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THE U.S. CLAM INDUSTRY

by

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ABSTRACT

Abundant clam resources occur naturally along the coasts of the United States, and commercial fishermen from the U.S. reportedly harvest one-third of the world clam catch. Clam harvesting provides employment for more fishermen and vessels than any other American commercial fishery, including shrimp, oyster, tuna and salmon. Record clam landings were made in the United States in 1974, but they have been decreasing since then; directly responsible for the reduction is the decrease in surf clam landings.

More than fourteen species of clams are commercially harvested in eighteen different states, but only four clam species account for 99 percent of the volume and dockside value of the total U.S. clam catch. The major and minor clam species are reviewed with respect to the history, the current status, and the expected future of each commercial fishery. Industry problems at all levels are discussed and recommendations are made for resource management.
PREFACE

The Coastal Zone Management Act Amendments of 1976 provide for a comprehensive review of the clam industry. The University of Delaware Sea Grant College Program was asked to report on the status of the national clam industry, and this report was assembled from material gathered in the following manner. Individual reports were requested for each of the major and minor clam industries within each state or region. Persons with special knowledge of these regional clam fisheries were engaged as consultants to furnish up-to-date reports. Consultants were expected to solicit pertinent information from all industry segments, as well as local, state and federal, conservation, and health agencies. Copies of the papers prepared by the various clam industry consultants are on file in the College of Marine Studies Library in Lewes, Delaware, and are also noted as references at the end of each chapter in this report.

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I

INTRODUCTION

More than fourteen different species of clams are commercially harvested along the coasts of the United States. Eighteen states report commercial landings of one or more clam species. Recreational and subsistence clammers annually harvest significant quantities, but the total volume harvested in this manner is seldom reported and generally unknown.

Extensive clam resources occur naturally along the coasts of the United States, and in FAO estimates of world clam stocks (Gulland, 1971), the abundant American clam resources were considered to be a significant portion of the world stocks. Commercial clam landings throughout the world averaged 1,343 million pounds round weight, including shells, during the period from 1965 through 1972. Japan has been the major clam-producing nation, averaging landings of 615 million pounds, which accounts for about 45 percent of the world clam catch during this time period. The United States has traditionally been the nation with the second largest clam catch, averaging 443 million pounds, or around one-third of the world catch during this eight-year period (Yearbook of Fishery Statistics FAO, 1965-1972). A large part of Japan's annual catch is attributed to maricultural effort and productive clam farming, but clam production in the United States is now, and has always been, almost entirely dependent on harvesting wild or naturally-occurring clams.

National Industry

In 1975, the reported U.S. commercial clam catch was 113.2 million pounds of clam meat (51.3 thousand metric tons), valued at 43.7 million dollars to clam fishermen. During the period from 1971 through 1975, the commercial catch averaged 103.5 million pounds and dockside values averaged 35.8 million dollars.

Approximately 24,710 clam fishermen and 14,582 boats were involved in clam harvesting during 1975, in addition to 3,775 persons employed
onshore in 130 clam-processing plants. Clam harvesting employment has averaged 20,106 persons and 11,711 vessels during the past five years. Employment in onshore processing has averaged 3,415 persons in 125 plants during the same time period. The wholesale value of all processed clam products amounted to 106.8 million dollars in 1975 and averaged 87.9 million dollars during the period from 1971 through 1975.

The quantity and value of clam landings during the past 26 years are presented in Figure 1, which shows relatively stable volumes and values from 1950 to 1962. Volume and value increases which began in 1963 continued until 1974 because of greatly increased harvesting of surf clams.

In volume, the 1975 clam catch was seven percent less than the record volume of 1974. The decrease resulted from a 9.5 percent reduction in landings of surf clams. During the past eighteen years, surf clams have constituted a large portion of total clam landings (Figure 2). Estimates of the total commercial catch for 1976 predict a quantity decrease of more than 40 percent from 1975, as a result of expected reduced landings of surf clams.

Although the volume of clams harvested in 1975 was lower than in 1974, its value to the fishermen was 5.5 percent higher than the record set in 1974. Estimates of the 1976 clam catch predict a value increase of more than 5 percent over the 1975 record values despite the significant reduction in landing volumes.

Although more than fourteen species are commercially harvested throughout the United States, four types of clams accounted for 99 percent of the volume and dockside value of all commercial clams landed during the past ten years: hard, soft, surf, and ocean quahog (Table 1).

The hard clam fishery has been responsible for 17 percent of the volume and 53 percent of the dockside value. Hard clam landing volumes are composed almost entirely (96.5 percent) of a single species, Mercenaria mercenaria. Several Pacific Coast clam species are responsible for the remaining 3.5 percent volume of hard clam
Figure 1. Total U.S. commercial clam meat landings and total dockside values, 1950-1975.
Figure 2. Total U.S. commercial clam meat landings and total surf clam meat landings, 1950-1975.
TABLE 1
U.S. landings and value of clams by major species, 1966-75

(Quantity: Thousand pounds of meat weight)
(Value: Thousand dollars)

<table>
<thead>
<tr>
<th>Year</th>
<th>Hard Quantity</th>
<th>Hard Value</th>
<th>Soft Quantity</th>
<th>Soft Value</th>
<th>Surf Quantity</th>
<th>Surf Value</th>
<th>Ocean Quahog Quantity</th>
<th>Ocean Quahog Value</th>
<th>Other Quantity</th>
<th>Other Value</th>
<th>Total Quantity</th>
<th>Total Value</th>
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</thead>
<tbody>
<tr>
<td>1966</td>
<td>15,324</td>
<td>10,524</td>
<td>11,919</td>
<td>3,974</td>
<td>45,413</td>
<td>3,876</td>
<td>91</td>
<td>11</td>
<td>304</td>
<td>166</td>
<td>72,751</td>
<td>18,551</td>
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<tr>
<td>1967</td>
<td>16,182</td>
<td>11,981</td>
<td>9,823</td>
<td>3,936</td>
<td>45,054</td>
<td>4,352</td>
<td>45</td>
<td>6</td>
<td>396</td>
<td>211</td>
<td>71,500</td>
<td>20,486</td>
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<tr>
<td>1968</td>
<td>15,426</td>
<td>12,176</td>
<td>10,368</td>
<td>4,189</td>
<td>40,532</td>
<td>4,137</td>
<td>225</td>
<td>29</td>
<td>675</td>
<td>197</td>
<td>67,246</td>
<td>20,728</td>
</tr>
<tr>
<td>1970</td>
<td>16,015</td>
<td>14,364</td>
<td>12,908</td>
<td>5,982</td>
<td>67,318</td>
<td>7,730</td>
<td>1,742</td>
<td>305</td>
<td>1,221</td>
<td>430</td>
<td>99,204</td>
<td>28,791</td>
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<tr>
<td>1971</td>
<td>16,666</td>
<td>16,918</td>
<td>12,652</td>
<td>6,798</td>
<td>52,555</td>
<td>6,890</td>
<td>2,032</td>
<td>345</td>
<td>604</td>
<td>355</td>
<td>84,489</td>
<td>31,306</td>
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<tr>
<td>1972</td>
<td>16,153</td>
<td>19,220</td>
<td>9,078</td>
<td>5,563</td>
<td>63,471</td>
<td>7,941</td>
<td>1,401</td>
<td>233</td>
<td>586</td>
<td>256</td>
<td>90,689</td>
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<td>1973</td>
<td>14,505</td>
<td>17,361</td>
<td>8,627</td>
<td>6,905</td>
<td>82,370</td>
<td>9,867</td>
<td>1,457</td>
<td>250</td>
<td>581</td>
<td>275</td>
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<td>1974</td>
<td>14,668</td>
<td>20,617</td>
<td>9,588</td>
<td>8,088</td>
<td>96,111</td>
<td>12,225</td>
<td>838</td>
<td>146</td>
<td>620</td>
<td>320</td>
<td>121,825</td>
<td>41,396</td>
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<tr>
<td>1975</td>
<td>14,808</td>
<td>21,652</td>
<td>9,174</td>
<td>8,669</td>
<td>86,955</td>
<td>12,570</td>
<td>1,296</td>
<td>249</td>
<td>974</td>
<td>563</td>
<td>113,207</td>
<td>43,703</td>
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</tbody>
</table>

Source: Fishery Statistics of the United States, 1966-75
landings and these are discussed separately in Chapter IX of this report. The surf clam, Spisula solidissima, has accounted for 69 percent of the volume and 25 percent of the dockside value, while the third major species, the soft shell clam Mya arenaria, accounted for 12 percent of the volume and 20 percent of the dockside value. The species fourth in importance, the ocean quahog, Arctica islandica, accounts for one percent of the volume and less than one percent of the dockside value. All four major clam species occur primarily along the Atlantic coast.

During the past five years, commercial landings of clams along the Pacific coast have accounted for one percent of the volume and almost two percent of the dockside value of the total clam catch. Pacific landings are composed of several types of clams and more than six different species. The clams and industries of the Pacific Coast are discussed separately in Chapter IX. A summary of regional clam landings is presented in Table 2.

Evolution of Clam Processing

In the United States, large-scale utilization of clams for human food did not begin until canneries became established during the early 1900's. Prior to that time, and even until the early 1940's, clams were generally sold fresh and were available only in areas relatively close to harvesting sources. However, in 1913, the pack of Pacific Coast razor clams (Siliqua patula) amounted to 2.7 million one-pound cans; and in 1925, peak production occurred with 4.4 million pounds packed from 11 million pounds of unshucked clams. Landings of razor clams along the Pacific coast declined steadily after 1925, directly in relation to stock depletions. Landing quotas and limited seasons were imposed on the commercial fishery.

During the 1940's, the Dungeness crab fishery expanded; since razor clams are the preferred bait, increased demand was placed on the already declining supply. Finally, in the early 1950's, inexpensive canned surf clams captured the remaining market for canned razor clams. Razor clams, harvested by hand and therefore
TABLE 2
Summary of Regional U.S. commercial clam meat landings and dockside values, 1971-75
(Thousands of Pounds and Thousands of Dollars)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Value</td>
<td>Value</td>
<td>Value</td>
<td>Value</td>
</tr>
<tr>
<td></td>
<td>Quantity</td>
<td>Quantity</td>
<td>Quantity</td>
<td>Quantity</td>
<td>Quantity</td>
</tr>
<tr>
<td>New England</td>
<td>11,196</td>
<td>10,881</td>
<td>11,738</td>
<td>10,224</td>
<td>11,382</td>
</tr>
<tr>
<td></td>
<td>6,459</td>
<td>7,219</td>
<td>9,060</td>
<td>9,257</td>
<td>10,773</td>
</tr>
<tr>
<td>Middle Atlantic</td>
<td>51,453</td>
<td>43,545</td>
<td>40,866</td>
<td>42,485</td>
<td>53,002</td>
</tr>
<tr>
<td></td>
<td>17,944</td>
<td>19,241</td>
<td>16,644</td>
<td>19,882</td>
<td>22,503</td>
</tr>
<tr>
<td>Chesapeake</td>
<td>20,414</td>
<td>34,189</td>
<td>52,861</td>
<td>67,233</td>
<td>46,847</td>
</tr>
<tr>
<td></td>
<td>6,091</td>
<td>5,920</td>
<td>7,797</td>
<td>10,927</td>
<td>8,946</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>413</td>
<td>395</td>
<td>619</td>
<td>505</td>
<td>534</td>
</tr>
<tr>
<td></td>
<td>220</td>
<td>225</td>
<td>446</td>
<td>548</td>
<td>537</td>
</tr>
<tr>
<td>Gulf 1/</td>
<td>103</td>
<td>395</td>
<td>244</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>27</td>
<td>33</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Pacific Coast 2/</td>
<td>910</td>
<td>1,464</td>
<td>1,212</td>
<td>1,370</td>
<td>1,442</td>
</tr>
<tr>
<td></td>
<td>580</td>
<td>583</td>
<td>678</td>
<td>779</td>
<td>944</td>
</tr>
</tbody>
</table>

1/ Clam production in the Gulf States is confined to the west coast of Florida.
2/ Includes Alaska, but excludes Hawaii.
expensive, could not compete with the low raw product cost of mechanically-harvested surf clams, the greater meat yield, and the greater relative availability.

In 1913, another clam-canning industry was established on the west coast of Florida in the vicinity of the Ten Thousand Islands. This fishery was based on the mechanical harvesting and canning of the southern quahog or hard clam, Mercenaria campechiensis. The harvesting area of 150 square miles was reported as the largest clam bed in the United States, and a 1943 survey reported an estimated abundance of one bushel of clams per six yards dredged. Although more than 1.1 million pounds (meat weight) were harvested in 1932, landings gradually decreased until the canneries closed in 1947, and no commercial landings have been reported since 1972.

Shortages of meat during and immediately after World War II created increased demand for clams. Inshore clam species, including hard, soft, and razor clams, were traditionally harvested by hand and expensive, but improved employment opportunities and a general increase in living standards enabled consumers to purchase large quantities of them. Prior to the war, clams were marketed fresh, canned, or as ingredients in chowders. New prepared clam products were developed during the war, especially in the New England area. The soft clam was used extensively for frying. Ocean quahogs, although not suitable for frying, and generally inferior in color and flavor to surf clams, were also harvested and processed during and immediately after the war.

In the early postwar years, production of hard clams increased and consumers were able to purchase quantities of the expensive small-size clams that are mostly consumed from the shell. Producers were able to sell large clams to manufacturers of prepared clam products. Although some manufacturers considered surf clams inferior to hard clams, the increasing availability and low cost of surf clams favored their use. Eventually, processors of clam products began to use surf clams exclusively, and the hard clam chowder market ceased to exist.
Surf clams soon began to replace ocean quahogs, soft clams, and canned razor clams. The abundant surf clams could be used for frying and did not have the grit and shell sometimes encountered in soft clams. Gradually they became the main meat ingredient in nearly all prepared clam products.

The surf clam industry is now confronted with serious problems because of recent significant decreases in surf clam landings and indeed in total commercial clam landings. Industries associated with harvesting and processing clams are encountering major problems that threaten their economic viability. In this report, the major clam industries are reviewed and recommendations are made for the alleviation of industry problems.

Reference
II

THE HARD CLAM INDUSTRY

Background

The hard clam industry is the largest clam industry in the United States, involving approximately 17,000 fishermen and 13,300 vessels. Hard clams are found in all 18 clam-producing states, generally occurring close to shore in protected and relatively shallow bays. Commercial quantities of hard clams can be harvested with inexpensive harvesting implements, and license fees and other requirements are minimal. In many states, hard clams can be harvested only by hand or with hand-held implements. In general, the industry is not highly capitalized because most harvesting gear is inexpensive. Where mechanical harvesting is done, a considerably larger capital investment is required.

Atlantic coast landings of Mercenaria mercenaria account for 96.5 percent of all hard clam landings. M. campechiensis and a subspecies, M. mercenaria texana, occur along the Gulf coast of Florida, but there have been no recent commercial landings of these species. Additional hard clam species landed along the Pacific coast, primarily from the State of Washington, account for the remaining 3.5 percent of hard clam landing volumes. The Pacific hard clam species are reviewed separately (Chapter IX). M. mercenaria will be of primary consideration in this section.

Brief History

The commercial fishery for hard clams is one of the oldest in the United States. Hard clams, Mercenaria sp., are found in most high salinity bays, inlets, and sounds along the Atlantic coast. The historical center of the industry has been southern New England and Long Island. The industry existed in colonial times and before that, American Indians used hard clams for food and trade.

Although early catch records are not entirely reliable, they indicate that hard clams were harvested abundantly during the 1930's.
It seems that during periods of recession or high unemployment, hard clams are harvested more heavily because little or no capital investment is required.

Meat shortages immediately after World War II helped to improve the marketability of hard clams. Landings of 21.5 million pounds in 1947 appear to be the largest recorded yearly volume. At that time, and for a few years thereafter, the large clams could be sold to processors. The more expensive, more desirable small-size clams are marketed to be consumed from the shell, either raw or steamed.

The volume and value of hard clams during the past 26 years are presented in Figure 3. Near-record landings occurred in 1950. Net total hard clam landing volumes have averaged 15.6 million pounds (7071.5 metric tons) during the past ten years. The value of hard clams to fishermen has increased during the past eleven years.

![Figure 3. Total hard clam meat landings and dockside values, 1950-1975.](image-url)
Industry Problems

Pollution

Water pollution threatens the hard clam industry in many ways. Most resources are located in shallow, nearshore areas where pollution sources are most numerous. Hard clams are sessile organisms and cannot avoid adverse environmental conditions. Although the larger-size hard clams are processed into chowders and other clam products, nearly all of the smaller-size hard clams are consumed from the shell, either in raw form or lightly steamed. In fact, small hard clams (Mercenaria sp.) appear to be the only major clam species in the United States that is consumed raw.

Under the existing National Shellfish Sanitation Program (NSSP), molluscan shellfish can be harvested only from approved, or conditionally approved, shellfish harvesting areas. Approval is based on the bacteriologic quality of the water in the area. The NSSP guidelines for approved harvesting areas require that the median value of total coliforms not exceed 70 MPN/100 ml and that not more than 10 percent of the samples exceed 230 MPN/100 ml.

Nearly all pollutants threaten the hard clam industry by increasing public health hazards. The immediate availability of the resource is reduced because hard clams cannot be harvested from non-approved areas. The long-term availability of the resource is also threatened by pollution because some pollutants may be detrimental to the survival of larval, juvenile, and even adult hard clams.

Industrial and Domestic Pollutants

The principal industrial pollutants of known concern to the hard clam industry are pesticides, PCB's, and heavy metals. Most hard clam harvesting areas currently closed because of industrial pollutants are also impacted by domestic pollutants. The long-term accumulation of industrial pollutants in Raritan Bay in New Jersey and Narragansett Bay in Rhode Island have resulted in the permanent closure to clamming of large portions of these bays. Industrial pollutants are not only a hard clam industry problem, but also an increasingly significant public health problem.
Increasing water pollution from domestic sources is an issue of major importance for the hard clam industry. Some appreciation of the relative size of some of the areas that are closed to hard clam harvesting can be seen in information recently obtained from the State of New York.

New York is the major hard clam producing state and has accounted for about 49 percent of the volume and 63 percent of the value of all hard clams landed in the past ten years. New York reports that out of a total of 575,000 acres of underwater land potentially productive for shellfish, approximately 25 percent (about 143,350 acres) is now closed to shellfishing because of poor water quality. Additional closures, primarily due to domestic pollutants, are currently under consideration.

