



2,5-2510.0





# NOAA Technical Report NMFS SSRF-632

U.S. DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
National Marine Fisheries Service

## An Annotated Bibliography of Attempts to Rear the Larvae of Marine Fishes in the Laboratory

ROBERT C. MAY



## NOAA TECHNICAL REPORTS

### National Marine Fisheries Service, Special Scientific Report--Fisheries Series

The major responsibilities of the National Marine Fisheries Service (NMFS) are to monitor and assess the abundance and geographic distribution of fishery resources, to understand and predict fluctuations in the quantity and distribution of these resources, and to establish levels for optimum use of the resources. NMFS is also charged with the development and implementation of policies for managing national fishing grounds, development and enforcement of domestic fisheries regulations, surveillance of foreign fishing off United States coastal waters, and the development and enforcement of international fishery agreements and policies. NMFS also assists the fishing industry through marketing service and economic analysis programs, and mortgage insurance and vessel construction subsidies. It collects, analyzes, and publishes statistics on various phases of the industry.

The Special Scientific Report—Fisheries series was established in 1949. The series carries reports on scientific investigations that document long-term continuing programs of NMFS, or intensive scientific reports on studies of restricted scope. The reports may deal with applied fishery problems. The series is also used as a medium for the publication of bibliographies of a specialized scientific nature.

NOAA Technical Reports NMFS SSRF are available free in limited numbers to governmental agencies, both Federal and State. They are also available in exchange for other scientific and technical publications in the marine sciences. Individual copies may be obtained (unless otherwise noted) from NOAA Publications Section, Rockville, Md. 20852. Recent SSRF's are:

586. The Trade Wind Zone Oceanography Pilot Study. Part VII: Observations of sea birds March 1964 to June 1965. By Warren B. King. June 1970, vi + 136 pp., 36 figs., 11 tables.
591. A bibliography of the lobsters, genus *Homarus*. By R. D. Lewis. January 1970, i + 47 pp.
592. Passage of adult salmon and trout through pipes. By Emil Slatick. January 1970, iii + 18 pp., 8 figs., 12 tables.
594. Seasonal and areal distribution of zooplankton in coastal waters of the Gulf of Maine, 1967 and 1968. By Kenneth Sherman. July 1970, iii + 8 pp., 6 figs., 3 tables.
595. Size, seasonal abundance, and length-weight relation of some scombrid fishes from southeast Florida. By Grant L. Beardsley, Jr., and William J. Richards. May 1970, iii + 6 pp., 5 figs., 2 tables.
596. Fecundity, multiple spawning, and description of the gonads in *Sebastes*. By John S. MacGregor. March 1970, iii + 12 pp., 6 figs., 7 tables.
597. Fur seal investigations, 1967. By Bureau of Commercial Fisheries Marine Mammal Biological Laboratory. March 1970, vii + 104 pp., 31 figs., 79 tables.
599. Diagnostic characters of juveniles of the shrimps *Penaeus aztecus aztecus*, *P. duorarum duorarum*, and *P. brasiliensis* (Crustacea, Decapoda, Penaeidae). By Isabel Perez Farfante. February 1970, iii + 26 pp., 25 figs.
600. Birectilinear recruitment curves to assess influence of lake size on survival of sockeye salmon (*Oncorhynchus nerka*) to Bristol Bay and forecast runs. By Ralph P. Silliman. March 1970, iii + 9 pp., 13 figs., 2 tables.
601. Effect of flow on performance and behavior of chinook salmon in fishways. By Clark S. Thompson. March 1970, iii + 11 pp., 8 figs., 3 tables.
602. Biological characteristics of intertidal and freshwater spawning pink salmon at Olsen Creek, Prince William Sound, Alaska, 1962-63. By John H. Helle. May 1970, iii + 19 pp., 11 figs., 5 tables.
603. Distribution and abundance of fish in the Yakima River, Wash., April 1957 to May 1958. By Benjamin G. Patten, Richard B. Thompson, and William D. Gronlund. June 1970, iii + 31 pp., 26 figs., 37 tables.
604. The flora and fauna of a basin in central Florida Bay. By J. Harold Hudson, Donald M. Allen, and T. J. Costello. May 1970, iii + 14 pp., 2 figs., 1 table.
605. Contributions to the life histories of several penaeid shrimps (Penaeidae) along the south Atlantic Coast of the United States. By William W. Anderson. May 1970, iii + 24 pp., 15 figs., 12 tables.
606. Annotated references on the Pacific saury, *Cololabis saira*. By Steven E. Hughes. June 1970, iii + 12 pp.
607. Studies on continuous transmission frequency modulated sonar. Edited by Frank J. Hester. June 1970, iii + 26 pp. 1st paper, Sonar target classification experiments with a continuous-transmission Doppler sonar, by Frank J. Hester, pp. 1-20, 14 figs., 4 tables; 2d paper, Acoustic target strength of several species of fish, by H. W. Volberg, pp. 21-26, 10 figs.
608. Preliminary designs of traveling screens to collect juvenile fish. July 1970, v + 15 pp. 1st paper, Traveling screens for collection of juvenile

Continued on inside back cover.



U.S. DEPARTMENT OF COMMERCE

Maurice H. Stans, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Robert M. White, Administrator

NATIONAL MARINE FISHERIES SERVICE

Philip M. Roedel, Director

NOAA Technical Report NMFS SSRF-632

**An Annotated Bibliography of  
Attempts to Rear the Larvae of  
Marine Fishes in the Laboratory**

ROBERT C. MAY



SEATTLE, WA.

August 1971





## CONTENTS

	Page
Introduction .....	1
Bibliography .....	2
Appendix I. Species of marine fishes used in laboratory rearing attempts .....	16
Appendix II. Foods used in attempts to rear the larvae of marine fishes .....	20



# An Annotated Bibliography of Attempts to Rear the Larvae of Marine Fishes in the Laboratory

By

ROBERT C. MAY

Scripps Institution of Oceanography  
University of California, San Diego  
La Jolla, California 92037

## ABSTRACT

A bibliography has been compiled of papers which describe attempts to rear the larvae of marine fishes in the laboratory, covering the period 1878 to 1969. Annotations summarize each paper, and appendixes list the species of fishes studied and the types of food used in the attempts to rear them.

## INTRODUCTION

The past few years have seen a resurgence of interest in rearing marine fishes under laboratory conditions. The literature pertaining to this subject, however, is widely scattered and in some cases relatively inaccessible. The present annotated bibliography was prepared as an aid to researchers desiring a source of references to, and quick summary of, previous attempts to rear the larvae of marine fishes in the laboratory.<sup>1</sup> It includes all papers which have been found, after an extended search of the literature, describing attempts to rear larval marine fishes under laboratory conditions, from 1878 through 1969. Certain papers (mostly recent ones concerned with larval behavior and physiology), whose rearing methods are described in greater detail by the same authors in other papers, are excluded.

<sup>1</sup> The bibliography was originally assembled for the benefit of workers at the Bureau of Commercial Fisheries (now National Marine Fisheries Service) Fishery-Oceanography Center in La Jolla, where an extensive program of research on larval fishes has developed. The author was supported by a Bureau of Commercial Fisheries Predoctoral Fellowship during the preparation of this manuscript.

Appendix I lists by families all fish species studied in the papers included in the bibliography. Since the choice of a suitable larval food appears to be one of the most important prerequisites for successful rearing, Appendix II lists the types of food whose use is described in these papers. Appendix II is taken, with a few additions, from May (California Cooperative Oceanic Fisheries Investigations Reports 14: 76-83, 1970), where detailed discussions of the different food types will be found.

For each paper, annotations are given under as many of the following headings as the information supplied by the original author permits.

**FISH STUDIED:** The currently accepted genus, species, author and family of the fish are given.

**FOODS:** (+) indicates that the preceding food was taken by the larvae, (—) indicates that the food was not taken, and (?) indicates that the author does not say whether the food was taken.

**CONTAINERS:** The volume and material, and occasionally the shape, of the rearing containers are given, and if circulating or periodically

renewed rather than static water was used, this is noted.

**TEMPERATURE:** The temperature or range of temperatures to which larvae were exposed during rearing is given; temperatures separated by commas or by the word *and* indicate that separate rearing attempts were carried out at different temperatures.

**MAXIMUM TIME KEPT:** Unless otherwise noted, this refers to the maximum time the larvae were kept alive after hatching. The values given under this heading may have different meanings in different papers, since in some cases the experiments ended due to death of all the larvae while in others the experiments were terminated purposely by the experimenters, and occasionally it is impossible to tell from the reports whether they were terminated purposely or not. For further information on this point, the original papers must be consulted.

**MAXIMUM LENGTH REACHED:** The length at the maximum time that larvae were kept is given, unless otherwise noted. The range of lengths attained is given where possible. TL denotes total length, SL standard length (i.e., measured to the tip of the notochord), and the absence of TL or SL indicates that the author does not state how the lengths were measured.

**SURVIVAL:** The percentage of hatched larvae surviving a specified length of time, or past a specified stage, is given. If not otherwise noted, the survival value refers to the percentage of larvae alive at the end of the experiment as indicated under **MAXIMUM TIME KEPT**.

**REMARKS:** These are self-explanatory.

## BIBLIOGRAPHY

ANTHONY, R. The cultivation of the turbot. 1910. Proceedings of the 4th International Fishery Congress, Washington, 1908, Pt. 2, Bull. U.S. Bur. Fish. 28: 861-870. (Translation.)

**FISH STUDIED:** *Scophthalmus maximus* (L.), Bothidae.

**FOOD:** Wild plankton (+).

**CONTAINERS:** 50-liter glass jars with rotating discs, part of water renewed daily.

**TEMPERATURE:** 18°-20° C.

**MAXIMUM TIME KEPT:** 20 days + (?).

**SURVIVAL:** 90% passed yolk absorption.

BARDACH, JOHN E. The status and potential of aquaculture, particularly fish culture. Vol. 2, Part III, Fish Culture. Amer. Inst. Biol. Sci., Wash., D.C. 225 p. [P. 22-29 of this work describe the rearing experiments of G. O. Schumann.]

**FISH STUDIED:** *Scomber japonicus* Houttuyn, Scombridae.

**FOODS:** Wild plankton (+); *Artemia* nauplii given to older larvae.

**CONTAINERS:** 19,000 liters (500 gal).

**MAXIMUM TIME KEPT:** 6 months +.

**MAXIMUM LENGTH REACHED:** 200 mm fork length at 6 months.

**REMARKS:** Food was collected at night with a submersible pump and a light to attract plankton. More than 20 other species of fishes were reared using these methods, but detailed descriptions of the work are not available.

BISHAI, H. M. Rearing fish larvae.

1961. Bull. Zool. Soc. Egypt 16: 4-29.

**FISH STUDIED:** *Clupea harengus* L., Clupeidae.

**FOODS:** *Artemia* nauplii (+), *Tigriopus fulvius* nauplii (+), copepods (?), phytoplankton ("*Chlamydomonas*, *Nitzschia*, etc.") (+), liver of shore crab (*Carcinus maenas*) (?); rearing aquaria prepared by stocking with *Artemia*, *Tigriopus* and "other copepods," and attached algae; food introduced from a "food supply tank" containing algae and copepods including *Tigriopus*.

**CONTAINERS:** 64-liter, concrete; water filtered, and renewed every 3 days; various other containers used in some experiments.

