History of Oystering in the United States and Canada, Featuring the Eight Greatest Oyster Estuaries

CLYDE L. MacKENZIE, Jr.

Introduction

The United States and Canada have two native oyster species (Fig. 1) of commercial value. By far the more important is the eastern oyster, *Crassostrea virginica*, which ranges from northern New Brunswick into the Gulf of Mexico on the Atlantic coast (Fig. 2). The other is the Pacific coast's Olympia oyster, *Ostreola conchaphila*, which ranges from Alaska to Baja California (Fig. 2).

The Pacific oyster, *C. gigas*, (Fig. 3) was introduced from Japan in the early 1900's and now forms the basis of a large industry which cultures them from Alaska to Mexico, but mainly in Washington. Another introduced species is the Kumamoto oyster, *C. sikamea*, also grown on the Pacific coast on a small scale. The introduced European flat oyster, *Ostrea edulis*, (Fig. 3), has minor commercial importance in the State of Maine.

North American oyster landings have declined considerably since the early 1900's. At the production peak from about 1880 to 1910, the United States produced as much as 160 million pounds of oyster meat (27 million bushels) per year, more than all other countries combined (Ruge, 1898), and oysters led all U.S. mollusks in production (Lyles, 1969). U.S. oyster production today runs about 40.4 million pounds of meat (5.9 million bushels) (Anonymous, 1996).

In 1995, oysters were third in overall U.S. bivalve landings behind surfclams, *Spisula solidissima* (63.3 million pounds of meats) and ocean quahogs, *Arctica islandica* (49.0 million pounds of meats), but they were first in landed value at $101.6 million/year (Anonymous, 1996). In 1995, Louisiana led the United States in oyster production, but Connecticut led in landed oyster value. In the 1990's, oysters landed on both U.S. coasts comprise about 15% of world oyster landings, while Canada

Clyde L. MacKenzie, Jr. is with the James J. Howard Laboratory, Northeast Fisheries Science Center, National Marine Fisheries Service, NOAA, 74 McGruder Road, Highlands, NJ 07732.

ABSTRACT—Oyster landings in the United States and Canada have been based mainly on three species, the native eastern oyster, Crassostrea virginica, *native Olympia oyster,* Ostreola conchaphila, *and introduced Pacific oyster,* C. gigas. *Landings reached their peak of around 27 million bushels/year in the late 1800's and early 1900's when eastern oysters were a common food throughout the east coast and Midwest. Thousands of people were involved in harvesting them with tongs and dredges and in shucking, canning, packing, and transporting them. Since about 1906, when the United States passed some pure food laws, production has declined. The causes have been lack of demand, siltation of beds, removal of cultch for oyster larvae while harvesting oysters, pollution of market beds, and oyster diseases. Production currently is about 5.6 million bushels/year.*

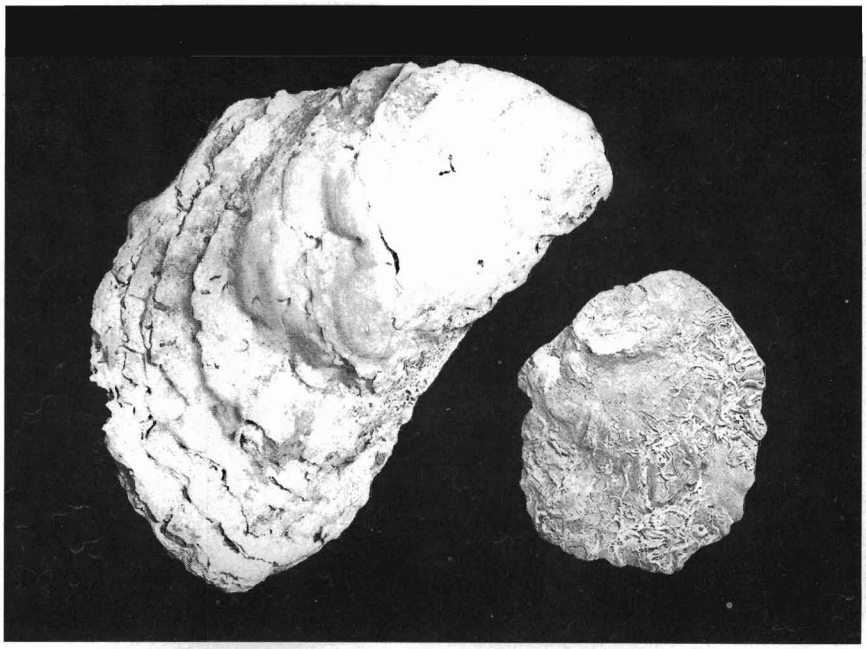


Figure 1.—The two native U.S. oyster species are the eastern or American oyster, *Crassostrea virginica*, (left), and the Olympia oyster, *Ostreola conchaphila* (right).

landed about 0.6% of the world's oysters, 77% of which are Pacific oysters (FAO, 1993).

Around 1880, the U.S. oyster industry employed 52,805 persons (38,249 fishermen and 14,556 shoremen) (Ingersoll, 1887). Today, the industry employs about 4,336 fishermen (MacKenzie and Burrell, In Press).

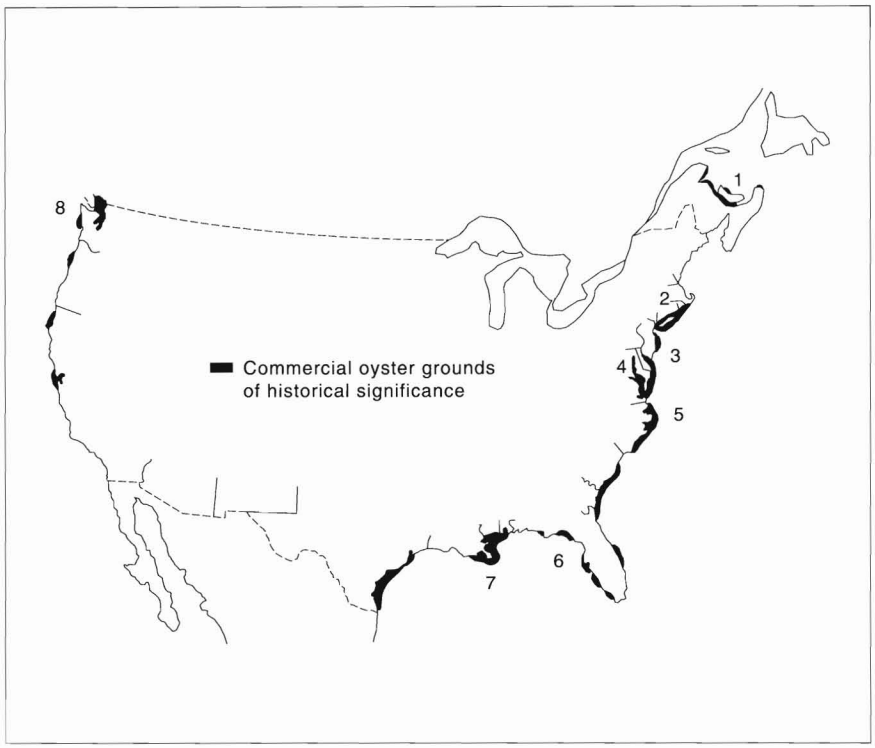


Figure 2.—General distribution of oysters in the continental United States and eastern Canada, with the locations of the eight greatest oyster estuaries: 1) Bedeque Bay, Prince Edward Island; 2) New Haven Harbor, Conn.; 3) Delaware Bay, N.J. and Del.; 4) Upper Chesapeake Bay, Md.; 5) James River, Va.; 6) Apalachicola Bay, Fla.; 7) Louisiana Estuaries; and 8) Puget Sound and Willapa Bay, Wash.

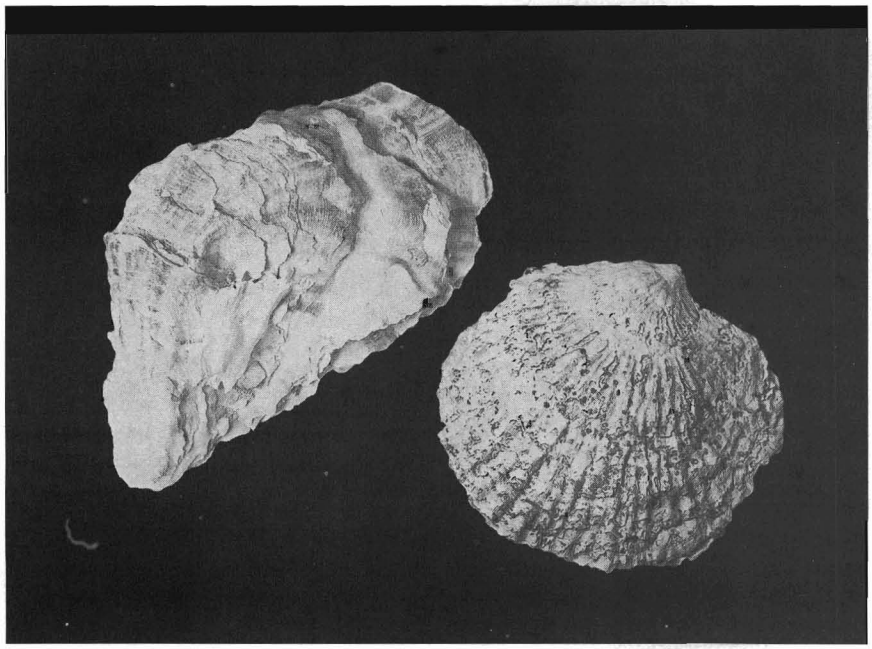


Figure 3.—Two of the important introduced oysters: *C. gigas* and *Ostrea edulis*.

Causes for the oyster industry's eventual decline have included falling demand, siltation of beds, removal of cultch (needed by oyster larvae) while harvesting oysters, pollution, and virulent oyster diseases. This paper features an historical overview of the U.S. oyster industry and the histories of the eight greatest oyster estuaries in the United States and Canada (Fig. 2).

Background

During the early 1800's, oysters were eaten mainly by wealthier people, except in local harvesting areas, but later, especially after 1880–85 when production surged, consumer prices were much less than for meat, poultry, and fish, and oysters were eaten by people at all economic levels (Anonymous, 1899). And today, oysters have again become a relatively expensive article in the diet. In 1994, they cost as much as 4–5 times more than beef and 9 times more than chicken.

Oysters traditionally have been eaten in the 8 months with the letter "R" in them, September–April. This comes from the fact that oysters have extremely thin, flabby meats after they spawn in the warm months, when a lack of refrigeration has also been a problem. The custom may be partly a carryover from Europe; European oysters are not eaten in the summer because they carry their shelled larvae within their mantle cavities and would be difficult to eat.

Oyster meats become fatter as water temperatures become cool in the fall. The oyster marketing season traditionally began on September first each year, but demand usually was slow until the weather became cold in November; an unusually warm fall retarded the demand. The demand usually remained good through February and then weakened when the weather became warmer in March and April. Most sales were made in 4 months from November the through February.

Oysters have always been sorted for eating. The smaller ones are set aside to be eaten raw usually on the half-shell;

the "culls," or medium-sized oysters, fill the ordinary culinary purposes; while the large or "box" oysters usually are reserved for frying. Manifold cooking methods evolved in the late 1800's and early 1900's (Moore, 1915).

In the late 1800's (and into the 1900's) in the northeastern and mid-Atlantic states, northern quahogs, *Mercenaria mercenaria*, nearly always eaten raw on the half-shell, partially filled in for half-shell oysters in the summer when hundreds of men were busy digging them and many oyster dealers were handling them. Some quahog diggers worked as crewmen on oyster dredge boats and as tongers during the oyster seasons. The consumption of quahogs in the summer was far smaller than that of raw oysters in the winter (Anonymous, 1897).

Along the Atlantic coast, many oysters have the commensal pea crab, *Pinnotheres ostreum* (Fig. 4), living within their shell cavities; the pea crab is uncommon in Gulf of Mexico waters (Butler, 1954). The gray-green crabs, which have a soft shell, have had a small commercial value primarily as additions to oyster stews. Individual oysters commonly have one or two crabs in them; if so, their meats are slightly thin. Occurrence in oysters ranges from 6 to 80% (Sandoz and Hopkins, 1947; Haven, 1958). Pea crabs are limited to salinities above 15 ‰ (White and Wilson, 1996). Pea crabs have had culinary importance since at least the 1700's, and George Washington, first president of the United States (1789 to 1796), enjoyed eating soup with them in it (Anonymous, 1882). Small numbers of America's oysters also have tiny pearls in their shell cavity, but the pearls have rough textures and no commercial value.

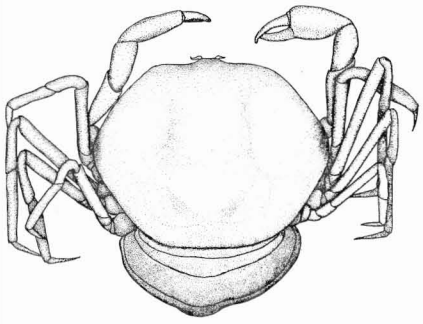


Figure 4.—The pea crab, *Pinnotheres ostreum*, from Williams (1965).

During the 1800's and much of the 1900's, oyster production was centered in Chesapeake Bay with lesser landings primarily in eastern Canada, Long Island Sound, Delaware Bay, and certain Gulf of Mexico estuaries. In the United States, production varies, by state, from mostly private culture to entirely public culture.

The oyster industries in most American estuaries began in similar ways. In pre-Columbian times, Native American women harvested the oysters and prepared them for eating or preserved them for winter use (Ingersoll, 1881). During and after European settlement, the colonists harvested and used oysters locally. Such early small-scale harvesting, usually by hand picking, raking, or tonging, eventually expanded into industrial fisheries, mainly in the late 1800's when vessels began to be fitted with engines and propellers, and trains allowed transportation of huge quantities of oysters to larger towns and cities. In 1876, for example, the development of the Canadian Intercontinental Railway opened markets for Maritime oysters in Montreal and central Canada (Morse, 1971).

From its beginnings, the oyster industry has improved its tools, vessels, packing containers, and operations for culturing, harvesting, packing, and shipping oysters. As Schock (1918) put it, "Competition was the life of the business. It was all friendly and the incentive to outstrip the other fellow in production and quality helped mightily to develop the industry."

Historical Overview

Much of our knowledge of oystering history in North America from the early colonial period to 1880 comes from two published monographs of Ernest Ingersoll (1881, 1887). Ingersoll (Fig. 5) surveyed the shellfishing industries from 1 October 1879 to 1 July 1881, making personal observations, interviewing many people, and collecting printed material (MacKenzie, 1991). Since then, *The Fishing Gazette*, published in New York City beginning in 1894, U.S. Fish Commission and Bureau of Fisheries publications, and various books (mainly on Chesapeake Bay resources) provide valuable sources on oystering history.

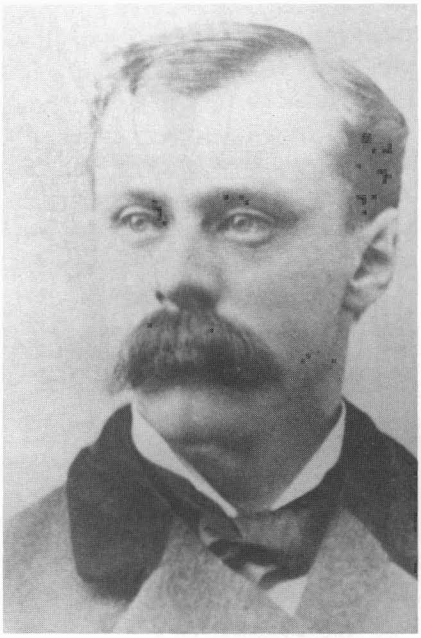


Figure 5.—Ernest Ingersoll authored two important monographs on the shellfisheries of North America which were published in 1881 and 1887. Photograph courtesy of the Linnaean Society of New York.

A comprehensive history of the oyster industry including detailed numbers and types of boats, numbers of people and packing houses involved, gear introductions and development, operations, marketing, economics, effects of manipulations of river flows, pollution, and dredging of bottoms, and State and Federal actions through time is beyond the scope of this article, because the documented accounts are sporadic, and, while many details sometimes are given, some subjects are sparsely covered. State and Federal regulations are available, but are time-consuming to collect because they are often in obscure locations. In addition, oyster landings statistics are rough measures of actual landings, as nearly all the data have been provided by oyster companies on a volunteer basis.

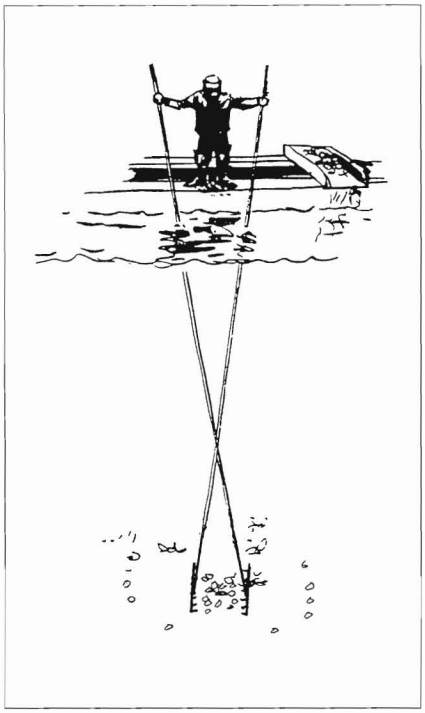


Figure 6.—Hand tongs have been used to harvest oysters along the east coast of North America from at least the early 1700's to the present.

Figure 7.—A Maryland oysterman empties oysters from his tongs, ca. 1960's. Photo by Ray J. Baudel, courtesy of The Chesapeake Bay Maritime Museum.

Harvesting

Tongs may have been the first tool used to harvest oysters (Fig. 6, 7). Their use was first recorded in eastern North America in the early to mid-1700's (de Charlevoix, 1744; Kalm, 1937; Witty and Johnson, 1988). In winter, the tongs could be used to harvest oysters through the ice (Fig. 8).

In the United States, use of dredges[1] (Fig. 9) to harvest oysters from sailing vessels began in the early 1800's. The idea for using them from sailing vessels may have come from England.

Figure 8.—Winter oyster tonging through the ice on an arm of Narragansett Bay, R.I., ca. 1904. Photo courtesy of Rhode Island Historical Society. Negative No. RHi X3 2274.

The first type of boat from which U.S. fishermen tonged oysters was the dugout canoe (Fig. 10); the large ones carried

[1]J. R. Nelson (1927) stated that dredges can be destructive to oysters if improperly used. Many oysters would have their shell edges or "bills" broken, and would not ship well to markets since they lose their liquor and the meats become dry. Poor dredging could also be destructive to certain bottoms in Delaware and Chesapeake Bays by making them soft and unfit for planting oysters. He recommended that 1) heavy dredges be used so they would go under oysters and collect all of those in their paths as they are towed and that 2) a captain tow his dredges slowly, harvest at the edge of a bed first and then move into it gradually, and use the proper length of towing chain. If too much chain is used, the dredge will be retrieved with much mud and shell or "trash," leaving the captain having to hoist the dredge up and down in the water by the side of the vessel to wash out the mud and the crew with much sorting of the "trash" while picking out oysters. If too little chain is used, the dredge does not reach bottom. Nelson was incorrect in believing that dredges pass under all the oysters when being towed over a bed. My scuba observations in the late 1960's showed that dredges pass over most oysters, collecting 15–20% of those in their path. Several passes must be made over the same bottom to remove most oysters from it, and nearly always some oysters remain behind after the vessels have finished harvesting. Oyster companies have since been using lighter and smaller dredges (holding 10–12 bushels) than the ones Nelson described to lessen the breakage, but still towing them slowly.

about 40 bushels. Later, log canoes, sharpies with wide flat bottoms (Fig. 11, 12A), sloops 9–12 m long, and eventually larger sloops and schooners up to 27 m long were used. The dugout canoes were used in some areas into the early 1900's.

The skipjack (Fig. 12B), developed in the late 1800's, is one of the best known among the various oystering craft used on the eastern shore of Maryland and in Connecticut (it is further described in the Upper Chesapeake Bay section). Steam engines began to be installed in the various types of vessels in the late 1800's and in the early 1900's to pull dredges. The rapidity with which oysters were dredged and brought to packing centers by the early motor vessels enabled production to expand sharply (Parks, 1985; Vojteck, 1993).

In the late 1700's and early 1800's, oysters,

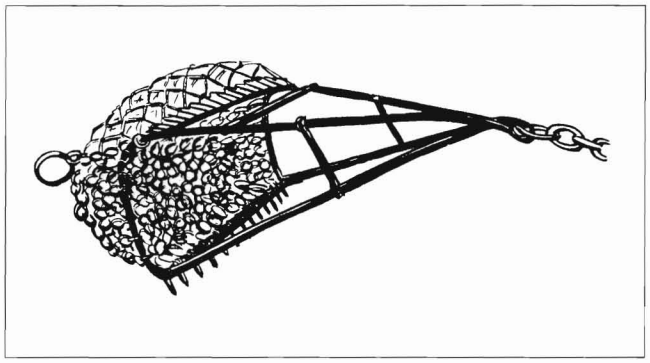


Figure 9.—A typical oyster dredge.

Figure 10.—This white pine dugout, 8.8 m (29 feet) long and 0.9 m (3 feet) wide, was the largest oyster boat in Connecticut in 1832. Dug out of a single log it was brought down from Lake Cayuga, N.Y., by water, and delivered in New Haven, Conn., for $42.00. Photograph provided by author; original source unknown.

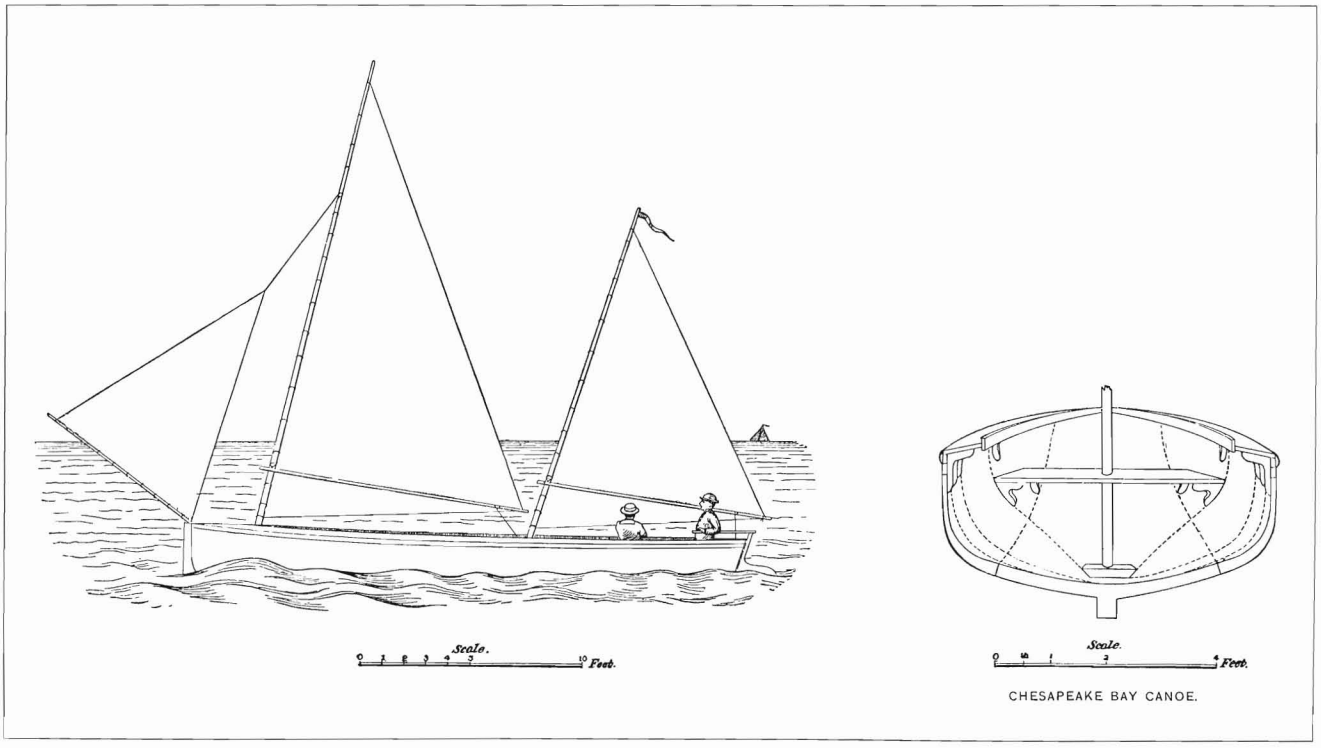


Figure 11.—Sketch of the Chesapeake Bay log canoe.

apparently plentiful in estuaries from Massachusetts to Delaware Bay, were a common food for local or nearby people of all incomes. As the human populations grew in the northeast, the oysters near cities became scarcer from heavy harvesting and environmental degradation, while their demand increased. Eventually they became a luxury only the well-to-do could afford (Ingersoll, 1881).

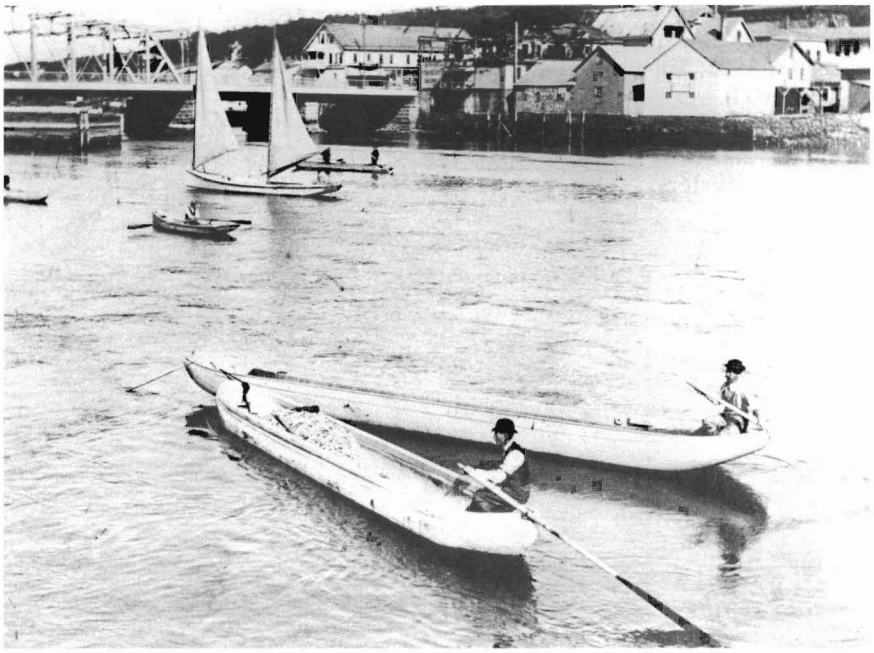


Figure 12A.—A two-masted sailing sharpie and dugout canoes being sculled on the Quinnipiac River, Conn. Both types of boats were used for harvesting oysters in the early 1900's. Courtesy of the New Haven Colony Historical Society, New Haven, Conn.

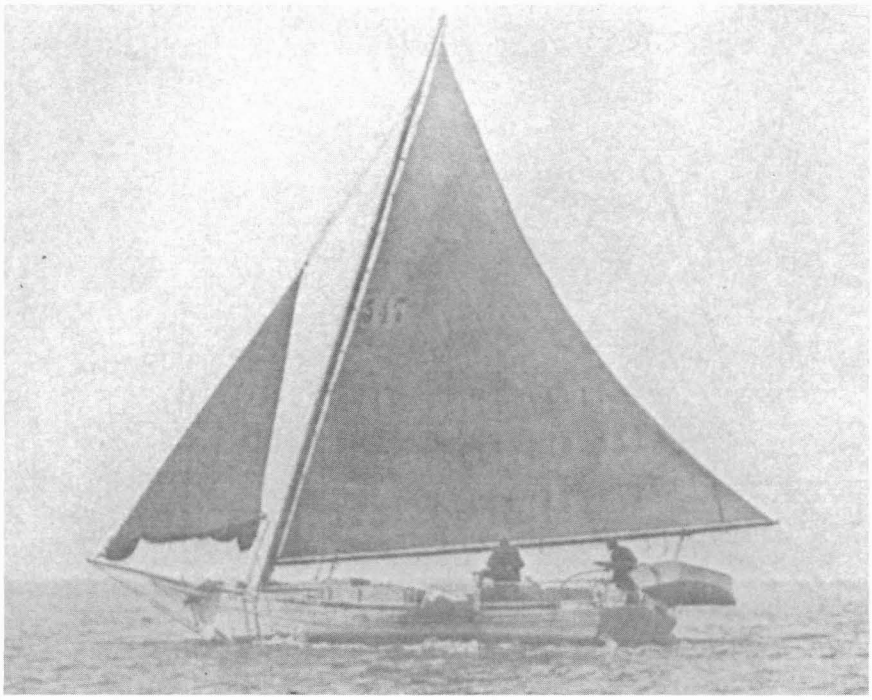


Figure 12B.—A skipjack dredging oysters in Maryland (Churchill, 1921).

Around 1825 and shortly thereafter, oystermen in Narragansett Bay, Long Island Sound, Raritan Bay, Delaware Bay, and smaller northern bays began transporting oysters from Chesapeake Bay on schooners and sloops to northern ports and to their bays to meet the demand and to increase supplies. (This was a period when many schooners were being built along the Atlantic coast of the United States [Chapelle, 1973].)

Ingersoll (1881) stated that immense quantities of oysters were taken yearly for bedding in northern waters. He wrote: "The Chesapeake is a great storehouse from which several million bushels of oysters are annually carried to restock the exhausted beds of other localities . . . More than two hundred vessels . . . are for eight months of the year engaged in the trade between the bay and northern markets. During the winter, the oysters which are taken north are used for immediate local consumption, while those taken in the spring are used almost exclusively for bedding purposes." The oysters planted in the spring were left to grow over summer and sold during the subsequent fall. By the late 1870's, about 2 million bushels of Chesapeake seed per year were being transplanted to the northern estuaries. The supply became so large that oysters again became a common food, eaten by poor and rich alike (Ingersoll, 1881). The transplanting of Chesapeake seed northward continued into the early 1900's, but on a smaller scale.

In some states, such as New Jersey, most oysters were held in floats (Fig. 13) tied to the docks of packing houses or placed along the shore, usually in water less saline than that in which they grew, for up to 24 hours before being taken in to be bagged for shipment in the shell. The floats held about 600 bushels of oysters each. The floating of oysters allowed them to pump out any mud and sand in their mantle cavities and brackish water was absorbed into their flesh, swelling it, lightening its color, and to some people, improving their taste. Floated oysters yielded more meats and had a better appearance (Nelson, 1912b). The floating was beneficial to sections of the industry that sold oysters on the half-shell.

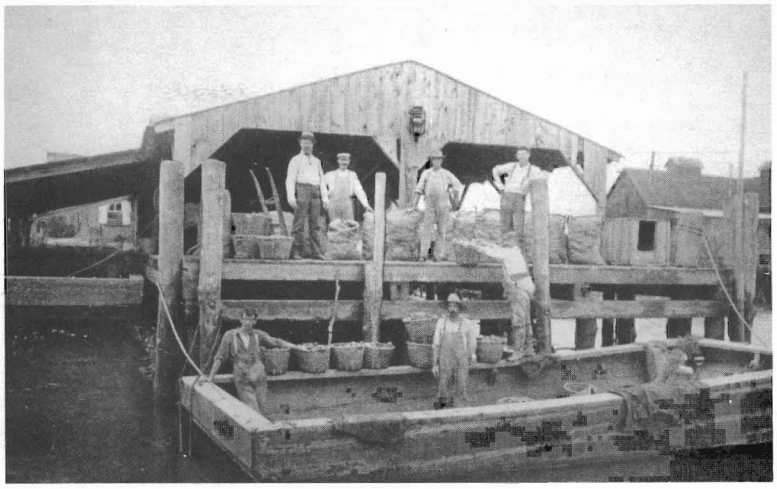


Figure 13.—Views of "floats" used to hold oysters. Left: from *Under Sail, The Dredgeboats of Delaware Bay* (Rolfs, 1971). Right: from the New Jersey Bureau of Shellfisheries.

Shucking

The commercial oyster industry may have developed first in New Haven, Connecticut. Oyster shucking began there in the 1820's and 1830's. Local people at first shucked oysters in their homes and sold them in their neighborhoods or to dealers. Oyster dealers packed the meats in little wooden kegs or in square tin cans with ice[2] for shipment. By the 1870's, oysters were opened at packing houses on the wharves where dealers' vessels unloaded (Ingersoll, 1881) (Fig. 14). Ingersoll (1881) quoted an article printed in *The New York Tribune* of January 9, 1857 describing the handling of oysters in New Haven:

Figure 14A.—An oyster packing plant with shell pile alongside. From *Under Sail, The Dredgeboats of Delaware Bay* (Rolfs, 1971).

"There are the openers, the washers, the measurers, the fillers, the packers, etc., each of which performs only the duties pertaining to its own division. At this season of the year (January) few of the oysters are 'planted,' but are generally taken directly from the vessel to the places occupied by the openers, who form a large number of operatives, and are composed of females and boys, who earn from $5 to $9 per week. An expert at this branch will open 100 quarts per day, but the average is not perhaps over 65 quarts. The standard price is, I think, 2 1/2 cents per quart. This work gives employment to many hundreds, and much of the work is performed at private dwellings, thus affording opportunity for labor to many who cannot go into a general workshop. The oysters, as they come from the vessel, are heaped upon the center of the room, the operators occupying the wall-sides. Each person has before him a small desk or platform, some 3 feet in height, on which is placed, as occasion requires, about half a bushel of oysters, from which the opener takes his supply to

[2]The ice used then probably was pond ice, for the natural ice industry began in about 1830. During winter, ice was harvested from freshwater ponds and lakes and stored in windowless buildings for later sale, usually during the summer months. In winters too warm for the formation of ice in the middle Atlantic region, ice was imported from Maine (Jones, 1984).

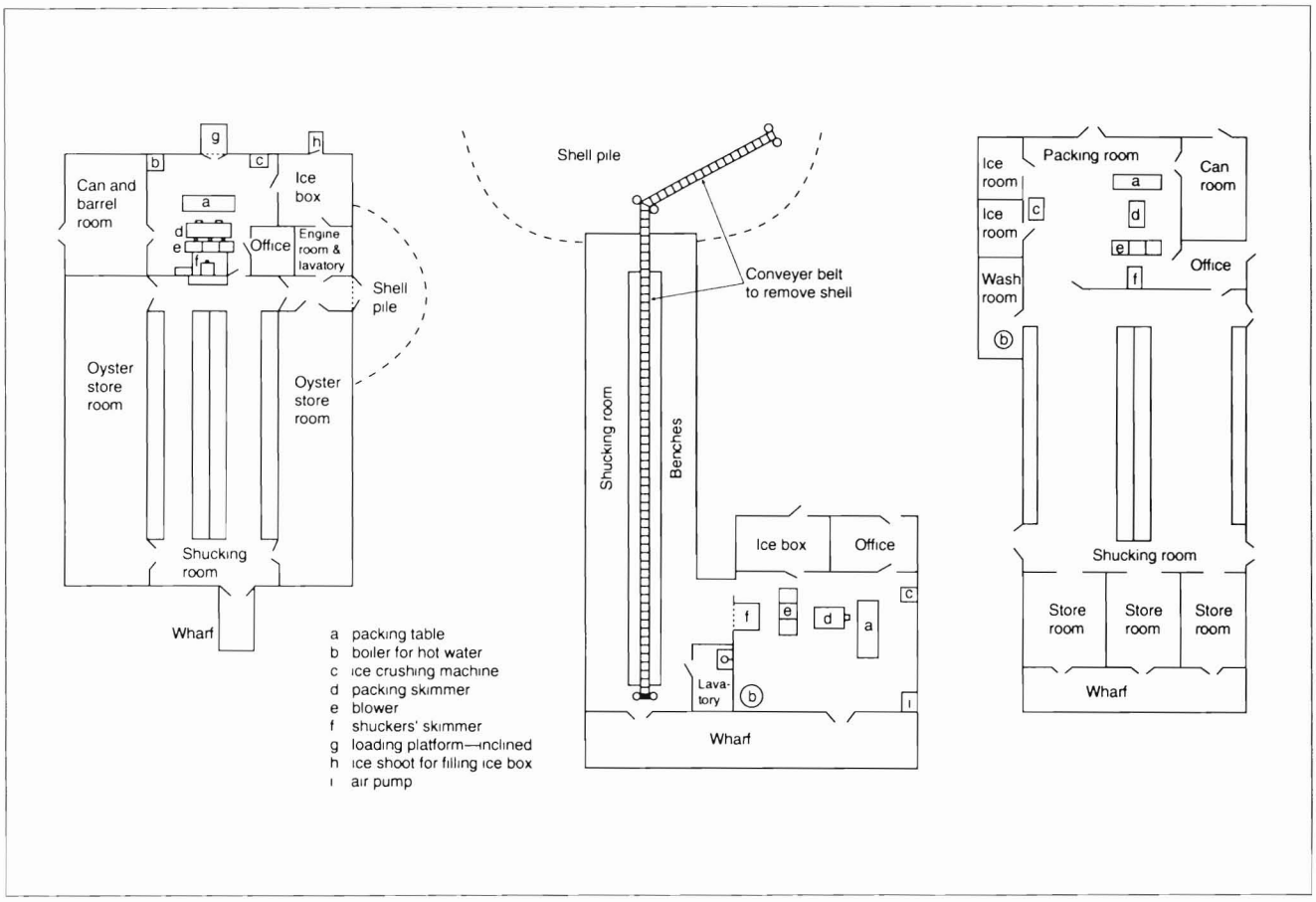
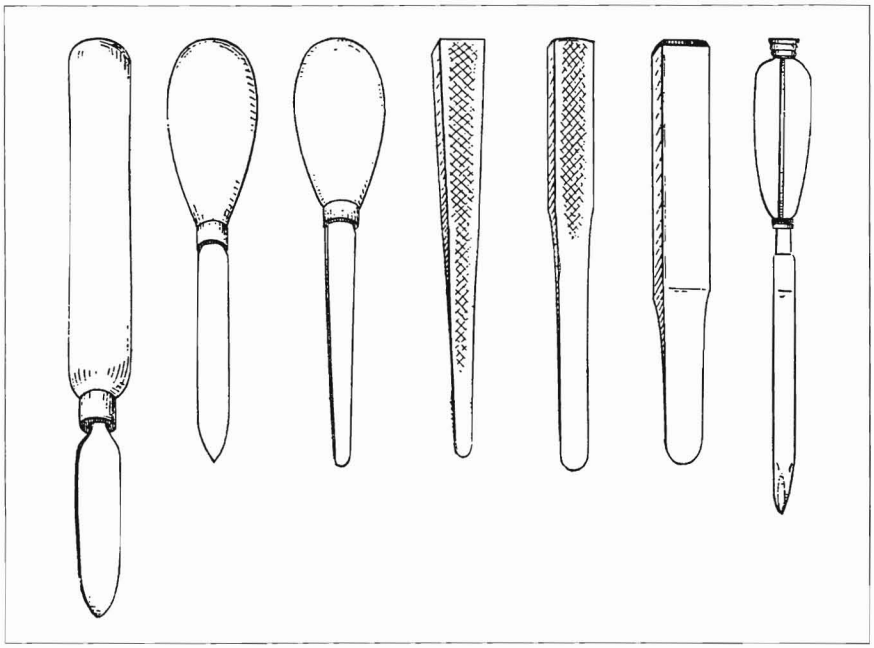


Figure 14B.—Plans of three typical oyster shucking houses in the 1900's.



open with a knife and hammer. . . .Two tubs or pails, of about three gallons capacity each, are placed within about 3 feet of the workman, into which he throws, with great dexterity and rapidity, the luscious morsel which is to tickle the palate and gratify the taste of some dweller in the far west. . . . From the opening-room the oysters are taken to the filling-room, and thence to the packing department. In the filling-room, on a platform, are placed a dozen or more kegs or cans, with bungs out. The oysters are first poured into a large hopper pierced with holes, in which they are thoroughly washed and drained, when they are ready to be deposited in packages. This is done by placing a funnel

Figure 15.—Various styles of oyster knives, from Ingersoll (1881).

in the aperture of the keg, by one person, while another 'measures and pours.' This operation is performed with great rapidity, two or three men being able to fill some 2,000 kegs in a day. After depositing the requisite number of 'solid oysters,' as they are termed, in each package, a pipe conveying fresh water is applied, and the vacant space filled with nature's beverage—the bungs placed and driven home—when it is ready to be shipped." In hot weather, the article adds, kegs are placed in boxes surrounded with chipped ice. The H. C. Rowe Company[3] used 150,000 kegs a year, costing about $15,000. Oysters eventually were opened in packing houses in every oyster-producing state along the Atlantic and Gulf coasts (Ingersoll, 1881).