The total water area that is approved for hard clam harvesting is irrelevant unless hard clams occur in commercial quantities throughout the entire approved harvesting area. Hard clam harvesting areas are not precisely defined as are most oyster harvesting areas, and average effective closure rates are more difficult to obtain.

Sewage outfalls are the major point sources of domestic pollution. Effluents from municipally treated and untreated sources are directly responsible for the closure of large areas. Additional closures of hard clam harvesting areas are necessary because of the required establishment of buffer zones around point pollution sources as a safety factor.

Seaside towns and cities are experiencing an increasingly large summer influx of visitors. The related massive growth of recreational boating has created waste disposal problems. All recreational boats are not equipped with waste-holding tanks and many marinas lack facilities for disposing of such wastes. This situation has caused a significant public health problem for the hard clam industry because the major portion of harvesting occurs during the warmer months of the year. MacMillan (1975) illustrated the impact of summer influx by citing an increase in fecal coliform levels in hard clams from 50 MPN to 9200 MPN per 100 g. in dry weather at one location during a summer weekend.
Because of poor watershed management, the volume of storm water runoff has increased directly in relation to population density, as for example in new seaside residential areas and shopping mall parking lots. Storm water has been found to contain high coliform counts and also high concentrations of lead and zinc. The lead is presumed to come from gasoline and the zinc from tires. Zinc is toxic to the larvae of most molluscan bivalves.

Chlorine is used extensively to reduce bacterial levels in sewage treatment plant effluents. There is recent scientific evidence that high chlorine concentrations can increase mortality in the larval stages of marine organisms (Strand, 1976). Chlorine can also combine with the hydrocarbons to produce chlorinated hydrocarbons, and this has been reported as a problem associated with the drinking water in New Orleans.

Agricultural and Wildlife Pollutants

There is some degree of pollution associated with drainage from agricultural land. Pesticides and herbicides used on crops eventually enter streams, rivers, and bays through storm runoff. The ban on use of DDT has ameliorated the pesticide problem. The recent experience with Mirex and kepone in Virginia has again brought attention to the fact that pesticides are recycled through the marine environment. The overall effects of herbicides on marine phytoplankton is not clear.

Coliform contributions from large concentrations of livestock and domestic fowl have been reported (Rinaldo and Scott, 1976). The impact of general wildlife pollutants is not understood. In some remote areas high coliform counts have been noted where no consequential wildlife populations were observed. Reports have been made of significant coliform contributions in harvesting areas by large flocks of migratory water fowl, particularly Canada geese.

Oil and Chemical Spills

The principal hard clam regions are located in shallow nearshore places where small coastal tankers and barges transport petroleum and
chemical products through or close to production areas. The prospect of collisions, groundings, and spills is a constant threat to the resource.

Petroleum and chemical products are a potential hazard to the hard clam industry because they can affect survival and growth at all stages of the life cycle. Petroleum imparts off-flavors to hard clam meats, making the product unpalatable and unsalable (Blumer et al., 1970; Anderson et al., 1974). Oil residues are possible carcinogens.

Biotoxins

Consumption of molluscan shellfish that have accumulated toxic dinoflagellates can result in paralytic shellfish poisoning (PSP). Incidents of PSP have been reported from the Pacific and Alaskan Coasts, northern New England and Florida. Massive blooms of toxic and non-toxic dinoflagellates often color sea water, and blooms are sometimes referred to as red tides. Toxic dinoflagellate blooms are both a public health hazard and an industry problem. The industry problem is associated with prolonged and adverse publicity concerning red tides which affects the marketability of clams and most seafood (Marine Research, Inc., 1976). On the East Coast, the first PSP-related harvesting area closures were made in Maine in 1958 (Dow, 1976). Before 1972, the bloom-causing toxic dinoflagellate, Gonyaulax tamarensis, was reported only in the waters of northern Maine. In 1972, a toxic red tide did develop in other New England waters; it extended as far south as Cape Cod. Now, hard clam production north of Cape Cod is insignificant, and the major hard clam producing areas south of the Cape were unaffected by the bloom, but adverse publicity discouraged the sale of hard clams and most seafood (Marine Research, Inc., 1976).

Since 1972, all New England hard clam producing states have established monitoring programs to detect the presence of toxic dinoflagellates. The Pacific coastal states and Alaska have long had similar monitoring programs.

Dinoflagellate blooms also occur in Florida, primarily along the Gulf coast. The dinoflagellate that is responsible for red tides in Florida is G. brevis, which is not considered as toxic to humans as northern dinoflagellates.
Climatic Problems

Climate and weather are responsible for a number of hard clam industry problems. Rainfall associated with hurricanes can overload sewage treatment facilities and the drainage capacity of entire watersheds. Severe storms sometimes deposit hard clams on beaches or they can smother resources.

Biological Problems

Fluctuations in total hard clam landings have been attributed to biological as well as economic causes. Short-term fluctuations are minimal because several age groups are included in the stocks. All states that harvest hard clams commercially report variations in natural abundance. But although the general life history of hard clams is understood, and the minimal food requirements of larval, juvenile, and adult hard clams is known; and although the major predators, and the developmental stages of clams in which these predators have the most impact are reasonably well-known (MacKenzie, 1976), the manner in which all this information interacts in the natural environment and causes fluctuations in hard clam abundance is not known.

An adequate brood stock, capable of maintaining a fishery resource at full biological productivity, is one of the most important objectives of fishery research and management (McHugh, 1976). Because hard clam resources fluctuate so much from "natural causes," basic brood stock information is difficult to obtain.

Large brood stocks are present in areas that are closed to harvesting for public health reasons; in fact, they have significantly larger clam populations than open harvesting areas. In many places where heavy fishing pressure occurs, the larger chowder-size hard clams are not harvested because the larger clams, especially M. mercenaria, have had little or no market value until recently.

Low-level recruitment is generally attributed to environmental conditions that adversely affect the successful spawning, and subsequent survival and growth, of larval and juvenile clams. Reduced recruitment is also attributed to overharvesting, which reduces total clam populations to levels that are incapable of significant reproduction.
Most hard clam harvesting states report a low-level recruitment of juvenile clams in areas that are harvested regularly. High-level recruitment occurs occasionally, but when it does occur, one successful year class of juvenile clams can sustain a sizable commercial fishery for a number of years.

Hatchery techniques for the production of large volumes of juvenile hard clams are well established (Loosanoff and Davis, 1963). Several state universities and clam industry companies are currently engaged in research projects aimed at developing inexpensive methods of rearing large quantities of juvenile hard clams, which must be protected from predation for one or more years until they attain a size that affords protection from major predators (Castagna, 1970).

Predation and Disease

Mackenzie (1976) identifies the principal invertebrate predators of hard clams (Mercenaria sp.) as oyster drills (Urosalpinx cinerea and Eupleura caudata), moon snails (Polinices duplicata and Lunatia heros), whelks or conchs (Busycon canaliculatum and B. carica), crabs (Neopanope savi, Cancer irroratus and Callinectes sapidus), and the sea star (Asterias forbesi). Puffer fish, drum fish, skates, rays, and diving ducks also feed on hard clams. Predation rates vary, and the smallest clams are the most vulnerable. Eventually, as hard clams increase in size, they are less vulnerable to most predators except blue crabs, whelks, drum fish, moon snails, and rays.

Other than Chlamydia (Otto, personal communication), no specific hard clam diseases have been reported. Several mass mortalities of hard clams have occurred, but causes have not been identified. Bacterial disease has caused mortality of Mercenaria larvae in the laboratory (Tubiasch, 1965).

Resource Management Problems

It is extremely difficult to achieve effective management control over any natural marine resource. Marine resource management problems are considerably increased when the resource is essentially owned by the state or public and when the resource is or has been subjected to continuous commercial and/or recreational harvesting. In states that
have designated subaqueous land to be molluscan shellfisheries, clam harvesting grounds have usually been the areas left over after natural oyster beds and leased oyster grounds have been designated.

Hard clam resource management regulations and existing laws pertaining to utilization of resources in the major producing states have generally favored industrial utilization. New resource regulations are written with the consent of the harvesting industry (Cole, 1976); in many cases, the industry had existed prior to the establishment of resource management agencies.

There are sometimes problems of split jurisdiction within states, especially in the New York and New England areas, where the clam resources are the property of local towns or communities. When the resource is locally owned, the towns can and do establish their own regulations, which may be in conflict with state regulations. There may also be jurisdictional disputes with subareas that have been legally leased to individuals.

In New York, the regulation of hard clam harvesting is the joint responsibility of town, county, state, and federal agencies.

Stock Assessment

In order to develop a resource management model, five basic types of information are essential: 1) the size of the standing crop; 2) rate of renewal by growth; 3) rate of renewal by recruitment; 4) rate of removal by natural causes; and 5) rate of removal by harvesting (McHugh, 1976). The agencies responsible for managing hard clam resources generally lack such basic information. No consultants have reported MSY's (Maximum Sustainable Yield) for hard clam resources, and it is doubtful if any of this information exists along the east coast. In many states, the total hard clam resource is insignificant in relation to other major fisheries, and consequently little effort is expended to obtain the required information. Reliable harvesting data are difficult to obtain because most hard clam landings are under-reported and there are only a few scattered estimates of recreational catch (McHugh, 1976).
Harvesting Pressure

Recreational effort is increasing in nearly all areas. Commercial effort is increasing only in areas where harvestable hard clam resources are still relatively abundant. In approved harvesting areas, productive hard clam populations are generally declining, and seldom increase even when fishing pressure is eliminated. This is in sharp contrast to observed increase of hard clams in areas that are closed to harvesting because of domestic pollution. There is speculation that nutrient enrichment from moderate amounts of domestic pollution may contribute to the growth of polluted clam populations (McHugh, 1976).

Inclement Weather

Clam harvesting operations are hampered by inclement weather. In northern areas, winter ice in harbors and ice accumulation over clam harvesting grounds cause a significant decrease in hard clam landings. In all areas, severe winds often prevent harvesters from reaching clamming grounds and also from using effectively some of the harvesting gear.

Harvesting Methods

Hard clam resources occur naturally on public or leased grounds. In general, only hand methods are legal for harvesting the clams on public beds; these methods include signing, treading, hand raking, bull raking, and tonging. Some states allow mechanical harvesting on both leased and public grounds when water is too deep for hand harvesting methods. Mechanical methods include use of modified oyster dredges, Fall River dredges, hydraulic cage and hydraulic escalator dredges, and patent tongs.

Hydraulic escalator dredging has proved efficient in harvesting hard clams, but this dredge causes serious damage to rooted marine vegetation (Menzel, 1976). However, all dredging methods and most hand harvesting methods also harm rooted vegetation. Despite the known relative inefficiency of hand harvesting methods, most states report that their hard clam resources are currently being harvested at, or very close to, their estimated maximum sustainable yield (MSY).
Harvesters are required to return illegal-size clams to the bottom of the harvesting area. The hard clam harvesters grade their catch into three or more trade sizes. The smallest and most valuable hard clams are referred to as littlenecks; harvesters generally receive 3 or 4 cents each for them, or from $30 to $40 per bushel of around 1,000 clams. The second most valuable size hard clams are called cherrystones; they are larger than littlenecks, but still small enough to be consumed raw or steamed, and are also marketed at 3 or 4 cents each. The hard clams that are larger than cherrystones are referred to as chowders, and harvesters are paid 1 to 3 cents each for them, if they can find a buyer.

Regulations

The specific regulations for the hard clam industry vary with state, county, town, and federal agencies, but because there is not enough available information, it is not possible to compile a table summarizing the various governmental regulations pertaining to hard clam harvesters. Generally, the state or local town conservation agency has had management jurisdiction over natural hard clam resources: issuing commercial clam licenses, establishing minimal size limits, and defining legal harvesting methods. A designated state agency, in compliance with NSSP criteria, has management jurisdiction over all sanitary aspects of the hard clam industry; it establishes bacteriologically-approved harvesting areas and sanitary methods of handling and marketing hard clams.

Transportation

Harvested clams are transported by boat or truck to clam buyers. Buyers must have a state shellstock shippers permit and it is their responsibility to purchase clams only from approved harvesting areas. Under state and NSSP guidelines, all transported hard clam shellstock must be packaged and identified by the permit number of the clam buyer. Hard clams have good keeping qualities; in dry storage of 4°C, they will usually live from one to three weeks.
If more product could be assured, the transportation costs per unit would undoubtedly fall. Here, as in many fisheries, costs are higher because of the limited quantities at numerous access points (piers). It is not efficient for a truck to haul a half-full load from five different piers. This problem relates more to the supply availability than to transportation problems, and the losses from this inefficiency may be relatively minor.

**Processing**

Hard clams and nearly all other clams in the United States are sold by the harvesters as shellstock. Practically all of the small hard clams are sold in the shell for direct consumption; only relatively small quantities of the larger chowder-size hard clams are actually shucked and processed into clam products. Industry problems associated with hard clam processing are relatively minor, due to this small volume. All hard clam shucking and processing plants are regulated by state health and NSSP guidelines.

There are few problems with cleaning. The exterior shell is quite clean prior to arrival at the processor and, since ninety percent of the clams are sold intact, the interior cleaning problem is not significant. The small amount of sand in the clam is apparently acceptable to consumers. No research has been done on either consumer preference for sandless clams or methods of removing sand from a live clam.

Although there are inexpensive sorters available, sorting of clams is often done by hand. This provides work for employees who do not have enough shucking to occupy their time. It is considered important to employ the workers as many hours as possible, so that wage levels remain competitively high.

At present, identification of the product is not a problem; however, the Food and Drug Administration proposed new rules and regulations last year. These rules would require records to be kept throughout the market chain on exactly where shellfish were landed. The proposal has been dormant for some time now. If these regulations are implemented, then identification would become a substantial problem to the industry. Having to divide lots according to landing area would undoubtedly raise
costs throughout the market. The larger, more efficient companies would be hurt the most since their large volume comes from a variety of landing areas.

**Shucked Meat Problems**

In Virginia, chowder-size hard clams are shucked by hand and the meats are sold in fresh or frozen form. Since the majority (90%) of trade is shell market trade, there is really not enough product flow to make mechanical processing economical. Thus the only problem area is in the hand shucking and washing operation. Many plants handling both oysters and hard clams use laborers to shuck both products.

**Waste Disposal**

Since most hard clams are shipped out of state in shell form, little waste disposal is necessary, and therefore presents only a minor problem.

For the processors that shuck hard clams, the shell can be given away or sometimes sold as a base for driveways and roads. It also provides a good oyster cultch. Most processors that shuck hard clams also shuck oysters, and it is believed that the FDA's state requirements for waste treatment can be met, at least in the short run, by static screening.

**Labor Problems**

Labor problems in Virginia are related to high absenteeism and stiff competition from the poultry industry. There are complaints that some workers miss two days a week, and this makes controlling product flow difficult. When product (i.e., oysters and clams) is not available, the workers are able to find work in the poultry plants and often do not return to the clam processors.

**Marketing**

Marketing the smaller littleneck or cherrystone hard clams is not considered a problem at the present time because demand currently exceeds supply in all areas. There does not appear to be any indication of declining demand or consumption of hard clams. It is likely, however,
that unless management of the hard clam fisheries is not substantially improved, consumption might decline because the supply may be reduced. Any incident that potentially endangers the public health of hard clam consumers will have a marked influence on the marketability of all hard clams. Infectious hepatitis, typhoid, or any illness attributed to the consumption of hard clams can cause economic chaos with long-lasting effects. Unfortunately, techniques do not exist for an intensive and thorough study of viral agents in clams.

The marketing of the larger chowder-size Mercenaria has always been a problem. The recent and continuing significant increase in the dockside value of surf clams may improve the marketability of chowder-size hard clams.

The market is somewhat seasonal in that prices are normally higher in winter months than in summer months. For the firm that processes both hard clams and oysters, this is a dilemma. Oysters are most available in the winter months when the price for clams is greatest. This means that processing capacity is overloaded in the winter and sometimes idle in the summer. This has caused some processors to diversify further, going into surf clam products to maintain summer operation of the plants.

There is almost a complete lack of advertising in the industry. Market channels are known by tradition, and processed product in a fast food form is untried. These two factors make advertising unattractive to the companies. There are apparently good profits, as firms are not attempting innovative processed forms and advertising.

One major concern is the encroachment that surf clams have made into the chowder clam market, at least in the Virginia area. Because of the dark gonads in hard clams, they may be used only for Manhattan-style chowder. The enormous increases in Virginia surf clam volumes have glutted the chowder clam market and lowered the dockside price of hard clams significantly. In fact, few chowder-sized hard clams are now harvested. To the degree clammers can be selective in their landings, they will work areas with smaller-sized clams.
Consumption Problems

In a consumer survey of two Virginia metropolitan areas, consumers identified lower prices, availability of more fresh products, and water pollution control as the major ways of encouraging seafood consumption. It may be logical to infer from this information that consumers refrain from buying seafood products (including clams) because they are unhappy about (1) high seafood prices, (2) lack of availability in the market, and (3) water quality in the growing areas.

Recently, the shotgun effects throughout the nation of the closure of the James River due to the presence of kepone demonstrated another common problem in the industry. When New England or Florida are hit by red tide problems, clammers and processors along the whole coast are hurt through adverse publicity. Consumer demand for clams, in general, drops and prices fall.

