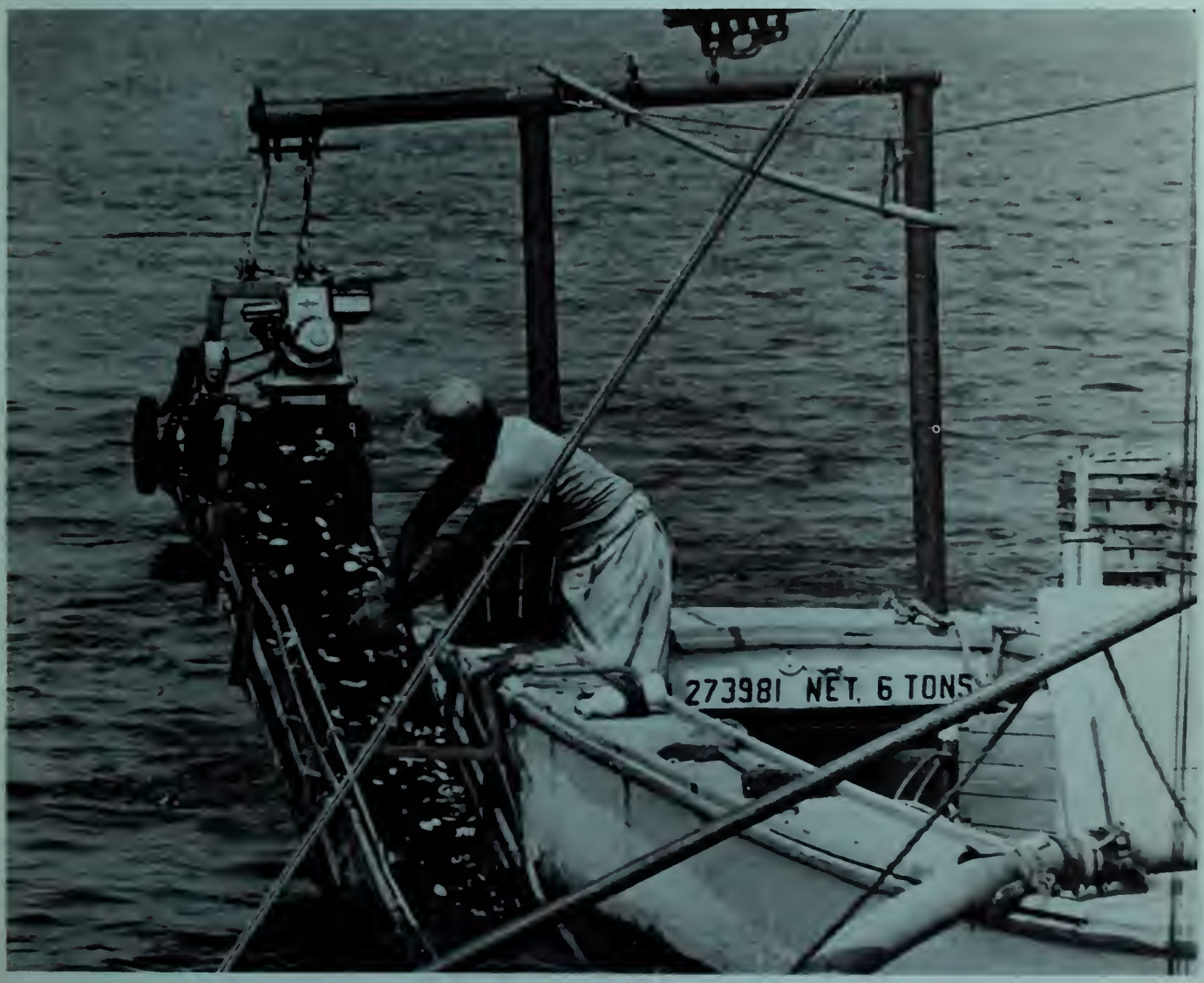
Report to Congress

The Molluscan Shellfish Industries and Water Quality: Problems and Opportunities



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

The Molluscan Shellfish Industries and Water Quality: Problems and Opportunities

Prepared by
Office of Fisheries Development
National Marine Fisheries Service

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U.S. DEPARTMENT OF COMMERCE
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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

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Sirs:

I have the honor to transmit herewith the report "The Molluscan Shellfish Industries and Water Quality--Problems and Opportunities" with related technical studies. This report is submitted in fulfillment of Section 16(a) of the Coastal Zone Management Act Amendments of 1976, P.L. 94-370, (16 U.S.C. 1462).

Shellfish waters and the molluscan shellfish industry are vital to the economies of communities along our entire coastline. The report identifies a complex array of problems facing the molluscan shellfish industry including: overregulation, a lack of coordinated Government research and service programs, a decreasing resource base largely due to inadequate protection of shellfish growing waters, and the need for new technology and market development.

Study findings show there are numerous Government programs to improve water quality, enhance the quality of coastal resources, and assist the industry. While those programs have provided benefits, this study identifies certain Government efforts that can be made more effective and efficient. The recommendations therefore, which may relate to programs within the Department of Commerce or other agencies, must be further analyzed with a view toward developing better program coordination to achieve the recognized goals.

Sincerely,

Juanita M. Kreps

Juanita M. Kreps

Enclosure

President of the Senate
Speaker of the House of Representatives

PREFACE

This report was developed in cooperation with 22 shellfish-producing States, 5 Federal agencies, and major shellfish trade associations. The report identifies the involvement of the many Federal agencies and their State counterparts which, in whole or in part, regulate the use of shellfish waters and the growing, harvesting, transporting, processing, and marketing of oysters, clams, and mussels.

The report develops information that will be useful to individuals, industries, and units of government for making decisions about water quality and the Nation's shellfish resources. Although the shellfish industry has decreased in size over the past 50 years while water quality problems have increased, these trends appear to be stabilizing. The challenge now is to conserve, use, and enhance the existing shellfish resources, and the water quality upon which they depend, in the most cost-efficient manner.

The composite recommendations of this report are based on information contained in four individual reports on water quality, oysters, clams, and mussels. The Department of Commerce is carefully reviewing these recommendations and assessing how it can best direct its efforts to help other Federal agencies, State and local governments, and industry make economic progress in the productive use of these water and shellfish resources.

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I. INTRODUCTION

A. General

The Molluscan Shellfish Industry contributes over $600 million annually to the Nation's Net National Product by the production of oysters, clams, and mussels from U.S. coastal waters. The industry is of major significance to the economies of many rural coastal communities and has substantial growth potential. Harvesting this important food supply, however, is permitted only from high-quality waters that must conform to more rigid standards than are prescribed for other seafood production or even swimming. Consequently, the well-being of shellfish-producing communities and their industries is extremely dependent on the efficacy of institutional provisions for safeguarding the Nation's water quality as well as its food supply.

Recognizing this situation, the Congress amended the Coastal Zone Management Act of 1972, which the President signed on July 26, 1976. Pursuant to Section 16 of the amended Act, the National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Department of Commerce (DOC), reviewed all aspects of the Molluscan Shellfish Industry and the impact of Federal law on water quality. Under contract to NMFS, the Universities of Delaware and Maine, as well as the Stanford Research Institute, assisted in this study.

B. Purpose and scope of study

The purpose of the overall study undertaken by NMFS was to (1) identify the principal technical, environmental, socio-economic, institutional, political, and public health issues associated with the growing, harvesting, processing, and marketing of shellfish products, (2) review how Federal laws concerning water quality affect molluscan shellfish, and (3) summarize the principal findings and recommendations. The National Shellfish Safety Program (NSSP) proposed by the U.S. Food and Drug Administration is under revision and therefore was not considered in this review.

Water quality was investigated to obtain information on threats to the shellfish acreage open to recreational and commercial harvesting, the availability of the shellfish resource, and the closures of harvestable areas in the interest of public health. The relevant laws and various enforcement, abatement, and advisory programs were reviewed as to their effects on shellfish resources.

The status of commercially important species of oysters, clams, and mussels in the shellfish-producing States was investigated by means of personal interviews and studies of available literature. Members of the study teams interviewed individuals from the shellfish industry, industry trade associations, State public health and conservation agencies, Federal agencies, universities, and large institutional purchasers of shellfish products.

The principal findings and recommendations presented in this report are based on information contained in the following four individual reports:

"Water Quality and Molluscan Shellfish: An Overview of the Problems and the Nature of Appropriate Federal Laws," Stanford Research Institute, 1977;

"A Comprehensive Review of the Commercial Oyster Industries in the United States," Office of Fisheries Development, National Marine Fisheries Service, 1977;

"A Comprehensive Review of the Commercial Clam Industries in the United States," College of Marine Studies, University of Delaware, 1977;

"A Comprehensive Review of the Commercial Mussel Industries in the United States," Department of Oceanography, University of Maine, 1977.

Study findings show there are numerous Government programs to improve water quality, enhance the quality of coastal resources, and assist the industry. While those programs have provided benefits, this study identifies certain Government efforts that can be made more effective and efficient. The specific recommendations, however, which may relate to programs within the Department of Commerce or other agencies, must be further analyzed with a view toward developing better program coordination to achieve the recognized goals.

II. PRINCIPAL FINDINGS AND RECOMMENDATIONS

A. Findings

Principal findings and major problem areas identified in this report are summarized as follows:

1. Competition for use of the coastal zone

- Competition for use of the coastal zone is one of the major causes for many problems of the shellfish industry. The relatively small size of the industry compared to its chief competitors (urban development, industry, recreation) and lack of public awareness result in a low priority given to the shellfish industry when economic assessments of the coastal areas are made.

- The industry is facing a continuously decreasing resource base due to environmental changes and pollution from competing users.

- Many Federal, State, and local authorities have jurisdictions and responsibilities related to parts of the shellfish resources and the industry. This adds to the complexities of making equitable evaluations and determinations regarding competitive uses of the coastal zone.

2. Jurisdictional authorities and regulations

- The numerous jurisdictional authorities over shellfish production, processing, and marketing complicate the coordination, implementation, and enforcement of regulations to protect, develop, manage, and monitor shellfish waters and to inspect and regulate the shellfish industry.

- More than five Federal agencies with a multiplicity of divisions, branches, services, and programs and often numerous State and local counterparts have various degrees of control over activities that affect wetlands, estuarine waters, and regulation of the industry.

- Numerous private and Government entities compete for often conflicting uses of coastal waters and attendant resources. Their interests include municipal, industrial, agricultural, and recreational activities.

3. Water quality and decreasing resource base

- Molluscan shellfish waters line our coasts and cover wide areas from the brackish, low-salinity waters of most tidal rivers to the bays and adjacent coastal waters of the continental shelf; some more than 3 miles off the Nation's coastline. There are 22 States in the continental United States that produce oysters, clams, or mussels for recreational or commercial harvesting.

Water quality criteria are used to define a body of water by its physical and chemical properties, which control the quality of life the water will support. The Water Quality Act of 1965 created four classes of water based on their designated uses. These classes, in order of descending water quality are: waters used for water-contact recreation, propagation of desirable fish and wildlife, public water supplies, and agricultural and industrial uses. Molluscan shellfish can be harvested only from waters which, in fact, must meet quality standards more rigid than those acceptable for swimming.

- To assure the safety of shellfish growing and harvesting, the cooperative National Shellfish Sanitation Program, administered by the U.S. Food and Drug Administration, requires that all shellfish-growing areas be certified by the States as "safe" prior to the harvest of mollusks for human consumption. States commonly classify their waters as "approved," "conditionally approved," "restricted," "prohibited," or "nonshellfish/nonproductive" areas. Most certifications of harvesting waters are based on bacterial levels, but may be classified for closure because of the presence of shellfish toxins, paralytic shellfish poison, radionuclides, and toxic industrial wastes.

- Terminology confuses the issue when national summaries are used. The term "prohibited," by definition, means "closed to all harvesting due to hazardous levels of contamination." Some States use the terms "closed," "restricted," and "condemned" in place of "prohibited." A State control agency may, because of a variety of reasons, classify an area "prohibited" even though the waters may be safe for shellfish production. Areas can be closed for conservation purposes or because of the threat of contamination, e.g., areas near shipping lanes.