Various types of narrow-bladed knives of hardened steel and narrow blades have been developed to open oysters (Fig. 15). Individual shuckers had their own favorites. Most oyster knives had wooden handles, but some, fashioned from metal files, had metal handles.

There have been two ways to open an oyster. In the "stabber" method, the knife blade is inserted between the oyster's valves and the muscle is cut from the top shell. In the "cracking" or "billing" method, the bill end of the oyster is placed on a sharpened bar and struck with the blunt end of a steel knife or a small hammer. The shuckers then can easily insert the blade to sever the muscle. Oyster shuckers have stood by a bench and quickly opened the oysters, being careful not to tear the meats which would then lose their shape and fluids, and flicked them into one of three or four containers (Fig. 16) according to the size of the meats. Good shuckers can open about 20–25 bushels (4,000–5,000

[3]Mention of trade names or commercial firms in this paper does not imply endorsement by the National Marine Fisheries Service, NOAA.

Figure 16.—Opening oysters and placing meats into cans holding three sizes of meats.

Figure 17.—Washing shucked oysters in one of the big packing houses. They were washed in several changes of water before packing. *Fishing Gazette* photograph courtesy of *National Fisherman* magazine.

Figure 18.—Oyster meats on a tray after being washed in the blower behind it.

Figure 19.—Planting shells in Long Island Sound, N.Y., to catch set (Churchill, 1921).

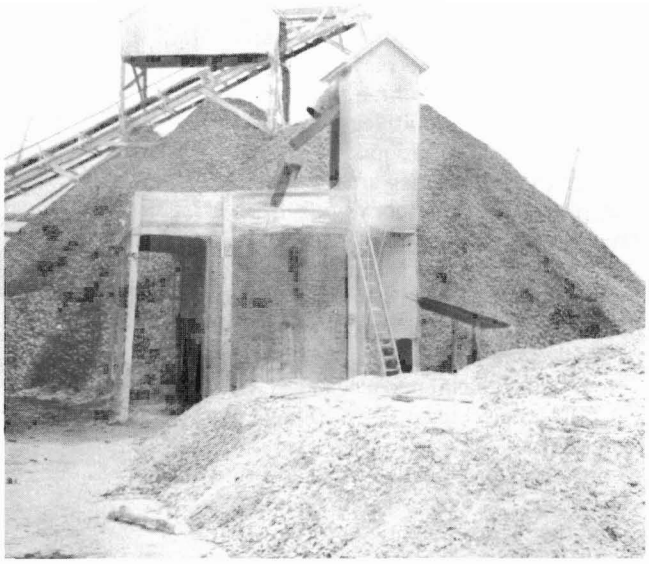


Figure 20.—Kiln for burning oyster shells to make lime, showing shell heap in background and pile of lime in foreground (Churchill, 1921).

oysters) a day. Their pay has been based on the quantity of meats shucked.

In some packing houses, tokens were given to shuckers when a predetermined quantity of oysters was shucked. The tokens usually were made of metal and were stamped with designs and quantity. Around 1900, the pay for shucking a gallon of oysters was $0.25, a number often included on the token (Karnitz and Karnitz, 1993b). In the 1800's and early 1900's, in some states oyster meats were washed in metal containers (Fig. 17) or shucked meats were poured over a grate and fresh water was poured over them to wash away any mud and bits of shell. Since about 1900, most oysters have been washed in "blowers" (Fig. 18) which are tanks each containing about 200 gallons of freshwater, where they are washed free of mud and shell particles. Bubbles of air are forced into the bottoms of blowers to keep the meats agitated. The source of air used in some early blowers was engines and fans from discarded vacuum cleaners.

Oyster Shell Uses

Oyster shells have long been used for a variety of nonfood purposes, including as cultch spread over beds (Fig. 19) for oyster larvae; "metal" for roads and footpaths; filling for wharfs, lowlands, fortifications, and railway embankments; ballast for vessels; raw material for lime (Fig. 20), a "sweetener" for agricultural fields, a component in mixed fertilizers, and a component of cement. At the turn of the century, oyster shells for roads cost $0.015/bushel (Anonymous, 1900), but most of the shells from the floating oyster barges in New York City were loaded back on the vessels and taken back to the beds and planted for cultch (Anonymous, 1895b).

Lime kilns of the shore towns in New England once used nothing but oyster shells (Ingersoll, 1887). Oyster shells have also been used as a source of lime to make cement and to feed to laying hens to harden their egg shells. In 1935, 264,282 tons of crushed oyster shell was used as poultry feed at a value of $1,257,624, and 60,403 tons of oyster-shell lime was made at a value of $209,202 (Anonymous, 1936). Limestone has largely supplanted oyster shell in the egg industry because the shell supply is unstable, wears out feeders, and is dusty, though in the 1990's, about 100,000 tons of crushed oyster shell/

year was being used by the poultry industry. The pharmaceutical industry also used ground oyster shell, incorporating it in pills to prevent osteoporosis. Oyster shell, also used in making paint, plastics, and rubber, now is the premier source of calcium in the world. Supplies come from all three U.S. coasts: Atlantic, Gulf, and Pacific.

Oyster Canning and Container Development

Oyster meats may have been canned first in New York City in 1819. Glass containers were used then, but by 1839 most glass containers were replaced by tin-plated cans. In 1840, oyster canning began in Baltimore, which was close to Chesapeake Bay oyster beds and had plentiful labor (Fig. 21). Oysters from there were shipped throughout the Midwest in cans packed in wooden cases. From Baltimore, oyster canning moved south and west, to Apalachicola, Fla., beginning in 1884; to Brunswick, Ga., beginning in 1886; and to Biloxi, Miss., in about 1915. Biloxi surpassed Baltimore in quantities of oysters canned in the early 1900's. On the Pacific coast, oysters from Puget Sound were first canned in 1931 (Karnitz and Karnitz, 1993b).

The cans were first made by hand, cutting tin sheets that were bent around a cylindrical mold and seam soldered. Tops and bottoms then were cut and soldered to the body. A cap hole was left in the top through which the oys-

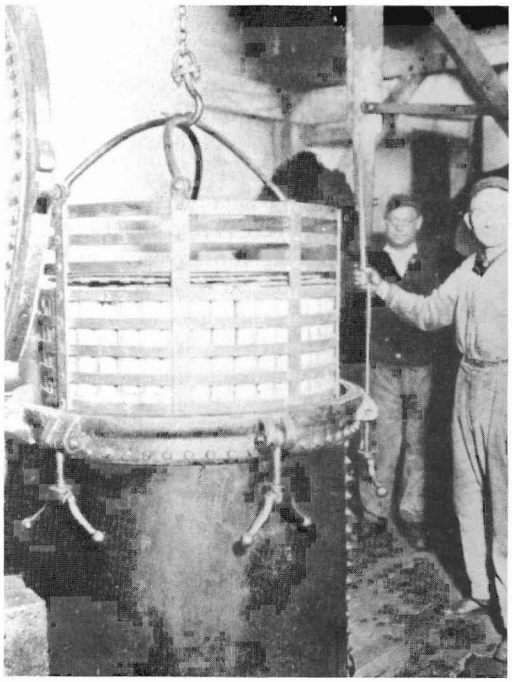


Figure 21.—At left (facing page), wearing rubber gloves, an operator in a Baltimore plant is supervising the sealing of shucked oysters in cans. Source: *Fishing Gazette*, 1926, courtesy of *National Fisherman* magazine. Above, labeling and boxing cans of oysters in a Baltimore oyster cannery (Churchill, 1921). At right, a basket of canned oysters is lowered into a kettle or steamer to be processed (Churchill, 1921). Top right, women opening steamed oysters at Crisfield, Md., ca. mid to late 1800's. Source: *Harper's Weekly*.

Figure 22.—Soldering the cans after the oyster meats have been placed in them. Source: *Harper's Weekly*, March 1872.

ters were inserted. It was closed by soldering a cap over the hole (Fig. 22). The same type of can was used by vegetable and fruit canners in the summer and fall of the year (Karnitz and Karnitz, 1993b).

Improved can and preservation methods gradually developed. A machine to stamp cans with extension edges was patented in 1847, and a press for semi-automatically making can tops and bottoms was invented in 1849. New ways of applying solder to cans and improved machinery enabled the start of assembly-line production (Karnitz and Karnitz, 1993b). Some of the small tins of oysters even found their way into the far western American frontier by the 1840's and 1850's.

Colorful Shipping Cans

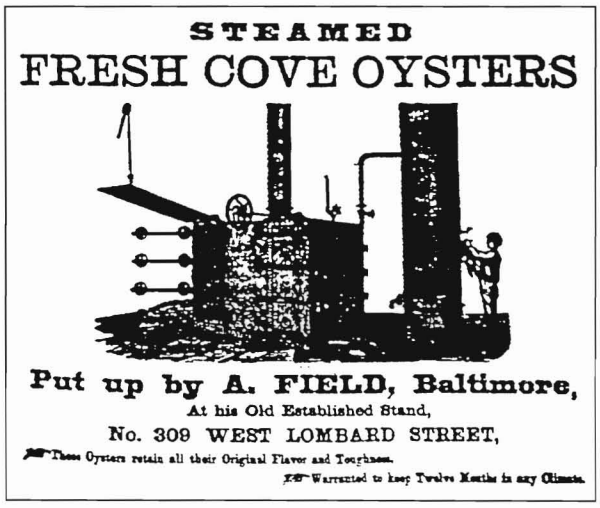
Later, in the 1920's and 1930's, companies began to ship oysters in cans with advertising on them. Some of the cans showed great artwork and color. The metal lids of the containers have been marked with a name denoting the size and number of oysters in a gallon as either Extra-Counts (under 90/gallon), Counts (90–150/gallon), Extra-Selects (150–200/gallon), Selects (200–240/gallon), Extra-Standards (240–280/gallon), and Standards (280–400/gallon) (Karnitz and Karnitz, 1993b).

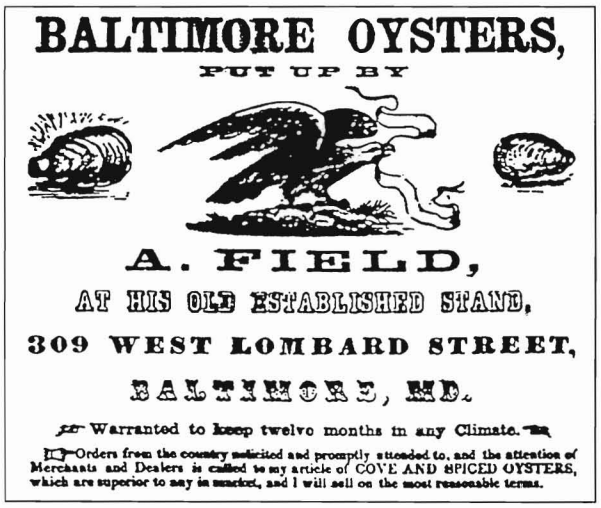
In the late 1930's or early 1940's, the open-top pint can, requiring the lid to be attached by machine, came into use. The half-pint can followed a few years later and the twelve-ounce can came a few years after that. In the early 1950's, the window top was developed. In about 1970, small plastic jars began to replace metal ones for sales of oysters in markets. The jars have the names of the packer and locality printed on them in monocolor. Besides being lighter and cheaper, plastic containers can be nested for shipping to the packer, saving space and shipping costs (Karnitz and Karnitz, 1993b). Adoption and development of canning allowed broad distribution of oysters.

Handling Oysters for Canning

Hunt (1903) described the handling of oysters being canned: "Originally the oyster shells were opened by hand, but in 1858, Louis Murray, of Baltimore, introduced the scalding of the oysters before they were shucked, and this treatment greatly facilitated their removal from the shell. This method was replaced two years later by steaming, a process in which the oysters were put in baskets having a capacity of three pecks or more, and a larger number of the baskets were placed in a large box, through which steam was passed. The modern method of shucking was inaugurated by Henry Evans in 1862. His process consists of placing the oysters in cars of iron framework, 6 to 8 feet [1.8 to 2.4 m] long, and holding about 20 bushels of unshucked oysters, and the cars are run on a track from the wharf to a steam-tight box, ranging from 15 to 20 feet [4.6 to 6.1 m] long, and fitted with appliances for admitting the steam at any desired pressure, and a door at each end of the box permitting the entry of the car, and then so arranged that the doors can be closed, thus making a practically air-tight compartment. The steam is turned on for about 15 minutes, the chest is then opened and the cars run into the shucking shed, where employees, each provided with a knife, are able to separate very easily the oysters from the shell. After they are steamed and shucked they are washed in cold water and sent to the fillers' table. Here they are placed in cans, weighed and hermetically sealed. The cans are then put into a cylindrical basket and lowered into the process kettle, in which they are steamed to a sufficient degree to kill all germs of fermentation. After coming from the process kettle, they are cooled in a large vat of cold water and then transferred to the labeling and packing department. The total cost of handling a bushel of oysters in the Baltimore canneries has been estimated at 29 cents,

Top: labels on oyster cans from the early 1900's. From *Fishing Gazette*, courtesy of *National Fisherman* magazine. Bottom: oyster advertisements from the middle 1800's. From Nichol, 1937.





while the average price during recent years of a bushel of oysters for the canning trade has been about 55 cents."

Production Variability

As with farm crops, oyster production has not always proceeded smoothly. Available oyster supplies could be larger or smaller than market demand. When demand was strong and supplies short, buyers had to accept whatever sizes and quality of oysters the growers had to sell. But when supplies were ample, buyers were selective in what they would purchase. Ample supplies usually were available whenever sets had been good. A series of poor sets, losses from storms, and unexplained mortalities reduced supplies, and oyster meats varied in fatness. A dry spring and summer meant thinner than usual meats, and more oysters would be needed to fill containers. Stormy weather, freeze-ups, and labor shortages on vessels and docks during peak demand periods also hindered production.

The Industry's "Golden Age," 1860–1906

As the U.S. population grew and spread in the second half of the 1800's, so did the demand for oysters. Railroad development between 1840 and 1860 and the transcontinental link in 1869 greatly expanded the nation's oyster markets (Fig. 23). (The United States had 4,500 km of railroad line in 1840 and 50,000 km of line in 1860 (Anonymous, 1975)). Spurred by the increased demand and profits being made, oyster culture expanded in Long Island Sound with more boats, while more dredge boats harvested the vast quantities of oysters in Delaware Bay, Chesapeake Bay, and along the U.S. Gulf coast, and more oyster packing houses were built to facilitate shucking and packing. Besides, late in the century, vessels were being fitted with engines to replace sails when Atlantic coast oyster production at times surged above 20 million bushels/year.[4]

[4]Population growth, development of railroad lines with ice preservation of perishable cargoes, more and better sailing vessels, and, after 1830, year-round availability of large supplies of natural ice from ponds and lakes also spurred a large expansion of finfisheries along the Atlantic coast, especially in New England (Chapelle, 1973).

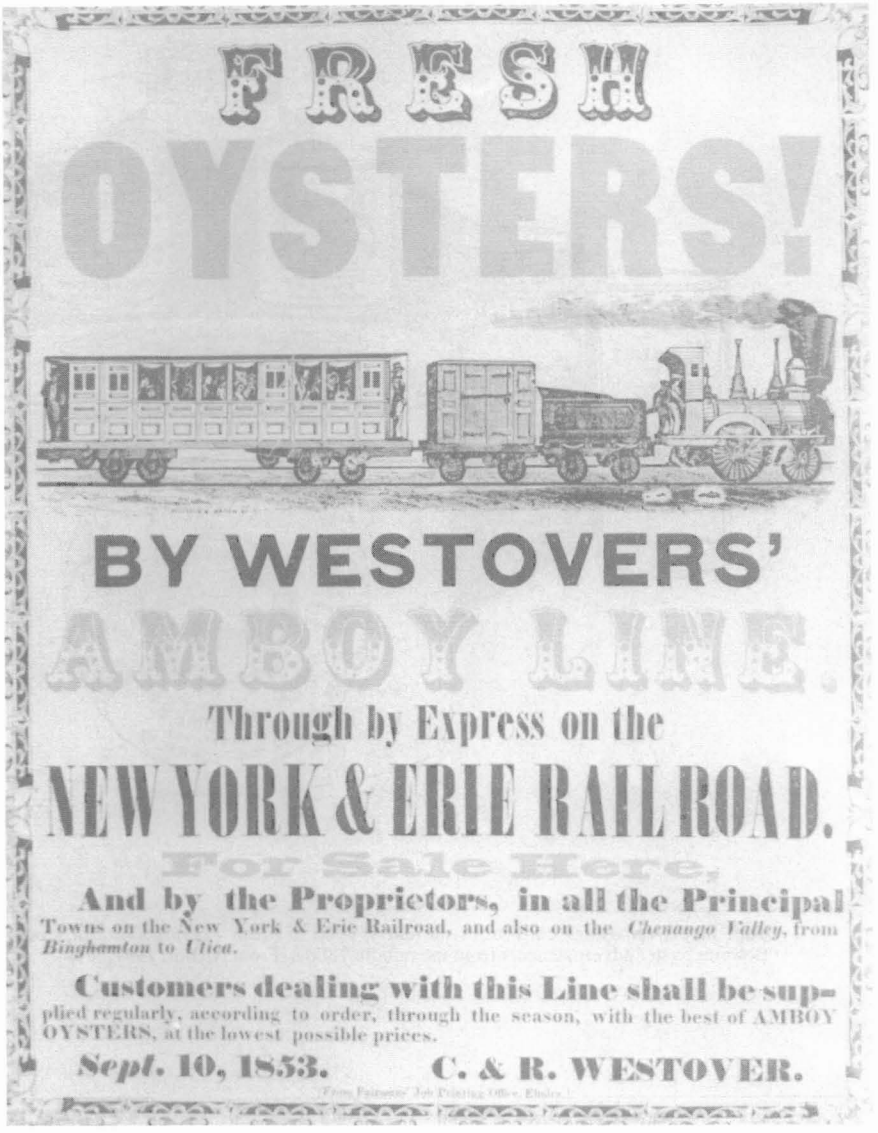


Figure 23.—Oysters were transported inland by railroad as the lines were laid down in the 1800's and into the 1900's. The New York and Erie Railroad carried oysters harvested in Raritan Bay; most oysters planted there came initially from Chesapeake Bay. Illustration provided by author; original source unknown.

Oyster Popularity Booms

Oysters, harvested in huge quantities in the mid 1800's to early 1900's, became a popular fresh food for Americans. The major oyster markets were New York City (Fig. 24–27), Philadelphia (Fig. 28–30), Baltimore, and New Orleans, but they were also eaten fresh in all coastal towns and cities and inland population centers "as far as railroads and careful packing could get oysters without spoilage" (Furnas, 1969). Major inland cities importing oysters from the east coast were Pittsburgh, Cincinnati, Cleveland, Detroit, Chicago, Milwaukee, St. Louis, St. Paul, and Minneapolis (Anonymous, 1896). In the 1890's, the railroad rate for shipping 500-pound lots of oysters to Chicago was $1.50/hundred pounds (Anonymous, 1895a).

After about 1880, most fresh oysters were shipped as meats to avoid high freight costs for whole oysters (Anonymous, 1906b). Rather than shipping in

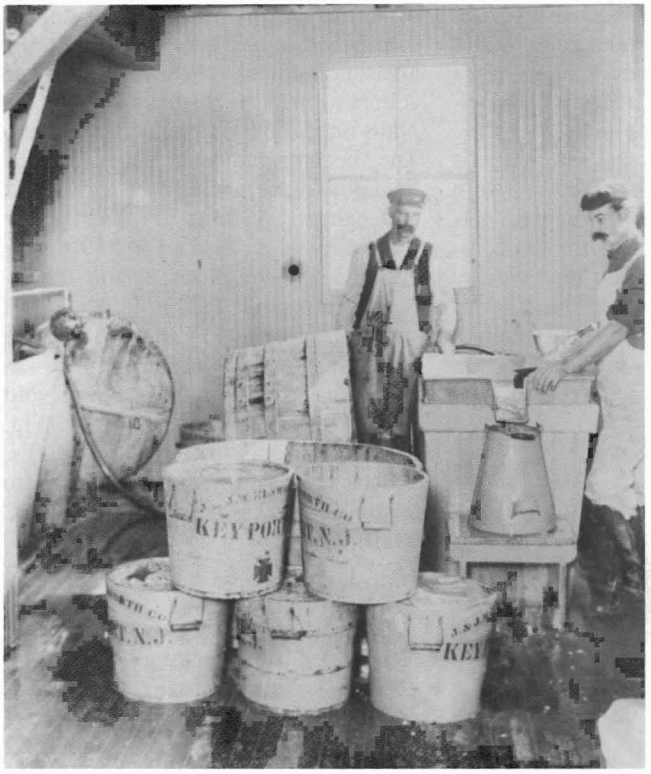


Figure 24.—Packing oyster meats in metal cans at Keyport, N.J., ca. 1910; the cans were then placed in wooden tubs and covered with ice. Photograph courtesy of the Steamboat Dock Museum, Keyport, N.J.

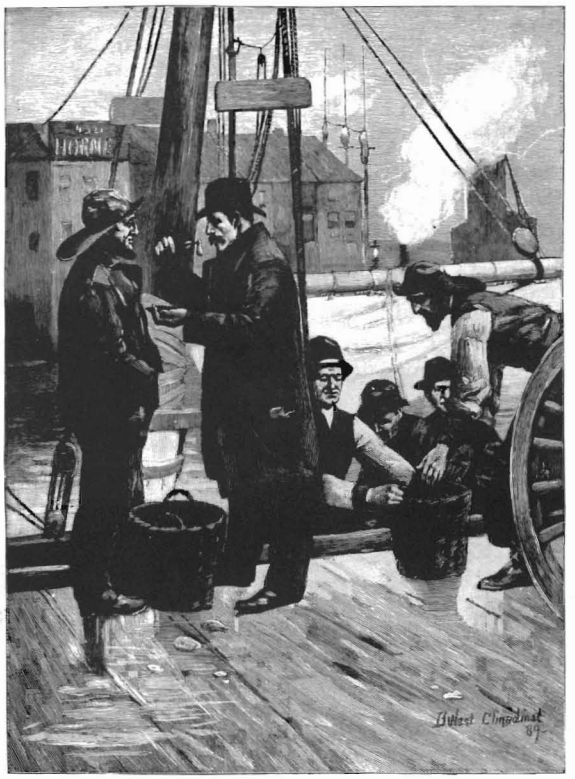


Figure 25.—Sampling oysters on the dock; the man eating them probably is a potential buyer. Source: *Harper's Weekly*, 2 March 1889, and courtesy of Frederick Parks.

Figure 26.—A street vendor selling oysters on the half-shell. The Oyster Stand, ca. 1840–44, by Nicolino Calyo, donated by Mrs. Francis P. Garvan to the Museum of the City of New York.

Figure 27.—An oyster establishment in New York City, mid to late 1800's. From *Harper's Weekly*, ca. 1967, courtesy of Frederick Parks.

hermetically sealed cans developed earlier, dealers packed the meats in wooden tubs (holding 5 or 6 gallons) or half barrels (holding 25 gallons), placing a large piece of ice[5] in the middle of the meats to preserve them; a head was then

[5]The ice used in direct contact with oyster meats probably was artificially made; much purer than natural pond or lake ice, it was also inexpensive. Artificial ice first became available around 1880 (White, 1976; Jones, 1984).

nailed onto the tub. The empty tubs were returned to the dealers for reuse. Loss of oysters thus shipped was slight, perhaps less than 1 gallon in 2,000, and that only when delayed in transit or by some transportation accident (Anonymous, 1909c).

Any whole oysters shipped in barrels were packed so they would not open, lose their shell liquid, and become dry. Workers emptied the oysters into barrels, shook the barrels to pack the oysters tightly, heaped their tops with more oysters, and then nailed a burlap cover tightly over them, to keep them tightly packed. The largest companies were shipping oysters to as many as 100 dealers in 50 cities (Anonymous, 1909f).

According to Parks (1985), Americans (in the mid to late 1800's) were enveloped in a "great oyster craze," noting: "No evening of pleasure was complete without oysters; no host worthy of the name failed to serve 'the luscious bivalves,' as they were actually called, to his guests. In every town there were oyster parlors, oyster cellars, oyster saloons, and oyster bars, houses, stalls, and lunchrooms" (Fig. 31, 32). Oyster cellars were in the basements of homes, plain on the outside but fancy inside. They became gathering places for politicians and the socially elite (Karnitz and Karnitz, 1993a). By 1874, New York City alone had over 850 oyster cellars, saloons, houses, and lunchrooms (Ingersoll, 1881).

Oysters were also sold from house to house in cities by street peddlers. In Baltimore, for example, peddlers sold shucked meats in the late 1800's (Fig. 33) and probably into the early 1900's, and the street sale of whole oysters there continued into the late 1900's (Freeman, 1989).

Figure 28.—A Philadelphia oyster cellar, ca. 1830. Courtesy of the Historical Society of Pennsylvania.

Consumption

Describing oyster consumption in New York City, Ingersoll (1887) wrote: "Oysters pickled, stewed, baked, roasted, fried, and scalloped; oysters made into soups, patties, and puddings; oysters with condiments and without condiments; oysters for breakfast, dinner, supper; oysters without stint or limit, fresh as the pure air, and almost as abundant, are daily offered to the palates of the Manhattanese, and appreciated with all the gratitude which such a bounty of nature ought to inspire."

Oysters were also commonly served separately in stews with cream, fried in

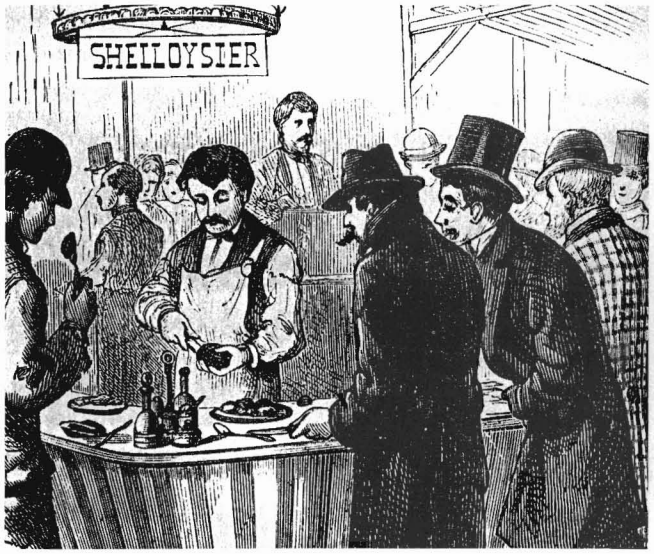


Figure 29.—Serving oysters at a bar in Philadelphia in the 1800's. Courtesy of the Travelers Insurance Company, Hartford, Conn.

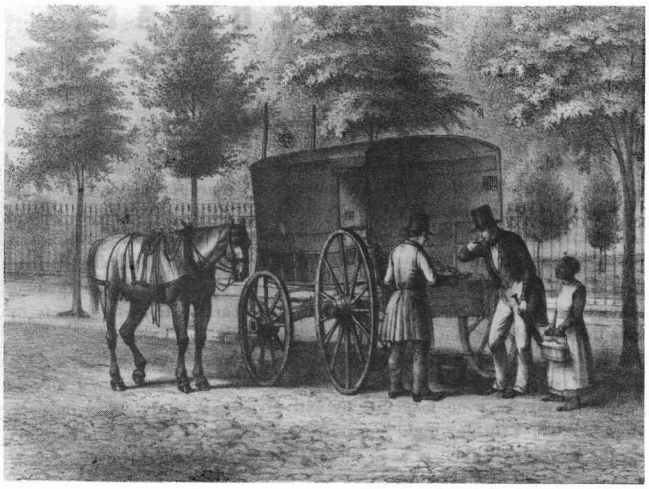


Figure 30.—Selling oysters on the half-shell off the back of a wagon in Philadelphia, 1853. Courtesy of the Historical Society of Pennsylvania.

Figure 31.—One of many hundreds of lunch rooms which served oysters, this one on Staten Island, N.Y., 1898. Photograph courtesy of the Staten Island Historical Society.

Figure 32.—An Oyster Supper. "We Don't Go Home 'Till Morning." By N. Currier. From the Harry T. Peter Collection of the Museum of the City of New York.

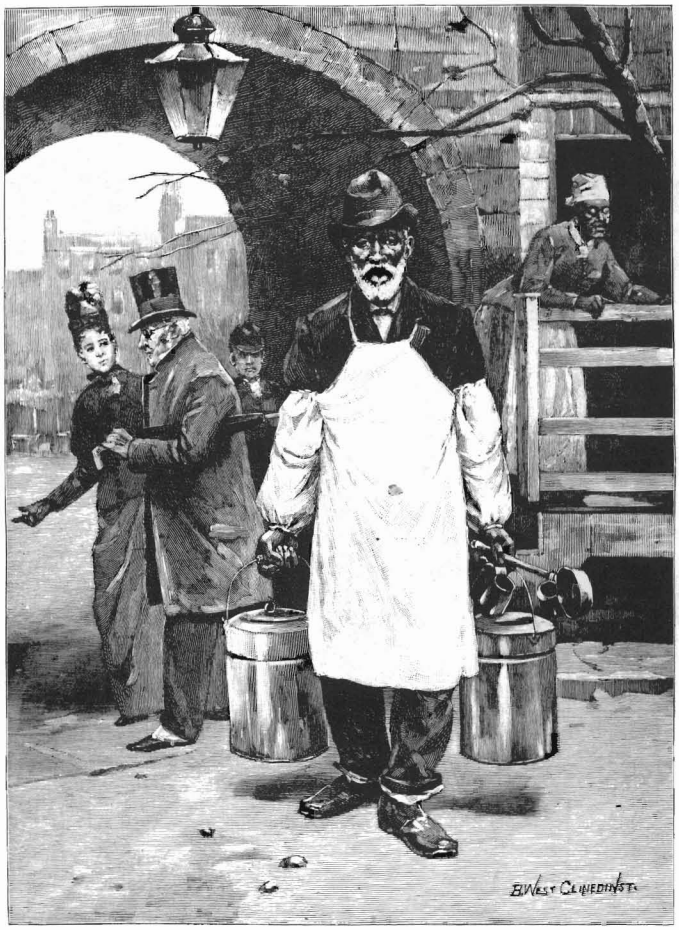


Figure 33.—Peddling oyster meats in Baltimore, Md., 1800's. Source: *Harper's Weekly*, 2 March 1889, and courtesy of Frederick Parks.

Figure 34.—Serving Cape May (Delaware Bay) oysters on the half-shell from a wagon, 1800's. From *A Century After: Picturesque Glimpses of Philadelphia and Pennsylvania.*

heavy batter, and baked in rich sauces in many types of dishes, and with fish, lobsters, crabs, clams, and crayfish (Furnas, 1969; Parks, 1985). Eating establishments along the Gulf of Mexico have long served a sandwich with 6 or 12 oysters termed a "po boy" (poor boy).

By the early 1900's, New Yorkers were still consuming 500,000 bushels of oysters/season, or an average of two meals of oysters per person per week in the greater city (Anonymous, 1907a). An estimated annual per capita consumption was 660 oysters in New York City, 60 oysters in London, and 26 oysters in Paris (Anonymous, 1916b). In the early 1900's, a bowl of oyster stew cost $0.30 (Anonymous, 1909d). In that period, a typical family of 5 or 6 had an income of $12–15/week (Anonymous, 1909c). In 1919, an oyster stew cost $0.35, and fried oysters were $0.40/half dozen and $0.75/dozen in Washington, D.C. (Anonymous, 1919d).

In the 1870's, the 1 million people of Philadelphia and its suburbs were consuming an average of 6 oysters/week, or 12/week during the oyster marketing season. Some 2,419 Philadelphia establishments (hotels, oyster houses, restaurants, and beer saloons) served oysters, besides 158 peddlers and curbstone stands (Ingersoll, 1881). Even as late as the 1920's, most every small eating place in Philadelphia displayed a sign "Oysters" in its window (McCarthy, 1923).

In 1917, the people of New Orleans consumed about 750,000 bushels of oysters/year, or about one-third of the state's production. About three-fourth's of New Orleans' consumption took place between 1 October and 1 April (Anonymous, 1917b).

Preferred Estuaries and Shell Shapes

Oysters harvested from particular estuaries had their own loyal followings. For oysters on the half-shell, many establishments served 10–15 varieties simultaneously. Some famous oyster names were Malpeques, Wellfleets, Cotuits, Narragansetts, New Havens, Saddle-rocks, Blue Points, Rockaways, Perth Amboys, Raritan Bays, Shrewsburys, Absecon Salts, Cape May Salts (Fig. 34), Maurice Coves, Lynnhavens, Chincoteagues, Assateagues, Roanokes, Tangier Sounds, Apalachicolas, Barataria Bays, and Olympias (Parks, 1985). Gourmets claimed they could identify each one by its taste.

Consumers of oysters on the half-shell have wanted the shells to be oval rather than long and narrow. Oval oysters have grown as singles or doubles on hard bottom, whereas the long, narrow oysters grow in clusters or on soft mud or both. Connecticut growers have transplanted their oysters every year so they will grow in an oval shape and

bring good prices. The quality of Canadian Maritimes oysters is based solely on shape; the principal market for those oysters is Quebec, with principally a French population which prefers oval oysters. The only area in which the shape of oysters has actually been measured when selling is in the Maritimes, where oysters have been sold in three main categories. To be "choice," the best grade, the length of the oyster is no more than 1.5 times its width. For "standard," the medium grade, the length is between 1.5 and 2 times the width, and for "commercial" grade, the lowest, the length is more than 2 times the width. The "choice" grade oysters bring fishermen about 3 times as much as the "commercial" grade oysters.

An important aspect of oyster quality is saltiness of taste. Many people in the northeast prefer the saltiness (strong flavor) of Long Island Sound, Maritimes, and Chincoteague oysters grown in salinities of 24–27 ‰; the flavor of the three oysters is similar. In contrast, many people in the mid-Atlantic region and in the Midwest prefer the blander flavor of Chesapeake Bay oysters grown in waters of salinities of 7–12 ‰, and many people in the eastern United States prefer the flavor of eastern oysters to that of Pacific oysters eaten raw; Pacific oysters eaten in the eastern United States often have a markedly different flavor than eastern oysters grown in Long Island Sound, the Maritimes, and Chincoteague Bay. Gulf coast oysters have a slightly different taste than Atlantic coast oysters (personal observ.).

In the early 1900's, Julius Nelson, the State biologist of New Jersey, said (perhaps in jest) that in frequent cases raw oysters were swallowed without chewing, so that some people never got the flavor of the meat itself. They simply got the taste of sea water and a whiff of the odor of the mud on which the oyster grew, and this was supposed to be the specific flavor of an oyster (Anonymous, 1912c).