**TEMPERATURE:** 13°-15° C.

**MAXIMUM TIME KEPT:** 21 days.

**MAXIMUM SIZE REACHED:** 12 mm.

**SURVIVAL:** 0.

**REMARKS:** Not kept beyond "critical stage" on phytoplankton alone.

BLAXTER, J. H. S. Herring rearing—IV. 1962. Rearing beyond the yolk-sac stage. Mar. Res. Scot. 1962 (1): 18 p.

FISH STUDIED: *Clupea harengus* L., Clupeidae.  
FOODS: Commercial fish fry food (?); *Asterias* eggs (?); cultures of *Chlamydomonas* (?), *Nitzschia* (?), *Dunaliella* (?), *Chlorella* (?), and *Skeletonema* (?); *Artemia* nauplii (+); *Balanus nauplii* (+); *Tigriopus* "young stages" (?); *Tisbe* (?); *Anguillicula* (?).

CONTAINERS: 50-liter glass (painted black) or "perspex"; 2000-liter fiberglass; circulating water.

TEMPERATURE: 7°-8° and 11° C.

MAXIMUM TIME KEPT: 78 days at 7°-8° C, 91 days at 11° C.

MAXIMUM LENGTH REACHED: 33 mm.

SURVIVAL: ca. 50% passed yolk-absorption, none reached metamorphosis.

REMARKS: "No real success" with any food except *Balanus nauplii*; *Artemia* nauplii were given from day 40-50 on, due to unavailability of *Balanus nauplii*.

BLAXTER, J. H. S. Rearing herring larvae 1968. to metamorphosis and beyond. J. Mar. Biol. Ass. U.K. 48: 17-28.

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOODS: *Balanus nauplii* (+) and wild plankton (+), *Artemia* nauplii (+) when plankton scarce; *Artemia* alone (+); *Tigriopus fulvus* (+) and other foods given to advanced larvae.

CONTAINERS: 200-liter black "Darvic"; 1500-liter fiberglass for older larvae; circulating water in most experiments, "semi-static" water in some (i.e., 20 liters renewed daily in each 200-liter tank).

TEMPERATURE: 7°-14° C.

MAXIMUM TIME KEPT: 182 days on wild plankton plus *Balanus nauplii*.

MAXIMUM LENGTH REACHED: 25 mm on *Artemia* alone, 44-77 mm on wild plankton plus *Balanus nauplii*.

SURVIVAL: On wild plankton plus *Balanus nauplii*: 25-35% through yolk-absorption, 1-4% through metamorphosis; on *Artemia* alone: 16-28% through yolk-absorption, none past metamorphosis.

REMARKS: Natural plankton was used when *Balanus nauplii* no longer available.

BLAXTER, J. H. S. Experimental rearing of 1969. pilchard larvae, *Sardina pilchardus*. J. Mar. Biol. Ass. U.K. 49: 557-575.

FISH STUDIED: *Sardina pilchardus* (Walbaum), Clupeidae.

FOODS: Wild plankton, from both inshore and offshore collections (+); cultures of *Chlamydomonas* sp. (+), *Dunaliella primolecta* (+), *Olisthodiscus* sp. (+), *Cryptomonas maculata* (-), *Halosphaera minor* (+), *Proocentrum micans* (+), *Ditylum brightwellii* (+), *Lauderia borealis* (+).

CONTAINERS: 25-liter circular black plastic, 10 liters renewed daily; phytoplankton fed to larvae in 1-liter beakers.

TEMPERATURE: 13.9°-18.8° C.

MAXIMUM TIME KEPT: 10 months.

MAXIMUM LENGTH REACHED: 52 mm.

SURVIVAL: 12% alive 2 weeks after yolk absorption, at 15.8°-16.3° C using offshore plankton.

REMARKS: Larvae feeding on phytoplankton survived no longer than starved controls.

BLAXTER, J. H. S., and G. HEMPEL. Biologische Beobachtungen bei der Aufzucht von Heringsbrut. Helgoländer wiss. Meeresunters. 7: 260-284. [English summary.]

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOODS: Wild plankton (+); *Artemia* nauplii (+); wild plankton plus *Artemia* nauplii (+); wild plankton plus *Mytilus* trochophores (?).

CONTAINERS: 120-liter earthenware, either continuous circulation or 30 liters renewed every 2 days.

TEMPERATURE: 7°-15° C.

MAXIMUM TIME KEPT: 4 months, on wild plankton plus *Artemia* nauplii.

MAXIMUM LENGTH REACHED: 20-39 mm TL on wild plankton plus *Artemia* nauplii; 20 mm TL on *Artemia* nauplii alone.

SURVIVAL: 0.3% passed metamorphosis on wild plankton plus *Artemia* nauplii.

BÜCKMAN, ADOLF, WILHELM HARDER, 1953. and GOTTHILF HEMPEL. Unsere Beobachtungen am Hering, *Clupea harengus* L. Kurz. Mitt. fischerei-biol. Abt. Max-Plank Inst. Meeresbiol. 3: 22-42. [English summary.]

FISH STUDIED: *Clupea harengus* L., Clupeidae.  
FOODS: Copepods (+), *Daphnia* (+), egg yolk (+).

CONTAINERS: Various.

REMARKS: This paper comprises mainly behavioral observations on advanced larvae. *Daphnia* were taken only when moving in the manner of copepods, egg yolk only when tossed about by water turbulence.

BUDD, PAUL L. Development of the eggs and 1940. larvae of six California fishes. Calif. Dep. Fish Game, Fish Bull. 56, 50 p.

FISHES STUDIED: *Parophrys vetulus* Girard, *Pleuronichthys verticalis* Jordan and Gilbert, *Pleuronichthys decurrens* Jordan and Gilbert, *Pleuronichthys coenosus* Girard, Pleuronectidae; *Atreidius lateralis* (Girard), *Clinocottus analis* (Girard), Cottidae.

FOODS: Wild plankton (?); *Nitzschia* (?); *Dunaliella* (?); "freshly hatched larvae" of *Strongylocentrotus purpuratus* (?), *Artemia salina* (?), and *Tigriopus fulvus* (?).

CONTAINERS: 3.8-liter jars with rotating celluloid discs.

REMARKS: All larvae died during "critical period," apparently through starvation.

CHIRINOS de VILDOSO, AURORA, and 1964. ESMERALDA CHUMAN. Notes sobre el desarrollo de huevos y larvas del pejerrey *Odontesthes (Austromeni- dia) regia regia* (Humboldt). Bol. Inst. Mar Peru 1: 3-31. [English summary.]

FISH STUDIED: *Odontesthes (Austromeni- dia) regia regia* (Humboldt), Atherinidae.

FOOD: *Artemia* nauplii (+).

CONTAINERS: 6-liter jars.

TEMPERATURE: 20° C.

MAXIMUM TIME KEPT: 42 days.

MAXIMUM LENGTH REACHED: 18 mm TL.

CUNNINGHAM, J. T. The life-history of the 1893-95a. pilchard. J. Mar. Biol. Ass. U.K. 3: 148-153.

FISH STUDIED: *Sardina pilchardus* (Wal- baum), Clupeidae.

FOODS: Minced worms (+) and wild plank- ton (+).

TEMPERATURE: 17° C.

MAXIMUM TIME KEPT: 10 days.

MAXIMUM LENGTH REACHED: 5.5 mm.

SURVIVAL: 0.

CUNNINGHAM, J. T. Experiments on the 1893-95b. rearing of fish larvae in the sea- son of 1894. J. Mar. Biol. Ass. U.K. 3: 206-207.

FISHES STUDIED: *Gadus merlangus* L., Gadi- dae; *Pleuronectes platessa* L., Pleuronectidae.

FOODS: *Nereis* eggs (*G. merlangus* —, *P. platessa* +), wild plankton (+).

CONTAINER: "Small tank," circulating water.

TEMPERATURE: 12° C.

MAXIMUM TIME KEPT: *G. merlangus* 11 days, *P. platessa* 37 days.

REMARKS: *P. platessa* took *Nereis* eggs more readily than wild plankton.

DANNEVIG, ALF. Rearing experiments at 1948. the Flodevigen sea fish hatchery 1943- 1947. J. Cons. 15: 277-283.

FISHES STUDIED: *Clupea harengus* L., Clupei- dae; *Scomber scombrus* L., Scombridae; *Microstomus kitt* (Walbaum), Pleuronecti- dae; *Solea solea* (L.), Soleidae.

FOODS: *Ostrea edulis* larvae (+), wild plank- ton plus *Artemia* nauplii (+), *Pomatoceros* sp. (?), *Balanus* nauplii (?), "raw cultures of phytoplankton" (?), "cultures of single species of green algae and naked flagellates" (?).

CONTAINERS: 35-liter glazed earthenware pipes, circulating water.

SURVIVAL: Feeding *Ostrea* larvae to smaller fish larvae, *Artemia* nauplii and wild plank- ton to larger larvae: 21% of herring sur- vived to "size large enough for vertebrae to be counted"; soles reared "with no appre- ciable mortality."

REMARKS: Phytoplankton gave "no positive results."

DANNEVIG, ALF, and SIGFRED HANSEN. 1952. Faktorer av betydning for fiskegenes og fiskeyngelens oppvekst. Fiskeridir. Skr., Ser. Havunders. 10(1): 36 p. [English summary; English translation of p. 6-16, the section on herring: Translation No. 415, Marine Laboratory, Aberdeen, Scotland.]

FISHES STUDIED: *Clupea harengus* L., Clupeidae; *Gadus morhua* L., Gadidae; *Pleuronectes platessa* L., Pleuronectidae; "other flatfishes."

FOODS: *Artemia* nauplii plus wild plankton (+).

CONTAINERS: 35-liter glazed earthenware pipes, circulating water.

MAXIMUM TIME KEPT: Past metamorphosis.

DANNEVIG, HARALD. On the rearing of 1897. the larval and post-larval stages of the plaice and other flatfishes. Rep. Fish. Bd. Scot. 1896, Pt. 3: 175-193, pl. IV.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.

FOOD: Wild plankton (+).

CONTAINER: 50-liter glass carboy, water renewed once or twice daily.

MAXIMUM TIME KEPT: Past metamorphosis.

MAXIMUM LENGTH REACHED: 13.76 mm TL on day 45.

DAVID, LORE R. Embryonic and early larval 1939. stages of the grunion, *Leuresthes tenuis*, and of the sculpin, *Scorpaena guttata*. Copeia 1939: 75-81.

FISH STUDIED: *Leuresthes tenuis* (Ayres), Atherinidae.

FOODS: Wild plankton (+), cultured diatoms (species not given) (+).

TEMPERATURE: 18° C (?).

MAXIMUM TIME KEPT: ca. 2 weeks.

MAXIMUM LENGTH REACHED: ca. 9 mm.

REMARKS: Found *Rhizosolenia*, *Chaetoceros*, and "small crustaceans" in larval guts. No attempt to rear *Scorpaena* is described.

DELMONTE, PETER J., IRA RUBINOFF, 1968. and ROBERTA W. RUBINOFF. Laboratory rearing through metamorphosis of some Panamanian gobies. Copeia 1968: 411-412.

FISH STUDIED: *Lophygobius cyprinoides* (Pallas), Gobiidae.

