 24-55.

Spikes were recorded from single axons of siphonal nerve of hard clam, which respond to dimming of light. No axons responded to onset or increase of illumination. In a dark-adapted state little or no spike activity was seen. The responsive area of a single axon was a circle of approximately 85 μm diam on the inner siphon wall. The number of spikes elicited by the off-phase of constant-duration flashes grows as approximately the 0.4 power of flash intensity. At constant intensity and constant light-time fraction the off-response increases with increasing duration at least up to 500 sec duration. For long durations the response grows as the logarithm of stimulus duration. Subthreshold light can suppress the off-response from preceding illumination. In light-adapted state the off-response is greater and its latency shorter than in dark-adapted state. The fine structure of groups of cell processes believed to compose the photoreceptor is described and illustrated. It is suggested that phototransduction occurs in the fine distal processes of the axons, which contain well-organized pentalaminar whorls which may be the site of photopigment concentration. The action spectrum obtained from integrated responses of nerve bundles appeared to be that of a single Dartnall pigment with maximal absorption at about 510 nm. - modified authors' abstract - J.L.M.

2009
Wieser, Wolfgang. 1960.

Benthic studies in Buzzards Bay. II. The meiofauna. Limnol. Oceanogr. 5(2): 121-137.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

2010
Wijsman, Theodorus C. M. 1977.

Reliability of the enzymatic determination of adenosine phosphates in crude extracts of marine bivalves. Comp. Biochem. Physiol. 58B(3): 313.

Mercenaria mercenaria is not mentioned. - J.L.M.

2011
Wilber, Charles G. 1947.

Urea and uric acid in molluscs. Anat. Rec. 99(4): 111.

Urea in *Venus mercenaria* was surprisingly high, 92 mg/100 cm^3. - J.L.M.

2012
Wilber, Charles G., and E. S. McDonald. 1947.

Iron and ironic compounds in molluscs. Anat. Rec. 99(4): 112.

Venus mercenaria is included. - J.L.M.

2013
Wilbur, Karl M. 1960.

Shell structure and mineralization in molluscs. In Calcification in Biological Systems. Reidar F. Sognnaes (ed.), AAAS Pub. 64, Washington, D.C.: 15-37.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

2014
Wilbur, Karl M. 1964.

Shell formation and regeneration. Chapter 8 in Physiology of Mollusca. Vol. 1. Karl M. Wilbur and C. M. Yonge (eds.). Academic Press, New York: 243-282.

Shell formation in mollusks essentially consists of deposition of crystals of calcium carbonate on an organic matrix which is largely protein (conchiolin). Shell is laid down by mantle. Rate of increase in shell area is a function of increase in mantle area, whereas rate of increase in thickness and weight of shell is a function of rate of secretion of $CaCO_3$ and organic matrix. Shell is formed within a thin layer of fluid (extrapallial fluid) enclosed between mantle and inner shell surface. Two solid phases form from this fluid, organic matrix and crystalline components. In *Crassostrea* and others extrapallial fluid has access to the external medium, but in *M. mercenaria* not. Not much is known about composition of this fluid. In *M. mercenaria* exposure of extrapallial fluid to air for 2 min resulted in a decrease of a few tenths of a pH unit in summer or a slight increase in winter, presumably from uptake or loss of CO_2. In hard clam pH of extrapallial fluid was 7.37 $\pm$ 0.02, of blood 7.52 $\pm$ 0.11 (confidence limits at 95% level). Summer values were approx. 0.4 pH unit higher than winter. Species with aragonite shell, like *M. mercenaria*, have 3 or more protein fractions in extrapallial fluid, as in blood, although migration velocities are not always the same for the 2 fluids. The mechanism by which mantle cells are caused to secrete periodically has not been examined experimentally. Apparently stimuli are received by the shell side of the mantle. A potential of 0.5-2.0 mv is present across the isolated mantle of *M. mercenaria*, the shell side is positive. X-ray diffraction shows that the structure of the organic matrix of regenerated shell differs from that in normal shell in *Crassostrea virginica* but not in *M. mercenaria*. Oyster shell is calcitic, hard clam aragonitic. The normal matrix of hard clam shell is β-keratin, so is regenerated shell. Regenerated shell in oyster is calcite and aragonite, in hard clam only aragonite. The matrix can influence crystal type. Regenerated hard clam shell does not have altered matrix structure or altered crystal type. - J.L.M.

2015
Wilbur, Karl M., and Louise H. Jodrey. 1952.

Studies on shell formation. I. Measurement of the rate of shell formation using Ca^{45}. Biol. Bull. 103: 269-276.

Crassostrea virginica was the experimental animal. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S.

2016
Wilbur, Karl M., and Louise H. Jodrey. 1955.

Studies on shell formation. V. The inhibition of shell formation by carbonic anhydrase inhibitors. Biol. Bull. 108(3): 359-365.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

2017
Wilbur, Karl M., and Gareth Owen. 1964.

Growth. Chapter 7 in Physiology of Mollusca. Vol. 1. Karl M. Wilbur and C. M. Yonge (eds.). Academic Press, New York: 211-242.

Haskin (1954) used percent weight increment against initial size in g to measure relative growth of *V. mercenaria*, because age determination was uncertain. At initial size of about 10 g weight increased about 300% in 1 yr, 25 g about 120%, 50 g about 60%, 100 g about 30%, 150 g about 15%, and 200 g about 10%. Rate of filtration decreases with size increase which means reduced intake of food per unit weight of tissue. Pratt and Campbell (1956) found growth rate was a function of abundance of small diatoms in environment, but such correlation not necessarily meaningful; conditions favorable to production of large blooms may also favor growth of mollusks. Growth of *Venus* is negligible below 10°C. Usually growth rate is a function of temp. Loosanoff (1959) found approximately rectilinear growth for *M. mercenaria* between 18 and 30°C, but in individual experiments the rate decreased with temp increases of a few degrees within the viable range or showed relatively little change. Papers cited are abstracted elsewhere in this bibliography. - J.L.M.

2018
Wilbur, Karl M., and Norimitsu Watabe. 1963.

Experimental studies on calcification in molluscs and the alga *Coccolithus huxleyi*. Ann. N.Y. Acad. Sci. 109(1): 82-112.

Mercenaria mercenaria and other species were held in running water, or in aerated seawater which was renewed frequently. Shell of hard clam is aragonitic. When a hole was bored in the shell the clam did not alter its crystal type in regeneration. - J.L.M. and M.W.S.

2019
Wilbur, Karl M., and C. M. Yonge (eds.). 1964 and 1966.

Physiology of Mollusca. Volumes 1 and 2. Academic Press, New York.

This valuable review should be consulted for details. References to *Mercenaria (Venus) mercenaria* cited in the text have been abstracted and appear elsewhere in this bibliography under the names of authors Morton and Yonge, Newell, Fretter and Graham, Raven, Walne, Wilbur and Owen, Wilbur, Robertson, and Hoyle. These volumes contain also extensive general information on lamellibranchs, much of which can be taken as generally applicable to *Mercenaria*. - J.L.M.

2020
Wilcox, J. Ross, and H. Perry Jeffries. 1974.

Feeding habits of the sand shrimp *Crangon septemspinosa*. Biol. Bull. 146(3): 424-434.

The species of *Crangon* have diverse feeding habits. Among materials found in the digestive tract have been bivalves. In the natural environment, mollusks (species not mentioned) were a minor element in the diet in R.I. waters. In laboratory feeding studies fresh *Mercenaria*, frozen *Artemia*, and hard-boiled egg gave best growth. - J.L.M.

2021
Wildman, Robert D. 1974.

Aquaculture in the National Sea Grant Program. NOAA Tech. Rept. NMFS Circ. 388: 41-56.

At the time of writing about 20% of Sea Grant funds were being spent on aquacultural development. Research on more than 30 species of shellfish, finfish, and algae is described briefly. The appendix contains a list of projects underway. Work on hard clam included use of aggregates, broken shell or rock for protection of seed against predation, efforts to develop pond culture of Japanese littleneck clams in Hawaii, and closed-cycle aquaculture. In the U.S. Virgin Islands nutrient-rich water from a depth of 830 m is used to culture diatoms, mainly *Cyclotella nana*, which are fed to *Crassostrea virginica* and *Mercenaria mercenaria*, giving unusually fast growth. - J.L.M.

2022
Wilhelmi, Raymond W. 1944.

Serological relationships between Mollusca and other invertebrates. Biol. Bull. 87(1): 96-105.

Mercenaria (Venus) mercenaria is not mentioned. From results of precipitin tests on other molluscan species the author concluded that, serologically and developmentally, Mollusca are more closely related to Annelida than to any other group of invertebrates when lipid-free materials are used as antigens. The results suggest that Mollusca evolved from animals which also gave rise to present-day Annelida. - J.L.M. and M.W.S.

2023
Wilkens, Lon A., and Michael J. Greenberg. 1973.

Effects of acetylcholine and 5-hydroxytryptamine and their ionic mechanisms of action on the electrical and mechanical activity of molluscan heart smooth muscle. Comp. Biochem. Physiol. 45(2A): 637-651.

Conclusions were based on experiments with *Modiolus demissus*. *Mercenaria (Venus) mercenaria* is not mentioned except indirectly by reference to papers abstracted elsewhere in this bibliography. - J.L.M. and M.W.S.

2024
Wilkins, N. P. (with comment by Jeffrey Levinton). 1973.

Genetic variation in marine bivalvia (Mollusca). Science 182(4115): 946.

The author criticises a paper by Levinton (1973), abstracted elsewhere in this bibliography, which concluded that the absolute and effective number of alleles at the phosphohexose isomerase and leucine aminopeptidase loci in 6 species of bivalve mollusk from Long Island Sound decreased with depth of burial within the sediment intertidally and with depth of water subtidally. He argues that data available to Levinton were inadequate to support the conclusions drawn. In his reply, Levinton stands by his argument. Among other things he states that *Mercenaria mercenaria* is a very shallow burrower. - J.L.M.

2025
Wilkins, N. P. 1976.

Genic variability in marine bivalvia: implications and applications in molluscan mariculture. 10th European Symposium on Marine Biology, Ostend, Belgium. Vol. I: 549-563.

Changes in allele frequencies or genotype proportions may vary clinally over large geographic areas, e.g., LDH in *Mercenaria mercenaria*. A great deal remains to be done before genetic variability and its implications for mariculture can be understood, but the stabilization of environmental variation which accompanies hatchery production of poikilothermic invertebrates adds a strongly directional element to natural selection. In the long term, a narrower range of genotypes may suffice for optimum fitness under such stabilized conditions. - J.L.M.

2026
Willey, Gordon R. 1949.

Archaeology of the Florida Gulf coast. Smithson. Misc. Coll. 113, xxiii+ 599 p. + 60 pl.

Mercenaria (Venus) mercenaria is mentioned in several places as a fossil. - J.L.M.

2027
Williams, L. W. 1907.

A list of the Rhode Island Copepoda, Phyllopoda, and Ostracoda with new species of Copepoda. Rept. R. I. Commr. Inland Fish. 37: 69-79.

List only. - J.L.M.

2028
Williams, Richard B., and Marianne B. Murdoch. 1970.

A general evaluation of fishery production and trophic structure in estuaries near Beaufort, North Carolina. Ctr. for Estuarine and Menhaden Research, Bu. Comm. Fish., Ann. Rept. to AEC: 178-216 (xerox copy of ms).

This report deals primarily with community and trophic structures and energy exchange rather than with particular species. Its importance to hard clam fisheries lies in its discussion of levels of fishery production in relation to basic productivity and possibilities for increasing sustainable yields from fishery resources by manipulating food webs and shortening the trophic chain by at least one link. (Abstracter's note: this was received 9 Nov 1977 through the SUNY-SB library.) - J.L.M.

2029
Williams, Robert J. 1970.

Freezing tolerance in *Mytilus edulis*. Comp. Biochem. Physiol. 35(1): 145-161.

Mytilus edulis can survive at -10°C, *Venus mercenaria* to -6°C. Both species succumb to freezing injury when 64% of their tissue water has been changed to ice, which supports the hypothesis that freezing injury is caused by removal of a maximum tolerated proportion of cell water, with accompanying reduction in cell volume to a minimum tolerated level, regardless of the absolute concentration or constitution of solutes involved. In *Mytilus* adapted to higher salinity, freezing tolerance increases also. Lower salinity reduces freezing tolerance. About 20% of the water in *Mytilus* was osmotically inactive at freezing temps and salinities studied; the mechanism of binding of this water is not thoroughly understood. A similar mechanism was not seen in *Venus*, in which solutes do not seem to behave differently from those calculated for seawater. - J.L.M.

2030
Wilson, Douglas P. 1958.

Some problems in larval ecology related to the localized distribution of bottom animals. In Perspectives in Marine Biology. A. A. Buzzati-Traverso (ed.). Univ. Calif. Press, Berkeley: 87-103.

Reference to *Venus* in this chapter is to the effect that larvae will live and grow to setting under conditions in which oyster larvae die, attributed to Davis (1953), abstracted elsewhere in this bibliography. In the discussion, V. L. Loosanoff commented on the role of microorganisms in affecting water quality, especially dinoflagellates, so that lamellibranch eggs and larvae do not develop normally. He also remarked that glass containers, especially soft glass, may contain toxic substances that do not leach out in a short time. Washing containers in fresh water that has come through copper pipes, or diluting seawater with such water, also causes problems. - J.L.M.

2031
Wilson, Ronald F., and A. Harry Brenowitz. 1966.

A report on the ecology of Great South Bay and adjacent waters. Rept. to Suffolk County Board of Supervisors, Adelphi Univ., Inst. Mar. Sci., Oakdale, N.Y., v+57 p.

The dominant plant prior to 1931 was *Zostera marina*. Its disappearance in 1931 was accompanied by reduction or total disappearance of one-third of the animal species. *Mercenaria mercenaria* is not mentioned specifically, but it is stated that phytoplankton blooms were accompanied by a decrease in quality and quantity of shellfish. By 1932 99% of the eelgrass had disappeared. Eelgrass was extremely scarce in 1854 and 1894 also, although not nearly as scarce as in 1932. In the last few years (1950s and 1960s ?) eelgrass returned in abundance. In water less than 6 ft deep the average dry weight of grass was about 8 tons/acre. Drifting grass was now a problem. In the period prior to 1931 the same conditions existed, but in those days loose grass drifted onto marshes, where it bothered none, whereas now the marshes have been filled and developed in many places where now stranded eelgrass is considered a nuisance. Oxygen budget and total biological activity in the 1960s showed that the Bay was comparatively healthy and highly productive, with a suggestion of superproductivity, perhaps caused by fertilization. This contrasts with a study of the Carmans River area (Bellport Bay), a grossly disturbed system. Especially from Smith's Point eastward phosphate is high in areas of duck farms. In Aug 1965 high nutrient levels had spread throughout the Bay, coinciding with an algal bloom, probably *Nannochloris*. Such blooms had not occurred in Great South Bay for several yrs prior to 1965. The bloom coincided with general mixing of water of high phosphate throughout the entire Bay system, traced to duck farms. It cleared up in spring 1966. Experiments showed that filtered Bay water inoculated with "small forms" would not support growth of additional numbers, but if as little as 1% of duck wastes were added a bloom developed. - J.L.M.

2032
Winslow, Ron. 1978.

Bay closures stir quahoggers. Upstream, Save the Bay, Inc. Dept. Envir. Mgmt. 2(1): 1-3.

Since January 1978 there have been 12 closures of upper Narragansett Bay to shellfishing. Closures totaled 99 days. The only alternatives to closing: transplanting clams, depuration of clams, or cleaning the Bay. Cleaning the Bay would give us 100% recovery, depuration 100%, and transplanting 40%. - J.L.M.

2033
Winter, Jurgen E. 1977.

Suspension-feeding in lamellibranchiate bivalves, with particular reference to aquaculture. Medio Ambiente 3(1): 48-69.

Refers to the work of Coughlan and Ansell (1964) in which at temp 18-20°C the general allometric equation for *Mercenaria mercenaria* was $F=2.595\ W^{0.73}$ at dry tissue weights ranging from 0.360 to 4.810. Also refers to the work of Tenore and Dunstan (1973) in which assimilation efficiency was 74.7 at 19 to 21°C in *M. mercenaria* with dry tissue weight 0.84 g. This review paper says that the relationships between body size and filtration rate, ration ingested, oxygen consumption, ration assimilated, rate of excretion, and maintenance ration follow the general allometric equation. This makes possible useful predictions for culture of economically important species. - J.L.M.

2034
Winter, Jurgen E. 1978.

A review on the knowledge of suspension-feeding in lamellibranchiate bivalves, with special reference to artificial aquaculture systems. Aquaculture 13: 1-33.

The principles of the mechanism of filter-feeding in suspension feeding bivalves are described, with particular reference to food selection, particle retention efficiency, formation of pseudofaeces, and food concentration. Papers on *Mercenaria mercenaria* by Coughlan and Ansell (1964), and Tenore and Dunstan (1973) are abstracted elsewhere in this bibliography. - J.L.M.

2035
Wise, John P. (ed.). 1974.

The United States Marine Fishery Resource. U.S. Dept. Commerce, NOAA, NMFS, MARMAP Contrib. 1 (for review purposes only). 29B. Clams other than surf clams: 327-333.

Recent landings of hard clam have been about 135 million pounds, live weight, per year, worth $12 million. Hard clam ranges from Canada to Mexico, but most production is from middle Atlantic states. Discussion of biology, exploitation and management, and status of stocks, is too general and brief to provide much specific information. Clam stocks would appear to be particularly susceptible to effective management for maximum sustainable yield, and yields could be increased. Adequate statistics on harvesting effort are needed. - J.L.M.

2036
Wise, John P. 1978.

Food from the Sea: Myth or reality? In Drugs and Food from the Sea: Myth or Reality? Pushkar N. Kaul and Carl J. Sindermann (eds.). University of Oklahoma, Norman: 405-413.

The only well-documented history of aquaculture in the United States is for oysters, and it tends not to support the optimistic predictions often made. For the last quarter century landings of eastern public oysters have been increasing at a moderate rate, while those of eastern private, Pacific, and western oysters, although largely aquacultured, have been decreasing. The reasons are many, but they do not change the fact that a reversal of present and past long-term downward trend of production is not in sight. Aquaculture may not in the short run make large contributions to production of food from the sea. The problems are largely economic. - J.L.M.

2037
Wittenberg, Jonathan B. 1959.

Oxygen transport - a new function proposed for myoglobin. Biol. Bull. 117(2): 402-403.

Marine invertebrates were used. No species is mentioned, but it is possible that *Mercenaria mercenaria* was included. Membranes containing oxyhemoglobin absorbed oxygen 1.6 times as quickly as the same membrane containing carboxyhemoglobin. A new function, oxygen transport, is proposed for myoglobin. Studies were continuing to determine the mechanism. - J.L.M.

2038
Woelke, C. E. 1967.

Measurement of water quality with the Pacific oyster embryo bioassay. In Water Qual. Criteria, ASTM, Spec. Tech. Pub. 416, Am. Soc. Testing Mats.: 112-120.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

2039
Wolfe, Louis. 1972.

Aquaculture. Farming in Water. G. P. Putnam's Sons, New York, 107 p.

This popular account touches briefly on life history and culture of hard clam, not mentioned by scientific name but obviously *Mercenaria mercenaria*. - J.L.M.

2040
Wood, Albert Elmer, and Horace Elmer Wood 2nd. 1927.

A quantitative study of the marine mollusks of Cape May County, New Jersey. Nautilus 41: 8-18.

The study concentrated on Seven Mile Beach, along the Bay side of the spit which forms the northern side of Hereford Inlet, just north and east of Wildwood, N.J. *Venus mercenaria* was found in mud or sandy mud below the intertidal zone, and all the channels. The species was not dominant at any station. On open ocean beaches pelecypods outnumbered gastropods enormously. In the main sounds gastropods were dominant. - J.L.M.

2041
Wood, L., and W. J. Hargis, Jr. 1971.

Transport of bivalve larvae in a tidal estuary. In Fourth European Marine Biology Symposium. D. J. Crisp (ed.). Cambridge Univ. Press: 29-44.

Mercenaria mercenaria is not mentioned. As a matter of interest this is the paper in which the fortuitous occurrence of coal particles from the coal-loading docks at Newport News in plankton samples provided an inanimate tracer against which the behavior of oyster larvae in the James River, Va. could be compared and interpreted. - J.L.M.

2042
Wood, P. C. 1957.

Factors affecting the pollution and self-purification of molluscan shellfish. J. Cons. 22(2): 200-208.

No mention of *Mercenaria (Venus) mercenaria*. *Ostrea edulis* and *Mytilus edulis* were the organisms studied. - W.J.B.

2043
Wood, P. C. 1970.

The principles and methods employed for the sanitary control of molluscan shellfish. In Marine Pollution and Sea Life. Mario Ruivo (ed.) Fishing News (Books) Ltd., London: 560-565.

This paper does not refer directly to *Mercenaria mercenaria*, but the discussion is pertinent to that species. It covers objectives and standards for sanitary control in the United States, Britain, and France. Indicator organisms are discussed, methods of analysis described briefly, and the need for further research is noted. - J.L.M.

2044
Woodburn, K. D. 1957.

Investigation of the hard shell clam *Mercenaria campechiensis* Gmelin, in Collier-Monroe County coastal waters.

Title given, without annotation, in Annotated Bibliography of Unpublished Estuarine Research in the Gulf of Mexico. Philip A. Butler (ed.). Gulf States Mar. Fish. Comm., 1925-1959. New Orleans, 51 p. (1959). In Florida series. - J.L.M.

2045
Woodburn, K. D. 1961.

Operation baby clam in Florida. Fla. State Bd. Conserv., Mar. Lab., Contrib. 58, 9 mimeo p. (Originally mimeo 1 Aug 61, reissued Feb 65.)

Recorded hardshell clam production began in Florida in 1880, reached a peak in 1932 in the area of the Ten Thousand Islands, and dropped to a low at the end of the second world war. The west coast has been by far the largest producer. The decline has been blamed on many things, but causes are not known. Maximum landings in 1932 were about 1.1 million pounds of meats. Recent landings have been much less. On the west coast densest concentrations are found on firm sticky mud with abundant growth of sea grasses. On the east coast production has been from Volusia County northward. Clams grow through the winter in Florida waters and reach marketable size sooner than farther north. Baby clams were shipped by air from Milford, Conn. in plastic bags, chilled, in November 1960. Between 12 and 16 November the clams were planted at several places along the Florida coast in screen-top boxes for protection against predators. At each of six locations about 600 *Mercenaria mercenaria* 1/4 to 1/2 inch long and 2,000 hybrid *M. campechiensis* female x

M. mercenaria male 1/16 to 1/8 inch long were received. Sites were chosen at which salinities would not be likely to drop below 20°/∘∘. Of 8 separate plantings, 3 experiments failed for various reasons and a 4th succeeded only partially. All hybrids in that experiment died by 30 May 1961, but 278 of 600 *M. mercenaria* survived and were 5/16 to 11/16 inches long. At St. Petersburg salinities rarely go below 30°/∘∘ or above 34. By 19 February 1961 hybrids had tripled or quadrupled in size and *M. mercenaria* had doubled. Mortality had been negligible and virtually confined to *M. mercenaria.* Clams were shifted to extra boxes to avoid overcrowding. By mid-June 1961 hybrids had reached maximum lengths of 1 1/4 inch, *M. mercenaria* a max. of 1 3/4 inch. About 25% of the hybrids had survived, but 1/2 of the *M. mercenaria* were lost when the screen was lost and clams were washed out or eaten by predators. Those that survived outside the box were larger than those in boxes. At Sarasota young clams brought earlier from Milford grew about one inch from 1 April to 5 August 1960, when they were killed by fresh water. From November plantings, hybrids grew to max. lengths of 1 1/2 inch and *M. mercenaria* to a max. of 1 1/4 inch by mid-June 1961. Some of these clams were planted on open bottom enclosed with chicken wire, and grew faster than those in boxes. At Sebastian, on the east coast, salinities are somewhat below optimum range for hard clam. Seven days after planting, 50% of the hybrids and 10-15% of the *M. mercenaria* were dead. In the next 7 days no further mortality was seen. By mid-June hybrids had grown to max. length of 1 1/4 inch and *M. mercenaria* to a max. of 1 3/8 inch. At Oak Hill, also on the east coast, by 19 January 1961 hybrids and *M. mercenaria* had about doubled in size. By 15 May 1961, both lots were one inch long. Hybrid survival was about 90% and *M. mercenaria* about 83%. Salinities range from 23 to 32°/∘∘ except during unusually heavy runoff. - J.L.M.