Consumers of oysters on the half-shell also prefer oysters that are free or nearly free of black mud blisters caused by the worm *Polydora websteri* on the inside of the shell (Fig. 35) which otherwise appears white with some pale yellow patches. While blisters reduce the aesthetic appeal of the shell, they do not harm the flavor or food value. Oysters from Prince Edward Island usually are free of the blisters (Medcof, 1961), those from Long Island Sound are nearly free of the blisters, whereas oysters from Chesapeake Bay often have several such blisters which can

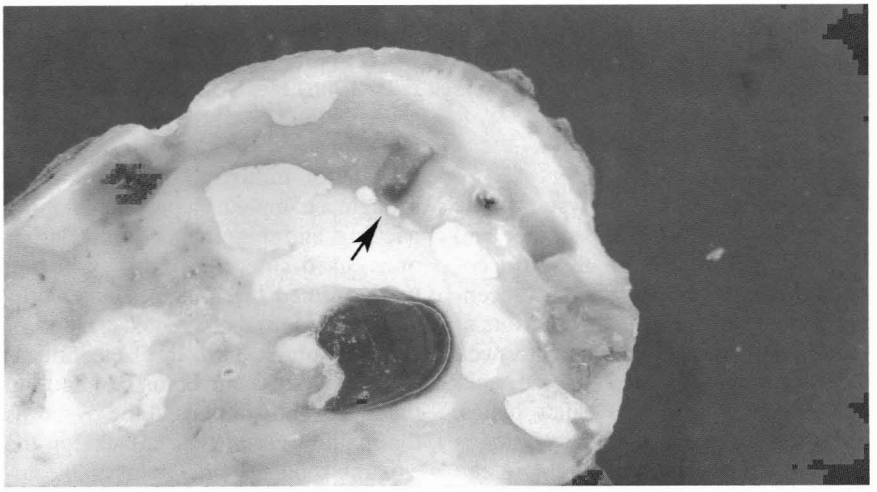


Figure 35.—Dark mud blisters are caused by a small worm (arrow).

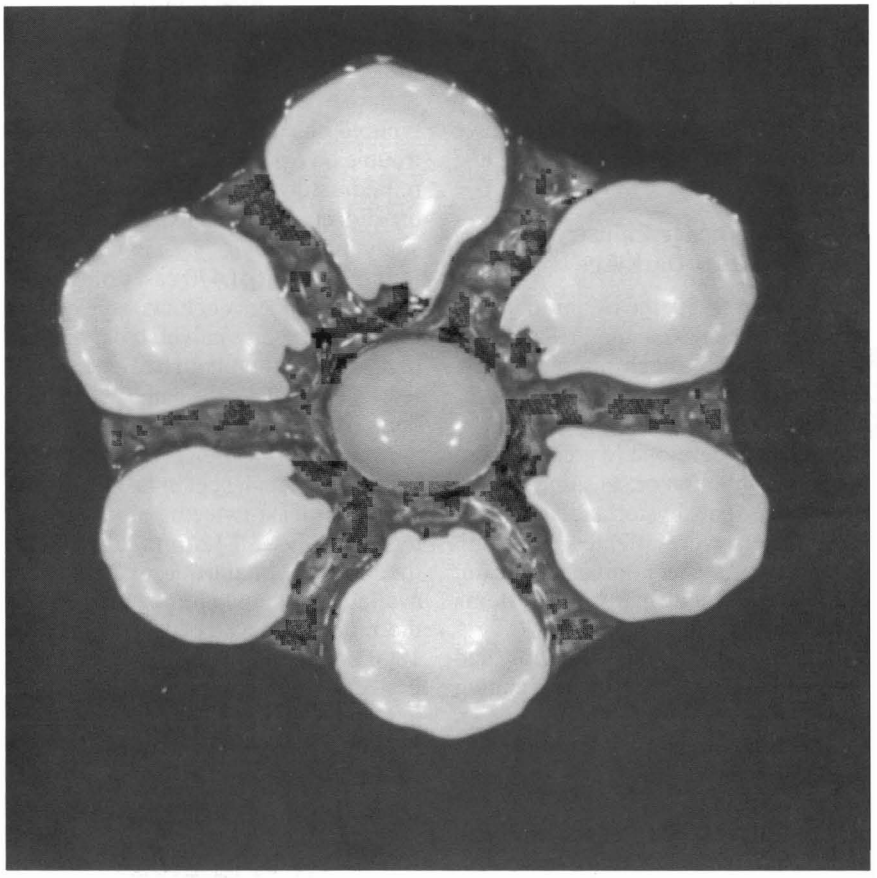


Figure 36.—A special plate for serving oysters. Photograph by the author.

cover at least a third of the interior surface of the shell. As is true with all oyster pests, the numbers of mud blisters in shells vary among years.

Oyster Plates

The great popularity of oysters in the late 1800's led to the appearance and popularity of highly ornate and decorated oyster plates. Most had six receptacles made to resemble the interiors of oyster shells, and usually a center well to hold a wedge of lemon or some cocktail sauce (Fig. 36). The fancy plates, ordered for American use by famous china distributors, were kept in the homes of the affluent in their butler pantries and dining rooms. Special forks were also made to pick up the oyster meats (Parks, 1985; Karnitz and Karnitz, 1993a). Nearly all oyster plates remaining today were made in the period from 1860 to 1910 and are highly prized by collectors. Such plates have also been made in Europe (Karnitz and Karnitz, 1993a).

The Oyster Industry's First "Dark Age"

Soon after 1900, the oyster industry, which had been expanding since 1885, began to face a much poorer market demand. Owing to a variety of health-related problems in the early 1900's, the United States developed a great concern for good sanitation or, as some termed it, a "pure-food hysteria." Nearly all food dealers were affected including producers of oysters, milk, ice cream, candy, drugs, and many other items (Anonymous, 1909b).

In the 1800's, oyster packing had been carried out under widely ranging sanitation conditions. Little was known about sanitation, and little thought had been given to the possibility that oysters could pick up diseases in beds and packing plants. But outbreaks of typhoid (*Salmonella typhosa*) and gastrointestinal disorders were common, and some were tied to the consumption of oysters. Articles about the oyster-typhoid connection were printed frequently in newspapers. Oysters could have picked up the typhoid organism in beds polluted with domestic sewage or during transporting or processing from water, flies, or from the hands of a worker harboring it.

In 1906, the U.S. Congress passed several "Pure Food Laws" which regulated the food business generally. For the oyster industry, the regulations brought a complete change in handling, packing, and shipping methods. Earlier ones, used since the industry began, were deemed inadequate. Health officials and journalists vented a flood of criticism about the lack of cleanliness of oyster beds and industry handling practices, and some used the oyster as the main target of their attacks on the existing food system. Owing to the adverse publicity, much of which the oyster industry believed was unfair and misleading, the public began to draw away from its regular use of oysters, and it became much less fashionable to eat oysters (Killian, 1918).

Some people blamed every case of typhoid poisoning and gastrointestinal trouble on oysters if the patient had admitted eating them. The oyster industry did not accept this, pointing to a study in Brooklyn, N.Y., in which only four people out of 470 cases of typhoid had eaten oysters or clams, and another in New York City in which only 15 out of 450 cases of typhoid had eaten shellfish. Nevertheless, the damage had been done (Anonymous, 1916b).

Many people began switching to beef, even though beef in 1909 cost consumers at least twice as much as oysters ($0.30 vs. $0.12/lb.) (Table 1). By then, ample quantities of beef were available in population centers. When the railroads developed in the middle 1800's, the beef industry had exploded in size with large stock yards being built in Kansas City and Chicago.

Government officials soon took steps to determine how to handle oysters properly. By 1909, they condemned the practices of shipping fresh oyster meats in wooden buckets and barrels, shipping the meats in direct contact with ice, and adding water or any foreign substance (Anonymous, 1909e). Can manufacturers helped the situation by producing improved single cans with patented tops for shipping fresh meats. The Federal Department of Food and Drugs also refused to permit the floating of oysters except in the same water in which they were grown. This was an additional hardship to the packers. The more stringent rules forced many packing houses in Maryland and Virginia to close (Jennings, 1930).

Afterward, with the industry's cooperation, fresh oyster meats had to be shipped in sealed cans, usually in sizes of 1, 3, or 5 gallons. Cans were placed in boxes, and ice was packed around them. Such packs were sanitary (Moore, 1915) but more costly than shipping oyster meats in the wooden tubs (Anonymous, 1917a). The cans of fresh oysters were shipped in refrigerator railroad cars. From 3 to 4 and sometimes 5 tons of ice was spread over the cans in each full carload. According to the size of car, insulation, and the weather, it was often necessary to re-ice a car in transit with from 0.5 to 3 tons of ice. The average loading of oyster meats/car was 18,000 pounds (Anonymous, 1916a).

Food Inspection Decision No. 110 issued in 1909 prohibited the growing of oysters in polluted waters. The decree was that every condition surrounding the oyster from beds to consumer tables should be sanitary to the highest degree[6] (Anonymous, 1910b).

Lee (1914) reported that the last big production year in Virginia was 1907, because until then the state was producing about 10 million bushels of oysters a year; after the scare, he said production dropped to 4 million bushels a year. Various states, including Virginia, had

Table 1.—Comparison of retail price/pound of oyster meat with beef, chicken, fish, and eggs in 1909 and 1996.

Item	Retail price/lb.	
	1909 (minus refuse[1])	1996
Oyster meat	$0.12	$9.00
Beef	0.24 ($0.30)	2.00
Chicken	0.25 (0.356)	0.99
Fish	0.15 (0.30)	4.50
Eggs	0.24 (0.30)	1.49

[1] Bones, fat, scales, head, shells.

[6]Frank W. Darling, an oyster grower and packer in Virginia said: "When an attempt was made in my State to have the General assembly pass a pollution [control] bill, we were told that if our oyster grounds were being ruined by pollution caused by the increase in population, we must not object, but politely stand aside, give up our business and not interfere with the march of progress" (Anonymous, 1916d).

large oyster supplies, but they had to leave most in the beds for the next season because only a portion could be sold (Anonymous, 1910a). The result was severe injury to the industry in loss of sales, and while other foods were nearly doubling in price between 1905 and 1917, oyster prices stagnated or declined even though production costs increased. Oyster company profits became minimal, and many companies failed in business or were merged. The poor demand and low prices brought critically low incomes throughout the oyster industry, to company workers on boats and in plants and to public fishermen (Anonymous, 1917d). William H. Killian (1918), President of the Oyster Growers and Dealers Association of North America, thus termed the period the industry's "Dark Age."

The Oyster Industry's Second "Dark Age"

The U.S. oyster industry was again seriously imperiled in 1924 when many people, but mainly in Chicago, became ill, with some dying of typhoid, after eating oysters. As far as is known, the oysters involved had been harvested in Raritan Bay, N.Y. and N.J., just south of New York City. The illnesses and tainted oysters were highly publicized by newspapers and radio stations (Kochiss, 1974), and oyster demand fell 50–80% in almost every section of the country, as suspicion was cast over all oysters. McCarthy (1925) termed the scare "the greatest disaster which ever befell the industry."

Additional causes of the decline in oyster production in the 1920's may have been related to the Prohibition Era and a loss of labor. During Prohibition, which lasted from 1918 into the early 1930's, saloons and other drinking places where many oysters had been served were legally closed. No analysis has yet been made of this impact. During the same general era, *The Fishing Gazette* frequently mentioned labor shortages in the Chesapeake Bay shucking houses during World War I, and the 1920's was a period of development during which labor was attracted to other industries by higher wages.

The Oyster Industry's Third "Dark Age"

A third "Dark Age" began for the oyster industry in the late 1950's when a new disease, later named MSX and caused by the *Haplosporidium nelsoni* parasite, began to kill huge quantities of oysters in Delaware and Chesapeake Bays. Another disease, Dermo (*Perkinsus marinus*) also discovered in the 1950's, has since caused additional heavy mortalities, crippling the oyster industries in those bays. The diseases and consequent large mortalities, which still persist in the mid-1990's, are described in more detail in the sections on Delaware Bay, Upper Chesapeake Bay, and the James River estuary. Neither disease makes the oysters unsafe for human consumption.

MSX, a spore-forming protozoan in the phylum Haplosporidia, is most prevalent along the mid-Atlantic U.S. coast, but is reported from Maine to Florida. Active at temperatures above 10°C, it is intolerant of salinities below 10 ‰. While its mode of transmission to oysters remains unknown, with favorable salinities MSX can spread rapidly over large distances (Andrews and Wood, 1967; Andrews, 1979; Haskin and Ford, 1982; Ford and Tripp, 1996). It was first recognized as the cause of massive oyster mortalities in lower Delaware Bay in 1957 by Haskin et al., (1965) and 2 years later in lower Chesapeake Bay by Andrews and Wood (1967). Some resistance to the MSX disease developed in Delaware Bay oysters within a few years: 90–95% of oysters died during the original epizootic, whereas 70% died by the time they attained market size in later years (Haskin et al., 1965; Ford and Tripp, 1996). Selective breeding programs at Rutgers University and the Virginia Institute of Marine Science developed strains of oysters that suffered far lower mortalities than wild stocks (Andrews, 1968; Haskin and Ford, 1979; Ford and Tripp, 1996).

Dermo is also a protozoan, but in the phylum Apicomplexa. The Dermo disease was identified in the late 1940's as the cause of extensive oyster mortalities in the Gulf of Mexico and was described first by Mackin et al. (1950). In 1950, Dermo was discovered in Chesapeake Bay and was already widely distributed. It kills oysters during the warm months in Chesapeake and Delaware Bays. At temperatures around 20°C, it kills oysters about a month after infection; at temperatures above 25°C, it can kill much more quickly (Andrews, 1965; Hewatt and Andrews, 1955; Fischer et al., 1992). In the mid-1950's, Dermo was found in Delaware Bay, but it disappeared until 1990; since then, along with MSX, it has caused large oyster mortalities. Since 1991, it has also been found in Connecticut, New York, and Massachusetts, but oyster mortalities have been low in those states (Ford, 1996; Ford and Tripp, 1996). Dermo is intolerant of salinity below 8–9 ‰, and 12 ‰ and above is required for a full epizootic (Ford and Tripp, 1996).

A Professional Association

In 1907, during the first "dark age" problems, fearing the oyster industry might collapse, the leading oyster dealers formed the "Oyster Growers and Dealers Association of North America" (Fig. 37). It was instigated by Henry C. Rowe, a large oyster grower in New Haven, Conn., and president of both the Connecticut Oyster Growers' Association and the New York and New England Oyster Shippers' Association (Anonymous, 1911). Members were drawn from all oyster-growing states on the Atlantic, Gulf, and Pacific coasts. It held its first meeting in New York City in 1908, and elected a president, three vice presidents, secretary, treasurer, and 30 directors, representing the trade in ten states, to serve for 1 year.

The association's primary objective was to educate the public that oysters were a wholesome food, high in protein, vitamins, and minerals. In doing so, they anticipated that the oyster trade would return to good times, and that the business of each oyster company might be a financial success. The association caused articles to be printed in many popular magazines, and it published many interesting and attractive advertisements. It also strove to promote the

Figure 37.— Members of the National Oyster Growers and Dealers' Association of North America in session, 1919. *Fishing Gazette* photograph, courtesy of *National Fisherman* magazine.

most sanitary methods for handling oysters and to favor regulations that would insure the purity of all oysters offered for sale (Anonymous, 1908b, c, d). But many people had already condemned oysters, and in 1911 Rowe acknowledged that the Association had not accomplished its goals. While the industry had spent heavily to advertise oysters and to improve their sanitation, it was selling fewer oysters and receiving even less money for them (Anonymous, 1911). The decline in oyster demand in subsequent decades was frequently mentioned in *The Fishing Gazette*.

In 1916, the association brought a complaint to the Interstate Commerce Commission about the railroads threatening to charge extra for the ice they put in cars when oysters were shipped. Until then the railroads had been adding, free of charge, from 3 to 4 and sometimes 5 tons of ice to each car when it was held in bunkers (boxes) to preserve the oysters during the trip. When it was necessary to re-ice a car in transit, another 0.5–3 tons of ice were added. Around 1915, a full railroad car of oysters weighed 18,000 pounds. This presumably included the shucked meats, the cans they were in, the wooden boxes holding the cans, and the ice put in the boxes around the cans; if whole oysters were shipped, it included the barrels.

The railroads were charging the following rates for a full carload: from South Norwalk, Conn., to Chicago, $142; from Crisfield, Md., to Chicago, $127. (The railroad cars returned from Chicago to east coast cities loaded mainly with beef.) In 1916, the railroads wanted to charge an additional $16 for the ice. The association strongly objected to this, claiming the extra charge would seriously handicap and curtail their business. The railroads paid $0.25/ton for ice, and they had the cost of putting ice in the cars and of carrying the weight on the railroad[7] (Anonymous, 1916a).

The association, now called the Shellfish Institute of North America (SINA) and one of the Nation's oldest trade associations, has since included public relations and forming good relations with pertinent Federal agencies in its efforts. It has long sought the help of shellfish researchers in solving the problems of the industry, i.e., predators, diseases, spawning and setting, and oyster bed productivity.

SINA has always held an annual convention for its members. From the 1920's through the 1950's, about 300 members of SINA attended every national meeting along with 200–300 National Shellfisheries Association (NSA) members, made up of shellfish biologists and administrators, but recently attendance has fallen to about 50 members per meeting (Martin[8]). The convention has been held at the same site and time as the NSA convention to allow members of both organizations to share ideas in a 4-day meeting. The convention was commonly held in June at the end of the oyster season (Wallace, 1951). For the past decade or so, the two conventions usually have been held separately.

[7]The owners of some of the oyster companies, e.g., the Bluepoints Company and the Radel Company, had stockholdings in the railroads.

[8]Roy Martin, Vice President, Science and Technology, National Fisheries Institute, 1901 Fort Meyer Drive, Arlington, Va. 22209. Personal commun., 1996.

A National Shellfish Sanitation Program

In 1924, following the serious outbreak of typhoid and crash in demand for oysters, SINA asked the Surgeon General of the U.S. Public Health Service to develop better control methods to ensure the safety of shellfish for consumers (Anonymous, 1985). The public health principles and state controls formulated in 1925 became the basis of the National Shellfish Sanitation Program (NSSP). The principles of shellfish sanitation are:

1) The beds on which shellfish are grown must be identified, inspected, and controlled,
2) The plants in which shellfish are shucked, or otherwise prepared or packed, must be inspected and controlled,
3) The source of shellfish must be identified to prevent one source from being substituted for another,
4) Methods of shipping must be supervised by state agencies, and
5) The shellfish product must conform to established food bacteriological and labeling standards.

The NSSP today sets forth guidelines for the management of state shellfish programs. A voluntary program developed in cooperation with shellfish producing states and the Food and Drug Administration, the NSSP establishes uniform sanitation standards for the growing, harvesting, processing, and interstate shipping of shellfish. The criteria and standards for the sanitary control of shellfish are contained in the NSSP Manual of Operations: Part I, Sanitation of Shellfish Growing Areas; and Part II, Sanitation of the Harvesting and Processing of Shellfish. State agencies have adopted these standards

and incorporated them into laws or regulations.

The shellfish control agency in each state monitors shellfish harvest and distribution to assure that shellfish products are safe for human consumption. Following the standards and guidelines of the NSSP, the states conduct "sanitary surveys" of the harvest areas and their watersheds. Based on these surveys, the states classify shellfish growing waters. The surveys evaluate all factors affecting the quality of shellfish growing areas. Legal notices are published, and, in some states, signs are posted and maps produced to alert harvesters of areas that are prohibited for the harvest of shellfish. States are required to conduct surveys during periods of worst pollution conditions prior to classifying any area as approved, conditionally approved, or restricted.

The primary criterion used to limit areas approved for shellfish harvest is the contamination of water by coliform bacteria, which is generally associated with the presence of human fecal material. Other criteria include the presence of toxic substances, oil, radioisotopes, viruses, and natural marine biotoxins.

Classification of shellfish growing waters is affected by many factors. They include changes in stock abundance, coastal development, sewage treatment practices, dredging activities, the ability of states to conduct sanitary surveys, economic importance of the available shellfish resources, and the ability of states to manage the classification. Trends for each state are found in Table 2. Nationwide there was a 6% decline in approved shellfish-growing waters from 1985 to 1990 (Anonymous, 1991).

Table 2.—Distribution of classified estuarine waters in states mentioned in text, 1985 and 1990. Data refer to states as a whole and not to specific estuary mentioned in the text. (Anonymous, 1991).

	Approved		Conditional		Restricted		Prohibited	
State	1985	1990	1985	1990	1985	1990	1985	1990
Connecticut	73%	68%	1%	2%	15%	12%	11%	19%
New Jersey	59	60	5	5	5	6	31	30
Delaware	91	74	1	1	0	0	8	25
Maryland	96	91	0	5	1	1	4	3
Virginia	83	83	2	1	8	8	8	7
Florida	28	15	39	43	0	5	33	35
Louisiana	52	56	13	10	11	0	24	35
Washington	61	50	19	18	0	11	20	22

Approved Areas

Approved areas are those determined by sanitary surveys to be free of hazardous concentrations of pathogenic organisms or pollution or both. Shellfish may be harvested from the waters at any time.

Conditionally Approved Areas

The conditionally approved classification may be used when the suitability of an area for harvesting shellfish is affected by predictable levels of pollution. Levels of pollution may be related to the performance standards of wastewater treatment facilities discharging effluent, directly or indirectly, into the area. In other cases, the sanitary quality of the area may be affected by seasonal population, nonpoint source pollution, or sporadic use of a dock or harbor facility. The application of the conditionally approved classification requires that the state shellfish control authority develop an area management plan. The plan must include performance standards for sources of pollution, procedures for inspecting and monitoring pollution sources, and adequate monitoring to prevent illegal harvest during the period when the area is closed for harvest. Management of conditionally approved shellfish waters is costly, and some states, because of limited budgets, will use approved and prohibited classifications only. However, the use of the conditionally approved classification has increased as states try to achieve maximum utilization of their shellfish resources.

Restricted Areas

Shellfish production may be classified as restricted when a sanitary survey indicates the presence of limited fecal coliform levels or poisonous or deleterious substances that would make shellfish resources unsafe for direct marketing. Shellfish taken from restricted areas could be safe following purification in a depuration facility or relaying in approved shellfish waters.

Prohibited Areas

Prohibited areas are those closed due to hazardous levels of contamination. Most prohibited areas are closed to shellfishing due to unacceptable quantities of fecal coliform bacteria in the water. The areas may be upgraded when improved sewage treatment facilities have been built, nonpoint runoff to water bodies is decreased, or other sources of contamination have been eliminated. The NSSP also requires that shellfish waters must be classified as prohibited until a sanitary survey has been conducted, and the waters determined to be free of hazardous levels of contamination.

A hypothetical use of the four recognized area classifications is from Jensen (1962) and is shown in Figure 38. The idealized situation depicts an estuary receiving sewage from two cities, "A" and "B." City "A" has complete sewage treatment including chlorination of effluent. City "B" has no sewage treatment. The estuary has been divided into five areas, designated by Roman numerals, on the basis of sanitary survey information:

Approved: Area I. The sanitary survey indicates that sewage from cities "A" and "B" (even with the "A" sewage plant not functioning) would not reach this area in such concentration as to constitute a public-health hazard. The median coliform MPN of the water is less than 70/100 ml. The sanitary quality of the area is independent of sewage treatment at city "A."

Conditionally Approved: Area II. This area is of the same sanitary quality as area I; however, the quality varies with the effectiveness of sewage treatment at city "A." The area would probably be classified prohibited if city "A" had not provided sewage treatment.

Restricted: Area III. Sewage from "B" reaches this area, and the median coliform MPN of water is between 70 and 700 per 100 ml. Shellfish may be used only under specified conditions.

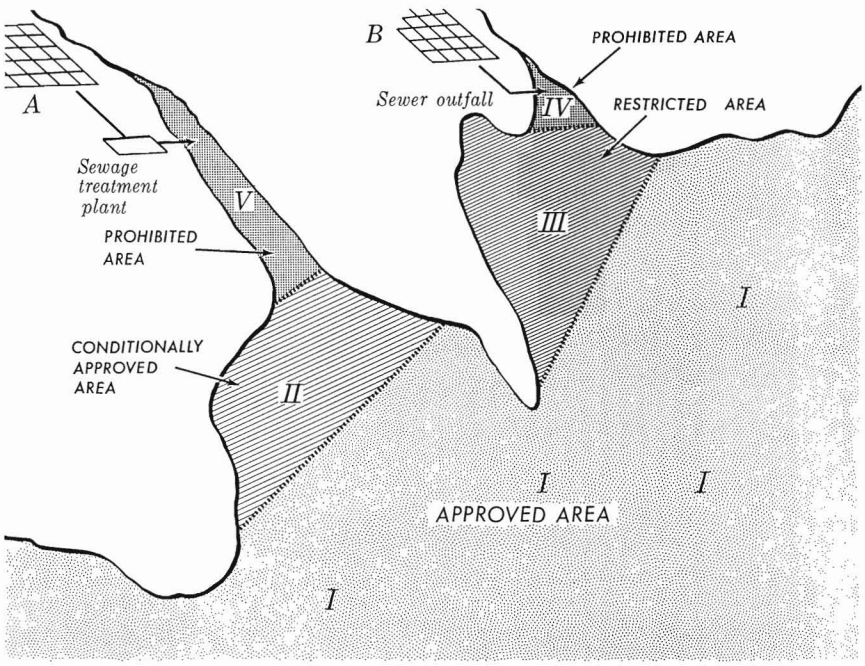


Figure 38.—Hypothetical use of four recognized area classifications (from Jensen, 1962).

Prohibited: Area IV. Direct harvesting from this area is prohibited because of raw sewage from "B." The median coliform MPN of water may exceed 700/100 ml. Area V. Direct harvesting from this area is prohibited because of possible failure of the sewage treatment plant. Closure is based on need for a safety factor rather than coliform content of water or amount of dilution water.

As a result of the typhoid problem in 1924, each state was required to regulate the industry with regard to sanitation. Numbered certificates were issued to each packing house enabling authorities to trace all shipments to a specific packer (Karnitz and Karnitz, 1993b).

Sanitary Improvements

In the early 1900's, high bacterial counts in fresh-packed oysters had often been traced to utensils made of improper material and construction. Oyster fragments and mud had collected in cracks and crevices of buckets, tubs, and skimmers unless they were crack-proof and noncorroding.

Public officials forced additional measures onto the packers. In the 1920's, plants switched to using Monel Metal (65% nickel, 28% copper, 5% all other metals) which does not rust, and buckets, washing tanks, and skimmers were made with rounded corners so that particles could not become lodged and breed bacteria. From the blowers (Fig. 18), oyster meats were poured over a large skimmer and put into sanitary gallon cans. Fresh oysters to be shipped in quart and pint cans were measured by hand into cans which were fed automatically into a capping machine and then placed under immediate refrigeration.

From the time oysters had been shucked until they were opened by the dealer or consumer, no human hand had touched them. All equipment and utensils were sterilized at the end of each day. Moreover, the floors of the packing and shipping rooms, made of smooth cement, were washed down each day with powerful streams of water. Packing room walls were painted white, making it impossible for dirt to remain hidden. Plant toilets had dressing rooms, liquid soap, and individual towels. And the plants were closely inspected by state officials to ensure the oysters were handled under proper conditions (Anonymous, 1926).

Oyster Landings and Prices

Leading Production States

In the late 1800's and most of the 1900's, among the major areas described later in this paper, the Chesapeake Bay States of Maryland and Virginia were the leading oyster producers, followed by New Jersey, Louisiana, Connecticut, Florida, Washington, and, finally, the Province of Prince Edward Island. Production has declined in Maryland, Virginia, New Jersey, and Connecticut since the late 1800's-early 1900's, but it has remained fairly steady in Louisiana from 1900 to 1994. It has been variable in Florida and Washington but has not declined overall. Connecticut production has risen sharply since 1970 (Table 3).

Landed Oyster Prices

In the big production years from 1880 to 1910, landed oyster prices were only

Table 3.—Approximate landings of oysters (thousand U.S. standard bushels) in Prince Edward Island (from Morse, 1971, and Fisheries Statistics Branch, Dep. Fish. Oceans, Monction, N.B.) and various states, every 10 years, 1880–1990 and 1994 (from Lyles, 1969, and Fisheries Statistics Division, NMFS, Silver Spring, Md.).

	Landings (1,000 bu.)							
Year	P.E.I	Conn.	N.J.	Md.	Va.	Fla.	La.	Wash.[1]
1880	51	318	2,443	14,374	9,964	69	255	
1890	88	1,834	1,406	14,170	8,852	409	728	
1900	45	2,407	2,588	7,710	8,843	776	1,036	
1910	28	1,276	1,197	7,455	6,421	289	2,665	
1920	7	670	1,952	6,166	4,701	384	970	
1930	12	729	1,629	3,421	4,293	381	1,040	29
1940	10	501	818	3,949	3,876	170	2,664	1,208
1950	41	465	997	2,881	3,402	221	1,870	886
1960	35	47	23	2,354	3,357	490	1,783	1,151
1970	12	16	93	3,325	1,760	907	1,854	813
1980	31	90	104	2,989	1,717	1,715	1,491	690
1990	44	214	69	468	295	473	1,521	1,125
1994	36[2]	653	0	163	64	572	2,431	1,123

[1] Thousands of gallons.
[2] 1995 data.

$0.22–0.39/bushel in Chesapeake Bay, about the same in Florida, and only slightly higher in Louisiana. But they were considerably higher in New Jersey, $0.66–0.87/bushel, and higher still in Connecticut, $0.63–1.22/bushel, and in Prince Edward Island they ranged from $1.20 to $2.52/bushel. Prices have generally risen through the years, but did not exceed $1/bushel in Maryland, Virginia, Florida, and Louisiana until after 1940. Prices have escalated rapidly since 1950. Prices for New Jersey oysters have been considerably above those in states to the south, while prices for Connecticut and Prince Edward Island oysters have been similar to one another and much above those in New Jersey (Table 4). The northern oysters sold for more than those from the south because they were nearer to markets, they yielded more meats per bushel at 8–11 pints vs. 6 pints (Lee, 1914), and they have fewer mud blisters on the insides of their shells than those from Chesapeake Bay.

During the 1995–96 oyster season, the prices fishermen received for oysters varied widely in the major producing areas: Connecticut, $50–$60/bushel; New Jersey, $18–$20/bushel; Maryland, $16/bushel; Virginia, $20–$25/bushel; Apalachicola Bay, $9.35–$10.50/bushel ($8–$9/60-pound sack); and Louisiana, $14/bushel ($12/60-pound sack). While Gulf of Mexico oysters bring less than those from Virginia northward, they are easier to raise. Good oyster sets occur every year, and growth to market size takes less time.

Oysters cost relatively little to produce in the beds. The high costs come in the labor involved in the harvesting, packing, shucking, packaging, and transporting aspects.

Comparative Landed Prices of Foods

During 1920–40, landed prices/pound of oyster meats were consistently much higher than those for finfish,($0.06–0.15 vs. $0.02–0.05), but they were roughly similar to those of hogs and cattle (at about $0.06–0.15 vs. $0.05–0.17). Thereafter, they became substantially higher. Farmers' prices for hogs, cattle, and chickens were consistently above that of fishermen's prices for finfish from 1930 to 1960. In 1970 and 1980, the prices for hogs and cattle were higher than for finfish, while chicken prices were similar to fish (Table 5).

Finfish vs. Oysters

During the century from 1880 to 1980, more finfish than oysters were landed at U.S. Atlantic and Gulf coast ports. Through the years, the quantity of finfish landed generally rose while oyster numbers fell. The quantity of finfish landed was about 4.5 times larger than that of oysters in 1880; the multiple increased thereafter and was 52 times larger in 1980. But, owing to the higher and escalating prices of oysters, the landed value of finfish grew only from 2 to 12.6 times higher than oysters from 1922 to 1980, respectively (Table 6).

Consumer Food Prices

In much of the 1800's, oysters were eaten mostly by the well-to-do. In 1885, they cost consumers $0.03 each. As oyster production increased sharply, the consumer price dropped, and by 1889 the most expensive oysters cost $0.01 each; half-shells, $0.006 each, and the smallest, $0.0045 each (Anonymous, 1899). By then, all classes of people ate them, and in the early 1900's, oysters were considered a "poor-man's food." People could get a wholesome oyster

Table 4.—Approximate landed prices of oysters per U.S. standard bushel in Prince Edward Island (P.E.I.) (From Morse, 1971, and Fisheries Statistics Branch, Dep. Fish. Oceans, Moncton, N. B.) and various U.S. states every ten years, 1880-1990 and including 1995 (from Lyles, 1969, and Fisheries Statistics Division, NMFS, Wash., D.C.).

	Landed prices							
Year	P.E.I.[1]	Conn.	N.J.	Md.	Va.	Fla.	La.	Wash[2]
1880	$1.20	$1.22	$0.85	$0.33	$0.22	$0.23	$0.78	
1890	1.20	0.63	0.87	0.34	0.28	0.27	0.41	
1900	1.59	1.09	0.66	0.39	0.30	0.21	0.48	
1910	2.52	0.65	0.68	0.28	0.39	0.50	0.30	
1920	3.23	0.74	1.06	0.37	0.50	0.37	0.51	
1930	2.15	1.12	1.14	0.60	0.53	0.31	0.53	
1940	2.56	1.08	0.87	0.42	0.41	0.29	0.26	$0.48
1950	2.60	2.41	2.90	1.92	1.64	1.77	1.52	2.00
1960	10.34	9.57	6.96	3.58	3.24	0.99	1.29	1.52
1970	15.36	14.00	5.88	2.90	3.08	1.63	1.96	2.88
1980		26.26	11.00	6.63	5.53	2.95	7.58	6.34
1990	78.66	59.60	33.32	19.45	16.68	8.90	17.29	14.72
1994	75.18[3]	49.51		16.15	12.34		8.25	15.60

[1] Values in Canadian dollars.
[2] Dollars/gallon.
[3] 1995 data.

Table 5.—Landed prices per pound of oyster meats in three states, landed prices of cod and flounder (yellowtail), and average prices of meats received by U.S. farmers, every 10 years, 1920-90 and 1994. Sources: for oysters, Lyles (1969) and Fisheries Statistics Division, NMFS, Silver Spring, Md.; for meats, Anonymous (1942, 1992).

	Oyster prices			Fish prices		Meat, poultry prices		
Year	Conn.	Md.	La.	Cod	Flounder	Hogs	Cattle	Chickens
1920	$0.10	$0.07	$0.15			$0.13	$0.09	
1930	0.15	0.12	0.11	$0.03	$0.05	0.08	0.08	
1940	0.14	0.08	0.06	0.03	0.02	0.05	0.08	$0.17
1950	0.31	0.38	0.33	0.06	0.11	0.18	0.23	0.27
1960	1.24	0.71	0.28	0.07	0.08	0.15	0.20	0.17
1970	1.82	0.58	0.42	0.11	0.15	0.23	0.27	0.14
1980	3.40	1.33	1.63	0.30	0.47	0.38	0.62	0.28
1990	7.79	3.89	3.71	0.64	0.89	0.54	0.75	0.33
1994	6.43	3.23	1.77	0.94	1.19			

Table 6.—Comparison of landings (pounds of oyster meats and whole fish) and value of food fish (all species) along the U.S. Atlantic and Gulf of Mexico coasts in various years, 1880–1990. Values for finfish in 1880 and 1902 are not available. Sources: Annual statistical summaries, Bureau of Commercial Fisheries and National Marine Fisheries Service, and Lyles (1969).

	Oysters		Finfish	
Years	Weight[1]	Value[2]	Weight[1]	Value[2]
1880	150,047	$11,694	675,518	
1902	152,931	12,155	791,394	
1922	103,713	12,868	618,055	$26,777
1940	78,487	7,713	866,961	24,240
1960	48,982	26,965	1,034,192	61,298
1980	49,081	70,075	2,553,184	883,178

[1] Thousands of pounds.
[2] Thousands of dollars.

meal for less money than they paid for other protein foods (Usinger[9]). Oysters then were cheaper than other seafoods or meats, especially when the others had bone, fat, heads, or shells removed (Table 1).

In the early 1900's, people paid $0.40–0.50 for an oyster stew in upscale city restaurants (Anonymous, 1907a), while a gallon of oyster meats cost $0.60 (Galpin, 1989). But the relative retail prices of oysters and other protein foods have changed sharply between the early 1900's (1909) and the late 1900's (1996). Oysters now are many times more expensive than the other foods (Table 1).

In recent decades, oyster companies have been too small to advertise their oysters except on a very small scale and in a limited area. The job of promoting sales of oysters and other seafoods has often been done by a public agency in coastal states. Their actions consist of placing recipes in newspapers, mailing out promotional brochures, participating in trade shows, and exhibiting products at national restaurant shows.

The Greatest U.S. and Canadian Oyster Estuaries

Over the centuries, oysters have been harvested from many estuaries in eastern Canada and the United States, but the greatest producers have been: 1) Bedeque Bay, Prince Edward Island (P.E.I.), Can.; 2) New Haven Harbor, Conn.; 3) Delaware Bay, N.J. and Del.; 4) upper Chesapeake Bay, Md.; 5) James River, Va.; 6) Apalachicola Bay, Fla.; 7) Louisiana estuaries; and 8) Washington estuaries: Puget Sound and Willapa Bay (Fig. 2).

Bedeque Bay, Apalachicola Bay, the Louisiana estuaries, and Washington's estuaries have continued as large producers. New Haven Harbor produces somewhat less than it once did, and, mainly because of diseases, production in Delaware Bay, upper Chesapeake Bay, and the James River has fallen substantially.