- There is a lack of uniform State standards for classifying shellfish waters and keeping records. Consequently, assessments, evaluations, and recommendations to improve the environment and the resource base are difficult.

- Based on water quality criteria, the prohibited areas for shellfish production increased during 1971-74. Degradation of water quality is continuing, but nationally at only half the rate of the 1966-71 period. Several States show decreases, or little or no increase, in prohibited areas, while others show significant increases.

- Domestic waste discharges have the greatest negative effect on the sanitary condition of growing waters. Dredging and filling operations, siltation, chemical contamination, industrial discharges, and other pollution sources contribute to the overall degradation of shellfish waters.

• Molluscan shellfish resource losses because of area closures were estimated to be over $29 million during 1975.

4. Effect of existing legislation

• Existing laws, if adequately implemented over a period of years, should result in a healthy shellfish environment. At present, however, there are shellfish beds closed to harvesting because of water quality problems, but the mechanisms provided by existing laws are beginning to achieve positive results. Of particular importance to molluscan shellfish is the permit program of the Federal Water Pollution Control Act Amendments of 1972. In the 23 coastal States (including Hawaii), 90 percent of the identified municipal dischargers have been issued permits. However, the Environmental Protection Agency estimates that only 50 percent of that number will be in compliance by July 1977. Nonmunicipal dischargers are estimated to have a higher percentage of compliance. Of equal concern to molluscan shellfish interests are the programs covered by this act dealing with areawide water management and river basin planning. There is substantial planning underway for the first program, but only limited efforts in the second. Initial areawide water quality management plans will not be received by EPA until 1978. It is premature to judge how effective these plans will be.

• Fish and wildlife agencies appear to have difficulties fully complying with the review and consultative provisions under the Fish and Wildlife Coordination Act of 1958. These agencies participate in reviews of permit applications pursuant to Section 10 (River and Harbor Act of 1899) and Section 404 (Federal Water Pollution Control Act of 1972), National Pollution Discharge Elimination System permit applications and Federal projects.

5. Characteristics of industry

• The molluscan shellfish industry is composed of numerous small units scattered along much of the U.S. coastal region. Less than 1 percent of all businesses have annual sales over $500,000.

• Harvesting is essentially a fishing operation by individuals or small groups using simple gear.

• Processing and packing facilities tend to be small, family-owned, labor-intensive, and marginally profitable.

• Institutional constraints adversely affect the use of labor-saving mechanical equipment used in other seafood- and food-processing plants.

• Resource replacement largely depends on natural reproduction, management of the industry, and protection of the environment.

• Many operators, both harvesters and processors, would benefit from sound financing for acquisition of labor-saving and more efficient equipment.

- Industry development and revitalization could be encouraged by adequate research and technical assistance.

6. Research and information requirements

- Research on manmade and natural pollution that affect molluscan shellfish environments and resources could be used advantageously by environmental managers.

- Information on developments in the following areas would be particularly helpful:

  - Freshwater flooding: the effects on natural systems.

  - Toxic substances: their causes, movements through the environment, and subsequent effects and control.

  - Shellfish predation and diseases: their causes, effects, and control.

  - Plankton blooms: their causes, effects, and control.

  - Agricultural and silvicultural practices: analyses of their significance to estuaries, control techniques, and background information.

B. Recommendations

The recommendations address the major problems noted in this report and emphasize what needs to be done. Specific roles for implementing these recommendations have not been determined nor has the need, if any, for additional legislation, manpower, and funding been addressed. These areas should be collectively addressed by the States, industry, and the Federal agencies.

1. Adequacy of present legislation

Present Federal laws, including the Fish and Wildlife Coordination Act, do not fully protect shellfish resources from pollution and habitat changes, but do provide a framework for both fishery and regulatory agencies to develop better coordination of their activities related to water quality.

It is recommended that:

- Federal and State fish and wildlife agencies develop means to ensure that activities related to the planning of Federal water development projects and the issuance of permits for waste discharge and construction adequately protect and restore molluscan shellfish waters.

- Federal agencies cooperatively examine the Fish and Wildlife Coordination Act to determine if it assures adequate coverage of actions affecting commercial and recreational fisheries.

2. More effective use of present legislation

The Federal Water Pollution Control Act Amendments of 1972 and the Coastal Zone Management Act of 1972, as amended, provide a sound legislative frame work to deal with environmental problems that adversely affect shellfish stocks. However, their potential is not being fully realized in this respect. More effective use of legislation by Federal and State administrators could have an important positive effect on increasing the stocks of shellfish.

Implementation of the Federal Water Pollution Control Act Amendments is not fully protecting shellfish waters. Raw or inadequately treated sewage is the principal cause for closing shellfish-harvesting areas. Coordination of pollution control activities on interstate waters should be improved.

It is recommended that:

Federal and State activities under the Federal Water Pollution Control Act Amendments be better coordinated and developed with emphasis on:

- Making effective and efficient use of available Federal, State, and local support for construction of necessary sewage treatment plants through area-wide domestic waste planning.

- Improving enforcement of regulations governing the manufacture, distribution, application, and disposal of toxic substances.

- Initiating efficient development of "Level B" river basin plans for coastal rivers in concert with State Coastal Zone Management Plans.

- Providing the means for identification and resolution of any jurisdictional conflicts surrounding the origin, implementation, and enforcement of water quality control laws.

The Coastal Zone Management Act, as amended, should be implemented in a manner that promotes realization of all the benefits derivable from the Nation's shellfish resources.

3. Rehabilitating shellfish resources

Resources continue to be lost from overfishing, natural disasters, predation, disease, and pollution. Additional shellfish resources are needed to maintain a strong molluscan shellfish industry.

It is recommended that the resources be enhanced by:

- Cooperative State/Federal shellfish programs consistent with forthcoming regional fishery management programs being developed under the Fishery Conservation and Management Act of 1976.

- Acceleration of implementation and enforcement of existing pollution control laws to prevent resource destruction or contamination.

- Cooperative State/Federal efforts to validate growing-water criteria to redefine "safe" harvesting areas, and the development of precise and more rapid analytical tests to detect the presence of toxins and human pathogens. The present associative indicator tests may well be restricting the use of resources that are, in fact, safe.

- Improved habitat restoration and production techniques.

- More efficient techniques of relaying, depuration, and processing.

- Economic assessments of public and private hatcheries, so that development costs can be evaluated in terms of the following benefits:

  -- supplement of natural, wild production to offset mass mortalities caused by natural disasters, disease, and predators;

  -- production of genetically improved, disease-resistant stocks; and

  -- seed production to stock nonproductive bottoms that are capable of shellfish production.

4. Strengthening the shellfish industry

The continuing loss of shellfish resources and increasingly burdensome and overlapping regulatory requirements have seriously affected the industry and may threaten the continuing domestic supply of wholesome shellfish to the consumer.

It is recommended that:

A comprehensive program be developed for strengthening the molluscan shellfish industry. The program should be a joint industry/Government undertaking with direct support and involvement of industry and Government at the State and Federal levels. Major components of the program should include new technology development, product and market development, consumer education, financial assistance, and revision of regulations that affect productivity needlessly and adversely. Examples of the type of research and development that should be considered are:

- Detailed economic analyses to determine action that can be taken to improve the economic position of the industry.

- Improvement of harvesting and processing operations.

- Expanded information on the relaying of shellfish to approved areas for cleansing and on the depuration of shellfish in onshore facilities, when economically and technically feasible.

- More extensive use of aquaculture for the production of seed and market-size oysters, clams, and mussels, when economically and technically feasible. Hatcheries onshore would provide an opportunity for genetic studies to improve certain characteristics of the species as well as for the production of seed.

- Permitting shellfish farming on private beds. Planters would prepare the bottom by applying cultivating techniques, and would have the advantage of control over a more consistent and reliable supply source. Productivity on private beds is greater than on most public beds.

- New product development, market development through consumer education, and effective industry advertising to expand markets for existing and new product forms.

- A review of the availability of financial assistance from private and public institutions and of the industry's financing needs.

- Thorough review of current laws and regulations that adversely affect harvesting efficiency.

This report identifies the problems confronting the U.S. molluscan shellfish industry. The dominant issue interwoven throughout is the effect of the complicated array of programs, regulations, and business-reporting requirements generated by Federal and many State and local agencies. This complex and pervasive issue requires serious attention at all levels of Government.

It is recommended that:

- Coordinated reviews be made of the jurisdictional conflicts surrounding the origin, implementation, and enforcement of laws controlling uses of estuarine waters necessary for shellfish production and full use of the resources.

- Coordinated reviews be made of State and Federal research and service programs that affect that industry, and thus identify possible deficiencies.

- Investigation be made of mechanisms or new legislation needed to ensure resource protection and use. Coordination, direction, and assessment of the investigation should be unified under one entity, such as a special investigative committee, e.g., an Interdepartmental Task Force on molluscan shellfish.

III. MOLLUSCAN SHELLFISH INDUSTRY

A. Scope of the study

1. Purpose and approach

This section summarizes the principal technical, socioeconomic, institutional, political, and public health issues associated with the growing, harvesting, processing, and marketing of shellfish and shellfish products and makes recommendations for their resolution. The information in this report was obtained by small task groups that held interviews in the shellfish-producing States with members of industry, industry trade associations, State public health and conservation agencies, Federal agencies, universities, and large institutional purchasers of shellfish products.

2. Species investigated

The commercially important species of the following types of shellfish were investigated: (1) oysters--one species common both to the Atlantic and Gulf Coasts, and two Pacific Coast species; (2) hard clams--one Atlantic and one Gulf Coast species, the three Pacific Coast species; (3) surf clams; (4) ocean quahog clams; (5) soft-shell clams--one species common to the Atlantic and Pacific Coasts; (6) razor clams--one Pacific Coast species; (7) geoduck and horse clams; and (8) mussels--one Atlantic Coast species, and two Pacific Coast species. These are among the species of mollusks controlled by the Department of Health, Education, and Welfare under its Food and Drug Administration's National Shellfish Sanitation Program.

B. Industry profile

1. General industry characteristics

The shellfish industry comprises numerous entities scattered over the U.S. coastal regions. Table 1 shows the totals of U.S. landings, in pounds and dollars, for oyster, clam, and sea mussel meats during the 1971-75 period.

The value of the 1973 fish and shellfish catch was $937 million, which, after processing and sale, contributed an estimated $6.7 billion dollars to the Net National Product (the total value of the flow of final product).[1] Assuming that the above relationship between the value of fish landed during 1973 and value added was true for the molluscan shellfish industry during 1975, it is estimated that the 1975 catch for the molluscan shellfish industry (valued at $89.7 million) contributed, after processing and sale, $636.8 million to the Net National Product.

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[1]"Economic Impacts of the U.S. Commercial Fishing Industry," prepared by CENTAUR Management Consultants, Inc., Washington, D.C., Jan. 1975.

Table 1.--Landings and values of oysters, clams, and sea mussels, 1971-75

	Oyster meats		Clam meats		Sea mussel meats	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
1971	57,938	34,028	84,489	31,306	677	181
1972	56,058	37,066	90,689	33,215	877	262
1973	51,931	38,987	107,540	34,658	1,208	340
1974	50,178	40,851	121,825	41,396	941	334
1975	53,564	45,643	113,207	43,703	1,010	332

Exvessel value.

Table 2 shows the number of U.S. fishermen and crafts in the oyster, clam, and sea mussel fisheries during the 1971-75 period.

Table 2.--U.S. fishermen and craft in the oyster, clam, and sea mussel fisheries, 1971-75

	Oysters		Clam		Sea mussels	
	Fishermen	Craft	Fishermen	Craft	Fishermen	Craft
	Number					
1971	13,268	7,789	16,472	8,112	8,111	2,814
1972	11,419	7,464	11,704	8,944	7,784	1,849
1973	11,748	7,634	17,765	7,936	9,455	1,620
1974	11,472	8,019	23,285	14,046	10,341	3,406
1975	11,559	7,196	24,710	14,482	9,258	2,703

Data on fishermen and craft include duplication among the oyster, clam, and sea mussel fisheries. This means that the number of sea mussel fishermen is exaggerated. Data do not include count of all units on the Pacific Coast.