FOODS: Commercial fish fry foods (+), cultured *Dunaliella* (?), *Artemia* nauplii (+), attached filamentous algae (+) and zooplankton (+) growing in rearing containers.

CONTAINERS: Plastic wading pools, 320-570 liters (85-150 gal).

TEMPERATURE: 24°-29° C.

MAXIMUM TIME KEPT: 153 days.

MAXIMUM LENGTH REACHED: 32 mm.

SURVIVAL: ca. 15% (presumably, past metamorphosis).

REMARKS: Brief mention is also made of the rearing of three specimens of *Bathygobius andrei* (Sauvage) through metamorphosis.

DEUEL, DAVID G., JOHN R. CLARK, and 1966. A. J. MANSUETI. Description of embryonic and early larval stages of bluefish, *Pomatomus saltatrix*. Trans. Amer. Fish. Soc. 95: 264-271.

FISH STUDIED: *Pomatomus saltatrix* (L.), Pomatomidae.

FOOD: Fertilized *Arbacia* eggs (?).

CONTAINERS: Aquaria of 19, 38, and 76 liters (5, 10, and 20 gal).

TEMPERATURE: 18°-22° C.

MAXIMUM TIME KEPT: 7 days.

SURVIVAL: 0.

REMARKS: Behavior indicated that larvae may have taken the food.

DÔTU, YOSIE, and SATOSHI MITO. The 1958. bionomics and life history of the gobioid fish, *Luciogobius sakaiensis* Dôtu. Sci. Bull. Fac. Agr. Kyushu Univ. 16: 419-425. [In Japanese, with English summary.]

DÔTU and MITO—Cont.

FISH STUDIED: *Luciogobius sakaiensis* Dôtu, Gobiidae.

FOODS: Copepods from wild plankton (+).

CONTAINER: Glass jar.

MAXIMUM TIME KEPT: 32 days.

MAXIMUM LENGTH REACHED: 12.2 mm TL.

FABRE-DOMERGUE, and EUGÈNE

1897. BIÉTRIX. Recherches biologiques applicables à la pisciculture maritime sur les oeufs et les larves des poissons de mer et sur le turbot. Ann. Sci. Nat. (Zool.). 8 Sér., Tome 4: 151-220.

FISHES STUDIED: *Clupea harengus* L., *Alosa* sp., Clupeidae; *Taurulus bubalis* (Euphrasen), Cottidae; *Trachinus* sp., Trachinidae; *Scomber scombrus* L., Scombridae; *Atherina presbyter* Valenciennes, Atherinidae.

FOODS: Powdered cooked egg yolk (—); crushed mussel (—); wild plankton (+); "algae" (—); cultured infusorians (mainly *Euplotes*) (—); dissociated elements of a filamentous brown diatom and of a blue-green alga (—); *Philaster digitiformis* (—); Ascidian larvae (—).

CONTAINERS: Crystallizing dishes, water renewed frequently.

TEMPERATURE: Various, within the range 6°-17° C.

MAXIMUM TIME KEPT: *T. bubalis* 22 days, *A. presbyter* 16 days, *S. scombrus* 9 days, *Alosa* 7 days, *Trachinus* 6 days, *C. harengus* 4 days.

MAXIMUM LENGTH REACHED: *A. presbyter* 8 mm, *Alosa* 5.4 mm.

SURVIVAL: 0.

FABRE-DOMERGUE, and EUGÈNE

1905. BIÉTRIX. Développement de la Sole (*Solea vulgaris*). Introduction à l'étude de la pisciculture marine. Travail du Laboratoire de Zoologie Maritime de Concarneau. Vuibert et Nony, Paris. 243 p.

FISH STUDIED: *Solea solea* (L.), Soleidae; brief references to rearing of other species.

FOODS: *Dunaliella salina* (+), wild plankton with larval fishes (+).

CONTAINERS: 50-liter glass jars with rotating discs; crystallizing dishes.

MAXIMUM TIME KEPT: 8 months.

MAXIMUM LENGTH REACHED: 55-76 mm.

REMARKS: *Dunaliella* was collected from salt marshes and cultured in the laboratory. Larvae fed first on *Dunaliella*, but soon became carnivorous and preyed upon other larval fishes (particularly sprat larvae, *Sprattus sprattus* (L.)). Larvae lived only 8 days in crystallizing dishes but passed metamorphosis in large jars with rotating discs. In an earlier paper (C. R. Acad. Sci. Paris, 132: 1136-1138, 1901) these authors give a survival value of 50% for sole larvae feeding on *Dunaliella* and wild plankton containing larval fishes.

FAHEY, WILLIAM E. A temperature controlled salt-water circulating apparatus for developing fish eggs and larvae. J. Cons. 28: 364-384.

FISH STUDIED: *Alosa pseudoharengus* (Wilson), Clupeidae; *Fundulus majalis* (Walbaum), Cyprinodontidae; *Bairdiella chrysura* (Lacépède), Sciaenidae; *Mugil cephalus* L., Mugilidae.

FOODS: *Artemia* nauplii (+), first and second naupliar stages of *Tigriopus californicus* (+).

CONTAINERS: 4-liter polyethylene, water forced in and out of mesh-covered window on bottom.

TEMPERATURE: 19.0°, 23.0°, and 27.0° C.

MAXIMUM TIME KEPT: *Fundulus* 79 days.

SURVIVAL: *Fundulus* 92-98%.

REMARKS: *Fundulus* was fed *Artemia* nauplii, other species fed *Tigriopus* nauplii; results of rearing are given only for *Fundulus*. *Tigriopus* nauplii were reared in mass culture.

FISHELSON, L. Observations on littoral fishes of Israel. II. Larval development and metamorphosis of *Blennius pavo* Risso (Teleostei, Blenniidae). Israel J. Zool. 12: 81-91.

FISH STUDIED: *Blennius pavo* Risso, Blenniidae.

FOODS: Cooked egg yolk (+), small copepods (+), *Artemia* nauplii (+).



TEMPERATURE: 23°-25° C.  
MAXIMUM TIME KEPT: 27 days +.  
MAXIMUM LENGTH REACHED: 11.4 mm SL.

FÜLÜCHTER, JÜRGEN. Versuche zur Brut-  
1965. aufzucht der Seezunge *Solea solea* in  
kleinen Aquarien. Helgolaender wiss.  
Meeresunters. 12: 395-403. [English  
summary.]

FISH STUDIED: *Solea solea* (L.), Soleidae.  
FOOD: *Artemia* nauplii (+).  
CONTAINER: 30-liter glass aquarium.  
TEMPERATURE: 15°-18° C.  
MAXIMUM TIME KEPT: 6 months.  
MAXIMUM LENGTH REACHED: 70-82 mm TL.  
SURVIVAL: 80% passed metamorphosis.  
REMARKS: Growth was comparable to growth  
in nature.

FORRESTER, C. R. Laboratory observations  
1964. on embryonic development and larvae  
of the Pacific cod (*Gadus macroceph-  
alus* Tilesius). J. Fish. Res. Bd. Can.  
21: 9-16.

FISH STUDIED: *Gadus macrocephalus* Tilesius,  
Gadidae.

FOODS: *Artemia* nauplii (?), *Skeletonema*  
*costatum* (?), *Monochrysis lutheri* (?).

TEMPERATURE: 5°-11° C.

SURVIVAL: 0.

FUJITA, SHIRO. On the larval stages of a  
1957. scorpaenid fish, *Sebastes pachyceph-  
alus nigricans* (Schmidt). Jap. J.  
Ichthyol. 6: 91-93. [In Japanese,  
with English summary.]

FISH STUDIED: *Sebastes pachycephalus nigri-  
cans* (Schmidt). Scorpaenidae.

FOOD: *Artemia* nauplii (+).

CONTAINER: Glass jar.

MAXIMUM TIME KEPT: 28 days (i.e., past meta-  
morphosis).

FUJITA, SHIRO. On the egg development  
1958. and larval stages of a viviparous  
scorpaenid fish, *Sebastes oblongus*  
Günther. Bull. Jap. Soc. Sci. Fish. 24:

475-479. [In Japanese, with English  
summary.]

FISH STUDIED: *Sebastes oblongus* Günther,  
Scorpaenidae.

FOOD: *Artemia* nauplii (+).

CONTAINER: Glass jar.

MAXIMUM TIME KEPT: Approximately 1  
month.

MAXIMUM LENGTH REACHED: 12-14 mm TL.

FUJITA, SHIRO. Early development and  
1965. rearing of two common flatfishes,  
*Eopsetta grigorjewi* (Herzenstein)  
and *Tanakius kitaharai* (Jordan et  
Starks). Bull. Jap. Soc. Sci. Fish.  
31: 258-262. [In Japanese, with Eng-  
lish summary.]

FISHES STUDIED: *Eopsetta grigorjewi* (Her-  
zenstein), *Tanakius kitaharai* (Jordan and  
Starks), Pleuronectidae.

FOODS: Fertilized sea urchin eggs (?) and  
*Artemia* nauplii (+).

CONTAINER: Glass jar.

TEMPERATURE: 11.0°-13.8° C.

MAXIMUM TIME KEPT: *E. grigorjewi* 12 days,  
*T. kitaharai* 29 days +.

MAXIMUM LENGTH REACHED: *T. kitaharai* 7.5  
mm TL on day 29.

FUJITA, SHIRO. Egg development, larval  
1966. stages, and rearing of the puffer,  
*Lagocephalus lunaris spadiceus*  
(Richardson). Jap. J. Ichthyol. 13:  
162-168. [In Japanese, with English  
summary.]

FISH STUDIED: *Lagocephalus lunaris spadi-  
ceus* (Richardson), Tetraodontidae.

FOODS: Boiled egg yolk (+) and *Artemia*  
nauplii (+).

TEMPERATURE: 21.7°-24.5° C.

MAXIMUM TIME KEPT: 36 days + (i.e., past  
metamorphosis).

MAXIMUM LENGTH REACHED: 6.6 mm TL at  
21-36 days.

FUJITA, SHIRO. and KEITARO UCHIDA.  
1959. Breeding habits and rearing of larvae  
of a blennoid fish, *Ernogrammus hex-  
agrammus* (Temminck et Schlegel).

FUJITA and UCHIDA—Cont.

Sci. Bull. Fac. Agr. Kyushu Univ. 17:  
283-289. [In Japanese, with English  
summary.]

FISH STUDIED: *Ernogrammus hexagrammus*  
(Temminck and Schlegel), Stichaeidae.

FOOD: *Artemia* nauplii (+).

CONTAINER: Glass jar.

MAXIMUM TIME KEPT: 34 days (i.e., past  
metamorphosis).

MAXIMUM LENGTH REACHED: 13 mm TL.

GARSTANG, WALTER. Preliminary experi-  
ments on the rearing of sea-fish  
larvae. J. Mar. Biol. Ass. U.K. 6:  
70-93.

FISH STUDIED: *Blennius ocellaris* L., Blenniidae.

FOOD: Wild plankton (+).

CONTAINER: 13-liter plunger jar.

TEMPERATURE: 18.8°-19.2° C.

MAXIMUM TIME KEPT: 13-14 weeks (i.e., past  
metamorphosis).

MAXIMUM LENGTH REACHED: 19-25.5 mm TL.

SURVIVAL: 20% at 52 days.

REMARKS: Polychaetes were given to ad-  
vanced (ca. 20 mm) larvae.