2046
Woodburn, Kenneth D. 1962.

Clams and oysters in Charlotte County and vicinity. Fla. State Bd. Conserv., Mar. Lab., FSBCML 62-12, 29 mimeo p. (originally mimeo 1 Aug 62, reissued Mar 65).

Mercenaria campechiensis was being harvested extensively from productive natural beds along the inside of Gulf of Mexico barrier islands. Recorded production of hardshell clams in Fla. began in 1880, increased significantly in 1908 with exploitation of large beds in Collier and Monroe Counties near the Ten Thousand Islands, grew steadily until the peak year 1932, remained high through most of the second world war, then fell to a low by 1950. Subsequently, production increased modestly, then jumped rapidly in 1962 as intensive harvesting began in Charlotte County and vicinity. The increase was made possible by new markets in the Middle Atlantic states. In Fla., hard clams usually are processed into chowder or canned minced clams. Spawning condition does not affect quality of meats as markedly as it does in oysters, and no closed season is necessary. Hard clams do not tolerate salinities below 20°/∘∘. Large canals draining raw upland and emptying into coastal rivers and bays have increased salinity variations, and have created lower salinities at times of heavy runoff. An extensive survey of 18 major areas found hard clams at only 4, where salinities and substrate were favorable. Clams were most concentrated where firm, sticky mud bottom and seagrass were found. In one part of Gasparilla Sound, which supports one of the best hard clam beds in Fla., large clams were growing at 15 to 20 clams/yd^2. Commercial clam beds most vulnerable to dredging in the intracoastal waterway development were identified. - J.L.M.

2047
Woodburn, Kenneth D. 1963.

Survival and growth of laboratory-reared northern clams *(Mercenaria mercenaria)* and hybrids *(M. mercenaria* X *M. campechiensis)* in Florida waters. Proc. Natl. Shellf. Assn. 52: 31-36.

Recorded hard clam production in Fla. began in 1880, increased significantly in 1908 when large clam beds near the Ten Thousand Islands on the west coast were discovered, peaked in 1932, remained high through most of WW II and plummeted to a low in 1950. Production has increased modestly since then.

Hurricanes, red tides, fresh water, and mechanical harvesting have been blamed for disappearance of clam stocks in the Ten Thousand Islands area, but the cause has not been identified. Densest concentrations of hard clam on the west coast of Fla. are found on firm, sticky mud bottoms with abundance of sea grasses, *Thalassia testudinum* or *Diplanthera wrightii*. Clam growth is not normally interrupted by winter temps as in northern waters. Clams were carried by air from Milford, Conn. and planted in screened boxes. Northern clams were 0.25 to 0.5 in long and hybrids of male *M. campechiensis* and female *M. mercenaria* were 0.0625 to 0.125 in long. At Crystal River, in salinities from 13 to 28°/₀₀, most clams were lost, and results were inconclusive. At St. Petersburg, in salinities between 30 and 34°/₀₀, hybrids quadrupled in size and northern species doubled in size from Nov. 1960 to Feb. 1961. By June 1961 maximum length of hybrids was 1.5 in, northern species 1.75 in. Survival of hybrids was 75%, but about half of the northern species were lost. In Sarasota County northern clams grew about 1 in from Apr. to Aug. 1960, when they were killed by fresh water. By mid-June 1961 hybrids planted in Nov. 1960 had grown to max lengths of 1.5 in and northern clams to max 1.25 in, at salinities of 27 to 31°/₀₀. Clams on open bottom grew faster than those protected in boxes. At Sugarloaf Key northern clams at the end of May 1961 ranged from 0.3 to 0.7 in long, and about half had survived. Hybrids were all lost. At Sebastian in Indian River County 50% of hybrids and 10-15% of northern clams were dead 7 days after planting in Nov. 1960. By mid-June 1961 max length of hybrids was 1.25 in, of northern clams 1.375 in. Salinities were 21 to 29°/₀₀. At Oak Hill in Volusia County, at salinities 23 to 32°/₀₀, except during heavy rains, hybrids and northern clams had nearly doubled in size by mid-Jan. By mid-May 1961 both groups were 1 in long. Mortalities in this area were relatively low. - J.L.M.

2048
Woodwell, George M., Charles F. Wurster, Jr., and Peter A. Isaacson. 1967.

DDT residues in an East Coast estuary: A case of biological concentration of a persistent insecticide. Science 156(3776): 821-823.

Samples of water, plankton, crustacea, bivalve mollusks, insects, saltmarsh plants, fishes, and birds from Carmans River estuary, Long Island, N.Y. were analysed for DDT, DDE, and DDD. Residues of DDT varied from 0.00005 ppm wet weight of whole organism in water to 75.5 ppm in ring-billed gull, *Larus delawarensis*. In general, values were lowest in invertebrates and plants, intermediate in fishes, and highest in birds, but variation was considerable. *Mercenaria mercenaria* had 0.42 ppm in the proportions DDT 71%, DDE 17%, and DDD 12%. - J.L.M.

2049
Wright, Anne McCoy, Merilyn Moorhead, and J. H. Welsh. 1962.

Actions of derivatives of lysergic acid on the heart of *Venus mercenaria*. British J. Pharmacol. Chemother. 18(2): 440-450.

Lysergic acid derivatives showed a wide spectrum of action on isolated heart of *V. mercenaria*. Lysergic acid diethylamide had an exciter effect resembling closely that of 5-hydroxytryptamine (5-HT). Methysergide failed to excite, even at high concentrations, and inhibited the response to 5-HT in a molar ratio of 1:1. Other derivatives were intermediate in their actions. The order of relative activities of lysergic acid derivatives on *Venus* heart was tentative, partly because it was difficult to make repeated tests on a given heart. Even if this were not so, it would be unwise to generalize on the actions of these derivatives on other molluscan hearts, because pharmacology of different classes and families show considerable variation. - J.L.M.

2050
Yagi, N., M. H. Ito, H. Nakajima, T. Izumi, and I. Matsubara. 1977.

Return of myosin heads to thick filaments after muscle contraction. Science 197(4304): 685-687.

This paper deals with *Rana catesbeiana*, but may have a bearing on similar research on muscle activity of hard clam, abstracted elsewhere in this bibliography. Heads of myosin molecules play a major role in producing contractile force of muscle. Heads move to the vicinity of thin filaments to react with actin during contraction. Return to the thick filaments has 2 stages: rapid return of most myosin heads, then slow return of the rest. - J.L.M.

2051
Yentsch, C. S., F. P. White, and W. S. Richardson. 1969.

Is a closed system for growing shellfish a realistic approach? In Proc. Conf. Shellf. Culture, Nassau-Suffolk Regional Marine Resources Council, Hauppauge, N.Y.: 7-10.

The diatom *Phaeodactylum tricornutum* has been fed to adult *Mercenaria mercenaria* in a closed system. The diatom culture had a volume of about 1/2 m^3 and about 450 clams were kept in very crowded conditions in 200 l of sea water. In Florida massive growth of phytoplankton was obtained in one week. A portion of the culture was poured over clams, which fed until water was visually free of algae in 6-10 hrs. Clams were kept with no mortality for 5 mo. Fecal matter was removed periodically, and fresh water was added to regulate salinity. The system was easily managed and could be expanded. It was concluded that the closed system is a realistic approach. - J.L.M.

2052
Yeung, A., and R. W. Cowgill. 1976.

Structural difference between α-paramyosin and β-paramyosin of *Mercenaria mercenaria*. Biochemistry 15(21): 4654-4659.

Previous studies of α-paramyosin have been hampered by very low yields when the protein was extracted by ethanol denaturation. A modification of the procedure for sodium dodecyl sulphate gel electrophoresis permitted separation of α-paramyosin (207,000 daltons) and β-paramyosin (200,000 daltons). - J.L.M. and M.W.S.

2053
Yevich, Paul P., and Marcia M. Berry (sic). 1969.

Ovarian tumors in the quahog *Mercenaria mercenaria*. J. Invert. Pathol. 14(2): 266-267.

Earlier reviews of occurrence of tumors in invertebrates included no reports of tumors in *Mercenaria mercenaria*. In routine histopathologic examination of 1,300 hard clams the authors found 3 cases of neoplasia in ovaries. No unusual gross morphological anomalies were seen. Histology of the tumors is described. In one animal, kidney tissue had been invaded. There was no apparent relationship between incidence of tumors and water quality. (Abstracter's note: the junior author's name is spelled Berry in the original paper, but elsewhere, several times, M. M. Barry appears in association with the name Yevich.) - J.L.M.

2054
Yevich, P. P., and M. M. Barry. 1970.

Histopathologic finding in molluscs exposed to pollutants. Abstract of papers, Session III, Sect. 4, 33rd Ann. Meeting Am. Soc. Limnol. Oceanogr. Univ. R.I., August 25-29.

Abstract not seen. - J.L.M.

2055
Yonge, C. M. 1928.

Feeding mechanisms in the invertebrates. Biol. Rev. 3(1): 21-76.

In this extensive review paper the author cites the conclusion of Colton (1908), abstracted elsewhere in this bibliography, that *Sycotypus* and *Fulgur* (and probably *Nassa* and *Lunatia*) never bore through the shells of lamellibranchs. *Fulgur* seizes the strong shell of *Venus* in the hollow of its foot, brings it against the margin of its own shell, and by contractions of the columellar muscle forces the valves together so that fragments are broken off. The process is repeated until the crack is about 3 mm wide. The proboscis may then be flattened and forced in, or the clam be killed with a secretion, or the shell may be forced open. The extensive bibliography contains 189 references plus mention of 2 other exhaustive bibliographies. - J.L.M. and M.W.S.

2056
Yonge, C. M. 1930.

The crystalline style of the mollusca and a carnivorous habit cannot normally co-exist. Nature 125(3151): 444-445.

Mercenaria (Venus) mercenaria is not mentioned. Development of a carnivorous habit demands, with rare exceptions, presence of an enzyme capable of breaking down flesh of prey into soluble polypeptides and amino acids. The crystalline style of lamellibranchs and many gastropods is formed of protein of a globulin type, which could be digested readily by any extracellular proteoclastic enzyme. It follows that a mollusk cannot normally possess a style and be a carnivore. The point is emphasized by a review of mollusks that have a style. The only extracellular enzyme is that set free by dissolution in the stomach of the head of the style, and that acts exclusively on starch and glycogen. Zooplankton may survive passage through the gut. Minute particles of animal matter may be ingested and digested by wandering phagocytes which pass through the gut wall into the lumen, then back into the tissues. The one exception is in the septibranchs, which have lost the ciliary feeding mechanism and have developed a muscular feeding mechanism which allows them to swallow small dead or dying animal prey. The stomach acts as a crushing gizzard. The small style is apparently functionless. Food is digested intracellularly in tubules of digestive diverticula. - J.L.M.

2057
Yonge, C. M. 1946.

Digestion of animals by lamellibranchs. Nature 157(3996): 729.

Mercenaria (Venus) mercenaria is not mentioned. It had been suggested that living and disintegrating animals in the gut of lamellibranchs are digested by protease secreted by digestive diverticula. The author disagrees. Phagocytic blood cells pass in great numbers into the lumen. They contain proteolytic and lipolytic enzymes, which may be released into stomach fluids when phagocytes cytolize. Presence of animals in the stomach may stimulate migration of phagocytes into the lumen. Extracellular enzymes obviously are not usually present in sufficient quantity to digest the crystalline style. - J.L.M.

2058
Yonge, C. M., and T. E. Thompson. 1976.

Living marine molluscs. William Collins Sons & Co., London, 273 p.

Chapters 15 to 17 contain occasional reference to *Mercenaria mercenaria*, details of which are contained in other papers in this bibliography. - J.L.M.

2059
Yonge, Maurice, and T. E. Thompson. 1978.

Evolutionary systematics of bivalve molluscs. Philosoph. Trans. Roy. Soc. London, B. 284: 199-436, ill. + plates.

We did not find any special mention of *Mercenaria mercenaria* in any paper. Many of the discussions touch upon the evolutionary systematics of *Mercenaria*, however. - M.W.S. and J.L.M.

2060
Yoshino, Timothy, and Thomas C. Cheng. 1976.

Fine structural localization of acid phosphatase in granulocytes of the pelecypod *Mercenaria mercenaria*. Trans. Am. Microsc. Soc. 95(2): 215-220.

Acid phosphatase (EC 3.1.3.2, orthophosphoric monoester phosphohydrolase) activity within electron-opaque, membrane-bound vesicles of *M. mercenaria* granulocytes has been localized. These vesicles now can be considered lysosomes. They presumably function, at least in part, as storage organelles for acid hydrolases, and are therefore analogous to granules in mammalian polymorphonuclear and monocytic leucocytes. Lysosomes containing acid phosphatase are probably the sources of this enzyme, found in cellular and serum fractions of the hemolymph of *M. mercenaria*, although the mechanism for enzyme release remains uncertain. - modified authors' abstract - J.L.M.

2061
Young, David K., Martin A. Buzas, and Martha W. Young. 1976.

Species densities of macrobenthos associated with seagrass: A field experimental study of predation. J. Mar. Res. 34(4): 577-592.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

2062
Young, Stephen D., and Miles A. Crenshaw. 1971.

Synthesis of extrapallial proteins in the clam, *Mercenaria mercenaria*. Am. Zool. 11(4): 655 (abstract).

In whole clam 12% of the ^{3}H-glycine incorporated into protein appeared in extrapallial and other excreted proteins. In isolated mantle only 4% appeared in excreted protein. This demonstrates that a greater proportion of proteins formed by the whole clam are extrapallial and other excreted proteins, than in protein formed by the mantle. Mantle is the main tissue lining the extrapallial space, and it has been assumed that mantle was responsible for extrapallial proteins, and that by this means the mantle may control mineralization of the shell. It is suggested that most extrapallial proteins, perhaps including those involved in mineralization, are synthesized in tissues other than mantle. - J.L.M.

2063
Young, S. D., M. A. Crenshaw, and D. B. King. 1977.

Mantle protein excretion and calcification in the hardshell clam *Mercenaria mercenaria*. I. Protein excretion in the intact clam. Mar. Biol. 41(3): 253-257.

Incorporation of ^{3}H-glycine into, and excretion of, soluble tissue and extrapallial fluid proteins in hard clam were monitored to follow metabolic events that occur antecedent to shell deposition. Most tritium incorporated was in insoluble tissue proteins. Much more was found in the hemocoelic-tissue fluid fraction than in extrapallial fluid. The ratio of ^{3}H-protein to ^{3}H-glycine was greater in extrapallial fluid than in hemocoelic-tissue fluid, suggesting either protein secretion into, or glycine removal from, the extrapallium. Concentrations of ^{3}H-protein and ^{3}H-glycine were higher in mantle fluid than in external sea water, although ratios of ^{3}H-glycine to ^{3}H-protein were not different in the 2 fluids. - from authors' abstract - J.L.M.

2064
Young, S. D., M. A. Crenshaw, and D. B. King. 1977.

Mantle protein excretion and calcification in the hardshell clam *Mercenaria mercenaria*. II. Protein synthesis and excretion by the isolated mantle. Mar. Biol. 41(3): 259-262.

M. mercenaria was used because it was easily available and because information was available on composition of its shell and structure of its mantle. Isolated mantle will continue protein synthesis for at least 20 hrs after excision. The proportion of excreted protein rose steadily, so that at the end of 20 hrs 16.8% of all the ^{3}H-glycine that had been incorporated had been excreted. Excretion of labelled protein from mantle tissue appeared to show a lag of 60 to 70 min from initial application of labelled glycine and its incorporation. Intramantle proteins included insoluble mantle proteins and hemolymph. Excreted proteins included seawater, mantle, and extrapallial proteins. Physiological differences were observed between isolated mantle and whole clam. Protein synthesis by intact mantle must contribute to proteins excreted into extrapallial and mantle fluids. Mantle may be the main source of these proteins and thereby be important in synthesis and regulation of proteins involved in shell-formation processes, in addition to its reported role in Ca regulation. - J.L.M.

2065
Zacks, Sumner I. 1955.

The cytochemistry of the amoebocytes and intestinal epithelium of *Venus mercenaria* (Lamellibranchiata), with remarks on a pigment resembling ceroid. Quart. J. Microsc. Sci. 96(1): 57-71.

Cytoplasm of hard clam amoebocytes contains specific granules, always present, interpreted as being atypical mitochondria. Amoebocytes also contain glycogen and a material that may be a neutral polysaccharide, unsaturated lipid, or mucoprotein. Structures not always present in amoebocytes were sudanophil droplets, neutral red vacuoles, metachromatic granules, and granules of an excretory pigment resembling ceroid. Sudanophil droplets may be stored neutral fat or lipid, associated with the Golgi apparatus. Neutral red vacuoles are not preformed inclusions, but form as dye accumulates within the cells. Metachromatic granules, confined solely to intestinal amoebocytes, consist of phagocytosed intestinal mucus liberated from goblet cells. It is suggested that these cells may be active in digestion and absorption of nutrients, because eosinophil granules, lipid droplets, alkaline phosphatase, lipase, and serum cholinesterase are present. Masses of ceroid-like excretory pigment and goblet cells containing mucus are present between columnar intestinal epithelial cells. The pigment contains phospholipid and apparently arises as an oxidized end-product of lipid metabolism. Occurrence of this ceroid-like pigment in amoebocytes and intestine was unexpected. The pigment appears to be a lipofuscin, closely related to ceroid observed in cirrhotic and vitamin E-deficient animals. The relation of excretory pigment to digestion is suggested by its absence in starved animals. - modified author's summary - J.L.M.

2066
Zacks, Sumner I., and John H. Welsh. 1953.

Cholinesterase and lipase in the amoebocytes, intestinal epithelium and heart muscle of the quahog, *Venus mercenaria*. Biol. Bull. 105(1): 200-211.

Homogenates of whole *Venus mercenaria* heart hydrolyze acetylcholine (ACh) and benzocholine slowly. Enzymatic activity of such homogenates is the sum of that contributed by amoebocytes, intestinal epithelium, and heart muscle. Isolated amoebocytes hydrolyze ACh, and the enzyme responsible is inhibited by 10^{-4}M physostigmine, indicating presence of cholinesterase. Serum cholinesterase and lipase are present in amoebocytes, intestinal epithelium, and heart muscle. Greatest lipase activity is present in amoebocytes and intestinal epithelium. Serum cholinesterase activity is greatest in ventricular muscle. Potentiation of the action of ACh on isolated *Venus* heart by physostigmine is caused by inhibition of serum cholinesterase in amoebocytes and especially in heart muscle. Presence of varying levels of lipase in intestinal epithelium of *Venus* supports the suggested presence of extracellular lipolytic enzymes in certain mollusks. In *Venus* amoebocytes, cholinesterase activity is associated with structures which stain supravitally with Janus green B. The role of serum cholinesterase, in sera or in tissues, is not known. A digestive role might be suspected in *Venus* because the enzyme occurs in amoebocytes and intestinal epithelium. - modified authors' summary. - J.L.M.

2067
Zafiriou, O., K. J. Whittle, and M. Blumer. 1972.

Response of *Asterias vulgaris* to bivalves and bivalve tissue extracts. Mar. Biol. 13(2): 137-145.

Experiments were conducted with *Crassostrea virginica*, *Mytilus edulis*, *Mya arenaria*, and *Venus mercenaria*. There was little variation in response to soluble homogenates of different shellfish species. *A. vulgaris* approached very dilute tissue homogenates; *A. forbesi* did not approach oyster solutions. *Asterias* species distinguished between intact prey and injured tissue. Conversion of normal prey to injured tissue by predation may be a factor in forming feeding aggregations. Considerable variability in behavior of sea stars was noted. Poor flow conditions alone did not explain seemingly contradictory results. - J.L.M.

2068
Zakaria, Sheryl P. 1979.

Depuration - As it relates to the hard shell clam of Narraganset (sic) Bay, Rhode Island. In Proc. Northeast Clam Industries: Management for the Future. Ext. Sea Grant Advisory Program, U. Mass., and MIT Sea Grant Program, SP-112: 109-119.

There is a potential $1.5 million of harvestable quahogs (*Mercenaria mercenaria*) in areas of the Bay presently closed to shellfishing, or open only conditionally. The harvest could be nearly doubled if these areas could be harvested. There has been a steady increase for the past 12 yr in numbers of fishermen licensed, but a decline in total bushels harvested. The decline cannot be attributed to a decline in fishing effort because the amount of closure has been about the same. The total area closed has increased, however. The value per bushel has increased from a low in 1965 of $5.75 in 1965 to a high of \$15.24 (erroneously given as \$114.32) in 1975, an almost threefold increase in value. Depuration would be feasible at any combination of ex-vessel and wholesale prices. However, pollution from heavy metals, petrochemicals, and hydrocarbons is also present, and depuration does not have any effect on these pollutants. Further research is needed on pollutants in Narragansett Bay and their effects on the quahog and on humans. If the problem of heavy metals, hydrocarbons, and other pollutants cannot be solved, investments in alternative methods of preserving the quahog resource, such as a transplant program or aquaculture, should be investigated. - J.L.M.

2069
Zaroogian, Gerald E., Gerald Pesch, and George Morrison. 1969.

Formulation of an artificial sea water media (sic) suitable for oyster larvae development. Am. Zool. 9(4): 1144.

Mercenaria mercenaria is not mentioned, but from the context of the paper in which the reference was found the formulation is satisfactory also for hard clam. It is made up from the following reagent-grade chemicals: NaCl 23.5 g; $MgCl_2.6H_2O$, 5.0 g; Na_2SO_4, 4.0 g; $CaCl_2.2H_2O$, 1.1 g; KCl, 0.7 g; KBr, 0.1 g; H_3BO_3, 0.03 g; $Na_2SiO_3.9H_2O$, 0.02 g; $SrCl_2.6H_2O$, 0.02 g; NaF, 0.003 g; $NaHCO_3$, 0.2 g; EDTA (tetra-Na-salt), 0.001 g. Dissolve in one liter of water. If needed adjust pH to 8.0 with concentrated solutions of reagent-grade $NaHCO_3$ in distilled water, and bring salinity to 22°/₀₀ (or desired salinity) with distilled water. Fertilized eggs of *Crassostrea virginica* developed identically with others in natural seawater at the same salinity, pH, and temp. Additional trace elements were not essential for normal development, and in presence of EDTA vitamin mixtures were unnecessary. Presence of a product such as EDTA, capable of interaction with inorganic elements of the formulation, is essential for normal development of larvae. - J.L.M.

2070
Zink, Robert M. 1953.

Certain aspects of the ecology of *Venus* and *Mya* at Morgan Bay and at Bunganuc, Maine. Rept. State Geologist, Augusta, Me. 1951-1952: 71-115, 8 maps.

V. mercenaria and *M. arenaria* can live in the same general area, but each lives in a different type of sediment. At Morgan Bay commercial quantities of *Venus* live in a large expanse of homogeneous, soupy, clayey silt, but only a few *Mya* near high tide in a pebbly sand containing boulders and cobbles. At Bunganuc both species are in commercial quantities, although *Venus* is more abundant. *Venus* live in all the different types of littoral sediment, but *Mya* live at high tide and only in homogeneous blue marine clay, with or without a thin covering of soupy, clayey silt. Many *Venus* at Bunganuc live in a concentration known as the "seedbed". Overcrowding causes stunting, and many die in winter because they are not fully buried, and are unprotected against extreme low temps. Most mortality occurs on bottom ridges rather than in depressions. *Venus* appeared to be able to live in a more acid sediment than *Mya*. Winter digging increases mortality in the seedbed because jarring tears frozen tissues and more clams are exposed to freezing. Winter mortality of *Venus* can be reduced by transplanting to areas where they are protected by a layer of water. This also increases growth. The two areas are different geologically. - J.L.M.