Table 3 shows the numbers of employees engaged in the U.S. production of fresh, frozen, and canned oyster and clam products and the values received for this production in the processing plants during the 1971-75 period.

Table 3.--Employees engaged in U.S. processing of fresh, frozen, and canned oyster and clam products, with values, 1971-75

	Oysters		Clams	
	Employees[1] Number	Value Thousand dollars	Employees[1] Number	Value Thousand dollars
1971	6,166	63,080	3,371	63,348
1972	5,769	67,279	3,002	62,948
1973	5,563	73,707	3,208	83,262
1974	5,297	68,634	3,321	102,952
1975	5,556	80,684	3,775	106,854

Data include only employees in processing plants.

[1] Average employment for year. Data include only edible products. Almost all sea mussels produced in the United States now are sold to the consumer without being processed. There has been no processing of sea mussels since World War 11, when small amounts were canned.

A few large and efficient commercial harvesting operations dredge oysters from private beds. Other efficient operations involve the escalator harvesting of soft clams and the high-volume dredging of surf clams. However, industry's harvesting operations on public oyster beds, for example, have been generally restricted from initiating efficient vessel and gear development associated with other fisheries. State and local agencies often impose gear restrictions to satisfy social as well as conservation needs. Many processing and packing facilities are small, family-owned, labor-intensive, and marginally profitable. Economic constraints and the predominance of small plants make it difficult to acquire and use labor-saving mechanical equipment such as that used in other seafood- and food-processing plants.

Certain segments of the industry are subject to sudden and severe changes in resource availability or product demand. Examples are:

(1) The soft clam industry, at one time in large production in New England and Maryland, suffered drastic reductions from natural and man-made causes. Later, surf clams replaced a large share of the soft-clam market for commercial use as fried clams in large chain restaurants.

(2) Oyster harvesting from public beds, which was extensive in the 1890's in New York waters, Delaware Bay, and Chesapeake Bay, has declined because of overfishing, pollution, habitat destruction, and damage to the resource by ravaging diseases. With the decline in supply from this area, the Gulf of Mexico and Pacific Coasts supplied much of the demand. The oyster populations in the Delaware and Chesapeake Bays have shown signs of renewal, but the destructive threats to the industry in these areas remain.

(3) The demand for mussels increased during World War II owing to other protein shortages. Currently, the demand is low because of consumer and industry indifference. A few local areas have shown some increase in demand.

There is need for development of new competitive products and markets, particularly for use of shellfish currently suitable for supplying U.S. consumer demand. As an example, the current market for large Pacific oysters is small, because canning of domestic meats and chowders has been sharply reduced by the inability of domestic processors to compete with low-priced imports. Overall, oyster imports have tripled since 1975, but the dependability of this supply cannot be assured.

The shellfish industry is beset with severe economic stresses, such as declining resource and labor bases, increased labor costs, declining demand, inflation, and generally restrictive regulations. Furthermore, the wholesale price of the product is generally not keeping up with the increase in the cost of living. While industry considers these conditions challenging, both capital and labor recognize their unique dependence on the availability of renewable resources from public waters certified suitable for shellfish harvesting.

2. Nature and size of the industry

a. The oyster industry

1) East and Gulf Coast industry

The oyster industry on the East and Gulf Coasts harvests the American or Eastern oyster, *Crassostrea virginica*. This species ranges from Canada to Mexico. Maryland, Louisiana, Virginia, and Florida are the leading producers of Eastern oysters. The oyster thrives in protected and nutrient-laden estuaries and tolerates a wide range of salinities. Throughout its range, its growth rate depends on temperature and varies considerably. In Southern and Gulf States, market-size oysters can be produced in 2 years; from the Chesapeake Bay and north, it takes 4 to 5 years to produce a market-size oyster.

The U.S. oyster harvest depends mainly on the availability of natural stocks. Naturally produced seed oysters from densely populated estuaries are transferred and planted on both public and private oyster-growing areas. The James River in Virginia is the largest seed oyster-producing area in the world and supplies 70 percent of the oysters planted in Virginia. James River seed oysters are also sold to neighboring States. The Connecticut estuaries are important seed producers which supply most of the seed used by Long Island oyster farms. Because environmental conditions and water quality are

critical to oyster production and larvae development, it is essential that seed-producing areas be adequately protected. Hatchery operations, while of increasing importance, supply a relatively small percentage of the total seed production.

Aquaculture is important to the national production of oysters. In 1974, aquacultural activities accounted for about 40 percent of the U.S. oyster harvest. The term "aquaculture" includes a wide array of activities from the simple transfer of seed oysters to growing areas to the most sophisticated closed systems. Aquaculture is helping to replenish and stabilize wild populations, which have declined drastically during the last 70 years due to pollution, natural disasters, and disease.

Harvesting techniques vary, and, in accordance with local regulations, are frequently limited to inefficient, labor-intensive methods on public grounds. Private growers, however, can often use efficient escalator and hydraulic dredge boats capable of harvesting up to 2,000 bushels of oysters per day with a two-man crew. In addition, private oyster farmers can harvest their beds throughout the year, whereas public areas are frequently closed 4 to 5 months of the year depending on local regulations.

2) West Coast industry

West Coast oyster production is centered on the large Pacific oyster, *Crassostrea gigas*, with limited production of the small Western native oyster, *Ostrea lurida*, in the Puget Sound area. Early attempts to introduce the American oyster, *Crassostrea virginica*, were initially successful at the turn of the century, but unexplained massive mortalities have virtually eliminated the species. West Coast production is almost entirely by aquaculture on privately leased bottoms, with Washington the major producer; Oregon and California also contribute. Most seed oysters are still imported from Japan, a practice which started in the 1920's; however, there is an increasing reliance on hatchery seed, and some limited natural set occurs.

Harvesting techniques vary and depend largely on the bottom and tidal amplitude. Oysters can be harvested by hand at low tide on exposed bars and by large hydraulic dredges in deeper waters.

3) National oyster production

Oysters are processed in plants more than any other single marine species in the United States. In 1975, a total of 448 plants processed specialty products. Most of the production is fresh shucked oysters. Canned oysters, canned oyster stew, and breaded oysters make up most of the remainder.

The sale of oysters in the shell for raw consumption, although limited, has significant regional importance. Almost all of the oysters produced by oyster farms in Long Island are sold for the raw bar trade, and in Louisiana private beds are harvested year-round to meet the high raw bar demands in New Orleans. By contrast, most Pacific Coast oysters are not normally eaten raw.

The largest number of plants is engaged in processing Eastern oysters. About 85 percent of the 448 oyster plants in the United States process Eastern oysters. Fresh shucked oysters dominate production. The processing sector is composed on many small, family-owned businesses. Table 4 shows that 24 percent of the plants have sales of $25,000 or less, which means their annual production would be about 2,600 to 2,800 gallons of oysters. Over a 200-day season, these plants would average about 13 gallons or less per day.

Table 4.--Structure of plants producing fresh and frozen Eastern oysters

1975 sales[1]	Plants	
	Number	Percent
Less than $25,000	91	23.8
$25,000 to $49,999	50	13.1
$50,000 to $99,999	57	14.9
$100,000 to $199,999	83	21.7
$200,000 to $299,999	38	10.0
$300,000 to $399,999	18	4.7
$400,000 to $499,999	12	3.1
$500,000 to $599,999	14	3.7
$600,000 to $699,999	3	0.8
Over $700,000	16	4.2
Total	382	100.0

[1]At wholesale level.

Source: "A Comprehensive Review of the Commercial Oyster Industries in the United States," Office of Fisheries Development, National Marine Fisheries Service, 1977.

The oyster industry is one of the top five fisheries providing employment in the harvesting, processing, and distribution of seafood. In 1973, there were about 11,748 oyster harvesters. This figure includes part-time harvesters. The total number of harvesters has been decreasing owing to, among other things, a declining resource. The number of harvesters averaged 14,000 in the 1950's, and 13,700 in the 1960's. There were about 6,200 workers in 1971. Employment in the processing sector was 5,556 in 1975 and is decreasing. By region, the Chesapeake Bay and the Gulf of Mexico areas have the highest number of employees (2,519 and 1,189, respectively).

Domestic landings of oysters have been declining for decades. In 1929, 90 million pounds (meat-weight) were landed. In the 1971-75 period, an average of 53.9 million pounds were landed--32.4 million pounds from public beds and 21.5 million pounds from private grounds. The decrease was largely in landings from East Coast States.

The value of oyster landings has increased. The harvest value in 1967 was $32.2 million compared to $45.6 million in 1975. Corrected for inflation, the exvessel prices actually declined in the period 1968-73 and then increased by 14 percent in 1975. This trend can be compared with prices paid to fishermen for all edible fish and shellfish, which more than doubled since 1967.

The total preliminary value of products at the plant level in 1975 was $81 million plus $5.8 million for shells. Table 5 shows the dollar value of oyster meats and oyster products during 1975. The final retail value of these products was estimated to be $121 million, assuming a 50 percent markup, which is conservative.

Table 5.--1975 sales of oyster products (f.o.b. plant)

Products	Sales
	Dollars
Eastern:	
Fresh shucked or steamed	59,916,695
Canned	4,064,946
Breaded	5,389,104
Specialties, fresh or frozen	362,883
Specialties, canned	2,898,837
	72,632,465
Pacific:	
Fresh shucked	5,436,332
Breaded	109,425
Specialties, canned	2,505,249
	8,051,006
Byproducts:	
Crushed shell and lime	5,846,584
Grand total	86,530,055

Source: "A Comprehensive Review of the Commercial Oyster Industries in the United States," Office of Fisheries Development, National Marine Fisheries Service, 1977.

b. The hard clam industry

The hard clam industry is the largest U.S. commercial clam industry in terms of fishermen and craft. About 17,000 fishermen and 13,300 craft produce hard clams in all 18 clam-producing States--13 on the East Coast and 5 on the West Coast.

The commercial fishery for hard clams on the East Coast has existed since colonial times. During periods of recession or high employment more people use hard clam resources as a source of income because of the easy accessibility of the shellfish beds and the simple, inexpensive harvesting gear required. Meat shortages immediately after World War II helped to increase the demand for hard clams, resulting in a record landing of 21.5 million pounds. At that time, and for a few years thereafter, large clams were in demand by industrial clam meat processors, but recently (1975-76), the surf clam has filled this demand. The small clams are generally less abundant than the larger sizes, but are more desirable and, consequently, more expensive. The small clams are marketed to be consumed from the shell, either raw or steamed.

The major West Coast hard clam resource is in Washington. There is no significant commercial use in California and Oregon because of limited areas suitable for harvesting and heavy recreational demands. Alaska has the greatest commercial potential on the West Coast.

Alaska's subtidal and deepwater clam resources--composed of several species of hard shell clams, as well as razor and surf clams--are untapped resources of unknown magnitude that may exceed quantities available in the rest of the United States. The potential presence of paralytic shellfish poisoning (PSP) and high labor costs are problems limiting the use of these vast resources.

Washington however, has many protected estuarine areas where extensive populations of intertidal and subtidal clams are found. Most of Washington's hard clam fisheries are found in various parts of Puget Sound. Farming of Manila clams and native littlenecks is closely associated with the oyster industry of southern Puget Sound. In central Puget Sound there is intertidal harvest of Manila clams and native littlenecks, and subtidal harvest of native littlenecks, butter clams, and horse clams by mechanical harvesters.

Most of the harvest is from privately owned tidelands and is taken by hand-digging with forks or rakes during low tides. The demand often exceeds the supply. Productive intertidal beaches could be lost if unmanaged development of the Puget Sound region continues. There is potential for increasing production by rehabilitating the beach and planting hatchery-reared clam seed.