Current Status

Hard clam harvesters were paid 21.7 million dollars for 14.8 million pounds (meat weight) landed in 1975. The national average dockside value to harvesters was 146.2 cents per pound and values ranged from 81.5 to 170.1 cents per pound. During 1975, the dockside value per pound of hard clams ranked third in relation to dockside value of other molluscan bivalves (Table 3).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Molluscan Bivalves</th>
<th>Dockside Value Cent Per Pound Meat Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Razor clams (Pacific)</td>
<td>189.1</td>
</tr>
<tr>
<td>2</td>
<td>Scallops</td>
<td>185.0</td>
</tr>
<tr>
<td>3</td>
<td>Hard clam</td>
<td>146.2</td>
</tr>
<tr>
<td>4</td>
<td>Soft clam</td>
<td>94.5</td>
</tr>
<tr>
<td>5</td>
<td>Oysters</td>
<td>80.0</td>
</tr>
<tr>
<td>6</td>
<td>Mussels</td>
<td>32.8</td>
</tr>
<tr>
<td>7</td>
<td>Ocean quahog</td>
<td>19.2</td>
</tr>
<tr>
<td>8</td>
<td>Surf clam</td>
<td>14.5</td>
</tr>
</tbody>
</table>

The 1976 midyear dockside value of small hard clams landed in New York was $2.03 per pound (meat weight). The demand for small hard clams is high because supplies are limited. Dockside values for chowder-size hard clams have increased slightly, but demand for processing them continues to be low, because these clams are still more expensive than surf clams or ocean quahogs.
Complications related to water pollution appear to be the cause of major industry problems. Since hard clams are consumed raw, any illness reportedly related to the consumption of hard clams affects their marketability and the economic viability of the industry. Several hundred thousand acres of existing or potentially productive grounds are closed to harvesting because the water quality does not meet federal and state standards. These closed areas remove a significant part of the total resource from commercial and public use, and they also constitute a potential public health problem. The opportunity exists to harvest clams illegally from polluted areas, because the number of closed areas and the total acreage closed in each state is usually far greater than any state's ability to maintain 24-hour law-enforcement surveillance. Although most closed areas are posted, and commercial harvesters are required to know the location of closed areas, recreational clammers and visitors are not always informed about the exact closure lines.

Commercial and recreational clam harvesters continue to question the validity of federal water quality harvesting standards and the adequacy of sanitary surveys. In 1961, an outbreak of infectious hepatitis was attributed to consumption of hard clams that had been illegally harvested from Raritan Bay. The incident caused widespread illness and some deaths, and the publicity resulted in adverse economic effects that were felt throughout the entire industry. Despite continued illegal harvesting of hard clams, no documented outbreaks of human disease have been attributed to the consumption of contaminated hard clams during the past fifteen years. Consequently, the public health aspects of harvesting from uncertified grounds are taken lightly by many people in the industry, by the public generally, and by the courts.

Increased domestic pollution has been responsible for the closure of most clam harvesting grounds, and additional closures are under consideration in New York and Delaware. The total legal harvesting area has been reduced and harvesting pressure has increased in the remaining approved areas. There are serious signs of declining resource availability in Rhode Island, Connecticut, New Jersey, Delaware, Maryland,
and Virginia. As the available supply of legal clams declines, harvesters are more tempted to gather clams illegally. Hard clam populations tend to increase in many areas that are closed to harvesting because of pollution. Unfortunately, clam populations seldom increase in areas that are closed for conservation purposes.

Increasing volumes of treated domestic waste and considerably larger volumes of untreated storm water runoff are entering estuaries and clam-producing bays. There is some question as to the ability of pollution abatement programs to keep pace with the situation.

The basic structure of the hard clam industry may be characterized as a part-time fishery. Almost all of the harvesting is done by fishermen from other fisheries during slack times or off seasons. Most of them work independently with at best an oral agreement to sell to specific processors or distributors. The majority of landings are sold in the shell with little processing. There do not appear to be any economic barriers to entry either into the harvesting or the clam buying sectors. Indeed, one of the problems may be the ease with which unemployed, retired people, or people who want a second income can obtain the necessary equipment and skills to begin clamming.

The distributors believe that substantially greater quantities could be sold without affecting the price significantly. They see relative scarcity of the product as the primary problem. This is particularly evident in the winter months when prices rise because the northern clam output declines.

There is some seasonal deterioration in the quality of hard clams in early summer, but it is not considered to be a major problem. The best quality clams are landed in the winter.

A census of recreational fishing is incomplete and its extent varies between areas. Procurement of recreational catch data should be considered as a major problem. All of the problems associated with multiple-use management are present in this fishery. How should the resource be allocated between commercial or recreational fishermen? How can recreational fishing be measured or regulated when it is practiced at many places by very large numbers who take a relatively small amount
each, but whose total effect can be massive? These questions are especially hard to answer when the stocks are essentially fully utilized.

Most states freely admit that they lack the information, the means, and the attitude required for successful management of hard clam resources. Nearly all hard clam landings are due to the harvesting of naturally occurring clams. Until recently, there has been little maricultural effort applied toward the actual production of hard clams.

Expected Future

The greatest threats to the continued existence of the hard clam industry appear to be water pollution, declining resource availability, and inadequate enforcement of existing sanitary harvesting regulations. Total hard clam landings have remained essentially stable during the past 22 years, while dockside values have increased almost 200 percent during the past fourteen years. These data and supporting data from individual states indicate that the legally harvestable stocks of hard clams have been overharvested in nearly every state. Unless radical changes occur in pollution abatement, control of harvesting, and the attitude of resource management and regulatory agencies, the harvestable portion of the resource will most likely decline.

Present levels of harvesting might be maintained if polluted clams and more particularly polluted clam-growing areas could be utilized effectively and economically without the creation of public health hazards. Increased costs associated with relaying or depurating clams grown in polluted areas would have to be reduced through more efficient methods of material handling. Even increased utilization of polluted clams could merely maintain harvesting levels for a short time, unless positive steps are taken soon toward the actual production of hard clams.

Recommendations

1. All segments of the hard clam industry, including governmental regulatory agencies, should demand and support pollution abatement
programs in order to maintain and enhance water quality standards throughout coastal areas.

2. Resource management agencies should make immediate stock assessments and increase efforts for attaining realistic commercial and recreational harvesting data.

3. The Food and Drug Administration should re-evaluate the bacteriologic water quality standards that are currently used for the certification of sanitary shellfish harvesting areas.

4. The illegal harvesting of clams from non-approved harvesting areas should be curtailed through increased surveillance and enforcement of existing sanitary harvesting regulations.

5. Resource management agencies should re-evaluate existing regulations in order to obtain effective management control of hard clam resources.

6. Resource management agencies should encourage hard clam mariculture by leasing grounds for production, and such grounds should not be restricted to barren or only marginally productive grounds.

7. Depuration and relaying of polluted clams should be encouraged.

8. The population dynamics of moderately polluted clam-growing areas should be studied and the feasibility of mariculture in such areas should be investigated.

References


III
THE SURF CLAM INDUSTRY

Background
In terms of volume of clams landed, the most significant industry is the one associated with harvesting and processing the surf clam (Spisula solidissima). The landing of surf clams has accounted for about 69 percent of the volume, and 25 percent of the dockside value during the past ten years. The volume and dockside value of surf clam landings during the past 26 years is presented in Figure 4.

There were approximately 400 fishermen and 100 vessels actively engaged in the 1975 harvest of 87.0 million pounds of surf clam meats, valued at 12.6 million dollars. The fishery is concentrated off the coasts of New York, New Jersey, Delaware, Maryland, and Virginia.

Brief History
The surf clam industry began as a New England bait fishery around 1870 (Yancy and Welch, 1968). There are reports of American Indians roasting clams that washed ashore on Virginia beaches as early as 1634 (Parker, 1972).

Increased demand for food during World War II led to the use of surf clams for human consumption. An early constraint to consumption was the inability of processors to remove sand from surf clams, but this problem was solved in 1943, when processors developed an effective drum washer.

Harvesting efficiency was improved with the development of the hydraulic jet cage dredge in 1945. Apparently, most of the surf clam industry entered the field of food processing around 1946. Hand methods of processing surf clams continued until the development of automatic shucking machines in the early 1970's. The machines supplemented hand processing and catalyzed the harvesting, processing, and marketing sectors of the industry.

Early surf clam landings began off New York and continued from 1945 through 1954. Since surf clams were much cheaper and more readily
Figure 4. Total U.S. surf clam meat landings and dockside values, 1950-1975.
obtainable than hard or soft clams and had better marketing qualities than ocean quahogs, producers of prepared clam products began to utilize them exclusively, and surf clam processing companies began to increase their own production of prepared clam products.

The surf clams harvested off New York yielded approximately 12 pounds of meats per bushel. Of particular importance to the industry was the discovery of extensive and densely populated surf clam beds off the coast of New Jersey. The offshore New Jersey surf clams yielded approximately 17 pounds of meats per bushel. Between 1961 and 1966, New Jersey landed 96 percent of all U.S. surf clams (Yancy and Welch, 1968).

Surf clam harvesting vessels usually concentrated their efforts in one productive area until the catch rate declined. The vessels then moved on to more productive grounds. The diminishing availability of surf clams off New Jersey resulted in a shifting of effort to Virginia in the early 1970's, when Virginia surf clam landings rose from 1.6 million pounds in 1971, to 58.2 million pounds in 1974. Federally-funded resource surveys to evaluate distribution and abundance of the stock in the Middle Atlantic States began in 1964.

**Industry Problems**

**Pollution**

Surf clams inhabit a zone extending from the surf of ocean beaches out and along the continental shelf to depths of approximately 36 meters. Small surf clam populations are sometimes found in inlets and also in the more saline portions of coastal bays. At the northernmost range of the fishery, commercial quantities of surf clams are found close inshore. Further south, commercial quantities of surf clams are found progressively further offshore. Because nearly all commercial surf clam harvesting occurs offshore in relatively deep water of near-oceanic quality, water pollution was not considered to be a major industry problem until recently.
Industrial and Domestic Pollutants

New York reports that 120 square miles of harvesting area in the apex of the New York Bight is closed to surf clam harvesting because of industrial pollution. A similar area offshore from Delaware and Maryland is also closed to surf clam harvesting because of ocean dumping of industrial waste and sewage sludge. The closure of these large areas was not considered a major industry problem while surf clam stocks were abundant, but now that they have been reduced, the closed areas have become more significant. The industry is not appeased by reports that ocean dumping may be phased out by 1981.

The enrichment of nearshore waters from ocean dumping and effluents from ocean outfalls is suspected to have had some influence on the prolonged dinoflagellate bloom that occurred off the New Jersey coast during the summer of 1976.

New Jersey reports that 90,800 acres of the total 230,400 acres of ocean water within the three-mile limit is closed to surf clamming because of pollution (Sugihara, 1976). Due to the progressively off-shore distribution of surf clam resources, and the lack of significant pollution sources, few inshore areas are closed to surf clam harvesting southward along the Delmarva Peninsula.

Potential pollution problems also exist offshore. Large East Coast cities have traditionally used offshore sites for ocean dumping of sewage sludge and industrial wastes. The recent oil industry activity in Baltimore Canyon and other offshore tracts is of some concern to the surf clam industry. It had been previously estimated that 80 percent of the total surf clam resource occurred in water depths ranging between 12 and 31 meters (Merrill and Ropes, 1969), and oil exploration and development will occur well below these depths.

Biotoxins

Paralytic shellfish poisoning has been reported north of Cape Cod, and surf clam stocks extend into this area. Toxic dinoflagellate blooms are not considered to be a surf clam industry problem at the present time, because all major surf clam harvesting areas are still well south of the Cape. Publicity about red tides could reduce the
marketability of surf clams and most seafood (Marine Research, Inc., 1976). Although dinoflagellate blooms do occur within surf clam harvesting areas, thus far no toxic species have been involved in the present areas.

Climatic Problems

Storms can and sometimes do cause massive surf clam mortalities to occur by depositing large quantities of clams on ocean beaches. Ropes et al. (1969) cited an observation made over 50 years ago which estimated that five million adult surf clams per linear mile were stranded on Rockaway Beach, Long Island, New York, after unusually severe storms. According to Merrill (Sugihara, 1976), these occurrences are probably not significant over a period of time because the incidents are locally scattered and probably involve only a small part of the inshore surf clam resource. It is interesting to note that previously, storms deposited surf clams on Virginia beaches about once every five years. There have been no reports of beached surf clams in Virginia during the past 12 years (Strand, 1976), and there is speculation that increased fishing pressure may be responsible.

Water temperature is known to affect reproduction cycles (Ropes, 1968), and possibly may account for part of the shell size difference between offshore and inshore populations (Starypan, 1976).

Biological Problems

The most recent and complete report on surf clam resource availability is provided by Chang, Ropes, and Merrill (1976). The estimated population size of surf clam resources in the Middle Atlantic Bight has declined steadily since 1970 and is now considered to be at a record low.

Chang et al. (1976) estimated that surf clam population remained relatively constant between 1965 and 1970 at a level around 1100 thousand metric tons of clam meat. It then began to decline and eventually reached a level of around 245 thousand metric tons of surf clam meat in 1975.

A major cause in the decline in total surf clam resources has been the extremely effective fishing pressure recently exerted on the resource.
Harvesting has reduced the estimated spawning stock and recruitment size of the surf clam resource to 53 thousand metric tons in 1975. This is a significant decline from the estimated level of 228 thousand metric tons reported for 1971.

**Predation and Disease**

Moon snails are probably important predators of surf clams *Lunatia heros* in deeper waters and *Polinices duplicata* nearer shore. Bottom feeding fish, crabs, and shore birds also consume surf clams (Ropes et al., 1969).

No diseases of surf clams are known. A parasite (*Proboscidioasactus enigmaticus*) of uncertain taxonomic position has been found in the related European surf clam species *Spisula solida* (Yancy and Welch, 1968). Nematode infestations have been found in the Middle Atlantic surf clam population, but are not deemed a health hazard.

**Resource Management Problems**

The surf clam fishery actually evolved outside the jurisdictional limits of most state regulatory agencies. Therefore, until just recently, the harvesting sector of the surf clam industry has never been subjected to state or federal regulations that tend to be restrictive. In sharp contrast to the much older and traditional inshore clam and oyster fisheries, the offshore surf clam fisheries had no legal restraints to prevent them from developing effective harvesting methods.

Resource management problems stem directly from commercial fishing, as there is no recreational fishery. The principal problems have been management without an adequate information base and a poorly defined management regime. Inadequate stock assessments and economic information left the loosely knit federal and state authorities with unsubstantiated arguments for strict regulations. Moreover, the informal state/federal program had no legislative basis on which to induce industry participants to compromise. A consensus between state, federal, and industry groups was necessary to achieve management objectives. The consensus has not been reached.
Despite the growing evidence of stock depletion, new large vessels are entering the fishery. There is much concern that continued unrestricted exploitation will deplete surf clam beds still further. It is hoped that the newly established Mid-Atlantic Regional Council can provide the necessary forum to obtain rational management of the stocks. A necessary forum objective includes not only strong management goals but also a budget that can provide the needed biological and economic information base.

In the relatively short time period of only 30 years, the surf clam industry has managed to solve the harvesting, processing, and marketing problems that continue to restrict inshore clam and oyster fisheries.

**Stock Assessment**

When the fishery began, most state regulatory agencies lacked facilities for making surf clam stock assessments. Through a cooperative state/federal surf clam management program, the resources within the three-mile inshore jurisdictions of New York, New Jersey, Delaware, Maryland, and Virginia were surveyed in 1974. New Jersey has continued to survey its inshore resources because of intense fishing activity. Resources beyond the three-mile limit have been surveyed by the federal government (Ropes, 1975).

**Harvesting Pressure**

Effective surf clam harvesting pressure has been enhanced since 1969, when stern dredgers began to enter the fleet. The trend has been toward larger vessels that handle larger dredges and sometimes more than one dredge. The increase in the dockside value of surf clams has encouraged some smaller and older harvesting vessels to reenter the fishery.

**Inclement Weather**

Severe weather conditions often interfere with harvesting operations of the offshore fisheries. In New Jersey, bad weather has limited surf clam harvesting to 180 (plus or minus 20) days per year (Sugihara, 1976).
With larger and more modern vessels, the ability to keep dredging gear on the bottom is the major factor in bad weather harvesting; but distance from shore, fast-moving weather fronts, over-aggressive captains, and occasional poor communication have contributed to a loss of five Eastern Shore surf clam vessels in the last three years. This is an industry problem because it raises insurance rates, raises wages of the crew (to pay for risk element), and leads to conservative attitudes toward winter harvesting.

**Harvesting Methods**

Harvesting of surf clams occurs offshore from relatively large vessels using hydraulic jet cage dredges — an extremely effective method. This effective gear is known to cause damage to juvenile and adult surf clams, and ways of improving the equipment have been recommended (Scott and Rinaldo, 1976).

There is speculation that the old smaller vessels are more efficient at landing surf clams and methodically working the clam beds, but harvesters say that the offshore distance has made larger capacity and greater speed necessary vessel characteristics. Thus, the new large fast vessels may have the competitive advantage.

There are problems associated with deck loading surf clams during hot, sunny summer days. Clams are perishable and, by the time a vessel returns and is off-loaded, the quality of the clams can be significantly reduced. There is economic pressure by the wholesalers and processors for better quality control, and harvesters have begun improving their on-board storage procedures.

The deck storage of clams also creates stability problems. In rough seas, the increase in topside weight reduces the righting moments of the vessels, and can produce increased roll. This can lead to the large cages shifting, causing safety hazards for the crews.

**Regulations**

Most states now have regulations and requirements, including licensing of harvesting vessels or crew members. New York has a
minimum three-inch size clam limit. New Jersey has recently begun
to regulate surf clam harvesting within the three-mile limit. In
New Jersey waters, harvesting vessels are limited to a single dredge
with maximum cutting bar width of 60 inches. Some of the larger
vessels have dredges with 120-inch cutting bars. In New Jersey, the
inner mile is closed to surf clam harvesting south of Great Bay, and
from May 1 to November 30 all New Jersey state waters are closed.
There are no state regulations pertaining to surf clam harvesting
within the state waters of Delaware, Maryland, or Virginia, and
there are no offshore regulations.

Designated state agencies, under NSSP guidelines, do prohibit the
harvesting of surf clams from non-approved areas.

Transportation

Handling of harvested surf clams is relatively modern and efficient.
Although clams were previously stored on board harvesting vessels in
the shell in one-bushel bags, nearly all surf clams are now stored in
32-bushel wire cage containers or 20-bushel drums. Containers can be
unloaded at processing plant docks or shipped by truck from any landing
area. No harvesting vessels have refrigeration capacity at the present
time but, because of the perishability of surf clams and because harvesting
trip durations are being extended, refrigeration will be installed on
many of the larger harvesting vessels in the near future.

Surf clams do not remain alive for a long time. Except for very
small quantities sold in the shell as bait, the entire surf clam catch
is processed within one or two days after unloading from harvesting
vessels. Surf clams are stored in the shell in refrigerated rooms at
processing plants or shipped by refrigerated truck to processing plants.

Processing

Many of the larger surf clam processing firms have purchased their
own harvesting vessels in order to obtain a continuous supply of raw
product. There are also many privately owned surf clam harvesting vessels
that now sell their catch to the highest bidder among the processing
plants.
There is stiff competition for surf clams among Eastern Shore processors and other buyers. This has led to dockside prices rising from $2/bushel in 1972 to over $10/bushel currently. Processors, however, are able to pass these costs along to their purchasers, and profit margins are apparently satisfactory.