2071
Zinn, Donald J. 1971.

The impacts of oil on the east coast. Trans. N. Am. Wildl. Conf. 36: 188-206.

The West Falmouth, Mass. oil spill of Sept 1969 produced pollution of the sea bottom which was still spreading 10 months later. It presently covered at least 5,000 acres of bottom offshore and 500 acres of marshes and tidal rivers. Oil was incorporated into subtidal sediments down to 42 feet of water. Bacterial degradation was slow and still negligible in the most heavily polluted areas. More rapid degradation in less affected areas was being reversed by influx of oil from more polluted regions. Kill of bottom plants and animals reduced the stability of marshland and sea bottom, leading to increased erosion and perhaps spread of bottom pollution. In the most polluted areas the kill of animals was almost total, while outside the affected area bottom fauna were normal and healthy. Oil was incorporated into quahogs and other shell- and finfishes. The area had to be closed to shell-fishing. The 1970 shellfish crop was as heavily contaminated as in 1969, and the area closed would have to be extended. All crude oils, and all except highly purified oil products, are toxic to all marine organisms. In addition to outright mortality, oils reduce resistance of marine animals to stress and may cause reproductive failure. Precise estimates of economic losses to the clam and other shellfish industries were not possible. - J.L.M.

2072
Zinn, Donald J. 1973.

Quahog - queen of the mudflats. Maritimes, Nov. 1973: 4-7.

A popular article. Gives distribution, the reason for the name, and the various common names used along the coast. The environment is usually just subtidal or near the lower limit of the intertidal area, and in water of reduced salinity, which keeps down populations of predators. The various methods of harvesting are described. Rakers and tongers have argued that dredgers damage the bottom, but the evidence does not support this. Laws limiting the take of resident amateurs, placing a minimum size on clams, and prohibiting taking of clams from polluted areas, are enforced. Oil is detrimental to hard clam and causes mortality. Quahogs from areas polluted by domestic sewage can be purified by transplanting to clean areas. Anatomy of the quahog is reviewed. The current of water through the clam is strongest at about 22°C and stops at below 5°C when a sort of hibernation occurs. Spawning occurs when water temp rises to about 21°C and an individual may spawn more than one time during the season. By the third summer it matures to legal size. Two species may be mistaken for the hard clam, *M. M. notata*, which has zigzag lines on the shell and lacks the purple border, and *Pitar morrhuana*, which is smaller, the inside of the shell is bluish and never has a purple spot, and has a bitter taste. Recipes are included for stuffed clams and Manhattan clam chowder. - J.L.M.

2073
ZoBell, Claude E., and Catharine B. Feltham. 1937-8.

Bacteria as food for certain marine invertebrates. J. Mar. Research 1(4): 312-327.

Mercenaria (Venus) mercenaria is not mentioned. - M.W.S.

2074
Zoellner, David R. 1977.

Water quality and molluscan shellfish: An overview of the problems and the nature of appropriate federal laws. U.S. Dept. Commerce, NOAA, Natl. Mar. Fish. Serv., Washington, D.C., x+106 p., appendices A to D.

The report reviews in general problems of the United States shellfish industry. Appendix A includes case studies of Great South Bay, N.Y., Raritan Bay and the New Jersey coast, and Virginia, which have a bearing on the hard clam industry. (Abstracter's note: this was part of a study, popularly called the Baughmann study, called for under the Coastal Zone Management Act Amendments of 1976 (PL94-370), to review all aspects of the shellfish industry to determine if additional regulations should be imposed upon that industry by the Food and Drug Administration.) - J.L.M.

2075
Zs-Nagy, Imre. 1977.

On the validity of enzymatic assay of adenosine phosphates in crude extracts of some marine bivalves. Comp. Biochem. Physiol. 56B(3): 271-272.

Mercenaria (Venus) mercenaria is not mentioned. - J.L.M.

2076
Zs-Nagy, I., S. K. Rozsa, J. Salanki, I. Foldes, L. Perenyi, and M. Demeter. 1965.

Subcellular localization of 5-hydroxytryptamine in the central nervous system of lamellibranchiates. J. Neurochem. 12(4): 245-251.

Deals with freshwater mussels, genus *Anodonta*. *Mercenaria (Venus) mercenaria* is not mentioned. - M.W.S. and J.L.M.

2077
Zuraw, E. A., D. E. Leone, and W. T. Sommers. 1969.

Ecology of bivalve mollusks and the culture of *Mya arenaria*. General Dynamics, Elect. Boat Div., Groton, Conn., 1 Sept. 1969 99 p. + 16 p. appendix.

Of 7 species of relatively abundant bivalves in Green Hill Pond, R.I., only *Mercenaria mercenaria* remained relatively constant in abundance over a 3-year period. Juveniles were found principally in channel regions where maximum water interchange takes place with Charlestown Pond (which in turn connects with the sea). *Mercenaria* survives best in sand, and can be called mud-intolerant, but substrate alone is not an important factor limiting bivalve distributions. *Gemma* was found in 82% of samples containing *Mercenaria*. Other bivalves found with *Mercenaria* were not found frequently enough to demonstrate definite relationships. In traps containing various substrate types *Mercenaria* most frequently colonized those containing sand. *Mercenaria* were not found in traps at a depth of 2 feet, although all other species were. The authors believed that the most important ecological factors determining bivalve distributions are water circulation, mode of breeding, mode of feeding, and larval behavior. *Mercenaria* were found only in regions of greatest water movement. This species is a suspension feeder. Salinities in the section of the Pond inhabited by hard clam apparently were usually 25.5°/oo or greater. - J.L.M.

Addendum

2078
Abelson, Philip H. 1956.

Paleobiochemistry. Sci. Am. 195(1): 83-92.

Mercenaria mercenaria has been common for more than 25 million yrs, and its fossil shells appear identical with their modern counterparts. It was possible to study the content of protein and amino acids in the shells of living clams, and in clams one thousand, 500 thousand, and 25 million years old. Laminated sheets of protein in modern clam shells are colorless and have some mechanical strength. Amino acids found in this protein are typical of amino acids found in other animals. Some 15 were actually identified. The thousand yr old shell was aged by the carbon-14 method, and had been buried in moist soil. Its protein content was undiminished and its amino acids were identical with those of the modern specimen. However, the sheets of protein had turned brown and had lost all mechanical strength. The 500,000 yr old shell, which because of the uncertainty of the dating method may have been as young as 100,000 yrs or as old as a million yrs, contained no protein at all. In place of the protein was a black, tarlike substance. The amino acid content of the shell had diminished to about one-tenth of that of the modern shell. About half of the amino acid was in the form of peptide chains consisting of two or more amino acids. Only individual amino acids remained in the 25 million yr old shell. Where the modern shell contains the usual protein building blocks, the ancient specimen consists predominantly of alanine, glutamic acid, glycine, isoleucine, proline, and valine. The sequence of steps in the decay of protein seems clear. Water penetrates the shell and reacts with the protein so that it breaks down into peptide chains and individual amino acids. These smaller molecules are more soluble in water, and some of them may drain out of the shell. Of the amino acids that remain in the shell, some (such as serine, threonine, and tyrosine) are unstable and tend to break down more rapidly. After a few million years they will tend to vanish altogether. This explains why older fossils contain the same unusual assortment of amino acids. Originally they all contained proteins composed of the same amino acids we find in proteins today, but only the stable amino acids have survived. Is it possible that these specimens are contaminated? We find similar amino acids in fossils of the same species collected from many different formations, which strongly supports the assumption that the amino acids were there during the whole life of the animal. Certain amino acids are adsorbed on calcium carbonate precipitated in the laboratory. Aspartic acid and glutamic acid tend to be adsorbed on such a precipitate, others are not. The fossil material is composed of calcium carbonate, and if amino acids had been adsorbed in water from the ground, we would expect to find an abundance of aspartic and glutamic acids, but we do not. By laboratory tests it can be demonstrated that at 450°C it took only about a second for alanine in water to decrease by 63%, but at room temp alanine could last for billions of yrs. The most stable amino acids are alanine, glutamic acid, glycine, isoleucine, proline, and valine, and the least stable were arginine, aspartic acid, lysine, phenylalanine, serine, threonine, and tyrosine. Thus laboratory studies confirm the findings in fossils. - J.L.M.

2079
Abelson, Philip H. 1959.

Geochemistry of organic substances. In Researches in Geochemistry. Philip H. Abelson (ed.). John Wiley & Sons, Inc., New York: 79-103.

The protein myosin is involved in combination with ATP. In *Mercenaria mercenaria* scars on the shell show the points of muscle attachment, and these are preserved in fossils. The shape of the shell of 25 million yr old clams is identical with those of today, including the muscle scar. It seems quite likely that the old clams had musculature exactly like that of modern species and that the conventional myosin-ATP system was employed. The amino acids in *M. mercenaria* shells are described exactly as in Abelson's 1963 chapter, abstracted in this bibliography. - J.L.M.

2080
Abelson, Philip H. 1963.

Geochemistry of amino acids. In Organic Geochemistry. Irving A. Breger (ed.). Earth Sci. Ser. Monogr. 16. Macmillan Co., New York: 431-455.

Mercenaria mercenaria is represented by fossil specimens dating back at least 25 million years. Comparison of recent and older specimens showed that marked changes had occurred in fossil proteins (e.g., specimens from the Pleistocene thought to be in the range of 100,000 to 1 million years old). Total amino acid content of Pleistocene shells was only 18% of that found in recent shells. When Miocene shells (25 million yrs old) were examined, amino acids were found, but no traces of proteins or peptides. Initially most protein of the shell is evidently present in water-insoluble layers. For thousands of yrs only moderate changes occur, which do not affect solubility of protein. By the time 1 to 5% of the peptide bonds are broken (10,000 to 100,000 yrs) protein fragments are much more soluble and some can be leached out of the shell. Some of the amino acids or peptides are probably entrapped in the aragonite structure. Eventually, in the presence of water, these peptide bonds are broken, leaving only free amino acids in the shell.

Amino acid content of *M. mercenaria* in µM/gram

Age	Protein bound	Soluble protein or peptide	Free
Recent	33.0	1.50	0.35
Pleistocene	2.1	2.25	1.00
Miocene	0	0	0.75

- J.L.M.

2081
Andrews, Jay D. 1980.

A review of introductions of exotic oysters and biological planning for new importations. Mar. Fish. Rev. 42(12): 1-11.

Mercenaria mercenaria was imported early to the west coast, along with *Mya arenaria* and *Crassostrea virginica*. Although *Mya arenaria* was successful, the oyster and hard clam were not, which necessitated continued importations to produce crops. *M. arenaria* was able to breed at low temps but the other two were not. They can be reared on the west coast if hatchery seed is used.

- J.L.M.

2082
Anonymous. 1980.

Poaching fine hikes cut contaminated clam catch. Natl. Fisherman 61(4): 60.

A clam poacher can easily make $200 to $300 a night by clamming in illegal waters. If caught, he probably would receive only a $25 to $50 fine. The New York State Department of Environmental Conservation is proposing legislation which would provide a maximum $1,500 fine and impound clam poachers boats to use them as evidence. The minimum fine would be $500 and a second offense might cost $1,000. - J.L.M.

2083
Arimoto, Richard, and M. R. Tripp. 1977.

Characterization of a bacterial agglutinin in the hemolymph of the hard clam, *Mercenaria mercenaria*. J. Invert. Pathol. 30(3): 406-413.

Hemolymph of the hard clam was found to agglutinate nonspecifically 4 of 30 bacteria tested and a marine alga. The agglutinin is a protein (or a conjugated protein) because it is: 1) precipitated by trichloracetic acid and ammonium sulfate; 2) inactivated by extraction with chloroform, but not with toluene or xylene; and 3) inactivated by chymotrypsin and protease, but not by deoxyribonuclease. Electrophoretic analysis shows that the agglutinin is composed of subunits each with a molecular weight of approximately 21,000. Calcium ions are required for the activity of agglutinin and contribute to heat stability of the molecule. Several saccharides, which may constitute a portion of the bacterial agglutinin receptors, were able to partially inhibit agglutination. In vitro studies using clam hemocytes showed that the phagocytosis of a marine bacterium, designated as RS-005, was enhanced by the presence of hemolymph. Adsorption of hemolymph samples with RS-005 bacteria removed the agglutinin activity for all types of cell tested and also abolished the opsonic effect. Further information on the roles of these substances in vivo is needed to clarify their biological significance. - modified authors' abstract - J.L.M.

2084
Avault, James W., Jr. 1980.

Aquaculture. Chapter 16 in Fisheries Management. Robert T. Lackey and Larry A. Nielsen (eds.). John Wiley & Sons, New York: 379-411.

Hard clam or quahog *(Mercenaria mercenaria)* is found along the Atlantic coast of the United States from Maine to Florida in the intertidal zone to water as deep as 15 meters. Hard clam can be farmed using procedures similar to those used for oysters. They do not require cultch on which to settle. Crushed stone or gravel can be placed on the bottom, so that clams are safe from predatory crabs and fish. Clams can be dredged, or harvested with hoes and hand labor. Clam culture is not widespread. - J.L.M.

2085
Ayres, David C., and Gary R. W. Denton. 1975.

On the diversity of products obtained during synthesis of polychlorobiphenyls by the Van Roosmalen procedure. Bull. Envir. Contam. Toxicol. 14(3): 361-369.

Polychlorobiphenyls were required for in vivo toxicity testing with the hard clam *Mercenaria mercenaria*, and the importance of pure substrates for this work has already been stressed. - J.L.M.

2086
Ayres, P. A. 1978.

Shellfish purification in installations using UV light. Gt. Britain Min. Agric. Food Fish., Dir. Fish. Res. Lab., Leaflet 43: 1-20.

Detailed reference to *Mercenaria mercenaria* unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

2087
Bagshaw, Clive R., and John Kendrick-Jones. 1980.

Identification of the divalent metal ion binding domain of myosin regulatory light chains using spin-labelling techniques. J. Mol. Biol. 140(3): 411-433.

By the criterion of their primary structure myosin regulatory light chains belong to the "calcium binding protein" family and are thought to contain domains related to the E-F hand structure found in parvalbumin. However, the presence of deletions and non-conservative substitutions in the regulatory light chains indicates that, of the four domains apparent in their structure, only the first is competent to bind Ca^{++} or other divalent metal ions. Electron paramagnetic resonance studies were performed in an attempt to provide experimental verification of this hypothesis. The approach is based on the finding that the paramagnetic Mn^{++} ion substitutes for Ca^{++} at the divalent metal ion site and that different regulatory light-chain isotypes contain cysteine residues in different domains which may be spin-labelled with a nitroxide derivative. The electron spin interaction between these two paramagnetic centers is a function of the distance of their separation. Clam *(Mercenaria mercenaria)* regulatory light chain contains a single cysteine residue located near the first domain and, when spin-labelled, the intensity of the nitroxide signal is reduced by 25% on binding one mole of Mn^{++}. Rabbit skeletal regulatory light chain contains two cysteine residues located in the third and fourth domains and no (<5%) interaction is observed when Mn^{++} binds to spin-labelled derivatives. Qualitatively, these results suggest that domain 1 is the most likely candidate for the Mn^{++} binding site. A more quantitative evaluation using the Leigh theory for the dipolar coupling between rigid-lattice electron spins and various models for the regulatory light chain tertiary structure, including that predicted by Kretsinger and Barry for the possibly isologous troponin C structure, substantiates this conclusion. - authors' abstract. - J.L.M.

2088
Burrier, Dale. 1975.

The depth of burial in different sediment types of the hard shell clam *Mercenaria mercenaria* in the Babylon area of Great South Bay. Research paper completed at State University of New York, Potsdam (unpublished).

Depth of burial is in part related to the nature of bottom sediments. *M. mercenaria* burrows deeper in poorly sorted, very fine-grained sands with a high silt and clay fraction (mud) than in well-sorted fine-grained sands with little or no silt and clay (sand). Depth of burial is a function of compactness of sediment. In mud, clams were found as deep as 21 cm; in sand, only to 9 cm. Larger clams do not burrow as deeply as smaller. Turbidity and salinity apparently have little influence. - J.L.M.

2089
Butera, Jay. 1980.

The great quahog war: Narragansett Bay wardens step up attack on polluted-clam trafficking. Natl. Fisherman 61(6): 43-45.

Although many parts of Narragansett Bay are closed to hard clamming *(Mercenaria mercenaria)* some quahoggers do not obey. There is money in illegal clamming and the clammers point out that people are not getting sick from eating the illegal clams. They operate mostly at night, with high powered vessels, and employ various devices to avoid being caught. By degrees, the enforcement people are gaining on them, however, and are beginning to confiscate boats, and recently succeeded in having one man sent to prison as well. But a gambling man with a good boat can take in as much as $500 for an hour of good digging, while an honest man in legal waters may work all day to make $30 to $300. Enforcement agents are afraid of typhoid, dysentery and infectious hepatitis, but there has not been a reported case since 1963. The R.I. Shellfishermen's Association has been trying to roll back restrictions, but the problem varies with the weather, and a safety factor must be built into the regulations. One method of handling the problem is to transplant quahogs from closed to open areas for depuration, but this is inefficient and not always 100% effective. Another way is to build a depuration plant, but this is opposed by many fishermen who believe that this also would create other problems. Meanwhile, some people continue to make fortunes, even though the war has been going on since the 1950s. - J.L.M.

2090
Carmichael, N. G., K. S. Squibb, D. W. Engel, and B. A. Fowler. 1980.

Metals in the molluscan kidney: uptake and subcellular distribution of ^{109}Cd, ^{54}Mn and ^{65}Zn by the clam, *Mercenaria mercenaria*. Comp. Biochem. Physiol. 65A(2): 203-206.

The kidney plays a major role in bioaccumulation of trace metals in *M. mercenaria*. Cadmium was concentrated to the greatest extent by the kidney, while manganese and zinc, essential trace elements, were more evenly distributed among other organs. Zinc was also concentrated in the kidney, although to a much lesser degree and at a level not markedly different from gill tissue. Subcellular fractionation of the kidney showed that

34.3% of the ^{54}Mn, 5.6% of the ^{65}Zn, and 1.3% of the ^{109}Cd had been incorporated into mineral concretions present in kidney cells. Gel permeation chromatography of renal cytosol fractions showed the isotopes to be bound to macromolecules with molecular weight of approximately 60,000, 12,000, and 7,500. - J.L.M.

2091
Chandler, R. A. 1965.

Shoal-water relaying of ocean quahogs before canning. Fish. Res. Bd. Canada, Manuscript report, Atl. Biol. Sta. 1017, 11 p.

Fisheries Research Board could not locate. Search terminated. - J.L.M.

2092
Chantler, Peter D., and Andrew G. Szent-Gyorgyi. 1978.

Spectroscopic studies on invertebrate myosins and light chains. Biochemistry 17(25): 5440-5448.

Myosin was isolated from 14 invertebrate muscles, including *Mercenaria mercenaria*, all of which exhibited myosin-linked regulation: 9 of these muscles solely exhibited this form of regulation. None of these myosins showed any change in tryptophan (Trp) or tyrosine (Tyr) fluorescence upon addition of Ca^{2+} in the presence or absence of MgATP, and all myosins showed either a small or zero Trp fluorescence change upon addition of MgATP in the presence or absence of calcium. Thus a conformationally sensitive Trp, such as that present in rabbit myosin, is not a necessary requirement for the myosin ATPase. Several light chains were modified with the fluorophore N-iodoacetyl-N'-(1-sulfo-5-naphthyl)ethylenediamine and each modified light chain was added back to 0°C-desensitized scallop myosin, and the fluorescence and fluorescence polarization were examined. No change in these parameters occurred upon addition of MgATP and/or calcium. Circular dichroism (CD) spectra of scallop myosin and desensitized scallop myosin showed no change upon addition of MgATP and/or calcium. Similarly, no change was observed in the electron spin resonance spectra of scallop myosin or myofibrils using 0°C-desensitized preparations that had been resensitized with spin-label-modified light chains. CD studies on isolated regulatory light chains reveal a low affinity divalent-cation-dependent transition [for the scallop regulatory light chain, pK=3 7±0.1(Ca^{2+}); 3.1±0.1(Mg^{2+})] monitored at 220 nm, while an analogous change in the rabbit 5, 5'-dithiobis(2-nitrobenzoic acid) light chain has a pK of 5.1±0.2. These results are discussed in light of the fact that the above techniques indicate large conformational changes when applied to other calcium-binding proteins such as troponin C and parvalbumin. It is concluded that the calcium switch in regulatory myosins is of a more subtle nature. - modified authors' abstract - J.L.M.

2093
Chantler, P. D., and A. G. Szent-Gyorgyi. 1978.

Reversible dissociation of both regulatory light chains from scallop. Biophys. J. 21, Muscle proteins II: 45a (abstract M-PM-E9).

EDTA treatment at 30°C removes both regulatory light chains completely from *Placopecten magellanicus* (>90%) and extensively (>75%) from *Aequipecten irradians*. Myofibrils free of regulatory light chains fully retain their K^+-EDTA and Ca^{++}-activated ATPase (10mM $CaCl_2$). Their actin activated ATPase has no calcium sensitivity and the activity in the presence of 0.1mM $CaCl_2$ is reduced by about 60%. Regulatory light chains readily rebind in stoichiometric amounts and restore the actin activated ATPase and the Ca sensitivity. Ca binding is proportional to light chain content. Regulatory light chains of *Mercenaria mercenaria* can fully substitute for scallop light chains. - J.L.M.

2094
Cheng, Thomas C. 1967.

Marine Molluscs as Hosts for Symbioses. With a review of known parasites of commercially important species. In Advances in Marine Biology, Vol. 5, Sir Frederick S. Russell (ed.). Academic Press, London and New York, xiii + 424 p.

Vogel (1933) reported that a German became infected with the intestinal trematode *Himasthla muehlensi* after eating several raw "littlenecks" *(Mercenaria mercenaria)* on the half-shell in New York. Recently Cheng and Burton (1965) demonstrated that the nematode *Angiostrongylus cantonensis* can develop to the infective third-stage larva in *M. mercenaria*, which, since it is commonly eaten raw, could serve as a potential transmitter. The plasma of several species of pelecypod, including the hard clam, will induce encystment of cercaria of *Himasthla quissetensis*. It is believed that in nature, once the cercariae succeed in penetrating one of these mollusks, contact with plasma in the open circulatory system induces encystment and the cercaria develops into a metacercaria. The decarboxylation product taurine has been identified in almost all marine mollusks examined, including *M. mercenaria* (Allen 1961). *Himasthla quissetensis* of the Class Trematoda has been found in *M. mercenaria*. *Himasthla muehlensi* was described from a human who had eaten raw hard clams in New York, and later, on returning to Germany, complained of gastrointestinal disturbances. It had not been found yet in *M. mercenaria* in America. It is uncertain whether it is distinct from *H. quissetensis*. Tissues of *M. mercenaria* surrounding *H. quissetensis* cysts undergo chemical change. Among these changes is accumulation of short-chained fatty acids, provisionally identified as butyric acid among others. It was postulated that if sufficient numbers of clams which include toxic short-chained fatty acids in their tissues are ingested, gastrointestinal disturbances could occur. *Angiostrongylus cantonensis* is a nematode, a metastrongylid lungworm of rats. It is not a natural parasite of salt-water clams, but Cheng and Burton (1965) showed that young quahogs can be infected experimentally. The snail *Odostomia impressa* will not feed on *Mercenaria*, a few may crawl on the clam but do not stay. *Odostomia bistularis* will become attached to *M. mercenaria* but is not likely to be an important parasite. *Odostomia seminuda* also will become attached to *M. mercenaria* according to Boss and Merrill (1965). *Myticola porrecta* of the Class Crustacea has been found in *M. mercenaria* in the intestine (Humes 1954). *Myocheres major* was found in mantle cavity of *M. mercenaria* by Williams (1907) and Pearse (1947). *Ostrincola gracilis* was found by Humes (1953) in mantle cavity of hard clam from Barataria Bay, La. *Neopanope texana*, a crab, preys upon young *M. mercenaria* according to Landers (1954). - J.L.M.