Nationwide, the commercial landings of hard clams in 1975 were 14.8 million pounds. The value of the catch was $21.7 million. Exvessel values ranged from $0.81 per pound for Pacific Coast hard clam meats to $1.59 per pound for East Coast species. The 1966-72 figures for nationwide landings remained quite steady at about 16 million pounds. During the period 1966-75, the dollar value more than doubled. The 1966 value was $10.5 million; the 1975 value was $21.7 million.

The West Coast landings also remained quite steady between 1966 and 1975 at about 1.8 million pounds.

c. The surf clam industry

The surf clam industry began as a New England fish bait industry in 1870 and continued until increased demand for food during World War II led to human consumption of surf clam meats. The industry continued to grow after the war, because processors of clam meats and clam products found that the large surf clams were easier to process, cost less, and were more readily obtainable than hard or soft clams. Major producers of prepared clam products and large chain restaurants began to use surf clams exclusively, resulting in a rapid increase in production. As demand increased, more and more technological improvements were made. Larger harvesting vessels equipped with larger and more productive dredges were used, and improvements were made in the handling and processing equipment in the packing houses.

Harvesting began off New York and continued from 1945 at a diminishing rate of production until 1954. During that period, harvesting activity transferred to the extensive and densely populated beds off the coast of New Jersey. Between 1961 and 1966, about 96 percent of the U.S. production was landed in New Jersey. There was then a transfer of some harvesting to beds off the coasts of Delaware, Maryland, and Virginia.

Surf clam beds in Virginia and New Jersey were under intense fishing pressure during the years 1971-75, and the telltale signs of overfishing began to show--smaller clams and lower catch per unit effort. Surveys in 1975 provided scientific evidence of a decline in the surf clam resource. Federal and State/Federal surveys revealed that the Atlantic Coast clam standing crop, which in 1965 was estimated to be 1,093,000 metric tons, had decreased to 245,000 metric tons in 1975.

In addition to overfishing, massive mortalities of surf clams occurred off the New Jersey coast during the summer of 1976. The mortalities were attributed to depleted oxygen conditions below the thermocline for an extended period. The anoxic condition resulted from decay processes associated with a dinoflagellate bloom (*Ceratium tripos*) of unusual size and duration, and presumably the presence of high levels of nitrates and phosphates discharged by sewage treatment effluents. While at least 59,000 metric tons, or 28.5 percent of the total surf clam resource off the New Jersey coast was known to be lost, the total loss might be significantly greater than initial forecasts indicated.

The closure of growing areas because of domestic and industrial pollution has become much more significant now that the surf clam resource has been reduced. In New York waters, 76,800 acres of harvesting area in the apex of the New York Bight is closed because of ocean dumping of sewage sludge and industrial wastes, effluents from ocean outfalls, and proximity to heavily polluted estuaries. In New Jersey, 90,800 acres of the total 230,400 acres of ocean water within the 3-mile limit are closed.

Demand for surf clams continues to be high, but due to the diminished resources following massive mortalities in 1976 there has been a marked reduction in landings. Landings in 1966 were 45 million pounds, with an exvessel value of $3.9 million. The 1974 landings were 96.1 million pounds with an exvessel value of $12.2 million. The 1975 landings declined to about 87 million pounds, but the exvessel value increased to $12.6 million. Due to the current low level of surf clam abundance, landings in 1976 will be about 49 million pounds, or about one-half of the 1974 landings. As evidence of the continued demand, however, exvessel values increased from $2.25 per bushel in 1975 to $11.00 per bushel in October 1976.

d. The ocean quahog industry

The ocean quahog industry handled the fourth largest volume of clam meats in the United States in 1976. Ocean quahog meats have accounted for about 1 percent of the total volume, but only 1-half of 1 percent of the total value, of all the U.S. clam production in the last 10 years.

The surf clam industry has developed a strong, large market for prepared clam products. The demand for ocean quahogs is increasing, because they are being used as an alternate for surf clams, whose production has been reduced by one-half in 2 years because of overfishing and mass mortality.

The ocean quahog is found in greatest abundance off the coast of Long Island, but there is a significant concentration off the New Jersey coast. It is estimated that between 150 and 173 million bushels are off New York and about one-half of that quantity off New Jersey. Preliminary information indicates that the recruitment rate is greater than that of the surf clam and that the natural mortality rates are lower.

The major portion of the known resource occurs well offshore, in waters ranging from 25 to 61 meters, and is not usually subjected to nearshore pollution sources, but is affected by pollution from ocean dumping of domestic and industrial waste.

The methods of harvesting and transportation are the same as those for surf clams. Some surf clam vessels harvest ocean quahogs as an alternate resource. The ocean quahog has some disadvantages that constrain its use. The principal adverse characteristics are that processing is more expensive and the meat is darker and has a stronger taste than the surf clam. The use, therefore, is limited to products like stuffed clams or Manhattan clam chowders in which the color of the meat is not objectionable and the taste is changed by spicing. The meats are not

suitable for use in New England type chowder or fried clam strips, a product in very high demand by large chain restaurants. The meat yield is about one-half that obtained from surf clams.

e. The soft-shell clam industry

The industry involved in the harvesting and processing of the soft-shell clam is currently the third largest commercial clam industry in the United States. For the past 10 years it has contributed about 12 percent of the volume and 20 percent of the exvessel value of all commercially harvested clams.

About 7,000 fishermen and 1,000 boats harvested 9.2 million pounds of meats in 1975. The exvessel value was $8.7 million. Five East Coast States and one West Coast State reported commercial landings, but Maine, Massachusetts, and Maryland accounted for about 92 percent of the total landings in the United States.

The increased demand for fried soft clams and steamed clams in the 1940's put heavy pressures on the New England supply, which accounted for about 10 million pounds. New England landings declined steadily after 1949, reaching a record low of 2 million pounds in 1959. Meanwhile, commercial harvesting of subtidal stocks was made possible in 1951 by the introduction of the escalator dredge. During the period 1956-70, the Maryland catch exceeded the entire New England catch. When the Maryland resources showed signs of overfishing in 1970-71, the catch limits were reduced from 40 to 25 bushels per day. Severe flooding from tropical storm Agnes caused extensive mortalities, forcing a closure of the entire industry for 1 year.

Currently, New England exceeds Maryland in soft clam production. New England landings in 1975 were about 7.7 million pounds, as compared to about 1 million pounds in Maryland. Exvessel values in 1975 increased 7 percent over the 1974 values. Landings during the first 6 months of 1976 were about 12 percent higher than during the same period in 1975, and the landed value rose 41 percent.

Harvesting by hand is done by individuals working at low tides using a rake or a fork. The escalator harvester attaches to the boat and is operated by a two- or three-man crew. The packing houses are small, employing only a few people, even if shucking operations are conducted. Soft clams require careful handling and icing or refrigeration to maintain the high quality and safety of the product.

Processing may consist of simple washing to remove exterior mud and sand, storage in tanks of disinfected seawater to induce elimination of sand in the shell cavity, shucking, or combinations of these processes. The equipment required is simple and usually manually operated. During shucking, the siphons are sometimes completely or partially removed. One of the many washing processes removes shell fragments and materials such as sand.

Domestic and industrial pollution are threats to the soft clam resources in New England. These clams inhabit the intertidal or very shallow subtidal areas and are therefore closer to existing and potential sources of pollution. Large areas throughout the East Coast are closed to harvesting because of water pollution. Soft clams from moderately polluted areas may be cleansed by exposure to disinfected seawater in tanks, a process known as "depuration." Depuration plants are in use in Maine, Massachusetts, New York, and New Jersey. Cleansing in natural bodies of water, however, is not successful because of heavy predation.

A major problem is fluctuating resource abundance due to variation in the annual productivity of natural clam beds. Flats that once produced large numbers of clams may suddenly become barren, whereas others may be consistent producers year after year. Occurrence of predators, changes in environmental conditions, and pollution may be some of the contributing factors. Restocking from natural sources or by stocks produced by hatcheries has not been generally applied.

f. The western razor clam industry

Commercial razor clam harvests of more than 1 million pounds during the late 1940's have declined to 148,000 pounds in 1975. From 1955 to the present, the sports catch has been estimated to range from 125,000 to 375,000 pounds per year.

The coastline of Washington has more suitable beach frontage for the growth of razor clams than does Oregon. Commercial canning of razor clams began at the turn of the century and reached a peak in 1915 when the production of canned razor clams represented about 8 million pounds of unshucked clams. Concern over the diminishing resources in 1917 resulted in imposing a closure to eliminate harvest of clams during the summer spawning season. The restrictions became progressively severe, and in the 1940's, because of continuously declining stocks, a poundage quota was imposed in addition to the season limit. Also, commercial harvesting was illegal off certain beaches. During the 1950's, the razor clam industry encountered keen market competition from the East Coast surf clam meats, placing canned razor clams at a distinct competitive disadvantage. The loss of production for canning was absorbed by the crab bait market.

Currently, the bulk of harvesting is through an intensive recreational fishery and a small, Indian-operated commercial fishery in Washington. Razor clams from the Quinault Indian reservation are sold mainly to licensed buyers who pay uniform prices for clams in the shell. Most of the clams are now used for crab bait, but some enter the fresh and frozen retail and restaurant markets. Processing of razor clams could be a successful enterprise if solutions were found to overcome high-processing costs and the problems of labor and quality control. During 1971-76 (spring season), the catch ranged from 135,000 to 399,000 pounds per year. Razor clam harvesting is now the principal revenue-producing fishery on the reservation.

The Quinault Indian clam fishery may prove to be the most viable in Washington. It is under closer control than the fishery from public lands, since the beach and the uplands are exclusively held and managed by the tribe. The Quinaults are not subject to most of the State and Federal regulatory machinery nor to many other political, social, and economic forces that encroach on the clam fishery on public lands. However, clam supply will still be limited by the vagaries of natural setting.

Alaska has abundant razor clam resources, but commercial production has been limited owing to lack of State funding for PSP monitoring and beach certification, mechanical harvesting restrictions, and the limited markets for razor clam meats.

The future of the razor clam market is difficult to predict, the present market being limited and quite variable. The crab bait market depends largely on demands of the crab fishery, the extent of out-of-State imports, and the development of bait substitutes.

g. The geoduck and the horse clam industries

Two additional kinds of clams are commercially important in the Pacific Northwest. They are the geoduck, *Panope generosa*, and the horse clam, *Tresus capax* or *T. nuttalli*.

The geoduck clam in Washington waters is certainly impressive. It is said to be the largest burrowing bivalve in the world; the largest specimen weighed more than 10 pounds. However, the average clam weighs about 2-1/2 pounds. Apparently, the geoduck was never abundant on the intertidal beaches of Puget Sound, and due to the fear of extinction, commercial harvest was prohibited in the 1920's. However, the geoduck has supported a small but popular sport fishery for years.

During the late 1960's, the Washington Department of Fisheries, in cooperation with the National Marine Fisheries Service, surveyed subtidal lands of Puget Sound to assess the distribution and abundance of clams. An unexpectedly large standing crop of geoducks was found in four regions in Puget Sound (table 6).

Table 6.--Standing crop of geoducks in Puget Sound

Location	Area	Estimated geoduck population
	Acres	Thousands of pounds of meat
San Juan Islands	160	
Strait of Juan de Fuca	6,685	12,788
Central Puget Sound (including Hood Canal)	17,272	68,427
Southern Puget Sound	8,807	24,905
Total	32,924	106,427

Source: Theodore P. Ritchie, "A Comprehensive Review of the Commercial Clam Industries in the United States," College of Marine Studies, University of Delaware, 1977.

Based on these impressive findings, the Washington State Legislature in 1969 legalized the commercial harvest of geoducks, but with strict limitations summarized as follows:

1) Harvest is restricted to areas further than one-quarter mile from shore and exceeding 10 feet in depth;

2) The harvest method is limited to divers using a hand-held water jet or suction device;

3) Harvest is limited to daylight.