GROSS, F. Notes on the culture of some ma-  
rine plankton organisms. J. Mar.  
Biol. Ass. U.K. 21: 753-768.

FISHES STUDIED: *Clupea harengus* L., Clupei-  
dae; *Lophius piscatorius* L., Lophiidae; *Sar-  
dina pilchardus* (Walbaum), Clupeidae.

FOODS: *Chlamydomonas* sp. (+), *Prorocen-  
trum micans* (+), *Thalassiosira* sp. (+),  
*Coscinodiscus radiatus* (-), *Skeletonema*  
*costatum* (-), *Artemia* nauplii (+), wild  
plankton (-).

CONTAINERS: Fingerbowls and "small tanks."

TEMPERATURE: 8°-17° C.

MAXIMUM TIME KEPT: *C. harengus* 27 days,  
*L. piscatorius* 29 days, *S. pilchardus* 15 days.

SURVIVAL: 30% of the *L. piscatorius* were  
alive after 20 days.

REMARKS: *L. piscatorius* ate only *Artemia*  
nauplii; other fishes were offered only phyto-  
plankton. Author attributes death of larvae  
to lack of temperature control.

HERTLING, HELMUTH. Die Züchtung von  
1932. Meeresfischen für wissenschaftliche  
und praktische Zwecke. In E. Ab-  
derhalden (ed.), Handbuch der bio-  
logische Arbeitsmethoden. Abt. 9,  
Teil 6, Heft 2: 195-366.

FISH STUDIED: *Agonus cataphractus* L., Agon-  
idae.

FOODS: *Coscinodiscus concinnus* (+), *Biddul-  
phia mobiliensis* (+), copepods (+).

MAXIMUM TIME KEPT: Past metamorphosis.

REMARKS: This paper reviews in detail much  
of the rearing work done prior to the 1930's  
and also includes a few apparently original  
observations; the rearing of *Agonus* is the  
only original work for which information on  
feeding is given.

HEUTS, M. J. Experimental studies on adap-  
tive evolution in *Gasterosteus aculea-  
tus* L. Evolution 1: 89-102.

FISH STUDIED: *Gasterosteus aculeatus* L.,  
Gasterosteidae.

FOODS: Powdered eggs (+); aquaria con-  
tained "a rich microfauna and flora."

CONTAINERS: "Large aquaria."

TEMPERATURE: Various, within the range 10°-  
23° C.

MAXIMUM TIME KEPT: 1 year +.

REMARKS: The author states that the "rich  
microfauna and flora" in the aquaria is "nec-  
essary for successful rearing of the off-  
spring."

HIRANO, REIJIRO. Rearing of black sea  
1969. bream larva. Symposium on Culture  
and Propagation of Sea Breams.  
Bull. Jap. Soc. Sci. Fish. 35: 567-569,  
603-604. [In Japanese, with English  
summary.]

FISH STUDIED: *Mylio macrocephalus* (Basi-  
lewsky), Sparidae.

FOODS: *Crassostrea gigas* larvae (+), *Brach-  
ionus plicatilis* (+), *Balanus amphitrite al-  
bicostatus* nauplii (+), *Artemia* nauplii  
(+).

IVANCHENKO, L. A., and O. F. IVANCHEN-  
1969. KO. Transition to active feeding by

larval and juvenile white sea herring (*Clupea pallasii* Natio *Maris-albi* Berg) in artificial conditions. Dokl. Biol. Sci. 184: 207-209. (Translated from Dokl. Akad. Nauk S.S.S.R. 184: 1444-1446.)

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.

FOODS: Wild plankton (+); homogenates of *Mytilus* (+), periwinkle (—), *Fucus* (—), and kelp (—); phytoplankton (+); cooked egg yolk (+); cooked egg yolk plus wild plankton (+).

CONTAINERS: "Aquarium" and crystallizing dishes.

TEMPERATURE: 7°-19° C.

MAXIMUM TIME KEPT: 120 days + on cooked egg yolk plus wild plankton.

MAXIMUM LENGTH REACHED: 43-50 mm.

REMARKS: On all foods except egg yolk plus wild plankton, larvae failed to survive longer than starved controls. Larvae ate yolk until 14 days after hatching, then switched to planktonic crustaceans.

JOSEPH, EDWIN B., and VISHNU P. SAK-1966. SENA. Determination of salinity tolerances in mummichog (*Fundulus heteroclitus*) larvae obtained from hormone-induced spawning. Chesapeake Sci. 7: 193-197.

FISH STUDIED: *Fundulus heteroclitus* (L.), Cyprinodontidae.

FOOD: *Artemia* nauplii (+).

CONTAINERS: 3.8-liter (1 gal) jars.

TEMPERATURE: 22° C.

KASAHARA, SHOGORO, REIJIRO HIRANO, 1960. and YASUO OSHIMA. A study on the growth and rearing methods of black porgy, *Mylio macrocephalus* (Basilewsky). Bull. Jap. Soc. Sci. Fish. 26: 239-244. [In Japanese, with English summary.]

FISH STUDIED: *Mylio macrocephalus* (Basilewsky), Sparidae.

FOODS: *Oxyrrhis* sp. (+), *Stylonichia* sp. (+), copepod nauplii (+), *Balanus amphitrite albicostatus* nauplii (+), *Artemia* nauplii (+), young *Neomysis japonica* (+).

CONTAINERS: 2-5 liter glass aquaria, 39 liter bowl, large concrete tanks.

TEMPERATURE: 17°-25° C.

MAXIMUM TIME KEPT: 60 days +.

MAXIMUM LENGTH REACHED: 32 mm TL on day 60.

SURVIVAL: 13% at day 52.

REMARKS: Growing larvae were given progressively larger food types.

KLIMA, EDWARD F., IZADORE BARRETT, 1962. and JOHN E. KINNEAR. Artificial fertilization of the eggs, and rearing and identification of the larvae of the anchoveta, *Cetengraulis mysticetus*. Bull. Inter-Amer. Trop. Tuna Comm. 6: 155-178.

FISH STUDIED: *Cetengraulis mysticetus* (Günther), Engraulidae.

FOODS: Natural and cultured phytoplankton (?), prepared aquaria (?), *Artemia* nauplii (?), powdered yolk from hard-boiled eggs (?), 12 commercially prepared fish fry foods (?), 4 water-soluble vitamin compounds (?), dry yeast microorganisms (?), human blood (?).

CONTAINERS: Various.

TEMPERATURE: 19°-23° and 26°-31° C.

MAXIMUM TIME KEPT: 154 hr.

SURVIVAL: 0.

KOTTHAUS, ADOLF. Zuchtversuche mit 1939. Heringslarven (*Clupea harengus* L.). Helgolaender wiss. Meeresunters. 1: 349-358.

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOODS: Nudibranch (? Nacktschnecken) larvae (—), *Mytilus* larvae (—), "Monadinen" (—), copepod nauplii cultured from wild plankton (+).

CONTAINERS: 165-liter earthenware pipes with circulating water; 3- to 5-liter glass jars, water changed every 3 days.

TEMPERATURE: 7.2°-9.6°, 10.0°-13.2°, and 9.3°-12.9° C.

MAXIMUM TIME KEPT: 54 days.

MAXIMUM LENGTH REACHED: 25 mm.

SURVIVAL: 4-10% after 12 days at 10.0°-13.2° C, 0.8°-1.7% after 15 days at 9.3°-12.9° C.

KOTTHAUS—Cont.

REMARKS: The only successful rearing was conducted in the 165-liter pipes with copepod nauplii as the major food; older larvae ate green algae, presumably *Enteromorpha* from the tank walls. Kotthaus refers to an unpublished report of Marx (1935) which describes the rearing of 30-40 herring larvae past the "critical stage"; some larvae attained 30 mm in 5 weeks, and of the food offered (mussel and snail larvae, copepod nauplii, and wild plankton) only nudibranch (? Nacktschnecken) larvae and copepod nauplii were found in the larval guts.

KRAMER, DAVID, and JAMES R. ZWEIFEL.  
1970. Rearing and growth of anchovy larvae (*Engraulis mordax* Girard) as influenced by temperature. Calif. Coop. Oceanic Fish. Invest. Rep. 14: 84-87.

FISH STUDIED: *Engraulis mordax* Girard, Engraulidae.

FOOD: Wild plankton (+).

CONTAINER: 380-liter glass, water either not renewed or partially (10-20%) renewed daily.

TEMPERATURE: 17° and 22° C.

MAXIMUM TIME KEPT: 34 days.

MAXIMUM LENGTH REACHED: 9.8-20.7 mm SL.

KURATA, HIROSHI. On the rearing of larvae of the flatfish, *Liopsetta obscura*, in small aquaria. Bull. Hokkaido Reg. Fish. Res. Lab. 13: 20-29. [In Japanese, with English summary.]

FISH STUDIED: *Liopsetta obscura* (Herzenstein), Pleuronectidae.

FOODS: *Skeletonema costatum* (?), *Mytilus* larvae (+), *Artemia* nauplii (+).

CONTAINERS: 1.3-liter glass jar, one-third of water renewed once or twice daily.

TEMPERATURE: 6.8°-14.5° C.

MAXIMUM TIME KEPT: 1 year.

MAXIMUM LENGTH REACHED: 64 mm TL.

SURVIVAL: 9% at 25 days.

REMARKS: Early larvae ate larval *Mytilus* ("an excellent food for the larvae"), later switched to *Artemia* nauplii. Larvae fed

*Skeletonema* survived only 1 day longer than starved controls.

KURATA, HIROSHI. Preliminary report on 1959. the rearing of the herring larvae. Bull. Hokkaido Reg. Fish. Res. Lab. 20: 117-138. [In Japanese, with English summary.]

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.

FOODS: *Artemia* nauplii (+), *Chone teres* trochophores (+), *Skeletonema costatum* (?), chicken yolk (?), minced shrimp or crab meat (?).

CONTAINERS: 1.2-liter glass jars.

TEMPERATURE: 4.9°-7.7° C.

MAXIMUM TIME KEPT: 40 days +.

MAXIMUM LENGTH REACHED: 14.5 mm.

SURVIVAL: 10-20% at 40 days.

REMARKS: Only larvae fed *Artemia* nauplii survived significantly longer than starved controls. Larvae feeding for the first time took *Chone teres* trochophores in preference to *Artemia* nauplii, perhaps because of their smaller size; however, *C. teres* had the disadvantages of a short spawning season and trochophores which settled quickly.

LASKER, R., H. M. FEDER, G. H. THEILACKER, and R. C. MAY. Feeding, growth, and survival of *Engraulis mordax* larvae reared in the laboratory. Mar. Biol. 5: 345-353.

FISH STUDIED: *Engraulis mordax* Girard, Engraulidae.

FOODS: *Gymnodinium splendens* (+), *Prorocentrum micans* (+), *Protoceratium reticulatum* (—), *Fragilidium heterolobum* (+); veligers of *Bulla gouldiana* (+), *Haminocia vesicula* (+), and *Navanax inermis* (+); *Gymnodinium* plus veligers; *Artemia* nauplii (+).

CONTAINERS: 10-liter circular black plastic; 510-liter fiberglass.

TEMPERATURE: 16°-18° C.

MAXIMUM TIME KEPT: 50 days.

MAXIMUM LENGTH REACHED: 7.2 mm on *Gymnodinium* and 9.6 mm on *Gymnodinium* plus veligers, at day 19.