There has been some complaint that deck storage lowers quality and, recently, that the newly-introduced large dredges damage the shells of landed and unlanded clams. The deck storage problem is partially overcome by prompt processing. If there is increased damage to clams from the large dredges, mortality of the unlanded clams increases, with consequent reduced yield from the landed clams. More investigation is necessary to determine the extent of damage, if any, from large dredges.

Shucking Problems

The recent sharp decline in surf clam landings has created a situation in which the harvested supply is inadequate for processing demand. The reduction in landings has driven the dockside value of surf clams up to three and four times the former landed value. Processors are faced with the problem of diminishing supplies of raw product that is only available at increasingly higher prices. The smaller supplies make it difficult to maintain a reliable labor force.

The clam meat processing sector of the surf clam industry is, for the most part, both modern and efficient. Although surf clams are still hand shucked in a few small plants, most large plants use automated equipment. Most modern plants use ovens for opening surf clams and brine solutions for meat shell separation. Automated eviscerating, washing, chopping, and packing equipment is used extensively.

The problems associated with this process relate mostly to the recently increased prices of fuels needed to produce heat for the process. Natural gas scarcities in the past have introduced problems to the Virginia industry, but the supplies have been available. The deregulation of natural gas prices in the last year may have an impact on industry costs. The hot water process is a less efficient heat transfer system and will probably be replaced in the future by the gas-oven system. For the
processors that hand shucked, the major problem is to have enough product on hand to keep the laborers consistently employed.

Product flow is continuous from the input of clams in the shell at the beginning of the line to the output of canned and retorted clam products at the end of the processing line. The smaller clam processing plants generally produce shucked clam meats that are frozen in blocks and sold to other plants that process these meats into a variety of surf clam products.

Much of the meat separation is mechanized, but there is still a considerable amount of hand separation on the Eastern Shore. At this stage, the major problems are the waste associated with the hand shucking operation, and assurance of quality control in the mechanized process. Hammers and paddles break up much of the meat that is attached to the shell. In general, the meat separation process is not a problem.

Undesirable Material Problems

The shell fragment problem tends to be prevalent in surf clam production. The fragility of the shells and the tremendous volume of processed product make it practically impossible to produce a shell-free product. The mechanical shuckers and hand shuckers do perform adequately, and it is not of overriding importance at this time. There is a potential problem associated with fresh water use to remove the fragments. Fresh water is a scarce resource on the Eastern Shore and will become much scarcer.

Evisceration or "pinching bellies" is accomplished both by hand and mechanical means in Virginia. There are only the general problems associated with labor and fresh water use.

The washing of meats is accomplished both in the separation phase (shaker) and later "blowing" phase. Again, there is considerable fresh water used in this process and, in the regions where processors are located, fresh water use will undoubtedly become either more expensive or regulated. In the washing phase, the product is separated into "tongue" and "salvage."

After this stage, the product is generally either chopped, diced, cut into strips, and frozen, or frozen in its raw product form. The
packaging is not a problem, and the product is usually sent out of state for further processing into chowder, casseroles, or breaded strips.

**Waste Disposal**

Wastes from surf clam processing plants consist of shells and shell fragments, sand, processing washwater, and viscera. Solid waste is disposed of in landfill areas, and dried for fill, to be used, for example, in drywells or driveways. Surf clam shells are sometimes used as oyster cultch. Viscera are disposed of in sanitary landfill areas, and they are also liquefied before transfer to treatment facilities. Processing washwater is either treated by processing plants or disposed of in municipal treatment systems.

In areas where municipal waste treatment is not available, the screening of processing waste discharges must meet requirements for the 1972 Amendments to the Water Quality Act of 1975 for 1977. Generally, the goal of near-zero effluent discharge will require substantial investment by plants that must treat their own effluents.

**Labor Problems**

In plants that shuck by hand, each laborer is paid by the product he or she produces. Labor generally becomes a problem only when there is little product to process. As a result, some oyster shuckers have become surf clam shuckers. At other times, there are complaints of high absenteeism among the laborers.

The increased mechanization trend has, to a large extent, reduced reliance on a large labor force. This trend will probably continue as offshore oil development and general economic growth on the Eastern Shore continue to increase the competition for the labor force.

**Marketing**

The market demands for surf clam products are high. During the mid-1960's, the marketing problem was oversupply, and this caused dockside values to decrease. Landed values were three to four times
higher in 1976 than 1975. Surf clam processors have passed increased costs on to consumers thus far, but processors generally feel that they cannot continue to do so, since it will decrease demand. Other clam resources are being sought as alternatives.

Surf clams are not consumed raw, but meats are processed into such a variety of clam products that the identity of surf clam meats is lost. Consequently, there is no information available specifically on the consumption of only surf clam meats.

However, some indication of surf clam demand and consumption can be obtained from an analysis of aggregate consumption data for all species of clams in the United States. The aggregate consumption of all clams in the United States rose from 72.3 million pounds of meat in 1965 to 114.4 million pounds of meat in 1975. During this time period, United States per capita consumption of all clam species rose from .38 pounds of meat to .54 pounds. The total meat landings of hard clams and soft shell clams did not increase during this time period. The increase in United States aggregate and per capita clam consumption may be due to consumption of surf clam meats.

Current Status

Landings of surf clam meats were down approximately 9 percent in 1975, and would have been considerably lower if approximately 18 million pounds of surf clams had not been harvested from inshore New Jersey waters. Current estimates indicate surf clam landings in 1976 will not exceed 45 million pounds. With the significant decrease in total surf clam resources, dockside values for surf clams have increased from approximately $2.25 per bushel in October 1975, to approximately $11.00 per bushel in October 1976.

The basic structure of the industry varies as one goes down the coast from north to south. In the New England states it is a very small fishery. For instance, the output in Rhode Island is hardly enough to support one man. In New Jersey, Delaware, Maryland, and Virginia, it is a full-time fishery with large vessels and full-time crews, and processing plants with full-time labor forces. As mentioned
earlier, the industry does tend to move around in search of unutilized stocks. The necessity for such activity is, of course, due to overuse of the unregulated stocks. Almost all of the output is processed, and the processors' need for a guaranteed constant source of product has led to formal agreements with harvesters, and in some cases, the actual purchase of harvesting equipment.

At present, the industry is in a period of flux. Vessels moved from Virginia to New Jersey in early 1976. Expected productivity on the northern beds did not materialize, and many returned to Virginia. Unfortunately, Virginia and New Jersey surf clam beds have been under intense fishing pressure now for four years, and the telltale signs of overfishing are showing -- smaller clams and lower catch per unit effort. The landings for 1976 have not been compiled and released yet, but all expectations are that much smaller production will be shown.

The record harvests of 1974 and 1975 will be felt for many years. Vessel productivity and clam size are two indicators that may decrease substantially. Moreover, attempts at regulation of the industry have proven unsuccessful because of lack of agreement among the harvesters. The extended jurisdiction bill that formed a Mid-Atlantic Regional Council may provide the structure to achieve control; however, it will come substantially after the beds are depleted.

There is scientific evidence of a decline in surf clam resource abundance (Chang, Ropes, and Merrill, 1976). In addition, massive surf clam mortalities have occurred off the New Jersey coast during the summer of 1976, in association with anoxic water conditions. Surf clam mortalities were attributed to low oxygen levels observed below the thermocline for an extended period (Sharp, 1976). The low oxygen levels resulted from decay processes associated with a dinoflagellate bloom (Ceratium tripos) of unusual size and duration (U.S. Department of Commerce, 1976; Sharp, 1976). Of the estimated 207 thousand metric tons of surf clam meat off the New Jersey coast, at least 59 thousand metric tons, or 28.5 percent of the total surf clam resource in New Jersey, was lost. This loss represented approximately 5 percent of the total surf clam resources along the Middle Atlantic Bight (Ropes, 1976). This loss may be even
more significant in time, because some scientists believe that reproduction of northern surf clam stocks contributes to recruitment of surf clam stocks in southern areas (Sugihara, 1976).

There is some indication that the surf clam industry may have overcapitalized, because industry leaders believed surf clam stocks to be inexhaustible. At the present time, there are not enough surf clams available for processing demand. Processing plants are working at a reduced production level, and some plants are working only when they can obtain surf clams. Nearly all harvesting vessels are increasing harvesting effort and some modern vessels and processing plants in New Jersey and Delaware have begun to utilize ocean quahogs, *Arctica islandica*, as an alternate resource. The Delaware processors report no strong iodine flavor associated with ocean quahogs harvested from sand bottoms off New Jersey. Industry processors have been searching throughout the world and have thus far found no ideal substitute for surf clam meat, although the Bering Sea is known to have extensive clam resources, which may in time be utilized.

**Expected Future**

The expected future of surf clam resources and the surf clam industry is not bright. Surf clam stocks are low, and harvesting effort is increasing as is harvesting cost. Ocean quahog meat is not an ideal substitute for surf clam meat, but the surf clam industry is increasingly being forced into the utilization of ocean quahogs as an alternative source of inexpensive clam meat.

The major surf clam industry problem is the declining availability of resources. Analysis of landing and catch data shows that significant overharvesting of the resource has occurred (Chang et al., 1976; Starypan, 1976). The ability of the resource to recover from the effects of overharvesting is questionable. Clam mortalities associated with anoxic water that occurred off New Jersey during the summer of 1976 (Sharp, 1976) further impair recovery potential.

The surf clam industry needs to establish a sound, long-term resource management program. Increased harvesting effort is being applied to surviving surf clam populations, and effective management of remaining surf clam resources should be undertaken immediately. The harvesting
and processing sectors of the industry are overcapitalized in relation to the amount of the remaining surf clam resource.

Recommendations

1. Action should be taken by the Mid-Atlantic Regional Management Council to attain the intended goals of maintaining the health of the resource and the industry which depends on it. Through a state/federal surf clam management program, regional schemes to limit entry of vessels in the fishery and allocation of the available resource on a sustainable yield basis have been developed. A system of vessel logbooks to collect data on fishing locations, catch, and effort has been proposed but not implemented. New Jersey has enacted regulations to limit fishing, but only on inshore resources; other states have taken little or no recent action.

2. Action to reverse the effects of the recent mortality of surf clams off New Jersey should include: a) pollution abatement to control or eliminate ocean dumping, resulting in better quality water and increased resource availability; b) biological studies leading to recovery of the resource by reseeding and transplanting strategies.

3. Continued support of state/federal surf clam management programs to effect coordination of research and management efforts among agencies involved with the resource.

References


IV

THE SOFT SHELL CLAM INDUSTRY

Background

The East Coast industry associated with harvesting and processing the soft shell clam (*Mya arenaria*) is currently the third largest commercial clam industry in the United States. Soft shell clams have contributed 12 percent of the volume and 20 percent of the dockside value of all commercially harvested clams during the past ten years. The volume and dockside value of soft shell clam landings during the past 26 years are presented in Figure 5.

There were approximately 7,000 fishermen and 1,000 vessels actively engaged in the 1975 harvest of 9.2 million pounds of soft clams. The dockside value of the 1975 soft clam catch was 8.7 million dollars. Although five East Coast states report commercial soft clam landings, the States of Maine, Massachusetts, and Maryland have landed 92 percent of the soft clams harvested during the past ten years.

Brief History

In the New England area, soft clams have been utilized since colonial days, primarily as a source of food when other types of food were not readily available.

Commercialization of soft clam resources began around 1850, when soft clams were dug, shucked, salted in barrels, and sold as bait for the Grand Banks fisheries (Belding, 1930). During the late 1800's, trawling for finfish lessened the importance of soft clams as bait. Landing records indicate that the most recent maximum landings of approximately 16.5 million pounds occurred in 1937, 1939, and 1940.

Increased human consumption began in New England during the war, when steamed and fried soft clams became popular food items. The New England supply of soft clams could not meet industry demand, and New England processors encouraged soft clam production in Maryland. The New England soft clam resource was most probably overharvested in 1948 and 1949, when around 10 million pounds of soft clams were landed annually. After 1949, New England landings declined steadily; they reached a record low of around 2 million pounds in 1958.
Figure 5. Total soft shell clam meat landings and dockside values, 1950–1975.
Maryland's extensive subtidal soft clam populations were not commercially utilized until the hydraulic soft clam escalator dredge was developed in 1951. Production then increased rapidly, and Maryland became the major supplier of soft clams to New England markets, her catch exceeding the entire New England catch from 1956 to 1970. In the early 1970's, the Maryland soft clam resources began to show signs of overfishing, and daily catch limits were reduced from 40 to 25 bushels per day. Then in 1972, severe flooding from tropical storm "Agnes" caused extensive mortalities in the existing soft clam resources in Maryland, and the industry was closed for one year. Maryland landings in 1975 were around one million pounds, while New England landings were around 7.5 million pounds.

The possibility of paralytic shellfish poisoning became an industry problem in the New England area in 1972 when an extensive bloom developed. All soft clam harvesting areas north of Cape Cod were closed to harvesting in 1972, and subsequent but less extensive blooms have occurred north of Cape Cod from 1974 through 1976.

Industry Problems

Pollution

The water pollution problems that threaten the soft clam industry are similar to those previously reported for the hard clam industry. Soft clams are perhaps even more susceptible to sources of pollution than hard clams because a large portion of the New England soft clam resource occurs only in intertidal areas that are very close to shore, and therefore closer to existing or potential pollution sources. In some areas, commercial quantities of soft clams exist in low salinity water, and these areas are also closer to pollution sources from rivers and streams.

Throughout the East Coast of the United States, large stretches of soft clam grounds are closed to harvesting because of water pollution, so that a significant portion of the resource is not available for harvest by the industry. These large populations of polluted soft clams are also a potential public health hazard.
Industrial Pollutants

The major industrial pollutants adversely affecting soft clams have been heavy metals, petroleum oils, and pesticides. In Maine, process water from an intertidal heavy metal mine was associated with increases in heavy metal concentrations in soft clams. The increases ranged from a doubling of cadmium levels to a twentyfold increase in chromium levels. Copper and lead increased elevenfold, and zinc increased by a factor of ten during the 1967-1972 life of the mine. The population of soft clams in the affected area also declined (Dow, 1976).

Petroleum oils have also caused damage to soft clam populations, causing a decline in growth rate from 40 to 60 percent. As a result of some oil fractions, mortalities have been 100 percent (Dow, 1976).

Soft clams have been observed to concentrate pesticides, but thus far there have been no reports of mortalities due to pesticides. The accumulation of pesticides creates a potential public health problem and possibly biotic effects upon the resource.

Domestic Pollutants

Most of the areas that are closed to soft clam harvesting are closed because of domestic pollution. Maine reports that 72,000 acres of coastal shellfish growing area have been closed for many years because of domestic pollution. In Massachusetts, it is estimated that 64 percent of the potential soft shell clam harvesting area is closed because of pollution. Most states report that large areas are closed to soft clam harvesting. Maryland reports that few soft clam harvesting areas are now closed because of domestic pollution, but this was the only state that had a significant subtidal population of soft clams.

Agricultural and Wildlife Pollutants

Agricultural pollution associated with livestock has been shown to be the major cause of pollution in some small tributaries in Maryland. Maryland also reports that large concentrations of waterfowl (Canadian Geese) can create pollution problems in localized areas (Scott and
Rinaldo, 1976). The impact of wildlife pollution on the clam beds is not understood.

**Oil and Chemical Spills**

With the exception of Maryland, most soft clam resources are intertidal and more likely to be affected by oil and chemical spills. One highly productive soft clam area in Maine has been closed since 1971 because of contamination from #2 fuel oil and jet fuel (Dow, 1976).

**Biotoxins**

The first paralytic shellfish poisoning (PSP) closures in Maine were made in 1958. Since that time, in eastern Maine, periodic closures as a result of seasonal increases in the levels of *Gonyaulax tamarensis* blooms have been made. A major bloom occurred in 1972, and smaller blooms occurred from 1974 through 1976. These red tide blooms have caused extensive economic damage to the soft clam industry and they are increasingly a potential public health hazard. Present data show red tides that cause PSP seldom occur below Cape Cod.

**Climatic Problems**

Soft clam populations have been devastated by tropical storms, hurricanes, and blizzards; and since most of them are intertidal, they are more susceptible to physical disruption by storms. All clam populations are subject to damage from severe flooding and long-standing quantities of fresh water. Periodic mortality in the Chesapeake and other areas appears to be related to weather extremes.

**Biological Problems**

The relative abundance of soft clam resources is directly related to environmental factors that cannot be controlled.

In the New England area, the green crab (*Carcinus maenas*) is the major soft clam predator. Periodic increases in sea water temperature have led to a proliferation of green crabs, which have been known
to reduce soft clam populations by 90 percent. Sea water temperatures are not likely to decline in the New England area until after the mid-1980's (Dow, 1976).

Although the biology and life history of the soft clam (Mya) is well-known, and the major predators are also known; and although the environmental factors that cause fluctuation in soft clam abundance are partially known -- thus far, mariculture efforts have been totally unsuccessful. In Massachusetts, flats which once produced large numbers of clams may suddenly become barren, while others may be consistent producers year after year, as observed by Belding (1907; 1916; 1930). Why intense sets occur in certain areas and not in others that appear ecologically similar is not understood.

Setting intensity in many of the traditionally productive clamming flats appears to have declined, and market-size clams have become scarce. Whether the processes of reproduction and setting are being adversely influenced by chemical or biological changes in the environment or by inadequate parent stocks is unclear. Efforts at restocking barren flats have been tried for more than 70 years (Belding, 1907). In some cases, resurfacing flats with spoil or other materials was followed by heavy sets, while in other instances no change occurred (Turner, 1948). In summary, very little is known about inducing or obtaining good sets of soft clams, or improving their natural habitat.

In the New England area, and even in Maryland, the lack of adequate brood stocks is not likely to be the cause of major fluctuations in population abundance, because a significant portion of the soft clam resource cannot be harvested for a variety of reasons. Some harvesters in New England refuse to work in heavy cobble and shell areas. Legally, in Maryland, harvesters may not work within several hundred yards of the shore line, and soft clams may not be harvested from grossly polluted areas.

Inadequate juvenile survival appears to be one of the major factors involved in the relative lack of abundance of soft clam populations. It is known that in Maine, the failure of juveniles (2-4 mm) to survive to commercial size is associated with predation by correspondingly small green crabs, and that predation continues by larger crabs as surviving
clams grow larger. It is also known that warm winter weather increases green crab populations.