Additional surveys have indicated that Puget Sound has about 33,000 acres of geoduck beds. However, most of the acreage is excluded from commercial harvest owing to close proximity to shore and/or water depth. About 6,534 acres are legally harvestable; of these only 2,400 are commercially feasible.

Commercial harvesting began in 1970. Although the annual potential harvest was estimated to be as much as 2 million pounds per year, the landings during 1971-73 average about 150,000 pounds meat weight. Attempts were made to sell the product as whole clams, and later as steaks and chowder meats, but because the markets for these products were limited, the industry floundered unprofitably for 3 years.

In mid-1974, a market for geoduck steaks was developed in Japan and geoduck landings jumped to 2,400,000 pounds in 1975. Catch statistics

indicate production may approach 4 million pounds in 1976. There is some concern regarding the long-term supply of geoducks to meet the market demand.

The horse clam (or gaper) has a number of characteristics that tend to discourage commercial use. Hand harvesting tends to break the fragile shell. Also, the valves gape, resulting in water loss, which lowers the shelf life. The meat yield is low--only 25 to 30 percent of the total body weight. The neck, 60 percent of the shucked body weight, requires considerable processing effort to remove the tough, leathery siphonal skin. The introduction of the mechanical clam dredge has resulted in a small commercial fishery. It is an incidental fishery, however--a byproduct of the native littleneck and butter clam industry.

Until recently, the cannery was the only market for horse clams, but now a crab bait market has developed. There have been recent inquiries, primarily by foreign buyers, for quantities of horse clams ranging as high as 20,000 to 30,000 pounds per month. One harvester reported that a company in Japan was interested in shipping whole live clams to Japan by air freight.

h. The blue mussel industry

The blue mussel, Mytilus edulis, is abundant along the East Coast of North America from Cape Hatteras to Labrador. The same species is also abundant on the West Coast. Another species, Mytilus californianus, occurs in large numbers on the ocean beaches of the West Coast. Except during World War II, there has been little interest in harvesting these species for food. A renewed interest in the harvest of the blue mussel has resulted from pressures on shellfish resources, especially clams. The availability and price of clams has been affected by a greatly diminished supply and an increased demand. The blue mussel is a candidate to supplement the dwindling supplies of clams.

As a food, blue mussels have many characteristics that are different from oysters and clams. They are not eaten raw and generally are used in recipes that enhance their flavor. When clams and oysters were abundant and inexpensive, there was little impetus to try something new. With the present shortage of these species, it would be appropriate to undertake programs to encourage greater consumer acceptance of mussels.

The most productive mussel beds are in New England, New York, and New Jersey. Pollution, resulting in seasonal or permanent closure of beds in the latter two States, seriously restricts commercial harvesting. In addition, the mussels harvested in these two States are lower in quality than those in New England.

The most productive growing areas are found in Maine and Rhode Island. One fisherman in Rhode Island, using a standard shellfish dredge to work the beds of Narragansett Bay, sometimes harvests 5,000 bushels per week. The coast of Maine west of Cape Elizabeth is largely closed to harvesting because of pollution. Dense mussel populations, free from

pollution, are found east of Cape Elizabeth, in Muscongus and Penobscot Bays. More than 3,000 bushels per week are harvested for shipment to markets in Boston and New York.

Many productive growing areas in Maine, Rhode Island, and Massachusetts have been permanently closed because of pollution. Extensive areas in western Maine, the estuaries in the vicinity of metropolitan Boston, and upper Narragansett Bay in Rhode Island are the largest areas affected.

Some use of mussels from moderately polluted waters can be accomplished by the use of two well-understood cleansing processes: (1) relaying to clean areas, and (2) treating in onshore depuration facilities. These processes are effective and are widely used in Great Britain and the European continent, but operating costs must be reduced for successful use of these processes in the United States at current market prices for mussels.

In addition to pollution, the presence of pearls within mussel meats represents one of the chief limiting factors to the commercial use of large quantities of mussels along the Atlantic coast. Basic research is needed to define the factors responsible for the presence or absence of pearls in discrete populations.

Aquaculture is promising. The blue mussel is a good candidate for shellfish culture. Compared to other species of molluscan shellfish it exhibits more rapid growth and has a higher meat to total weight ratio.

Mussel culture is widely practiced in Spain, France, and the Netherlands. The suspended culture system practiced in Spain has distinct advantages over bottom culture. The first is the use of three-dimensional space resulting in production per water surface area that far surpasses the yield per acre accomplished through use of the sea bottom only. The second advantage is that by suspending mussels above the bottom, one effectively removes them from the natural habitat of bottom predators such as starfish, snails, and crabs. Another advantage is that mussels in suspended culture are less infested with the trematode that causes the formation of numerous pearls in the flesh.

Resource availability is also seriously impaired by the repeated occurrence of blooms of the dinoflagellate, Gonyaulax tamarensis, the causative agent of paralytic shellfish poisoning (PSP) in man. In the United States the blooms occur most frequently in the Gulf of Maine, but there have been widespread occurrences extending as far south as Cape Cod, Mass., in 1972, 1974, and 1976. A closely related species, Gonyaulax catenella, occurs on the Pacific Coast.

The poison is lethal and quick-acting when consumed by man. There is no known antidote, and there are no outward signs of its presence in shellfish. The only control method is to monitor shellfish at key stations, which is often very expensive, and, when nessary, to close the area to the harvesting of shellfish.

The mussel resources on the West Coast that are available for commercial harvesting are found almost entirely in Washington. There is a ban on commercial harvesting in California; the estuaries in Oregon are small and relatively unproductive; and, although Alaska has extensive resources, they cannot be used because of the lack of rapid field techniques to determine the presence of paralytic shellfish toxins, inadequate information on production and marketing, and, therefore, little economic incentive to develop the resource.

The mussel industry on both coasts is small, owing to a lack of market demand, but if an expected increase in demand occurs, the supply could be critically short. Appropriate growing areas are limited in size and numbers, and the success of spawning is sporadic. This latter problem is being circumvented by the development of an experimental hatchery that would supplement the seed from natural stocks.

Overall production in 1975 was about 1.1 million pounds. The industry is scattered, with sometimes widely separated growing areas in four States on the East Coast and one on the West Coast. Harvesting is mostly by hand rakes from small skiffs. There is some harvesting by conventional shellfish dredges, but there are very few of these because the limited resource, fluctuations in productivity of beds, threat of PSP, and low market price do not encourage the required capital investment.

Harvesting, cleaning, and shucking mussels are very time-consuming and quite inefficient from an engineering and economic point of view. Present revenues from the mussel industry could not support major improvements in technology. Except for a brief period during World War II, when almost 3 million pounds per year were produced, mostly for canning, the production ranged between 450,000 and 1,200,000 pounds per year. The trend has been slightly upward during the period 1972-75, probably reflecting continuously decreasing supplies of oysters and clams and increased promotional efforts. However, excluding the tremendous potential offered for mussel culture, the outlook for the industry is not bright. Standing crops are limited and will experience the same threats as the oyster and clam resources.

Finally, there may exist a potential for culture of mussels other than *Mytilus edulis*, but additional biological information and aquaculture feasibility studies are needed.

C. Principal issues

1. General

The shellfish industry as a whole has many problems that are common to all or most of the species. In varying degrees, the entire industry feels the pressures brought to bear by increases in human population, the attendant adverse impact on the environment, and the increased demands placed on the sea for food. Several species also share the effects of natural disasters such as floods, hurricanes, and high winds and, to varying extents, the effects of coastal zone and water resource development.

These problems that are common to all or most of the commercially important species of shellfish will be discussed first, followed by discussions of problems that are unique to one or two species or to molluscan shellfish, but not fish, in an individual geographic area.

2. Competition for use of the coastal zone

Competition for the use of the coastal zone is among the major issues that affect the shellfish industry. Forecasts indicate that such competition will continue and escalate. The shellfish industry, due to its relatively small size and the lack of public awareness, has low priority when only economic benefit/cost studies dictate the use of coastal zone waters. The shellfish industry's plight is similar to that of agriculture in its inability to compete for the use of the land with urban development and industry of high economic value.

3. Decreasing resource base

Several hundred thousand acres that could support productive resources are closed because water quality does not meet Federal and State sanitation requirements for shellfish. Many areas that formerly produced oysters and clams are no longer suitable because of domestic and industrial pollution. Seed oyster supplies from natural reproduction have also decreased, because water quality has become unsuitable for larvae and juveniles.

4. Jurisdictional authorities

The industry is regulated by many Federal, State, and local authorities, each of which has requirements to which the industry must comply. Major Federal regulatory and inspection responsibilities are shared by the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), the National Marine Fisheries Service, and to lesser extent, the Occupational Safety and Health Administration, and the U.S. Army Corps of Engineers. Major State agencies involved are the health, conservation, and water pollution control agencies.

5. Classification of growing areas

It is the general opinion that the sanitation requirements for approval of shellfish-growing areas as prescribed by the FDA provide for reasonable consumer protection if all three functions of the approval process--namely, sanitary reconnaissance, hydrographic survey, and bacteriological surveys--are conducted. The absence of enteric disease from shellfish grown in approved areas confirms this opinion. However, an issue raised is whether or not the prescribed microbiological criteria are too strict, and might result in unnecessary closure to some areas. Allowable microbiological counts have not been correlated to present public health needs.

6. Chemical standards for toxic agents in shellfish

There is a lack of information about the effects of toxic agents on molluscan shellfish resources, the industry, and consumers.

Millions of tons of toxic chemical agents are discharged into the marine environment annually. Some of these, even when diluted in the receiving waters, are lethal or harmful to larvae and/or adult shellfish. Additionally, filter-feeding mollusks such as oysters, clams, and mussels can accumulate toxic discharges and concentrate them at levels that harm consumers. Although studies have been made on how heavy metals and a few pesticides may affect fish, shellfish, and consumers, the toxic properties and adverse effects of chemical waters are matters of growing concern to industry, consumers, and government agencies. FDA has established chemical standards (action levels) for some toxic agents--that is, limits that serve to alert the control agencies that a health hazard may be imminent, and parallel action by EPA should gradually eliminate certain high-risk chemicals from marine waters. However, it is recognized that the problem of insufficient knowledge regarding the management of toxic substances in the marine environment is hampering efforts directed toward adequate control measures.

7. Industry revitalization

Except for the surf clam and ocean quahog industries and a few large commercial operations in other molluscan shellfish industries, the methods of operation could be improved. Harvesting is done largely by individuals or family groups, often with inefficient gear mandated by State or local regulations. Many processing facilities are small, family-owned, labor-intensive, and marginally profitable.

Improved gear is available for harvesting some species, but, for various reasons such as physical damage to the shellfish or to the bottom, the gear is not suitable for certain species of shellfish. In addition, the costs may be prohibitive to individual fishermen or the use of the gear may be prohibited by States for political, economic, social, or conservation reasons.

Many operators, both harvesters and processors, would benefit from sound financing for acquisition of labor-saving and more efficient equipment.

There is low public or market demand for certain species. For example, demand for large Pacific oysters is low because much canning of oysters has been discontinued in the Northwest, owing to heavy importation of such products. To some extent, demand is also low for large chowder clams, although this problem may be alleviated by the sharp decrease in the surf clam resources. Additionally, consumer acceptance of the blue mussel is very low.

8. A sound management program

The shellfish industry in general, and especially the surf clam industry, are suffering severe reductions in available resources. The known surf clam resources, estimated to be 1,093,000 metric tons in 1965, were reduced to 245,000 metric tons by 1975. The decrease is due mainly to lack of sound management. As ocean quahogs begin to be harvested, they will be subject to the same threat unless a sound management plan is developed and followed.

9. Recovery of shellfish from closed areas

Areas closed because of pollution have immense stocks of shellfish that could be made available to man for use as food if cleansing processes were used. An example is the potentially available oyster resource in Maryland, Louisiana, Texas, and Virginia, where about 702,000 acres are closed. Assuming that closed areas are as productive as open areas, these losses are estimated in excess of $2 million. Losses of condemned resources in other States may be of similar magnitude.