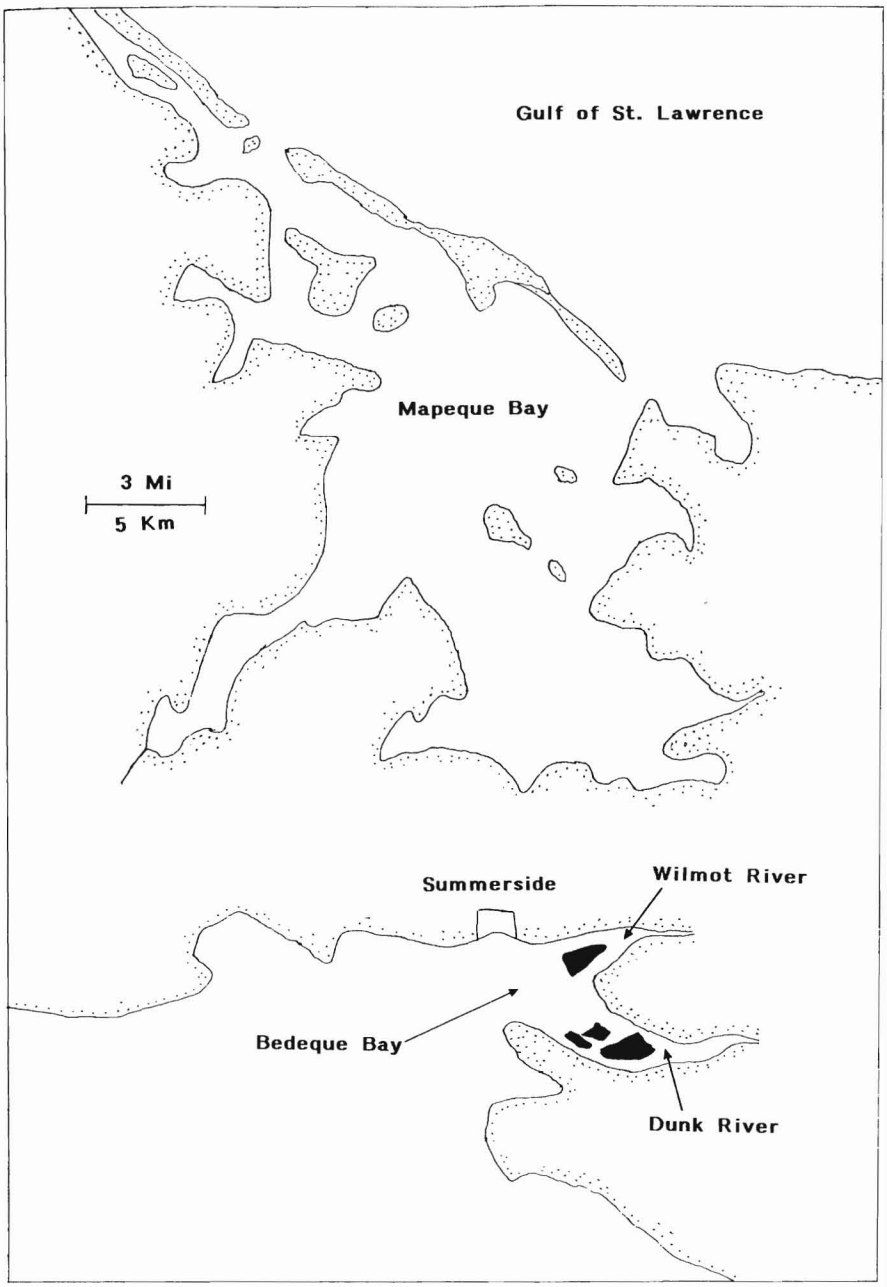


Figure 39.—Bedeque Bay and Malpeque Bay, Prince Edward Island. The oyster beds in Bedeque Bay are shaded.

Bedeque Bay

Bedeque Bay (Fig. 39) consistently produces about half the total oysters in Prince Edward Island (Fig. 40), which leads the three Canadian maritime provinces in oyster production. The bay's oysters are of high quality, i.e., now mostly "choice" grade, based on shell shape. P.E.I. oysters, sold under the trade name of "Malpeque oysters," are shipped mostly to cities of eastern Canada, especially Montreal, and also to many points in the United States. They nearly always are eaten on the half-shell. The oysters have thinner meats than those grown in the United States, and they yield poor returns when sold as meats.

[9]Emil Usinger, President (Retired), Bluepoints Corporation, West Sayville, Long Island, N.Y. Personal commun., 1996.

Figure 40.—Harvesting oysters in Bedeque Bay: Fisherman at left is measuring an oyster; fisherman at right is getting another grab of oysters in about 1.7 m of water. Recent photograph by A. Morrison.

Description

Bedeque Bay, on the south side of Prince Edward Island, faces westward with the town of Summerside, population about 13,600, on its northwest side. Two rivers, the Wilmot and the Dunk, both about 5 km long, flow into its east side. The oyster beds are in the mouths of the rivers and are well protected from storms. The bay has a firm sand-clay-shell bottom with eelgrass, *Zostera marina*, growing in higher salinity regions. Oysters inhabit salinity zones of about 7–15‰ in the spring but reach 25‰ in summer. Most oysters occur at depths from 0.5 to 1.8 m at low tide. The Dunk has somewhat more oysters than the Wilmot. The bay's broad shallow flats are a deep red color that effectively absorb solar radiation. As a result, summer water temperatures are between 21° and 24°C. Commercial-intensity spatfall occurs nearly every year, and the oysters grow rapidly at 25–40 mm/year.

Biota in the bay affect oyster abundance and harvesting. Starfish, *Asterias vulgaris* (and perhaps *A. forbesi*), inhabit bottoms where salinities are above 15‰ just seaward of the oyster beds, and they tend to restrict the seaward distribution of the oysters. During July, when salinities are relatively high, about 25‰, juvenile starfish can settle on the seaward edges of the oyster beds and kill most spat that settle. Those starfish eventually are killed by low salinities in the subsequent spring. Small numbers of Atlantic oyster drills, *Urosalpinx cinerea*, are present in high salinity regions of the Wilmot River, but they do little damage to oysters. Tube worms, *P. websteri*, grow abundantly on oysters along the higher salinity and more seaward borders of the oyster beds, and they are a benefit to harvesting because a cover of the worms prevents oysters from cementing themselves to each other in clusters. When fishermen work on the clusters to obtain market-sized 3-inch oysters, clusters can be cleaned faster, and undersized oysters are separated into singles or small clusters when returned to the bottom. Few are killed, and the oysters can grow into better shapes or grades than in locations where the worms are absent. Tube worms do not tend to bore holes in the shells of live oysters, and market oysters thus have few or no mud blisters on their interior faces. Sea lettuce, *Ulva lactuca*, thrives in the Wilmot River where solid patches cover many oysters and hinder harvesting (MacKenzie, 1975).

About 1–3 spat per large oyster or shell survive to the yearling stage. The resulting oyster clusters consist of several age groups. The best quality oysters ("choice" and "standard" grades) grow along the seaward edges of the beds, while, farther in, the oysters tend to be crowded and many grow long and narrow (the "commercial" grade).

History of Oystering

The earliest history of Bedeque Bay oystering remains incomplete, for there are no known shell middens on its shores. In 1879, Ingersoll (1881) reported a scarcity of oysters in the bay, but that the name "Bedeque oysters" was famous. This implies that the bay was an early producer which may have been overharvested. No records exist of the oystering history in the bay during the next few decades, but we can assume the oysters became abundant again through natural production.

The first act providing for a closed season for oysters was passed in 1864, and forbade the fishing, selling, or possession of oysters from 1 June to 1 September in each year (Arsenault, 1916). In the 1920's, the Canadian government decreed that oysters harvested from P.E.I. waters must be at least 3 inches (7.6 cm) long. This included Bedeque Bay oysters, even though in later years they were all to be relayed to other grounds. Since then, the fishermen have tonged up clusters of oysters and shells, and, with the tong handles pointing skyward, opened the tongs to release the contents onto their culling boards, 18 cm wide, and, with a culling iron, knocked away any undersized oysters (seed) and shells from the market oysters, put the market oysters (usually 1–3 from each lift of the tongs) in a 5-peck wooden box, pushed the seed and shells back overboard, and then pushed the tongs into the water again to get another grab. Some small seed attached to market oysters (perhaps 1/lift) have been killed in the process. The oystermen previously had often taken oyster clusters ashore, culled out the market-sized oysters, and discarded the seed to die.

The early type of boat used by Bedeque oystermen was a common double-bow fishing dory, which was

rowed or sailed to the beds. The culling board was in the bow (Fig. 41). Since the 1940's, fishermen have replaced the dories with outboard motor-powered wooden boats, 4.25 m long, with a square stern; they are still called dories with culling boards still in the bow (Fig. 42).

From 1915 to the 1950's, P.E.I. oysters died in large numbers from "Malpeque Disease" (pathogen unknown). The oysters in Bedeque Bay apparently were one of the first groups to become resistant to the disease and increase in abundance. Morse (1971) implied that in the 1940's the Bedeque Bay oysters were more resistant to Malpeque disease than other Maritimes oysters and that the bay's waters also became polluted in that decade, stating: "Pollution in Bedeque Bay led to transplanting Bedeque oysters to Malpeque. Since the Bedeque stock proved to be disease resistant, the annual movement of such oysters to Malpeque, although requiring double handling or fishing, added to the commercial use of leases in Malpeque in the late 1940's." The Malpeque Bay beds are 20–25 km north of Bedeque Bay. Fishermen harvest the oysters from Malpeque Bay during the September–November marketing season.

In the late 1950's, 1960's, and early 1970's, about 100 fishermen usually harvested Bedeque Bay oysters each spring season (from 1 May to 15 July). Most lived at the shore during the week in temporary shacks or trailers. The harvest rate was about 2.5 bushels (two 100-pound wooden fish boxes) of >3-inch oysters/man/day, or 12.5 bushels/man/week during the 10-week season. During a season, fishermen harvested about half the market-sized oysters available on the beds for a total of 7,500–11,250 bushels (6,000–9,000 boxes)/season. Harvests were fairly consistent from year to year, as reproduction and growth of the oysters matched losses from harvesting. Fishermen stored their oysters on shore during the week and sold them to buyers or put them on their own leases in Malpeque Bay on weekends. In 1972, the percentages of oysters sold in each grade (based on shell shape) were: "fancy," 3; "choice," 35; "standard," 43; and "commercial," 19 (MacKenzie, 1975).

In 1972, the provincial government began a program (overseen at times by the Canadian government) to enhance the industry. In Bedeque Bay, it has involved transplanting overcrowded oysters from low salinity areas to higher

Figure 41.—A fisherman tonging in his dory, which he propelled with oars. Culling board is at the bow, and the tongs have a wooden head, ca. 1920's. Photograph courtesy of the Canadian Department of Fisheries and Oceans, Charlottetown, P.E.I.

Figure 42.—Modern style oyster "dory" used in Bedeque Bay, propelled by outboard motor. The oysters are held in fishboxes which hold about 1.25 U.S. standard bushels. Photograph by A. Morrison.

salinity areas, and enhancing spat collection by spreading shells mined in Malpeque Bay and by scouring shell beds to remove thin layers of silt. About 24,000 bushels of oysters were transplanted, 200,000 bushels of shells were spread, and 20 acres of shells covered by silt were desilted over a period of several years. The result has been a large increase in oyster production to as many as 38,000 bushels a year, and the grade of oysters has increased to 65% "choice" with fewer "commercials" present. The number of fishermen increased to as many as 250 during the early part of seasons, and they have enjoyed more prosperous seasons (Fig. 43, 44) (Jenkins et al., In Press).

New Haven Harbor

New Haven Harbor, Conn., once was the major oystering area in New England. With the harbor as its oystering center, Connecticut became a large producer of market oysters, and it also supplied other areas, such as Narragansett Bay, R.I.; Wellfleet Harbor, Mass.; and Great South Bay, Peconic Bay, and Northport Bay, N.Y., with most of their seed oysters (Fig. 45). Some of the wealthiest and largest oyster firms in the world have been located in Connecticut (Ruge, 1898), and that is the case today.

Description

New Haven Harbor (Fig. 46), fed by the Quinnipiac River, is about 5 km long and has mostly a hard sand-gravel-shell bottom. Its salinity ranges from about 7 to 27‰ along a stretch from the upper part of the river to the main oystering area, while water temperatures range from about 2° to 24°C. Water depths in the main oystering area range from 3.5 to 5.5 m.

Oyster sets of commercial density in New Haven and the remainder of Connecticut to Bridgeport have been irregular from year to year. The New Haven beds received a commercial set in about three of every five years (Nelson[10]). Rarely did a heavy set (>2,000 spat/bushel of shells) occur on most all beds on which companies spread shells. In a good year, a commercial set (at least 1,000 spat/bushel) might occur on at least half the prepared beds. Every August and September, the oystermen ex-

[10]J. Richards Nelson, former President, Long Island Oysters Farms, New Haven, Conn. Personal commun., 1968.

Figure 43.—Measuring a Bedeque Bay oyster, 1996. Photograph by A. Morrison.

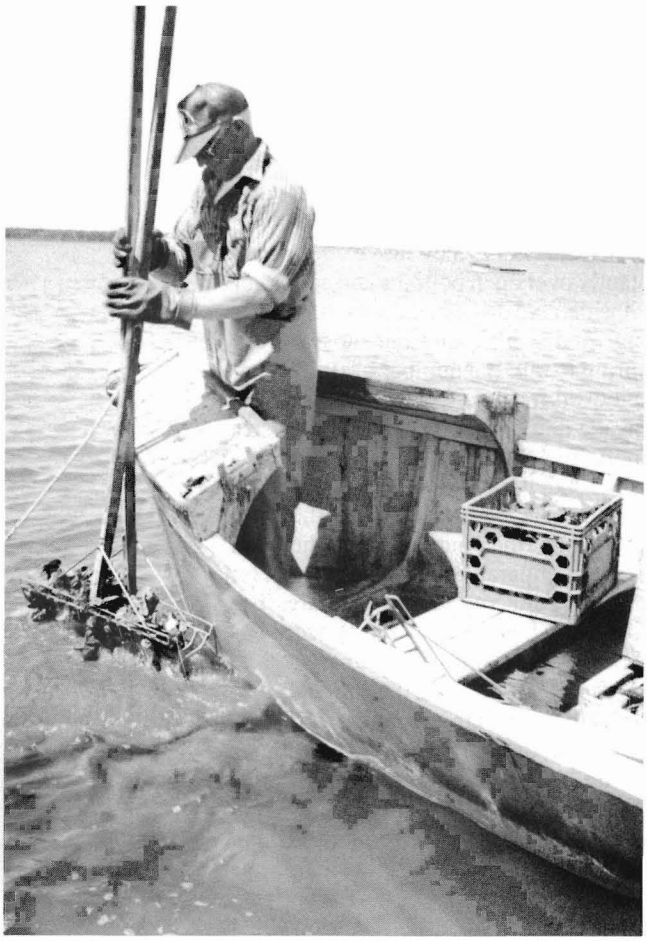


Figure 44.—Tonging for oysters in Bedeque Bay, 1996. Photograph by A. Morrison.

Figure 45.—An advertisement for Connecticut seed oysters, ca. 1926, from the *Fishing Gazette*, courtesy of *National Fisherman* magazine.

amined the shells they had planted on beds to determine whether a commercial set had occurred. Oysters grow about 25 mm/year, and it takes them 3 years to attain market size if they are to be eaten on the half-shell and 4–5 years if they are to be shucked.

Oyster predators present in salinities roughly above 15‰ are starfish, *A. forbesi* (Fig. 47); Atlantic oyster drills (Fig. 48); thick-lip drills, *Eupleura caudata;* and Atlantic rock crab, *Cancer irroratus* (Fig. 49). Xanthid mud crabs (Fig. 50) are present over a wide salinity range. In the late 1960's and early 1970's, predator abundances on various Connecticut beds were: juvenile starfish, mostly 1–6/m^2 but as high as 45/m^2; adult starfish, 1.4/m^2 outside oyster beds but as high as 100/m^2 inside oyster beds; Atlantic oyster drills, 0.3–6.3/m^2; thick-lip drills, 0.5–25.2/m^2; rock crabs, 3–4/m^2 (October–February) and 0.2/m^2 (March–September); and mud crabs, 54/m^2 in winter (MacKenzie, 1981). Starfish are always a menace because they move about constantly over open bottoms and can cover considerable distances, apparently seeking food, year-round but mostly from spring to fall. If a number of starfish are removed from an oyster bed, more can invade it and cause considerable oyster mortalities within a few days. The drills move much more slowly and kill oysters more slowly, but since they are more numerous than starfish, they can kill a comparable number of oysters; drills are inactive at temperatures below 10° C, usually from November–April. Oyster companies currently take measures to control the starfish and drills, but they ignore the crabs.

I made the only scientific survey of oyster abundance in the harbor almost 30 years ago (1968), and a record from only one bed, lot 16, remains. It had 10.36 oysters (2-year-olds) per $foot^2$ (451,282/acre), 722 oysters were in a bushel, and 9,134 bushels were on 20.24 acres of the bed. The numbers may have been typical of many beds in the har-

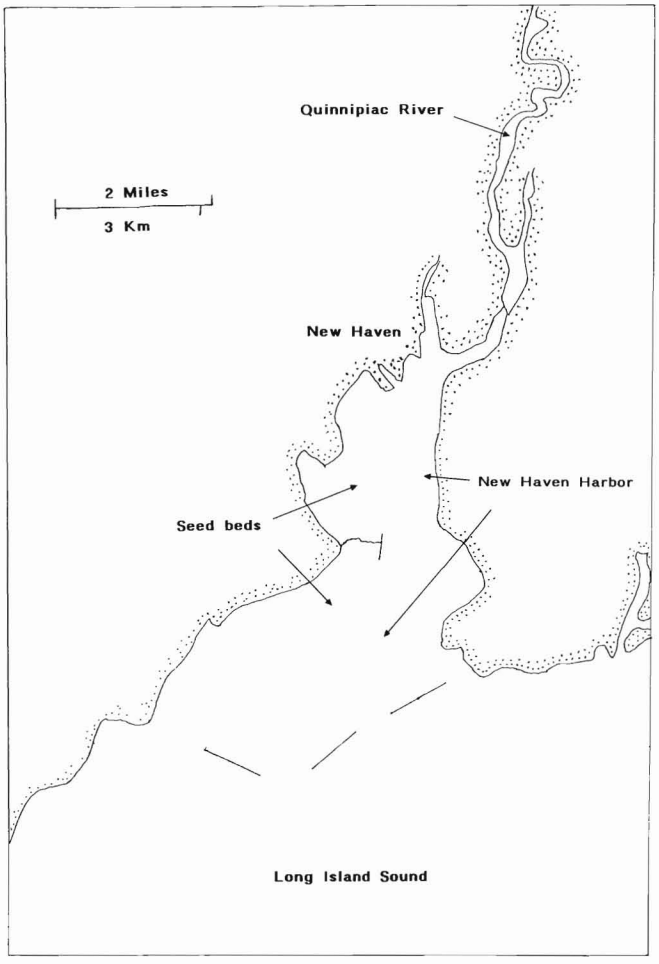


Figure 46.—New Haven Harbor, Conn., showing locations of oyster beds.

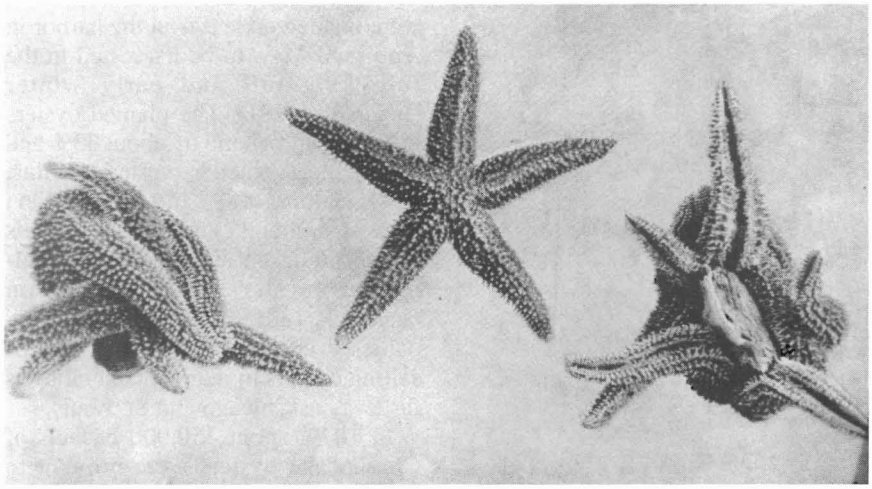


Figure 47.—Starfishes, left and right, destroying oysters (Collins, 1891).

bor. The largest quantity ever seen on a harbor bed (lot 152) was 2,500 bushels of seed (1-year-olds) per acre. One bed in Norwalk had 24 oysters/foot or about 1 million/acre (MacKenzie, 1981).

Since 1912, market-sized oysters have had to be transplanted (relayed) from the New Haven grounds to "approved growing waters" for a period of at least 14 days before being marketed in Connecticut or 30 days in New York. Nearly all oysters are seed when transplanted and take 2–3 years to reach market size.

History of Oystering

Shell heaps along the banks of the Quinnipiac River showed that Ameri-

Figure 48.—The Atlantic oyster drill, *Urosalpinx cinerea*. In Connecticut, it will devour barnacles before oysters, but it remains an important oyster predator. This drill has oyster spat attached to its shell. Photograph courtesy of and copyrighted by R. Noonan.

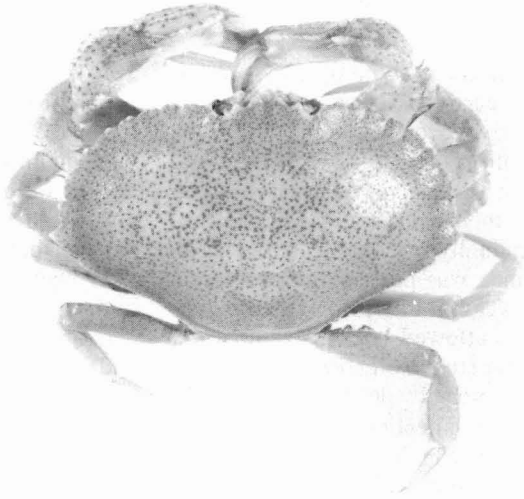


Figure 49.—The rock crab, *Cancer irroratus*.

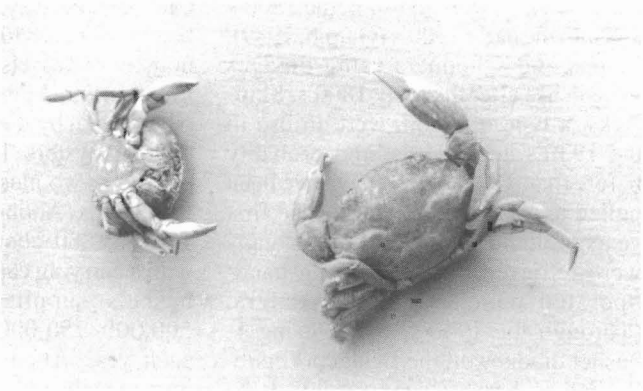


Figure 50.—Xanthid mud crabs. Photograph by the author.

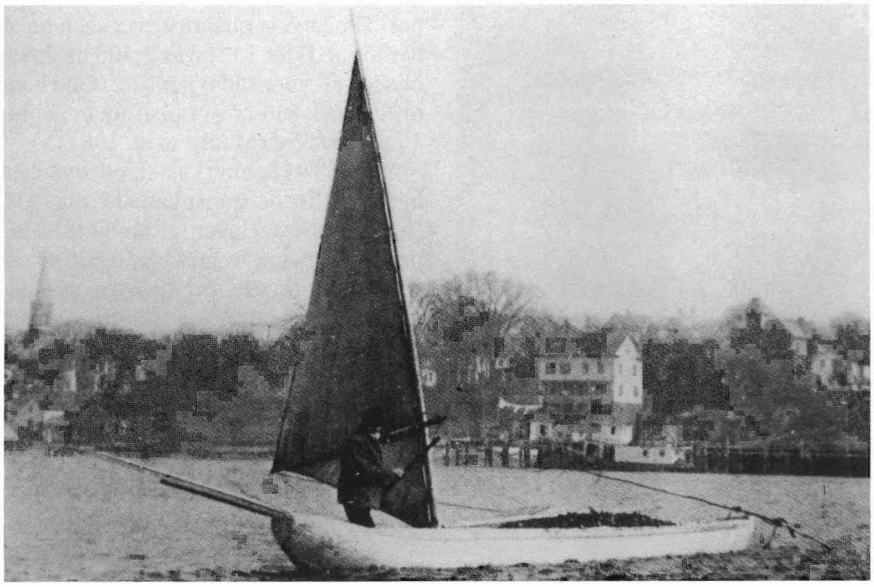


Figure 51.—A 50-bushel dugout canoe on the Quinnipiac River. From the Annual Report of the Shell-Fish Commissioners, State of Connecticut, 1901.

can Indians harvested oysters there, as did the earliest settlers from Europe. The early European settlers near the river gathered oysters from the natural beds for themselves and for peddling around their neighborhoods. The supply gradually became scarcer and an ordinance was passed that prohibited warm-weather harvesting; no harvesting was allowed until November 1st each year (Ingersoll, 1881).

The principal type of oyster boat used early in Connecticut was the dugout canoe (Fig. 51). It could carry as many as 40 bushels, was loaded by a man tonging from the beds, and was in use throughout the 1800's. Sailing sharpies, 8.2–11 m long, that held from 70–170 bushels of oysters loaded by tonging and dredging, were in use in the 1800's and into the early 1900's (Galpin, 1989). Sloops and schooners using dredges were in use after the early 1800's. Skipjacks, a type of sloop, were in use in the 1930's and 1940's, and probably before that. The dredges may have been pulled aboard by hand during the first years of their use, but eventually many were retrieved by crews using hand-operated winches called winders. (Through the 1940's, crews using 1-bushel dredges on the Bridgeport public bed to harvest seed retrieved the dredges by hand.)

In the mid-1800's, local residents and people from as far as 32 km away went out on the beds in dugout canoes, sharpies, square-enders, and skiffs to tong and dredge oysters. Thousands of bushels were taken, most to be stored in seaweed in the harvesters' cellars along the river banks. After about a week, most of the available crop was harvested, but enough oysters usually remained on the beds to furnish a good supply for the next season (Ingersoll, 1881). The oysters were opened in the cellars by household members or often a neighbor who was paid by the quart (Anonymous, 1898a).

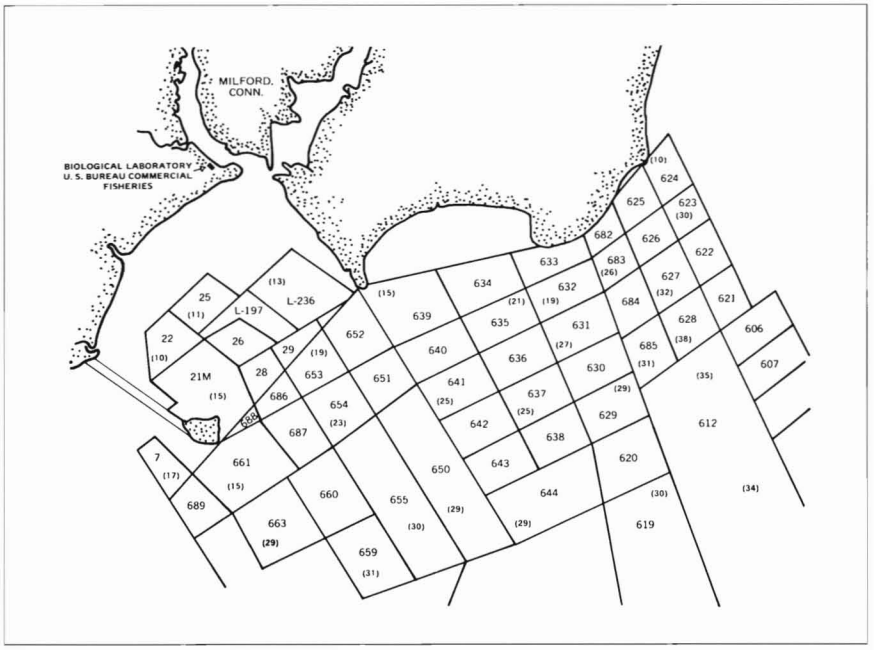
Oyster demand later increased, and local people began to import oysters, first from New Jersey and then from Chesapeake Bay. The Virginia trade began in the 1830's, and an increasing number of vessels were involved in the importation. Many homes throughout New Haven by then found employment opening oysters. The oyster meats were packed in wooden kegs and sold in inland towns (Anonymous, 1898b). From 1855 to 1860, about 80 schooners, each with a carrying capacity of 2,000–4,500 bushels, supplied New Haven with 500,000–750,000 bushels of oysters each year. About 75% were shucked immediately and sold in the winter trade to customers all over the state; the rest were bedded on leases in the harbor in April and May, to be harvested in the following fall and early winter (Ingersoll, 1881). The planted oysters increased in volume by about 33% and had fat meats when harvested (Collins, 1891; Galpin, 1989). In 1856, the Levi Rowe Co. alone employed 20 vessels and 100 shuckers and sold 150,000 gallons of oyster meats per season (Ingersoll, 1881). The New Haven companies eventually had branch offices selling oysters in many inland cities as far away as Chicago and St. Louis.

In 1879, about 450,000 bushels of Chesapeake oysters were brought to New Haven. Oysters from the Rappahannock River, Va., were the favorites for immediate shucking. But for planting purposes, Rappahannock oysters were undesirable, and those from Fishing Bay, St. Mary's River, and Crisfield, Md., were most preferred. All available inshore harbor grounds eventually were occupied, and the bottom was divided into separate lots (Fig. 52) in the shape of squares and rectangles; the lots of different planters adjoined one another. They looked like a submerged forest with boundary stakes marking the various beds (Ingersoll, 1881). The oysters likely were harvested by canoes, sharpies, and sloops.

Starfish predation was not a serious problem, because each grower controlled them on his grounds and there were few to invade adjoining grounds. The starfish mop, still used on Connecticut oyster grounds in the 1990's, was first fabricated in New Haven to control starfish sometime before 1879 (Ingersoll, 1881). A grower happened to tow a frayed rope along the bottom and caught some starfish on it. From that, he designed an effective mop, i.e., a metal bar about 3.7 m wide and trailing large cotton bundles (Fig. 53).

By observing sets of local spat on the imported oysters, New Haven oystermen found that local seed could be produced by spreading shells from shucking houses on their beds in early July. The first planting of shells to collect local seed in New Haven Harbor was in 1855 (Galpin, 1989) (Fig. 54). The practice expanded after that, but the entire planting did not exceed 5,000

Figure 52.—An example of how leased oyster beds can be laid out. Here are oyster beds off the city of Milford, Conn.: large numbers show lot numbers, while numbers in brackets show depths of water in feet.



bushels in 1868 (Anonymous, 1898b). (Ingersoll (1881) believed the shelling practice in Long Island Sound was founded at City Island, N.Y., about 72 km west of New Haven.) The grounds were first dredged clean of fouled shells and starfish, and the mud was dispersed. For many years, the oystermen planted mature oysters before spreading shells on their beds to collect spat. They spread from 30 to 50 bushels of oysters and then about 500 bushels of shells per acre on the beds from 5 to 15 July (Ingersoll, 1881). Besides shells, the growers planted crushed stones and gravel as

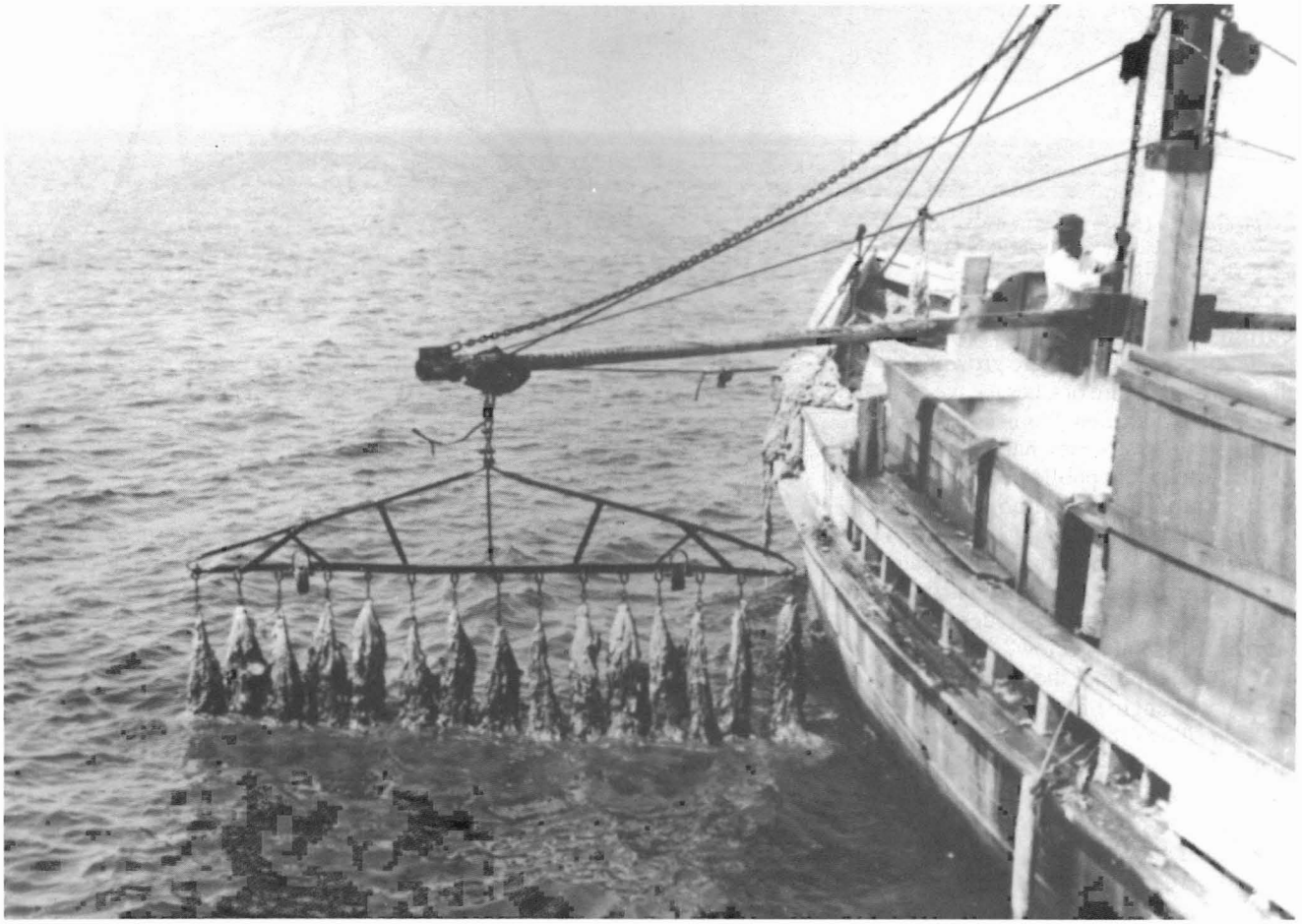


Figure 53.—An oyster mop as used in Connecticut since the mid-to-late 1800's to remove starfish, *Asterias forbesi*, from oyster beds. The mops are dragged over the bottom and lifted periodically to be dipped into a tank (at right of the mop) of boiling water to kill the starfish.

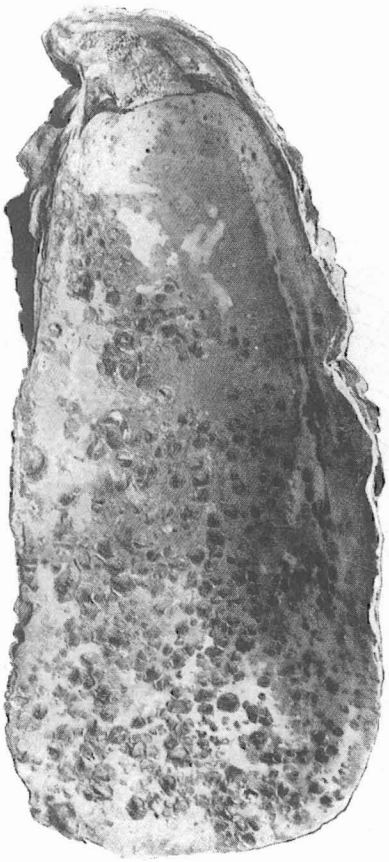


Figure 54.—Oyster spat 2–3 weeks old on the inside of an oyster shell, in Connecticut. USBF photo.

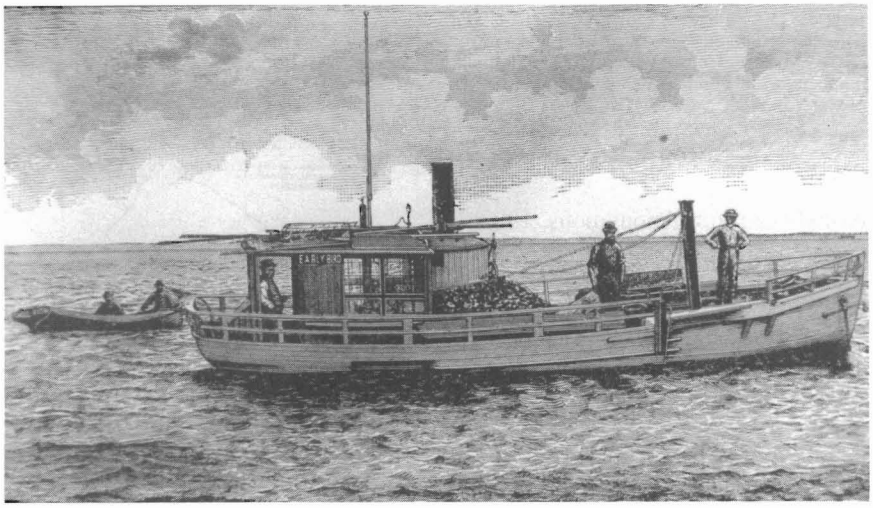


Figure 55.—The first oyster steamer, *Early Bird*, used in Connecticut, at Norwalk, ca. late 1800's (Collins, 1891).