**Predation and Disease**

Crabs are the major predators of soft shell clams. The major crab predators are the green crab (*Carcinus maenas*), horseshoe crab (*Limulus* sp), blue crab (*Callinectes sapidus*), and various species of mud crabs.

Predation by water fowl, crabs and boring snails reduces populations of soft shell clam in varying degrees, depending on climatic condition and the abundance of the predator. The green crab is a voracious predator in New England waters (Marine Research, Inc., 1976); and in the Gulf of Maine, cycles of green crab abundance have roughly paralleled a serious depletion of the clam resource here.

The green crab abundance in the waters of Massachusetts from 1940 on, due to a general warming of coastal waters, has no doubt played a significant role in the continued decline of clam stocks.

Disease in the soft clam does not appear to be a significant problem except in some localized areas. In Maine, during periods of considerable fresh water runoff, the resultant lowering of salinity is associated with elimination of a digestive enzyme, B-amylase, which apparently prevents the soft clam from utilizing starchy foods. Surviving soft clams in jet fuel spill areas have developed gonadal tumors (Dow, 1976). Soft clam mortalities have been observed in association with stress conditions related to high water temperatures and low-salinity water.

**Resource Management Problems**

There are complex problems associated with managing a commercially harvested marine bivalve resource that is essentially owned and constantly utilized by the public, as there would be with any wild or naturally occurring public resource.
As yet there has been no interest on the part of the industry in developing a soft clam culture system. There has been interest in the installation of crab fences, as was done in the 1950's, to protect the more important clam-growing areas. Thus far, interest in this type of protective measure has been limited to a few coastal municipalities. Until such methods have been used rather extensively, the commercial operations of the industry are likely to decrease (Dow, 1916).

Stock Assessment

Fortunately, large resources of commercially harvested soft clam populations are intertidal, and when manpower has been available, reasonably good stock assessments have been made in Maine, and also in Maryland.

Harvesting Pressure

Since the area of approved soft clam harvesting has been considerably reduced by pollution, more commercial harvesting effort is being applied to the remaining open areas. Recreational and part-time harvesting is also increasing as leisure time increases, and more pleasure boating has provided more people access to soft clamming areas.

Inclement Weather

Harvesting can be restricted by inclement weather, including blizzards, flooding, ice, and severe winds; and in intertidal areas, by ice accumulation on clam flats. Monthly variations in tide and length of day play an important role in soft clam harvesting. In Maryland, harvesting vessels cannot work when wind speeds increase above 20 knots.
Harvesting Methods

In intertidal areas, hand digging of clams is the only legal method of harvest. Hoes, forks, and shovels are the implements generally employed in hand harvesting soft clams. In areas where mechanical harvesting is legal, soft clams can be efficiently harvested by the hydraulic escalator dredge. Although considered inefficient, hand harvesting methods have effectively reduced natural soft clam populations in some areas to a point where clam removal surpasses recruitment.

Regulations

The soft clam industry has been subject to regulations similar to those imposed on the hard clam industry, and for a similar length of time. As a public resource, the state conservation agency or local town generally has jurisdiction over the clamming areas. The designated state agency and the NSSP regulate the sanitary aspects of the industry by the establishment of approved and restricted harvesting areas, and rules for the sanitary handling and marketing of soft clams.

Under strict state supervision and NSSP guidelines, soft clams can be harvested from moderately polluted harvesting areas, providing that they are depurated. Soft clam depuration plants exist in Maine, New York, Massachusetts and New Jersey.

Transportation

Soft clams are usually sold in the shell by the bushel. Soft clam buyers pick up harvested soft clams from diggers at convenient locations. Transportation from collection sites may be by boat, car, or truck. Soft clam harvesters generally have no storage facilities and must deliver their harvest to a buyer or processor within a few hours after harvesting.

In warm weather, transportation by refrigerated trucks is necessary if long distances are involved. All shellstock in transit, once it has entered the certified dealer/processor trading process, must be identified in accordance with state and NSSP regulations. Receiver states may complain, warn, embargo, or confiscate improperly tagged or untagged
shipments. Shipments within the states have been detained until properly tagged.

Processing

Removal of shellfish meats from the shell is another of the regulated shellfish activities that is controlled under the NSSP. Only processors meeting the requirements set forth by law and regulation may legally engage in this type of processing. Upon delivery to the processor, shellstock is refrigerated. According to the intended use of the product, shellstock may be washed, sorted, and/or packed for shipment, prior to refrigerated storage. Shellstock is shipped in 1/2, 3/4, and 1-bushel containers.

Soft clams are sold in the shell as steamers, and meats are shucked as ingredients for chowders and fried clams. Soft clams are seldom consumed raw. Nearly all soft clams are shucked by hand, and various thermal water shock methods are used to facilitate rapid hand opening. The viscera or belly is not usually removed, but the siphons sometimes are.

Shucking Problems

Steam has been used, but only experimentally. However, a number of processors use a hot-dip-thermal-shock method to assist in opening of the valves. The process consists of immersion of a set volume (1/2 bu. max) in a washtub-sized container of water at a temperature of 212°F. Length of immersion is determined by the processor for each different lot of shellfish, because of varying shellstock temperature, source, and condition. Rapid cooldown following the hot dip is effectuated through dipping in cold water or use of a heavy volume spray. The shellfish react vigorously to the cold water, and in addition to the physiological change that results in easier shucking, the gut content is violently ejected to produce a cleaner meat with a lower bacterial content. This assumes that all handling and time practices are within acceptable limits; otherwise the process reduces quality.
The opening of valves and removal of shellfish meats is done by hand. Size variations, shell thickness, brittleness, and length-to-thickness ratio have deterred development of automated shucking machines.

Most shell fragments and other unwanted material are removed by blowing, soaking, or rinsing, either manually or by a combination of these methods. Blowing consists of placing the meats in a large hopper-like piece of equipment that is partially filled with water, and then subjecting the whole to agitation produced by air pumped into the bottom of the device. Heavy material drops to the bottom through a grating where it is collected. Soaking is accomplished in any container that will hold water and the shellfish meats. Agitation may be supplied by mechanical means or by running water. Rinsing, as the term implies, is the result of directing a spray of water, from any suitable nozzle, onto the shellfish meats. Some unwanted materials must be picked out by hand regardless of the washing method used.

All containers of shellfish meats packed for shipment or transport in the inter- or intrastate trade must have the following permanently marked upon the container: the processor's name and address, the certificate number under which the meats were shucked, the contents of the container, and the volume or quantity. In addition, there must also be a code date on the body of the container, from which it is possible to ascertain the date of shucking and the source of the shellstock.

Shellfish processing is a low-prestige occupation, at a minimum wage, calling for a high degree of dexterity. Many of these workers could not find other employment. Absenteeism and turnover are high. Welfare payments are competitive enough to remove many people from the labor market.

In many instances, shellstock shucking is a cottage-type industry with labor supplied by the immediate members of a family. In larger shucking operations, or where family members are not available, one or more employees may be hired. Such employees are usually male.
Because of the much smaller volume of shucking wastes, soft clam processors do not usually have significant waste disposal problems.

Marketing

Marketing of soft clam meats is not considered to be a problem because demand usually exceeds supply. In the New England area, some consumer confidence in soft clams and other seafoods has been eroded by PSP publicity.

Current Status

Total landings of soft clam meats are decreasing while dockside values are increasing. Total soft clam landings during 1975 were only 9.2 million pounds of meats, a little less than the 1974 landings of 9.6 million pounds. Dockside value for soft clam meats in 1975 increased seven percent over values reported for 1974. Soft clam landings for the first six months of 1976 were about 12 percent higher in volume than the volumes reported in 1975. The dockside value of soft clams rose 41 percent during the first six months of 1976. Limited supplies of all clam resources are the major factors involved in dockside value increases for soft clams.

The industry is composed primarily of independent harvesters and processors. There appear to be no formal ties or contracts between the two except in those cases where verification is necessary due to harvest from contaminated areas (in that case, harvesters must make arrangements for access to purification processing equipment). While there are no contract or company diggers, informal arrangements are necessary so the highly perishable product can be moved into processing channels as soon as possible.

Restrictions on harvesting methods keep the diggers from operating as efficiently as possible. They do help to preserve the stock, but it would be far better in terms of efficiency to cut down the number of diggers and allow those that remain to use efficient techniques.

Although soft clams are the third most valuable type of clam, their value is limited by the following factors: the harvesters are relatively
small; the operation is influenced by weather, season, other activity, competition, or personal whim; and the harvesters owe allegiance to no dealer.

There is also considerable competition from recreational diggers in some areas and it is likely that their catch is significant. Where stocks are small, and decreasing because of overharvesting and contamination of grounds, this competition can be very important. Management decisions to allocate the stock between the two uses must be made.

The major soft clam industry problem is the lack of a consistent, dependable, and sustainable supply of soft clams. Pollution is one of the major causes of the dwindling supply, but there are other environmental reasons. In fact, environmental factors like elevated seawater temperatures and excessive fresh water runoff which cannot be controlled are directly related to soft clam mortalities.

Thus far, attempts to produce or increase soft clam production by mariculture efforts have not been successful.

Expected Future

The future of the soft clam resources and industry is not favorable. The resource occurs close to pollution sources and in the northern New England areas, is exposed to toxic dinoflagellate blooms. The relative abundance of the resource is influenced by environmental factors that cannot be controlled and effective management is almost impossible. Demand for soft clams will increase but supply will probably remain low.

Recommendations

1. Implement proven predator control techniques by appropriate agencies, particularly in New England waters.

2. Continue support and expansion of PSP monitoring to minimize impact on industry through adverse publicity.

3. Update assessments of designated shellfish grounds by state agencies to identify availability of present stocks.

4. Support sound pollution abatement programs.
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THE OCEAN QUAHOG

Background

The industry associated with harvesting and processing the ocean quahog, black quahog, or mahogany clam, (Arctica islandica) handles the fourth largest volume of clams in the United States. Ocean quahogs have accounted for one percent of the total volume but only one-half of one percent of the total dockside value of all clam landings during the past ten years. The volume and dockside value of ocean quahog landings during the past 32 years are presented in Figure 6.

Brief History

The ocean quahog resource is understood to be a large one. It is considered underutilized. The industry began in Rhode Island around 1943 when the war food program became interested in obtaining additional food and red meat substitutes (Parker and McRae, 1970; Arcisz and Sandholzer, 1947). After the war, ocean quahog meats were used as inexpensive substitutes for the more expensive hard and soft clam meats.

Two of the major deterrents to the successful marketing of ocean quahogs were the darker color and the strong iodine flavor of the meats. The Rhode Island fishery landed 1.5 million pounds of ocean quahog meats in 1946, and then the entire industry declined to low levels due to greater production in the surf clam industry.

Industry Problems: Pollution

Arctica islandica is a boreal species, and in the United States, commercial quantities usually occur offshore in water depths ranging from 25 to 61 meters (Merrill and Ropes, 1969). Since a significant portion of the known resource occurs well offshore, ocean quahogs are not usually affected by nearshore pollution sources. On the other hand, they are vulnerable to pollution from ocean dumping of sewage sludge and industrial waste.
Figure 6. Total U.S. Ocean Quahog Meat Landings and Dockside Values 1944-1975
Anoxic water conditions that occurred off New Jersey during the summer of 1976 (Sharp, 1976) caused ocean quahog mortalities to increase from 0.8 percent to 7.7 percent in one month (Ropes, 1976). The recurrence of anoxic water in ocean quahog harvesting areas is a distinct possibility.

Uptake of biotoxins associated with plankton blooms is not considered to be a problem in the areas where ocean quahogs are now harvested. In Maine, studies of PSP concentrations of Gonyaulax tamarensis in three specimens of Arctica indicate average levels of 1250 μg/100g. This is roughly halfway between the average levels of 3000 μg/100g. for the mussel Mytilus edulis and 850 μg/100g. for the hard clam, Mercenaria mercenaria (Dow, 1976).

Resource Availability

Data on the distribution of the ocean quahog have been provided from surveys by the National Marine Fisheries Service. This work indicates that a large portion of the resource lies off the coast of Long Island. It was estimated that between 150 and 173 million bushels occur in this area (U. S. Dept. Commerce, 1976b). There is also a significant concentration off the coast of New Jersey, and Sugihara (1976) has estimated that the New Jersey density of ocean quahogs is about half that off Long Island. These two areas have a greater production potential than the surf clam population existing at present.

Preliminary information indicates the recruitment rate of ocean quahogs is greater than that of surf clams (Sugihara, 1976). The natural mortality rate of ocean quahogs is low, compared to that of surf clams. Ratios of .039 dead-to-live ocean quahogs have been observed, while surf clam dead-to-live ratios were .25.

The ocean quahog resource management problems will be identical to those of the surf clam industry. State regulations are not specific for ocean quahogs; federal regulation reserves ocean quahogs for U. S. fishermen as creatures of the continental shelf. The resource is offshore and beyond the jurisdictional limits of most states.
Harvesting and Transporting

The harvesting and transporting methods of the ocean quahog industry are the same as those described for the surf clam industry. Harvesting is done by using hydraulic jet cage dredges from large modern surf clam vessels designed to gather and transport large volumes. The surf clam catch rate per unit effort has decreased, and many of these vessels now have excess harvesting and transporting capacity. Several of the more modern vessels of the surf clam fleet are now engaged in harvesting ocean quahogs, and more vessels are expected to enter the fishery.

Processing

Ocean quahogs are more difficult to open than surf clams. In Rhode Island, they are opened with pressurized steam. Clam processing plants that use ovens for opening shellstock report that ocean quahogs require twice the amount of opening treatment as surf clams, and the meat yield is only about half that obtained from surf clams.

Nearly all clam meat processors have managed to eliminate or disguise the strong flavor and aroma associated with ocean quahog meats. The dark color problem has been partially solved by using the meat in prepared clam products that do not require light meat.

Marketing

Ocean quahogs are marketed under the general category of clam meats and are used as an alternative to the more expensive surf, soft, and hard clams. In many prepared products, such as stuffed clams and Manhattan clam chowders, ocean quahog meats are an acceptable substitute for more expensive and unavailable clam meats. However, thus far, ocean quahog meats have been considered unsuitable alternatives for New England type chowders or fried clam strips, because of their color and flavor, although work is being done on extruded products. The problem here is to develop and sell ocean quahog meat as a desirable product in itself.
Current Status

There were six vessels engaged in the 1975 harvest of 1.3 million pounds of ocean quahog meats valued at .25 million dollars. The resource occurs along the northeast coast of the United States; significant commercial landings have been made off Rhode Island, and recently off New Jersey.

Recently, harvesting and processing of ocean quahogs has increased. The increase is directly related to the declining availability and increased cost of surf clams. In Rhode Island, six vessels are still engaged in the full-time harvesting of ocean quahogs. Three clam processing plants there utilize ocean quahog meats in prepared clam products (Bockstael, 1976). In New Jersey and Delaware, nine relatively modern surf clam harvesting vessels are now engaged in harvesting ocean quahogs, and six clam plants there are processing them at the present time (Sugihara, 1976). Delaware processors report no strong iodine flavor associated with ocean quahogs harvested from sand bottoms off New Jersey.

The major industry problem appears to be the complete lack of a sound management program for commercial utilization of the ocean quahog resource. Support for such a program requires research on the standing stock, reproduction, mortality, and growth in order to regulate this developing fishery on a maximum sustainable yield basis.

Expected Future

The surf clam industry created a strong market demand for prepared clam products, but the supply of surf clams is decreasing, and their cost has escalated significantly. Because the available supply will be limited when proposed surf clam catch restrictions become effective, processors are increasingly utilizing ocean quahog meats in suitably prepared clam products. As a result, the ocean quahog industry is expanding now and will certainly continue to expand in the near future. The ocean quahog is already considered an alternate for the surf clam; however, overexploitation of the ocean quahog resource could lead to the creation of identical problems now encountered in the surf clam industry (McHugh, 1976).
Recommendations

A sound management program for the ocean quahog resource and industry should be developed and put into effect immediately to avoid repetition of the existing surf clam industry problems. A strong ocean quahog research program should also be developed immediately to obtain management information pertaining to the resource while the clam populations are still relatively abundant.

References


VI

EAST COAST RAZOR CLAMS

Although the East Coast razor clam *Ensis directus* is included in statistical landing data, the harvesting and processing of this clam is unimportant compared to other species. During the past ten years, reported annual commercial landings have averaged only 3,700 pounds valued at only $2,400. This is a value too low to support even one full-time harvester.

The resource is not abundant, and landings are usually made for a temporary specialty market (Marine Research, Inc., 1976). The East Coast razor clam is an inshore species, subject to the same pollution problems previously described for the hard clam and soft shell clam industries (McHugh and MacMillan, 1976).

References


VII

THE SUNRAY VENUS CLAM

A commercial fishery for the sunray venus clam Macrocystis
nimbosa existed on the northwest coast of Florida from 1967 through
1973. During the seven-year period, more than 2.5 million pounds
of sunray venus clam meats were harvested by hydraulic jet cage
dredge and processed. Nearly all the commercially harvested clams
were obtained from one eight-square-mile area. Subsequent surveys
by the Florida Board of Natural Resources along the entire west
coast of Florida indicated that commercial quantities of sunray venus
clams were found only in the primary harvesting area (Menzel, 1976).

The future for a large sunray venus clam fishery in Florida is
not promising. Exploratory hydraulic clam dredging has been observed
to cause extensive damage to rooted vegetation in Florida. Although
the sunray venus resource is sparsely distributed throughout Florida
waters, commercial quantities of the clams are found only near St.
Joseph Bay. This one relatively small and localized population of
sunray venus clams could not sustain prolonged and effective commer-
cial fishing pressure.

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VIII

THE BRACKISH WATER CLAM RANGIA

A small but promising fishery for the brackish water clam *Rangia cuneata* existed in North Carolina from 1966 through 1972. The development of the industry utilizing *Rangia* in commercial quantities was perhaps the first successful attempt to process the species throughout its range from Mexico to Maryland. The fishery and industry ended in February 1972, when the major harvesting area was closed because of domestic pollution. Average annual *Rangia* meat landings during the life of the fishery averaged 57,000 pounds annually, and were valued at $17,000. *Rangia* was harvested by hand rakes and small hand dredges from shallow waters in North Carolina. The catch rate per day, per fisherman, averaged forty to fifty bushels. (Chestnut and Porter, 1976).