Much of this resource could be recovered through the application of two well-understood cleansing processes:

(1) Relaying shellfish to clean, approved areas and holding the contaminated shellfish in these waters while they purge themselves of contamination.

(2) Holding the shellfish in tanks or running, disinfected seawater. This process is called "depuration."

Each process has its benefits and constraints. The cost effectiveness of each would be dependent on the particular situations and conditions affecting a specific fishery.

With the present state of technology, relaying is the least expensive and is adaptable to large volumes of shellfish; the quantity is limited only by the size of the cleaning areas. Relaying is currently practiced in many States. The process is applicable to oysters, hard clams, and mussels, but not to soft clams unless predation can be controlled.

Depuration is applicable to oysters, clams, and mussels. The limitation of the feasibility of depuration is the cost of constructing facilities and their operation in relation to the products' current market value. Depuration, a short-term process usually lasting 48 hours, will not remove toxic agents such as pesticides and heavy metals, or toxins such as PSP.

In addition to relaying and depuration, a followup application of thermal processing, either that routinely used by commercial food canners or a variation, could make additional resources safe for human consumption. Heat processing and canning is partially effective in destroying marine biotoxins and has provided a means for safe use of resources when the raw product has low levels of toxin. The heat process, properly carried out, would also destroy pathogenic microorganisms and viruses. However, the process will not remove heat-stable contaminants, e.g., heavy metals and pesticides.

Present FDA policy does not permit the canning of shellfish from areas closed because of pollution. One reason for this is that such raw shellfish are considered to be adulterated. This policy, in effect, requires that raw shellfish meet microbiological standards that are more stringent than those for many other canned food processing industries even though documentation of thermal processing conditions would assure production of safe products. Use of shellfish could be increased if the standards for shellfish canning were more consistent with those for other food canning.

10. Aquaculture

The issue with respect to aquaculture is to determine the extent that application and improvement of aquaculture practices could augment dwindling stocks of both seed and shellfish of marketable size.

The term "aquaculture," for the purpose of this report, means the propagation of shellfish by means induced or aided by man in tanks, onshore facilities, or natural bodies of water. It also means culture, to marketable size, in natural bodies of water on bottoms prepared by man or in or on structures such as rafts, racks, trays, or similar devices.

Propagation in onshore facilities, often called hatcheries, is a partial solution to the dwindling supply of molluscan shellfish seed in natural water bodies. Although shellfish hatcheries are still in the technological improvement phase, they also offer the possibility of genetic improvement of the species.

Seed collection in natural waters is an important part of shellfish farming. It is imperative that the valuable seed-producing grounds be protected from pollution that would destroy their productivity.

Currently, the most economical method for growing most mollusks to marketable size is bottom culture on or in prepared beds. Shellfish farming is adaptable to all species of oysters, mussels, and clams.

For restocking public lands, some States prepare the bottom and transplant seed stocks, mostly oysters. The oyster industry in the Pacific Northwest is a private fishery. Limitations of natural seed production require the planting of seed obtained from local hatcheries or by imports. Many industry members on the East and Gulf Coasts farm on private beds to assure a more consistent and reliable source of supply.

Suspended culture, on rafts, is limited in application by economics, local water depths, and salinities.

D. Federal/State agency and industry roles

1. Sanitary control of the shellfish industry

One of the responsibilities of the FDA under the Food, Drug, and Cosmetic Act (FD&C Act) as amended (21 U.S.C. 301) is to ensure that food, including shellfish shipped or received in interstate commerce, is processed under sanitary conditions and is not adulterated. If FDA finds adulterated products, unsanitary plant conditions, or a contaminated product, it can take legal action to (1) prosecute an individual who violates the provisions of the act, (2) enjoin a plant or individual to correct the unsanitary plant conditions, and (3) seize a food that is adulterated or contaminated when introduced to or while in interstate traffic. In practice, FDA seldom uses the powers of the FD&C Act to ensure that fresh or frozen shellfish are safe. Instead, it relies on its participation in the National Shellfish

Sanitation Program (NSSP) to achieve this purpose. Under the FD&C Act, FDA monitors processed shellfish, whether domestic or imported.

NSSP is a voluntary tripartite, cooperative program participated in by FDA, State agencies, and the shellfish industry under guidelines established jointly by the three participants. The roles of the participants are as follows:

FDA

- Publishes guidelines to be followed by State control agencies and industry for the sanitation of shellfish-growing areas and the harvesting and processing of shellfish.

State

- Adopts adequate laws and regulations for sanitary control of the shellfish industry.
- Makes sanitary surveys of growing areas.
- Delineates and patrols restricted areas.
- Inspects and certifies shellfish plants.
- Forwards list of certified shippers to FDA.

The laws and regulations of all of the 22 shellfish producing States have been judged to be adequate by FDA, which currently endorses the programs of all States.

Industry

- Cooperates by adhering to the provisions of the guidelines for harvesting and processing.
- Maintains adequate records that show the origin and the disposition of all shellfish.

NSSP applies to all edible species of oysters, clams, or mussels either shucked or in the shell, fresh or frozen. Scallops are excluded because only the muscle is consumed and usually it is not eaten raw.

It has been the policy of NSSP that to export fresh or frozen shellfish into the United States, a foreign country must submit to program evaluation by FDA, and the evaluation must demonstrate that the program of that country is as effective as the U.S. program.

Canada has been a participant in NSSP from the beginning. The United States has endorsed the programs of one prefecture in Japan and one prefecture in Korea for exporting oysters only.

In addition to FDA and State inspection, shellfish processing plants and products may also be inspected under programs in the U.S. Departments of Commerce and Defense.

DOC

Under its program of Voluntary Fishery Products Inspection and Certification, inspectors of the National Marine Fisheries Service inspect processed shellfish at participating plants. The nature of this effort is to verify that raw shellfish used in the manufacture of prepared food items such as breaded clams and oysters come from certified shellbeds and that good manufacturing practices are followed in the processing of such products.

DOD

The military veterinary services conduct sanitation inspection of those shellfish-processing plants that are awarded contracts to furnish shellfish products to the military establishment. The Department of Defense recognizes plants participating in the Department of Commerce's Voluntary Inspection Program as sanitarily approved, and does not duplicate sanitation inspections in those instances.

2. Resource protection and management

The role of the Food and Drug Administration with respect to public health has already been mentioned. The Environmental Protection Agency plays a major role in developing effluent guideline limitations for municipal and industrial discharges, issuing discharge permits, evaluating discharges in interstate and coastal waters, developing water quality criteria, and performing general research.

Three major components of the National Oceanic and Atmospheric Administration (NOAA) have important interrelated roles in the molluscan shellfish industry. These NOAA elements are the National Marine Fisheries Service (NMFS), the Office of Coastal Zone Management (OCZM), and the National Sea Grant College Program. All three carry out or support programs to provide research, development, and advisory services that relate not only to the molluscan shellfish resources, but also to various user groups whose activities affect these resources. The NMFS programs are carried out mainly through its own projects and grants to the States, the OCZM programs are carried out mainly by States aided by OCZM grants, and the National Sea Grant Program provides grants to colleges and universities for marine resource projects.

Counterpart State agencies have a more direct role in resource protection and management of the shellfish industry by providing enforcement, monitoring, and conservation programs.

E. Findings and conclusions

The findings and conclusions of this study of the molluscan shellfish industry are as follows:

(1) The shellfish industry is made up of small entities widely scattered over the entire coastline of the United States. Except for a few large commercial harvesting operations, harvesting is done by individuals or by family groups using simple gear. Most processing and packing

facilities are small, family-owned, labor-intensive, and marginally profitable. The accompanying economic, political, and legal constraints adversely affect the use of labor-saving mechanical equipment that is used in other seafood- and food-processing plants. Resource replacement largely depends on natural propagation, management of the industry, and protection of the environment. As a consequence, harvesting is essentially a limited fishing operation.

(2) Competition for the use of the coastal zone is one of the major causes for many problems of the shellfish industry. The relatively small size of the industry and lack of public awareness result in a low priority in economic benefit/cost studies on the use of coastal waters or the use of land.

(3) The industry has had to cease harvesting in over 18.5 percent of the shellfish waters because they were classified as prohibited areas. The annual rate of increase in prohibited areas for the 1971-74 period was 0.6 percent.

(4) The industry is regulated by many Federal, State, and local authorities, many with overlapping jurisdictions and responsibilities, requiring multiplicity and often duplication of recordkeeping and reporting. Serious consideration should be given to consolidation or better coordination of these regulatory functions related to such matters as plant construction, maintenance and safety, product safety, inspection requirements, and public health.

(5) It is generally regarded that the FDA requirements for approved growing areas are sufficient for consumer protection. However, there is some question as to whether the prescribed microbiological criteria are too strict, resulting in unnecessary closure of some areas.

The limiting coliform density values currently being used date back to 1926 when the principal target disease was typhoid fever, a disease that is rarely contracted from oyster consumption. Today, the disease of concern is infectious hepatitis, also of fecal origin. The relationships between the disease-producing agent and the coliform indicator organism have not been firmly established; therefore, the validity of the limiting coliform values needs further study.

There should be some studies both in the field and the laboratory to determine these relationships, but until methods are developed that would permit the culture of the hepatitis virus, dependence much be placed on epidemiological studies to relate the indicator organism density to the occurrence of disease. Any change in the numerical tolerance limits for water should be reflected in the tolerance limits for shellfish.

(6) A better information base on contaminants in shellfish is needed for the establishment of guidelines for shellfish products. Otherwise, guidelines may be not provide adequate protection to consumers.

(7) The shellfish industry needs revitalization. Many operators, both harvesters and processors, would benefit from sound financing for acquisition

of labor-saving and more efficient equipment. Industry and consumers could benefit from technological research to discover new shellfish products that could be promoted through market development and public education programs. Current laws and regulations that control harvesting efficiency should be revised and modified as needed.

(8) Sound management programs for the industry are needed, particularly in the control of harvesting. Full use should be made of the provisions of the Coastal Zone Management Act in the development of such plans.

(9) The repeated but unpredictable occurrence of paralytic shellfish poison is a significant deterrent to the use of shellfish in New England, the Pacific Northwest, and Alaska. Continued research is needed to determine the environmental phenomena that stimulate the blooms of the causative organisms, thus making possible the development of more reliable monitoring systems. Rapid, inexpensive field techniques for determining PSP levels in harvesting areas are needed.

(10) There should be expansion in the programs of relaying shellfish to approved areas for cleansing and of depuration of shellfish in onshore facilities when these processes are economically feasible.

Investigations should be made to determine the feasibility of heat processing as a means of decontaminating shellfish from lightly polluted areas.

(11) More extensive use should be made of aquaculture for the production of seed and culture of market-size mollusks. Onshore hatcheries would provide an opportunity for genetic studies to improve certain characteristics of the shellfish species as well as the production of seed.

Application of aquaculture techniques for the production of seed to repopulate natural water bodies should be encouraged. It is imperative that the valuable seed-producing grounds be protected from pollution that would destroy their productivity. Shellfish farming on private beds should be encouraged. It is well known that owing to the preparation of the bottom and the application of cultivating techniques, productivity is greater on private than on most public beds. Another advantage is a more consistent and reliable source of supply under private control.

(12) There is a need for increased effort in mission-oriented research in both the biological and public health aspects of culture and processing of shellfish. Difficulties in coordination could be expected because of the spread of jurisdictional authorities among several Federal and State agencies. Coordination of research activities by designated Federal agencies and the development of a system of exchange of information could result in more productive programs of research and avoid duplication of effort that has occurred in the past.

IV. IMPACT OF FEDERAL LAW ON WATER QUALITY AND THE MOLLUSCAN SHELLFISH INDUSTRY

A. Scope

This study examines the quality of water in representative commercially important molluscan shellfish-growing areas, identifies leading threats to the resources and to the industry, examines the causes of these problems, and reviews the relevant Federal laws for their effectiveness in addressing the problems.