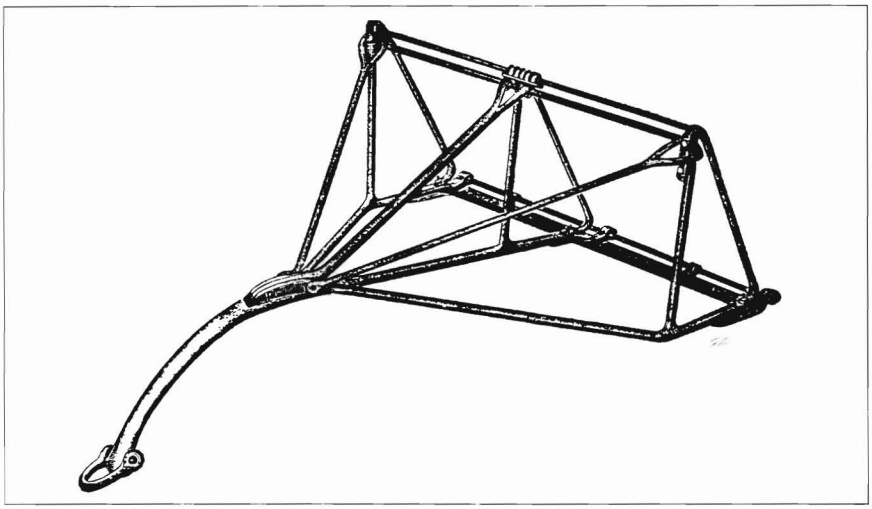


Figure 56.—The frame of the first oyster dredge used from an oyster steamer in Connecticut. Source: *Fishing Gazette*, courtesy of *National Fisherman* magazine.

cultch (Anonymous, 1898b). The oystermen apparently were growing on their beds a mixture of Chesapeake oysters, seed obtained from spreading shells, and oysters they had purchased or harvested from public beds.

The sloops and schooners were slowly converted to engine power beginning in 1874, and thereafter many oyster steamers were built. The first use of the engine was to haul dredges to the surface and soon a "screw" (propeller) was added to propel the vessels. Each dredge was engine-hauled over a roller on each side of the vessel (a procedure that lasted into the 1940's). Crews of six were required on such vessels. The first engine-converted sloop (Fig. 55, 56) loaded and carried up to 200 bushels a day (Collins, 1891). The growth in use of the steamer allowed deep-water oyster culture to develop in the harbor (Anonymous, 1898a).

With steam-powered vessels available to dredge oysters, H. C. Rowe initiated deep-water oyster culture in the late 1870's. He leased hundreds of acres of grounds for growing oysters southward beyond the beds in the main harbor at depths of 12–14 m in Long Island Sound. The industry thereafter expanded, and New Haven became the largest seed producing area north of Delaware Bay (Kochiss, 1974). Rowe also built some of the largest oyster steam vessels in the world (Fig. 57). One built in 1905 was 38.9 m long, used four dredges, and could load on 1,500 bushels of oysters/hour (Anonymous, 1905b).

In 1888, Rowe constructed the largest oyster house on the banks of the Quinnipiac River. It had four-stories, measured 11×14.6 m, and had 104 m of wharf frontage. Its fourth story was used to store packing barrels for shipping shelled oysters, the third floor for culling oysters, the second for shucking (50 shuckers could work there), and the first floor for the watchman and his family and Rowe's office. This was the larger of Rowe's two oyster houses (Galpin, 1989).

When crews took in market oysters from the beds, they usually put them overboard in the Quinnipiac River to

"give them a drink" (allow them to pump in brackish water for several hours). Some oystermen used their river lots for this purpose, while others had small areas near their oyster houses where the bottom was firmed with planks, and still others put the oysters in large floats moored by their wharf or along the shore (Ingersoll, 1881).

Throughout the late 1800's, a great many Connecticut oysters were opened in the state for sale throughout New England, New York, and in Midwest cities. But whole oysters were also being shipped to Europe. From 1885 to 1898, average Connecticut shipments of whole oysters to Europe were 100,000 barrels/year; most went to England. After that, the overseas shipments declined (Beardsley, 1918). The English oyster industry had declined by then, but the consumer demand continued. The companies received more for oysters in Europe than in the United States (Usinger[9]). By 1900, the New Haven beds were producing as many as 2 million bushels of seed and market oysters annually (Anonymous, 1901), nearly the full capacity of the beds.

In the early 1900's, the seasonal activities of the oyster companies included importing market oysters from out of state, processing oysters in their oyster houses, transplanting seed, and shelling their setting grounds. From 1 September on, their vessels harvested market oysters and brought them to their plants (oyster houses) for shucking and packing. The shuckers were paid at the rate of $0.18–$0.20/gallon of meats opened (Anonymous, 1906c). (By 1920, the shuckers were paid $0.35/gallon of meats opened.) Nearly all the oysters were brought to New Haven from Raritan, Narragansett, and Jamaica Bays on 35 steamers having a total of 350 deck-hands (Anonymous, 1912g).

The plants employed 550 openers to shuck the oysters. During the season from 11 September 1911 to 19 March 1912, at least 390,000 bushels of oysters were shucked and shipped to points as far away as New Mexico and California. In addition, 3,000 bushels of shell oysters were shipped to Europe, many to Liverpool, England (Anonymous, 1912e).

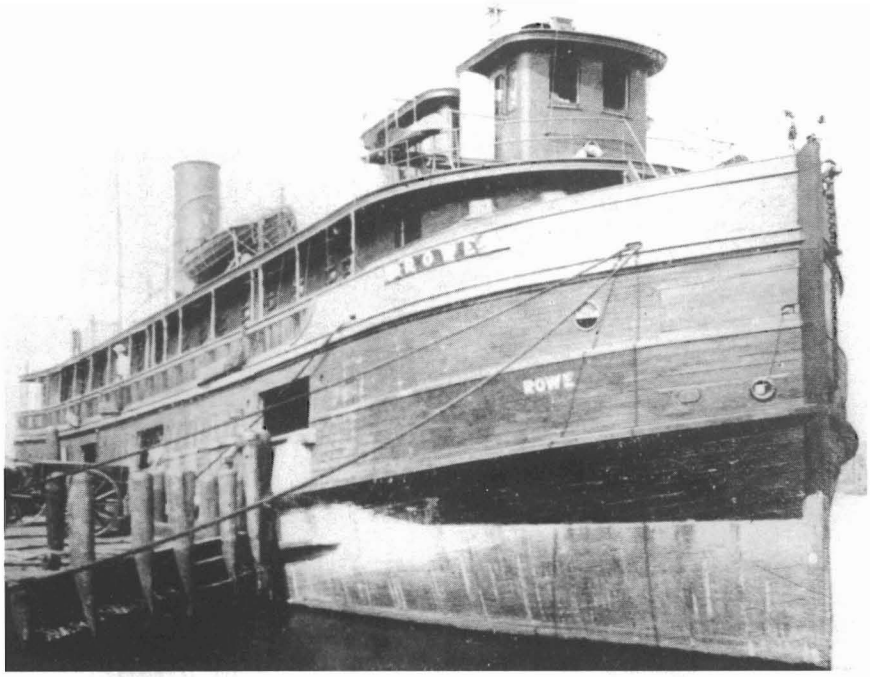


Figure 57.—One of the largest oyster steamers in the world in the early 1900's, owned by the H. C. Rowe Company of New Haven (Churchill, 1921). It towed six dredges at a time.

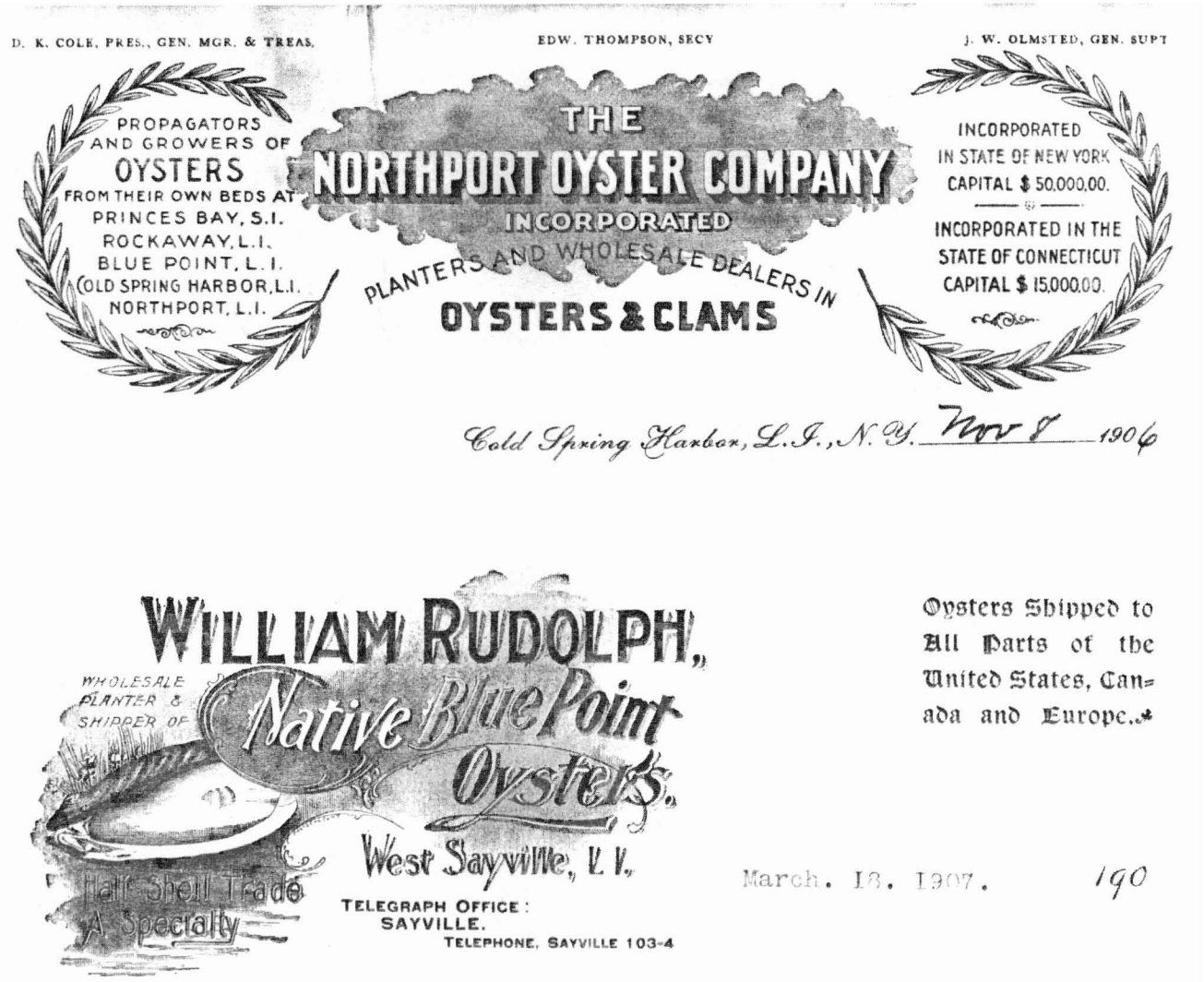
Pea crabs are not abundant in Connecticut oysters. Individual shuckers often got about half a tea cup/day. They ate them live as they found them or brought them home to fry (Usinger[9]).

Toward the end of the marketing season in late March, the companies laid off their shuckers and used most of their vessels to transplant thousands of bushels of seed oysters from bed to bed. Transplanting 1) removed seed from the setting beds, 2) broke up oyster clusters, and 3) thinned out the oysters as they grew. The seed was dredged aboard vessels and crews afterward shoveled it overboard as vessels slowly ran over planting beds. About 6 weeks was devoted to transplanting. The next task was to repair and paint the vessels (Anonymous, 1912h).

During July, the companies used their own and extra chartered vessels to spread shells on the setting beds. In 1912, the shells were worth $0.05–$0.06/bushel on the docks, and the cost of transferring them to the vessels and planting them cost $0.10/bushel. One company chartered a barge which carried 12,000 bushels of shells and loaded it every day. Crews used wheelbarrows to carry the shells from docks to the vessels, and they shoveled the shells onto the beds. The barge mentioned above carried 30 shovelers. The shelling of beds continued though all of July (Anonymous, 1912h). In August, the companies prepared their plants for shucking, packing, and shipping during the next marketing season (Anonymous, 1912i).

Some oyster companies used to grow oysters on shallow intertidal flats which they had leased on the west side of the harbor. In the fall, their crews gathered the oysters by hand and put them in baskets during low tides. As the tides rose, they floated in small boats, such as sharpies, and put the baskets of oysters in them (Usinger[9]). The same flats contained commercial quantities of softshell clams, *Mya arenaria*, and, at times, from 100 to 200 diggers worked there, leaving the grounds uneven. The companies had to ask the local sheriff to keep the clam diggers off the flats (Anonymous, 1905a).

In 1912, the New Haven Board of Health decided to prohibit the sale of oysters, northern quahogs, and softshell clams taken from New Haven Harbor



Two turn-of-the-century Connecticut–New York area oyster company letterheads, courtesy of the Staten Island Historical Society.

after tests showed typhoid bacteria in the water (Anonymous, 1912g). Pollution of the grounds forced New Haven companies to market all their oysters in New York, Rhode Island, and Massachusetts. They had to transplant all their seed to beds in those states and grow it to market size there. Seed from New Haven Harbor, but also grounds off Bridgeport, eventually replaced the imports from Chesapeake Bay that had been grown in Narragansett Bay, R.I.; Great South, Peconic, and Northport Bays on Long Island, N.Y.; Raritan Bay, N.Y. and N.J.; and Wellfleet, Mass. Shells from shucking houses in those states were returned to Connecticut and spread on New Haven and Bridgeport beds each summer.

Exports of Chesapeake oysters to Connecticut continued on a small scale during the early 1900's (Kochiss, 1974). By World War I, Connecticut oystermen were producing nearly all the seed they needed from the local beds. (Small quantities of Chesapeake seed were imported into the 1930's, but little after that. The last known import was to Norwalk in 1969.) Growers in the early 1900's observed that Chesapeake oysters planted in the spring grew well and took on the appearance of native Connecticut oysters. But many small Chesapeake seed did not survive winters and grow to market size (MacKenzie, In Press). The juvenile oysters that set on shells probably were from native oysters and not from the Chesapeake imports.

The Connecticut industry declined after about 1906. Highly publicized illnesses were being associated with eating raw oysters, and as people began to eat more beef, oysters were replaced as entrees except in select restaurants (Kochiss, 1974). Besides falling oyster prices, state taxes on the beds were increasing (Anonymous, 1916d), and the setting of spat was poor for a number of years. Still, in 1921, New Haven had 16 oyster houses where oysters were shucked and packed for sale (Churchill, 1921).

In the 1910's, 1920's, and 1930's, Connecticut companies were spreading about 3 million bushels of shells per year on their beds, mainly off New Haven and Bridgeport (Anonymous, 1916e; Usinger[9]). Besides the local oyster fleet, Connecticut companies hired schooners of 33–37 m length from Delaware Bay to "run" shells onto the beds. Every few years in the 1920's and 1930's, there was a heavy widespread oyster set, and light sets were in-between, so there was always an oyster crop to sell (MacKenzie, In Press).

In the Depression years of the 1930's, oyster demand was low and prices were low, and the industry was struck a calamitous blow by a 1938 hurricane which buried nearly all Connecticut oysters and damaged boats and shore property. During World War II, oyster demand increased and production rose a little, but the industry was hampered by short supplies of oysters and workers.

During World War II, a boom-dredging system (Fig. 58) was developed and used on all vessels, allowing the vessels to be loaded with a crew of 1–2. Soon after the war, the F. Mansfield and Sons Co. built a hydraulic or suction dredge (Fig. 59) mounted on a surplus U.S. army barge for harvesting shells and removing oyster drills from grounds. Modern-day oyster vessels carry 700–2,400 bushels of oysters which are loaded with boom dredges (Fig. 58) in about 4 hours (MacKenzie, In Press).

Following the war, the industry slowly began to produce more oysters, but in November 1950, a severe easterly storm lasting 3 days struck the beds and again buried nearly all oysters. Several long-time companies, including the H. C. Rowe Co., Sea Coast Oyster Company, Connecticut Oyster Farms, and eventually the Radel Oyster Company ceased oystering (Galpin, 1989). After the two storms, 12 years apart, the remaining companies had far fewer shells to spread as cultch—after 1950, about 200,000 bushels per year.

In 1957, starfish, relatively scarce for some years, exploded in abundance (MacKenzie, 1981). From then until the mid-1960's, starfish remained abundant and destroyed most sets of juvenile oysters; particularly damaging were nearly complete losses of heavy sets in 1958 and 1962, and few oysters from the lighter sets in 1959 and 1963 survived. Oyster drills also killed many oysters. Only small quantities of oysters remained, and most were inside New Haven Harbor. Few were available for transplanting.

After 1966, the New Haven industry rebounded when Long Island Oyster Farms, the only company active there, improved its farming practices by 1) controlling starfish by spreading granular quicklime (CaO) over infested beds and mopping, 2) avoiding early spring silt-smothering losses by earlier transplanting of oysters, and 3) more selective planting of shells on its best seed beds. The incentive to do so was high because the price of oysters had risen to $14–18/bushel. The company already controlled oyster drills with its suction dredge mounted on a barge. In 1969, J. R. Nelson, company manager, directed that its large crop of 1968 generation

Figure 58.—Connecticut oyster dredges have been lifted by booms since the 1940's. The deck hands empty oysters onto the boat by releasing a door at the bottom of the dredge.

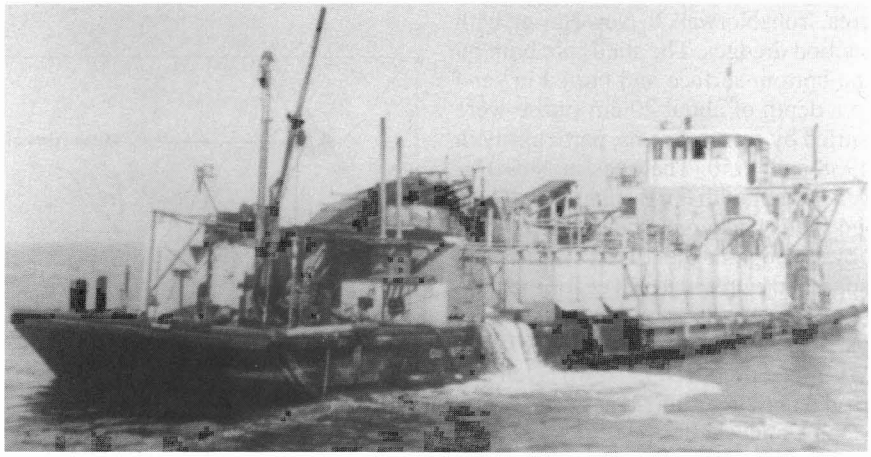


Figure 59.—A suction dredger in New Haven. Built right after World War II, it cleaned grounds and gathered oyster shells to be planted as cultch. National Marine Fisheries Service photograph.

seed oysters from the inshore New Haven beds be planted on about 1,000 acres in 9–12 m of water in Long Island Sound, following what H. C. Rowe had done some 95 years earlier. All its oysters eventually were transplanted to Peconic Bay, Long Island, to be marketed. The company's production rose from about 15,000 bushels in 1967 to nearly 250,000 bushels in 1975 (MacKenzie, 1981).

During the 1970's, Long Island Oyster Farms abandoned farming the beds in New Haven, and the beds were mostly left fallow until acquired by the Tallmadge Co. of South Norwalk. Since the early 1980's, the company has been spreading large quantities of shells on the best setting beds in the harbor to obtain seed for spreading on its growing and marketing beds mainly in Norwalk. The company obtains the shells from abandoned oyster beds throughout the Connecticut oystering area, from Norwalk to New Haven, with suction dredges. The shells are both on the bottom surface and buried in sand to a depth of about 20 cm (those were buried by severe storms, particularly in 1938 and 1950. The beds in New Haven Harbor with large quantities of buried shells had large quantities of northern quahogs in the 1970's: The shells apparently provided cover for the quahogs from predators). Oyster sets were particularly good in the late 1980's. With seed produced in New Haven and Bridgeport, the Tallmadge Co. and other small Connecticut oyster growers were producing from 653,000 to 700,000 bushels of market oysters with landed values from $34 to $40 million/year from 1992 to 1995[11] (Chew, 1995). The Connecticut industry has grown rapidly in part because a large gap in the U.S. oyster market became available after production collapsed in Delaware and Chesapeake Bays.

Connecticut's increased oyster production has been a financial boon to oystermen on private and public beds. Sales are made throughout the United States and Canada. Today, the Tallmadge Co. has a fleet of about 25 vessels maintained in excellent condition, and it plans to purchase a new steel vessel that will carry 6,000 bushels of oysters. The vessels of smaller companies and oystermen who harvest from the natural beds maintained by the State of Connecticut are also in good condition.

[11]Data on file at Fisheries Statistics Division, National Marine Fisheries Service, NOAA, Silver Spring, Md.

Delaware Bay

Delaware Bay, half under the jurisdiction of New Jersey and half under Delaware (Fig. 60), has long been a major oyster area, and its oyster production system has been described as one of the most efficient in the United States (Morgan[12]). New Jersey's oyster grounds consist of 20,000 acres of public seed beds in the upper narrow portion of the bay, and 30,000 acres of planting grounds in Maurice River Cove (Nelson, 1943). Delaware's oyster grounds are considerably smaller.

[12]Robert Morgan, oyster planter, Delaware Bay, N.J. Personal commun., 1986.

Description

Upper bay seed beds consist of firm sand. Most beds on the lower bay's leased grounds are similar, but some are soft and have been stiffened enough to support oysters with shell plantings. Salinities in the seed beds range from about 5 to 20‰, while on the leased beds most are 20–26‰. Oyster beds are more numerous on the New Jersey side than the Delaware side because the area is larger, and probably because the shells on the New Jersey beds have much thinner silt deposits than do those on the Delaware beds. The Delaware River, deflected to the right (south) as it enters Delaware Bay, deposits large quantities of silt on the Delaware beds (Fig. 61) (MacKenzie, 1983). Water

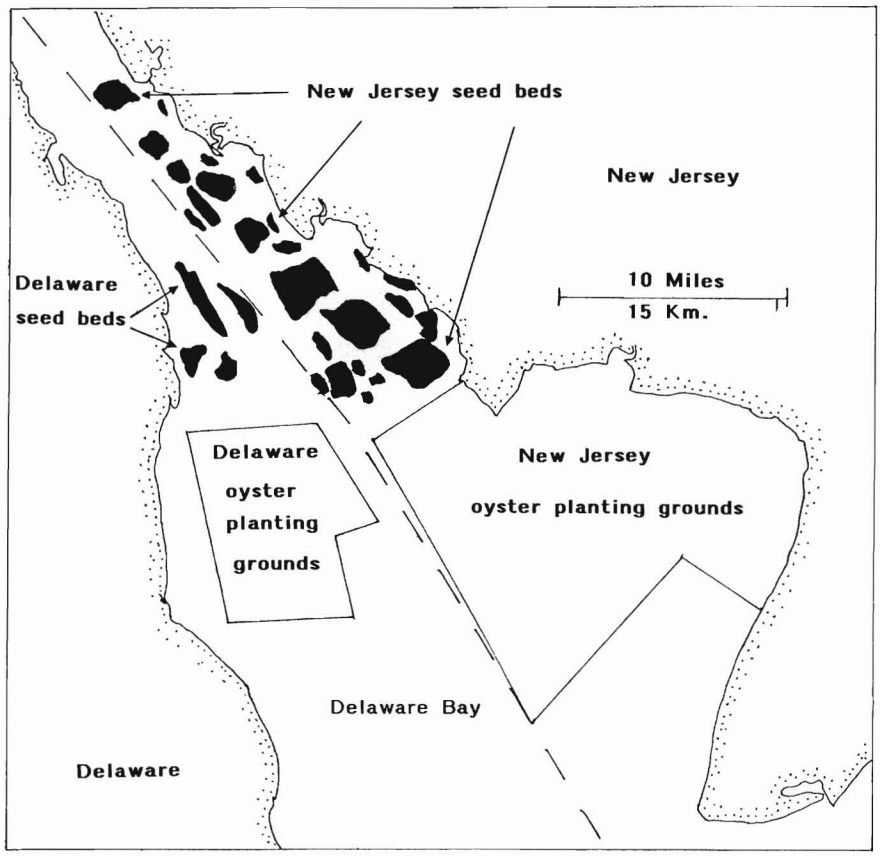


Figure 60.—Delaware Bay, N.J. and Del., showing the locations of seed beds (shaded) and leased planting grounds.

depths on the seed and leased beds are commonly 3.5–4.5 m.

Commercial-density oyster sets occur on the beds at least 3 of every 4 years, but, as is true universally, they vary in intensity. Bay anemones, *Diadumene leucolena* (Fig. 62), prey on oyster larvae, and xanthid crabs prey on tiny spat on the seed beds. Atlantic oyster drills occur in salinities above 15‰ and are abundant on oyster leases where seed oysters are planted. Oyster spat set on the leased grounds, but nearly all are destroyed by the drills, which also destroy a high percentage of yearlings, but far fewer older oysters that are transplanted from the seed beds to the leased grounds. Ford (1996) reports that the MSX disease has killed most oysters in the bay since 1957, and, in the 1990's, Dermo has caused additional heavy mortalities.

History of Oystering

Oysters were an important food for the early Dutch and Swedish settlers, and in the 1600's British settlements along Delaware Bay and in Philadelphia fostered early commercial harvests. The earliest oystermen were local farmers who tonged them (Ford, In Press). During the late 1700's, seed oysters from the bay were being sent to Connecticut and Massachusetts for further growth and subsequent marketing (Ingersoll, 1881; Kochiss, 1974).

The first oyster vessels in Delaware Bay were shallops and small sloops. Shallops were 5.8–12 m long and had two masts of equal height. In the early 1800's, the oyster fleet was made up of schooners and sloops. By 1888, nearly all the dredging vessels were schooners, commonly about 23 m long, and ranging to slightly above 30 m long. Some skipjacks and bugeyes from Maryland were part of the oyster fleet, but they did not perform as well as the schooners (Rolfs, 1971).

In the early 1800's, the dredge was introduced to Delaware Bay to harvest oysters (Miller, 1962). The first dredges were small and were hauled aboard by hand. Shortly afterward, owners installed winders on the decks of vessels to haul the dredges more efficiently (Rolfs, 1971). In 1835 and 1846, restricted seed-dredging seasons in Delaware and New Jersey, respectively, were legislated to maintain seed quantities on the beds. The New Jersey law contained a rough cull provision: Shells were to be returned to the seed beds (Ford, In Press). Most New Jersey oyster boats tied up in Bivalve, N.J., on the Maurice River.

To supplement the upper bay seed supplies, growers began to import Chesapeake Bay seed, beginning in 1829. During the 1830's, about 150,000 bushels of Chesapeake seed were planted each year. The imports increased, and by the 1880's they averaged nearly 500,000 bushels per year. The seed came mostly from Virginia's James River, or from Maryland beds in upper Chesapeake Bay. In the early 1950's, hundreds of thousands of bushels were imported from the seaside bays of Virginia, especially Chincoteague Bay. The practice ended later that decade when the MSX disease broke out in 1957 (Ford, In Press).

The Delaware Bay oyster industry developed substantially between 1850 and 1900. When the first market oysters were harvested in the bay, they were taken directly to Philadelphia by the vessel that harvested them, though they were sometimes hauled overland by horses and wagons if the weather did not allow sailing. Besides the large fleet of oyster vessels from New Jersey ports and a smaller one from Delaware ports, another fleet of 22 oyster sloops and schooners used Philadelphia as their port (Anonymous, 1902b). At times, as

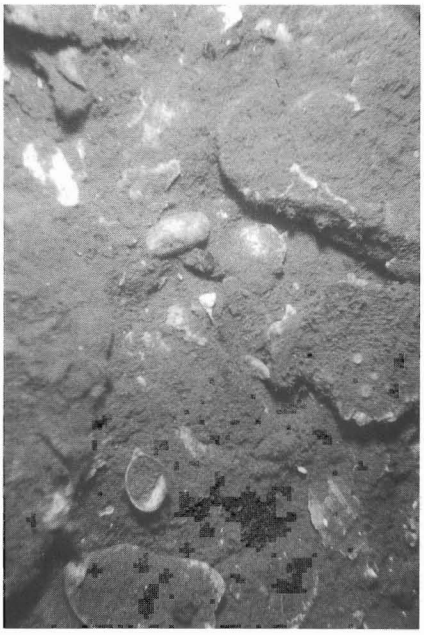


Figure 61.—A photograph of the large quantity of silt on an oyster bed.

Figure 62.—An anemone, *Diadumene leucolena* (right), on shell in Maryland (barnacles are at left). Photograph courtesy of and copyrighted by R. Noonan.

many as 300 vessels were unloading oysters onto Philadelphia docks (Schock, 1918). In Philadelphia, some oysters were taken to various establishments, while others were purchased by hucksters and peddlers who sold them along the cobbled streets out of wheelbarrows. The peddlers often sang special songs about the oysters along their routes (Rolfs, 1971).

In 1856, New Jersey granted individuals the rights to lease 10-acre plots to promote planting and growth of oysters. Individuals afterward began to harvest seed from the upper bay beds and plant it on their leased plots. The practice of transplanting oysters from the upper bay to the lower bay had arisen because oystermen observed that the oysters in the lower bay grew faster, became larger, and had fatter, saltier meats which were in high demand (Ford, In Press).

In 1872, a railroad line was extended to Bivalve, where oysters could be moved from docks to the boxcars only a few meters away (Fig. 63) and to Port Norris which was near Bivalve but inland. The railroad was a great impetus to production, and Port Norris and Bivalve became prosperous, shipping out huge quantities of oysters. In 1879, an estimated 1.5 million bushels of oysters were shipped to Philadelphia from beds in Maurice River Cove, and another 1 million bushels from the Delaware beds, a large part of which were southern oysters transplanted to those beds. An additional 250,000 bushels from Chesapeake Bay were shipped directly to the city. Many oysters were eaten in the city and surrounding areas, and some were shipped west (Ingersoll, 1881). The Delaware Bay oysters shipped to Philadelphia were packed in sacks, holding roughly two bushels each. In contrast, oysters shipped to outside markets, mainly New York City and Baltimore but also Pennsylvania, were shipped in barrels (Schock, 1918).

By 1888, about 1,400 vessels and 2,300 men were harvesting oysters in the bay, and most of the Delaware Bay oyster production was shipped by rail rather than by sailing vessels. Most vessels were used for harvesting seed oysters during an 8- to 10-week period in the spring. Fewer vessels were required to harvest oysters for market because marketing was done over a longer period (Ford, In Press).

In New Jersey, the long-recognized but tacit division between the upper bay seed beds (to be managed by the state) and lower bay planting grounds (to be leased) was officially acknowledged in an act of 1899. Seed dredging was to occur between 1 April and 15 June; in 1905 this was changed to 1 May to 30 June. The Rough Cull Law of 1899 mandated that no more than 15% of material, by volume, removed from the beds could be shell. Vessel crews had to cull out the seed and return shells to the seed beds. In Delaware, the official division between leased grounds and natural beds had occurred 30 years earlier (Ford, In Press).

During much of the 1900's, for an 8- to 10-week period each spring, the two states have permitted company-owned dredging vessels to harvest seed oysters from the public seed beds upbay and spread them on leased planting bottoms about 15–24 km downbay. But after a severe oyster decline, starting in the late 1950's, the season for seed harvest has become increasingly shorter (2–3 weeks) and there have been many years in which no seed harvest was permitted. Some firms have owned several vessels, while the smallest have had only one. Each vessel has been capable of harvesting 8,000–12,000 bushels of seed per season. In the fall and winter, the oysters have been harvested for marketing. Before the late 1950's, company costs amounted to a modest fraction of the selling prices of the oysters. They included a small license fee, operation and upkeep of vessels, and crew salaries.

The industry prospered during the early 1900's. The state of New Jersey bought shell and planted it on the seed beds, the total leased acreage increased from 12,000 acres in 1900 to nearly 30,000 acres in 1914, and more and larger dredge boats joined the fleet. At that time, from 250 (Fiedler, 1932) to 500 vessels (Anonymous, 1912a; Anderson[13]), 9–24 m long, were oys-

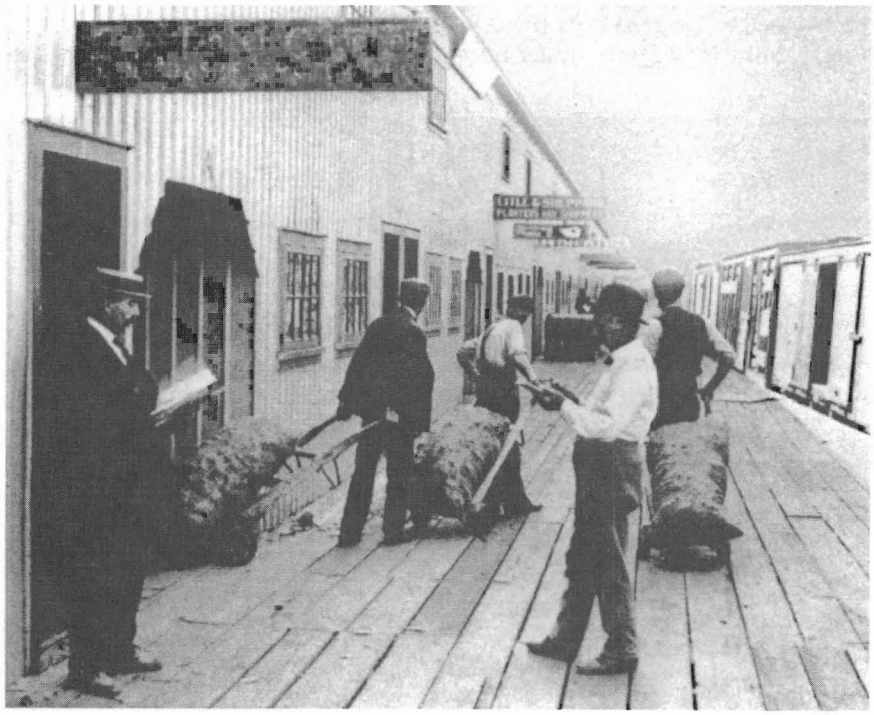


Figure 63.—Transferring oysters from a packing house (left) to railroad cars (right) at Bivalve, N.J., ca. early 1900's. From *Under Sail, The Dredgeboats of Delaware Bay* (Rolfs, 1971).

[13]Fenton Anderson, oyster planter, Delaware Bay, N.J. Personal commun., 1996.

Figure 64.—Delaware Bay dredge boats loading up with seed oysters. Photograph provided by author; original source unknown.

Figure 65.—The captain of an early Delaware Bay oyster schooner harvesting seed from the state grounds. Photograph provided by author; original source unknown.

Figure 66.—Oyster schooners at Bivalve, N.J. Photograph provided by author; original source unknown.

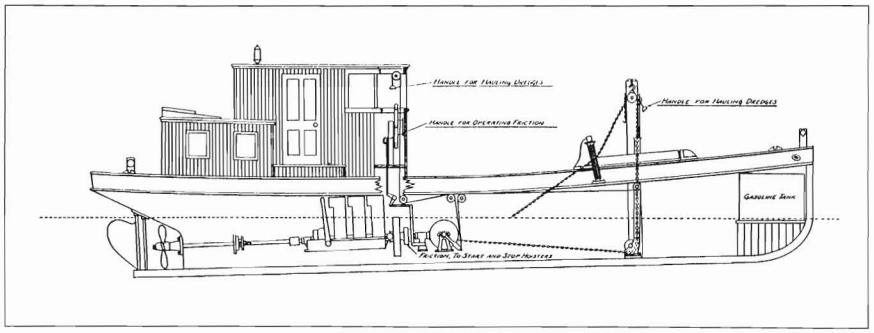


Figure 67.—Diagram of an oyster vessel with motor and hoister of dredges below decks (Nelson, 1927).

tering in New Jersey (Fig. 64, 65). Some were under sail (Fig. 66), but most had engines (Fig. 67). Engine-power dredging had been legalized on the New Jersey leased beds around 1905, but sail dredging was the only permitted method on the seed beds. The crew size for emptying dredges and culling the catch was about 11 men. In Delaware, 16 vessels were licensed with 6 men per vessel (Ford, In Press). Before the 1920's, a dredge with a 1.07 m drawbar was used; after that, dredges had a 1.32 m drawbar (Rolfs, 1971).

Nearly all oysters harvested were shipped in the shell. After being dredged from leased bottoms, the oysters to be shipped as shellstock were held in floats in brackish water to clean their mantle cavities of any mud and to absorb some brackish water (Nelson, 1911). Most floats were 30–32 m long, 6 m wide, and were divided into two compartments for holding the oysters; three air tanks, about 2 m long, one at either end and another in the middle held each float on the surface. Such floats held as many as 1,000 bushels each. Some companies had smaller floats with two tanks, one at each end (Anderson[13]).

Around 1912, the custom was to dredge oysters during the day, lay them in the floats for one tide, pack them at night, and ship them the next morning. Seven or eight men worked on each float at night, while the regular oyster crews were sleeping. About 15,000 bushels of oysters were shipped each day, based on 300 oysters/bushel. The oysters were packed in sacks, 600 to the sack; each railroad car held 100 sacks. Fifty carloads were shipped daily (Anonymous 1912j) (75 carloads were shipped daily in December 1922 (Anonymous, 1922b)). No dredging took place on Saturdays or Sundays and the crews went home. The men received $45–$60/month and their board. Most oysters were consumed in New Jersey, Pennsylvania, and New York (Anonymous, 1912j).

In 1918, from 40 to 50 New Jersey companies were shipping oysters from packing houses on the shores of the Maurice River (Schock, 1918). Nearly all oysters were being floated before being packed in sacks for shipment. Julius Nelson was able to convince authorities to allow the floating of oysters longer than they allowed it in other states, i.e. into the 1930's. In a 1912 hearing before the Board of Food and Drug Inspection in the Bureau of Chemistry Building in Washington, D.C., he said: "The process of floating oysters, if conducted in pure water, is greatly beneficial to the oyster and the one who eats it. Floating is merely an imitation of a work of nature, the oyster cleanses itself of the impurities taken in from the beds on which it grows to maturity, it holds up better in transit, keeps wholesome and palatable longer than the oyster directly from the beds, and few people would care to eat many of the strongly acrid specimens direct from the dredging grounds. From a biological point of view the oyster loses none of its nutriment, none of its health-giving properties, and none of its succulence by the process. But on the other hand, it is made much more palatable and digestible by the natural taking in of the partly salt water, which is not an adulteration and cannot be construed as such" (Anonymous, 1912b). The authorities were concerned about the purity of the water flowing through the floats at the end of the low tide.