The potential for a future industry still exists in North Carolina, and also in Maryland, Virginia, Louisiana, Texas, and other states.

Major problems with this clam are its strong musky flavor and pollution. Since commercial quantities of *Rangia* usually exist in very low salinity rivers and bays, nearly all of these harvesting areas are subject to domestic pollution.

The population dynamics of *Rangia* would also be a considerable industry problem. This clam has evolved to inhabit a particular ecologic niche and has few predators in the low salinity areas where commercial quantities occur. As a result, *Rangia* populations tend to build up gradually to significant numbers, and although the species appears to have a relatively long life span, recruitment is sporadic and may occur only once in ten or more years in some areas. Management of the resource would be difficult, but not impossible.

References


PACIFIC COAST CLAM FISHERIES

The Pacific Coast clam resources and the commercial and recreational industries associated with the various clam species that occur along the Pacific and Alaskan coast of the United States are unique in many respects. Pacific Coast clam industry consultants T. D. Schink and K. K. Chew prepared a comprehensive report entitled "Survey of Pacific Coast Clam Fisheries," from which the following has been abstracted.

Introduction

Currently, the Pacific Coast clam fishery is small compared to its counterpart on the Atlantic Coast. (A summary of United States clam landings by region is presented in Table 2.) In recent years the Pacific Coast clam harvest only amounted to about one percent of total United States production. Of this amount, Washington provides approximately 95 percent, and Alaska provides most of the rest, with negligible contributions from Oregon and California.

Washington's leadership in the Pacific Coast clam industry may be attributed to a number of factors:

1. There are relatively large areas of protected and very productive inland estuaries.
2. Most clam producing areas are free of water quality problems and paralytic shellfish poisoning.
3. Commercial clam production occurs on privately-owned lands or privately-held leased land, and a common property commercial clam fishery is virtually nonexistent.
4. There is presently a balance between the recreational and commercial utilization of the state's clam resources.

For several reasons, Oregon, California, and Alaska are not important contributors to the total United States clam harvest. California is notably lacking in the protected bays and estuaries necessary for significant clam production and, in addition, coastal clam habitat is limited. For this reason, the state was never a major clam producer. Even the
small commercial fishery the state once supported has disappeared since World War II, due to pollution, harbor dredging, and the recreational demands of a rapidly increasing human population. Oregon has even less coastal habitat suitable for supporting a clam industry, although it too supported a small clam industry into the 1960's. Like California, recreational demand for clams is presently consuming the bulk of Oregon's clam production. Alaska has an extensive coastline, rich in clam resources, but harvesting is restricted by paralytic shellfish poisoning and the high cost of labor.

CALIFORNIA

Brief History

California's long coastline is notably lacking in protected bays. It is not surprising, therefore, that California's clam stocks were never extensive (Bonnot, 1949); however, they supported a small commercial clam fishery prior to World War II.

The species which appeared in commercial catches included:
  Pismo clam (*Tivela stultorum*)
  Soft-shell (*Mya arenaria*)
  Native littleneck clam (*Protothaca stetina*)
  Cockle (*Chione* sp.)
  Caper, Horse clam (*Tresus capax* and *T. nuttalli*)
  Washington clam (*Saxidomus nuttalli* and *S. giganteus*)
  Razor clam (*Siliqua patula*)
  Jackknife clam (*Tagelus californianus*)
  Bean clam (*Donax gouldii*)

Commercial clam landings in California have steadily decreased, and the reported catch of 1975 was only around 1600 pounds.

Current Status

In recent years, California's clam resources have been insufficient to support both a commercial and recreational fishery. As a result, the
California legislature has reserved the state's clam resources almost exclusively for the recreational digger. Dahlstrom (Schink and Chew, 1976) believes that San Francisco Bay is the only area in California with sufficient clam abundance to permit a commercial fishery. There are considerable subtidal populations of Manila (Venerupis japonica) and soft-shell clams, as well as intertidal stocks on private grounds, which are inaccessible to the sport digger. Recently legislation was passed permitting a commercial fishery on these stocks. A private corporation which owns part of San Francisco Bay's subtidal lands and an aquaculture firm are interested in pursuing a commercial fishery. Since the bay is polluted, depuration is an essential prerequisite for sale of these clam stocks for human consumption.

Major problems facing the recreational clam fishery in California involve discharge of sewage and animal wastes into its marine waters (Dahlstrom, personal communication). There is also a negative attitude on the part of local owners toward allowing clamming. Harbor dredging, once a problem in clam producing areas, has largely been stopped, and marine development is closely controlled (Schwartzell, personal communication).

In those areas presently affected by sewage contamination, the installation of secondary sewage waste treatment facilities will apparently do little to improve the recreational clam fishery. Such treatment systems are not considered reliable; moreover, instituting a system of alerting the public of potential hazards during plant failures would be unmanageable.

Paralytic shellfish poisoning (PSP), a recurring problem for the Pacific Coast clam fisheries, also appears in California's coastal areas. As a result the California State Department of Health has instituted a coastwide warning from May 1 to October 31. In addition, the state monitors for paralytic shellfish poisoning on a monthly basis. There have been problems with mussels in the past, occasionally requiring the closure of bays to mussel harvest; however, there has never been a reported incidence of PSP in bay clams.
Expected Future

Although there is little future potential for commercial clam harvesting, California's clam farming potential was evaluated, and a number of important considerations are summarized below:

1. Most of the subtidal land in California is state-owned and the state retains fishing rights.
2. Intertidal and subtidal lands can be leased from the state.
3. There are procedures for engaging in land-based mariculture similar to those California's oyster farmers follow to obtain oyster land leases.
4. Clam farming would be permitted only in those areas where no native clams exist. Presumably, culture under these restrictions would involve some form of beach rehabilitation and/or the planting of artificially-reared clam seed.
5. In many areas residents might object to using public lands for private benefit.

As a result of stringent state regulations and economics, the potential for clam farming in California appears extremely limited.

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OREGON

Brief History
Oregon has few areas suitable for supporting clam populations. Along its 300 miles of coastline, only a small stretch of northern ocean beach is productive clam habitat. Although there are a number of protected bays and estuarine areas, each is relatively small. Nonetheless, Oregon has historically supported a small commercial and recreational clam fishery. It is customarily considered as two sections: the bay clam and coastal razor clam fisheries.

The principal clam species having commercial and recreational importance are:

Native littleneck clam: Protodonta staminea
Cockle: Clinocardium nuttalli
Soft shell clam: Mya arenaria
Gaper, horse clam: Tresus capax
Butter clam: Saxidomus giganteus
Razor clam: Siliqua patula

Bay Clam Commercial Fishery
The history of Oregon's commercial clam fishery is sketchy. Records of total clam catch were collected from 1928 to 1950. Between 1940 and 1950, the state made estimates of bay clam and razor clam catch, but it was not until 1950 that harvesters were required to report their catch by species (Marriage, 1954). Judging from these statistics, Oregon's
commercial clam harvest was never large. Peak production occurred in the 1930's, spurred by the demands of an economic depression (Cleaver, 1951). The highest production recorded was 664,297 pounds in 1938. Restrictions on night digging and ocean beach closures caused a sharp decline in clam production during World War II. Clam catches increased after the war, but production levels were below those of preceeding decades. Cleaver attributes this to reduced digging activity brought about by an improved post-war economy, and an increase in oyster farming in Tillamook, Yaquina, and Coos Bays, causing the loss of some traditional clam producing areas. Since the mid-1950's, bay clam production has steadily declined and in recent years has been negligible. Commercial clam landings in 1975 were only approximately 26,800 pounds of clams.

The future of Oregon's commercial bay clam fishery appears to depend on utilization of subtidal stocks. In 1955 an enterprising commercial harvester in Coos Bay began using a hand-held nozzle for harvesting intertidal gaper clams by water jet. State law immediately forbade the use of all mechanical clam harvesters, and water jets are considered to be mechanical harvesters. This law is still in effect.

Current Status

There has been little subtidal harvesting of clams due, in part, to the lack of information on the location and extent of the stocks. Oregon is reluctant to open its subtidal clam stocks for full-scale commercial harvest until a number of important management questions are answered, including:

1. the effect of harvest on existing stocks.
2. the effect of harvest on substrate.
3. the relationship between intertidal and subtidal clam populations. Of particular interest is the importance of subtidal stock as spawning stock.
Coastal Razor Clam Fishery

Razor clam production has its center on Oregon's Clatsop Beaches. According to Cleaver (1951), there is little statistical catch data prior to 1941. Data thereafter suggest an adverse impact of World War II restrictions on beach use and a shortage of diggers on total catch. From 1942 through 1950, the commercial fishery increased steadily from a low of 13,333 pounds to a high of 340,362 pounds. There was also an intense sport fishery, probably equal to the commercial catch during the post-war period (Cleaver, 1951).

By the mid-1950's, a marked decline in commercial catch began, and by the early 1960's it had fallen to about 20,000 pounds. Catches increased again in the late 1960's, peaking at 122,523 pounds in 1967. Another decline followed, and in recent years production has fluctuated between 20,000 and 108,000 pounds.

The fishery is regulated by a season closure extending from mid-July through August, and a 3-3/4-inch size limit. Each commercial digger must possess a $40.00 commercial license, and a state health certificate. A record indicating quantity of clams dug and their market destination must be in his possession, in order to prevent people from using commercial licenses to dig unlimited numbers of clams for personal use.

In Oregon, most commercially dug razor clams are sold to only two Oregon processors. Currently, diggers are paid as high as $.85 to $.95 per pound, whole wet weight, or $2.20 if cleaned. Most are processed into fresh or frozen steaks. However, the high cost of raw clams and labor intensive processing requires a high retail price ($4.75 to $5.00 per pound). This limits the sale of razor clams to the specialty retail and restaurant trade.

Razor clams are marketed primarily in Portland and along the Oregon coast, with lesser amounts sold in Seattle and along the Washington coast. Attempts to develop markets outside these localities have met with considerable resistance, because of high prices and product unfamiliarity.
The ocean beaches support a small razor clam fishery. The most productive are the 20 miles of Clatsop Beaches, extending from the Columbia River to Tillamook Head, south of the city of Seaside.

Expected Future
As stated earlier, Oregon's small subtidal clam stocks provide the basis for a potential commercial fishery. However, the resource is relatively small and as yet estimates of maximum sustained annual yield are not available. Other potential sources of clams on which to base a commercial industry do not appear promising. A variety of commercial clam species occur in Oregon's offshore coastal zone, and although little is known about their abundance, it is assumed to be low. In addition, there appears to be little potential for intertidal private clam farming, since land is in short supply in Oregon's estuaries (Snow, personal communication).

Oregon's Recreational Fishery
Surveys of the bay clam recreational fishery conducted sporadically through the years reveal a small but intensive fishery, particularly of cockles and gapers. In 1971, Oregon reported a recreational catch of 1.8 million clams. Spot surveys conducted in 1975 and 1976 indicate effort is increasing markedly, placing considerable pressure on clam stocks.

In 1977, a routine sampling program of the bay clam sport fishery will begin which will evaluate the effects of new clam regulations.

Beginning in 1955, the sports catch of razor clams has been estimated annually. The recreational harvest has ranged between about .5 and 1.5 million clams per year. In 1976, the catch was exceptionally good, with 235,000 pounds or about 940,000 clams taken.

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WASHINGTON

In contrast to California and Oregon, the State of Washington has a long coastline and large estuarine areas that provide suitable clam habitat. Relatively large stocks of Pacific razor clams (Siliqua patula) inhabit southern coastal beaches. In the more protected estuarine areas of Puget Sound, Grays Harbor, and Willapa Bay, extensive intertidal and subtidal hard clam species are found.
The species of clams found in Washington's estuaries having commercial importance are listed by scientific and commonly used local names as follows:

Native littleneck clam, rock clam, steamer clam: Protothaca staminea
Butter clam: Saxidomus giganteus
Japanese littleneck clam, Manila clam: Venerupis japonica
Horse clam, gaper: Tresus capax
Geoduck: Panope generosa
Soft shell clam, mud clam: Mya arenaria

In addition to the extensive clam beaches and the variety of commercial clam species, Washington has a long and favorable tradition of private ownership of intertidal beaches and the private leasing of state-owned subtidal bottom land. The coastal beaches, however, are publicly owned, with the exception of those attached to Indian reservations. This combination of generally favorable physical and political factors has given Washington a small but viable clam fishery.

Brief History

Razor Clam Fishery

Large-scale commercial harvesting of coastal razor clam stocks began in earnest just after the turn of the century, with the introduction of canneries. Statistics compiled by Schaefer (1939) indicate the magnitude of the Pacific Coast razor clam pack in early years. In the peak year of 1915, 67,463 cases of 48 one-pound cans were produced in Washington, representing a catch of about eight million pounds of unshucked clams.

From the time the fishery expanded, there was government concern about the condition of Washington's razor clam stocks. In 1917, the state legislature passed a bill reducing the harvesting season to three months and in 1929, a 3-1/2-inch commercial size limit was adopted (Tegelberg, personal communication).

In addition to the large commercial fishery, a relatively large unrestricted personal use fishery had developed by the late 1920's.
As reviewed by Schaefer (1939), this led to considerable clam wastage and also "bootlegging." In 1929, sports catch regulations were first instituted. The 1940's brought changes to the commercial industry. Because of declining clam stocks, a poundage quota system was imposed, which, together with the limited season described above, placed considerable economic strain on razor clam canners. During this period, Washington's dungeness crab fishery expanded rapidly with increased utilization of offshore stocks. Since razor clams are the preferred crab bait, the expanding crab fishery placed additional demand on an increasingly limited supply of commercially available razor clams.

In the early 1950's, the dramatic entrance of inexpensive East Coast canned surf clams into what had been traditional razor clam markets placed canned razor clams at a distinct competitive disadvantage. As a result, the canning industry in Washington rapidly declined. An increasing proportion of the commercial catch, formerly canned, was absorbed by the crab bait and fresh food markets.

A nominal $5.00 fee for a commercial license encouraged increasing numbers of sports fishermen to purchase these licenses in order to avoid limitations on recreational digging. By the 1960's, an estimated 30-40 percent of the commercial catch actually was diverted to personal use. This, together with the large quantities exported out of state for crab bait, led to a gradual phaseout of the commercial fishery until finally, a commercial fishery was permitted only if there was a surplus of clams above what was allowed for the recreational fishery.

In addition to previously noted restrictions, the phaseout of the commercial fishery was finally hastened by beach closures. Long Beach and Twin Harbors were permanently closed to commercial fishing in 1950, Copalis in 1960, and Moclips in 1968. The sole remaining non-Indian commercial fishery exists on the detached spits at the mouth of Willapa Bay. This area is not easily accessible and is quite unstable; as it is difficult to manage, it is left open to harvest without seasonal restriction. It produced well in the late 1950's, but production subsequently declined and has remained low.
Hard Clam Fishery

Early observations by Kincaid (1919) and Nightingale (1927) on the Puget Sound clam fishery suggest that the extensive clam beaches of Puget Sound had supported a small but stable industry. This industry was based almost entirely on two species, the native littleneck clam and the butter clam. The industry supplied both fresh and canned products to local markets, the largest being Seattle.

The early fresh market trade was determined by the keeping quality of the clams and the demands of the local market. The market for the canning industry was in competition with canned razor clams and hard clams from Florida (Nightingale, 1927).

The hard clam harvest from Washington's publicly owned beaches, once the major source of commercial supply, declined gradually after 1940. A number of factors were apparently involved in this decline. First, public beaches were dug heavily during the depression of the 1930's, and a subsequent lack of major setting reduced the standing stock. Second, there were fewer people harvesting, during and after World War II, due to improved employment opportunities. Third, during the 1940's, tidelands were purchased by private individuals and large areas were removed from production. Finally, the value of butter clams declined, which resulted in less harvesting (Lindsay, personal communication).

Historically, the commercial harvest of butter clams in Washington has been closely tied to the native littleneck industry. Part of the reason is biological. They occupy the same general habitat, that is, the lower third of the intertidal zone, although butter clams tend to be slightly lower. Unlike the native littleneck clam, however, they burrow deeper, to a depth of about 12 inches. Because of the similarity in habitat, they are often dug together. Since both species kept well in the shell, were palatable and relatively abundant, they found a ready place in the fresh and canned markets in Washington's early days (Nightingale, 1927).
Other Species

The horse clam or gaper, while harvested commercially and recreationally in Oregon and California, has never gained much acceptance in Washington despite its abundance on some intertidal beaches. It inhabits the low intertidal area and is one of the deepest burrowing clams in Puget Sound, occurring about 1-1/2 feet below the surface. Goodwin (1973) found two species of horse clams quite frequently in subtidal surveys of Puget Sound. There are no standing crop estimates but it is probably small (perhaps 10-20 million pounds); also, there are only a few areas where the horse clam is the predominant species (Goodwin, personal communication).

This clam has a number of characteristics which tend to discourage commercial use: hand harvesting tends to break its fragile shell, and its valves gape, resulting in water loss which lowers its shelf life; in addition, the meat yield is low — only 25-30 percent of the total body weight is marketable. The neck, which makes up about 60 percent of the shucked body weight, requires a considerable processing effort to remove the tough, leathery siphonal skin (Quayle and Bourne, 1972). However, many consider the meat excellent as chowder stock or clam steak.

Although commercial hand harvesting of horse clams was never practiced, the introduction of the mechanical clam dredge in Washington in 1959 has created a small industry. It has remained, however, a strictly incidental fishery, a by-product of the native littleneck and butter clam harvest. Prior to 1973, production was erratic and not economic. The price received by the harvester was about $1.00/bushel (a bushel = about 55 pounds), which did not even meet the 1-1/2¢ per pound royalty. In 1973, however, horse clam production increased substantially as the result of a price increase to 8¢ per pound (Lowman, personal communication).

The Manila clam is an exotic species introduced inadvertently into the United States Pacific Coast with Japanese oyster seed (Quayle, 1960). In Washington, Manila clams have established themselves in
Grays Harbor, Willapa Bay, and Puget Sound. Although accidentally introduced, they have proved a favorable addition to Washington's clam fisheries. They inhabit the intertidal zone, and areas of greatest abundance appear to be from -1.5 feet to just above the half-tide level, which is above the preferred range of two important indigenous species, the native littleneck clam and the butter clam. Unlike Washington's other commercial clam species, the Manila clam lives just below the substrate, which facilitates hand harvest.