2095
Cheng, T. C. 1976

The role of lysosomal enzymes in molluscan immunity. Cdn. Fed. Biol. Soc., 19th Ann. Meeting: 158 (abstract 630).

Cytoplasmic granules of hard clam, *Mercenaria mercenaria*, are lysosomes. A number of lysosomal enzymes from several species of mollusk have been identified and characterized. These include lysozyme, acid and alkaline phosphatases, β-glucuronidase, lipase, and aminopeptidase. When whole hemolymph is challenged with bacteria *in vitro* and *in vivo*, the levels of activity of all the lysosomal enzymes studied are elevated within phagocytes; however, only certain ones are released from cells into serum. It is concluded that those which are released can act upon susceptible bacteria extracellulary. - modified author's abstract - J.L.M.

2096
Cheng, Thomas C. 1976.

Humoral immunity in molluscs. In Proc. First International Colloquium on Invert. Pathol. and IXth Ann. Meeting, Soc. Invert. Pathol. Printing Dept., Queens Univ.: 190-194.

In *Mercenaria mercenaria* the cytoplasmic granules of granulocytes are not secondary phagosomes but true lysosomes. These deposit their enzymes into phagosomes formed during phagocytosis and effect the degradation of enclosed nonself materials. β-glucuronidase, acid phosphatase, alkaline phosphatase, lipase, and lysozyme are associated with the cellular and the serum components of the hemolymph of *M. mercenaria*. Lysozyme is released from cells into serum during phagocytosis of *Bacillus megaterium* by *M. mercenaria* cells. There are elevations in lipase and lysozyme levels in cells and serum of *M. mercenaria* challenged with *B. megaterium*. This is interpreted to mean that upon suitable challenge there is hypersynthesis of at least certain lysosomal enzymes, for example, lipase and lysozyme, within actively phagocytosing cells, and these enzymes are released in to serum where, at least theoretically, they can act on susceptible nonself materials. Preliminary experiments indicate that the released enzymes in serum do enhance inhibition and lysis of certain microorganisms. Thus, the serum lysosomal enzymes may be considered as induced humoral factors, although they are non-specific. - J.L.M.

2097
Chipman, W. A. 1958.

Accumulation of radioactive materials by fishery organisms. Gulf Caribb. Fish. Inst., Univ. Miami, Proc. 11: 97-110.

Detailed reference to *Mercenaria mercenaria* unlikely. Search terminated.

2098
Chipman, W. A. 1960.

Biological aspects of disposal of radioactive wastes in marine environments. IAEA, Vienna.

Unable to locate. Search terminated. - J.L.M.

2099
Clark, G. R., II. 1977.

Seasonal growth variations in bivalve shells and some applications in archeology. N. Am. Paleontol. Conv. II, J. Paleontol. 51, Pt. III of III, Suppl. to No. 2: 7 (abstract 25).

Shells of *Mercenaria mercenaria* collected alive at St. Catherine's Island, Georgia, were examined in thin section and found to exhibit several kinds of seasonal growth variation. Shell characteristics affected included surface relief (ledging), surface texture, disturbance lines, spacing of fine growth lines, transparency and patterns of transparency, crystal size, crystal orientation and extinction patterns, and offsetting of boundaries between shell layers. Some of these variations were found in all specimens, while others appeared at random or seemed restricted to particular growth stages. By making collections at different times of year, it was possible to determine the season at which the changes took place, even though the environmental stimuli are not yet established. Shells of *M. mercenaria* were also collected from human occupation sites (shell middens) and associated (?) burial mounds. Comparison of growth variations noted in thin sections of these shells with seasonal variations noted in recent shells has established, in most cases, the probable season of occupation of the sites. - modified author's abstract - J.L.M.

2100
Clarke, John R. 1978.

The effect of high pressure on the rhythmicity of bivalve hearts. Comp. Biochem. Physiol. 60A(2): 151-160.

Mercenaria mercenaria hearts, quiescent in diastole, responded to 34 atmospheric pressure changes with transient chronotropic excitations lasting for 35 to 80 seconds. In a hard clam heart which did beat spontaneously, beat amplitude was reduced 50% by 34 atmospheres, and 80% by 68 atmospheres. At 136 atmospheres a reversible quiescence was induced. Preliminary studies on *M. mercenaria* suggest a much greater inhibitory effect of pressure on this species than on two subspecies of *Modiolus demissus*. - J.L.M.

2101
Cooley, L. B. 1978.

Evidence for the phosphorylation of paramyosin. Biophys. J. 21(3), Muscle proteins IV: 141a (abstract TU-POS-F11).

Paramyosin isolated from *Mercenaria mercenaria* appears to contain bound inorganic phosphate which is involved in intermolecular interactions. Three to four phosphates per molecule have been found in native paramyosin. Dialyzing paramyosin against 0.01N KOH at 4°C for 24 hrs appears to remove one or more phosphates. Partial dephosphorylation may explain the change in solubility of alkali-treated paramyosin and the slight change in the near ultraviolet circular dichroism of alkali treated paramyosin. In addition, partial dephosphorylation may occur during the titrations of paramyosin, explaining why the forward and reverse titrations at high ionic strength are not the same. No change in molecular weight, length, or percent α-helicity was found in alkali treated paramyosin. - modified author's abstract - J.L.M.

2102
Cooley, L. B., and S. Krause. 1979.

The unusual minimum in solubility of paramyosin as the ionic strength is varied at pH 7.00. Biophys. J. 25(2), Part 2, Muscle proteins: 246a (abstract T-PM-Po82).

Native and partially degraded paramyosin from *Mercenaria mercenaria* exhibited a solubility minimum at pH 7.00 in the ionic strength range 0.05M to 0.07M. At higher and at lower ionic strengths the solubility increased. This is in sharp contrast to the behavior exhibited by most proteins. In general, a protein is insoluble in distilled water and its solubility increases as the ionic strength increases until a maximum in solubility is reached. At higher ionic strengths the protein is salted out. Alkali treatment which resulted in partial dephosphorylation of paramyosin affected the solubility at ionic strengths above 0.05 M, but not at lower ionic strengths. An explanation is suggested based on charge interactions between paramyosin molecules. The model is supported by the results of pH titrations at ionic strengths below and above the ionic strength of the solubility minimum. - modifed from abstract - J.L.M.

2103
Cooley, Linda B., William H. Johnson, and Sonja Krause. 1979.

Phosphorylation of paramyosin and its possible role in the catch mechanism. J. Biol. Chem. 254(7): 2195-2198.

Recent developments indicate that paramyosin may be located on the surface of thick filaments and that some thick filaments are surrounded by other thick filaments instead of by thin filaments. Paramyosin molecules on one thick filament may be able to interact with paramyosin molecules on other thick filaments, locking the muscle in the contracted state. It has been shown that solutions of α-R-paramyosin will form paracrystals which are essentially side by side aggregates of smaller paracrystals. The solubility of paramyosin and therefore certain paramyosin-paramyosin interactions are affected by the extent of phosphorylation of paramyosin. Thus, the phosphorylation of paramyosin may be involved in paramyosin aggregation in vivo and therefore in the catch mechanism. An increase in the degree of phosphorylation could result in an increase in the aggregation between paramyosin molecules and an increase in interactions between paramyosin contained in adjacent thick filaments and, therefore, in passive tension maintenance. Dephosphorylation could result in a decrease in interactions between filaments, and therefore in muscle relaxation. - from authors' discussion. - J.L.M.

2104
Cordes, Deborah A., and Robert W. Cowgill. 1979.

Extensive carboxypeptidase digestion of clam α-paramyosin. The effect on the size and solubility of the residual protein. Biochim. Biophys. Acta 577(2): 410-414, BBA 38150.

The paper provides further evidence that the C-terminal third of the α-paramyosin molecule is the portion responsible for the low solubility of α-paramyosin at neutral pH and low ionic strength. This was accomplished by digesting from the C-terminal end with carboxypeptidases A and B in 2M urea at pH 8.5. The solubility increased as molecular weight decreased until a stable segment two-thirds of the size of the molecule remained. - modified authors' summary - J.L.M.

2105
Crenshaw, M. A. 1970.

(The soluble matrix from *Mercenaria mercenaria* shell?) Akad. Wiss. Lit. Mainz, Abh. Math.-Naturwiss. Kl: (abstract).

This is probably an abstract of the paper that appeared in the same journal in 1972. Since no title was included, search terminated. - J.L.M.

2106
Cunningham, Patricia A. 1979.

The use of bivalve molluscs in heavy metal pollution research. In Marine Pollution: Functional Responses. Winona B. Vernberg, Frederick P. Thurberg, Anthony Calabrese, and F. John Vernberg (eds.). Academic Press, New York: 183-221.

Bivalves have several characteristics which make them attractive research models to study pollution: 1) they inhabit estuarine and coastal areas most susceptible to pollution; 2) they are sessile and cannot migrate away, and therefore must adjust or perish; 3) they live relatively long; 4) many are broadly distributed geographically and can be used as indicators of widespread pollution; and 5) they are easy to collect and usually of high density. Effects of heavy metals on *Mercenaria mercenaria* embryos showed that hard clam was less sensitive to $AgNO_3$ and $Pb(NO_3)_2$, equally sensitive to $HgCl_2$, and more sensitive to $ZnCl_2$ and $NiCl_2$ than *Crassostrea virginica* embryos. Embryos of both species were sensitive to five metals in the following order: Hg>Ag>Zn>Ni>Pb. These LC_{50} experiments at constant temp and salinity do not provide criteria for absolute toxicity of metals in the natural environment, but they are useful in comparing relative toxicities of some metals to embryonic stages. For larvae of *M. mercenaria* LC_{50} concentrations of $HgCl_2$ (0.015 ppm Hg), $AgNO_3$ (0.032 ppm Ag), $CuCl_2$ (0.016 ppm Cu), $NiCl_2$ (5.7 ppm Ni), and $ZnCl_2$ (0.195 ppm Zn) retarded shell growth to 69, 66, 52, 0, and 62% of control growth, respectively. Ni retarded shell growth completely at 5.7 ppm, and even at the LC_5 concentration (1.1 ppm Ni) growth was only 32% of control. Ni appeared to be the least toxic metal tested, yet it had the greatest inhibitory effect on growth. Also Ni-exposed clam larvae were abnormal, with tissues extruding from shells, although swimming apparently was normal. On respiration and heart rate, oxygen consumption in *M. mercenaria* increased as Ag concentration increased in adults from 0 to 1.0 ppm. Maximum pumping rate of hard clam occurred about 25°C, and below this temp pumping rate decreased until temp reached 7.6°C, at which time pumping ceased. *M. mercenaria* were exposed to 0.1, 1.0, and 10.0 ppm Hg (as mercuric chloride) for 6 days and then the mantle tissue was excised. Ultrastructural appearance of mantle epithelial cells exposed to 0.1 ppm Hg was indistinguishable from that of controls, but clams exposed to higher concentrations showed increasing numbers of dense cytosomes. X-ray microanalysis showed presence of high Fe concentrations in relation to Hg (Fe:Hg=1:0.06) within the cytosomes. This was one mechanism by which these cellular components protected other more sensitive organelles (i.e., mitochondria) from metal toxicity, allowing the mollusc to accumulate metals rapidly without showing increased mortality. For a complete discussion of the subject the original paper should be read. This abstract discusses only direct references to *M. mercenaria*. - J.L.M.

2107
Deaton, L. E., and M. J. Greenberg. 1978.

Systematic distribution of the ionic dependence of the action potentials of bivalve hearts. Am. Zool. 18(3): 641 (abstract 408).

The action potential (AP) of the bivalve heart has been shown to depend primarily on Na in *Mercenaria mercenaria*, of the Subclass Heterodonta. They examined 25 freshwater and Atlantic and Gulf of Mexico coasts species belonging to the Subclasses Pteriomorphia, Heterodonta, and Paleoheterodonta to determine correlations between ionic dependence of the AP and Subclass. Ventricles from all Heterodont and Paleoheterodont tested beat in Ca-free but not Na-free seawater (SW). The data suggest that the APs of pteriomorph hearts are dependent primarily on Ca and those of heterodont and paleoheterodont hearts depend on Na. - modified authors' abstract. - J.L.M.

2108
Deaton, Lewis E., and Michael J. Greenberg. 1980.

The ionic dependence on the cardiac action potential in bivalve molluscs: systematic distribution. Comp. Biochem. Physiol. 67A(1): 155-161.

Mercenaria mercenaria hearts are insensitive to ouabain but stop beating immediately in Li seawater. The sodium channels in *M. mercenaria* hearts (and those of other venerid species) may be much less permeable to Li than the Na channels of other bivalve hearts. Oysters and mussels belong to the bivalve subclass Pteriomorphia. Isolated ventricles from these species beat in Na-free seawater, but in Ca-free seawater all electrical and mechanical activity ceases, although in *C. gigas* and *G. demissa* modified action potentials can continue. The clams *Macrocallista nimbosa, Mercenaria mercenaria*, and *Spisula solidissima* have ventricles that beat in Ca-free seawater but not in Na-free seawater. The results of this study suggest that this difference has a systematic correlation. - J.L.M.

2109
DiGirolamo, Rudolph, John Liston, and J. Matches. 1977.

Ionic bonding, the mechanism of viral uptake by shellfish mucus. Applied Envir. Microbiol. 33(1): 19-25.

The process involves attachment of viruses to mucus secreted, and then ingested, by *Mercenaria mercenaria* and other bivalves during feeding. Analysis of the mucus-virus bond indicated that attachment of virus to mucus is primarily ionic and involves binding of viral particles to sulfate radicals on the mucopolysaccharide moiety of shellfish mucus. - modified authors' abstract. - J.L.M.

2110
Dugas, Ronald J. 1980.

A status report on commercial clamming efforts in Louisiana. La. Dept. Wildl. Fish., Contr. Mar. Research Lab. - 1978. Mar. Research Lab., Grand Terre Island, La., Tech. Bull. 31: 23-32.

Following a brief review of pertinent aspects of the biology of *Mercenaria* sp. there follows a review of exploratory fishing results for *M. campechensis*. The area covered Breton and Chandeleur Sounds. There were significant and harvestable populations of chowder size *M. campechiensis* east of the Mississippi River, but there is no real demand for these large quahogs. The rapid growth rate in the south makes littlenecks and cherrystones available to harvesters for a relatively short time, and the presence of large clams probably inhibits development of large numbers of young. Managerial recommendations include a number of alternatives including the advisability of designating public and private grounds, considerations of limited entry and quotas, and a variety of other options. - J.L.M.

2111
Duke, Thomas W. 1967.

Possible routes of zinc 65 from an experimental estuarine environment to man. J. Water Pollut. Control Fed. 39(4): 536-542.

A concrete-walled pond 30 x 60 m, adjoining the estuary surrounding Pivers Island, N.C., was used as the experimental environment. Less than one percent of the zinc 65 introduced into the water was accumulated by seafood organisms. Among several organisms in the pond were 20 *Mercenaria mercenaria* weighing 4.6 x 10^3 grams. Scallops, oysters, and clams are eaten by man and they accumulated zinc 65 more rapidly and to higher levels than the other organisms tested. Oysters and hard clams contained more zinc 65 in edible tissues than did scallops. If all organisms from the pond were eaten by man over a long period of time, he could have accumulated more zinc 65 from clams than other organisms because edible portions of the clams had the highest specific activity. These results cannot be extrapolated to include the possible movement of zinc 65 in an estuary under different conditions of pH, temp, salinity, and different rates of exchange of water. As these conditions vary, so would the movement of zinc 65. - J.L.M.

2112
Dykens, J. A., and C. P. Mangum. 1979.

The design of cardiac muscle and the mode of metabolism in molluscs. Comp. Biochem. Physiol. 62A(3): 549-554.

The structure of the squid cardiac myofiber differs fundamentally from that of lamellibranchs, most notably in mitochondrial and tubule density. Compared with *Mercenaria mercenaria*, *Lolliguncula brevis* shows 252 beats/min at 20°C compared with 10 for *M. mercenaria*, mitochondrial density (% cross-sectional area) 50 to 80 compared with 5 to 20, and the heart muscle obliquely striated compared with smooth. This information suggests that a critical event in the evolution of the highly aerobic metabolism and great swimming speed of decapod cephalopods, in which the oxygen-carrying capacity of the blood is not especially high, was the replacement of a lamellibranch type of cardiac myofiber with that found in the squid. - J.L.M.

2113
Edwards, Harold H., William H. Johnson, and Jacqueline P. Merrick. 1977.

Comparison of solubility properties of α-paramyosin, β-paramyosin, and acid-extracted paramyosin. Biochem. 16(10): 2255-2260.

We have found that acid-extracted paramyosin is very similar if not identical to α-paramyosin, but that acid and α forms differ considerably from β- and γ-paramyosin. β-paramyosin precipitates abruptly from solution in a narrow zone of pH below neutrality, and increases in ionic strength shift the zone of precipitation toward lower pH values. In contrast, acid and α-paramyosin show gradual aggregation with changing pH at lower ionic strength (<0.3) but sharp transitions similar to β-paramyosin at higher ionic strength (>0.3). Transitions were also found at lower pH (ca 4.0) which were not mirror images of transitions at higher pH (ca 7.0). Viscosity measurements show that acid-extracted paramyosin is close in behavior to a native extract obtained by extraction in mild, nondenaturing media containing mixed antibiotics. Each of these extracts differed considerably from β-paramyosin. Mild, nonhydrolytic procedures employed by others to remove small, noncovalent bonded components or to separate protein complexes were not effective in converting α- to β-paramyosin. Comparison of extraction procedures strongly supports the suggestion of Stafford and Yphantis (1972) that β- and γ-paramyosin are hydrolytic products of α-paramyosin and that the proteases responsible may be of bacterial origin. - modified authors' abstract. - J.L.M.

2114
Elliott, Ellen J. 1979.

Cholinergic response in the heart of the clam *Mercenaria mercenaria:* Activation by *Conus californicus* venom component. J. Comp. Physiol. 129(1): 61-66.

The spontaneously beating heart of *M. mercenaria* is inhibited by an extract from the venom of the marine snail *C. californicus*. This inhibition is antagonized by benzoquinonium, tetraethylammonium, phenyltrimethylammonium, and methylxylocholine, all of which antagonize cholinergic inhibition of *Mercenaria* heart, and is not blocked by d-tubocurarine, hexamethonium, atropine, or α-bungarotoxin. In addition, cholinergic inhibition of *Mercenaria* heart is mimicked by arecoline, blocked by methylxylocholine and phenyltrimethylammonium, and not significantly affected by hexamethonium or α-bungarotoxin. It is proposed that the *Conus* venom agent inhibits *Mercenaria* heart by activation of the cholinergic response of the heart. It is also concluded that the cholinergic response in *Mercenaria* heart is pharmacologically identical to the slow, potassium-mediated hyperpolarizing cholinergic response found on *Aplysia* neurons. - modified author's summary - J.L.M.

2115
Elliott, Ellen J. 1980.

Three types of acetylcholine response in bivalve heart muscle cells. J. Physiol. 300: 283-302.

Acetylcholine (ACh) responses of cardiac muscle cells from 3 species of bivalve, *Mercenaria mercenaria, Mytilus edulis*, and *Crassostrea virginica*, were studied by intracellular recording and ACh ionophoresis. Heart muscle contraction was abolished by bathing in artificial seawater in which Mn^{2+} had been substituted for Ca^{2+}. A slow hyperpolarization was observed in the clam, a rapid depolarization which was sometimes followed by a slower hyperpolarization in the mussel, and a biphasic response consisting of a rapid depolarization and slower hyperpolarization in the oyster. All responses were accompanied by an increase in membrane conductance, as measured by passing constant current pulses with an extracellular suction electrode. The hyperpolarizing response was blocked most effectively by methylxylocholine and not very effectively by tubocurarine or hexamethonium. The hyperpolarizing response was not altered by Cl^--free or Na^+-free seawater, but was affected by changes in external K^+. The rate of change of the inversion potential of this response with change in $(K^+)_o$ was 59 mV per tenfold concentration change. The 3 types of ACh response seen in bivalve heart muscles were similar with respect to time course, pharmacological sensitivity, and ionic mechanism to the 3 types of ACh response described in *Aplysia* central neurones. Analogies also can be drawn with vertebrate ACh responses. - modifield author's summary - J.L.M.

2116
Elliott, Ellen J., and Michael A. Raftery. 1979.

Venom of marine snail *Conus californicus*: Biochemical studies of a cholinomimetic component. Toxicon 17(3): 259-268.

The component responsible for cholinomimetic effects of the fractionated venom of *C. californicus* on *Mercenaria mercenaria* heart has not yet been identified. Its structure will be of particular interest to and may prove useful in, the study of the type of ACh response found in *Mercenaria* heart elicited by the *Conus* cholinomimetic. This type of ACh response is not effectively blocked by curare or atropine and in general does not correspond pharmacologically to any of the cholinergic responses found in vertebrates. The cholinomimetic is a low molecular weight, positively charged alkaloid compound. Its role in the venom of *C. californicus* is not known. It may simply be a metabolite, or it is possible that, as a small, positively charged molecule, it functions in intracellular osmoregulation and ion balance. - J.L.M.

2117
Elner, Robert W. 1980.

The influence of temperature, sex and chela size in the foraging strategy of the shore crab, *Carcinus maenas* (L.). Mar. Behavior Physiol. 7(1): 15-24.

No mention of *Mercenaria mercenaria*. - M.W.S.

2118
Endean, Robert. 1972.

Aspects of molluscan pharmacology. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.). Academic Press, New York: 421-466.

Cottrell (1966) showed that a large percentage of the total 5HT in nervous tissue of *Mercenaria mercenaria* is particle bound, he was unable to identify these particles with disrupted portions of the endoplasmic reticulum. Cottrell and Maser (1967) stated that the subcellular localization of 5HT in the bivalve nervous system is still an open question. Cottrell (1966) showed that a large proportion of the ACh present in nervous tissue of *Mercenaria mercenaria* was bound to subcellular particles, and it was suggested that the sedimentation properties of ACh particles resembled those prepared similarly from mammalian brain. Hill and Welsh (1966) listed values of 5HT in hearts of *Mercenaria mercenaria*. There is no appreciable dopamine content in heart of *Mercenaria mercenaria* (Sweeney 1963). Cottrell (1966) studied particles obtained from macerated *Mercenaria mercenaria* ganglia and reported that the greater part of substance X was particle bound. Later studies have shown that substance X is a mixture of molluscan cardioexcitor compounds rather than a single compound. Frontali et al.(1967) thought that the substance X they extracted from hearts of *M. mercenaria* could be a mixture of peptides, but this was challenged by Agarwal and Greenberg (1969), who postulated that their cardioexcitor agent could include a nucleotide and that it might be a long duration, long distance substitution for neurotransmitters involved in long-term rhythmicity of active hearts. Frontali et al.(1967) discovered compounds with excitatory activity on molluscan hearts in extracts of hearts and ganglia of *M. mercenaria*. A growth inhibiting substance was found to be highly concentrated in *Mercenaria* and was called mercenene (Schmeer 1963, 1964a,b, 1965, 1966, 1967a; Schmeer and Beery 1965; Schmeer and Cassidy 1966; Schmeer and Huala 1965; Hegyeli 1964; Li et al.1965). Systems against which the substance is active include HeLa cells, Krebs 2 carcinoma, and sarcoma 180 in mice (Schmeer 1963, 1964a,b; Schmeer and Beery 1965), murine leukemia induced by Moloney virus (Judge 1966), and adenovirus 12 tumors in hamsters (Li et al.1968). Mercenene has no inhibitory activity or toxic effects on normal human amnion cells (Schmeer and Beery 1965), and although it did not extend the longevity of mice infected with Friend leukemia virus, it inhibited the splenomegalic response of such animals (Judge 1966). Studies on the chemical nature of mercenene have shown that the compound is slowly dialyzable, heat stable (Schmeer et al.1966) and possesses a molecular weight 1000 (Schmeer 1966). It has been suggested that at least part of the active principle of mercenene extracts is a substance of molecular weight 1000 to 2000 which may have a glycopeptide type of structure (Schmeer et al.1966). The proposal that mercenene is a volatile derivative of methylglyoxal (Szent-Gyorgyi 1965; Egyud 1965) is considered improbable (Schmeer 1966). Attempts to identify mercenene's site of action resulting in its antineoplastic effectiveness have so far failed (Schmeer 1967b, 1968, 1969). However, it has been established (Schmeer 1968) that mercenene prevents tumor cells from entering the DNA synthetic period of the mitotic cell cycle. It remains to be shown whether mercenene possesses activity against spontaneous cancers comparable with its effects on cancers transplanted into mice. Nonetheless, since mercenene kills only neoplastic cells in vitro and in vivo, it is of potentially great significance as an anticancer drug and as a tool for cytological research. The adaptive significance of the presence of mercenene in the tissues of marine organisms is worthy of investigation. Is it a metabolic accident, or has the compound been evolved as a defense against neoplasia? Of what biological significance is the seasonal variation in mercenene concentration in clam tissues? As Schmeer and Beery (1965) have pointed out, mercenene occurs in more than one species, and its presence is therefore unlikely to be the result of a selective feeding device, concentrating mercenene produced by other organisms. - J.L.M.