In 1922, the first shucking house was established, others quickly followed, and eventually most oysters were shucked. In 1927, floating was temporarily banned after the 1924 outbreak of typhoid (Nelson, 1929). The meats were washed in tanks ("blowers") containing freshwater in the packing rooms of the shucking houses after being opened. By the early 1930's, floating was not needed anymore (Ford, In Press). As the oysters were being opened, the shuckers set aside the pea crabs and gave them to the workers in the houses' packing rooms; the workers sold them to the Fulton Market in New York. The shuckers also saved some pea crabs to eat at home in oyster stews or fritters (Anderson[13]).

In 1928, the New Jersey oystermen decided not to transplant seed oysters from the upper bay seed beds to their leased beds because an extremely heavy set had occurred on the beds in 1927. They believed most of the seed would be killed if they dredged it. This was the first year the beds were closed for an entire year (Anonymous, 1928). In 1929, the harvest from the seed beds may have been as high as 4 million bushels, at least four times the usual harvest (Anderson[13]).

From 1880 until 1930, Delaware Bay oyster production usually ranged between 1 and 2 million bushels per year. From 1930 to 1957, production was fairly steady at about 1 million bushels per year. During the 1930's, trucks began to replace railroads as the primary method for shipping oysters, and by 1946, the railroads ceased transporting oysters. In the mid-to-late 1940's, New Jersey and Delaware permitted vessel owners to use engines rather than sails to propel their vessels while dredging on the seed beds (Ford, In Press).

By the end of 1959, 90–95% of oysters on the leased grounds and half of those on the seed beds had died as a consequence of the MSX disease (Ford and Haskin, 1982). In the 1960's, Delaware Bay oyster production fell to an average of about 75,000 bushels/year (range, 7,000–200,000 bushels). The industry was mostly inactive, the vessels remained at their docks, and the vessel and shucking crews went to other jobs while some went on welfare. In the late 1960's and early 1970's, the industry gradually rebounded because oyster mortalities were smaller on the seed and leased beds (Ford, In Press). But since the severe decline, the season for seed harvest has become increasingly shorter, and there have been many years in which no seed harvest was permitted. Since then, company costs have amounted to a much larger fraction of the selling prices than they had been because a great many oysters have died on the leased bottoms.

From 1973 through 1985, harvests from New Jersey seed beds averaged 370,000 bushels per year. About 50–60 vessels, 12–25 m long, each harvested an average of 400–500 bushels/day of seed during 4-week seed harvesting seasons. In Delaware, from 6 to 12 vessels harvested seed. The average vessel's catch from the seed beds was 300–600 bushels per day or about 40,000 bushels annually (Ford, In Press).

Before the MSX disease was prevalent, many seed oysters planted were

yearlings, 20–25 mm long. They remained on leased grounds for 2–4 years before being harvested. Growth just balanced the volume lost to predation by oyster drills. After MSX hit, the growers sought seed oysters large enough to plant and market after only one growing season. Between 1973 and 1985, the harvests of market oysters probably were also about equal to the volume of seed planted.

Oyster mortalities were high in 1986 and 1987, and both states closed the beds to dredging for 3 years, 1987–89. In 1990, the New Jersey beds were reopened and 160,000 bushels of seed were dredged and planted. In 1991, 290,000 bushels of seed were planted, but in 1991, another disease, Dermo caused heavy mortalities in the planted oysters, and harvests of market oysters were much less than the quantity planted. Companies barely made expenses in that year (Ford, In Press). In 1995, the vessel crews got only about 150 bushels of live oysters from every 1,000 bushels of oysters dredged aboard; the remaining 850 bushels were "boxes" (dead oysters) that had been killed by Dermo and MSX (Anderson[13]).

Through the years, the growers improved culling operations on their vessels when harvesting seed. Before 1960, each vessel crew of 12 men dumped the two dredges and 6 men knelt around each pile picking out seed. When finished, they pushed the shells overboard with shovels. In about 1960, the growers installed two conveyor belts, running in opposite directions across the deck of each vessel. After they dumped the dredges, the crews shovelled the seed onto an end of each conveyor, and then a crew of 20 men, 10 men working on each one, picked off the seed and tossed it into piles. The shells fell off the opposite ends of the belts overboard. In 1975, the oyster growers replaced the conveyor with automatic culling machines (rotary drums about 2–2.5 m long with bars between which the shell and smallest seed fell out and overboard, but which retained the larger seed). They also installed devices which emptied the dredges mechanically (Fig. 68). That made it possible to operate the dredge vessels with a captain and only 1–2 deckhands when harvesting seed, but a crew of 8–10/vessel was needed when market oysters were harvested. A crew of 4–5 currently is used for harvesting market oysters because the harvests are small (Ford, In press).

In Bivalve, there currently are two oyster packing houses, one shucking house, and one clam processing plant (Fig. 69). They process out-of-state oysters (mainly from Connecticut), channeled whelk, *Busycotypus canaliculatus*; surfclams, *S. solidissima*; ocean quahogs, *A. islandica*; and small quantities of oysters from Delaware Bay. Several small oyster companies have gone out of business. The largest New Jersey company has 13 vessels, about 6 companies have 2–5 vessels, and several own one vessel each. Several companies lease planting grounds of 2,500–3,500 acres in size, and smaller companies each lease a few grounds totaling as much as several hundred acres each.

Figure 68.—Above, a New Jersey oyster vessel rigged with relatively new rotary drum for harvesting seed oysters from Delaware Bay. The *Cashier*, constructed in the 1860's, may be the oldest oyster vessel in the United States. Below is a modern dredging vessel with an automatic dredge dumper.

Dermo has become widespread on the oyster beds on the New Jersey side of Delaware Bay in the 1990's; in contrast, Dermo infections have been scattered and light on the Delaware side of the bay (Ford, 1996). As a result, New Jersey's oyster beds did not produce any oysters in 1993 and 1994. Delaware produced about 7,000 bushels in 1994.[11] Many oyster vessels that remain in the New Jersey and Delaware fleets are old and in marginal operating condition.

Upper Chesapeake Bay

In some years of the late 1800's, Chesapeake Bay, which encompasses the States of Maryland (Fig. 70) and Virginia, produced nearly 20 million bushels of eastern oysters, about 60% of North America's oyster production (Stevenson, 1894). Maryland produced somewhat more than Virginia (Ingersoll, 1881), and its oyster industry then had a value of 17% of the total fisheries products of the United States and employed 20% of the people involved in U.S. fisheries (Kennedy and Breisch, 1983). Stevenson (1894) reported that the Maryland oyster fishery was the most extensive and valuable oyster fishery in the world. It also affected many people in the state, for he stated: "Probably no state in the union has for its area so great an inland water-surface as Maryland. Of the twenty-three counties in the state, the oyster fishery is prosecuted from eleven, in which, because of the innumerable tributaries of the Chesapeake extending into land, there are few localities removed a greater distance than 6 miles (9.5 km) from navigable water, thus bringing all the residents into close contact with the fisheries."

Description

Maryland's oyster grounds in the upper Chesapeake Bay, most of which have been maintained as public, have included the Potomac and Patuxent Rivers on the western shore and the Chester River, Eastern Bay, Choptank River, and Tangier Sound on the eastern shore. Vast natural beds of oysters apparently were present in them in colonial times. Water salinities where nearly all Maryland oyster beds occur are below 15‰, except in periods of extreme drought. The tidal range is about 60 cm.

Figure 69.—Shucking oysters in Bivalve, N.J. The baskets carry oysters to the shuckers keeping them supplied. Photograph by S.E. Ford.

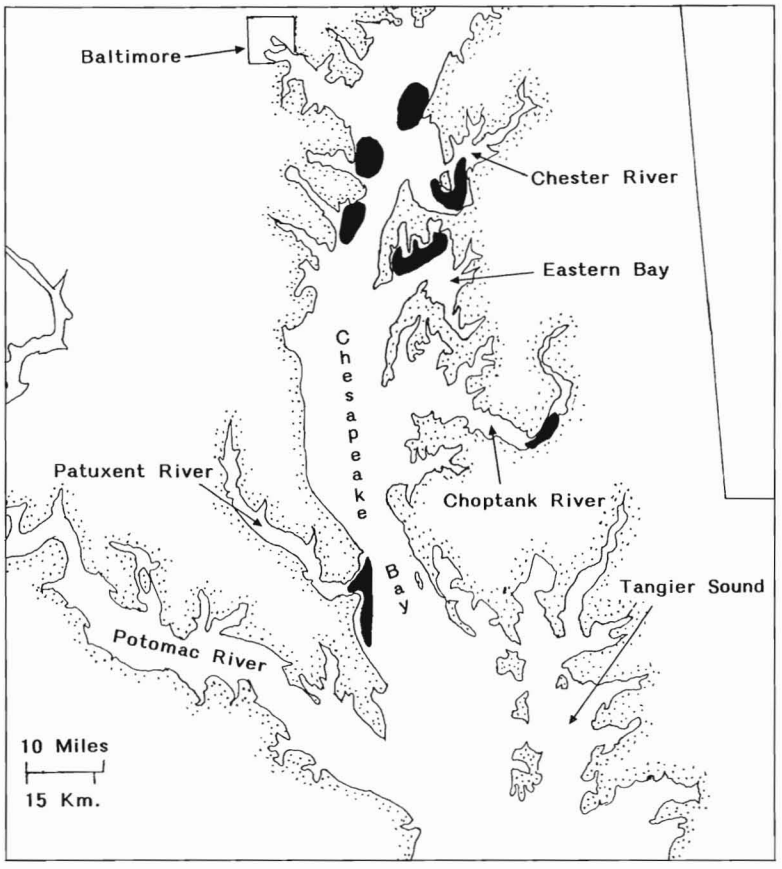


Figure 70.—Upper Chesapeake Bay, Md.; the major oyster grounds are shaded.

Predators of oyster larvae include scyphozoans, ctenophores (Nelson, 1925; Purcell et al., 1991), and anemones (MacKenzie, 1977; Steinberg and Kennedy, 1979). Tunicates, *Molgula manhattanensis*, frequently are com-

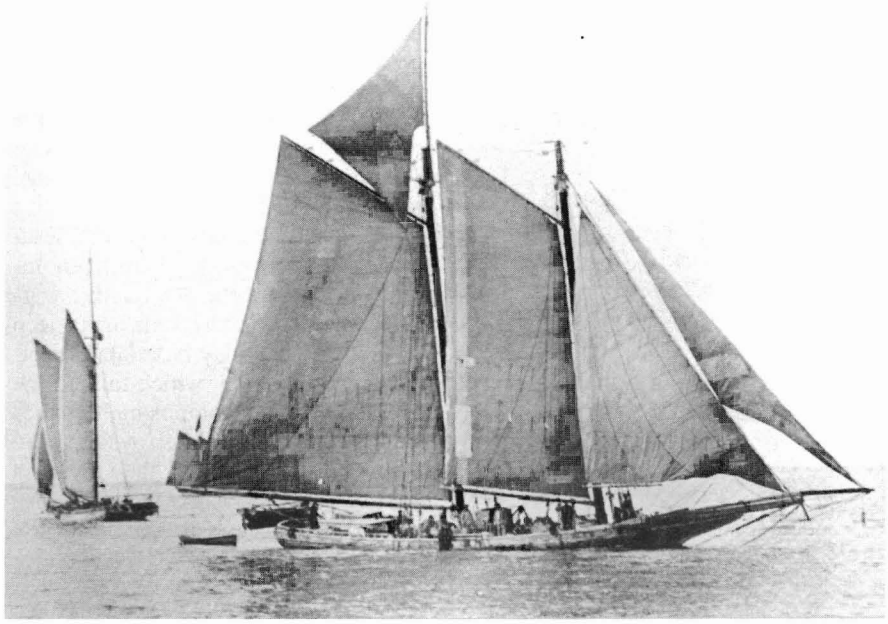


Figure 71.—Two bugeyes dredging oysters in Maryland (Churchill, 1921).

Figure 72.—Oyster dredgers at the hand windlass. Photograph courtesy of the Maritime & Seafood Industry Museum, Biloxi, Miss.

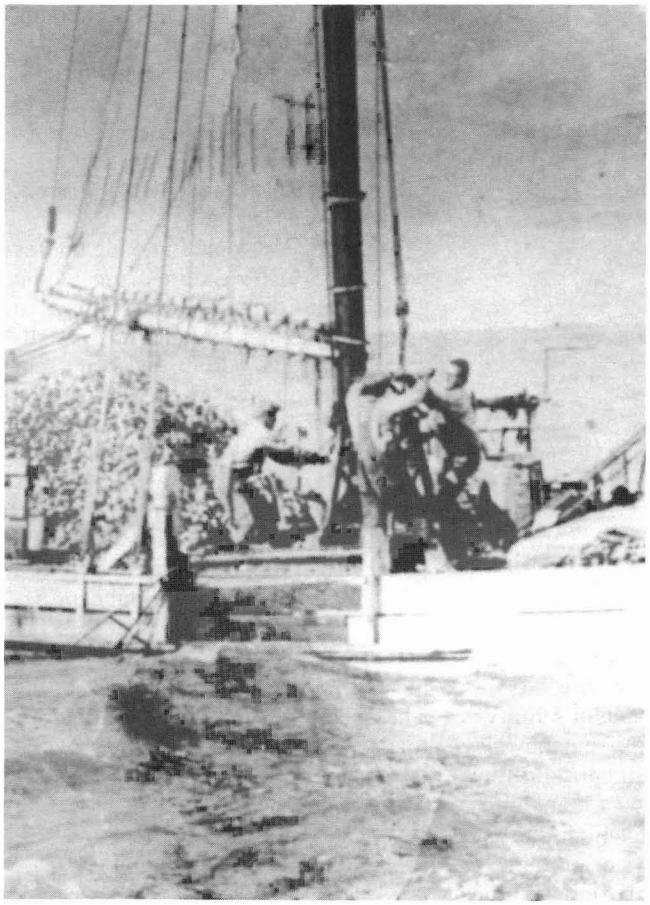


Figure 73.—Taking aboard a dredge on a Maryland oyster vessel. Photograph provided by author; original source unknown.

Figure 74.—Oyster dredges and winches for hoisting them (Churchill, 1921).

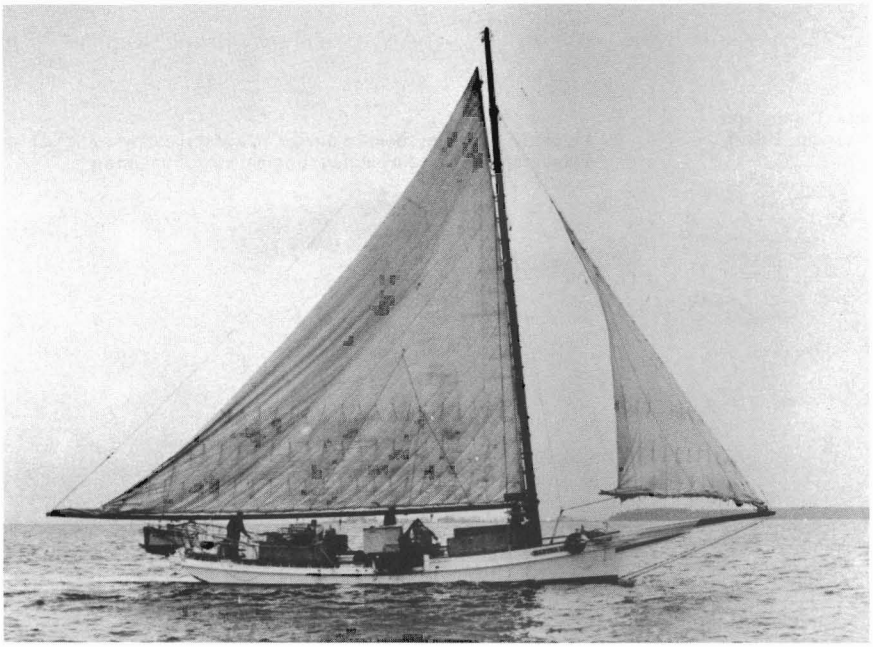


Figure 75.—A skipjack on the dredging grounds in Maryland. Courtesy of the Chesapeake Bay Maritime Museum.

mon on the beds; I am not aware that anyone has determined whether they prey on oyster larvae. Predators of sedentary oysters can include oyster leeches, *Stylochus ellipticus*; xanthid crabs, and blue crabs, *Callinectes sapidus* (Haven et al., 1978).

The MSX disease kills Maryland oysters during droughts, and Dermo kills additional oysters especially during droughts and long warm summers (Kennedy, 1989). According to Burreson and Ragone Calvo (1996): "Salinity is the primary environmental factor that controls local distribution and intensity of *P. marinus* infections. Infections remain light in intensity and no oyster mortality results if salinity is consistently less than 9‰, but they may persist for years. If summer/fall salinities range from 9 to 15‰, some infections may progress to moderate and heavy intensity, but oyster mortality is relatively low. If summer/fall salinities are consistently above 15‰, moderate and heavy infections may be numerous and oyster mortality may be high."

The salinities of most Maryland waters are too low for pea crabs. They are present only in Tangier and Pokomoke Sounds in the southern part of the state and in Chincoteague Bay (Sieling[14]).

Certain dense algal blooms in Chesapeake Bay may be a recent phenomenon, a consequence of a relative scarcity of oysters. And hypoxia in the deep areas of the bay may be related to excess phytoplankton, which falls to the bottom and, in decomposing, depletes the oxygen. Perhaps when oysters were abundant in the 1800's, they cropped most of the phytoplankton and the hypoxia did not occur or was much less severe (Newell, 1988).

History of Oystering

Middens along the shores show that Native Americans long used oysters for food (Wennersten, 1981). In the early 1800's, the main oystering activity was harvesting oysters from beds and transporting them on sailing schooners and sloops northward to the population centers of New York City, New Haven, and Boston. Local oyster consumption probably was relatively small, and no wholesale oyster markets existed (Ingersoll, 1881; Stevenson, 1894).

In the 1830's, some shucking houses were built in Baltimore from which Chesapeake oysters were shipped to Midwestern cities via railroads. Small-scale shipments earlier had been sent westward on horse-drawn wagons (Nichol, 1937).

During 1830–64, the oyster industry expanded sharply as more railroad lines to the west were laid opening markets, dredges came into use, and a wholesale shucking trade developed. Around 1850, oyster canning in metal cans began in Baltimore, and it became the principal means of shipping oyster meats. Baltimore was the center of the Chesapeake oyster trade. As more railroads were built in Maryland, several

[14]F. W. Sieling, Administrator (retired), Maryland Department of Natural Resources, Annapolis. Personal commun., 1996.

Figure 76.—A Chesapeake Bay tonging bugeye with deep-water tongs. U.S. Fish Commission illustration, 1892.

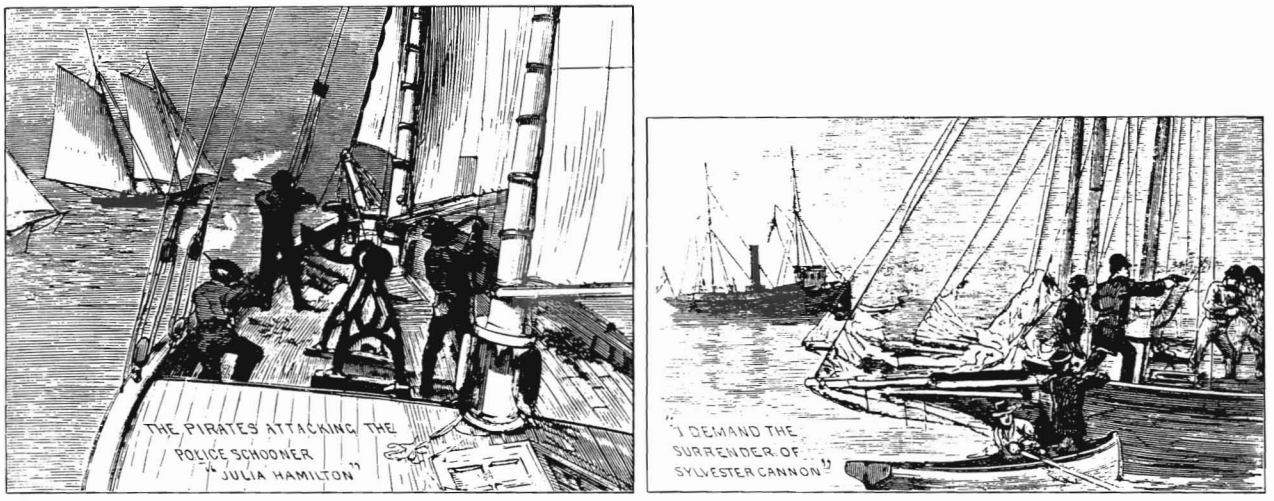
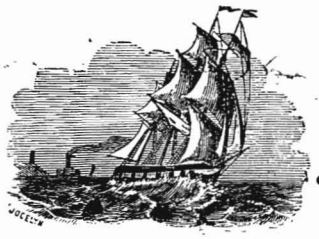


Figure 77.—Left: Oyster pirates attacking the police schooner *Julia Hamilton*; Right: the capture of an oyster pirate by police. Source: *Harpers Weekly*, 1 March 1884.



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At reasonable prices, and of a quality to insure satisfaction.

Our determination to continue the SMALL PROFIT AND QUICK RETURN PRINCIPLE, *and make no bad debts, enables us to give to our customers advantages not offered by houses doing a reckless business, and who make the good pay for the bad.*

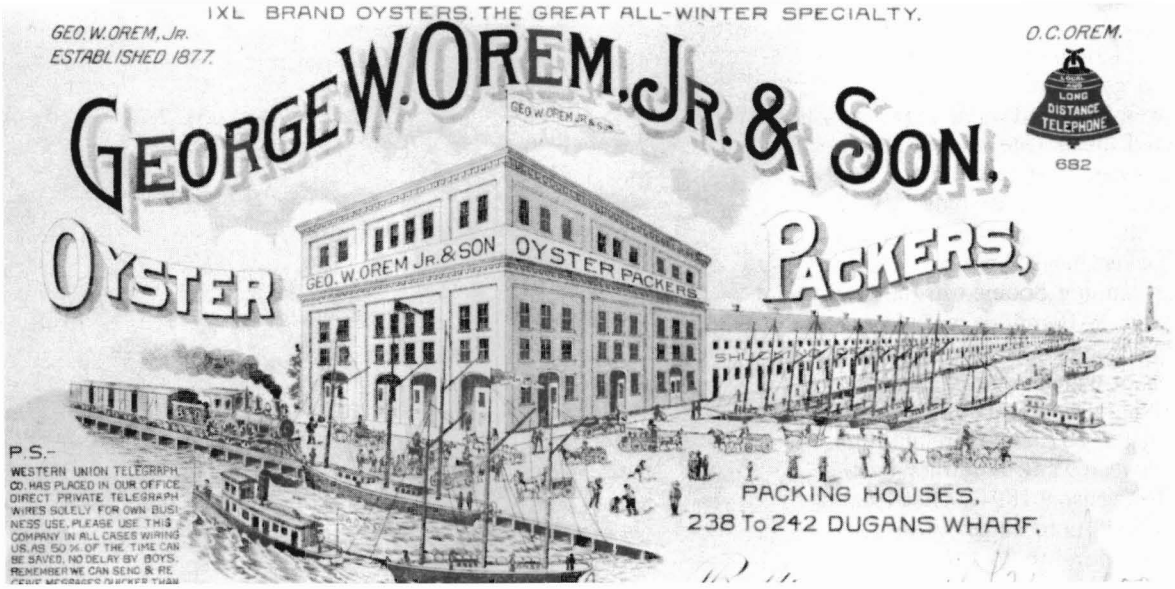
Being assured of our ability to supply you with Oysters of a Superior Quality on equal if not better terms than any other house, we respectfully solicit the favor of your trade.

I. N. SMITH & CO.

LUCAS & SON, PRS.

Over

An early advertisement for fresh oysters. Illustration courtesy of and copyrighted by Frederick Parks.



Above: Turn of the century oyster company bill of sale. Below, early oyster advertising cards. Illustrations courtesy of and copyrighted by Frederick Parks.

smaller ports around the bay, including Cambridge, Crisfield, and Oxford, also developed as oyster market centers. Oysters were marketed whole and as raw and canned meats (Stevenson, 1894). Crisfield, located between Tangier and Pokomoke Sounds, was the only packing center in Maryland's portion of the bay where shuckers handled pea crabs.

Oyster canning boomed in the late 1860's, when 9–10 million bushels/season of Maryland oysters were landed, two-thirds of which were shucked and canned (Nichol, 1937). During several seasons after 1870, oyster landings ranged between 9 and 14 million bushels/year (Stevenson, 1894). After 1900, however, Baltimore began to lose its canning leadership to other states (Nichol, 1937).

In the early 1800's dugout canoes, which originally had been used by Native Americans, were almost the only type of tonging boat used. By the late 1800's, boats used for tonging included skiffs, bateaux, and large log canoes, all under sail. (A dugout canoe was made from one large-diameter log, whereas a log canoe was made of from two to seven smaller logs joined together edgewise (Witty and Johnson, 1988)). The dredging vessels ranged from small two-man boats to schooners 23 m long and included pungies, bugeyes, and sloops. Pungies were first used in the oyster industry in the 1840's. They had a large keel and two raked masts. By the 1880's, bugeyes became the most important dredging vessels. Bugeyes (Fig. 71) were flat-bottomed schooners with the cabin aft and were cheaper to build and maintain than pungies (Wennersten, 1981). The smallest vessels carried a dredge and a winder to haul it aboard while the others carried two of each (Stevenson, 1894) (Fig. 72–74).

In the late 1800's, the first skipjacks (i.e., vessels with one mast and a V-bottom) were built for dredging oysters (Fig. 75). Cheaper to construct and more economical to operate, they eventually replaced the pungies and bugeyes. Power hoists, driven by gasoline engines, replaced the manual winders beginning in 1906 (Vojtech, 1993).

The first records of hand tongs being used for harvesting oysters in Maryland was in the early 1700's (Witty and Johnson, 1988). In 1887, patent tongs came into use (Fig. 76) to harvest oysters in waters too deep for hand tongs (Stevenson, 1894; Witty and Johnson, 1988).

In the early 1800's, oyster dredging began, and it soon took place on all Maryland grounds, except those the state had reserved for tonging. Winslow (1881) suggested that dredging of oysters may have enlarged the beds by spreading the oysters and shells. By state law, the tongers could begin oystering on 1 September while the dredging season began later, between 1 October and 1 November in different years (Anonymous, 1902b, 1905d, 1907b).

Before 1865, oyster regulations were enforced by local sheriffs and constables. In 1868, the state established an oyster police force, popularly termed the "oyster navy." Its duties included

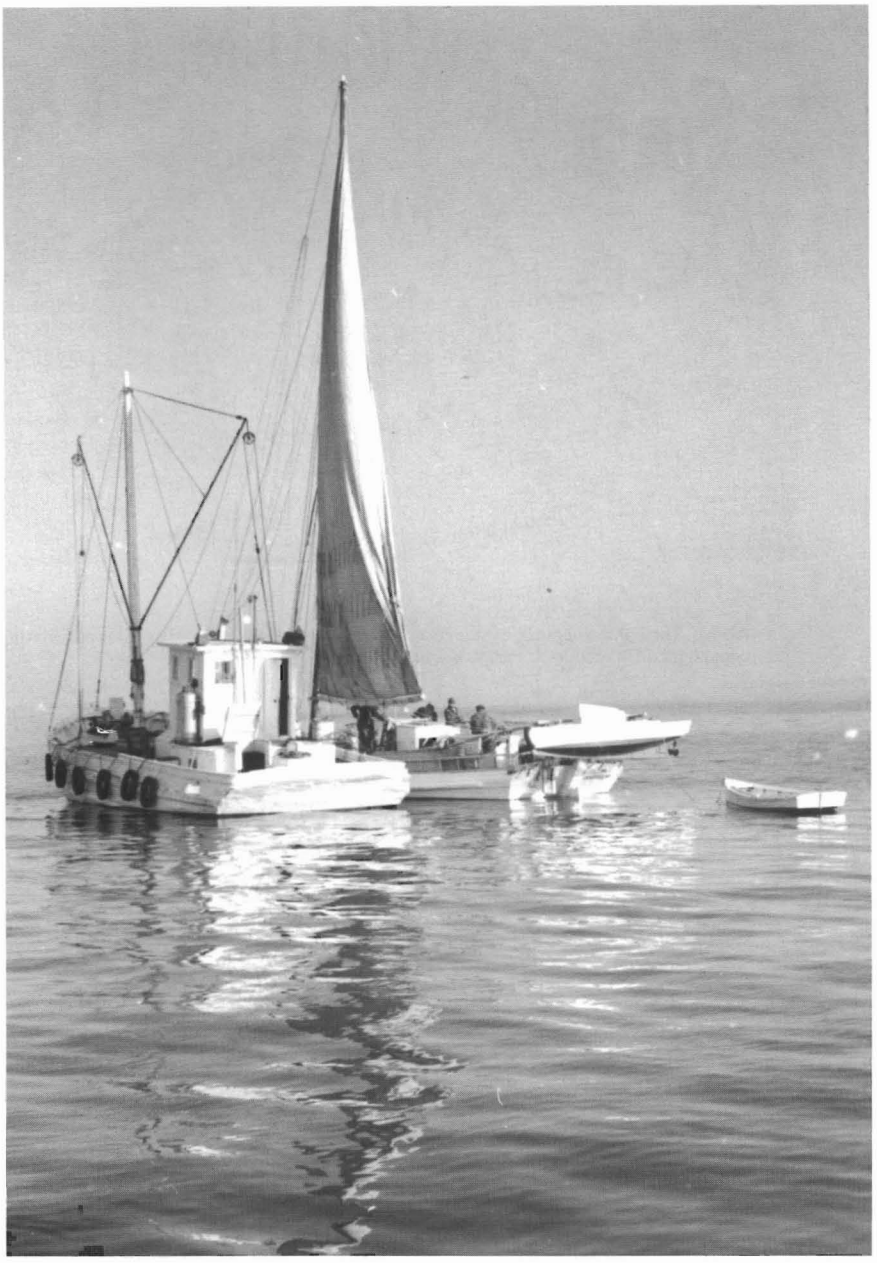


Figure 78.—A buyboat (left) buys oysters from a Chesapeake Bay skipjack (right), ca. 1940's–50's. Photograph by Fred Thomas, courtesy of the Chesapeake Bay Maritime Museum.

preventing dredgers from harvesting oysters on grounds reserved for the tongers (Stevenson, 1894). During the remainder of the century, many violations occurred when some of the dredgers did harvest on the tongers' grounds. The "navy" had to chase the dredgers many times, and the two groups frequently exchanged gunfire (Fig. 77). Such skirmishes were termed the "oyster wars" (Wennersten, 1981).

During the seasons from 1865–66 to 1892–93, from 1,658 to 4,741 boats were licensed for tonging oysters. In two-man boats, the harvest usually was 15–25 bushels of oysters/boat/day. Tongers harvested from 1.25 to 2 million bushels of oysters/season. During the season of 1892–93, some 719 vessels were engaged in dredging oysters; most were schooners and pungies (Stevenson, 1894).

Tonging and dredging boats that harvested at some distance from their ports sold their oysters to buyboats or "runners" which carried them to packing centers. From 1889 to 1892, Maryland's oyster fleet included 351 to 456 buyboats. They differed little from dredge boats, but all were large, 15–21 m long (Stevenson, 1894). (Selling to buyboats (Fig. 78) continued into the 1950's when the trucks collected oysters from boats in various ports (Vojteck, 1993)). In 1890, Maryland passed the "Cull Law": Oysters <2.5 inches had to be returned to the harvesting beds (Stevenson, 1894).

From the late 1860's to the early 1890's, Maryland oyster production was about level at about 8–11.6 million bushels/year, but the number of oystermen increased from about 7,000 to 21,000–22,000. The quantity of oysters harvested/man and their incomes from oysters had declined during the period (Table 7).

The 1880's were the most prosperous in the history of Maryland's oyster industry with Baltimore as the main port. During those years, Baltimore residents consumed at least 800,000 bushels of oysters/season, oyster canning factories were operating at full capacity, the city had at least 3,000 oyster shuckers, and dozens of raw oyster bars and oyster peddlers were common in the streets. In the fall, when raw oysters were packed, oyster trains with 30–40 cars left the city heading west every day (Nichol, 1937).

In the 1890's, some 33,171 people were engaged in all aspects of oystering. Besides these, several other vocations including vessel construction, sailmaking, blacksmithing, grocering, merchandising, medicine, and law were partly dependent upon the oyster industry. The oyster industry had enormous value to the state (Stevenson, 1894).

Around 1900, the Maryland oyster fleet included about 1,500 tonging canoes under sail, giving employment to 3,000 men. A record kept by one Crisfield oysterman showed that during the 1901–02 oystering season there were 203 legal working days. The most able tongers were able to work 95 days, and 108 days were "lost" due to winds, rain, and ice (Anonymous, 1902a).

Soon after 1900, the gasoline engine came into use in the oyster industry. Tongers installed them in their boats to shorten the once long hours of transport between their homes and the beds. Engines were also installed in dredge boats but only to haul the dredges; the state would not allow the use of engines to tow the dredges (Anonymous, 1912k).

Around 1900, in terms of quantities of oysters landed, Baltimore ranked first not only in Maryland but in the nation as well. The city was close to the oyster grounds and had good transportation facilities. During the oyster seasons, railroads shipped many cars daily, loaded entirely with shucked oysters throughout the Midwest. Many Maryland dealers had found it cheaper to shuck oysters in small towns close to the oyster beds and ship them by motor boat to Baltimore for distribution. Burning of oyster shells for lime also had some importance in Baltimore, with the product going to "sweeten" farmland. Another byproduct was crushed and ground shells which were sold to the poultry industry (Anonymous, 1903b).

In the early 1900's, shelled oysters sold for $0.60–$1.00/bushel, while oyster meats sold for $0.75–$0.90 ("standards") and $1.15–$1.40 ("selects") (Anonymous, 1909a). Crewmen on skipjacks and other oyster vessels were being paid $20–$25/month, while cooks were paid $35/month (Anonymous, 1905d). Each skipjack harvested 50–75 bushels of oysters/day. During summers, they were used to transport various types of freight (MacKenzie, In Press).

By 1915, the number of oyster packing houses in Baltimore had declined to 28 (15 were oyster canneries), but they increased in the counties: Crisfield had by far the most with 40, Oxford, 15; Annapolis, 13; Tilghman, 8; and St. Michaels, 6 (Churchill, 1921). Crisfield had become important because it was in the middle of Chesapeake Bay and had a railroad terminal. In the fall of 1919, the oyster packers were paying the oystermen $0.75–$0.90/bushel for oysters and $0.35/bushel to openers for shucking them (Anonymous, 1919c).

In the early 1920's, an abundance of mussels growing on the oysters plagued the oyster industry at times (Anonymous, 1920c, 1922a). For instance, the mussels caused the oystering around Cambridge, Md., to be a financial failure in 1920: It took 2 bushels of oysters and mussels to open one gallon of oyster meats, whereas it normally took

Table 7.—Numbers of oyster fishermen, landings of oysters, fishermen's incomes, and landed value of oysters in Maryland in various seasons, from 1860–61 to 1892–95 (Stevenson, 1895).

Season	No. of Fishermen	Bushels of oysters	Bushels of oysters/man	Gross income per man	Total value of oysters
1860-61[1]	3,000	3,000,000	1,000	$350	$1,050,000
1868-69	6,885	8,040,970	1,168	409	2,814,340
1869-70	7,470	9,233,475	1,236	432	3,231,716
1870-71	7,582	8,947,803	1,180	399	3,031,731
1879-80	13,748	10,600,000	771	281	3,869,000
1889-90	20,481	10,450,087	510	254	5,204,456
1890-91	21,878	9,945,058	455	259	5,665,866
1891-93	21,280	11,632,730	547	275	5,866,120
1892-93	21,200	10,142,500			5,500,000
1892-95			468	259	

[1] No oyster dredging.

Figure 79.—Tonging oysters in Maryland, 1920's (Churchill, 1921).

Figure 80.—The interior of a Maryland shucking house, with shuckers at work (Stevenson, 1894).

Figure 81.—Packing raw oyster meats in cans in boxes with ice, 1920's (Churchill, 1921).

Figure 82.—Shell pile of a large Maryland oyster company, showing the conveyor for carrying shells from shucking tables to the pile (Churchill, 1921).

about 1.5 bushels of oysters to open a gallon of meats. Neither the packers nor the shuckers made any money (Anonymous, 1920c). In later years, some harvests brought into packing houses contained roughly half oysters and half mussels, and the dredge boats had to avoid harvesting from many historically good grounds. Over the years, the mussels have been overly abundant only occasionally (Sieling[14]).

After the late 1800's, Maryland oyster production fell sharply until the early 1930's, it leveled off at between 2.3 and 3.2 million bushels/year during 1930–55, and then declined again. The decline was caused by reduced demand and reduced supply. Rothschild et al. (1994), neglecting to mention the poor demand for oysters, attribute most of the decline to habitat loss (removal of cultch by harvesting and siltation of cultch) and overfishing of oysters. Evidence for this included declines in the sizes of marketed oysters, and surveys in Pokomoke Sound showed large declines in natural oyster beds from 7,360 acres in 1880 to 5,120 acres in 1891, and 1,408 acres in about 1908 (Anonymous, 1908a).

The production drop was sharpest between 1920 when 6.5 million bushels were landed and 1930 when 3.5 million bushels were landed (Fig. 79–82). A major cause for the poor demand was the fear people had about illness from eating oysters that may have been polluted. During 1930–55, when oyster production was between 2.3 and 3.2 million bushels/year, fishermen, packers, and markets could rely on consistent annual supplies of Maryland oysters. After the mid-1950's, oyster production fell again, running about 1.5 million bushels/year in the early 1960's (Anonymous, 1990).