B. Water quality and shellfish resources

1. The resources and the environment

Molluscan shellfish waters line our coasts and cover wide areas from the brackish, low-salinity waters of most tidal rivers to the bays and adjacent coastal waters of the continental shelf, some beyond 3 miles of the Nation's coastline.

The shallow estuaries and coastal areas adjacent to our shores provide favorable combinations of temperature, nutrients, and light and are among the most productive marine environments in the world. Estuarine areas are not only the primary shellfish-producing areas but also are the nursery grounds for many of our coastal fisheries.

Twenty-two States harvest oysters, clams, or mussels. These bivalves are commonly known as "filter feeders" because they obtain food by using their gills to strain out and concentrate plankton as well as fine suspended and particulate matter from the water. Mollusks are often most severely affected by adverse changes in their environment. Unlike fish, crabs, shrimp, and other marine species, the commercial oysters, clams, and mussels are sessile organisms incapable of movement to avoid adverse environmental conditions.

Water quality not only controls the productivity and survival of mollusks, but also dictates their safeness for consumption. Adverse water quality can be the result of natural processes including flooding and hurricanes that lower salinities, scour bottoms, and silt-over oyster beds, or less dramatic local algae blooms that can produce toxins of paralytic shellfish poisoning (PSP). Changes in water temperature, salinity, and turbidity are greatly influenced by natural phenomena.

2. Pollution

Human populations within 50 miles of our coastal shorelines have increased tremendously over the past 20 years. Man's activities alter and degrade the marine environment in countless ways. Industrial, agricultural, and domestic waste directly affect shellfish resources. The toxic discharges of heavy metals, chlorinated hydrocarbons, and other industrial wastes can kill or damage the resources outright or make them unfit for human consumption. Oil spills and pesticides from agriculture and silviculture have

similar potential effects. Urbanization often alters natural watersheds and runoff, changes freshwater input into the estuary, produces silting from road construction and changes in natural ground cover, and contaminates water with discharges from inadequate municipal waste treatment facilities, septic fields, or pleasure boats. All of these can destroy the usefulness of the resources. Resources are also lost because of the dredging and filling of wetlands; harbor maintenance; and construction of dams, canals, and other water diversions, which produce changes in nutrients, temperature, salinity, circulation, and turbidity. These changes not only affect shellfish, but also alter the productivity and capability of the estuary and coastal waters to support other fisheries.

3. Classification of waters

Water quality criteria are used to define a body of water by its physical and chemical properties, which control the quality of life the water will support. The Water Quality Act of 1965 provided for classification of water based on designated use. These uses in order of descending water quality are: waters used for water contact recreation, propagation of desirable fish and wildlife, public water supplies, and agricultural and industrial uses.

Molluscan shellfish require the highest quality of water. Unlike most other marine species, mollusks filter vast quantities of water to obtain food and oxygen. They concentrate not only plankton and fine suspended matter but also microorganisms, some of which may be potential pathogens. Bivalves can also concentrate heavy metals, pesticides, and other contaminants found in trace quantities in the water. Shellfish-growing waters must therefore be the cleanest--even beyond those used for swimming and other forms of contact recreation.

4. Shellfish waters

To assure the safety of shellfish growing and harvesting, the cooperative National Shellfish Sanitation Program, administered by the U.S. Food and Drug Administration, requires that all shellfish-growing areas be certified by the States as safe prior to the harvest of mollusks for human consumption.

Most certification of harvesting waters are based on bacterial levels, but areas may also be classified for closure on the presence of shellfish toxins, paralytic shellfish poison, radionuclides, fresh fecal contamination, and toxic industrial wastes.

5. Closure of shellfish-growing waters

Bacterial levels of the waters overlying the shellfish are the most significant criteria for determining "safe" waters. However, toxic algae blooms have caused periodic closures of shellfish areas on all three coasts and the presence of PSP has necessitated the permanent closure of waters surrounding two islands off the coast of Maine and in many parts of Alaska. The States of Maine, Massachusetts, Alaska, Washington, Oregon, and California routinely monitor for PSP.

The presence of industrial toxic contaminants led to temporary closures in Texas during 1971 for mercury contamination, in Massachusetts during 1973 as a result of an oil spill, and in Virginia during 1976 as a result of Kepone contamination. These areas are now open. There are no known closures resulting from excessive quantities of radionuclides.

States commonly classify their waters as "approved," "conditionally approved," "restricted," "prohibited," or "nonshellfish/nonproductive" areas. Water analyses, shoreline sanitation surveys, and seasonal hydrographic conditions are evaluated in determining the safeness of waters for shellfish harvesting.

Statistical data on shellfish-growing areas in the continental United States are maintained by EPA and summarized every several years in The National Shellfish Register of Classified Estuarine Waters. This publication, originally issued by the FDA, is now compiled by EPA and was last issued in 1975 covering the 1971-74 period, with the previous summary covering 1966-71. There are currently no plans or efforts to gather data for future issues. This valuable resource management tool should not be allowed to lapse. The report should be issued annually using standardized State data to permit annual evaluation of progress, problems, and needs of shellfish-growing waters.

C. Changes in water quality

1. Documentation of national trends in water quality

Documentation of absolute changes nationwide in estuarine water quality is not possible with existing data. The absence of uniform standards for classifying waters and the lack of common terminology make absolute changes difficult to discuss. However, qualified conclusions can be drawn provided the limitations of standards and terminology are established.

In certifying their waters, States have the option of using either of two microbiological standards: the fecal coliform count or the total coliform count. Changes in open versus closed areas can result from switching standards. Such changes do not necessarily indicate changes in water quality, but reflect only the means of measurement used.

Terminology also confuses the issue when State reports and national summaries are examined. The term "prohibited," by definition, means "closed to all harvesting due to hazardous levels of contamination." For this classification, some States use the terms "closed," "restricted," and "condemned." The State control agency may, because of a variety of reasons, classify an area "prohibited" even though the waters may be safe for shellfish production. Areas can be closed because of conservation purposes or the threat of contamination, e.g., areas near shipping lanes. Furthermore, areas with waters that have not been certified are prohibited; safeness must be documented.

Considering the above limitations, the "prohibited" classification appears to be the best indicator for assessing changes in the quality of shellfish-growing waters. Most of the Nation's shellfish waters are now classified, which minimizes increases in this class due to lack of microbiological surveys or to reclassifying acreage previously listed as "nonproductive/

nonshellfish" waters. It is further recognized that the term "prohibited" is not absolute and may contain minor acreages where harvesting is prohibited for conservation purposes or where occasional contamination may be implied, but not documented.

Based on changes in prohibited areas (recognizing the term's limitation), water quality appears to be improving in some areas. Although prohibited acreage increases annually, the rate of degradation has been halved from the 1.3 percent annual increase per year during the 1966-71 period to 0.6 percent per year increase for 1971-74.

2. National findings

In 1974, a total of 22 States produced either oysters, clams, or mussels. The continental United States has 20,539,435 acres of classified estuarine waters. Whereas 71.4 percent of these waters produce shellfish, the remaining 28.6 percent are classified as "nonshellfish/nonproductive." Since 1971, the total number of classified shellfish areas remained essentially unchanged while the number of prohibited areas increased.

About 72 percent of the 14,647,163 shellfish-producing acres are open for harvest, and another 2 percent are conditionally opened. The remaining 26 percent are classified as restricted or prohibited.

3. Impact of losses

Data on estimated losses from resource contamination or destruction are scarce and fragmented at both the local and national levels. Losses can accrue from outright destruction of the resources, closure of harvesting areas to protect public health, or from the overall degradation of water quality.

One estimate indicates that resources valued at $226 million at the harvesting level were lost because of harvesting area closures between 1966 and 1975.[2] Table 7 shows the value of losses for oysters, clams, and mussels in 1966, 1971, and 1975.

Table 7.--Value losses for oysters, clams, and mussels, 1966, 1971, and 1975

Species	1966	1971	1975
	Dollars		
Oysters	7,005,243	17,486,457	18,017,693
Clams	3,533,836	10,643,255	11,069,088
Mussels	14,019	82,840	99,518
Totals	10,553,098	28,212,552	29,186,299

[2] "Water Quality Analysis and Environmental Impact Assessment of P.L. 92-500, Technical Volume," National Commission on Water Quality, Staff Draft Report, January 1976.

Nationally, there are no estimates of outright resource destruction; however, there are estimates regarding how continued water quality degradation affects overall biological productivity. Studies for the National Commission on Water Quality estimate that increases in biological productivity accruing from water quality improvements related to implementation of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) could increase nationwide catches, between 1972 and 1985, by 717 million pounds for oysters and 165 million pounds for clams.[3] This translates to increases in productivity of 84.5 percent for oyster harvesting and 88.5 percent for clam harvesting. However, this estimate is based on the assumption that full implementation of FWPCA is in effect, and that a greatly expanded resource base would be followed by proportionately expanded industry activities. The first assumption is not possible during the present year, and the second is questionable, because of technical and economic problems confronting the industry.

4. Selective State analysis

Seven key States were selected and examined to pinpoint causes for national trends in water quality. The States selected for review were Maine, New York, New Jersey, Maryland, Virginia, Louisiana, and Washington. These States are the leading regional producers of oysters, clams, and mussels; their local industries typify the molluscan shellfish industry. Table 8 shows the net changes in shellfish growing areas for these States, and reasons for those changes during selected time periods.

In the States reviewed, bacterial contamination caused the greatest number of shellfish-growing water closures. Sewage treatment plant overloads and malfunctions were the principal causes of contamination. Urban runoff and floods also elevated coliform counts and caused closures.

Local closures from industrial waste contamination were found in Virginia from contaminants originating from Kepone production, and in Washington from pulp waste effluents.

These findings provide a focus for examining the various Federal laws and programs that affect water quality.

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[3] "Water Quality Analysis and Environmental Impact Assessment of P.L. 92-500, Technical Volume," National Commission on Water Quality, Staff Draft Report, January 1976.

Table 8.--Net changes in shellfish-growing water areas between 1966 and 1976

State	Status	1966-71[1]	1971-74[2]	1974-76[3]	Reasons for opening/ closing	Type of pollutant
		--------Thousand acres----------				
ME	Open	+651	-12	No change[4]	STP* malfunction and overloads	Coliform bacteria (domestic)
	Closed	+28	+12	No change		
NY	Open	-343	-0.038	No change	Urban runoff	Coliform bacteria
	Closed	-13	+0.038	No change		
NJ	Open	-38	-11	+8.5	New survey	Coliform bacteria
	Closed	+51	+5	+0.9	New survey	
MD	Open	+114	-23	No change	STP Malfunction and overloads[5]	Coliform bacteria
	Closed	+44	-8	No change		
VA	Open	-0.1	-10	+58[6]	Chemical[6] contamination	Kepone
	Closed	+25	+80	-58		Kepone
LA	Open	+587	+414	No change	High flood waters in shellfish areas	Coliform bacteria
	Closed	+193	+265	No change		
WA	Open	+134	-22	No change	Surveys STP overloads and pulp waste	Coliform bacteria
	Closed	+308	+0.5	No change		

*STP--Sewage treatment plant.

[1]National Shellfish Register, 1971.

[2]National Shellfish Register, 1974.

[3]Personal communications, 1977, with State shellfish representatives.

[4]Does not include seasonal closures--e.g., as a result of heavy rains.

[5]As noted previously, Maryland adopted the fecal coliform standards. Changes, therefore, do not indicate absolute water quality.

[6]About 58,000 acres of shellfish areas were closed owing to Kepone contamination in the lower James River. Areas were reopened during 1976, but much of the growing waters do not contain harvestable quantities of shellfish.

Source: David R. Zoellner, et al., "Water Quality and Molluscan Shellfish: An Overview of the Problems and the Nature of Appropriate Federal Laws," Stanford Research Institute Center for Resource and Environmental Studies, 1977.