SURVIVAL: 47% on *Gymnodinium* plus *Bulla veligers*, 31% on *Gymnodinium* alone, 0 on *veligers* alone, at 19 days.

REMARKS: *Gymnodinium* was the only phytoplankton which gave survival better than starved controls.

LEBOUR, MARIE V. Young anglers in captivity and some of their enemies. A study in a plunger jar. J. Mar. Biol. Ass. U.K. 13: 721-734.

FISH STUDIED: *Lophius piscatorius* L., Lophiidae.

FOOD: Wild plankton (+).

CONTAINER: 50-liter plunger jar.

TEMPERATURE: 16.8°-18.8° C.

MAXIMUM TIME KEPT: 11 days.

MAXIMUM LENGTH REACHED: 7 mm.

SURVIVAL: 0.

McHUGH, J. L., and BOYD W. WALKER. 1948. Rearing marine fishes in the laboratory. Calif. Fish Game 34: 37-38.

FISHES STUDIED: *Leuresthes tenuis* (Ayres), *Atherinops affinis* (Ayres), Atherinidae.

FOODS: *Artemia* nauplii (+) in prepared aquaria.

CONTAINERS: 19-liter aquaria.

MAXIMUM TIME KEPT: 4 months +.

McMYNN, R. G., and W. S. HOAR. 1953. Effects of salinity on the development of the Pacific herring. Can. J. Zool. 31: 417-432.

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.

FOODS: *Artemia* nauplii (+), *Daphnia pulex* eggs (?), liver-skim milk (?).

CONTAINERS: 600-ml beakers.

TEMPERATURE: 8°-9° C.

MAXIMUM TIME KEPT: 20 days on *Artemia*, 5 days on *Daphnia* eggs, 14 days on liver-skim milk.

MAXIMUM LENGTH REACHED: 10.2 mm TL on day 20.

SURVIVAL: 56% at day 20.

MEYER, H. A. Biologische Beobachtungen 1878. bei künstlicher Aufzucht des Herings der Westlichen Ostsee. Wiegandt, Hempel and Parey, Berlin. (Translation in Rep. U.S. Comm. Fish. 1878, Pt. 6: 629-638.)

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOOD: Wild plankton (+).

CONTAINER: 700-liter wooden tub, one-half of water renewed daily.

TEMPERATURE: 11°-20° C.

MAXIMUM TIME KEPT: 5 months.

MAXIMUM LENGTH REACHED: 65-70 mm.

REMARKS: During the first month of rearing the plankton was strained, which the author believes may have restricted larval growth and survival by eliminating certain food organisms.

MITO, SATOSHI, MASAO UKAWA, and MA-1969. SAKI HIGUCHI. On the development and rearing of the larvae of a flounder, *Kareius bicoloratus* (Basilewsky) with reference to its spawning in the culturing pond. Bull. Nansei Reg. Fish. Res. Lab. 1: 87-102. [In Japanese, with English summary.]

FISH STUDIED: *Kareius bicoloratus* (Basilewsky), Pleuronectidae.

FOODS: *Brachionus plicatilis* (+), *Artemia* nauplii (+), wild plankton (+).

CONTAINERS: 40 liters, cylindrical.

TEMPERATURE: 14.2°-15.0° C.

MAXIMUM TIME KEPT: 47 days +.

MAXIMUM LENGTH REACHED: 32-33 mm TL on day 47.

SURVIVAL: 40-60% past yolk-absorption, 20-30% past metamorphosis.

MOLANDER, ARVID R., and MÄRTHA MO-1957. LANDER-SWEDMARK. Experimental investigations on variation in plaice (*Pleuronectes platessa* L.). Inst. Mar. Res., Lysekil, Ser. Biol., Rep. 7. 45 p.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.

FOOD: *Artemia* nauplii (+).

MOLANDER and MOLANDER-SWEDMARK  
—Cont.

CONTAINERS: 5 liters, glass.  
TEMPERATURE: 6°, 8°, and 10° C.  
MAXIMUM TIME KEPT: 1 year +.  
MAXIMUM LENGTH REACHED: 50-110 mm.  
SURVIVAL: 18.6-64.2% metamorphosed.

MORRIS, ROBERT W. Some aspects of the  
1956. problem of rearing marine fishes.  
Bull. Inst. Oceanogr. Monaco. 1082.  
61 p.

FISHES STUDIED: A total of 17 spp. were investigated. Of these, 5 spp. were reared through metamorphosis (identified below by \*\*) and 5 spp. well beyond yolk absorption (identified below by \*): *Clupea pallasii* Valenciennes, *Sardinops sajax* (Jenyns), Clupeidae; *Engraulis mordax* Girard, Engraulidae; *Spirinchus starksi* (Fisk)\*, Osmeridae; *Aulorhynchus flavidus* Gill\*\*, Aulorhynchidae; *Genyonemus lineatus* (Ayres)\*, Sciaenidae; *Oxyjulis californica* (Günther), Labridae; *Sebastes goodei* (Eigenmann and Eigenmann)\*, *Sebastobolus* sp., Scorpaenidae; *Hexagrammos* sp., Hexagrammidae; *Clinocottus recalvus* (Greeley)\*\*, *Oligocottus snyderi* Greeley\*\*, *Clinocottus analis* (Girard), *Scorpaenichthys marmoratus* (Ayres), Cottidae; *Leuresthes tenuis* (Ayres)\*\*, *Atherinopsis californiensis* Girard\*\*, Atherinidae; *Citharichthys* sp., Bothidae.

FOODS: Wild plankton (+), *Mytilus californianus* "larvae" (+), *Tigriopus fulvus* (+), *Artemia* nauplii (+), *Balanus glandula* nauplii (+), *Dendraster excentricus* "eggs and larvae" (+), *Strongylocentrotus purpuratus* "eggs and larvae" (+), *Oxyrrhis marina* (—), *Stichococcus* sp. (?), *Dunaliella* sp. (—), yeast (?), cooked chicken egg yolk (?).

CONTAINERS: 28-liter glass jars with rotating discs, water renewed periodically.

TEMPERATURE: Various, within the range 8°-22° C.

MAXIMUM TIME KEPT: 5 spp. through metamorphosis, 5 spp. well beyond yolk absorption.

SURVIVAL: 10-70%, among fish which had metamorphosed.

REMARKS: Successful rearing attempts employed *Artemia* nauplii as food for early larvae and adult *Tigriopus* for older larvae. *Genyonemus* was reared well past yolk absorption using *Dendraster* eggs and, later, *Artemia* nauplii as food. In all rearing attempts the main food was supplemented by "secondary foods," defined by the author as "items which are too small to be directly fed upon by the fish larvae but which are incidentally ingested"; these items apparently also served as nourishment for some of the main food organisms and included *Stichococcus*, *Dunaliella*, cooked egg yolk, and yeast.

NIKITINSKAYA, I. V. On the onset of active  
1958. feeding of the larvae of *Clupea harengus pallasii* Val. Zool. Zh. 37:  
1568-1571. [In Russian, with English summary.]

FISH STUDIED: *Clupea pallasii* Valenciennes, Clupeidae.

FOOD: Cooked egg yolk (+).

MAXIMUM TIME KEPT: 18-20 days after yolk-absorption.

REMARKS: A higher food concentration was needed for first-feeding larvae than for larvae at later stages. Author states that in the laboratory the food concentration must be 50 times greater than in nature.

OKAMOTO, RYO. Rearing of red sea bream  
1969. larvae. Symposium on Culture and Propagation of Sea Breams. Bull. Jap. Soc. Sci. Fish. 35: 563-566, 603. [In Japanese, with English summary.]

FISH STUDIED: *Pagrus major* (Temminck and Schlegel), Sparidae.

FOODS: Oyster and mussel trochophores (+), *Brachionus plicatilis* (+), *Artemia* nauplii (+), wild plankton (+).

CONTAINERS: 30 liters.

MAXIMUM LENGTH REACHED: 39 mm TL at day 45.

SURVIVAL: At 20 days, usually 10-20%, maximally 55.6%.

REMARKS: Growing larvae were given progressively larger food types.

ORCUTT, HAROLD GEORGE. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Calif. Dep. Fish Game, Fish Bull. 78. 64 p.

FISH STUDIED: *Platichthys stellatus* (Pallas), Pleuronectidae.

FOODS: *Tigriopus fulvus* nauplii (—), *Artemia* nauplii (—), *Strongylocentrotus purpuratus* motile blastulae (—), *Platymonas subcordiformis* (+), *Nitzschia closterium* (—), wild plankton (—).

CONTAINERS: 3.8-liter glass jars.

TEMPERATURE: 12.5° C.

MAXIMUM TIME KEPT: 10 days.

MAXIMUM LENGTH REACHED: 3.5 mm TL on day 4.

SURVIVAL: 0.

REMARKS: Larvae which ingested *Platymonas* appeared to be starving.

QASIM, S. Z. Rearing experiments on marine teleost larvae and evidence of their need for sleep. *Nature* (London) 175: 217-218.

1959. Laboratory experiments on some factors affecting the survival of marine teleost larvae. *J. Mar. Biol. Ass. India* 1: 13-25.

FISHES STUDIED: *Blennius pholis* L., *Centronotus gunnellus* (L.), Blenniidae.

FOODS: *Chromulina pusilla* (+), *Isochrysis galbana* (+), *Chlamydomonas* sp. (+), *Chlorella stigmata* (+), *Prorocentrum micans* (+), *Artemia* nauplii (+), barnacle nauplii (+).

CONTAINERS: 25-liter glass jars.

MAXIMUM TIME KEPT: 68 days +.

SURVIVAL: "A small percentage" passed metamorphosis.

REMARKS: The two papers seem to describe the same experiments. Larvae fed only phytoplankters did not survive significantly longer than starved controls. Nauplii plus phytoplankters gave no better survival than nauplii alone.

RICHARDS, WILLIAM J., and BARBARA J. 1969. PALKO. Methods used to rear the thread herring, *Opisthonema oglin-*

*um*, from fertilized eggs. *Trans. Amer. Fish. Soc.* 98: 527-529.

FISH STUDIED: *Opisthonema oglinum* (LeSueur), Clupeidae.

FOODS: Wild plankton (?), *Tripneustes esculentus* eggs (?), finely ground trout food (?), *Artemia* nauplii (?).

CONTAINERS: 38-liter glass aquaria, water partially renewed every 2 or 3 days.

TEMPERATURE: Approximately 21°-33° C.

MAXIMUM TIME KEPT: 95 days.

MAXIMUM LENGTH REACHED: 34-53 mm SL.

SURVIVAL: ca. 0.8% at day 95.

REMARKS: Tanks had a high concentration of *Chlorella* as food for plankton; authors had no evidence that fish larvae fed on *Chlorella*.

ROLLEFSEN, GUNNAR. Artificial rearing 1939. of the fry of sea water fish. Preliminary communication. *Cons. Perma. Int. Explor. Mer. Rapp. Proc.-Verb. Réunion.* 109, Pt. 3: 133.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.

FOOD: *Artemia* nauplii (+).

CONTAINERS: 200-liter tanks, petri dishes.

TEMPERATURE: 10° C.

MAXIMUM TIME KEPT: Past metamorphosis.

SURVIVAL: 50-75% "rearing percentage."