A feature of oysters harvested in most of Maryland where salinities range from 7–10‰ is a bland flavor. Around the

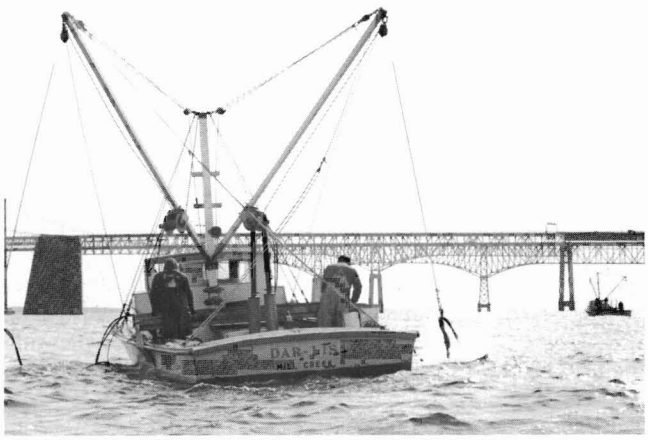


Figure 83.—Harvesting oysters with hydraulic patent tongs below the Chesapeake Bay Bridge in Maryland, 1990. Two crewmen setting two sets of tongs while culling. Photograph by Forest Wells, courtesy of the Chesapeake Bay Maritime Museum.

Figure 84.—Bringing the tongs and oysters out of the water. Photograph by Richard J. Dodds, courtesy of the Chesapeake Bay Maritime Museum.

Figure 85.—Bringing the tongs and oysters aboard. Photograph by Forest Wells, courtesy of the Chesapeake Bay Maritime Museum.

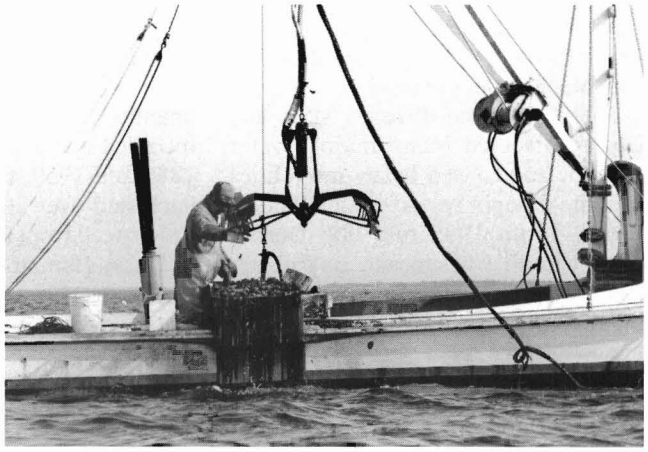


Figure 86.—Oysters are on culling board. Tongs are opened for another grab. Photograph by Forest Wells, courtesy of the Chesapeake Bay Maritime Museum.

1940's, to satisfy a market for stronger-flavored oysters, some dealers began transporting about 50,000 bushels/year of oysters to Chincoteague Bay where the oyster tissues absorbed salty water. Dealers held the oysters in wooden floats or on the bottom for 3–7 days and then sold them. They paid as little as $2.00/bushel for the oysters, $0.50 to $0.60/bushel to have them trucked to Chincoteague Bay, then sold them for about $15.00/bushel. Most were eaten raw on the half-shell and some were shucked to be eaten in stews which sold at a relatively high price because of their enhanced flavor. Restaurants added a

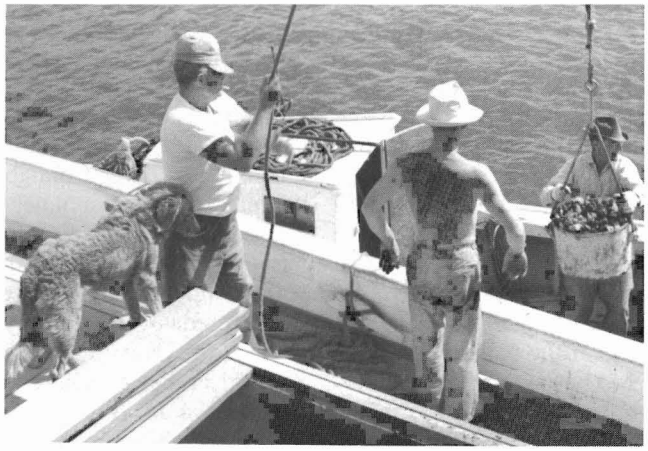


Figure 87.—Unloading oysters into a buyboat. Photograph by Caryl R. Firth, courtesy of the Chesapeake Bay Maritime Museum.

few pea crabs to each stew so the customers would know they were made with Chincoteague oysters; the crabs are orange when cooked and float around the edges of a bowl of stew. The practice continued into the 1960's (MacKenzie, In Press).

In 1960, the state began a program of shell planting and seed transplanting to increase oyster abundance. It involved mining and spreading 5–6 million bushels of shells each year on beds that had a history of good setting and then transplanting some resulting seed to growing beds. The program produced an increase in oyster landings to 2–2.7 million bushels/year from the mid-1960's through the early 1980's. In the 1960's, about 4,000–4,200 men worked on about 1,200 hand-tonging boats, 700 patent-tonging boats, 45 skipjacks, and some other types of boats harvesting oysters (MacKenzie, In Press).

After 1981, the diseases MSX and Dermo affected many major oyster grounds and caused heavy mortalities in some drought periods (Anonymous, 1990). From 1985 to 1988, Dermo spread to all Chesapeake Bay oyster beds either through natural means during drought years or by the transplanting of infected oysters. Oyster mortality was high on most beds, and oyster landings declined to record lows (Burreson and Ragone Calvo, 1996). Oyster landings fell to 1 million bushels in 1983. Landings were 1.6 million bushels in each of 1984 and 1985, but about 0.4 million bushels in 1987 and 1988. As production fell, so did the number of oyster fishermen (Anonymous, 1990).

In the 1990's (Fig. 83–87), the Maryland oyster industry has been severely depressed. In the 1992–93 season, about 125,000 bushels of oysters were landed. On good days, the oyster fleet was comprised of about 400 tonging boats (100 of which were patent tongers), 30 scuba divers, and seven skipjacks active on good days. Each tonger landed about 10–15 bushels at the beginning of the season and 3–4 bushels at the end. Each team of two divers harvested as many as 15 bushels/day, and the skipjacks got about 30 bushels/day when under sail and 40 bushels when driven by engines (MacKenzie, In Press). The harvest increased slightly in the 1993–94 and 1994–95 seasons following two consecutive years of heavier rainfall and consequent lower salinities and higher oyster survival in 1993 and 1994 (Krantz and Jordan, 1996). Some Maryland ports still have many oyster boats in them, but most are in disuse and in various states of decay.

James River

During the second half of the 1800's and first half of the 1900's, Virginia's James River (Fig. 88) produced more seed oysters than any estuary in the world. Fishermen consistently harvested at least 2 million bushels of seed per year from the river according to official state reports (Haven et al., 1978), but at times the local fishermen believe the quantity may have been as much as three times larger because the actual quantities harvested were not always recorded by the state agency. Between 1859 and 1959, the tongers may have harvested over 200 million bushels of oyster seed from the river (MacKenzie, In Press). Hampton Roads, at the mouth of the river, has been a large area of leased grounds for planting and growing seed to market size. The market oysters were processed in shucking/packing houses on its shores.

Description

The James River is the southernmost of several rivers flowing into the west side of Chesapeake Bay. Located immediately northwest of Hampton Roads, the oyster seed beds lie on various shoals of shell along nearly 20 km of its length. Salinities in the seed beds range from about 0.5 to 16‰ in winter and from 4 to 17‰ in summer, while temperatures range from about 5°C in winter to 30°C in summer (Andrews, 1964). Before the MSX disease in the late 1950's, oyster spat set in commercial densities on the beds every year. Oyster predators include bay anemones (which prey on the oyster larvae), xanthid crabs, and blue crabs, *Callinectes sapidus* (Fig. 89). In Hampton Roads, salinities are above 15‰, and the most damaging predator is the Atlantic oyster drill.

History of Oystering

The origins of seed harvests in the James River are obscure. They presumably began in the early 1800's or possibly a little earlier, for by 1825, seed began to be shipped from the river to estuaries in northern states for planting (Ingersoll, 1881). Seed harvests may have increased substantially soon after the mid-1800's when individuals began to control some bottoms for planting seed in Virginia. Fishermen, initially using boats propelled by sculling, harvested seed oysters with tongs and sold them each day to buyboats which carried them to private grounds where they reached market size in 2–3 years and then were harvested (Ingersoll, 1881).

A correspondent for *The New York Times* described the tong fishery on a James River oyster bed in the late 1870's (Ingersoll, 1881): "The shoal from which the *Dennis* was loaded extended over about 500 acres, and from this shoal, on the day that she was loaded, not less than 10,000 bushels of 'plants' were taken. To do this about 250 oystermen were employed, with about 100 boats. And this business of gathering plants had been going on from off the same shoal for upward of two months, with the probability that between 300,000 and 400,000 bushels of oysters have been gathered, and fully 200,000 bushels more will be taken away before the season ends, on May 20. This gives a yield of 1,000 bushels to the acre, and yet nowhere on all this shoal would it be possible to find a spot as large as a set of tongs will cover without oysters on it. The tongs are never pushed down and pulled back without bringing with them a number of oysters. In September the oystermen will begin to work again on the same shoals and work for three or four months catching plants; then, during the winter until the 1st of April, they are engaged in taking up, assorting, and selling the products of these plants. It seems as if the supply of oyster-plants in the James River could never be exhausted, yet the oystermen say they are growing less and less each year; but if they are correct in this assertion, it is difficult to conjecture in what abundance these oysters must have been when they were plenty.

"To see the oystermen balancing themselves in one of their canoes, and working with so much energy at the same time, was quite a novelty. Many of these canoes are so narrow that should a novice step into one it would almost probably be overturned; yet the oystermen work in them all day long in smooth weather, and sometimes in pretty stormy weather, and apparently keep them properly balanced without any effort. To propel them through the water they use a long paddle, and, balancing it over the stern (the canoes, of course, are sharp at both ends, having no row-locks and no indentation to aid them in keeping their paddle in place), they move them swiftly."

The practice of tonging oysters from the river's beds has continued without much change since then. The tonging boats have become larger and have been propelled with sails (Fig. 90, 91) or oars (Fig. 92), but since the 1920's, they have had engines and propellers. The boats which average about 12 m long, have had low washboards which enabled harvesting at most points around them. Each carried from 40 to 150 bushels of oysters. The buyboats were 15–21 m long and carried from 2,000 to 3,500 bushels of oysters each. Buyboats took the seed to planting grounds mainly in Virginia but also in Maryland, Delaware Bay, Raritan Bay, and other points north (Fig. 93). Dredging vessels which harvested on private leases in Hampton Roads at the mouth of the river were 18–27 m long with crews of 6–8.

Virginia established a season from 1 October to 30 May for harvesting seed from its public grounds. Lee (1914) said that spring freshets covered the James River beds with mud and silt and sometimes destroyed all the seed on some beds. He recommended the season be extended to June so the tonging of oysters would disperse the silt down river, thereby enhancing the quantity of seed by cleaning the cultch for oyster larvae.

From the 1920's into the late 1950's, about 700–800 boat crews (1–3 men/crew) were tonging oysters in the river. Typical daily catches were 50–75 bushels for boats with one tonger and 100–150 bushels for boats with two tongers and one culler. A substantial quantity of seed, perhaps close to 1 million bushels a year, was planted on the beds in Hampton Roads. A typical quantity of seed each buyboat carried to Hampton Roads in a season was about 90,000 bushels.

When the seed planted in Hampton Roads had grown to market size and

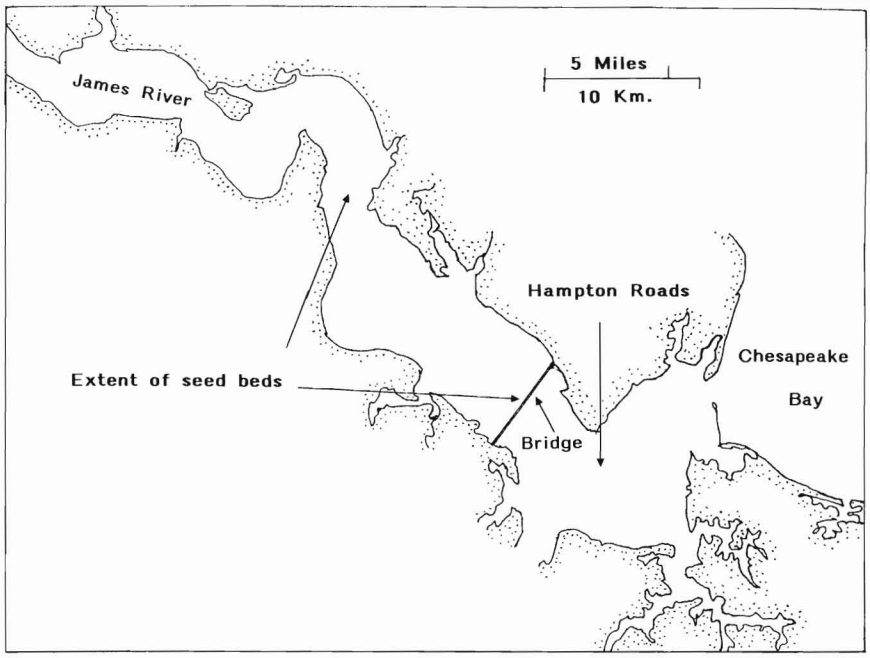


Figure 88.—The James River, Va. The solid line across the river is a bridge.

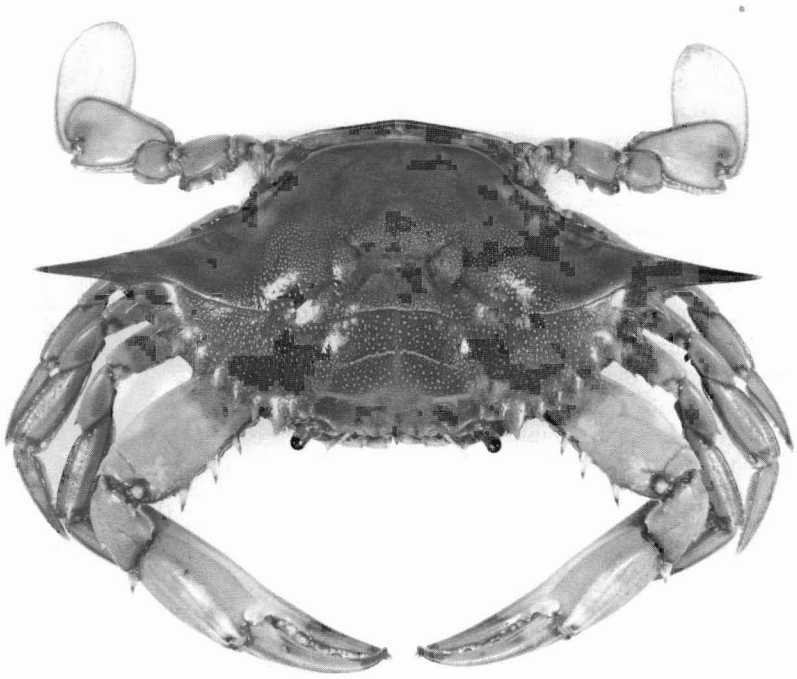


Figure 89.—The blue crab, *Callinectes sapidus*.

Figure 90.—Part of the oyster tonging fleet in port of Deep Creek off the James River in about 1910. Courtesy of the Mariners' Museum, Newport News, Va.

was ready to sell, the companies hired tongers to harvest the oysters or dredged them with their own boats. The companies often preferred tonging because dredging could have ruined many areas as planting grounds by breaking through the fragile bottoms which had a layer of packed surface shell over mud. The tongers transferred the oysters to company buyboats which brought them to nearby houses where the oysters were shucked or packed whole.

In 1915, there were 21 shucking/packing oyster houses in the Hampton Roads area (Churchill, 1921). By the 1950's, three large oyster houses dominated. The J. H. Miles and Co., Inc, had 425 shuckers and the Ballard Fish and Oyster Company had 275 shuckers, both in Norfolk; and the J. S. Darling Company had 75 shuckers in Hampton (Fig. 94) (MacKenzie, In Press).

The salinity in Hampton Roads was high enough for pea crabs and they invaded the planted oysters. The companies saved the pea crabs to sell; the Ballard Fish and Oyster Company produced 1–2 gallons of pea crabs/day. They put the crabs in cans, packed them in ice, and shipped most to Philadelphia (Ballard[15]). Probably most were served with oyster stews. In the 1920's, pea crabs sold for $4–6/gallon (Anonymous, 1920b). In the 1950's, while oyster meats sold for $2–3/gallon, pea crabs sold for $2.00/pint (Ballard[15]). At times, oysters were shucked and the crabs remained in the gills; the crabs were fried with the oysters (Perok[16]). When oyster meats were washed in "blowers," the crabs separated from them (Setterholm[17]).

Figure 91.—Oyster tonging in Virginia. The boats are called "sand bag cat boats." Photograph courtesy of the Mariners' Museum, Newport News, Va.

[15]C. Ballard, owner, Cherrystone Farms, Cheriton, Va. Personal commun., 1996.

[16]Steve Perok, shellfish dealer, Menchville, Va. Personal commun., 1995.

[17]O. Setterholm, shellfisherman, Perrin, Va. Personal commun., 1996.

Figure 92.—Tonging oysters in Yankee-designed skiffs in Virginia waters. A crewman propelled the boats by rowing in the bow while standing. Photograph courtesy of the Mariners' Museum, Newport News, Va.

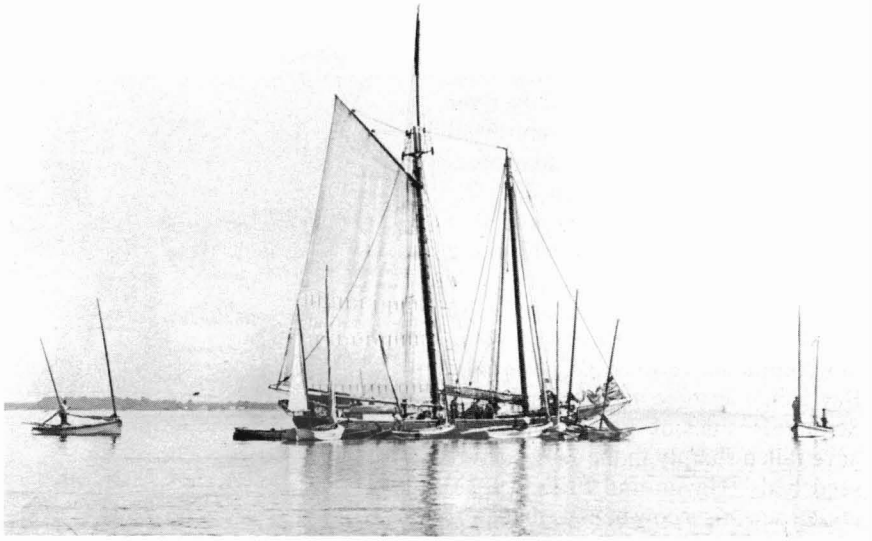


Figure 93.—Middle and bottom photos, schooners (buyboats) load seed oysters from tonging boats in the James River, 1910. Photographs courtesy of the Mariners' Museum, Newport News, Va.

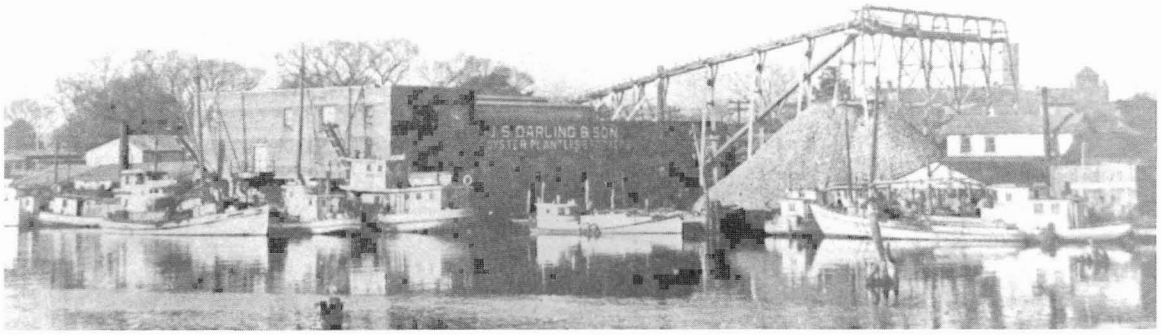


Figure 94.—Part of the harbor at Hampton, Va., an arm of Hampton Roads, showing the plant and vessels of a large oyster packing company in late 1920's. *Fishing Gazette* photograph, courtesy of *National Fisherman* magazine.

In 1957, most tongers began to harvest oysters that were 40–50 mm long, rather than smaller seed, from the river and sell them to a soup company. From 1966 to 1976, from 42 to 175 tong boats harvested about 3,000 bushels/day. The harvesting of the soup oysters ended in 1976 when keypone was found in the river (Haven et al., 1978).

Starting in 1959, the MSX disease began to kill most oysters >50 mm long in salinities above 15‰ in Chesapeake Bay, including those in Hampton Roads. Setting densities of oysters since then have fallen sharply in the James River seed beds (Haven and Fritz, 1985). Oyster scientists now believe that most of the oyster larvae which had set on James River seed beds came from mature oysters in Hampton Roads. The presence of chlorine in the river also may be a factor in the reduced oyster setting (Hargis and Haven, 1988).

In the 1980's and 1990's, Virginia oystering has been concentrated in the James River (Fig. 95). After the 1985–86 season, the river's original seed area became the state's major source of market size (>7.6 cm) oysters (Fig. 96). In the 1986–87 season, tongers harvested 238,000 bushels (U.S. standard bushels) of market-size oysters from the river (Hargis and Haven, 1988).

In 1988 and 1989, oysters were relatively scarce in the James River. During a dry period of the 1980's, Dermo had spread into its beds, persisted at low levels of infection during most winters, and killed oysters in areas where salinities were >20‰ in late summer (Andrews, 1996). Good sets in the late 1980's and early 1990's had produced a fairly abundant supply of oysters on upriver beds by 1994. The once-productive seed grounds in the lower part of the river have accumulated a layer of silt and have few oysters on them. In 1995, tongers harvested small quantities of market oysters and about 20,000 bushels of seed from the river (Perok[16]).

As a consequence of the small oyster stocks in Virginia, few tongers and planters remain active. The planters spread only test quantities of seed on their grounds to determine whether they will live. Most oyster boats have decayed, lie in disuse around the Virginia oystering ports, or are used in other ventures.

Figure 95.—Modern day oyster tonging vessels in port of Deep Creek off the James River, Va. Photograph by the author.

Figure 96.—A 3-inch culling iron used in the Virginia oyster fishery. VIMS photograph.

Apalachicola Bay

Apalachicola Bay, Fla., has long been a large oyster producer (Fig. 97). In recent years, it produced about 20% of U.S. Gulf of Mexico oysters, which is about 10% of the eastern oysters

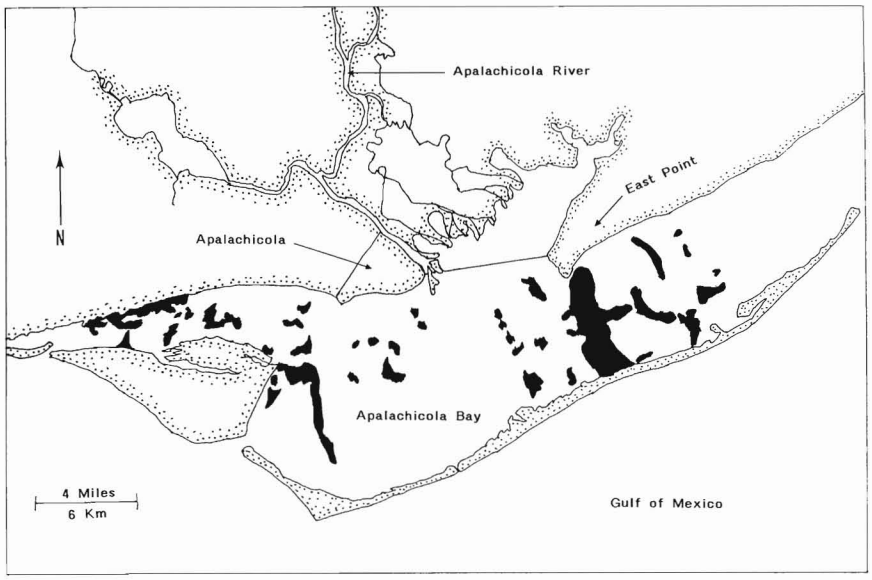


Figure 97.—Apalachicola Bay, Fla., showing locations of oyster beds (shaded).

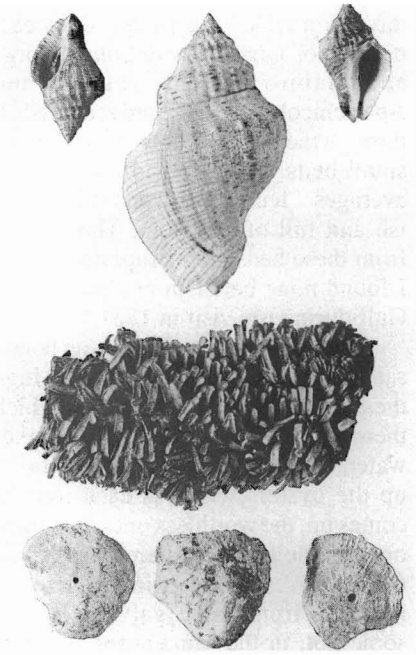


Figure 98.—The Florida rocksnail, *Thais haematoma*, of the Gulf coast (top), the so-called "red grass," center, is the egg cases of the "borer," while at bottom are oyster spat "drilled" by the rocksnail.

landed in the United States (Dugas et al., In Press).

Description

Greater Apalachicola Bay, almost landlocked with just three narrow outlets into the Gulf of Mexico, covers about 45,600 hectares (113,000 acres)(Thompson et al., 1984). About one-twentieth the size of Chesapeake Bay, the bay is shallow with depths mostly from 1 to 3 m and is dominated by extensive shoals and numerous oyster reefs. The turbid Apalachicola River, entering about midway along the north shore of the bay, is its principal source of fresh water and a major influence on bay salinity, which can range from fresh water to 42.5‰ (Ingle and Dawson, 1950). The bay's oysters are most abundant where salinities range from 10 to 30‰ (Dugas et al., In Press). Water temperatures, 10°–32°C, closely follow air temperatures (Livingston, 1983).

Areal estimates of productive oyster reefs ranged from 5,539 hectares around 1900 (Swift, 1897; 1898) to 2,268 hectares in the 1970's (Rockwood et al., 1973). More recently, the public oyster reefs cover about 4,300 hectares (Continental Shelf Associates, 1985; Summagraphics Corporation, 1981).

Oysters have high productive potential in the bay, as is true elsewhere in the Gulf coast estuaries. Spatfall is of long duration, beginning in April and ending in November, and is of commercial density every year. It is heaviest in the more saline eastern and southern areas (Ingle, 1951; Ingle and Dawson, 1952, 1953; Menzel et al., 1966; Berrigan, 1988). Oyster growth continues throughout the year: Oysters reach 75 mm long 16–18 months following setting and 75–85 mm long in 18–24 months (Ingle, 1950; Ingle and Dawson, 1950; Berrigan, 1988, 1990).

Oyster mortality here is caused by disease, predators, and natural disasters such as hurricanes. Distribution of the predatory Florida rocksnail, *Thais haemastoma floridana*, is limited to salinities >15‰ (Fig. 98). Dermo, the most important pathogen, also is salinity-limited and low temperatures limit its activity. Various crabs also prey on oysters (Dugas et al., In Press).

History of Oystering

Many shell middens near the bay show Native American oyster use long before European colonization (Dugas et al., In Press). Ingersoll (1881) wrote that an immense abundance of oysters and oyster reefs on the west coast of Florida astonished early explorers. For example, he quotes Pierre de la Charlevoix who surveyed the area in the late 1600's: ". . . this coast is the Kingdom of oysters, as the great Bank of *Newfoundland*, and the gulf and the river *St. Lawrence* are that of the cod-fish. All these low lands, which we coasted as near as possible, are bordered with trees, to which are fastened a prodigious quantity of little oysters, of an exquisite taste: others, much larger and less dainty, are found in the sea in such numbers that they form banks in it, which we take at first for rocks on a level with the surface of the water." Charlevoix's trees were mangroves, *Rhizophora* sp.

The first record of local oyster sales was in 1836, and the industry remained small until 1850 when it expanded somewhat; it further expanded after 1878 (Anonymous, 1917c).

Ingersoll (1881), citing an acquaintance, Silas Stearns, described Apalachicola Bay and its oyster fishery in 1881:

"This neighborhood has been highly favored with a large number of beds furnishing oysters of large size and fine flavor, which are easily procured and distributed by means of river steamers from (the town of) Apalachicola,

through a wide area inland. Besides a number of large reefs in Saint George and Saint Vincent sounds and Apalachicola Bay, there are scattered all through the deeper waters a great many small beds. The depth of water here averages 7 feet (2.1 m), and it is brackish and full of sediment. The oysters from these beds are of superior flavor; I found none better in any part of the Gulf during my visit in 1881.

"The reefs, or beds, are only an hour's sail from town . . . When the tide is high the boat anchors over a bed, on which there is from 5 to 10 feet (1.5 to 3 m) of water, and both men use tongs to bring up the oysters with. As each tongful comes up, the worthless ones are culled out and the good ones are thrown into the hold . . . The tongs in use here are made of iron, some galvanized and some not, in the same shape as those used on the Chesapeake. With these tongs, on a spot where the oysters are abundant, and need but little culling, two men can put 50 barrels of good oysters into the hold in one day."

"If the tide is very low, as is the case during 'northers', the boat is run aground on an oyster-reef, a gangway-plank is placed over the side, and the oysters are picked up by hand and carried aboard in tubs. Oystering in this manner is said to be harder and slower work than tonging them. When the boat is loaded she goes to town, and if there be a steamboat there, the oysters are turned over to the dealer on board of her; if not, they are not delivered until one does come. The oysters sell for 50, 60, and 75 cents per barrel, already for shipment, that is, in barrels and covered with gunny sack at the top; but the oystermen seldom get barrels or sacks, which have to be furnished by the dealer, at the rate of 10 cents for sacks and 20 cents for barrels, leaving the oysterman but 20, 30, or 45 cents per barrel for the oysters.

"The boats in use are all small sloops of 20 or 25 feet (6.1 or 7.6 m) length, carrying each two men. Last year (1878) there were twenty of these boats engaged in oyster-fishing. With their outfit of tongs, etc., they are thought to be worth about $2,500. Between forty and fifty men are engaged in this business, out of which they make little more than they spend for food while earning it. . . . . From $5 to $8 per week, therefore, is an oysterman's wages when working.

"The principal dealer at Apalachicola states, that he and other dealers there shipped up the river, during the winter of 1878–79, 15,000 barrels."

Until 1895, all oysters were shipped in the shell to local and nearby markets. Afterward, the first shipments of shucked meats were made (perhaps when a rail line reached the area) (Anonymous, 1917c). Tonging and culling of oysters continued for many years with little change in apparatus and techniques (Fig. 99).

Henry (1919) described the bay's oyster industry during the season of 1918–19: "The oysters are all gathered from the numerous beds, or bars, in Apalachicola Bay, which are from one to twelve miles (1.6 to 19.4 km) from Apalachicola. The oysters are all gathered by means of hand tongs. It takes a boat from one to three days to gather a load of oysters, depending on the size of the boat, weather conditions and the quantity or quality of the oysters on the various bars visited. During the present season, the oysters have been unusually poor and variable in quality. As many as twelve bars may be visited before obtaining a load, although very often the boat obtains its load on the first bar. After being unloaded it may be as long as three days before the oysters are all shucked. Thus an oyster may be out of water from a few hours to a week before it is shucked.

"The shucking houses are equipped with a number of stalls for the shuckers, a strainer for draining the oysters before measurement, a skimmer for washing them on, galvanized and tin containers for cooling and shipping, and a refrigerator for keeping the shucked stock in; and all the houses are supplied with city water. The strainer and skimmer are constructed of galvanized material with holes about 0.5 inch (12 mm) in diameter and about 2 inches (50 mm) apart. Each shucker is equipped with a gallon bucket, a thin bladed knife, a hammer, and a breaking block.

"The shucker breaks off the edge of the shell at the end opposite the hinge with the hammer on the breaking block and after cutting the muscle from the shell with the knife, he drops the oyster in the gallon bucket which has been filled about a quarter full of tap water before beginning. When the bucket is full of oysters the shucker pours them on the strainer where they are drained for a few seconds and are measured in a gallon cup; from which they are poured on the skimmer where they are washed with a stream of water from one to three minutes.

"The houses run the oysters from the skimmer into large galvanized contain-

Figure 99.—Oyster tonging and culling in Florida waters during the 1929–30 season. *Fishing Gazette* photograph, courtesy of *National Fisherman* magazine.

ers and chill by putting blocks of ice, twenty to fifty pounds, in the container with the oysters. These containers may then be left in the shucking room or put in the refrigerator. If these blocks of ice melt before the oysters are to be packed for shipment more ice is added. The oysters are stirred up several times during the day in order that all may come in contact with the ice. Some of the firms ship the same day the oysters are shucked, so that the oysters are not in contact with the ice and water longer than ten hours and usually not longer than four or five hours. One house states that on cold days no ice is used. The shipping containers are all supposed to be water tight. The containers used a five and ten-gallon galvanized returnable containers and one, three and five-gallon supposedly non-returnable tin containers.

"An analysis shows that where no ice or water was added to the oysters after washing and the oysters were kept overnight so that the water from washing and the leakage of the oyster could separate, the average amount of liquor in the stock prepared for sale at the time it would have been ready for consumption was 11.13%; after standing in contact with ice for four hours 23.67%; and after standing in contact with ice for one day 23.1%. It is possible and is being done to ship Apalachicola oysters that will not contain more than 15% of free liquor."

Little has since been written about the oyster fishery in Apalachicola Bay until the review by Dugas et al. (In Press), but, judging from historical landing statistics, oysters likely were harvested consistently from the bay in nearly all intervening years. The oyster harvests have fluctuated widely but usually ranged from 320,000 to 960,000 bushels (Dugas et al., In Press). The local people eat oysters year-round, but mostly in the "R" months.

Planting of seed oysters (Fig. 100) and shell planting on the public beds (Fig. 101), which may have begun as early as 1914 (Danglade, 1917), has helped to maintain and increase oyster abundance. Since 1949, the state has spread at least 7.6 million bushels of shells on the beds (Ingle and Dawson, 1953; Whitfield, 1973; Futch, 1983; Berrigan, 1990). From 1960 to 1992, shells of the Atlantic rangia clam, *Rangia cuneata*, from Louisiana as well as oyster shell have been used as cultch (Dugas et al., In Press).

The principal method for harvesting oysters has been by hand tonging, and to a lesser extent by wading and hand collection. And, in recent years, some scuba divers have harvested oysters. Fishermen tong from flat-bottom, shallow-draft wooden and fiberglass boats, 5.5–7.6 m long, which, since World War II, have been propelled by 5–250 hp outboard motors. The boats commonly have walk boards above the gunnels on which the fishermen stand while tonging (Fig. 102, 103). A culling board is placed across each boat. The oyster fleet usually consists of 250–500 boats with from 1–2 tongers and a culler working in each boat (Dugas et al., In Press).

Annual oyster production from the bay, highly variable since 1980, was about 1 million bushels (6.6 million pounds of meats) in 1981, but declined to less than 80,000 bushels (0.5 million pounds) in 1986 following oyster mortalities associated with Hurricane Elena which struck the bay in September 1985. A downward trend in production from 1986 to 1989 corresponded with extended periods of high salinity (Dugas et al., In Press).

Since 1985, the Florida Marine Fisheries Commission has regulated oyster harvesting to maintain the oyster resource. Its rules include limits on harvesting days, daily hours, and bag limits (Berrigan, 1988). The state closes the principal beds in the summer, but opens some and a small summer fishery exists. The main oystering season begins on October 1st. Most harvested oysters currently are landed at East Point, 12 km east of Apalachicola.

Early 1990's oyster abundance and landings increased over the late 1980's (Navarro, 1996). From 1990 to 1993, landings from the bay exceeded 300,000 bags/year, and during the 1992–93 season, many tongers got the

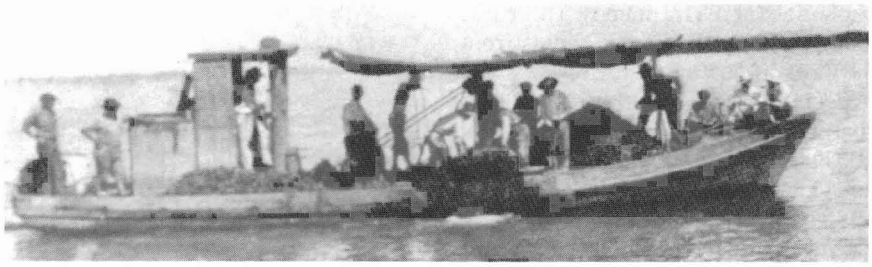


Figure 100.—Workmen aboard a dredge boat in Apalachicola Bay, Fla., gathering seed oysters for replanting (Galtsoff, 1943). *Fishing Gazette* photograph, courtesy of *National Fisherman* magazine.