Although the Manila clam began making significant contributions to the southern Puget Sound clam fishery after World War II, there are no statistical records documenting its early beginnings (Ward, personal communication). Catch statistics are available from the early 1950's, however, and are summarized in Table 4. Production has ranged from about 300,000 pounds (round weight) per year to almost one million pounds in 1975.

The most impressive clam in Washington waters is the geoduck. It is found low in the intertidal zone, most often in sand or sand-mud substrates (Quayle, 1960; Goodwin, 1973). It is said to be the largest burrowing bivalve in the world, the largest weighing in excess of 10 pounds, although the average weight is about 2-1/2 pounds (Goodwin, 1973).

Apparently the geoduck was never very abundant on Puget Sound's beaches. Fearing its extinction, commercial harvest was prohibited in the 1920's. However, the geoduck has supported a small but very popular sports fishery for years.

During the late 1960's, the Washington Department of Fisheries, in cooperation with the National Marine Fisheries Service, began surveying the shallow subtidal lands of Puget Sound to assess clam distribution and abundance. Although the discovery of significant hardshell clam beds was expected, the large standing crop of geoducks found was a surprise. While generally considered to lead a tenuous intertidal existence, the geoduck, in fact, was very plentiful. Estimates reported by Goodwin (1973) indicate a standing crop in four regions of Puget Sound as follows:
TABLE 4

Summary of Washington's commercial clam production in pounds round weight (including shells)

<table>
<thead>
<tr>
<th>Year</th>
<th>Native</th>
<th>Manila</th>
<th>Butter</th>
<th>Geoducks</th>
<th>Horse</th>
<th>Soft Shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>725,942</td>
<td>472,611</td>
<td>107,515</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1956</td>
<td>789,757</td>
<td>433,579</td>
<td>199,112</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1957</td>
<td>880,759</td>
<td>303,160</td>
<td>226,129</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1958</td>
<td>1,066,845</td>
<td>294,035</td>
<td>186,422</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1959</td>
<td>1,058,801</td>
<td>423,184</td>
<td>374,250</td>
<td>--</td>
<td>9,450</td>
<td>--</td>
</tr>
<tr>
<td>1960</td>
<td>1,411,106</td>
<td>469,731</td>
<td>389,299</td>
<td>--</td>
<td>13,992</td>
<td>--</td>
</tr>
<tr>
<td>1961</td>
<td>991,644</td>
<td>291,647</td>
<td>288,934</td>
<td>--</td>
<td>50</td>
<td>--</td>
</tr>
<tr>
<td>1962</td>
<td>958,573</td>
<td>299,837</td>
<td>350,059</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1963</td>
<td>857,549</td>
<td>420,023</td>
<td>204,348</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1964</td>
<td>786,761</td>
<td>414,301</td>
<td>180,866</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1965</td>
<td>675,408</td>
<td>606,884</td>
<td>136,591</td>
<td>--</td>
<td>6,960</td>
<td>--</td>
</tr>
<tr>
<td>1966</td>
<td>654,027</td>
<td>498,648</td>
<td>139,245</td>
<td>--</td>
<td>42,000</td>
<td>--</td>
</tr>
<tr>
<td>1967</td>
<td>534,004</td>
<td>395,458</td>
<td>191,453</td>
<td>--</td>
<td>14,100</td>
<td>--</td>
</tr>
<tr>
<td>1968</td>
<td>649,234</td>
<td>434,654</td>
<td>208,966</td>
<td>--</td>
<td>2,280</td>
<td>--</td>
</tr>
<tr>
<td>1969</td>
<td>708,874</td>
<td>542,303</td>
<td>525,860</td>
<td>--</td>
<td>36,490</td>
<td>6,998</td>
</tr>
<tr>
<td>1970</td>
<td>625,350</td>
<td>540,069</td>
<td>609,315</td>
<td>82,236</td>
<td>30,668</td>
<td>44,826</td>
</tr>
<tr>
<td>1971</td>
<td>626,896</td>
<td>762,226</td>
<td>465,920</td>
<td>610,250</td>
<td>2,150</td>
<td>1,020</td>
</tr>
<tr>
<td>1972</td>
<td>678,026</td>
<td>649,531</td>
<td>413,293</td>
<td>493,140</td>
<td>29,545</td>
<td>37,425</td>
</tr>
<tr>
<td>1973</td>
<td>780,312</td>
<td>539,820</td>
<td>598,698</td>
<td>463,994</td>
<td>97,411</td>
<td>103,944</td>
</tr>
<tr>
<td>1974</td>
<td>646,685</td>
<td>778,730</td>
<td>359,720</td>
<td>803,358</td>
<td>161,939</td>
<td>36,832</td>
</tr>
<tr>
<td>1975</td>
<td>545,188</td>
<td>963,745</td>
<td>323,364</td>
<td>2,369,515</td>
<td>149,544</td>
<td>32,885</td>
</tr>
</tbody>
</table>

Source: Washington Department of Fisheries
<table>
<thead>
<tr>
<th>Location</th>
<th>Acres</th>
<th>Estimated geoduck population in pounds of clams, round weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Juan Islands</td>
<td>160</td>
<td>307,000</td>
</tr>
<tr>
<td>Strait of Juan de Fuca</td>
<td>6,685</td>
<td>12,788,000</td>
</tr>
<tr>
<td>Central Puget Sound (including Hood Canal)</td>
<td>17,272</td>
<td>68,427,000</td>
</tr>
<tr>
<td>Southern Puget Sound</td>
<td>8,807</td>
<td>24,905,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>32,924</td>
<td>106,427,000</td>
</tr>
</tbody>
</table>

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

1. Harvest is restricted to areas greater than 1/4 mile from shore and in waters exceeding ten feet deep.

2. Harvest method is limited to divers employing hand-held water jets or suction devices.

3. Harvest is limited to daylight hours.

The commercial geoduck fishery originated as a limited entry fishery. State-owned geoduck tracts are leased to harvesters by the Department of Natural Resources on an auction basis. The highest bidder for a given tract has the exclusive right to harvest geoducks for a period specified in the lease. Original leases were for five years, but leases have since been reduced to two years without provision for renewal.

In addition to a lease, a harvester must have a Washington Department of Fisheries clam farm license and a geoduck harvest permit.

Goodwin (1973) estimated Puget Sound contains about 32,924 acres of geoduck beds; however, the majority are excluded from commercial harvest by their close proximity to shore and/or water depth. Therefore only about 6,534 acres are legally harvestable, and only 2,400 acres are commercially feasible. Although there are indications that geoducks occur in greater abundance in water up to 200 feet, harvest is limited to depths of about 60 feet because diving time is severely limited in deeper water (Goodwin, personal communication).
The early commercial fishery began in 1970, when 1,000 acres in subtidal leases were auctioned. The bonus bid per tract ranged from $200–$6,050 (Erickson, 1972). Besides the bonus bid, a lease fee is charged on acreage, a royalty on production quantity, and a one percent privilege fee is assessed on landed value.

Although potential annual harvest from these leases was estimated to be about two million pounds per year, the landings between 1971 and 1973 actually were in the 500,000-pound range.

The intent of industry pioneers was to harvest and sell whole unprocessed clams. Unfortunately, only a very limited although profitable whole clam market developed. In order to expand its market, the industry was then forced into developing a more salable product form, which led it logically into processing (Hodgson, personal communication). Erickson (1972), in an economic survey of the early industry, states that 90–95 percent of the harvested geoducks were processed into steaks and chowder meat. However, markets for these products proved insufficient.

The industry floundered in unprofitability for about three years, plagued by lack of capital, limited markets, and high production costs. At the industry low point, only one firm survived.

In mid-1974, geoduck neck steaks penetrated a large Japanese market and Washington's geoduck landings jumped to 2,400,000 pounds in 1975.

The soft shell clam is another exotic species; it has established itself in considerable abundance in the intertidal areas at the mouth of several rivers, such as Grays Harbor and Willapa Bay on the Washington coast, as well as at Port Susan and Skagit Bay in Puget Sound. It is not, however, found subtidally in Puget Sound in any great abundance (Smith and Herrman, 1972; Goodwin, 1973; Goodwin and Jones, 1976).

Current Status

Razor Clam Fishery

Currently, the bulk of Washington's razor clam stocks are harvested through an intensive recreational fishery and a small Indian commercial fishery.
Quinault Indian Razor Clam Fishery

Since 1960, most of Washington's commercial razor clam production has come from the Quinault Indian Reservation. Catch records, although incomplete, are available since 1953. From the early 1950's through the 1960's, production averaged about one quarter of a million pounds per year (Tegelberg, 1968). Recent records provided by the Quinault Reservation are summarized in Table 5. It is presently the principal revenue-producing fishery on the reservation.

Prior to 1972, reservation harvest was loosely regulated. Since then, stringent rules on the fishery were instituted by the tribe. Diggers now require a tribal license, issued only to the Indians. Buyers of reservation clams must be licensed, and must not be Indian. The tribe apparently takes a conservative view of clam management and has instituted relatively stringent harvest regulations. Harvest season is closed from May to mid-August. Digging is allowed only on low, minus tides (Wright, personal communication).

The tribe is developing an improved management program. Since 1972, an annual standing crop assessment of their beaches has been made. Future studies are planned to determine optimum tide to harvest and to estimate more accurately the optimum annual yield. The latter is particularly important, since some diggers feel the tribal beaches are not dug to their fullest extent (Wright, personal communication).

Harvest is by shovel. There is little interest in mechanizing the process since it is an important source of employment, and hand digging is an important part of tribal life.

Licensed buyers purchase clams from diggers on the beach at prices set by the tribe (presently 80¢/lb, whole wet weight). Most of them are sold for crab bait and the rest enter the fresh and frozen retail and restaurant markets. Razor clam processing on the reservation, although attempted, has not been developed successfully because of high processing costs, as well as labor and quality control problems (Reeves, personal communication).

Razor clams are now one of the most expensive types of clam meat. In 1975, commercial landings in Washington amounted to 92,000 pounds (meat weight) and the dockside value of the catch was $174,000. The average landed meat weight value was 189 cents per pound.
TABLE 5
Summary of razor clam catch by season for the Quinault Indian Reservation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>--</td>
<td>26,338</td>
<td>40,611</td>
<td>12,150</td>
<td>18,508</td>
</tr>
<tr>
<td>September</td>
<td>80,668</td>
<td>18,638</td>
<td>13,620</td>
<td>2,058</td>
<td>51,649</td>
</tr>
<tr>
<td>October</td>
<td>60,954</td>
<td>21,539</td>
<td>13,663</td>
<td>3,409</td>
<td>47,736</td>
</tr>
<tr>
<td>November</td>
<td>59,866</td>
<td>12,293</td>
<td>11,303</td>
<td>1,020</td>
<td>24,418</td>
</tr>
<tr>
<td>December</td>
<td>22,379</td>
<td>3,885</td>
<td>18,346</td>
<td>4,626</td>
<td>18,049</td>
</tr>
<tr>
<td>January</td>
<td>11,534</td>
<td>4,693</td>
<td>1,610</td>
<td>16,403</td>
<td>13,141</td>
</tr>
<tr>
<td>February</td>
<td>7,995</td>
<td>13,040</td>
<td>6,761</td>
<td>10,982</td>
<td>5,898</td>
</tr>
<tr>
<td>March</td>
<td>14,714</td>
<td>4,706</td>
<td>11,133</td>
<td>33,922</td>
<td>17,275</td>
</tr>
<tr>
<td>April</td>
<td>49,671</td>
<td>18,488</td>
<td>33,118</td>
<td>50,453</td>
<td>34,793</td>
</tr>
<tr>
<td>May</td>
<td>77,332</td>
<td>28,335</td>
<td>53,629</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>June</td>
<td>13,975</td>
<td>27,863</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TOTALS</td>
<td>399,088</td>
<td>179,818</td>
<td>203,798</td>
<td>134,993</td>
<td>231,467</td>
</tr>
</tbody>
</table>
Razor clams are not consumed raw and cannot be marketed whole except as crab bait. They are extremely perishable and must be processed within a few days, preferably within 24 hours after harvesting.

The cost of the raw product in the shell at $.80/pound is extremely high, because there is a 50-60 percent weight loss, and considerable hand labor involved in processing. Dressed razor clam meats presently retail for about $5.00 per pound.

Recreational Razor Clam Fishery

As noted earlier, Washington's razor clam fishery has evolved from commercial to predominantly recreational. The dramatic increase in digger trips from 208,000 in 1946, when annual monitoring of the sports fishery began, to 600,000-700,000 by the late 1960's demonstrates how important this personal use fishery had become. The economic impact of this fishery on nearby resort communities was, of course, considerable.

The present status of the recreational razor clam fishery is difficult to assess. Compared with the catch of previous years, recent statistics available for 1972-1974 suggest the fishery may be declining.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Catch (Millions of Clams)</th>
<th>Digger Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>3.5</td>
<td>362,000</td>
</tr>
<tr>
<td>1973</td>
<td>7.5</td>
<td>535,000</td>
</tr>
<tr>
<td>1974</td>
<td>7.5</td>
<td>604,000</td>
</tr>
</tbody>
</table>

What the statistics do not reveal, however, is the amount of illegal digging, which may be considerable (Tegelberg, personal communication).
Hard Clam Fishery

Most of Washington's hard clam fisheries are found in various parts of Puget Sound. Farming of Manila clams and native littleneck clams is closely associated with the oyster industry of southern Puget Sound. In central Puget Sound there is intertidal farming of native littleneck clams and butter clams, as well as the subtidal harvest of native littleneck clams, butter clams, and horse clams by mechanical harvesters. A new but rapidly expanding fishery is utilizing a small portion of Puget Sound's extensive subtidal geoduck populations. Another newcomer is a struggling soft shell clam fishery.

Total hard clam production for the Puget Sound district, which accounts for most of the production, has remained relatively stable at one to two million pounds per year, the exception being the late 1930's, when a peak of about 3-1/2 million pounds were harvested.

Table 4 indicates that while total hard clam production has remained relatively stable, production of native littleneck clams has declined during the last 20 years from approximately 1,000,000 pounds per year in the late 1950's and early 1960's to between 600,000 and 700,000 pounds in recent years. The type of fishery has changed as well. This is particularly evident when one compares the annual catch from hand and dredge harvesting. The hand harvesting catch has steadily declined since the early 1960's. Since 1959, however, production of littlenecks has been significantly supplemented by dredge harvested clams, primarily from subtidal stocks.

At present, the intertidal, hand harvest native littleneck fishery is centered in the west-central Puget Sound area.

Most of the harvest is from privately owned tidelands; either owned directly by the harvester or leased from other individuals, payment being based on a "stumpage fee" or a royalty on the number of pounds harvested. Under present law, the Washington Department of Natural Resources, which manages state-owned lands, may lease public tidelands to private clam harvesters; but in recent years they have discontinued new leases, reserving public beaches for recreational use.
Harvest is by hand digging with long-tined rakes during low tides. The clams generally are held in sink floats for at least 24 hours to allow for sand depuration. After depuration, the clams are either sacked or boxed, depending on market destination and type of transportation; no further processing is required since these clams are served steamed in the shell.

Currently, the butter clam and horse clam fisheries are incidental to the harvest of native littleneck clams. The butter clam is harvested both intertidally and subtidally; while the horse clam is harvested strictly by dredge.

The principal market for butter clams has been as fresh, frozen, and canned chowder stock. Demand in recent years has been small, primarily because of the availability of less expensive East Coast clam imports. As a result, butter clam prices have been severely depressed. Even with a currently improving market, dredge-harvested butter clams bring about 13¢ per pound dockside. Other markets include a small half-shell trade, clam strips, and fish and crab bait (Gunstone, personal communication). The fresh food market, although small, brings a better price (about 40¢ per pound).

Until recently there was only one market for horse clams, a local cannery. Horse clams are mixed with butter clams in chowder stock and are also used in the preparation of nectar. Because of the labor involved in processing, and the low meat yield, marketing this clam is little more than a break-even endeavor. A recent additional market has developed for horse clams as crab bait, but it has not improved product price.

The Manila clam industry is closely tied to the oyster industry in southern Puget Sound. Most farmers, in fact, are involved with both. South Sound clam farming is economically viable and perhaps the most profitable of all intertidal bivalve farming in Washington. There are no serious problems in marketing the clams and their price is going up faster than the general price level. Production costs are relatively low, consisting primarily of an original investment in clam ground, a small overhead, minimal processing costs, and the cost of hand harvesting.
Unlike its neighboring oyster industry, which is dependent on imported seed, South Sound clam farming relies totally on natural reproduction, which is cost-free; however, while there is no seed cost, there is also no control over seed availability. Fortunately, setting is fairly regular, particularly when compared with the native littleneck and butter clam. Although setting intensity is variable, there are enough good years to bridge the poor ones. Various clam beds grow clams at different rates, so farms may be managed for fairly steady maximum sustained yield to match the demand of established markets.

The clams are harvested year-round by contract diggers using a fork or rake. Harvested clams are held in sink floats for 24 hours prior to shipping to allow for the sand depuration necessary for quality. Typically, clams are then sacked and transported by refrigerated truck to market. Most clam farms sell fresh whole clams to wholesale fish houses in Seattle and Portland; however, a few market directly to retail outlets. At least one producer markets in California. In the past some clams have been shucked for the restaurant trade, but more than 99 percent are presently sold fresh in the shell. It is a clam with excellent keeping quality.

Japanese demand has greatly broadened the market for Puget Sound's geoducks, and the industry has expanded to three principle companies. Catch statistics indicate production to be increasing rapidly and it will approach 4,000,000 pounds in 1976 (Goodwin, personal communication).

Whether or not the economic condition of the industry has improved in terms of profits is not known. One company indicated that it probably has not, and the economic squeeze between cost of production and market price is still present.

The potential of soft shell clams has long been recognized but never realized. Surveys of commercially harvestable areas in Port Susan and Skagit Bay indicate a standing crop of about 18,740,000 pounds, covering 1,200 acres, with an estimated annual maximum sustained yield of about 1,900,000 pounds (Goodwin and Jones, 1973). Herrman (personal communication) has estimated an annual maximum sustained yield from harvestable areas in Skagit Bay, Port Susan,
Willapa Bay, and Grays Harbor, to be about 5,000,000 pounds whole wet weight. This allows for areas which could not be harvested due to sewage pollution, state regulation against harvesting near drainage slough areas, or areas with attached vegetation.