REMARKS: Rollefsen's 1940 paper (*Naturen* 6-7: 197-217; in Norwegian) contains roughly the same experimental results for plaice rearing as his 1939 paper—the survival is given as 70% (to metamorphosis?).

RUBINOFF, IRA. Raising the atherinid fish 1958. *Menidia menidia* in the laboratory. *Copeia* 1958: 146-147.

FISH STUDIED: *Menidia menidia* (L.), Atherinidae.

FOODS: *Arbacia* larvae (?), *Crepidula* larvae (?), "diatoms" (?), powdered fish foods (?), *Artemia* nauplii (+).

CONTAINER: 25-liter wooden trough, circulating water.

TEMPERATURE: 22° C.

MAXIMUM TIME KEPT: 48 days.

MAXIMUM LENGTH REACHED: 27-30 mm.

RUNNSTRÖM, SVEN. Quantitative investigations on herring spawning and its yearly fluctuations at the west coast of Norway. Fiskeridir. Skr., Ser. Havunders. 6(8). 71 p.

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOOD: "Plankton algae" (+).

REMARKS: The author makes only the following brief mention of his rearing attempt: "By hatching experiments with herring eggs I succeeded to keep the free-swimming larvae alive for 6 weeks without any great mortality, feeding them on plankton algae. Always, however, when they had reached a certain stage, they all died in a short time (p. 34)."

SCHACH, HELMUT. Die künstliche Aufzucht von *Clupea harengus* L. Helgolaender wiss. Meeresunters. 1: 359-372.

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOODS: Wild plankton (+), *Mytilus trochophores* (?).

CONTAINERS: 190- to 2500-liter tile and stoneware, circulating or static water.

TEMPERATURE: 10.5° C.

MAXIMUM TIME KEPT: 56 days.

MAXIMUM LENGTH REACHED: 20-60 mm.

SURVIVAL: 7% at day 56.

REMARKS: Food was held in a special container with a large crop of phytoplankton, from which it was siphoned into the rearing container; larvae probably ingested the phytoplankton as well as zooplankton.

SHELBOURNE, J. E. The artificial propagation of marine fish. Advan. Mar. Biol. 2: 1-83.

FISH STUDIED: *Pleuronectes platessa* L., Pleuronectidae.

FOOD: *Artemia* nauplii (+).

CONTAINERS: 40-liter glass, slowly circulating water.

TEMPERATURE: 7°-11° C.

MAXIMUM TIME KEPT: 100 days.

SURVIVAL: Maximum of 66% of original eggs passed metamorphosis.

REMARKS: In some earlier experiments the

author used *Balanus balanoides* nauplii as a first food. This paper summarizes several earlier papers on plaice rearing by the author and his coworkers and reviews the history of marine fish culture.

SHIOKAWA, TSUKASA, and HIROSHI TSUKAHARA. Studies in habits of coastal fishes in the Amakusa Islands. Part 1. Early life history of the purple rockfish, *Sebastes pachycephalus* Temminck et Schlegel. Rec. Oceanogr. Works Jap., Spec. No. 5: 123-127.

FISH STUDIED: *Sebastes pachycephalus* Temminck and Schlegel, Scorpaenidae.

FOOD: *Artemia* nauplii (+).

TEMPERATURE: 15° C.

MAXIMUM TIME KEPT: 25 days (+?).

MAXIMUM LENGTH REACHED: 13 mm TL at 25 days.

SHOJIMA, YOICHI. On the development of eggs and rearing of larvae of a puffer, *Fugu (Higanfugu) pardalis* (T. and S.). Sci. Bull. Fac. Agr. Kyushu Univ. 16: 125-136. [In Japanese, with English summary.]

FISH STUDIED: *Fugu (Higanfugu) pardalis* (Temminck and Schlegel), Tetraodontidae.

FOOD: *Artemia* nauplii (+).

CONTAINERS: Glass jars.

TEMPERATURE: 11°-17° C.

MAXIMUM TIME KEPT: 50 days.

MAXIMUM LENGTH REACHED: 13.09 mm TL.

SURVIVAL: 5-15% at 3 weeks.

SOLEIM, PEDER A. Årsaker til rike og fattige årganger av sild. Fiskeridir. Skr., Ser. Havunders. 7(2). 39 p.

FISH STUDIED: *Clupea harengus* L., Clupeidae.

FOODS: Nauplii of *Artemia* and *Balanus balanoides* (+), "vegetarian diet" (?).

CONTAINERS: 7-14 liters.

TEMPERATURE: 10°-15° C.

MAXIMUM TIME KEPT: 2 months.

MAXIMUM LENGTH REACHED: 18 mm.



REMARKS: Author states that "... a vegetarian diet alone was unable to keep the larvae alive in early life." In an earlier paper (Fiskeridir. Skr. 6(4): 39-55, 1940) the author reported a 50% mortality of larvae at the time of yolk absorption, at 14° C.

TSUKAHARA, HIROSHI. Studies on habits 1962. of coastal fishes in the Amakusa Islands. Part 2. Early life history of the rockfish, *Sebastiscus marmoratus* (Cuvier et Valenciennes). Rec. Oceanogr. Works Jap., Spec. No. 6: 49-55.

FISH STUDIED: *Sebastiscus marmoratus* (Cuvier and Valenciennes), Scorpaenidae.

FOOD: *Artemia* nauplii (—).

TEMPERATURE: 15° C.

MAXIMUM TIME KEPT: 10 days.

MAXIMUM LENGTH REACHED: 5 mm TL.

REMARKS: *Artemia* nauplii were "too large to be swallowed."

TSUKAHARA, HIROSHI, and TSUKASA 1957. SHIOKAWA. Studies on the flying-fishes of the Amakusa Islands. Part 2. The life history and habits of *Parexocoetus mento* (Cuvier et Valenciennes). Sci. Bull. Fac. Agr. Kyushu Univ. 16: 275-286. [In Japanese, with English summary.]

FISH STUDIED: *Parexocoetus mento* (Cuvier and Valenciennes), Exocoetidae.

FOOD: *Artemia* nauplii (+).

TSUKAHARA, HIROSHI, TSUKASA SHIO- 1957. KAWA, and TADASHI INAO. Studies on the flying-fishes of the Amakusa Islands. Parts 3 and 4. The life histories and habits of three species of the genus *Cypselurus*. Sci. Bull. Fac. Agr. Kyushu Univ. 16: 287-311. [In Japanese, with English summary.]

FISHES STUDIED: *Cypselurus opisthopus hiraii* Abe, *Cypselurus heterurus döderleini* Abe, *Cypselurus starksi* Abe, Exocoetidae.

FOOD: *Artemia* nauplii (+).

YAMAMOTO, GOTARO, and CHUZO NISHI- 1952. OKA. The development and rearing of hatched larvae of North Pacific cod (*Gadus macrocephalus* Tilesius). Spec. Publ. Jap. Sea Reg. Fish. Res. Lab., on the third anniversary of its founding: 301-308. [Translation No. 402, Fish. Res. Bd. Can.]

FISH STUDIED: *Gadus macrocephalus* Tilesius, Gadidae.

FOOD: Wild plankton (+).

CONTAINERS: Glass bowls, 20-30 cm diameter; circulating water, or static water changed daily.

TEMPERATURE: 3°-6° C (?).

MAXIMUM TIME KEPT: 28 days in static water.

REMARKS: Larvae ate small crustaceans and larval molluscs, along with a few diatoms. Results from experiments conducted with running water were unsatisfactory.

## APPENDIX I

### Species of Marine Fishes Used in Laboratory Rearing Attempts.

Fish	References
<b>CLUPEIDAE (herrings)</b>	
<i>Alosa</i> sp. ....	Fabre-Domergue and Biéatrix, 1897
<i>Alosa pseudoharengus</i> (Wilson) ....	Fahey, 1964
<i>Clupea harengus</i> L. ....	Bishai, 1961; Blaxter, 1962, 1968; Blaxter and Hempel, 1961; Bückman et al., 1953; A. Dannevig, 1948; Dannevig and Hansen, 1952; Fabre-Domergue and Biéatrix, 1897; Gross, 1937; Kotthaus, 1939; Meyer, 1878; Runnström, 1941; Schach, 1939; Soleim, 1942
<i>Clupea pallasii</i> Valenciennes ....	Ivanchenko and Ivanchenko, 1969; Kurata, 1959; McMynn and Hoar, 1953; Morris, 1956; Nikitinskaya, 1958
<i>Opisthonema oglinum</i> (LeSueur) ....	Richards and Palko, 1969
<i>Sardina pilchardus</i> (Walbaum) ....	Blaxter, 1969; Cunningham, 1893-95a; Gross, 1937
<i>Sardinops sajax</i> (Jenyns) ....	Morris, 1956
<b>ENGRAULIDAE (anchovies)</b>	
<i>Cetengraulis mysticetus</i> (Günther) ....	Klima et al., 1962
<i>Engraulis mordax</i> Girard ....	Kramer and Zweifel, 1970; Lasker et al., 1970; Morris, 1956
<b>OSMERIDAE (smelts)</b>	
<i>Spirinchus starksi</i> (Fisk) ....	Morris, 1956
<b>EXOCOETIDAE (flyingfishes)</b>	
<i>Cypselurus heterurus döderleini</i> Abe ....	Tsukahara et al., 1957
<i>Cypselurus opisthopus hiraii</i> Abe ....	Tsukahara et al., 1957
<i>Cypselurus starksi</i> Abe ....	Tsukahara et al., 1957
<i>Parexocoetus mento</i> (Cuvier and Valenciennes)	Tsukahara and Shiokawa, 1957
<b>CYPRINODONTIDAE (killifishes)</b>	
<i>Fundulus heteroclitus</i> (L.) ....	Joseph and Saksena, 1966
<i>Fundulus majalis</i> (Walbaum) ....	Fahey, 1964
<b>GADIDAE (codfishes and hakes)</b>	
<i>Gadus macrocephalus</i> Tilesius ....	Forrester, 1964; Yamamoto and Nishioka, 1952
<i>Gadus merlangus</i> L. ....	Cunningham, 1893-95b
<i>Gadus morhua</i> L. ....	Dannevig and Hansen, 1952
<b>GASTEROSTEIDAE (sticklebacks)</b>	
<i>Gasterosteus aculeatus</i> L. ....	Heuts, 1947
<b>AULORHYNCHIDAE (tube-snouts)</b>	
<i>Aulorhynchus flavidus</i> Gill ....	Morris, 1956

Appendix I—Species of marine fishes used in laboratory rearing attempts—Cont.