D. Laws affecting water quality in molluscan shellfish waters

1. Principal laws

Many Federal laws affect water quality; however, there are four principal Federal laws that control quality in molluscan shellfish waters: The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500; 33 U.S.C. 1251 et. seq.), The Marine Protection Research and Sanctuaries Act of 1972, as amended (P.L. 92-532; 33 U.S.C. 1401 et. seq.), The Fish and Wildlife Coordination Act of 1958 (P.L. 85-624; 16 U.S.C. 661-664), and the River and Harbor Act of 1899 (30 Stat. 1151-54; 33 U.S.C. 401 et. seq.). In addition, a fifth law, Coastal Zone Management Act of 1972 (P.L. 92-583), is important in the implementation of those laws.

a. The Federal Water Pollution Control Act Amendments of 1972 provide for the principal and most important Federal regulatory authority for control of water quality. One declaration in this law states "it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985." As a first step, it is planned that by 1983 our waters will be clean enough to protect fish and shellfish and will be suitable for swimming and other recreational uses. Under this law, EPA and other Federal agencies have multiple responsibilities.

Two major regulatory functions have the greatest effect on molluscan shellfish resources. The first is the water quality standards program that establishes levels of quality suitable for shellfish growth and harvest. With Federal guidance and approval, the States set water quality standards that include conditions and criteria for classification of water uses. Enforcement is a State responsibility, and there is Federal backup under certain conditions.

The second is the National Pollutant Discharge Elimination System (NPDES) permit program of section 402 under which most point-source discharges are identified and quantified, and under which waste treatment and discharge limitations are specified and discharge monitoring requirements established. The NPDES permit program, to regulate most point-source waste discharges, is administered and enforced by EPA as a Federal program, except in those cases where the State has requested and been granted program control after EPA certification of State competence. This program provides an inventory and control of most point-source discharges, thereby creating a system for cleanup of pollution from these sources in U.S. waters.

Additional provisions of the FWPCA facilitate the above principal regulatory functions. One provision is for areawide planning to facilitate coordinated solutions to significant water quality problems. Other provisions address nonpoint source pollution, regional municipal sewage treatment facilities, and other areawide facilities. In addition, the law requires the Water Resources Council to prepare Level B plans under the Water Resources Planning Act for all U.S. river basins by not later than January 1, 1980, and to give priorities to those areas identified in the areawide planning efforts. Interstate planning is provided for in both.

Other important regulatory functions of FWPCA are the Marine Sanitation Device program under which sewage discharges from watercraft are controlled, and the Corps of Engineers permit program for control of all discharges of dredged or fill materials into navigable waters (Section 404). Under the Marine Sanitation Device program, EPA defines the limitations on sewage discharges from watercraft, but enforcement of regulations is a responsibility of the U.S. Coast Guard.

b. The Marine Protection, Research and Sanctuaries Act provides for an EPA-operated permit program to control all materials dumped in the ocean outside the 3-mile limit.

c. The Fish and Wildlife Coordination Act provides the essential mechanism for Federal and State fish and wildlife agencies to provide consultation services to Federal construction and permit-granting agencies concerning potential impact on fish and wildlife resources and their habitats and to recommend necessary corrective measures.

d. The River and Harbor Act (Section 10) provides control of construction activities in navigable waters under permits issued by the Corps of Engineers.

Other laws affect water quality in molluscan shellfish resource areas; however, none has the importance of the above four. The others provide for specific programs related to fishery habitats, environmental quality, or research activities, or, as in the case of the National Environmental Policy Act, require review of potential impacts.

Another related law is the Coastal Zone Mangement Act of 1972 under which States establish plans and policies to manage common coastal resources that are in demand by competing users, and may designate Geographic Areas of Particular Concern (GAPC) for special protection and restoration.

2. Implementation of laws

FWPCA is a massive and complicated act requiring substantial time for full implementation. Nevertheless, the act provides for development of comprehensive programs for water pollution control.

Water quality standards have been set by all States, and criteria are adequate to protect shellfish harvesting. However, about 3.8 million acres of shellfish waters are closed to harvesting. Many of these areas could be opened for shellfish harvesting as soon as all the municipal and industrial waste discharges are brought under control by the NPDES permit program and all watercraft sanitation requirements are met.

EPA estimates that, as of September 1976, 19,359 (88 percent) municipal waste discharges of 21,985 had been permitted, and 33,364 (78 percent) of 42,892 nonmunicipal waste discharges had been permitted. Estimates are that by July 1977, about 50 percent of municipal discharge permit holders and about 90 percent of industrial waste discharges will be in compliance. The increasing effectiveness of the point-source pollution control program can provide

encouragement and benefits to the shellfish industry. Twelve shellfish States now administer their own NPDES programs.

Under the regulations for marine sanitary devices, all vessels will be required to have approved sewage treatment devices or holding tanks by January 30, 1980. In the interim, or after January 30, 1980, States may establish zones of no discharge where more stringent control of watercraft discharges is necessary to protect water quality on shellfish beds.

Full implementation of the NPDES permit program and the Toxic Substances Act, passed in 1976, to limit contamination of the open environment will help control the pollution of shellfish waters by toxic substances. Residuals from normal use of materials in the open environment, accidents, illegal activities, and the past accumulations of toxins present problems that have no immediate or easy solutions.

One major pollution category is storm runoff from urban and rural areas. Urban problems are made more severe because of combined sewers that flood sewage treatment plants or result in bypass discharges of some raw sewage. The runoff may already contain coliforms, organic debris, silt, and chemical pollutants in substantial quantities. The sheer magnitude of runoff volume and lack of retention sites in urban areas accentuate the problem. Runoff from agricultural and silvicultural areas containing silt, organic debris, nutrients, and agricultural chemicals presents problems of similar magnitude.

The areawide waste treatment management provisions of FWPCA Amendments are designed to deal with nonpoint sources as well as other significant pollution problems. Planning in areawide programs is substantial, but initial plans will not be received until 1978.

Under the present FWPCA regulations, Section 404, if fully implemented, could prevent damage to shellfish-growing areas by controlling discharges of dredged or fill materials into navigable waters.

Initiatives under this act, or related legislation such as the CZMA and the Water Resources Planning Act, could benefit from better coordination of Federal and State planning activities. For example, efficient development of "Level B" river basin plans for coastal rivers might be undertaken in concert with State Coastal Zone Management Plans.

The Marine Protection, Research and Sanctuaries Act provides for the control of dumping in the ocean outside the 3-mile limit. EPA regulates dumping of all materials except spoil dredged from navigable waters, which is regulated under permit by the Corps of Engineers. The U.S. Coast Guard is responsible for surveillance of these dumping activities. EPA aims to reduce dumping activities by 1981 and is currently seeking to find alternative land-based disposal methods for sewage sludge.

The River and Harbor Act of 1899 is implemented by the Corps of Engineers. Permits issued under Section 10 control construction in waterways.

Federal fishery agencies have provided the Corps with advice on how the projects affect fish and wildlife resources.

The Fish and Wildlife Coordination Act is implemented by the National Marine Fisheries Service and the Fish and Wildlife Service. These agencies provide consultation to Federal contruction and permit-granting agencies. However, for projects requiring Corps of Engineers' construction and spoil discharge permits, and in the EPA and State NPDES discharge permit programs, the permit-granting agencies have not in all cases had the benefits of advice from the resource management agencies concerning potential impacts of proposed actions on molluscan shellfish and other fishery resources.

The Coastal Zone Management Act's implementation could protect and restore, to a certain degree, shellfish waters, if these waters were designated as Geographic Areas of Particular Concern (GAPC) in the State CZM Plans.

To aid this implementation, the Office of CZM should not forward any State CZM Plan to the Secretary of Commerce for approval until it is determined that the plan has fully dealt with the GAPC inventory and procedures and that adequate policies and actions are specified for protection of GAPC.

Additionally, the Office of CZM should ensure that, during the inventory and designation procedure of GAPC during development of the State CZM Plans, each State CZM Office consults with State and Federal fish and wildlife agencies, the fishing industry, and the public concerning location and importance of shellfish resources. Similarly, these public agencies and private interests should see that the State CZM planners are fully advised concerning molluscan shellfish resources including location, importance, needs, and other considerations.

E. Findings and conclusions

1. Shellfish-growing waters

Based on increases in areas prohibited to shellfishing in 1971-74, degradation or loss of shellfish-producing acreage is continuing. Several States show decreases, or little or no increase, in prohibited areas, while others show significant increases. Nationally, rates of closures have proceeded at about one-half the rate they were occurring in the period 1966-71. However, the lack of uniform recordkeeping makes absolute changes difficult to discern.

The greatest negative impact on the sanitary condition of growing waters results from domestic waste discharges. Siltation from upstream sources, dredging and filling operations, chemical contamination, and other water quality problems can also destroy shellfish resources or prevent their safe harvest. Physical alternations can lead to hydrographic changes that can directly affect shellfish resources. The resultant alterations and losses are variable, and in many cases, assessment of damages is difficult.

The standards for waters in which shellfish harvesting is permitted must be scientifically validated to assure public health protection without

being over-restrictive and preventing the use of safe resources. Uniform terminology, criteria, and reporting are needed to accurately document national changes in shellfish water quality. Annual publication of the National Shellfish Register should provide information to monitor progress in this area.

Attention should be given to municipal construction and permit-granting programs, and planning and construction of new treatment facilities. A mechanism should be considered to identify permits affecting shellfish waters for special attention and to explore class action permits.

2. Water quality control laws

The existing laws, if adequately implemented, should result in clean water and a healthy shellfish environment. There are, however, implementation problems.

All sections of the Federal Water Pollution Control Act Amendments of 1972, including construction grants, NPDES, compliance and enforcement, research and development, areawide waste treatment, and river basin planning should be implemented as quickly as possible within fiscal limitations.

Fish and wildlife agencies, NMFS in particular, have difficulties in implementing the responsibilities under the Fish and Wildlife Coordination Act of 1958. Particularly critical is the case load for review of Section 10 and 404 permits, NPDES permits, and Federal projects. Means for addressing this issue should be explored.

3. Implementation--agency jurisdictions

Numerous Federal and State agencies hold responsibilities for implementation and enforcement of regulations to protect molluscan shellfish waters to ensure consumer quality for shellfish harvested from those waters. These include State and Federal agencies responsible for resource management, pollution control, maintenance of navigable waters, enforcement and monitoring, shellfish sanitation, and land planning and zoning.

Implementation of these several programs to meet the objective of obtaining clean water involves specific responsibilities and special expertise within each agency. Programs and mechanisms are available to achieve pollution abatement and resource management and to ensure product safety for the consumer. Improved agency coordination and administration will minimize potential problems among the many entities involved.

Multiple jurisdictional authority complicates implementation and enforcement of regulations to protect shellfish waters. Sound conceptual arrangements sometimes result in practical difficulties with implementation. Interagency agreements such as that between EPA and COE for ocean dumping take time to develop and clarify.

Exceptionally good communication supported by adequate exchange and integration of all-important data systems of FWPCA, as is often the case with major regulatory legislation, has been delayed by the need for judicial

interpretation of the act. Delays while the mechanics of multiple authorities are worked out make program evaluation more difficult. The many intra- and intergovernmental entities interested in shellfish resources or habitat require an extremely high degree of coordination and cooperation through the Fish and Wildlife Coordination Act. A factor intensifying these complications is that of competing and often conflicting uses of coastal waters and attend- and resources. Municipal, industrial, agricultural, and recreational interests are involved and are represented by many Government agencies and special interest groups.

4. Research needs

- To validate shellfish-growing water criteria to protect public health (of consumers) without being restrictive and precluding the harvest of safe resources.

- To obtain predictive capabilities and improved monitoring techniques of causes and effects of algae blooms.

- To document the biocidal impact of chlorine and chlorinated waste effluents on estuarine life and develop effective disinfection practices that protect public health without destroying valuable estuarine resources.

- To determine potential impacts of a broad variety of toxic chemicals and microorganisms on shellfish and on consumers. Furthermore, techniques to purge resources of contaminants and/or processing techniques to render infrequent or mildly contaminated resources safe for consumption should be investigated.

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