2119
Epstein, Henry F., Bruce J. Aronow, and Harriet E. Harris. 1976.

Myosin-paramyosin cofilaments: Enzymatic interactions with F-actin. Proc. Natl. Acad. Sci. USA 73(9): 3015-3019.

Interaction of paramyosin and myosin was studied by enzymological methods. Paramyosin from adductor muscles of *Mercenaria mercenaria* inhibits the actin-activated, Mg^{++}-requiring, ATPase of clam-adductor and rabbit skeletal muscle myosins. Myosin and paramyosin must be rapidly coprecipitated for this inhibition. Incubation with F-actin in the absence of ATP does not alter this effect. This inhibition follows a hyperbolic function with respect to paramyosin concentration. Slow precipitation by dialysis of myosin and paramyosin together leads to copolymers with actin-activated ATPase equivalent to that of slowly formed myosin filaments. Both kinds of slowly formed filaments have enzymatic properties distinct from those of the rapidly precipitated proteins. Paramyosin is competitive with F-actin for their effects upon myosin. The apparent affinity of myosin for F-actin is markedly reduced by association with paramyosin, but the extrapolated maximal velocity of actomyosin is unaffected. The specificity of this inhibition is strongly suggested by marked quantitative differences between native and cleaved paramyosins. No inhibition of intrinsic myosin ATPase by paramyosin was seen. These studies suggest that at least two types of condition-dependent association between myosin and paramyosin are possible. One class of interaction is associated with enzymic inhibition in rapidly coprecipitated filaments, whereas slowly formed cofilaments exhibit catalytic activity similar to that of identically treated myosin and have a characteristic 14.5 nm axial repeat. - modified authors' abstract - J.L.M.

2120
Eversole, Arnold G., William K. Michener, and Peter J. Eldridge. 1980.

Reproductive cycle of *Mercenaria mercenaria* in a South Carolina estuary. Proc. Natl. Shellf. Assn. 70: 22-30.

Hatchery seed of *M. mercenaria* planted at two tidal locations and at three clam densities were sampled for three yrs. Gonadal development was determined histologically and related to clam size and experimental treatments. Male gametogenesis preceded female development and a 9.5:1 male to female sex ratio occurred during the first yr. Equal numbers of males and females were approached in the 2nd yr and maintained through the 3rd yr. Changes in % lumen; in % lumen filled with oocytes or spermatocytes, spermatids, and spermatozoa; and the number and size of ovocytes were used to delineate spawning and tissue regeneration periods. Spawning lasted for approximately 6 months with peaks in May and June and in September and October. Spawning was followed by rapid regeneration of gonadal tissue. Shell length, tissue wet weight, and internal shell volume varied significantly between sexes and developmental stages of clams. Females were longer, weighed more, and had more space within the shell than male clams. No histological differences were detected between clams from different densities or tidal locations. Age, size, and sex relationships to gonadal development are presented with a discussion of seasonal gonadal changes. - modified authors' abstract - J.L.M.

2121
Figley, Bill, and Ray Townsend. 1980.

Fish facts: Hard clam. The Fisherman (New Jersey, Delmarva and Hatteras) 8(36): 15.

A brief review of the biology of the hard clam *(Mercenaria mercenaria)* covers common names, range, size, food, habitat, spawning, and predators. It contains nothing new. In New Jersey the commercial fishery has had two peaks, one in the early 1950s, the other in the late 1960s. The decline in the 1950s was caused in part by the closing of shellfish areas from pollution.

In 1978 there were 22,728 licensed shellfishermen in New Jersey, of which 95% were recreational, 4% were part time, and 1% were full time commercial. Two-thirds of the 58 million clams harvested that year were taken commercially. Sixty percent of the catch was taken from the eelgrass beds of Little Egg Harbor. Full time commercial men averaged 622 clams per day, part time 416 and recreationalists 164. Methods of fishing are discussed. Hard clams are found in bays where salinity is above 15°/₀₀. A license is required. Clams smaller than 1 1/2 inches in length must be returned to the water. Clamming is not allowed in polluted water or leased beds. These areas are marked on available charts, and leased beds are marked with cedar stakes. - J.L.M.

2122
Florkin, Marcel, and S. Bricteux-Gregoire. 1972.

Nitrogen metabolism in mollusks. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.), Academic Press, New York: 301-348.

Tropomyosin has been isolated from *Venus mercenaria* (Riddiford and Scheragra 1962). 5-Hydroxytryptamine has been found in nerve and heart tissue of *Venus mercenaria* (Welsh and Moorhead 1959). 5-Hydroxytryptophan was found in presence of nerve extracts of *Mercenaria mercenaria* (Welsh and Moorhead 1959). Carnitine (β-Oxy-γ-butyrobetaine) has been found in *Venus mercenaria* by Fraenkel (1954). - J.L.M.

2123
Florkin, Marcel, and Bradley T. Scheer. (eds.). 1972.

Chemical Zoology. VII. Mollusca. Academic Press, New York, xxi + 567 p.

A very complete survey of the mollusks, arranged according to the following chapter headings: The Molluscan Framework, Structure of the Molluscan Shell, Shell Formation in Molluscs, Byssus Fiber-Mollusca, Chemical Embryology of Mollusca, Pigments of Mollusca, Respiratory Proteins in Mollusks, Carbohydrates and Carbohydrate Metabolism in Mollusca, Lipid and Sterol Components and Metabolism in Mollusca, Nitrogen Metabolism in Mollusks, Endocrinology of Mollusca, Ionoregulation and Osmoregulation in Mollusca, Aspects of Molluscan Pharmacology, Biochemical Ecology of Mollusca. Chapters that specifically mention *Mercenaria mercenaria* are abstracted under authors' names, but the whole thing is worth reading for a complete discussion of the subject up to about 1971. - J.L.M.

2124
Fowler, Bruce A., Douglas A. Wolfe, and William F. Hettler. 1975.

Mercury and iron uptake by cytosomes in mantle epithelial cells of quahog clams *(Mercenaria mercenaria)* exposed to mercury. J. Fish. Res. Bd. Canada 32(10): 1767-1775.

The ultrastructural appearance of mantle epithelial cells from clams exposed to 0.1 ppm Hg concentration was indistinguishable from that of controls. Epithelial cells of clams exposed to 1 ppm mercury concentration contained increased numbers of dense cytosomes. These were most prevalent in the apical aspect of cells immediately beneath the microvilli of the brush border. Greater numbers of dense cytosomes were seen in mantle epithelial cells of clams exposed to 10 ppm Hg concentration. Examination of cytosomes in adjacent sections by energy dispersive X-ray microanalysis showed high iron concentrations in relation to Hg within these bodies. Using the thin section quantified model developed by Russ (1974), the Fe:Hg mass ratio within the cytosomes was calculated to be 4.73:1. The results indicate that cytosomal uptake is one mechanism by which molluscan cells may take up metals from their environment. Metal sequestration by cytosomes probably represents a mechanism by which shellfish can concentrate Hg rapidly from their environment without being killed. Alteration of essential trace metal levels in shellfish following chronic Hg exposure has not been reported previously. The mechanisms by which Hg could alter mantle fringe iron levels without discernible morphological damage are unknown and await further study. - J.L.M.

2125
Garlo, Elizabeth V. 1980.

Abundance and distribution of benthic macroinvertebrates near Little Egg Inlet, New Jersey, from 1972 to 1974. Internatl. Revue Gesamt. Hydrobiol. 65(3): 345-356.

No mention of *Mercenaria mercenaria*. - M.W.S.

2126
Garnas, R. L., and D. G. Crosby. 1979.

Comparative metabolism of parathion by intertidal invertebrates. In Marine Pollution: Functional Responses. Winona B. Vernberg, Frederick P. Thurberg, Anthony Calabrese, and F. John Vernberg (eds.). Academic Press, New York: 291-305.

Mercenaria mercenaria lacked the ability to oxidize parathion, and in less aerobic conditions reduced it to amino parathion and was capable of nitro-reductase activity. This was the only reference to hard clam in this paper. - J.L.M.

2127
Gaylinn, B. D., and W. H. Johnson. 1978.

The proteolysis of α-paramyosin during extraction from *Mercenaria mercenaria*. Biophys. J., Muscle proteins II, 21(3): 44a (abstract M-PM-E6).

Paramyosin isolated from adductor muscles of *Mercenaria mercenaria* contains three distinct forms designated α, β, and γ. β and γ-paramyosins appear to be degradation products while α-paramyosin is the native form. We have evidence that this degradation is caused by the action of bacteria carried over into the extraction step of the isolation procedure. This proteolysis can be slowed by antibiotics or completely prevented with the reducing agent 0.5 mM dithiothreitol or with 0.01 M EDTA or by extraction under acid conditions. The native protein is thought to be in the reduced state, and dithiothreitol can serve a dual purpose in the extraction step, thus avoiding the loss in yield caused by EDTA. We believe these organisms, identified as *Vibrio* and *Pseudomonas* types, exist within the adductor muscle tissue. - modified authors' abstract - J.L.M.

2128
Gaylinn, B. D., W. H. Johnson, L. B. Cooley, and L. C. DeMarco. 1977.

Some factors effecting the extraction and purification of α-paramyosin from *Mercenaria mercenaria*. Biophys. J. 17(2), Muscle proteins and structure II: 122a (abstract TH-AM-16).

We have developed several methods of extraction which yield principally α-paramyosin, and little β- and γ-paramyosin, which were thought to be degradation products of α-paramyosin, the native form. A modified acid extraction following the method of Hodge gives good yields. Inclusion of antibiotics in the extraction medium and use of osmotic shock in the initial stages of the ethanol methods of Johnson et al. have given α-paramyosin in smaller yields. All the methods employed to extract the α- form are consistent with the hypothesis that degradation of α-paramyosin is a result of the proteolytic activity of marine bacteria carried over from the animal into the extraction steps. We have observed bacterial growth during extraction in procedures which yield β and γ forms. Preliminary evidence suggests that these bacteria are capable of growth in 0.6 M KCl, pH 7.5, and 4°C and that antibiotics which we have used give protection in short term extractions. We suggest that the types of marine psychrophillic, halophillic bacteria isolated from shellfish by Colwell and Liston and shown by them to have high proteolytic activity may be responsible for the effects which we have observed, and may be a complicating factor in extraction of other proteins from tissues of marine invertebrates. - modified authors' abstract - J.L.M.

2129
Ghiretti, F., and A. Ghiretti-Magaldi. 1972.

Respiratory proteins in mollusks. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.). Academic Press, New York: 201-217.

Muscle myoglobin of *Mercenaria mercenaria* has a very high oxygen affinity (T_u = 0.55 mm Hg), the hemocoelic hemoglobins, either dissolved or contained in the erythrocytes, show considerably lower oxygen affinity (Manwell 1963). - J.L.M.

2130
Gilles, R. 1970.

Intermediary metabolism and energy production in some invertebrates. Arch. Internatl. Physiol. Biochim. 78: 313-326.

Adductor muscle of *Mercenaria mercenaria* (Tappel 1960) contains the following concentrations of respiratory chain components: a = 0.08, a_3 = 0.8, b = 5.3, c + c_1 = 3.7, and fp = 3.8 μM/kg wet weight. - J.L.M.

2131
Gilles, R. 1972.

Biochemical ecology of mollusca. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.). Academic Press, New York: 467-499.

Table II is from Gilles (1970) and shows, among other species, the concentration of the respiratory chain components in muscle of *Mercenaria mercenaria.* The respiratory chain component concentration in μM/kg wet weight was: a = 0.08, a_3 = 0.8, b = 5.3, c + c_1 = 3.7, and fp = 3.8 in adductor muscle. - J.L.M.

2132
Gordon, J. 1980.

Evidence for sclerotization of the shell matrix of a marine bivalve. Proc. Natl. Shellf. Assn. 70: 125-126 (abstract).

Scanning electron micrographs of sections of shell of *Mercenaria mercenaria* show prominent growth lines, especially in the prismatic region of the shell. The lines seem to become indistinct near the growing shell margin. When shell is decalcified and thin sections of insoluble shell matrix are treated histochemically, lysine, tyrosine, and a phenoloxidase can be identified in regions of the section corresponding to most recent growth of shell. It is suggested that progressive polymerization of the matrix takes place after shell deposition, the entire process taking 2 to 3 days to be complete. Cross-linking of organic molecules is effected by amino-quinone bonds involving epsilon-amino groups and tyrosine. The ultrastructural appearance of growth lines near the edge of calcified sections can be explained by differential solubility of regions of organic matrix exposed to preparatory treatments. - modified author's abstract - J.L.M.

2133
Gordon, J., and M. R. Carriker. 1980.

Sclerotized protein in the shell matrix of a bivalve mollusc. Mar. Biology 57(4): 251-260.

The epsilon-amino groups of lysine and phenolic groups of tyrosine are most heavily concentrated in newly deposited organic matrix of shell of *Mercenaria mercenaria.* A phenoloxidase enzyme which oxidizes L-dihydroxyphenylalanine is present only in this "new" area of shell matrix. Scanning electron micrographs of calcified secretions of shell show that accretion lines, thought to be layers of organic matrix separating diurnal accretions of calcium carbonate, are not developed until up to 4 days after deposition of shell material.

This suggests that shell matrix is hardened by some kind of polymerization, and that lysine and tyrosine residues in the matrix are involved. Accretion lines in polished and etched sections become visible only after complete hardening of the polymer occurs. - modified authors' abstract - J.L.M.

2134
Greenberg, Michael J., and David A. Price. 1979.

FMRFamide, a cardioexcitatory neuropeptide of molluscs: An agent in search of a mission. Am. Zool. 19(1): 163-174.

Aqueous extracts of molluscan ganglia have cardioexcitatory activity that is not attributable to the usual neurohumors: 5-HT, ACh, or dopamine. Morphological, physiological, and biochemical studies have suggested that this cardioexcitation is caused by a handful of unidentified neurohormones, mostly polypeptides. One of the active components of extracts of the pooled central ganglia of *Macrocallista nimbosa* has now been isolated, purified, characterized, and synthesized. This substance, previously designated peak C, is a tetrapeptide amide: phenylalanyl-methionyl-arginyl-phenylalanine amide (Phe-Met-Arg-Phe-NH_2; FMRFamide). Low concentrations of FMRF-amide (threshold: 10^{-9} to 10^{-8} M) induce rhythmical activity in isolated quiescent bivalve hearts and augment the force and frequency of contraction of those already beating. The peptide also produces contractures of non-cardiac molluscan muscles, including especially the radula protractor of the whelk, *Busycon contrarium*, a sensitive assay object. The effects of FMRFamide on *Mercenaria mercenaria* hearts appear to be mediated by adenosine 3', 5'-monophosphate (cyclic AMP). Peak C activity occurs in all species tested in all the major molluscan classes; but we do not know yet whether all peak Cs are FMRFamide. That FMRFamide is a neurosecretory product has still to be established, and its normal physiological role in molluscs has yet to be defined. Nevertheless, we suppose that, together with other neuropeptides, FMRFamide is released into the hemolymph to provide long-term maintenance and regulation of tone, rhythmicity, and excitability of visceral muscle. - modified authors' synopsis. - J.L.M.

2135
Greenberg, M. J., and T. Roop. 1977.

Cholinesterase diversity in homologous tissues of bivalve molluscs. In Comparative Physiology of Synaptic Receptors. M. J. Michelson (ed.). Acad. Sci. USSR, Leningrad.

Isolated ventricles of *Macrocallista nimbosa*, *Mercenaria mercenaria* and *Spisula solidissima* beat in Ca-free seawater but not in Na-free seawater. (Cited in Deaton and Greenberg 1980.) - original publication not seen - J.L.M.

2136
Gregoire, C. 1972.

Structure of the molluscan shell. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.). Academic Press, New York: 45-102.

As shown by Travis and Gonsalves (1969) in *Mercenaria* the mineral prisms are composed of well ordered parallel rows of microcrystals rectangular in shape. The three-dimensional morphological orientation of these microcrystals coincides with a well-defined three-dimensional crystallographic orientation. Bevelander and Benzer (1948) detected mucopolysaccharides in *Venus* shells. Abelson (1956, 1959, 1963) identified 15 amino acids in the organic matrix of the shell. Hare (1965-1966) found that the relative proportions of most of the amino acids in the soluble proteins in extrapallial fluid and in the largely insoluble shell matrix are similar. Mitterer (1966) identified the most abundant amino acids in the insoluble fraction of conchiolin in *Mercenaria*. Crenshaw (1970) from *M. mercenaria* isolated a water soluble glyco-protein amounting to 18% of the weight of the organic matrix. Mitterer (1966) found little variability in amino acid composition of organic matrix due to environmental effects. - J.L.M.

2137
Greig, Richard A. 1979.

Trace metal uptake by three species of mollusks. Bull. Environm. Contam. Toxicol. 22(4-5): 643-647.

Oyster, surf clam and ocean quahog were studied. *Mercenaria mercenaria* was not used. American oysters took up more of all metals studied than the other two species, especially copper. - J.L.M.

2138
Hammen, C. S. 1978.

Metabolic rates of marine bivalve mollusks determined by calorimetry. The Physiologist 21(4): 49 (abstract).

Rates of heat production (Q_H) of 4 species of bivalve, a gastropod, and a decapod crustacean were determined with a differential heat-retention calorimeter, and rates of oxygen consumption (Q_O) of the same animals were determined by standard manometric methods. Q_H varied with species from 1.6 to 6.2 J/hr/gram tissue, and Q_O varied from 1.8 to 4.1 micromoles/hr/g. The equivalent ratios for *Mercenaria mercenaria* were 1.15, which indicated that rate of oxygen consumption was too low to represent accurately the total metabolism of this species. - modified author's abstract - J.L.M.

2139
Hammen, C. S. 1979.

Heat production and oxygen consumption as measures of total energy metabolism in marine bivalve mollusks. Am. Zool. 19(3): 941 (abstract).

Experiments with *Mercenaria mercenaria* indicated that large fractions of the heat production observed during maximum oxygen consumption must be caused by anaerobic processes. - modified author's abstract - J.L.M.

2140
Hare, P. E. 1965-1966.

Amino acid composition of the extrapallial fluid in mollusks. Carnegie Inst. Washington Yearbook: 364-365.

The shell of mollusks is formed in the presence of extrapallial fluid, a thin layer of fluid filling the space between mantle and inner surface of shell. The organic matrix of the shell is apparently secreted by the mantle as a soluble polymer into the extrapallial fluid from which it later precipitates. There are remarkable similarities as well as remarkable differences between amino acid composition of soluble protein in the extrapallial fluid and that of the largely insoluble organic matrix of the shell. The greatest difference is in relative amount of histidine, which makes up approximately 25% of total amino acids in extrapallial fluid but less than 1% in organic matrix of shell. There is also a marked contrast in amounts of proline and cystine, which are enriched by a factor of 7 for proline and of 20 for cystine in shell matrix protein. Cysteic acid is recovered from a hydrolyzed sample of extrapallial fluid. The comparative values of amino acid residues per thousand total residues in shell protein and extrapallial fluid of *Mercenaria* are: aspartic acid 209/184; threonine 49/56; serine 83/95; glutamic acid 75/71; proline 117/17; glycine 99/108; alanine 55/36; cystine 20/1; valine 33/30; methionine 12/9; isoleucine 26/20; leucine 34/31; tyrosine 45/16; phenylalanine 36/14; lysine 63/38; histidine 5/250; and arginine 44/34. Electrophoresis of protein in a dialyzed aliquot from extrapallial fluid of *Mercenaria* showed a single band. Elution of this band and hydrolysis furnished a mixture of amino acids extremely high in histidine. The fact that histidine remains after dialysis shows that most of it is bound rather than free. - J.L.M.

2141
Hare, P. E., and R. M. Mitterer. 1965-1966.

Nonprotein amino acids in fossil shells. Carnegie Inst. Washington Yearbook 65: 362-364.

Change with geologic age of the amino acid content in various sample aliquots of specimens of *Mercenaria*, micromole amino acid/gram shell:

Age	Insol.	Total soluble	Free	Dialyzed
Modern	15-25	5-10	n.d.	~2
Recent fossil age 820 yr, Fla.	0.6	4.5	1.0	1.0
Upper Pleistocene, Wailes Bluff, Md.	0.5	2.1	1.6	0.1
Pleistocene, La Belle, Fla.	0.1	2.4	1.8	0.03
Pliocene, Old Dock, N.C.	<0.01	1.0	0.6	n.d.
Upper Miocene, Natural Well, N.C.	<0.01	1.4	0.4	n.d.
Middle Miocene, Plum Point, Md.	0.04	0.4	0.3	n.d.

Change with geologic age of amino acid concentrations in total soluble fraction of specimens of *Mercenaria*, nanomole amino acid/gram shell:

	Modern	~1000 yrs	Upper Pleistocene	Pleistocene	Pliocene	Upper Miocene	Middle Miocene
Aspartic acid	2808	1182	520	425	149	167	17
Threonine	338	131	42	26	5	1	1
Serine	1152	226	54	12	22	8	6
Glutamic acid	555	428	216	270	138	172	60
Proline	651	594	311	341	154	238	68
Glycine	1457	558	193	259	159	160	54
Alanine	446	305	216	360	186	280	79
α-amino butyric acid	-	-	6	26	13	21	7
Valine	199	155	84	161	66	109	30
Methionine	16	20	15	20	tr	6	1
Alloisoleucine	-	14	19	51	26	41	11
Isoleucine	178	91	36	53	22	31	8
Leucine	288	129	68	115	37	60	18
Tyrosine	396	112	84	89	15	26	5
Phenylalanine	251	117	70	90	27	46	12
γ-amino butyric acid	-	-	12	6	8	23	10
Ornithine	-	43	40	72	24	31	6
Lysine	456	205	112	153	30	48	15
Histidine	40	-	-	-	-	-	-
Arginine	274	165	67	34	-	-	-
	9505	4475	2165	2563	1081	1468	408

- J.L.M.

2142
Haskin, H. H. 1967.

Clam survey, Lower Bay, Shrewsbury River, New Jersey. N.J. Dept. Conserv. Econ. Devel., 5 p.

No reply to request for interlibrary loan. Search terminated. - J.L.M.

2143
Haven, Dexter S., Joseph G. Loesch, and James B. Whitcomb. 1973.

An investigation into commercial aspects of the hard clam fishery and development of commercial gear for the harvest of molluscs. Final contract report for the period 1 July 1970 through 30 June 1973. Contract No. 3-124R, Virginia Inst. Mar. Sci., Gloucester Point, Virginia, 112 p. + illustr.