Fish	References
POMATOMIDAE (bluefishes)	
<i>Pomatomus saltatrix</i> (L.)	Deuel et al., 1966
SCIAENIDAE (drums)	
<i>Sciaenops ocellatus</i> (L.)	Fahey, 1964
<i>Sciaenops lineatus</i> (Ayres)	Morris, 1956
SPARIDAE (porgies)	
<i>Sparus macrocephalus</i> (Basilewsky)	Hirano, 1969; Kasahara et al., 1960
<i>Sparus major</i> (Temminck and Schlegel)	Okamoto, 1969
LABRIDAE (wrasses)	
<i>Parablennius californicus</i> (Günther)	Morris, 1956
TRACHINIDAE (weevers)	
<i>Trachinus</i> sp.	Fabre-Domergue and Biéatrix, 1897
SCOMBRIDAE (mackerels and tunas)	
<i>Scomber japonicus</i> Houttuyn	Schumann, in Bardach, 1968
<i>Scomber scombrus</i> L.	A. Dannevig, 1948; Fabre-Domergue and Biéatrix, 1897
GOBIIDAE (gobies)	
<i>Gobiosoma aureum</i> (Snyder)	Delmonte et al., 1968
<i>Gobiosoma cyprinoides</i> (Pallas)	Delmonte et al., 1968
<i>Gobiosoma sakaiensis</i> Dôtu	Dôtu and Mito, 1958
SCORPAENIDAE (scorpionfishes and rockfishes)	
<i>Scorpaenopsis oblongus</i> Günther	Fujita, 1958
<i>Scorpaenopsis pachycephalus nigricans</i> (Schmidt)	Fujita, 1957
<i>Scorpaenopsis pachycephalus pachycephalus</i> Temminck and Schlegel	Shiokawa and Tsukahara, 1961
<i>Scorpaenopsis marmoratus</i> (Cuvier and Valenciennes)	Tsukahara, 1962
<i>Scorpaenopsis goodei</i> (Eigenmann and Eigenmann)	Morris, 1956
<i>Scorpaenopsis</i> sp.	Morris, 1956
HEXAGRAMMIDAE (greenlings)	
<i>Hexagrammos</i> sp.	Morris, 1956
COTTIDAE (sculpins)	
<i>Clinocottus analis</i> (Girard)	Budd, 1940; Morris, 1956
<i>Clinocottus recalvus</i> (Greeley)	Morris, 1956
<i>Clinocottus snyderi</i> Greeley	Morris, 1956
<i>Scorpaenichthys marmoratus</i> (Ayres)	Morris, 1956
<i>Pleuronectes bubalis</i> (Euphrasen)	Fabre-Domergue and Biéatrix, 1897

Appendix I—Species of marine fishes used in laboratory rearing attempts—Cont.

Fish	References
AGONIDAE (poachers and alligatorfishes)	
<i>Agonus cataphractus</i> L. ....	Hertling, 1932
BLENNIIDAE (combtooth blennies)	
<i>Blennius pavo</i> Risso .....	Fishelson, 1963
<i>Blennius pholis</i> L. ....	Qasim, 1955, 1959
<i>Blennius ocellaris</i> L. ....	Garstang, 1900
<i>Centronotus gunnellus</i> (L.) .....	Qasim, 1955, 1959
STICHAEIDAE (pricklebacks)	
<i>Ernogrammus hexagrammus</i> (Temminck and Schlegel) .....	Fujita and Uchida, 1959
MUGILIDAE (mulletts)	
<i>Mugil cephalus</i> L. ....	Fahey, 1964
ATHERINIDAE (silversides)	
<i>Atherina presbyter</i> Valenciennes .....	Fabre-Domergue and Biéatrix, 1897
<i>Atherinops affinis</i> (Ayres) .....	McHugh and Walker, 1948
<i>Atherinopsis californiensis</i> Girard .....	Morris, 1956
<i>Leuresthes tenuis</i> (Ayres) .....	David, 1939; McHugh and Walker, 1948; Morris, 1956
<i>Menidia menidia</i> (L.) .....	Rubinoff, 1958
<i>Odontesthes (Austromenidia) regia regia</i> (Humboldt) .....	Chironos de Vildoso and Chuman, 1964
BOTHIDAE (lefteye flounders)	
<i>Citharichthys</i> sp. ....	Morris, 1956
<i>Scophthalmus maximus</i> (L.) .....	Anthony, 1910
PLEURONECTIDAE (righteye flounders)	
<i>Eopsetta grigorjewi</i> (Herzenstein) .....	Fujita, 1965
<i>Kareius bicoloratus</i> Basilewsky .....	Mito et al., 1969
<i>Liopsetta obscura</i> (Herzenstein) .....	Kurata, 1956
<i>Microstomus kitt</i> (Walbaum) .....	A. Dannevig, 1948
<i>Parophrys vetulus</i> Girard .....	Budd, 1940
<i>Platichthys stellatus</i> (Pallas) .....	Orcutt, 1950
<i>Pleuronectes platessa</i> L. ....	Cunningham, 1893-95b; H. Dannevig, 1897; Dannevig and Hansen, 1952; Molander and Mo- lander-Swedmark, 1957; Rollefson, 1939; Shel- bourne, 1964
<i>Pleuronichthys coenosus</i> Girard .....	Budd, 1940
<i>Pleuronichthys decurrens</i> Jordan and Gilbert ..	Budd, 1940
<i>Pleuronichthys verticalis</i> Jordan and Gilbert ..	Budd, 1940
<i>Tanakius kitaharai</i> (Jordan and Starks) .....	Fujita, 1965

Appendix I—Species of marine fishes used in laboratory rearing attempts—Cont.

Fish	References
SOLEIDAE (soles)	
<i>Solea solea</i> (L.) .....	A. Dannevig, 1948; Fabre-Domergue and Biéatrix, 1905; Flüchter, 1965
TETRAODONTIDAE (puffers)	
<i>Tetraodon (Higanfugu) pardalis</i> (Temminck and Schlegel) .....	Shojima, 1957
<i>Tetraodon (Gocephalus) lunaris spadiceus</i> (Richardson) ..	Fujita, 1966
LOPHIIDAE (anglers)	
<i>Lophius piscatorius</i> L. ....	Gross, 1937; Lebour, 1925

## APPENDIX II

### Foods Used in Attempts to Rear the Larvae of Marine Fishes.<sup>1</sup>

Food	References
WILD PLANKTON	
	Anthony, 1910; Blaxter, 1968, 1969; Blaxter and Hempel, 1961; Budd, 1940; Cunningham, 1893-95a & b; A. Dannevig, 1948; H. Dannevig, 1897; Dannevig and Hansen, 1952; David, 1939; Dôtu and Mito, 1958; Fabre-Domergue and Biéatrix, 1897, 1905; Garstang, 1900; Ivanchenko and Ivanchenko, 1969; Kramer and Zweifel, 1970; Lebour, 1925; Meyer, 1878; Mito et al., 1969; Morris, 1956; Okamoto, 1969; Orcutt, 1950; Richards and Palko, 1969; Schach, 1939; Schumann, in Bardach, 1968; Yamamoto and Nishioka, 1952
PROTISTA: PLANKTONIC FORMS	
Chlorophyta:	
Loxophyceae:	
<i>Platymonas subcordiformis</i> .....	Orcutt, 1950
<i>Halosphaera minor</i> .....	Blaxter, 1969
Chlorophyceae:	
<i>Chlamydomonas</i> sp. ....	Bishai, 1961; Blaxter, 1962, 1969; Gross, 1937; Qasim, 1955, 1959
<i>Dunaliella primolecta</i> .....	Blaxter, 1969
<i>Dunaliella salina</i> .....	Fabre-Domergue and Biéatrix, 1905
<i>Dunaliella</i> sp. ....	Blaxter, 1962; Budd, 1940; Delmonte et al., 1968; Morris, 1956
<i>Chlorella stigmata</i> .....	Qasim, 1955
<i>Chlorella</i> sp. ....	Blaxter, 1962
<i>Stichococcus</i> sp. ....	Morris, 1956
Pyrrophyta:	
Cryptophyceae:	
<i>Cryptomonas maculata</i> .....	Blaxter, 1969
Desmophyceae:	
<i>Prorocentrum micans</i> .....	Blaxter, 1969; Gross, 1937, Lasker et al., 1970; Qasim, 1955
Dinophyceae:	
<i>Gymnodinium splendens</i> .....	Lasker et al., 1970
<i>Oxyrrhis marina</i> .....	Morris, 1956
<i>Oxyrrhis</i> sp. ....	Kasahara et al., 1960
<i>Protoceratium reticulatum</i> .....	Lasker et al., 1970
<i>Fragilidium heterolobum</i> .....	Lasker et al., 1970
Crysophyta:	
Xanthophyceae:	
<i>Olisthodiscus</i> sp. ....	Blaxter, 1969

<sup>1</sup>See footnote at end of table.

Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
<b>Chrysophyceae:</b>	
<i>Isochrysis galbana</i> .....	Qasim, 1955, 1959
<i>Monochrysis lutheri</i> .....	Forrester, 1964
<i>Chromulina pusilla</i> .....	Qasim, 1955
<b>Bacillariophyceae:</b>	
<i>Coscinodiscus concinnus</i> .....	Hertling, 1932
<i>Coscinodiscus radiatus</i> .....	Gross, 1937
<i>Skeletonema costatum</i> .....	Blaxter, 1962; Forrester, 1964; Gross, 1937; Kurata, 1956, 1959
<i>Thalassiosira</i> sp. ....	Gross, 1937
<i>Lauderia borealis</i> .....	Blaxter, 1969
<i>Rhizosolenia</i> sp. ....	David, 1939
<i>Chaetoceros</i> sp. ....	David, 1939
<i>Biddulphia mobiliensis</i> .....	Hertling, 1932
<i>Ditylum brightwellii</i> .....	Blaxter, 1969
<i>Nitzschia closterium</i> .....	Orcutt, 1950
<i>Nitzschia</i> sp. ....	Bishai, 1961; Blaxter, 1962; Budd, 1940
"Diatoms" .....	David, 1939; Rubinoff, 1958
<b>Uromycophyta:</b>	
<b>Ascomycetes:</b>	
"Yeast" .....	Klima et al., 1962; Morris, 1956
<b>Taxonomy uncertain:</b>	
"Natural and cultured phytoplankton" .....	Klima et al., 1962
"Raw cultures of phytoplankton" .....	Dannevig, 1948
"Cultures of single species of green algae and naked flagellates" .....	Dannevig, 1948
"Phytoplankton" .....	Bishai, 1961; Ivanchenko and Ivanchenko, 1969
"Plankton algae" .....	Runnström, 1941
"Algae" .....	Fabre-Domergue and Biéatrix, 1897
"Monadinen" .....	Kotthaus, 1939
"Vegetarian diet" .....	Soleim, 1942
<b>PROTISTA: NONPLANKTONIC FORMS</b>	
<b>Cyanophyta:</b>	
"Blue-green algae" .....	Fabre-Domergue and Biéatrix, 1897
<b>Chlorophyta:</b>	
<i>Enteromorpha</i> sp. ....	Kotthaus, 1939
<b>Chrysophyta:</b>	
"Filamentous brown diatom" .....	Fabre-Domergue and Biéatrix, 1897
<b>Ciliophora:</b>	
<b>Ciliata:</b>	
<i>Euplotes</i> sp. ....	Fabre-Domergue and Biéatrix, 1897
<i>Philaster digitiformis</i> .....	Fabre-Domergue and Biéatrix, 1897
<i>Stylonychia</i> sp. ....	Kasahara et al., 1960
<b>Taxonomy uncertain:</b>	
"Filamentous algae" .....	Delmonte et al., 1968
"Cultured infusorians" .....	Fabre-Domergue and Biéatrix, 1897

Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
METAZOA: PLANKTONIC FORMS	
Aschelminthes:	
Rotifera:	
<i>Brachinous plicatilis</i> .....	Hirano, 1969; Mito et al., 1969; Okamoto, 1969
Mollusca:	
Gastropoda:	
<i>Crepidula</i> sp. "larvae" .....	Rubinoff, 1958
<i>Bulla gouldiana</i> veligers .....	Lasker et al., 1970
<i>Haminoea vesicula</i> veligers .....	Lasker et al., 1970
<i>Navanax inermis</i> veligers .....	Lasker et al., 1970
"Nacktschnecken" (? nudibranch) larvae	Kotthaus, 1939
Pelecypoda:	
<i>Mytilus californianus</i> "larvae" .....	Morris, 1956
<i>Mytilus</i> sp. trochophores .....	Blaxter and Hempel, 1961; Okamoto, 1969; Schach, 1939
<i>Mytilus</i> sp. "larvae" .....	Dannevig, 1948; Kotthaus, 1939; Kurata, 1956
<i>Ostrea edulis</i> "larvae" .....	Dannevig, 1948
<i>Crassostrea gigas</i> "larvae" .....	Hirano, 1969
"Oyster" trochophores .....	Okamoto, 1969
Annelida:	
Polychaeta:	
<i>Chone teres</i> trochophores .....	Kurata, 1959
<i>Pomatoceros</i> sp. "larvae" .....	Dannevig, 1948
<i>Nereis</i> sp. eggs .....	Cunningham, 1893-95b
"Minced worms" .....	Cunningham, 1893-95a
Arthropoda:	
Crustacea:	
<i>Artemia salina</i> nauplii .....	Bishai, 1961; Blaxter, 1962, 1968; Blaxter and Hempel, 1961; Budd, 1940; Chirinos de Vildoso, 1964; Dannevig, 1948; Dannevig and Hansen, 1953; Delmonte et al., 1968; Fahey, 1964; Fishelson, 1963; Flüchter, 1965; Forrester, 1964; Fujita, 1957, 1958, 1965, 1966; Fujita and Uchida, 1959; Gross, 1937; Hirano, 1969; Joseph and Saksena, 1966; Kasahara et al., 1960; Klima et al., 1962; Kramer and Zweifel, 1970; Kurata, 1956, 1959; McHugh and Walker, 1948; McMynn and Hoar, 1953; Mito et al., 1969; Molander and Molander-Swedmark, 1957; Morris, 1956; Okamoto, 1969; Orcott, 1950; Qasim, 1955, 1959; Richards and Palko, 1969; Rollefson, 1939; Rubinoff, 1958; Schumann, in Bardach, 1968; Shelbourne, 1964; Shiokawa and Tsukahara, 1961; Shojima, 1957; Soleim, 1942; Tsukahara, 1962; Tsukahara and Shiokawa, 1957; Tsukahara et al., 1957
Cladocera .....	Gross, 1937



Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
Pharopoda—Cont.	
Crustacea—Cont.	
<i>Daphnia pulex</i> eggs	McMynn and Hoar, 1953
<i>Daphnia</i> sp.	Bückmann et al., 1953
Copepods	Bishai, 1961; Bückmann et al., 1953; Fishelson, 1963; Gross, 1937; Hirano, 1969
Copepod nauplii	Kasahara et al., 1960; Kotthaus, 1939
<i>Tigriopus californicus</i> nauplii	Fahey, 1964
<i>Tigriopus fulvus</i> nauplii	Bishai, 1961; Budd, 1940; Orcutt, 1950
<i>Tigriopus fulvus</i> adults	Blaxter, 1965, 1968; Morris, 1956
<i>Tigriopus</i> sp. "young stages"	Blaxter, 1962
<i>Tisbe</i> sp.	Blaxter, 1962
<i>Balanus balanoides</i> nauplii	Blaxter, 1962, 1968; Dannevig, 1948; Qasim, 1955, 1959; Shelbourne, 1964; Soleim, 1942
<i>Balanus glandula</i> nauplii	Morris, 1956
<i>Balanus amphitrite albicostatus</i> nauplii	Hirano, 1969; Kasahara et al., 1960
<i>Neomysis japonicus</i> "young"	Kasahara et al., 1960
Phoronodermata:	
Echinoidea:	
<i>Dendraster excentricus</i> eggs or larvae	Morris, 1956
<i>Strongylocentrotus purpuratus</i> eggs or larvae	Budd, 1940; Morris, 1956; Orcutt, 1950
<i>Tripneustes esculentus</i> eggs or larvae	Richards and Palko, 1969
<i>Arbacia</i> sp. eggs or larvae	Deuel et al., 1966; Rubinoff, 1958
"Fertilized sea urchin eggs"	Fujita, 1965
Asteroidea:	
<i>Asterias</i> sp. eggs	Blaxter, 1962
Tunicata:	
Ascidian larvae	Fabre-Domergue and Biéatrix, 1897
Mollusca:	
Fish larvae	Fabre-Domergue and Biéatrix, 1905

METAZOA: NONPLANKTONIC FORMS

Platyhelminthes:

Nematoda:

*Anguillicula* sp. . . . . Blaxter, 1962

MISCELLANEOUS

Prepared aquaria . . . . . Bishai, 1961; Delmonte et al., 1968; Heuts, 1947; Klima et al., 1962; McHugh and Walker, 1948

Finely ground trout food . . . . . Richards and Palko, 1969

Powered fish foods . . . . . Rubinoff, 1958

Commercial fish-fry foods . . . . . Blaxter, 1962; Delmonte et al., 1968; Klima et al., 1962

## Appendix II—Foods used in attempts to rear the larvae of marine fishes—Cont.

Food	References
<b>MISCELLANEOUS—Cont.</b>	
Cooked chicken egg yolk .....	Bückmann et al., 1953; Fabre-Domergue and Biéatrix, 1897; Fishelson, 1963; Fujita, 1966; Heuts, 1947; Ivanchenko and Ivanchenko, 1969; Klima et al., 1962; Kurata, 1959; Morris, 1956; Nikitinskaya, 1958
Water-soluble vitamin compounds .....	Klima et al., 1962
Liver of shore crab, <i>Carcinus maenus</i> .....	Bishai, 1961
Minced shrimp and crab meat .....	Kurata, 1959
Crushed mussel .....	Fabre-Domergue and Biéatrix, 1897
Homogenates of <i>Mytilus</i> , periwinkle, <i>Fucus</i> and kelp .....	Ivanchenko and Ivanchenko, 1969
Liver-skim milk .....	McMynn and Hoar, 1953
Human blood .....	Klima et al., 1962

<sup>1</sup> This table is taken, with some additions, from: May, R. C. 1970. Calif. Coop. Oceanic Fish. Invest. Rep. 14: 76-83.

salmon (models I and II), by Daniel W. Bates and John G. Vanderwalker, pp. 1-5, 6 figs., 1 table; 2d paper, Design and operation of a cantilevered traveling fish screen (model V), by Daniel W. Bates, Ernest W. Murphey, and Earl F. Prentice, 10 figs., 1 table.

Annotated bibliography of zooplankton sampling devices. By Jack W. Jossi. July 1970, iii + 90 pp.

Limnological study of lower Columbia River, 1967-68. By Shirley M. Clark and George R. Snyder. July 1970, iii + 14 pp., 15 figs., 11 tables.

Laboratory tests of an electrical barrier for controlling predation by northern squawfish. By Galen H. Maxfield, Robert H. Lander, and Charles D. Volz. July 1970, iii + 8 pp., 4 figs., 5 tables.

The Trade Wind Zone Oceanography Pilot Study. Part VIII: Sea-level meteorological properties and heat exchange processes, July 1963 to June 1965. By Gunter R. Seckel. June 1970, iv + 129 pp., 6 figs., 8 tables.

Sea-bottom photographs and macrobenthos collections from the Continental Shelf off Massachusetts. By Roland L. Wigley and Roger B. Theroux. August 1970, iii + 12 pp., 8 figs., 2 tables.

A sled-mounted suction sampler for benthic organisms. By Donald M. Allen and J. Harold Hudson. August 1970, iii + 5 pp., 5 figs., 1 table.

Distribution of fishing effort and catches of skipjack tuna, *Katsuwonus pelamis*, in Hawaiian waters, by quarters of the year, 1948-65. By Richard N. Uchida. June 1970, iv + 37 pp., 6 figs., 22 tables.

Effect of quality of the spawning bed on growth and development of pink salmon embryos and alevins. By Ralph A. Wells and William J. McNeil. August 1970, iii + 6 pp., 4 tables.

Fur seal investigations, 1968. By NMFS, Marine Mammal Biological Laboratory. December 1970, iii + 69 pp., 68 tables.

Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River Basin - past and present. By Leonard A. Fulton. December 1970, iii + 37 pp., 6 figs., 11 maps, 9 tables.

Macrozooplankton and small nekton in the coastal waters off Vancouver Island (Canada) and Washington, spring and fall of 1963. By

Donald S. Day, January 1971, iii + 94 pp., 19 figs., 13 tables.

620. The Trade Wind Zone Oceanography Pilot Study. Part IX: The sea-level wind field and wind stress values, July 1963 to June 1965. By Gunter R. Seckel. June 1970, iii + 66 pp., 5 figs.

621. Predation by sculpins on fall chinook salmon, *Oncorhynchus tshawytscha*, fry of hatchery origin. By Benjamin G. Patten. February 1971, iii + 14 pp., 6 figs., 9 tables.

622. Number and lengths, by season, of fishes caught with an otter trawl near Woods Hole, Massachusetts, September 1961 to December 1962. By F. E. Lux and F. E. Nichy. February 1971, iii + 15 pp., 3 figs., 19 tables.

623. Apparent abundance, distribution, and migrations of albacore, *Thunnus alalunga*, on the North Pacific longline grounds. By Brian J. Rothschild and Marian Y. Y. Yong. September 1970, v + 37 pp., 19 figs., 5 tables.

624. Influence of mechanical processing on the quality and yield of bay scallop meats. By N. B. Webb and F. B. Thomas. April 1971, iii + 11 pp., 9 figs., 3 tables.

625. Distribution of salmon and related oceanographic features in the North Pacific Ocean, spring 1968. By Robert R. French, Richard G. Bakkala, Masanao Osako, and Jun Ito. March 1971, iii + 22 pp., 19 figs., 3 tables.

626. Commercial fishery and biology of the freshwater shrimp, *Macrobrachium*, in the Lower St. Paul River, Liberia, 1952-53. By George C. Miller. February 1971, iii + 13 pp., 8 figs., 7 tables.

629. Analysis of the operations of seven Hawaiian skipjack tuna fishing vessels, June-August 1967. By Richard N. Uchida and Ray F. Sumida. March 1971, v + 25 pp., 14 figs., 21 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - 35 cents.

633. Blueing of processed crab meat. II. Identification of some factors involved in the blue discoloration of canned crab meat (*Callinectes sapidus*). By Melvin E. Waters. May 1971, iii + 7 pp., 1 fig., 3 tables.

636. Oil pollution on Wake Island from the tanker *R. C. Stoner*. By Reginald M. Gooding. May 1971, iii + 12 pp., 8 figs., 2 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price 25 cents.

UNITED STATES  
DEPARTMENT OF COMMERCE  
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION  
NATIONAL MARINE FISHERIES SERVICE  
SCIENTIFIC PUBLICATIONS STAFF  
BLDG. 67, NAVAL SUPPORT ACTIVITY  
SEATTLE, WASHINGTON 98115

OFFICIAL BUSINESS

POSTAGE AND FEES PAID  
U.S. DEPARTMENT OF COMMERCE