Expected Future

Razor Clam Fishery

In the future the Quinault Indian razor clam fishery may prove the most viable in Washington. It is one which can be controlled in a way not available to most of the state's clam industry. Both the beach and uplands are exclusively held and managed by the tribe, and consequently, they are less subject to the encroachment of residential development than those in Puget Sound. In addition, the Quinaults are not subject to most of the state and federal regulatory machinery as well as many of the other political, social, and economic forces encroaching on Washington's non-Indian clam fisheries.

The Quinault's management program initiated a few years ago may improve the productivity of the fishery. Clam supply, however, will still be limited by the vagaries of natural setting.

The future of the razor clam market is more difficult to predict. At present, the market apparently is limited and demand varies a good deal. The future crab bait market is dependent on the viability of the crab fishery, the extent of British Columbia and Alaska imports, and development of bait substitutes. The fresh and frozen razor clam market for human consumption is considered by some to have a limited future. However, rising prices for clam products in general, and more aggressive marketing could insure a continued solid base and modest growth for this segment of the market.

Recreational Razor Clam Fishery

Washington Department of Fisheries management personnel expect the fishery to continue at about the same level in the future. There is concern, however, over some physical changes occurring in several beaches which are affecting productivity, although the causes are not easily
explained. For example, the southern end of Twin Harbors beach is eroding and clam productivity is declining, while the northern three miles of beach is becoming gravel. In addition, good setting of clams is not occurring on the southern beaches (Long Beach and Twin Harbors), and as a result, clam populations are at relatively low levels. At the same time, however, record sets have occurred in the northern beaches of Copalis and Moclips (Tegelberg, personal communication).

The Puget Sound Fishery

The market for native littleneck clams is expected to remain favorable. Future supply will depend on a number of factors, including:

1. Reproductive success in the clam producing areas, which have a history of marked variation;

2. Continued farming of productive intertidal beaches; and

3. Continued production from subtidal areas.

The loss of productive intertidal beaches may increase as the Puget Sound region continues to develop. Both the Washington Department of Fisheries and clam dredgers interviewed believe we will be fortunate if present subtidal clam production can be maintained. At worst, subtidal clam dredging could disappear as a result of adverse public opinion and an increasingly complex and unpredictable regulatory environment.

There is some potential for increasing production; beach rehabilitation to improve the productivity of marginal lands is possible, and in fact, is presently being practiced by one farmer. The planting of hatchery-reared clam seed may help activate supply which has been limited by fluctuations in setting. Development of a subtidal clam dredge that can operate in waters deeper than the 18-foot depth to which most existing dredges are limited, could increase the subtidal production considerably.

The future of the butter clam industry hinges on a number of factors including:

1. Potential for expansion of the present limited market and the improvement of product prices, both of which appear promising.
2. Continued utilization of subtidal stocks is essential. According to Goodwin (1973), Puget Sound holds a standing crop of butter clams estimated at some 86,000,000 pounds. Although the resource is large, not all of it is harvestable. Some beds are too deep for harvesting by present dredges. In some areas, the water is too rough or the bottom substrate is too rocky. Pollution, particularly from domestic sewage, eliminates about one-quarter of the potentially harvestable subtidal clam stocks (Westley and Goodwin, personal communication). Other beds are subject to conflicts with other uses, particularly the aesthetic use valued by upland residents.

3. If prices increase sufficiently, some increase in intertidal harvest is expected from increased digging efficiency. At present, there is not sufficient incentive for hand diggers to dig to the depth (12 inches) required for effective harvest.

4. Occurrence of regular setting required for continued recruitment into the fishery.

There have been recent inquiries, primarily from foreign buyers, for quantities of horse clams, ranging as high as 20,000-30,000 pounds per month. One harvester reported that a Japanese company wanted horse clams air-freighted to Japan as whole live clams.

With interest in horse clams increasing, prospects for Washington's fishery may improve, not only for subtidal harvesters, but perhaps for the intertidal harvester as well.

The future of Manila clam farming in some respects is bright. The market is constantly improving as demand continues to exceed supply. Some feel there is a great potential for expansion in southern Puget Sound, through better bed management and the conversion of low-profit oyster ground into clam grounds. Beach rehabilitation may be a major area of investment for clam farmers in the future.

Planting clam beaches with hatchery-reared Manila clam seed is presently under evaluation as another possibility for increasing production by minimizing the impact of setting variation. This seed is available from a number of hatcheries on the coast, but its present cost is quite high, and experiments to date indicate survival rate to
market size is low. Therefore, it is probably premature to be optimistic about hatchery-reared seed as a major source of production.

The future of the geoduck fishery is questionable. Currently, the industry is expanding rapidly and is approaching the limits of Puget Sound’s estimated maximum sustained yield, which apparently is less than the industry’s future requirements. In addition, the present short-term lease arrangements make it difficult to ensure anything more than short-term future supply. As a result, bonus bids on geoduck tracts have been increased to levels which, according to industry, make future profits uncertain. In the last auction, bonus bids ranged from $6,000-$60,000 per tract, a marked increase over previous bids.

Some in industry believe the problem is one of land management and that each of the principal companies should have some assurance of long-term supply at a reasonable cost. The state, on the other hand, does not feel an obligation to secure such supplies, claiming that this is entirely the responsibility of industry.

The commercial harvest of soft shell clams on privately owned and leased intertidal ground began in 1969, based on the Hanks harvester. Table 4 shows that these clams are not yet a significant factor in Washington’s clam industry. According to one member of the industry, a profitable specialty retail and institutional market has been developed for shucked and steamer clams in California. The potential also exists for developing a canned steamer clam product for the institutional market. Production began to expand significantly by 1973, reaching 100,000 pounds that year. At present, the industry has been virtually halted by lawsuits prohibiting the use of mechanical dredges under the state’s Shorelines Management Act.

Puget Sound Recreational Clam Fishery

In 1973 the Washington Department of Fisheries began collecting information on the effort and catch of the Puget Sound recreational clam fishery. This was an ambitious undertaking, considering that the
Sound has some 2,000 miles of shoreline, about 800 miles of which are publicly owned. Over 300 major public-use locations are scattered throughout the state. In addition, creek sampling indicates the fishery consists of eleven species: native littleneck clam, butter clam, Manila clam, cockle, two species of horse clam, the geoduck, soft shell clam and three species of Macoma.

Effort was determined by a complicated sampling scheme, using aerial observations which covered about 60 percent of the shoreline and 80 percent of the use locations. Catch was estimated by creel census of users on the beach: 640,000 user trips and a catch of 2.1 million pounds of clams represents a considerable fishery. These use estimates were surprising even to those close to the fishery. Largely as a result of the magnitude of use, the Washington Department of Fisheries has instituted a sports fishery program in its shellfish unit. A major goal has been to compile an inventory of public beaches, defining locations, boundaries, and ownership -- since a variety of federal, state, and local governmental agencies own tidelands. A second goal is to open public beaches which are inaccessible at present or where ownership is in question.

In addition to expanding the number of beaches available to the recreational clam fishery, biological studies are in progress for evaluating ways to increase the productivity of the Washington public beaches. These include:

1. Habitat improvement, i.e., investigating ways of altering substrate to increase clam production.
2. Seeding of beaches with hatchery-reared juvenile clams.

The major problems in developing a management program for sports clam fishery include:

1. The lack of public beaches which will sustain good clam production. There are a few good beaches, such as the one at Fort Flagler State Park, which yields an estimated 44 tons per four acres per year. These are rare, however, since most productive clam beaches are under private ownership. Most public beaches are overused and may not be capable of very high sustained production.
2. Until recently the recreational fishery was not really recognized as a legitimate land use.

3. Lack of coordination between governmental agencies.

4. Problems of communicating information to the clam harvesting sportsmen, especially concerning bag limits.

Source: Al Scholz (personal communication).

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ALASKA

Alaska has abundant clam resources. According to Baxter (1965), about 160 different species are found, 28 of which have commercial potential. We do not have many reports about Alaska's clam abundance; however, estimates of annual yields approaching 50 million pounds per year are mentioned (Paul and Feder, 1976).

In addition to its clam resources, Alaska has pristine marine waters virtually free of industrial and domestic sewage pollution,
waters so cold that even natural background coliform counts are minimal (Schink and Chew, 1976).

The state views these clam resources as a very important potential addition to its economy, for the following reasons. The clam fishery could become a multimillion-dollar-a-year industry. It is a resource, unlike most in Alaska, that could be exploited year-round, providing a source of continuous employment. This is important in a state where most employment is highly seasonal.

Although extensive, Alaska's clam resources have never been developed to any great extent. The history of commercial clam harvesting in Alaska began in 1916 with the introduction of razor clam canning, but production was never very large, and in recent years has been minimal. Two other species, the butter clam and basket cockle, were also harvested and canned commercially during the 1940's and 1950's, but never in great quantities.

In this section, the history, current status, and future of Alaska's razor clam fishery will be discussed. In addition, brief mention will be made of other species which have in the past supported a commercial industry. Of particular interest in the general review of the present status are those factors which are restricting utilization of the clam resources, and the measures being taken to minimize their impact.

**Brief History**

Razor clams extend from Southeastern Alaska to the Bering Sea and the Aleutian Islands. In a review of razor clam populations in Alaska, Nickerson (1975) states that razor clams have been observed in 49 areas, of which about half could probably support a commercial fishery. There is little information on the extent and abundance of subtidal stocks, but they may prove to be considerable.

A commercial razor clam canning industry began in 1916 with the harvest of razor clam beds near Cordova. As these beds were depleted, additional razor clam beaches were discovered on Cook Inlet, Alaska Peninsula, and the Kodiak area, in the early 1920's. Production during the 1920's was erratic, owing to stock depletion and unfavorable market conditions (Orth et al., 1975).
During the early 1930's production declined, apparently related once again to stock depletion from excessive digging pressure, as well as extremely cold temperatures and heavy winter storms (Orth et al., 1975). In 1935, harvest quotas were placed on the Alaska razor clam fishery, and the 4-1/2-inch size limit established in 1924 continued (Nickerson, 1975). From the mid-1930's to the 1950's, razor clam production was relatively stable, ranging between one and two million pounds/year. By the mid-1950's, however, Alaska's razor clam industry began a sharp decline. There were several reasons. Canned razor clams from Alaska, produced with relatively high harvest and processing cost, could not compete with dredged harvested surf clams from the Atlantic. In addition, FDA withdrew its endorsement of Alaska's National Shellfish Sanitation Program (NSSP) in 1954 (Orth et al., 1975).

Since that time, Alaska's razor clam industry has been based on the crab bait market, which began expanding in the 1940's. In addition to meeting its domestic crab bait demand, Alaska has exported significant quantities of bait clams to Washington and Oregon. A small local market has persisted for fresh, frozen, and specialty canned razor clams as food (Orth, et. al., 1975).

Current Status

Recent catch statistics, consisting almost entirely of razor clams, indicate that over the last decade, production and value have been low, ranging from a high of 243,121 pounds in 1971 to a low of 31,651 pounds in 1975.

In 1975, Alaska re-entered the NSSP program, providing the basis for exploiting any potential food markets. At the present time, there is one processor licensed to ship interstate; however, few clams have been exported.

Dredge development has been active during the last several years. Recently a harvester in Cordova patented a hydraulic dredge for harvesting subtidal stocks, and another has purchased a dredge from the East Coast. These are the only two presently equipping for the mechanical harvest of razor clams for the bait market.
Expected Future

The industry is based at present on the crab bait market, the future of which depends on the viability of the dungeness crab fishery, the price of bait substitutes, and the continued preferences of crab fishermen for razor clams. At best, any future market is presumed small (Orth et al., 1975).

Since Alaska's population is small, out-of-state markets must be developed for expanded razor clam production in the future. The food clam market offers some potential for expanding markets; however, there is a considerable price barrier to overcome (Orth et al., 1975). High prices are related to: (a) high harvest costs. The development of a mechanical harvester offers considerable hope for reducing these costs and insuring supplies; (b) the processing bottleneck. Meat yields are relatively low and processing is labor intensive; (c) costly transportation.

The razor clam market may be very limited because of high product price and product unfamiliarity. Overcoming these barriers would require a considerable marketing effort.

Problems of the Razor Clam Fishery

Pollution

For the crab bait industry, paralytic shellfish poisoning does not present a major problem for either the management agencies or the industry. However, if clams are harvested from uncertified areas, legally they must be colored with an acceptable dye before leaving the harvest beach, in order to prevent uncertified clams from entering the food market.

Resource Availability

This refers to reduction in harvestable stocks due to environmental problems. The 1964 Alaska earthquake caused a considerable dislocation of some beaches. Cordova, in particular, experienced a beach uplift which has adversely affected production (Orth et al., 1975).
Harvesting and Transportation

Some restrictive problems are: (1) inclement weather — harvesting is somewhat seasonal, primarily from April through August. Alaska's severe climate discourages winter harvest (Orth et al., 1975); (2) inefficient methods — the hand harvest of razor clams is inefficient, costly and seasonal. The development of a suitable dredge would solve these problems, and although there is some concern about their effect on hand harvesting, dredges should lower clam prices (Orth et al., 1975); (3) since there are relatively few processors who purchase bait clams, and transportation is both difficult and costly, harvest must take place on nearby beaches; (4) perishability — razor clams are very perishable and must be processed soon after harvest; (5) regulations — according to legal harvesting methods, dredges are allowed only on certain beaches. State health agencies require that bait clams harvested from uncertified areas be dyed on the beach and properly labeled. This adds to harvest costs and is objected to by some (Orth et al., 1975); (6) labor difficulties — securing clam diggers is a problem. Other fisheries such as salmon and crab offer keen competition for labor. With the rising standard of living in Alaska, clam digging is becoming less attractive (Orth et al., 1975).

Processing

Other than the cost of hand-harvested clams there are no major problems in processing razor clams for the bait market. If required, the clams are dyed, sacked, frozen in the shell, and stored by processors until used (Orth et al., 1975).

Marketing

According to Orth et al. (1975), the crab bait market has been able to absorb all the razor clams harvested, but the potential size of the market is considered relatively small.

Major Industry Problems

To recapitulate, these are: a shortage of hand diggers; high labor costs; and the crab bait market is limited.
Butter Clam Industry

Butter clams (*Saxidomus giganteus*) are abundant throughout Southeast Alaska and on isolated beaches further north. There are no standing crop estimates; however, they occur on so many beaches, the resource is considered quite large (Paul and Feder, 1976). The clams are slow-growing in Alaska waters, taking eight to ten years to reach a commercial size of 2.5 inches. Recruitment is considered quite variable. Some butter clam beds were destroyed in the 1964 earthquake and have not yet completely recovered (Paul and Feder, 1976), but southeastern beaches were not affected.

According to Orth et al. (1975), butter clams were canned incidental to salmon just after the turn of the century. The butter clam canning industry really began in 1930 with a 25,000 pound catch. It remained at this level until 1942, when the wartime demand for protein spurred production dramatically.

In 1946, production was interrupted by the discovery of PSP in canned butter clams by the FDA. According to Orth et al. (1975), the PSP problem collapsed the industry; it was ubiquitous, and defining safe areas to harvest was difficult and costly. The fishery has never recovered.

Cockle Industry in Alaska

The cockle (*Clinocardium nuttalli*) is abundant in areas of suitable habitat. As reviewed by Paul and Feder (1976), Alaska was once the principle supplier of cockle meat. In the 1940's and 1950's, small amounts were harvested near Cordova and Kodiak for canning. The industry was apparently restricted by low meat recovery rates, high processing costs and PSP. There has been no significant commercial harvest of cockles since 1960.

Problems in the Exploitation of Alaska's Resources

Although Alaska's clam resources are sizable, only a small part of their productive potential has been utilized. The exploitation of these resources continues to be restricted by a variety of factors:
1. At the present time, there is a shortage of the risk capital necessary for development of the resources. However, there is capital in Alaska's other shellfish industries, some of which could be transferred to developing a clam industry, should these other fisheries decline.

2. Because of Alaska's small population, local clam markets are extremely limited. Therefore, any clam industry development will depend on out-of-state markets (Orth et al., 1975).

3. The labor required in a clam fishery can be considerable, particularly if hand harvest and labor intensive processing is required. Wages here are inflated by a high cost of living and competitive employment opportunities available in Alaska construction. High labor costs place this state at a distinct disadvantage when its industry has to compete for external markets.

4. If markets outside of Alaska must be developed, transportation presents another obstacle, since it involves great distances and is costly.

5. Paralytic shellfish poisoning is a major factor restricting the development of Alaska's clam resources. Before clams may be marketed interstate as food, it is necessary for Alaska to have an FDA-endorsed NSSP program. Alaska rejoined the NSSP program in 1975, after a 20-year absence. The program is new and the state is in the process of proving its ability to implement and administer a safe shellfish sanitation program.

The present shellfish sanitation program restricts the Alaska commercial food clam fishery to one species, the razor clam, and to three harvest areas, Cordova-Copper River Flats, Swikshak and Polly Creek. Beginning an NSSP program with razor clams was logical. Razor clams had been harvested, canned, and marketed interstate for decades without any incidence of shellfish poisoning (Nickerson, 1975). The three beaches were chosen because they had been used in Alaska's early razor clam fishery, they have been highly productive razor clam beaches, and have the best record of background information, which facilitated certification.
A food razor clam industry has yet to develop. There are problems in securing sufficient supplies from the three certified beaches, production costs are high, capital is scarce, and markets limited. Nonetheless, it was felt that once the NSSP program was established with razor clams and the state proved its ability to meet NSSP requirements, hard shell clams would be accepted under the system, and thereby open the way for their utilization (Nickerson, 1975). The cost of sanitary surveys, PSP monitoring, and surveillance is considerable. This is a particular burden in a state with a small tax base. The state is hesitant to fund an expanded program, both in terms of additional areas and/or more species, unless the proposed fishery appears to be well capitalized, intends to process in Alaska, and makes a significant contribution toward increasing Alaska's employment opportunities.

Despite the restrictions, interest in Alaska's clam stocks is increasing. For example, Alaskan clams are being investigated as a potential replacement for the East Coast surf clam products, which are presently in short supply. Both industry and various governmental agencies are exploring the potential of Bering Sea stocks, which are believed to be very abundant, and there is the impression, but with little data available to substantiate it, that PSP would not be present.

A number of species are thought to have potential. The Greenland cockle, *Seres gruenlandicus*; the basket cockle, *Clinocardium nuttalli*; the pinkneck clam, *Spisula polynema*; the soft shell clam *Mya prionus*; and the truncate soft shell *Mya truncata*.

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