Sampling was done by escalator dredge on 150 ft x 150 ft plots. A plot was considered worked out when harvest rate was less than 1 bu/hr. Total catches/acre varied from 78.5 to 0 bu. Average catch was less than 25 bu/plot. Growth in the 1968-69 period was the highest recorded since experimental planting began in the fall of 1967. Growth is believed correlated with river flow and salinity change. Growth at Hampton Flats was greater than at Gloucester Point and Yorktown. In 1971-72 there was total mortality in upper York River because Agnes reduced salinity to about 1.6°/₀₀ for a long period. Littleneck and cherrystone sizes were reached in about 2 1/2 and 4 1/2 yrs, respectively, at Hampton Flats, 4 and 8 yrs in lower York River. Growth of planted clams at Wachapreague was underestimated because inadequate numbers were recovered, but far superior to planted western shore clams in 1971-72 (salinity at Wachapreague was not affected by Agnes). - J.L.M.

2144

Higgins, William J. 1977.

5-Hydroxytryptamine-induced tachyphylaxis of the molluscan heart and concomitant desensitization of adenylate cyclase. J. Cyclic Nucleotide Research 3(4): 293-302.

High concentrations of 5HT first excite isolated ventricle of *Mercenaria mercenaria* and then specifically desensitize it to further additions of the neuropeptide. This 5 HT-induced tachyphylaxis is paralleled by a 5HT-specific desensitization of the myocardial adenylate cyclase and a decrease in intracellular cyclid AMP. However, FMRF-NH_2, a cardioexcitatory tetrapeptide, can still increase contractility, cyclid AMP, and the adenylate cyclase activity of a tachyphylactic ventricle. These results are consistent with the hypothesis that 5HT augments molluscan myocardial contractility by elevating intracellular cyclic AMP. - author's summary - J.L.M.

2145

Higgins, William J. 1977.

Inhibition of protein synthesis does not prevent 5HT-induced tachyphylaxis of the molluscan ventricle or desensitization of adenylate cyclase. Am. Zool. 17(4): 959 (abstract 567).

High concentrations of 5-hydroxytryptamine (5HT) first excite the isolated ventricle of *Mercenaria mercenaria* and then specifically desensitize it to further additions of the neurohumor. This 5HT-induced tachyphylaxis is paralleled by a 5HT specific desensitization of the myocardial adenylate cyclase and a decrease in intracellular cyclic AMP. The mechanism of desensitization and tachyphylaxis was examined using cycloheximide (100 μM) and actinomycin D (20 μM). Neither agent prevented 5HT-induced desensitization or tachyphylaxis, nor did they alter the time course of the restoration of hormone responsiveness following the removal of 5HT. However, both agents inhibited the incorporation of ^{3}H-leucine into trichloracetic acid-precipitable material, suggesting that in molluscan muscle, unlike many mammalian tissues, desensitization does not depend upon protein synthesis. - modified author's abstact - J.L.M.

2146

Hill, B. J. 1976.

Molluscan viruses: their occurrence, culture and relationships. In Proc. First International Colloquium on Invert. Pathol. and IXth Ann. Meeting, Soc. Invert. Pathol. Printing Dept., Queens Univ.: 25-29.

One virus isolate has been obtained from hard clam, *Mercenaria mercenaria*, from Whitstable in southeast England. The virus designation is CVL-1. There is no firm evidence at present that this group of viruses affecting molluscs can be virulent for their host. - J.L.M.

2147
Hochachka, Peter W. 1980.

Living Without Oxygen. Closed and Open Systems in Hypoxia Tolerance. Harvard Univ. Press, Cambridge, Mass., xi + 181 p.

It is well known that the hard clam, *Mercenaria mercenaria*, can live out of water for extended periods. During anaerobic respiration calcium carbonate is mobilized from the shell, inside the pallial line. Glycolysis leads to succinate formation, and the succinate is ultimately converted to propionate if anoxia is extreme and extended. Under ideal conditions anaerobic metabolism can continue for three weeks or possibly more, and the clam immediately reverts to aerobic respiration on being returned to seawater. *Mercenaria mercenaria* is not mentioned in this book, but much of the discussion is pertinent. Chapters include: Anaerobic Metabolism: What Can and What Cannot Change, Helminths and the Usefulness of Carbon Dioxide, Coupled Glucose and Amino Acid Catabolism in Bivalve Molluscs (oyster, mussel and mud clam are discussed), Coupled Glucose and Arginine Metabolism in Cephalopods, Key Elements of Anaerobic Glycolysis, Integrating Aerobic and Anaerobic Glycolysis, Integrative Mechanisms in Hypoxia-Adapted Fish, Air-Breathing Fish, and Diving Marine Mammals. - J.L.M.

2148
Hubschman, Jerry H. 1979.

The lowly invertebrates: An historical perspective. Ohio J. Science 79(6): 243-248.

On our side of the Atlantic Indians were using mollusk shells for trading purposes. The coastal Indians from Maine to Texas made wampum by cutting and grinding beads from *Mercenaria mercenaria*. This species was especially useful because it had a distinct blue (purple) region in the shell. This blue area is absent in the southern species *M. campechiensis*. There is a zone of confrontation somewhere north of Montauk Point and south of Cape Cod, between New England and Manhattan clam chowder. Try both. Recipes are included. - J.L.M.

2149
Jeffries, Harry P. 1964.

Comparative studies on estuarine zooplankton. Limnol. Oceanogr. 9(3): 348-358.

The seasonal cycle of zooplankton in Raritan Bay, N.J. was compared with Narragansett Bay, R.I. and the York River, Va. to determine the effects of local conditions on latitudinal gradients in species distribution. Lamellibranchs proliferated in each estuary during May. The first peak consisted primarily of *Mya arenaria* and *Mercenaria mercenaria* was responsible for the second peak in July and August. Maximum representation of *Mercenaria* occurred first in the York River, then in Raritan Bay, and finally in Narragansett Bay. Production of lamellibranch larvae was higher in 1958 than 1957, about 50 fold at the upper end of Raritan Bay and about 3 fold toward the mouth. This may have been caused by the operation of a trunk sewer, which began to discharge in January 1958. - J.L.M.

2150
Johnson, J. Kent. 1977.

A study of the shell length of *Mercenaria mercenaria* in relation to bottom sediments of Little Bay, New Jersey. Bull. N. J. Acad. Sci. 22(2): 52 (abstract).

Shell length of 1,895 *Mercenaria mercenaria* collected from 10 sites in Little Bay was correlated with particle size characteristics of sediment from each site. A highly significant correlation $r = 0.88$, $p < 0.001$, was established between mean shell length and a measure of central tendency of particle size. The significant correlations, and the comparison of shell length with cumulative curves of clam colonies and measures of central tendency of sediment support a pseudo-feces growth retardation hypothesis, i.e., slower growth in finer sediment because rate of expulsion of pseudo-feces is increased. - modified author's abstract - J.L.M.

2151
Jones, C. C. 1979.

Anatomy of *Chione cancellata* and some other Chionines, Bivalvia: Veneridae. Malacologia 1: 157-199.

Important information on *Mercenaria mercenaria* thought unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

2152
Keck, Richard T., Robert C. Heess, John Wehmiller, and Don Maurer. 1978.

Sublethal effects of the water-soluble fraction of Nigerian crude oil on the juvenile hard clams, *Mercenaria mercenaria* (Linne). Environ. Pollut. 15(2): 109-119.

Juvenile *Mercenaria mercenaria* were exposed to the water-soluble fraction of Nigerian crude oil at concentrations ranging from 7 ppm to 0.06 ppm. During the six-week experimental period the feeding rates of clams exposed to hydrocarbons were significantly lower than those of controls. Growth rates of control clams were three times as great than growth rates of experimental groups. Mortalities were low during the entire experimental period, but during a two-week depuration period all clams in the most polluted condition (7 ppm) died. - modified authors' abstract - J.L.M.

2153
Keith, M. L., and E. T. Degens. 1959.

Geochemical indicators of marine and fresh-water sediments. In Researches in Geochemistry. Philip H. Abelson (ed.). John Wiley & Sons, Inc., New York: 38-61.

Marine fossils measured include *Venus mercenaria*, which has nearly the same carbon isotope ratio as the marine belemnite standard. The isotopic composition of carbon appears to be more diagnostic in the samples studied. There is some overlap in points representing marine and fresh-water limestones, but the separation is good enough to justify the conclusion that measurement of the isotopic composition of carbonate carbon offers a promising criterion for environmental study of limestones. - J.L.M.

2154
Kellogg, J. L. 1915.

Ciliary mechanisms of lamellibranchs with descriptions of anatomy. J. Morphol. 26(4): 625-701.

In *Venus mercenaria* material on outer and inner lamellae of both demibranchs is moved to the free edges and forward to the palps. A tract between the gills, at their bases, moves particles forward to meet those brought on the margin of the outer demibranch, and all is moved downward to the lateral groove. On the outer faces of the palps, cilia streams move around the dorsal margins to the inner or apposed faces. Most material usually moves on to the palp folds and is then disposed of. Palps are narrow and respond to touch with great contortion, so that they are not easily studied. High on the side of the visceral mass the trend of general ciliation is forward. Movement of particles is rather directly toward its posterior wall from which it is thrown off to the mantle. Some part of the collection may be sent to the dorsal margin of the palp, and if not of too great volume, may ultimately reach the mouth. A distinct line, or narrow path, extends over the mantle from a point near lower edge of anterior adductor to base of incurrent siphon. A general ciliation, without definite lines or tracts, covers the rest of mantle wall, and everything on these cilia is moved to the line. An appearance of definite lines or tracts may be seen when a mucus mass is drawn out in a long thread. Waste accumulates in a bay just below the base of incurrent siphon, and on contraction of adductor muscles is discharged through incurrent siphon, not between mantle folds below the siphon as in some other bivalves. Direction of beat of cilia is never changed. Cilia streams on surfaces of organs exposed to water are divided into 2 systems, one leading to the mouth, the other bearing material outside the body. Palps exercise general control over the 2 ciliary systems, determining whether or not material shall enter digestive tract. Ciliary tracts on palps have greater complexity and are more important than those of other organs. There is no selection or separation of food organisms from other water-borne particles; volume alone determines whether collected material goes to the mouth or is discarded. A clam is able to feed only when waters are comparatively clear, when diatoms are brought to gill surfaces a few at a time. In muddy waters all suspended particles, of whatever kind, are led to outgoing tracts. The sand-eating genus *Macoma* is an exception. All ciliated areas produce mucus, which appears locally in response to stimulus of foreign particles. Long-continued stimulation of any surface may produce relatively enormous mucus secretion. The nervous system and muscles frequently aid in operation of ciliary tracts, as in exposure of tracts by spreading apart of palp folds, apposition of ventral margin and folds, of palps and gills, gills and mantle, and gills and visceral mass. In addition there are violent expelling contortions of gills, palps, and mantle edge, sudden contractions of adductor muscles, and other movements. Directions of flow in relation to major features of the anatomy are illustrated with clear line drawings. - J.L.M.

2155
Kennish, M. J. 1977.

Effects of thermal discharges on mortality of *Mercenaria mercenaria* in Barnegat Bay, New Jersey. N. Am. Paleontol. Conv. II, J. Paleontol. 51, Pt. II of III, Suppl. to No. 2: 17 (abstract 65).

Thermal discharges from the Oyster Creek Nuclear Generating Station do not affect mortality in natural populations of *M. mercenaria* in Barnegat Bay, N. J. The analysis of daily growth increments and disturbance bands in shell cross-sections of more than 300 specimens from death assemblages collected from the mouth of Oyster Creek (strongly affected by thermal discharges) and from three control sites (unaffected by thermal discharges) in the Bay indicate that similar mortality patterns exist in all assemblages. Statistically, there is no significant difference in the season of death and the absolute age and size at the time of death for individuals sampled from these four sites. This is revealed graphically by size-frequency and age-frequency histograms which are nearly identical for each assemblage. Each death assemblage is the result of natural rather than census mortality, as is evidenced by its corresponding death-frequency histogram which shows that individuals died at different times of the year. The peak frequency of stress and death occurs in summer and winter when environmental conditions are at extremes. - modified author's abstract - J.L.M.

2156
King, Kenneth, Jr. 1978.

Distribution of γ-carboxyglutamic acid in calcified tissues. Biochim. Biophys. Acta 542: 542-546.

γ-carboxyglutamic acid, found in vertebrate mineralized tissues of bone and dentin, was not found in any of six invertebrate species, including *Mercenaria mercenaria*, in the calcified skeletons. This indicates that it is not obligatory for the calcification process in invertebrates. Invertebrates as a group may lack the enzymatic capacity for biosynthesizing γ-carboxyglutamic acid. - modified author's summary - J.L.M.

2157
Koehn, Richard K., John G. Hall, and Anthony J. Zera. 1980.

Parallel variation of genotype-dependent aminopeptidase-I activity between *Mytilus edulis* and *Mercenaria mercenaria*. Mar. Biol. Lett. 1(5): 245-253.

Statistically significant among-genotype differences in specific activities were observed for aminopeptidase-I (*"Lap"*) enzyme in *Mytilus edulis* and *Mercenaria mercenaria* from oceanic salinity environments on Long Island. In Long Island Sound, where salinity is reduced, overall enzyme activity was reduced and the specific enzyme activities of genotypes did not differ within species. The parallel variation of enzyme activity among genotypes in different species suggests that similar phenotypic diversity has been maintained during the evolutionary divergence of the *Lap* gene. - J.L.M.

2158
Korringa, P. 1971.

Marine pollution and its biological consequences. In Fertility of the Sea. Vol. 1. John D. Costlow, Jr. (ed.). Gordon and Breach Science Publishers, New York: 215-223.

Mercenaria mercenaria, the American hard-shelled clam, thrives now in the Southampton region, because its reproduction has been made possible by higher water temps. Hot water discharged by power plants is one of the few waste products which may, although not always, have a positive effect in the sea. For reasons of economy discharge close inshore is preferred, but for fisheries and recreation discharge well offshore, if possible beyond the edge of the continental shelf is highly desirable. - J.L.M.

2159
Kraeuter, John N., and Michael Castagna. 1980.

Effects of large predators on the field culture of the hard clam, *Mercenaria mercenaria*. U.S. Dept. Commerce, Fish. Bull. 78(2): 538-541.

July 1977 results mirrored those of earlier sampling periods. The data show that trapping is essential in penned areas, but that when pens are absent trapping is of no benefit. Effect of large predators can be seen by comparing survival inside and outside the penned sites. Average survival for both penned sites was 94% from July to October-November. Average survival for the same period in the unpenned sites was 8.75%. Clams of all sizes were consumed. Only two species were common in the planted areas, *Dasyatis centroura* and *Rhinoptera bonasus*, and it was believed that the most likely was a school of *Rhinoptera bonasus*. Such losses would be unpredictable, but would be financially devastating to the clam grower. Use of a fence is essential in areas where these large predators occur. In Va. they should be kept in place from late March to early November. - J.L.M.

2160
Krause, S., and L. B. Cooley. 1978.

Titration of paramyosin at low and at high ionic strength. Biophys. J. 21 (3), Muscle proteins IV: 140a (abstract TU-POS-F4).

Titration data were obtained at low ionic strength (0.001 M KCl) and at high ionic strength (0.3 M KCl) on paramyosin extracted from *Mercenaria mercenaria* by several different methods. The low ionic strength titration curves of the different paramyosin preparations were similar to each other but indicated the slight difference between the number of groups titrating in the pH 3.2 to 3.3 region for the different preparations predicted earlier. High ionic strength titration curves of the paramyosin preparations were quite different depending on whether the titration was performed with base (pH 2 to 11) or with acid (pH 12 to 3.5). In titrations with acid, for example, over 70 groups were titrated abruptly near pH 8.5; this did not occur in titrations with base. The various titration data are probably connected with phosphate groups attached to native paramyosin which are removed slowly from the macromolecule at high pH. - modified authors' abstract - J.L.M.

2161
Krause, Sonja, and Donald E. DeLaney. 1977.

A study of paramyosin aggregation using transient electric birefringence techniques. Biopolymers 16(6): 1167-1181.

Aggregation of several forms of the molluscan muscle protein paramyosin at low concentration and at low ionic strength was studied in the pH range 6 to 10 using transient electric birefringence techniques. In the lower part of this pH range, aggregates exhibit negative birefringence, but this changes to positive birefringence when the pH increases. Analysis of the field-free birefringence decay transients of the paramyosin solutions showed that all aggregates coexisted with paramyosin monomer and allowed a determination of the rotational diffusion constant of aggregates present at each pH. The size and shape of these aggregates were estimated from their rotational diffusion constants and were compared with the known characteristics of larger aggregates such as paracrystals. Positively birefringent aggregates appear to be staggered dimers at certain values of pH; at other pH values these appear to be higher aggregates, probably formed by lateral aggregation of monomer or dimer onto one of these staggered dimers. The staggered dimers are formed by overlap of 200 to 600 A along each cylindrical paramyosin molecule, in agreement with the 530 A overlap distance found in paramyosin paracrystals by Cohen et al. (1971). Some speculations are given about the nature of the negatively birefringent species. - modified authors' synopsis - J.L.M.

2162
Kyte, M. A., and K. K. Chew. 1975.

A review of hydraulic escalator shellfish harvester and its known effects in relation to the soft shell clam, *Mya arenaria*. Univ. Wash. Sea Grant Publ. WSG-75-2: 1-32.

Details on *Mercenaria mercenaria* unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

2163
Leibovitz, L., T. R. Meyers, and M. Frey. 1976.

A shell deforming disease of hard clams (*Mercenaria mercenaria*). In Proc. First International Colloquium on Invert. Pathol. and IXth Ann. Meeting, Soc. Invert. Pathol. Printing Dept., Queens Univ.: 386-387.

A shell abnormality of hard clam from Great South Bay, Long Island, N.Y. was observed in wild and hatchery-grown planted stock. It was distinct from shell abnormality related to mechanical injury, predator damage and other abnormal shell changes including "Indian blanket" shell markings. Greatest incidence of the disease was associated with early stages of shell deformity in newly planted stunted hatchery reared stock. The stock suffered a high mortality rate immediately following planting, but the cause of the mortality was not known. Following the period of mortality, shell deformities became progressively more pronounced in individual surviving hard clams during growth from juvenile to adult marketing stages. The disease was not seen in other areas of Long Island. The appearance of affected *Mercenaria mercenaria* is described. - J.L.M.

2164
Malek, Emile A., and Thomas C. Cheng. 1974.

Medical and Economic Entomology. Academic Press, New York, x + 398 p. Chapter 8. Hematology.

A second class of hemolymph cell occurs in some mollusks. These are smaller, and have lower nuclear-cytoplasmic ratios. Such cells, designated hyalinocytes, have been found in *Mercenaria mercenaria*. - J.L.M.

2165
Malek, Emile A., and Thomas C. Cheng. 1974.

Medical and Economic Malacology. Academic Press, New York, x + 398 p. Chapter 12. Aquaculture.

Mercenaria mercenaria is briefly covered. There is nothing new on biology, and the aquaculture of mollusks generally is still in its infancy. - J.L.M.

2166
Mann, Roger. 1978.

A comparison of morphometric, biochemical, and physiological indexes of condition in marine bivalve molluscs. In Energy and Environmental Stress in Aquatic Systems. James H. Thorp and J. Whitfield Gibbons (eds.). Tech. Info. Center, U.S. Dept. Energy, DOE Symp. Series 48, Conf. 771114: 484-497.

Ansell (1965) concluded that if only length is known for *Venus (Mercenaria) mercenaria* the only transformations that can be made accurately are estimates of total weight, total volume, and shell-cavity volume. Thus, total body nitrogen and carbohydrate levels could not be estimated from length data because changes take place related to the gametogenic cycle. - J.L.M.

2167
Marsh, Mary, Gary Hamilton, and Ronald Sass. 1978.

The crystal sheaths from bivalve hinge ligaments. Calcified Tissue Research 25(1): 45-51.

Aragonite crystals in the molluscan bivalve hinge ligament are surrounded by an organic sheath which is distinct from the remainder of the ligament matrix. These sheathed crystals were isolated from the ligament of *Mercenaria mercenaria* and surf clam by papain digestion of the matrix protein. Sheathed crystals from *Mercenaria* had a $CaCO_3$/protein ratio of 29.6. Sheath proteins showed much smaller proportions of the amino acids glycine and methionine than hinge ligaments. These are characteristic amino acids of high concentration in hinge ligaments. Concentrations of acidic and basic amino acids were increased about two fold in sheaths over those of ligaments. Otherwise there was little similarity in amino acid content of sheaths in the two species. SDS electrophoresis showed the sheaths of both to contain a major protein component with a molecular weight of about 25,000. The sheath protein from *Mercenaria* ligament contained about 5% carbohydrate, and *Spisula* sheath less than 1% carbohydrate. - modified authors' summary - J.L.M.

2168
Maurer, Don. 1977.

Estuarine benthic invertebrates of Indian River and Rehoboth Bays, Delaware. Int. Revue Ges. Hydrobiol. 62(5): 591-629.

Based on 273 quantitative samples collected in the summer and winter of 1968 and 1969, an estuarine benthic invertebrate community consisting of 11 phyla and 149 species and dominated by *Ampelisca abdita*, *Gemma gemma*, *Tellina agilis*, and *Mercenaria mercenaria* was described from Rehoboth and Indian River Bays, Delaware. Exclusive of the top species, annual and seasonal changes in density and frequency of occurrence were substantial. Comparison of species composition, density, dominance, and biomass with other areas showed that these bays were very similar to shallow bays throughout the Middle Atlantic and southern New England areas. - from author's summary - J.L.M.

2169
McHugh, J. L. 1980.

Coastal fisheries. In Fisheries Management. Robert T. Lackey and Larry A. Nielsen (eds.). John Wiley & Sons, New York: 323-346.

Hard clam *(Mercenaria mercenaria)* landings in the United States peaked at 21.0 million pounds in 1950. The species was once most important in Rhode Island, now New York and New Jersey produce most of them, and New York is the principal producer. The total harvest has declined to about three-quarters of its level in the 1950s and is remaining remarkably steady since that time. This has occurred despite continued closure of beds because waters are becoming more polluted. In fact, there may be some merit in pollution if certain precautions are adequate because that maintains a reserve of clams that can be transplanted to clean waters for harvest later.

The surf clam has been overfished in a much shorter time, and it has been suggested that the use of more "efficient" gear may be responsible. - J.L.M.

2170
McHugh, J. L. 1981.

Recent advances in hard clam mariculture. J. Shellf. Research 1(1): (in press).

Failure to develop a satisfactory method of hard clam aquaculture, despite about 70 yrs of research, may be based on faulty premises. There is no problem to raising *Mercenaria mercenaria* to market size under artificial conditions provided that adequate attention is given to care and cleanliness. The only impediment is cost, which under present methods is too high for economic gain. The flaw in thinking may be reliance on small numbers of clams, thinking millions are sufficient when billions may be required to smother predation. Another flaw may be lack of adequate enforcement. Grounds must be patrolled constantly to keep out violators, and this means adequate coverage 24 hrs a day, 7 days a week, and 365 days a year. It also means adequate support in the courts, so that the penalty for being caught is not worth the risk. Experimental management might be better. One way would be to divide an area into three parts, keeping one open and two closed, and rotating the closed areas each year. If enforced adequately this would give adequate protection to seed, and the plan could be adjusted according to local conditions as knowledge accumulates. - J.L.M.

2171
McReynolds, J. S. 1976.

Hyperpolarizing photoreceptors in invertebrates. In Neural Principles in Vision. F. Zettler and R. Weiler (eds.), Springer-Verlag, New York: 394-409.

In *Mercenaria mercenaria* an off discharge has been studied which resembles in many ways that of the distal nerve fibers of *Pecten*, including the ability to integrate the light stimulus over a long period of time (Wiederhold et al. 1973). As in *Spisula* no definite photoreceptor cell bodies were found, but electron microscopy has revealed invaginated whorls of membrane in the nerve fibers in the area to which light sensitivity is restricted. Although no receptor potentials were recorded, it seems likely that these cells would also show a hyperpolarizing receptor potential. - J.L.M.

2172
Medcof, J. C. 1961.

Effects of hydraulic escalator harvestors on undersized soft-shell clams. Proc. Natl. Shellf. Assn. 50: 151-161.

New material on *Mercenaria mercenaria* unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

2173
Medcof, J. C., and R. A. Chandler. 1968.

Exploring for uses of ocean quahogs: Obstacles and opportunities. Fish. Res. Bd. Canada, Biol. Sta., St. Andrews, N.B. Tech. Rept. 101.

Mercenaria mercenaria not mentioned. - J.L.M.

2174
Menzel, R. W. 1962.

Experimental farming of hard clams, *Mercenaria mercenaria*, in Florida. J. Fish. Res. Bd. Canada 7: 545-551.

Incorrect reference. Could not locate. - J.L.M.

2175
Menzel, Winston. 1979.

Clams and snails [Mollusca: Pelecypoda (except oysters) and Gastropoda].

Chapter 12 in Pollution Ecology of Estuarine Invertebrates. Academic Press, Inc., New York, N.Y.: 371-396.

This review paper has numerous references to *Mercenaria mercenaria* and *M. campechiensis*, all of which are abstracted elsewhere in this bibliography. - J.L.M.

2176
Merrick, Jacqueline P., and William H. Johnson. 1977.

Solubility properties of α-reduced paramyosin. Biochem. 16(10): 2260-2264.

The reduced form of α-paramyosin is what is found in living adductor muscles of molluscs. In contrast to the solubility profile of β-paramyosin, the α-preparation showed a rapid, almost linear decrease in solubility over the ionic strength range 0.35 to 0.25 at neutral pH. Solubility in this range was further decreased by presence of physiologically small amounts of Ca ion. Lactate ion, which can accumulate during anaerobic glycolysis in molluscan muscles, also decreases the solubility at a level of 50 mM. The type of paracrystal formed by α-paramyosin differs greatly from those of β-paramyosin and paracrystal formed in the presence of lactate differs from those formed in buffer solutions. Reduced α-paramyosin is more sensitive to the above parameters than preparations made without reducing agents. The pH and ionic strength ranges in which greatest change in solubility behavior occurs are physiologic, as are Ca and lactate ion levels effective in increasing intermolecular interactions. A model is proposed for α-paramyosin in which the extra 5% presumably removed in β-preparations is a "sticky head" which protrudes from one end of the molecule and confers on it an increased tendency for interaction, particularly at physiological ionic strengths. Such molecules would be capable of promoting interactions between thick filaments which contain them, providing a means of accounting for the pH dependent stiffness observed in glycerinated preparations of molluscan catch muscles. - modified authors' abstract - J.L.M.

2177
Mitterer, Richard Max. 1966.

Amino acid and protein geochemistry in mollusk shells. Ph.D. Thesis, Florida State Univ. Dissert. Abstr., Sect. B. Geology, Apr.-June 1967, vol. 27: 3994-B.

Analysis of modern *Mercenaria mercenaria* shells from various environments shows little variability in amino acid composition of the organic matrix caused by environmental effects. All amino acids were found in lower amounts with increasing ages of fossil *Mercenaria* shells. Some amino acids increase in relative abundance with increasing age of shell. Alanine, proline, glutamic acid, glycine, valine, leucine, and aspartic acid are found in greatest abundance in Middle Miocene shells. Certain ratios such as Glu/Asp, Alloiso/Iso, Phe/Tyr, and Orn/Arg increase consistently with increasing ages of shells. These could possible provide a relative age-dating method. Application of Vallentyne's theoretical results on time-temp relations of amino acids to the data reported herein yields a maximum continuous diagenetic temperature of 14°C for the Middle Miocene Calvert Formation of Maryland. Temps obtained for Upper Miocene Duplin Formation and its equivalents are 18°C for North Carolina and North Florida and 20°C for South Florida. The presence of certain non-protein amino acids such as α-aminobutyric acid, γ-aminobutyric acid, and β-alanine, and high ammonia concentrations in the fossils shows that decarboxylation and deamination reactions are occurring within the shells. - J.L.M.

2178
Moore, Carol A. 1979.

Ultrastructure of the cytoskeleton in the amebocytes of *Mercenaria mercenaria*. J. Cell Biol. 83(2) Part 2: 315a (abstract M11723).

Amebocytes, initially rounded, attached by lamellipodia and filopodia. When fully spread, cells exhibited an extensive system of cytoplasmic fibers delineated into 3 zones: a perinuclear (50-65% spread cell width), a transition (25-35% spread cell width), and a marginal (10-15% spread cell width) zone. During cell spreading, disperse perinuclear cytoplasmic fibers were reorganized into: 1) numerous parallel bundles of filaments radiating outward from the nuclear area; these bundles seemed to coincide with the movement of organelles as seen with phase optics; 2) a network of filaments in which organelles appear suspended. A ring of filament bundles often confined organelles to the perinuclear zone and delimited it from the transition zone. Filament bundles in the transition zone were less abundant, with a more random arrangement. Some bundles originating in this zone traversed the outermost marginal zone where they meshed with additional bundles and microtubules to form the core of filopodia; occasional bundles from the perinuclear area were involved. The narrow marginal zone, as viewed by S.E.M. and time-lapse cinematography, revealed extensive membrane ruffling, particularly where long filopodia were absent. These ruffled edges consisted of a meshwork of short fibers in a dense cytoplasmic matrix. It is suggested that the intracellular fiber systems are responsible for support as well as the dynamic mobility of the amebocyte and its organelles. - modified author's abstract - J.L.M.

2179
Moore, C. A., and S. R. Gelder. 1979.

The relationship between phagocytized material and the "blunt" granules in hemocytes of *Mercenaria mercenaria*. Am. Zool. 19(777): 1007 (abstract).

Vital dyes and fluorescently labeled materials were used. Hemocytes were syringed from the posterior adductor muscle, settled on cover glasses and stained (neutral red followed by Janus green B; acridine orange) or allowed to phagocytize *Isochrysis galbana* or Congo red stained yeast. Cells were observed under phase contrast and epifluorescence illumination (violet-blue light). Vital staining revealed some blunt granules (70%) to be stained with neutral red/acridine orange while others took up Janus green B; some granules were seen to contain acridine orange particles. After hemocytes phagocytized *Isochrysis*, the algae fluorescent emission shifted from red to green-yellow. Blunt granules, previously non-fluorescent, were observed to emit a green-yellow fluorescence. Phagocytized Congo red stained yeast cells did not yield similar results. This work suggests that the blunt granules receive degraded material from the phagosome and may serve as a mechanism for containment of phagocytized materials. - J.L.M.

2180
Murawski, Steven A., and Fredric M. Serchuk. 1980.

Clams and scallops of the northeast coast. Underwater Nat. 12(4): 25-33.

Early records appear to show that the Indians used an increasing proportion of bay scallops, and relied less on the hard clam, *Mercenaria mercenaria*. This paper deals principally, however, with sea scallops, surf clam, and ocean quahog. - J.L.M.

2181
Nakahara, Motokazu, and Ford A. Cross. 1978.

Transfer of cobalt-60 from phytoplankton to the clam (*Mercenaria mercenaria*). Bull. Japanese Soc. Sci. Fish. 44(5): 419-425.

The transfer of cobalt-60 from phytoplankton (primary producer) to clams (primary consumer) was investigated to obtain additional information about the movement of cobalt-60 in the marine ecosystem. Retention of cobalt-60 in clams after feeding radioactive phytoplankton varies with size of clam and cell density and species of phytoplankton fed to the clams. At high cell densities ($2x10^8$ and $5x10^8$ cells/liter) retention of cobalt-60 by clams was reduced with increasing cell density and size of clam. More than 43% of the radioactivity introduced into the pallial cavity of the clams with the diatom *Nitschia closterium* at cell densities less than $5x10^7$ cells/liter was retained in clams two days after feeding. *Nitschia closterium* gave the largest retention at all clam sizes of the three phytoplankton organisms tested. The other two, *Dunaliella* sp. and *Platymonas* sp. lost more than 90% of the radioactivity in the first few hours in the pseudofeces. - modified authors' abstract - J.L.M.

2182
Nixon, S. W., C. A. Oviatt, and S. S. Hale. 1976.

Nitrogen regeneration and the metabolism of coastal marine bottom communities. In The Role of Terrestrial and Aquatic Organisms in Decomposition Processes. J. M. Anderson and A. Macfayden (eds.) The 17th Symp. of the British Ecol. Soc., Blackwell Sci. Pubs., Oxford: 269-283 (paper no. 11).

Three subtidal bottom areas chosen for study included an assemblage of macrofauna (>0.75 mm) dominated by hard clam, *Mercenaria mercenaria*, in the lower west passage; a polychaete-bivalve community with *Nepthys incisa* and *Nucula annulata* in the middle of the Bay; and an amphipod mat of *Ampelisca abdita* in the upper west passage. Metabolism of the lower bay station where *Mercenaria* was abundant was significantly different at the 95% confidence level from metabolism of bottom at the other two stations. Oxygen uptake ranged from 10 to 150 mg/m^2/hr, with an annual total of about 360 g O_2/m^2. Inorganic nitrogen was released to the water column almost totally as ammonia at rates up to 400 $\mu M/m^2$/hr. The total annual flux of inorganic nitrogen (about 870 mM/m^2) was only about half that expected on the basis of oxygen uptake or inorganic phosphate regeneration. The anomalously low inorganic nitrogen flux may be balanced by high rates of dissolved organic nitrogen release from the bottom. Rapid regeneration of inorganic nitrogen by bottom communities plays a major role in maintaining high rates of primary production in coastal waters, but the incomplete metabolism of nitrogen on the bottom may be responsible for the low N/P ratios characteristic of shallow waters and for the importance of nitrogen as a limiting factor in these areas. - J.L.M.

2183
Odum, Howard T. 1957.

Biogeochemical deposition of strontium. Inst. Mar. Sci., Univ. Texas, Publ. 4(2): 38-114.

Reproducibility of the reprecipitation procedure and variation in methods and in skeletal materials were measured with analysis of variance of 48 duplicate analyses of 6 *Venus mercenaria* clam shells. The average error was 5%. In shells of *V. mercenaria* where prismatic and nacreous layers are aragonite, Sr/Ca ratios were not statistically different. In various organs of *Venus* from Morehead City, N.C. the Sr/Ca ratio varied from 3.50 to 2.39. These tissues were permeated by white phosphate deposits, which were separated where possible, but the values are probably affected by that which remained. The ratios are expressed in atoms/1000 atoms. - J.L.M.

2184
Painter, S. D., and M. J. Greenberg. 1978.

Elapid α-toxins have no effect on the cholinergic responses of bivalve myocardia. Experientia (Basel) 34(12): 1608-1609.

Elapid α-toxins do not affect the myocardial nicotinic ACh receptors of *Mercenaria mercenaria*. - J.L.M.

2185
Pfitzenmeyer, H. T., and K. C. Drobeck. 1967.

Some factors influencing reburrowing activity of soft-shell clam *Mya arenaria*. Chesapeake Sci. 8(3): 193-199.

It was concluded that many soft clams, *Mya arenaria*, deposited on the bottom by commercial dredgers, reburrow back into the sediment. *Mercenaria mercenaria* was not mentioned. - J.L.M.

2186
Quin, Louis D. 1965.

The presence of compounds with a carbon-phosphorus bond in some marine invertebrates. Biochemistry 4(2): 324-330.

By a difference in total and phosphate phosphorus, the presence of compounds containing the carbon-phosphorus bond was detected in certain fractions derived from 6 marine invertebrates, including *Venus mercenaria*. *V. mercenaria*, 64 grams wet weight in fraction A had a weight of 1.96 grams, and gave 0.97 g total phosphorus, 0.80 g phosphate, and 0.17 g As C-P including aminoethylphosphonic acid; fractions B+C (the insoluble residue from extraction of fraction A) was 10.1 g by weight, and gave 0.37 total phosphorus, and 0.38 phosphate. Relative amounts of C-P material in marine animals in mg P/100 g dry tissue were *Tealia felina* 410, *Metridium dianthus* 302, *Busycon canaliculatum* 215, *Mytilus edulis* 76, *Asterias forbesi* 32, and *V. mercenaria* 28. *V. mercenaria* apparently had C-P compounds in fraction A only, and 2-aminoethylphosphonic acid was isolated from the hydrolysates. - J.L.M.

2187
Radlick, Lynn, and W. H. Johnson. 1980.

Paramyosin phosphokinase and phosphatase activity in molluscan muscle extracts. Fed. Proc. 39(6): 2042 (abstract 2302).

α-paramyosin extracted from adductor muscles of *Mercenaria mercenaria* contains up to 4 moles of phosphate/mole of paramyosin. Removal of phosphate by treatment at pH 12 increases the solubility of paramyosin in the physiological range. We attempted isolation of paramyosin phosphokinases and phosphatases from *Mercenaria* adductor muscles. Early, low salt washes contain C-AMP dependent phosphatase activity. Ca^{++} dependent activity coprecipitates with paramyosin from high salt (0.7 M KCl) extracts. α-paramyosin purified by modification of the method described by Edwards et al. behaves as if it has intrinsic phosphokinase activity, in that solutions containing paramyosin at concentrations above 1.0 mg/ml show considerable transfer of phosphate from γ^{32}P-ATP to TCA precipitable protein, i.e., purified paramyosin. Attempts to separate this activity from paramyosin have thus far failed. These results suggest the presence of enzymatic activity capable of either phosphorylation of or removal of phosphate from paramyosin in muscles known to have a catch function. - modified authors' abstract - J.L.M.

2188
Rapport, Maurice M., and Nicholas F. Alonzo. 1960.

The structure of plasmalogens. V. Lipids of marine invertebrates. J. Biol. Chem. 235(7): 1953-1956.

Total lipid extracts of tissues from 11 marine invertebrates, including *Venus mercenaria*, were studied for their content of aldehydogenic lipid and α,β-unsaturated ether. In 8 species the unsaturated ether linkage accounted for almost all the plasmalogen, and in three it accounted for 75% to 85%. Only a small proportion of total plasmalogen was found among choline lipids. The concentration of plasmalogen in lipids of many marine invertebrates is as high as that in lipids of mammalian brain (greater than 10% of the total). The most suitable animals for further study appear to be *Arbacia punctulata* and *Busycon canaliculatum*. - J.L.M.

2189
Renzoni, Aristeo. 1975.

Toxicity of three oils to bivalve gametes and larvae. Mar. Pollut. Bull. 6(8): 125-128.

Water soluble extracts of three crude oils, Kuwait, Nigerian, and Prudhoe Bay, were tested on sperm and eggs of *Mulinia lateralis* and *Crassostrea virginica*. Fertilization was depressed and developmental abnormalities sometimes appeared after exposure to these toxins. Spermatozoa, in particular, were very sensitive to water-soluble fractions of these oils. Nigerian crude is particularly toxic. *Mercenaria mercenaria* was not mentioned. - J.L.M.

2190

Rheinberger, Richard, Gerald L. Hoffman, and Paul P. Yevitch. 1979.

The kidney of the quahog *(Mercenaria mercenaria)* as a pollution indicator. In Animals as Monitors of Environmental Pollutants. National Academy of Sciences, Washington, D.C.: 119-129.

Kidneys of quahogs collected from 10 variously polluted areas in Rhode Island were analyzed histochemically, chemically, and histopathologically with methods involving light, electron microscopy, and atomic absorption. The quantity, size, and color of kidney concretions in quahogs *(Mercenaria mercenaria)* from high-pollution areas were different from those collected in areas of low pollution. Analysis of concretions showed a predominance of heavy metals. Interelemental ratios of trace metals depended on various colors of concretions. Metals determined were Mn, Ca, Zn, Cu, Pb, Cd, and Fe. Elemental analysis of concretions and other histopathological features of molluscan kidney may be a convenient method of tagging various heavy metal pollutants in the water sediment environment to which the benthic community is exposed. Quahogs collected at Sabin Point had many more kidney concretions than those collected at Charlestown Pond. - J.L.M.

2191
Rice, T. R., J. P. Baptist, and T. J. Price. 1965.

Accumulation of mixed fission products by marine organisms. Internatl. Conf. Water Pollut. Research, 1964, vol. 3: 263-286.

New information on *Mercenaria mercenaria* not likely in this publication. Could not find in SUNY-Stony Brook library and did not search elsewhere. - J.L.M.

2192
Roberts, H. M., Jr., R. J. Diaz, M. E. Dender, and R. J. Huggett. 1975.

Acute toxicity of chlorine to selected estuarine species. J. Fish. Res. Bd. Canada 32: 2525-2528.

(Reference not correct - could not locate - search terminated) - J.L.M.

2193
Robinson, W. E. 1979.

Digestive processes in subtital *Mercenaria mercenaria* (Linn.). Amer. Zool. 19(776): 1006 (abstract).

Digestive gland tubules were classified into one of four categories, indicative of the state of intracellular digestion. Digestive processes did not correlate with solar day, tidal cycle, salinity, or bottom water temp fluctuations. Patterns of secretion or dissolution of the crystalline style were discerned from either style length measurements, dry weight data, or histological study of the style sac epithelium. Peak numbers of adsorptive phase digestive tubules were found 3 hrs after peak levels of particulate

C, N, or suspended matter in the surrounding water. All 4 tubule types were present in each quahog sampled, showing that some intracellular digestion occurred continually. Similar tubule types were clustered within the gland, but a high degree of overall variability of tubule types was evident. Proper tubule grading and analysis methods are therefore necessary in all studies dealing with the changing morphology of bivalve digestive gland tubules. - J.L.M.

2194
Robinson, W. E., and R. W. Langton. 1980.

Digestion in a subtidal population of *Mercenaria mercenaria* (Bivalvia). Mar. Biol. 58: 173-179.

Hourly sampling of 4 to 5 quahogs was conducted over a 25 hr period in August 1978 at Woods Hole, Mass. Crystalline style length did not vary significantly with time, tide, particulate C, N, or suspended material in the water. Changes in secretory activity of the style sac epithelium were not evident from histological sections. Cellular morphological differences allowed digestive tubules to be classified into one of 4 categories, indicative of state of intracellular digestion within digestive cells. All 4 tubule types were present in each sample hr, signifying that intracellular digestion occurs continually within the digestive gland. A 3 hr time lag is evident between times of peak C, N, or suspended materials and apparent peak levels of absorptive (Type II) tubules. - J.L.M.

2195
Rosser, Robin W., John L. Schrag, Norio Nemoto, John D. Ferry, and Marion Greaser. 1979.

Infinite-dilution viscoelastic properties of two partially flexible macromolecules. J. Rheol. 23(1): 83-84 (abstract A2).

Paramyosin is a rodlike protein extracted from adductor muscle of *Mercenaria mercenaria*. Two solvents were used, of widely different viscosities. Results were matched well by an empirical hybrid relaxation spectrum consisting of one slow loss mechanism, corresponding to end-over-end rotation, together with a series of faster loss processes; the relaxation times of the latter were spaced as in the Zimm theory for the bead-spring model. - J.L.M.

2196
Ryther, J. H., and R. Mann. 1977.

Bivalve mollusk culture in a waste recycling aquaculture system. Rept. 77-59. Dept. Commerce, NOAA, Woods Hole Oceanogr. Inst., Woods Hole, Mass.

Important references to *Mercenaria mercenaria* unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

2197
Ryther, John, Thomas M. Losordo, A. Keith Furr, Thomas F. Parkinson, Walter H. Gutenman, Irene S. Pakkala, and Donald J. Lisk. 1979.

Concentration of elements in marine organisms cultured in seawater flowing through coal-fly ash. Bull. Environm. Contam. Toxicol. 23(1-2): 207-210.

In terms of toxicity the elements of most concern would be arsenic and selenium. These were moderately elevated in *Mercenaria mercenaria* over controls. Arsenic in marine species is present in various organic combinations, which in shrimp have been shown to be largely excreted when fed to rats, as compared to inorganic arsenic which is stored. Selenium, although toxic, is also essential and deficient in the diet of many animals and probably humans. Considering the relatively small proportion of marine species in the typical American diet and the relatively modest increase in selenium concentration in the fly ash-exposed organisms, this would not appear to constitute a hazard. - J.L.M.

2198
Saleuddin, A. S. M. 1976.

Ultrastructural studies on the structure and formation of the periostracum in *Heliosoma* (Mollusca). In The Mechanisms of Mineralization in the Invertebrates and Plants. Norimitsu Watabe and Karl M. Wilbur (eds.). The Belle W. Baruch Library in Marine Science Number 5, Univ. South Carolina Press, Columbia, S. C.: 309-337.

The membrane-like covering which makes up the outermost part of the periostracum in *Heliosoma* is also present in a number of molluscs including *Mercenaria mercenaria* (Neff 1972). In the bivalves, including *Mercenaria*, the periostracum originates in the intercellular space between the basal cell and the neighboring middle fold cell (or equivalent) and as it grows it moves toward the periostracal groove where it thickens. - J.L.M.

2199
Sastry, Bhagavatula R., Susan E. Zialkowski, Loretta M. Hansen, Joanne P. Kavanagh, and Evelyn M. Evoy. 1979.

Acetylcholine release in interpeduncular nucleus following the stimulation of habenula. Brain Research 164: 334-337.

These studies clearly demonstrate a release of ACh-like activity in anaesthetized rats in the interpeduncular nucleus (IPN) following stimulation of the habenulo-interpeduncular pathway (HIP). ACh was assayed with *Mercenaria mercenaria* hearts in one ml baths. The studies strongly indicate that HIP is an ideal pathway to elucidate cholinergic mechanisms in the brain. These results add further strength to the possibility that ACh is a "transmitter" associated with the HIP. - J.L.M.

2200
Schapiro, A. Z., and A. N. Bobkova. 1979.

Effect of some ecological factors on the malate dehydrogenase to lactate dehydrogenase activity ratio. Inst. of the Biology of Southern Seas, Academy of Sciences of Ukrainian SSR. Translated from Ekologiya 6: 68-73, Nov.-Dec. 1978.

The activity of lactate dehydrogenase and malate dehydrogenase was studied in tissues of various hydrobionts, including *Mercenaria mercenaria*, under conditions of hypoxia and changes in salinity. Changes in activity of the enzymes studied with exposure to abiotic factors occurs in different ways. The general result of changes is an increase in the malate dehydrogenase/lactate dehydrogenase ratio which determines the synthesis of succinate as one of the end products of carbohydrate metabolism and the inhibition of lactate formation. The possibility is suggested of using the activity ratio of these enzymes as a criterion for evaluating the state of the environment. - modified authors' abstract - J.L.M.

2201
Schmeer, M. Rosarii (Sister), O.P. 1964.

Chemical and biological characteristics of growth-inhibiting agents from *Mercenaria mercenaria* extracts. II. Biol. Bull. 127(2): 388.

Additional purification on Sephadex G-25 gel columns produces a still partially purified, effective agent that causes regression and inhibition of the Krebs-2 carcinoma in female, 3 to 4 week old, Swiss albino mice. A typical result, using many test animals, gives a control mean tumor weight of 2200 mg, while treated animals had a mean tumor weight of 750 mg. Animals treated to give such three-fold activity received one unit of growth inhibitor each day for 7 full days. The active material is released in distilled water. Varying percentages of water, from less than 1% to 100%, can be used to cause the active principle to enter into the supernatant. Usual methods of preparation, minus treatment with ammonium sulphate, can be used to produce an effective fraction of growth-inhibitor in our bioassay system using Krebs-2 carcinoma. Molecular weight of active principle is somewhat less than 5000. - J.L.M.

2202
Schmeer, Rosarii, Sister, O.P. 1967.

A study of the kinetics of cellular proliferation of the Krebs-2 transplantable solid carcinoma and co-existing duodenum as determined by ^3H-T uptake and autoradiography. Biol. Bull. 133(2): 483 (abstract).

An anticancer principle called mercenene, extracted from the clam *Mercenaria*, causes oncolysis of Krebs-2 (K-2) carcinoma in CF 1 mice. Cytological light and electron microscopy investigations of tumors from treated animals have failed to reveal the agent's mode of anticancer activity. The cellular kinetics of untreated K-2 carcinoma and duodenum were determined by ^3H-T uptake and autoradiography. A total of 184 mice with a palpable four-day-old tumor was used. Each animal received subcutaneously, at time zero, 0.80 μC/g body weight of triated thymidine. Mice were serially sacrificed, three per time interval, from 15 minutes to 24 hr after ^3H-T administration. Autoradiographs of tumor and duodenum sections were prepared and developed after 2 weeks. The mean duration of various phases of the cell cycle is based on mitotic curves derived from the rate of appearance and disappearance of labeled mitoses. For the K-2 carcinoma the mean S period (DNA synthetic time) was 7.5 hrs, G_2 (post-DNA synthesis) 2 hrs, G_1 (pre-DNA synthesis) zero, M (mitosis) 2.5 hrs, and generation time 12.0 hrs. The co-existing duodenum had a cell cycle essentially similar to that of the duodenum of non-tumor bearing mice. The S period was 7.5 hrs, G_2 equalled one hr, G_1 was 7.5 hrs, M was 1.5 hrs, and generation time 15.5 hrs. Presence of tumor does not seem to influence turnover rate of "normal" duodenal population. - J.L.M.

2203
Schmeer, Rosarii Sr. 1967.

Further studies on the utilization of the Krebs-2 carcinoma in an anticancer screening program. J. Cell. Biol. 35(2): 121A (abstract 252).

An anticancer agent, mercenene, has been extracted from *Mercenaria mercenaria*. It is effective against Krebs-2 (K-2) carcinoma in vivo, and HeLa and human amnion cells in vitro. Effective crude extracts are prepared by homogenizing the whole clam. The active agent may have a glycopeptide-type structure, possibly associated with a small proportion of protein. K-2 ascites cells were injected subcutaneously in the right axillary region of 4 to 6 week old female CF 1 mice. After a 7-day dosage schedule of the extract, tumors were excised and weighed. The agent caused a 3 to 4 fold regression of tumor as compared with controls. Cytological investigations of similar groups of treated mice, 6 months after termination of treatment, showed complete absence of tumor cells. The cell cycle of transplantable, solid K-2 tumor was determined by ^3H-T uptake and by radioautography. DNA synthetic time, S, was 7.5 hr; G_2, post-DNA synthetic time, was 2 hr; G_1, pre-DNA synthetic time, was zero; and M, the mitosis phase, was 2.5 hr. Total cell cycle equals 12.0 hr. - J.L.M.

2204
Schmeer, Arline C., Sister O.P. 1969.

Mercenaria *clam liver extracts: influence of the HeLa S3 cell cycle.* Biol. Bull. 137(2): 385 (abstract).

An in vitro autoradiographic study was begun to determine if *Mercenaria* clam liver extracts (mercenene) had any influence on cytokinetics of a HeLa S3 asynchronous cell population and to learn if these extracts were catabolized in vitro. The data suggest that G_2 (post-DNA synthetic time) cells progress into mitosis with a diminished rate with a lag in the entire curve. Cells in S progress into G_2 at a normal rate. DSI for control and experimental cultures was not significantly different. This suggests no direct effect on DNA synthesis. Data indicate catabolism of mercenene in vitro. Since inhibition in G_2 has been recorded, it is now possible to determine the mechanism involved in inhibition of new transcriptions observed in HeLa cell population exposed to clam liver extracts. - J.L.M.

2205
Schmeer, A. C. 1978.

Marine medicinal factor, mercenene: Biological activity, extraction procedures and chemical characterization. Fed. Proc. 37(3): 317 (abstract 563).

Among the most promising animals with anticancer, antibacterial, and antiviral activity is the clam *Mercenaria mercenaria*. Hydrophilic components are extracted by standard ammonium sulfate precipitation and dialysis to obtain crude samples. Organic solvents are used to collect biologically active compounds that may be among a new family of agents related to those that are water soluble. Samples prepared by both methods of extraction prolong the life of BDF1 mice implanted with P388 lymphocytic leukemia by at least 50%. Various types of liquid chromatography and thin layer chromatography (TLC) have been employed to identify the various components. Ultraviolet spectroscopy absorption is observed at 280, 260, and 253 nanometers, respectively. Elemental analysis results in a relatively low molecular weight compound of C, H, N, and O that has little or no toxicity in experimental animals. - modified author's abstract - J.L.M.

2206
Schmeer, A. C. 1979.

Chemical characterization and biological activity of an anticancer agent of marine origin. Physiol. Chem. Physics 11(5): 415-424.

The mercenene anticancer principle(s) from *Mercenaria mercenaria* are temperature dependent. Clams from polluted marine sites have spontaneous neoplasms (4 confirmed cancers in 10,000 clams) but in over 100,000 clams taken from approved, licensed beds not one neoplasm has been cytologically confirmed. Clams from unpolluted sites are biologically active and contain the mercenene anticancer factor, those from polluted areas lack the mercenene effect. The whole body of the youngest animal, the little neck, has the greatest concentration of biological activity, which probably is related to the metabolism of the young clam. Extracts from all ages of *Mercenaria* demonstrated some anticancer activity in experimental tumorous mice. Fresh material is best. Some deleterious chemical change occurs in cold storage. The presence of carbohydrate, phosphate, peptide, and unidentified material was indicated in the biologically active components. Studies completed at the National Institutes of Health and the National Cancer Institute document the effectiveness of mercenene clam extracts against bacteria and viruses, while retaining antineoplastic activity. Any substance having a 3-pronged therapeutic advantage merits intensive further study. - J.L.M.

2207
Schmeer, M. Rosarii, and Charles G. Wilber. 1965.

Mercenene: Growth-inhibitor extracted from natural products. Fed. Proc., Fed. Am. Soc. Exp. Biol. 24(1): 403 (abstract 1514).

Extracts from edible molluscs have shown an inhibiting and regressing activity on sarcoma-180 and Krebs-2 carcinoma tumor in Swiss mice. Of all species of mollusc studied, *Mercenaria mercenaria* was the most promising source of mercenene. The active agent, in crude form, can be extracted with water, ammonium sulphate, and organic solvents. Additional purification, using gel filtration, produces a partially purified, effective active principle that demonstrates growth-inhibitor activity on Krebs-2 carcinoma in female, 3 to 4 week old CF_1 mice. Bioassay produces a typical mean control tumor weight of approximately 2200 mg. Animals receiving mercenene for 7 days may have a mean tumor weight of 750 mg. The greatest concentration of growth-inhibitor occurs in void volume 2 to 3 (V_O 2 to 3) using sintered glass column 20 mm x 400 mm, Sephadex G-25, and eluant of 0.1 M NaCl or other suitable eluting material. Molecular weight of active principle, mercenene, is less than 1000. - J.L.M.

2208
Scott, Geoffrey I., and Winona B. Vernberg. 1979.

Seasonal effects of chlorine produced oxidants on the growth, survival and physiology of the American oyster, *Crassostrea virginica* (Gmenlin). In Marine Pollution: Functional Responses. Winona B. Vernberg, Frederick P. Thurberg, Anthony Calabrese, and F. John Vernberg (eds.). Academic Press, New York: 415-435.

Exposure to chlorination for 48 hrs is very toxic to *Mercenaria mercenaria* larvae. The 48 hr EC_{50} was less than 0.006 mg/liter for larval clams. (Abstracter's note: Gmenlin in the title is a misprint for Gmelin.) - J.L.M.

2209
Shumway, Sandra E. 1977.

The effect of fluctuating salinity on the tissue water content of eight species of bivalve molluscs. J. Comp. Physiol.-B 116(3): 269-285.

Normal *Mercenaria mercenaria* showed no significant changes in tissue water level when exposed either to a gradual or an abrupt change in salinity. Wedged-open specimens showed greater changes in tissue water content than normal animals. - J.L.M.

2210
Sica, D. 1980.

Sterols from some molluscs. Comp. Biochem. Physiol. 65B(2): 407-410.

Species examined were *Purpura haemastoma* and *Murex trunculus*, both gastropods, and *Loligo vulgaris*, a cephalopod. *Mercenaria mercenaria* was not included. - J.L.M.

2211
Simkiss, K. 1976.

Intracellular and extracellular routes in biomineralization. In Calcium in Biological Systems. Symposia of the Society for Experimental Biology XXX, Cambridge Univ. Press, London: 423-444.

In the clam *Mercenaria mercenaria* there are small calcium-rich granules in intercellular spaces and in microvilli and apical cytoplasm of mantle cells (Neff 1972). Calcium ions move across this tissue towards the shell, during calcification, and away from the shell during periods of anaerobic acidosis. Evidence from studies on *Mercenaria* suggests that granules present in intercellular spaces could influence the composition of extracellular fluids. - J.L.M.

2212
Simkiss, K. 1976.

Cellular aspects of calcification. In The Mechanisms of Mineralization in the Invertebrates and Plants. Norimitsu Watabe and Karl M. Wilbur (eds.). The Belle W. Baruch Library in Marine Science Number 5, Univ. South Carolina Press, Columbia, S.C.: 1-31.

The inorganic components of the extrapallial fluid of *Mercenaria mercenaria* in meq/liter were: Na 444, K 9.6, Ca 23.6, Mg 120, Cl 472, SO_4 46.1, CO_2 5.2mM, and pH 7.33; in dialyzed *M. mercenaria* they were: Na 427, K 9.0, Ca 20.3, Mg 110, Cl 492. Comparisons of extrapallial and blood pH values were: extrapallial fluid 7.37 to 7.33, blood 7.52; valves closed and calcification occurring: extrapallial fluid 7.0 to 7.2, blood 7.52; in other words the extrapallial fluid is slightly more acidic than blood. In *M. mercenaria*, Neff (1972) has demonstrated the presence of microgranules in the intercellular space of the mantle cells. The intercellular space opens by a leaky junction onto the epithelial surface associated with mineralization. The granules are only 100 to 200 A in size and thus likely to have abnormally high solubility characteristics. It is easy to envisage how this junction could regulate the efflux of ions from the "supersaturated" solutions in the intercellular spaces onto the mantle surface. One can also imagine how this "high calcium" solution on the lateral surfaces of the cells might increase the influx of calcium into the cells and thus lead to an anomalous accumulation of mitochondrial calcium during mineralization. More data on potentials and diffusion mechanisms across such layers are needed. - J.L.M.

2213
Sinclair, J. G., and G. F. Lo. 1978.

Acute tolerance to ethanol on *in vivo* release of acetylcholine. Cdn. J. Pharmaceut. Sci. 13(4): 100 (abstract).

ACh released from cortex of cat was assayed biologically using the heart of the clam *Mercenaria mercenaria*. Ethanol produced a peak depression of ACh release within 30 min but recovered to control levels in the following 30 min. Concentrations of ethanol in blood and in solution bathing the cortex remained stable during this recovery period. Thus acute tolerance to ethanol on the release of ACh does develop, and may be related to the acute tolerance that develops to the behavioral effects of ethanol. - J.L.M.

2214
Sipos, J. C., and R. G. Ackman. 1978.

Automated and rapid quantitative analysis of lipids with chromarods. J. Chromatographic Sci. 16(10): 443-447.

Lipid extract of a live-held northern quahog (*Venus mercenaria*) showed the following composition: 90% polar lipids, 3% sterol, 5% triglycerides, 2% cholesteryl esters, and 1% hydrocarbons. - J.L.M.

2215
Smith, J. N. 1977.

Comparative detoxication of invertebrates. In Drug Metabolism - from Microbe to Man. D. V. Parke and R. L. Smith (eds.). Taylor and Francis Ltd., London: 219-232.

Reduction of *p*-nitrobenzoic acid has been observed in the quahog *Mercenaria mercenaria* (Carlson 1972). - J.L.M.

2216
Stafford, Walter F., III, and Andrew G. Szent-Gyorgyi. 1978.

Physical characterization of myosin light chains. Biochem. 17(4): 607-614.

Reports the results of an investigation into the size and shape of the low molecular weight subunits (light chains) of myosin from several animal species. Hydrodynamic, analytical gel filtration, and fluorescence anisotropy decay measurements showed that these light chains could be represented by a general ellipsoidal model having a longest axis of about 100±20 A. Investigation into the stability of the internal structure of the light chains shows them to be very stable, and probably is characteristic of the light chains when they are attached to myosin. - J.L.M.

2217
Steinberg, Marian N. 1980.

A preliminary system dynamics model of the effectiveness of shellfish hatcheries on increasing harvestable yields. Proc. IEEE, 1980: 895-900.

The paper presents the first in a series of systems dynamics models examining the effect of fishing on the hard clam *(Mercenaria mercenaria)* resource which is also eaten by a predator, and is reinforced by addition of artificially reared clams. Clams are divided into five levels, from larvae to chowder clams. Predators contain only one level, a generalized predator on juveniles. In addition to the prey-predator relationship, heavy fishing pressure and hatchery operations are simulated in the model. The model suggests that seeding has no significant impact on harvestable yields, but instead increases the predator population. Unless predation is controlled, subsidization of hatcheries does not appear to be warranted. - J.L.M.

2218
Sutcliffe, W. H., Jr., K. Drinkwater, and B. S. Muir. 1977.

Correlations of fish catch and environmental factors in the Gulf of Maine. J. Fish. Res. Bd. Canada 34(1): 19-30.

A two-year lag for commercial catch of this species seems reasonable (r = 0.805). Recently, most hard clams harvested are near the lower size limit in Maine (5.1 cm), and approximate two-year olds. Correlation of hard clam catches with temperature two years previously appears quite good, and the month chosen appears reasonable (August). Three-year running means were used. Results should be used with caution. - J.L.M.

2219
Swinehart, James H., and Kenneth W. Smith. 1979.

Iron and manganese deposition in the periostraca of several bivalve molluscs. Biol. Bull. 156(3): 369-381.

Species examined were the freshwater molluscs *Anodonta californiensis* and *Unio novahollandae* and the marine mollusc *Mytilus californianus*. *Mercenaria mercenaria* was not mentioned. - J.L.M.

2220
Sykes, J. E. 1971.

Implications of dredging and filling in Boca Ciega Bay, Florida. Environ. Lett. 1: 151-156.

Important references to *Mercenaria mercenaria* unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

2221
Szent-Gyorgyi, A. G. 1976.

Comparative survey of the regulatory role of calcium in muscle. In Calcium in Biological Systems. Symposia of the Society for Experimental Biology XXX, Cambridge Univ. Press, London: 335-347.

Contraction of all muscles so far studied is triggered and controlled by calcium ions. The calcium binding protein has a significantly higher molecular weight (22,000 daltons) than the parvalbumins present in vertebrate muscles, and also contains tryptophan and tyrosine residues. Molluscan muscles lack troponin components, but it is possible that some components of troponin, possibly in altered form, are synthesized in these muscles. Desensitized scallop myofibrils combine with great affinity with regulatory light chains of *Mercenaria* myosins. These light chains retain a similar binding site to the heavy chains of scallop myosin, indicating that these sites on the heavy chains and light chains have been conserved during evolution. In addition to these invariant sites, there are calcium dependent interactions between heavy chains and regulatory light chains that correspond to the "on" and "off" states of myosin. - J.L.M.

2222
Taylor, J. D., N. J. Kennedy, and A. Hall. 1969.

The shell structure and mineralogy of the Bivalvia. Introduction, Nuculacea-Trigonacea. Bull. Br. Mus. Nat. Hist., Zool., Suppl. 3: 1-125.

Missing from SUNY-Stony Brook library and apparently lost. Did not search further. - J.L.M.

2223
Terry, Orville W. 1977.

Aquaculture. MESA New York Bight Atlas Monograph 17, New York Sea Grant Institute, Albany, N.Y., 36 p.

Hard clams, *Mercenaria mercenaria*, are being cultured commercially on Long Island, N.Y. Present culture of hard clam is being built around hatchery technology. Bivalve hatchery technology is still in a state of flux, and costs are an ever present problem. The author, however, is optimistic about the final result. - J.L.M.

2224
Travis, Dorothy F., and Mary Gonsalves. 1969.

Comparative ultrastructure and organization of the prismatic region of two bivalves and its possible relation to the chemical mechanism of boring. Am. Zool. 9(3): 635-661.

The structural components of the organic matrixes of the prismatic and nacreous layers in at least three bivalves, *Mytilus edulis*, *Crassostrea virginica*, and *Mercenaria mercenaria*, are similar. The framework of the organic matrix in mussel and oyster, and presumably also clam, which fails to mineralize in these heavily calcified, molluscan substrates, may provide the *primary* rather than the *secondary* source of chemical attack during boring, for once the sheaths and compartments surrounding the crystals are broken down or solubilized, the crystals are themselves loosened and freed for mechanical removal by shell-penetrating organisms. Only mussel and oyster are discussed here, but presumably *Mercenaria* is much the same, and the excellent drawings show the details. - J.L.M.

2225
Travis, Dorothy F., Camille J. Francois, Laurence C. Bonar, and Melvin J. Glimcher. 1967.

Comparative studies of the organic matrices of invertebrate mineralized tissues. J. Ultrastructure Research 18(5-6): 519-550.

The shell proteins of *Mercenaria mercenaria* were distinguished by their relatively high concentrations of aspartic acid, serine, proline, and glycine, which together accounted for roughly 50% of the total amino acid residues. Except for the collagens and enamel proteins, the concentrations of proline (10 to 12%) in these proteins is among the highest reported. As with the other molluscan shell protein, the absence of hydroxyproline and the X-ray diffraction data are consistent with the electron microscopic findings that collagen represents only a very minor matrix constituent. - J.L.M.

2226
Voogt, P. A. 1972.

Lipid and sterol components and metabolism in mollusca. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.). Academic Press, New York: 245-300.

Quin (1965) mentions the occurrence of aminoethylphosphonic acid in *Venus mercenaria*. Rapport and Alonzo (1960) showed the presence of plasmalogens to rather high values in *Venus mercenaria*. They also showed that only a small portion of total plasmalogens occurs in the choline-containing lipids. - J.L.M.

2227
Weiner, S., H. A. Lowenstam, and L. Hood. 1977.

Discrete molecular weight components of the organic matrices of mollusc shells. J. Exp. Mar. Biol. Ecol. 30(1): 45-51.

Discrete molecular weight components account for only a small part of the protein content of the soluble fraction. For example, discrete molecular weight bands of the soluble fraction of *Mercenaria mercenaria* on electrophoresis on 10% SDS polyacrylamide gels were eluted from the gel with 0.01% SDS. The protein content, as estimated from an amino-acid analysis, of the most prominent bands accounted for about 10% of the total protein loaded on the gel. The remaining protein fraction of *M. mercenaria* is composed of very high molecular weight components which do not enter the 5% polyacrylamide at the top, and lower molecular weight components which enter the gel and form a dense background of nondiscrete molecular weight material. Since the organic matrix of most species examined resembles *M. mercenaria* in this respect, it is thought that the protein content of the discrete molecular weight components constitutes only a small part of the soluble fraction protein, so that the degree of heterogeneity of these samples is probably much greater than the sum of the observed components. The discrete molecular weight constituents from the organic matrices of species of the same genus are most similar. The presence of these components shows that organic matrices are heterogeneous and presumably capable of performing diverse functions. - J.L.M.

2228
Wilbur, Karl M. 1972.

Shell formation in molluscs. In Chemical Zoology. VII. Mollusca. Marcel Florkin and Bradley T. Scheer (eds.). Academic Press, New York: 103-145.

Crenshaw (1971) found that mucopolysaccharide accounts for about 1/5 of the dry weight of the non-dialyzable material in extrapallial fluid of *Mercenaria*, the remainder being protein. Extrapallial fluids of *Mercenaria* were slightly alkaline, mean pH range being 7.33 to 7.41. When valves were closed pH decreased slightly (Wilbur 1964). Extrapallial fluid is probably saturated with respect to calcite and aragonite (Crenshaw 1971a). Ionic concentrations of extrapallial fluid and blood in *Mercenaria* are not identical with *Anodonta* (Crenshaw 1971c). Exposure to air gives some precipitation of calcium carbonate in extrapallial fluid of *Mercenaria* (Crenshaw 1971a). If residues in matrix of *Mercenaria* occur as glutamine and asparagine, Ca^{++} could not be bound to them (Crenshaw 1971b). In the second mechanism Ca^{++} would be selectively bound to a highly sulfated glycoprotein as in *Mercenaria* (Crenshaw 1971b). One of the striking features of *Mercenaria* and other molluscan shells is its growth by increments (Pannella and McClintock 1968; Pannella et al. 1968). Shell growth in *Mercenaria* is a two-way process, adding material when the shell is open, turning it over when the shell is closed (Crenshaw and Neff 1969). Changes in extrapallial fluid have been described during closure of the valves. Succinic acid makes up most of the organic acids in *Mercenaria*, lactic acid only about 2%. Equilibrium was not reached in *Mercenaria* for several hours, as shown by sampling extrapallial fluid with a catheter inserted through a hole in the shell (Goddard 1966; Crenshaw and Neff 1969). *Mercenaria* is normally aragonitic and deposits only aragonite on regeneration (Wilbur 1964). In *Mercenaria* the aragonitic prismatic and nacreous layers have a similar Sr/Ca ratio (Odum 1957). - J.L.M.

2229
Wilbur, Karl M. 1976.

Recent studies of invertebrate mineralization. In The Mechanisms of Mineralization in the Invertebrates and Plants. Norimitsu Watabe and Karl M. Wilbur (eds.). The Belle W. Baruch Library in Marine Science Number 5, Univ. South Carolina Press, Columbia, S.C.: 79-108.

From the soluble fraction of shell protein in *Mercenaria mercenaria* Crenshaw (1972) isolated a glycoprotein with high aspartic and glycine content which specifically binds Ca. A possible method of binding may be chelation of Ca by ester sulfate groups from two adjacent polysaccharide chains. The glycoprotein is thought to initiate crystal formation by acting as a nucleating factor by releasing Ca, thus bringing about a local increase in concentration and the precipitation of mineral. Our understanding of the manner in which crystals of $CaCO_3$, together with organic material form a molluscan shell, has been advanced considerably recently. The literature has been reviewed by Taylor et al. 1969; Kennedy et al. 1970; Gregoire 1972; and Wilbur 1972. - J.L.M.

2230
Wilkes, D. A., and M. A. Crenshaw. 1979.

Formation of a dissolution layer in molluscan shells. Scanning Electron Microscopy 2: 469-474.

Mercenaria mercenaria has been an excellent experimental animal for demonstrating that the shell is dissolved by acid produced when the animal metabolizes anaerobically. When the clam is removed from water its valves remain closed tightly to prevent significant gas exchange with the air. Therefore, there is a high and positive correlation between time out of water and the amount of shell solution and the extent to which the dissolution layer is developed. The two foci of shell solution are located under areas of greatest tissue mass in the muscle. This is the area within the pallial line. The inner shell surface outside the pallial line does not appear to be part of the alkali reserve that buffers anaerobically produced acid. It may reflect a functional zonation in the mantle. Or sufficient oxygen may diffuse between the closed shell margins to allow the mantle edge to continue aerobic metabolism. - J.L.M.

2231
Wilkins, N.(?) P. 1975.

Phospho glucose isomerase in marine mollusks. In Isozymes. IV. Genetics and Evolution. Clement L. Markert (ed.). Third Internatl. Conf., New Haven, Conn., USA, April 18-20, 1974. Academic Press, New York: 931-943.

Could not locate. Search terminated. - J.L.M.

2232
Wiltse, W. I. 1980.

Effects of *Polinices duplicatus* (Gastropoda: Naticidae) on infaunal community structure at Barnstable Harbor, Massachusetts, USA. Mar. Biol. 56(4): 301-310.

Predation and disturbance by snails lowered community diversity by removing individuals of the less abundant species, and generally maintained population densities below the level where strong competition would occur. *Mercenaria mercenaria* ranked fairly low in abundance in all treatments. The snails showed strong preferences for thin-shelled bivalves, especially *Mya arenaria*. - J.L.M.

2233
Woelke, C. E. 1960.

The effects of spent sulfite waste liquor on the development of eggs and larvae of two marine molluscs and three of their food organisms. Wash. Dept. Fish. Resources, Bull. 6: 86-106.

Major reference to *Mercenaria mercenaria* unlikely. Did not search beyond SUNY-Stony Brook library. - J.L.M.

Index

A

B

C

D

E

G

H

I

J

K

M

N

O

Q

R

S

T

U

X

Y

* GPO 594 - 474 1982

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