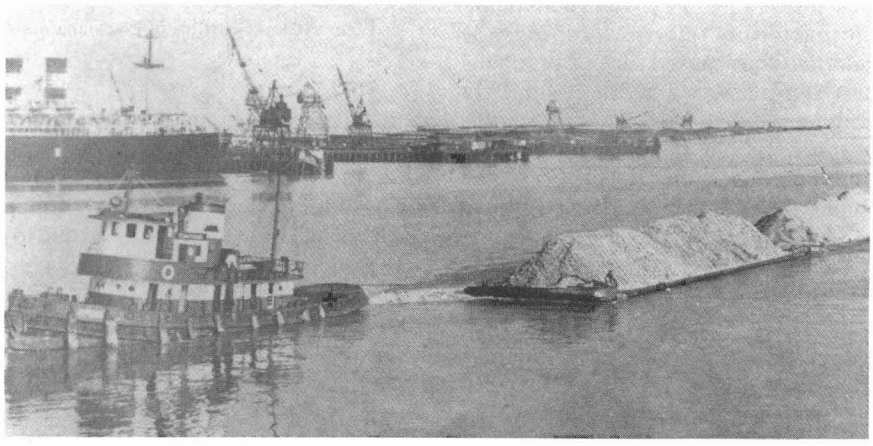


Figure 101.—A tugboat pulls a line of barges carrying oyster shell to be spread as cultch on beds in Apalachicola Bay, ca. 1950's. *Fishing Gazette* photograph, courtesy of *National Fisherman* magazine.

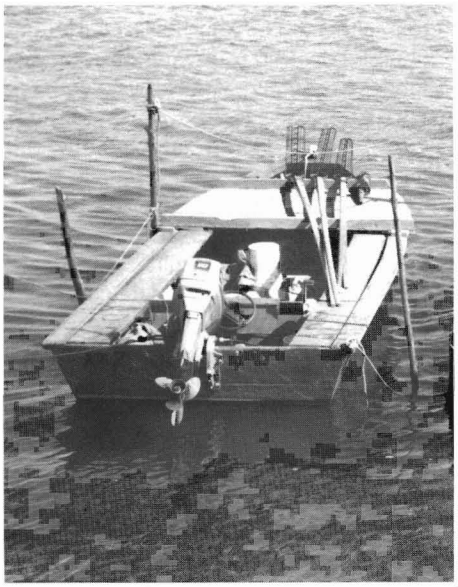


Figure 102.—A typical boat used for tonging oysters off East Point in Apalachicola Bay, Fla., in the 1990's. Note the walkboards on both sides of the boat, where the fishermen stand while tonging, the culling board at the bow, and the tongs.

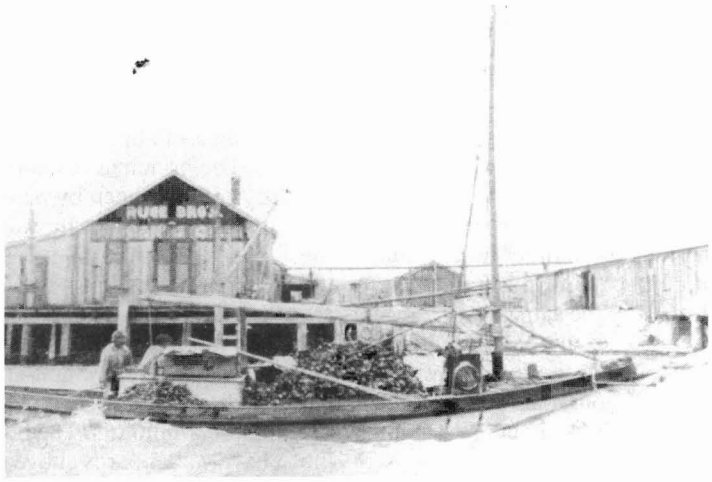


Figure 103.—Small sloop used in tonging oysters near Apalachicola, Fla., returning with a load of oysters, showing oyster canneries in the background (Churchill, 1921).

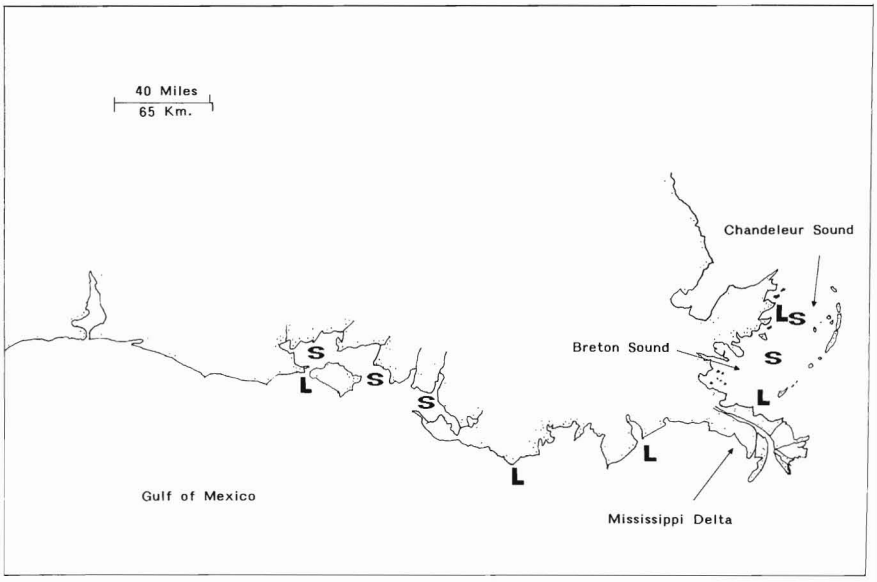


Figure 104.—Coastline of Louisiana showing locations of seed (S) and leased (L) beds.

daily state limit of 15 bags/boat/day (a bag weighs about 60 pounds, a little less than a bushel). Estimated yields from the most productive reefs exceeded 400 bags/acre, but harvesting effort was sharply reduced when yields fell below 200 bags/acre. The landed price of oysters ranged from $6 to $28/bag between 1986 and 1992.

Weak market demand has been limiting production and prices, mainly owing to concerns over reported instances in which people have become sick after eating raw oysters containing the bacterium *Vibrio vulnificus*. *V. vulnificus* has caused serious problems in oyster marketing because, similarly to other types of bacteria, it can multiply during commercial handling operations (Son and Fleet, 1980; Cook and Ruble, 1989). By 1993, prices had fallen to $6–$10/bag (Dugas et al., In Press).

During the mid-1990's, heavy rainfall forced the state to halt commercial oyster harvesting in the bay for prolonged periods because bacteria counts were high. In 1995, the bay also was closed to harvesting for an additional month and a half because of the presence of "red tide." But during the 1994–95 and 1995–96 seasons, the market demand increased, and the bay waters were in good condition most of the time for oystering. Apalachicola shucking plants often process oysters from Louisiana whenever the bay is closed due to pollution. In 1996–97, fewer fishermen than usual were on the beds, i.e., 150–200/day, because many had left the insdustry.

Louisiana Estuaries

Louisiana's estuaries (Fig. 104) yielded 50% of the oysters produced along the U.S. Gulf of Mexico during 1961–88 (Keithly and Roberts, 1988), and they produced 42% of the national oyster landings in 1995.[11] Chandeleur and Breton Sounds have been the state's largest producers.

Description

Following a survey of the oyster situation in Louisiana, Zacharie (1898) stated: "The extent of the oyster territory is so vast, the supply so abundant and cheap, and so little labor and capital are required for its development, that its wonderful advantages and enormous

profits once known, capital and labor will inevitably seek employment in what must eventually become a leading industry, far surpassing that of any other state in the Union. . . ." Zacharie's forecast nearly became true. He went on to say, "Besides these natural beds, the coast abounds in suitable places in which the mollusk can be transplanted from the seed bed . . ."

Permanent Louisiana oyster beds are concentrated in certain parts of the Louisiana coastline in salinities from 5 to 20‰ (Perret et al., 1991). Monthly average water temperatures range from 10° to 32°C. The tidal range is from 0.5 to <2 m (Dugas et al., In Press).

Commercial density spatfall occurs on the beds every year. Oyster predators include the rocksnail, *T. haemastoma*; crabs; and black drum, *Pogonias cromis* (Pausina, 1988; Dugas et al., In Press); however, low salinities bar rocksnails and most crabs from many oyster beds (Dugas et al., In Press). Dermo has been a major cause of oyster mortalities (Mackin et al., 1950; Pausina, 1988).

History of Oystering

Shell middens on Louisiana's shores provide evidence of Native American use of oysters (Wicker, 1979); early French settlers also ate oysters. By the 1800's, the market for oysters expanded and they were a common food, especially in New Orleans (Dugas et al., In Press).

The first commercial oystering operations began in the early 1800's in estuaries near the Mississippi Delta. In the mid-1800's, fishermen found that by transplanting oysters from natural reefs near the delta (where they were overcrowded, narrow in shape, and lacked good flavor owing to low salinities) to bedding grounds closer to the Gulf of Mexico, the oysters grew into a more attractive oval shape, reached market size in a few months, and had a better flavor.

Zacharie (1898) reported that, "The manner of cultivation, if it can be dignified by that name, and the methods of fishing and forwarding to market, are of the most primitive character. Small colonies of fishermen 'squat' on any available shore, generally along some stream, bay or lake emptying into the Gulf, regardless of the ownership of the land, erect their huts, and with the capital of a pair of oyster tongs, a skiff or two and a small stock of rough provisions, usually advanced by the dealers in the city, embark in the trade of oyster fishing. Few of them own luggers or engage in the business of forwarding their oysters to market. From the time they recruit their helpers from the freshly arrived of their countrymen, who, knowing neither the language nor the country, go to 'learn the trade' at nominal wages as a sort of apprenticeship, receiving as a part compensation for their labor board and lodging, such as it is. The master fisherman or 'captain,' as he is termed, thus equipped and assisted, starts out in the planting season and transports from the natural bed skiff loads of the shellfish, which he deposits in the brackish bayou or lake which he has selected near his cabin, marks the beds of 'plants' with stakes to designate his ownership, and keeps 'watch and ward' over his possessions until his crop is ready to ship to market. Others do not plant at all, but only fish the natural oysters from the bed to sell to 'lugger men.'

"When sufficiently matured, say, to an average length, between four and six inches (after about 22 months), depending to a great extent on the size when transplanted and the richness and abundance of the food, the crop is ready for marketing. . . . . Fully matured plants, vary in price from $1 to $2 per barrel (equal to about 3 U.S. standard bushels), according to the reputation of the place from which they come. These 'barrels,' however, are what are technically called 'bank measure,' that is two 'bank measure' barrels make about three barrels when sold in market. When the planter finds that his crop is sufficiently matured and fat, ready for market, say, six or eight months after being transplanted, he bargains and sells to the highest bidder.

"The trip to New Orleans usually takes from two to three days, a part of the journey consisting in threading narrow, shallow and tortuous bayous. Adverse head winds sometimes delay the passage so long that the cargoes are unmarketable on reaching their destination. Sometimes, when practical, 'cordelling,' or hauling the luggers by horse or man power is resorted to, and at times steam towage is employed, all of which, of course, is an element of further expense." Such was the beginning of oyster cultivation that has since been practiced (Korringa, 1976; Pausina, 1988; Dugas et al., In Press).

The lugger was one of the oldest types of boats built by Europeans in North America, and was perhaps the most important vessel used in the Louisiana oyster fishery in the 1700's, 1800's, and into the 1900's (Fig. 105, 106). Constructed of cypress and oak and propelled by a single lateen sail, the luggers were of two sizes: 1) length, 12.5 m; beam, 4 m; draft, 17.5 cm forward and 60–70 cm aft; 2) length, 18 m; beam, 5.2 m; draft, 30 cm forward and 90–105 cm aft. Up to about 1905, there were about 1,500 luggers in Louisiana. They carried all the oysters, shrimp, fish, and other seafoods to market for the fishermen, and took back to the fishing villages and marsh towns their food, clothing, mail, and school books. They slowly disappeared as other vessels replaced sails with engines, but many luggers were resurrected and engines were installed in them. Luggers carried a great deal of weight for their size. The 18 m luggers had their engines set far back, giving them cargo space of about 13.7 m in length with a greatest width of 5.2 m. They traveled at speeds reaching 14.3–19 km/hour (Dunn, 1920).

In recent years, most oyster vessels have been dredge boats ranging from 7.6–18 m long with crews of 1–3 depending on their size (Dugas et al., In Press). While dredging oysters, captains commonly steer and operate their two dredges from the bows of their vessels. A curtain is placed above the deck to provide shade from the sun.

Louisiana oystering operations somewhat resemble those in Delaware Bay. During much of this century, they have consisted of dredging seed oysters from state grounds, transplanting them to private leases for several months of growth, and then harvesting them as

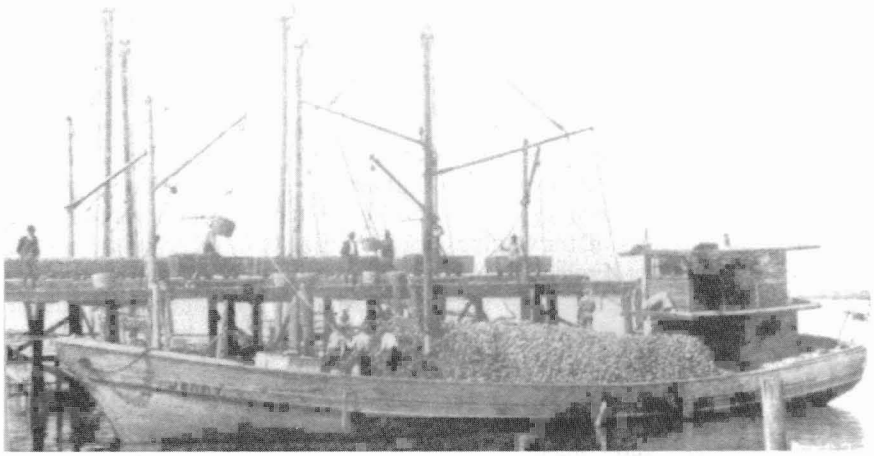


Figure 105.—An 18-m (59-foot) converted lugger, the largest size of these boats, with a load of oysters for a Mississippi coast cannery. The lugger is being unloaded at three sites (Dunn, 1920). *Fishing Gazette* photograph, courtesy of *National Fisherman* magazine.

Figure 106.—A loaded oyster lugger, Pearl River, La., December 1940.

market oysters. Louisiana's estuaries usually have a surplus of oysters, with the market demand controlling commercial utilization. The locals have eaten oysters year-round, but mostly in the "R" months.

Around 1900, the oyster industry was growing rapidly. Many new companies were going into the business. In 1904, about 2,000 vessels were engaged in the oyster fishery, and by 1905, the number reached 2,300–2,500 vessels (Anonymous, 1905c).

In 1905, fishermen began using dredges to harvest oysters. Dredges at first were hoisted aboard vessels using manually operated winches, but since 1913, power hoists have been used. Most dredges were about 1 m wide and weighed about 120 pounds (Dugas et al., In Press). Conversion from sails to engines and propellers began in the 1920's, and the development of water pumps to load oysters onto boats and unload them afterward took place in the 1970's (Pausina, 1988). Vessel trips to New Orleans with loads of market oysters were made within a day with engine power.

Many Louisiana oysters were sold in Biloxi, Miss. (Fig 107), where they were canned. In the early 1900's, Biloxi was second in importance to Baltimore in oyster canning. Cannery labor then was piece work; wages were from \$0.60–\$1.25/day for women and children, while day labor was paid \$0.15/hour. Most capping of cans was done by machinery, and a machine operator capped 20,000 cans/day (Anonymous, 1906a).

By 1912, Louisiana was producing 2,300,000 bushels of oysters worth \$1,000,000 to the fishermen. The state had 6 canning factories which processed 1,240,000 bushels of oysters. The shucking of raw oysters had developed and was increasing. Some 57 shucking plants processed 1,070,000 bushels of oysters (Anonymous, 1912d). The only information on the size of the industry in the early 1900's was published in *The Fishing Gazette*. Included are data for 1919 on numbers of boats, people employed, people dependent on the industry, leases, leased acreage, and values of boats, equipment, and shore property (Table 8).

In the 1850's, oystermen had been granted bottoms for growing oysters for the first time. They were leased from various parishes (equivalent to counties in other states), but since 1902 the leases have been issued by the state (Dugas et al., In Press). Since 1962, Louisiana's oyster grounds have been divided into two regions: 1) those set aside for leasing to individuals and 2) state controlled (Perret et al., 1971). In May 1980, about 230,000 acres were leased, and about 800,000 acres were state-controlled; of the latter, 16,453 acres are referred to as "Seed Ground Reservation," and 6,737 acres are maintained as a public reef in Calcasieu Lake. Seed grounds have been managed primarily for seed oyster production, but oysters at least 3 inches (7.6 cm) long can be harvested from them for direct sale. The public reef in Calcasieu Lake is used only for hand tonging (Pausina, 1988).

Since 1926, the state has planted at least 22 million bushels (764,000 m^3) of shells on the public beds to increase

Table 8.—Data for the Louisiana oyster industry in 1919 (Anonymous, 1920a).

Item	Number
Power boats	379
Schooners	168
Luggers	125
Barges	18
Sloops	5
Skiffs	3
Cat rigs	2
People employed	5,874
Dependent people	23,496
Leased acreage	19,906
Value of boats and equipment	\$1,837,500
Value of shore property	600,000

seed abundance (Fig. 108). Before 1956, the principal shell source was "steam-plant oyster shell" that was returned to the state from oyster canneries including those in Mississippi. In the late 1950's and early 1960's, oyster shell dredged from relic Louisiana reefs supplemented the "steam-plant shell" (Perret et al., 1991), and since the early 1960's, shells of the Atlantic rangia clam have been used along with oyster shells. The clam shells are much smaller than oyster shells, allowing the oysters to grow into better shapes, and they are easier to cull. Clam shells recently have become unavailable (Dugas et al., In Press), so the state has been spreading oyster shells dredged from old reefs.

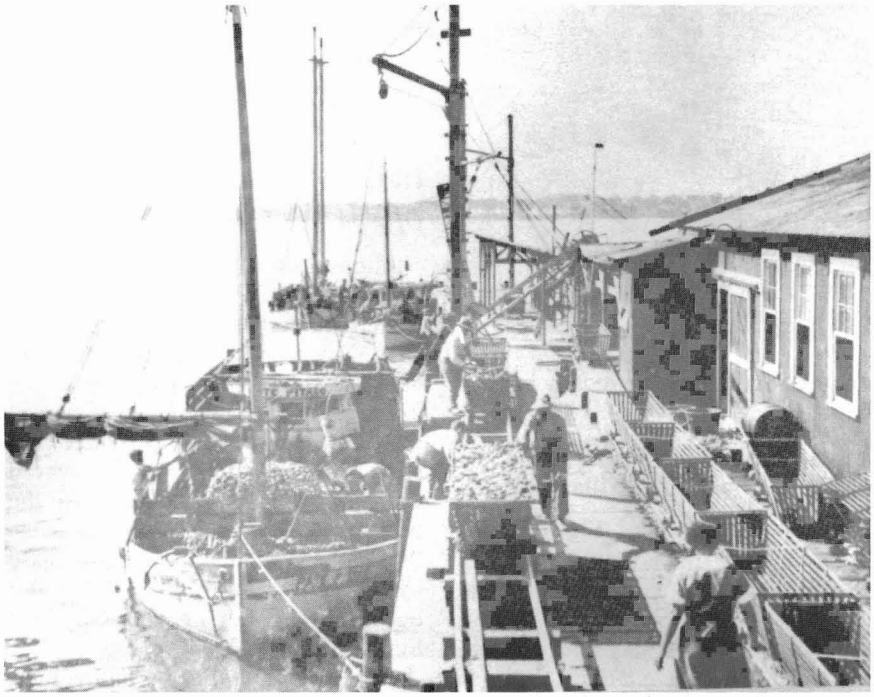


Figure 107.—Vessels unloading oysters at a cannery in Mississippi in about 1920. Photograph supplied by author; original source unknown.

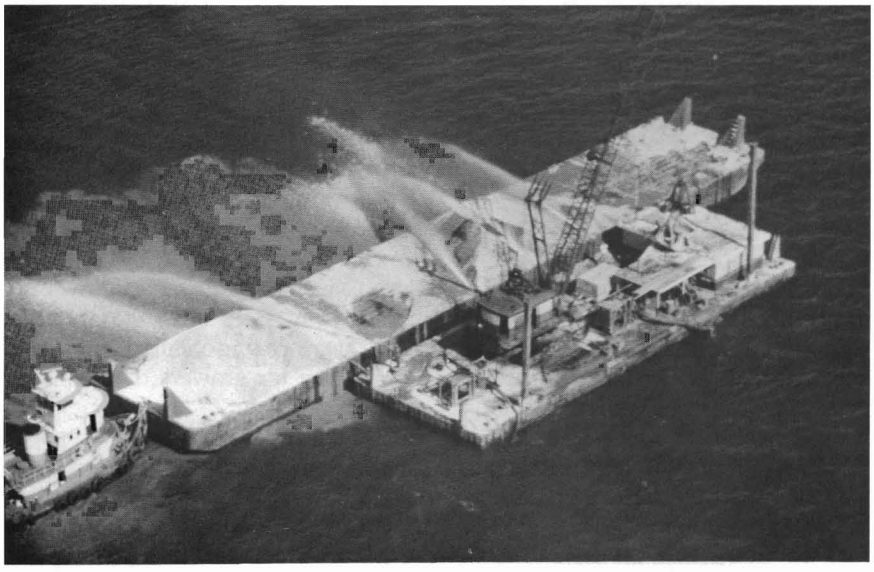


Figure 108.—Planting oyster shells for cultch in Louisiana. Photograph by Lloyd Poissenot, 1970's.

The state opens the seed grounds in early September, when most of the seed is 25–75 mm long. Oystermen dredge it aboard their vessels (Fig. 109) and transfer it to their leases which are usually in water of higher salinity where oyster growth is faster. On the oyster grounds, salinities fluctuate widely depending on the Mississippi River flow. The prevalence of Dermo fluctuates accordingly. Oystermen attempt to search for disease-free seed in low salinity, plant it, and then market it early to avoid excessive losses (Andrews, 1996). The oysters usually remain on the beds for 3–6 months and then are harvested for sale. Each boatload of seed taken from the state seed grounds and bedded in September can yield as much as 2–4 boatloads of marketable oysters by April of the next year (Perret et al., 1991).

In December 1991, about 2,000 people held about 9,000 leases covering 340,000 acres, mostly in the eastern part of Louisiana. The leases, issued for 15-year periods, average about 36 acres in size (Dugas, 1988). The leased grounds historically have produced from 65–85% of the state oyster harvest (Keithly and Roberts, 1988; Pausina, 1988; Dugas et al., In Press).

Louisiana has active oil development in its coastal waters, more so than any other state, and this has affected the oyster industry (Soniat, 1988). Between 1940 and the early 1980's, about 350 cases of possible damage to the oyster industry from oil industry operations were investigated. Some 75% of the damage was the result of dredging and siltation, 17% was from oysters being tainted with an oily taste, and the remaining 8% was from various complaints such as barge groundings and seismic damage (Soniat, 1988).

In recent decades, oyster production on a per acre basis has declined because fewer good areas have been available to the industry for growing oysters. Saltwater intrusion from the Gulf of Mexico has destroyed the usefulness of some oyster beds by allowing increased num-

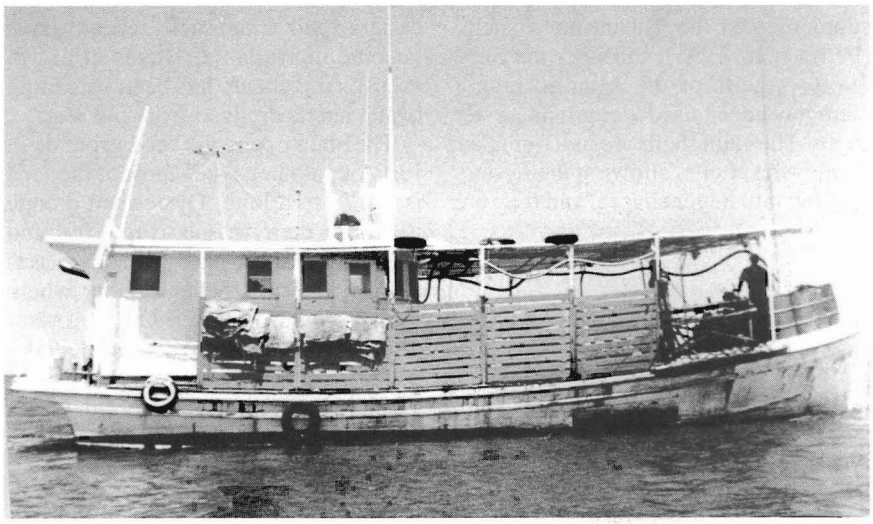


Figure 109.—A classic Louisiana oyster-dredging boat, NOAA photograph.

bers of rocksnails and predatory fish to inhabit them. The human population along the coast meanwhile has increased, resulting in closure of some beds owing to domestic pollution (Chatry et al., 1983; Keithly et al., 1993).

Some leases recently have been cancelled, suggesting a decline in oyster-lease-based businesses (Keithly et al., 1993), but the number of oyster vessels has increased from about 500 vessels working in any one day during 1960 through the mid 1980's, to 600 vessels/day by 1992–93 (Dugas et al., In Press). In most cases, individual vessel production decreased (Pausina, 1988). Since about 1980, oysters have been sold year-round instead of only in the cooler months as in the past (Dugas et al., In Press).

Despite the problems, Louisiana's oyster production has been consistently good each year and has averaged about 9 million pounds of meat (1.95 million U.S. bushels)/year through 1980. Owing to the state shelling program, the oystermen have been able to depend on a steady supply of oysters. Production increased to about 12.5 million pounds of meat (2.7 million bushels)/year into the mid 1990's as the market for its oysters increased. The threat of *V. vulnificus* being carried in oysters consistently impedes marketing, especially for raw consumption (Dugas et al., In Press). Oyster fleet vessels are mostly in good condition.

Washington Estuaries: Puget Sound and Willapa Bay

Puget Sound, Wash., (Fig. 110) and the coastal Willapa Bay (Fig. 111), about 80 km west, constitute the principal west coast oyster-producing area. Found there are the tiny native Olympia oyster, *O. conchaphila*, famous in the northwestern United States since the late 1800's and early 1900's, and the Pacific oyster, *C. gigas*.

Description

The bottoms of Puget Sound and Willapa Bay oystering areas consist of gravel-sand or mud. In Puget Sound, the oyster beds are in relatively small shoreline areas; most of the sound is extremely deep. Water salinities range from 15 to 30‰, temperatures from 5° to 23°C, and the tidal amplitude can be as much as 6 m. Olympia oysters once occurred along much of the sound's shores, growing best where salinities averaged about 25‰. The best habitats were tidepools and where predators were scarce. The main predators of Olympia oysters are crabs, especially the red rock crab, *Cancer productus;* several species of ducks; the Japanese rocksnail, *Ocenebra inornata;* and the flatworm, *Pseudostylochus ostreophagus* (Baker, 1995).

Pacific oysters grow well in Puget Sound and Willapa Bay, except where salinities are below 15‰ for extended periods (Fig. 112). The oysters do best on broad tidal flats with firm bottoms. Most are grown in areas between about 1 m above and 0.5 m below mean low water. Where bottoms are soft, the oysters must be suspended (Fig. 113, 114). Pests of Pacific oysters are the Japanese rocksnail; red rock crab; Dungeness crab, *C. magister*; starfish; and mud shrimp (Lindsay and Simons, In Press).

History of Oystering

Olympia and Eastern Oysters

Middens show that Native Americans commonly and widely ate the Olympia oyster. The early European settlers purchased oysters from Indian tribes and gathered some by hand for their own use and sale. In 1895, the state passed the Calhoun Act which permitted persons who occupied and cultivated Olympia oyster beds to purchase the beds. The Busch Act, passed at the same time, allowed individuals to purchase oyster land even if they had not used it before for oystering (Lindsay and Simons, In Press).

The Fishing Gazette (Anonymous, 1912f) quoted the newpaper, *Tacoma Ledger,* in 1912 describing oystering in Willapa Bay (Fig. 115), "When the tide is out there is set in Willapa harbor a table 24 miles (38 km) long loaded down with . . . oysters . . . and it might be added that the viand is served in only one style—in the shell. Nature's gigantic banquet table under the waters of Willapa Bay and outshooting streams extends over 22,000 acres, the area of the state reserve and commercial oyster beds. On not more than 5,300 of these acres are the bivalves grown for market, the state beds, comprising 14,000 acres, being conducted as a base of supplies for growers of the native product.

"By this process of official propagation there is carried out the idea of conservation with the purpose of perpetuation. Both the small native growth, the ideal component of the popular oyster cocktail, and the big Eastern product, raised from seed imported from Atlan-

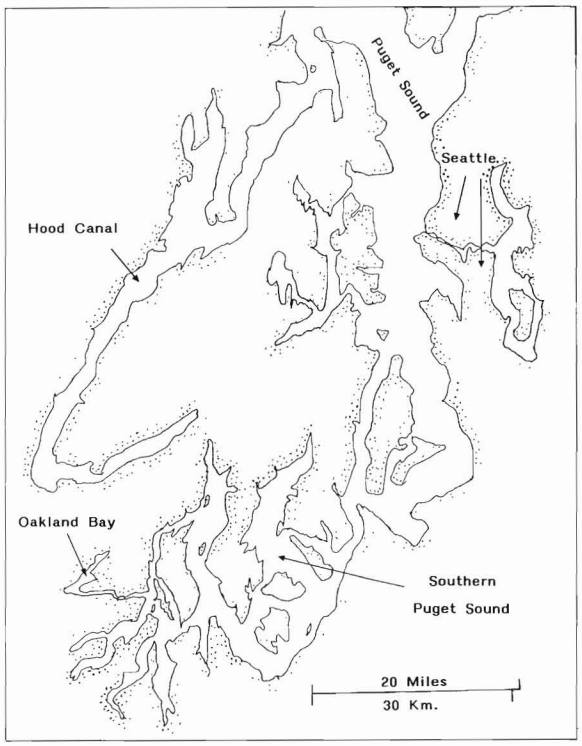


Figure 110.—Puget Sound, Washington.

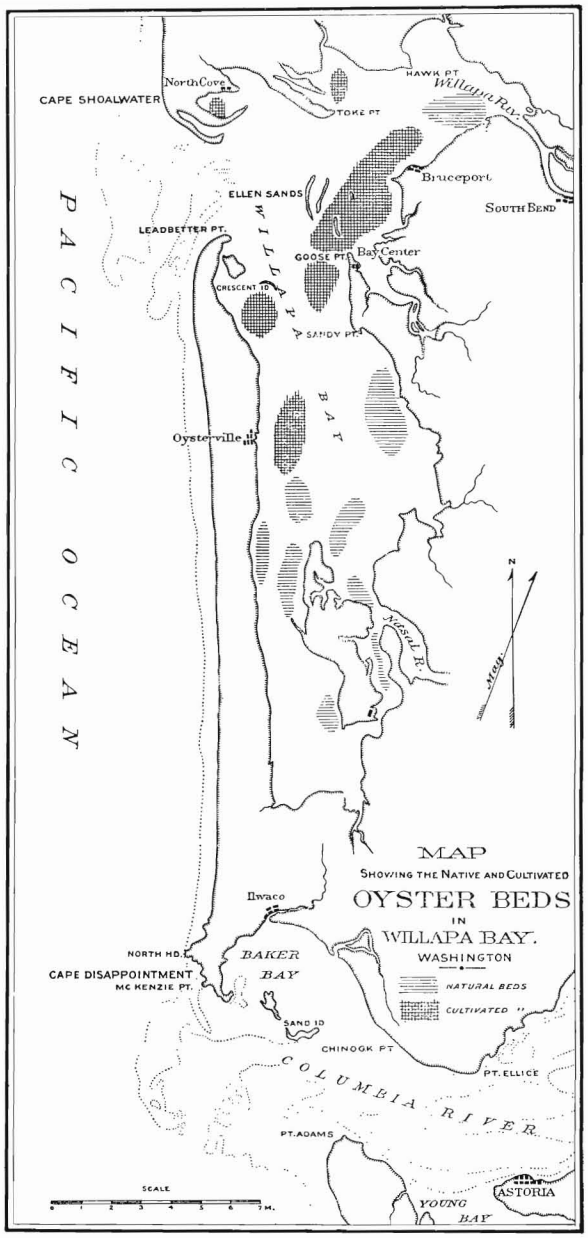


Figure 111.—Willapa Bay oyster areas in 1890.

tic coast waters, are outputs of the commercial beds in about equal quantities. The remaining 2,700 acres of commercial area are not under cultivation as yet.

"Oyster growing is one of the most valuable productive pursuits in the State of Washington. The immensity of this resource is shown by figures compiled by the State, which place the Willapa Harbor output last year at a valuation of $310,000. The greater output was of the eastern oysters, $180,000 worth, the value of the natives having been $110,000 [sic]. At the time the report was made there were 3,500 acres of native and 1,800 of eastern oysters under cultivation.

"The State's other oyster beds are in the waters of Puget Sound, where last year $336,000 worth of native or Olympia oysters were gathered up for market, the value of the easterns marketed being only $22,500, there being but 200 acres of the eastern oysters under cultivation. It will thus be seen that the total production for the State was $646,000.

"The native oyster first came into notice in a commercial way far back in the early '50's, at which time traders started to take cargoes from Willapa Harbor to San Francisco. The beds of Puget sound being too far away to supply the California market.

"About 20 years ago (1888) the United States Bureau of Fisheries planted a few barrels of eastern seed oysters at the southern end of Willapa Bay as an experiment, and in 1899 the initial commercial planting was done."

The Willapa Bay fishery with eastern oysters came to an end in the 1920's because of an unexplained mass mortality of the oysters (Lindsay and Simons, In Press). Eastern oysters were grown in Puget Sound without much success. A set was occasionally found but it did not reach market size. Few oysters beyond the 200 acres of oysters under cultivation in 1912 were grown (Anonymous, 1919a).

In Puget Sound, individuals found they could greatly expand the productive beds for growing Olympia oysters

Figure 112.—Pacific oysters, *C. gigas*, growing on a bed in Puget Sound. Photograph by Cedric E. Lindsay.

Figure 113.—Pacific oysters, *C. gigas*, growing on sticks in Puget Sound. Photograph by Cedric E. Lindsay.

by making dikes to create tide pools at successive levels above low ground. The ground behind the dikes was leveled, and 10–15 cm of water was retained over the oysters during low water. Areas within the pools were much better for oysters than those outside because they were more level, predators were scarcer, the food supply was more constant, and the danger of freezing was lessened by the sheet of protecting water (Anonymous, 1916c). The diking began in about 1905–10 (Lindsay and Simons, In Press).

The first dikes were ridges of earth and gravel, but this method was superseded by dikes built of a double wall of planks between which sand and gravel were deposited. Later dikes were made of concrete. The bottom of the dike was hardened by covering it with gravel (Anonymous, 1916c; 1919b).

The diked grounds ranged in size from 1 acre on steep beaches to 15 acres on broad flats. The total area of the diked grounds in the state reached at least 1,000 acres (Lindsay and Simons, In Press).

Olympia oyster growers collected spat on shells and oysters from within the dikes and from other areas including a State Oyster Reserve in Oakland Bay. Around 1900, seed oysters from the state reserve cost growers $0.15–$0.25/sack (Anonymous, 1903a). On most grounds, the oysters grew to market size, 25–40 mm, in 4–5 years. While the oysters were growing, crews culled them 2–3 times, usually every second year. Culling involved removing market-sized oysters and pests, separating out seed for replanting, and recovery of shells for use as cultch (Lindsay and Simons, In Press).

Early Washington production of Olympia oysters in the late 1800's, when they were collected only from natural beds, probably was at least 50,000 sacks (100,000 bushels) annually (Steele, 1957), but the natural beds eventually became depleted. With the diking of tidelands, production increased to a peak of at least 20,000 sacks (40,000 bushels) in 1925. Production afterward showed a downward trend and by the early 1990's it was slightly less than 400–500 sacks (1,000 bushels or 1,000 gallons of meats)/year (Lindsay and Simons, In Press).

A sulfite process pulp mill, which began operation in 1927 in Oakland Bay, had a strong adverse effect on Puget Sound's Olympia oyster industry. The oysters stopped setting and many adult oysters died. Only after the mill closed in the 1950's did good oyster setting and growth occur again (except in Oakland Bay). Most growers by then had planted Pacific oysters and abandoned the Olympia oyster (Lindsay and Simons, In Press). Olympia

oysters now have again increased and are slowly gaining in commercial importance (Chew, 1988). They have become a luxury item since the introduction of Pacific oysters. Though their value is high ($250/gallon of meats in 1988), the labor to produce the shucked product is too high for a hatchery-based industry (Baker, 1995).

Pacific Oysters

Washington's oyster industry imported and began growing Pacific oysters in the early 1900's, when several shipments of market-sized Pacific oysters from Japan were planted and harvested as demand warranted. In 1919, one of the oyster shipments contained attached spat. After some time on the bottom, the larger oysters died but the spat lived. This was followed by shipments of seed from Japan to be grown locally rather than shipments of large oysters ready for sale. Seed imports reached a peak of nearly 72,000 cases (at least 12,000 spat/case) in 1925 but declined afterward (Lindsay and Simons, In Press).

During the warm summer of 1936, Pacific oysters spawned and set in large numbers in Hood Canal, southern Puget Sound, and Willapa Bay. Other warm summers in 1942, 1946, and 1958, and again in later years, also allowed heavy setting in some areas. Growers provided cultch shells suspended in plastic mesh bags or spread loosely on the bottom to obtain local seed. Oyster seed grows to market size, 10–15 cm, in 2.5–5 years depending on ground quality (Lindsay and Simons, In Press).

In the early years of the industry, individuals harvested the oysters by hand. Oysters were picked into baskets and put in skiffs, scows, and floats. When companies made larger plantings, they used towed and self-powered dredges to harvest them. The oysters are hand shucked (Lindsay and Simons, In Press).

During the 1960's and 1970's, Pacific oyster hatcheries were built in Washington using information primarily developed and publicized by the Bureau of Commercial Fisheries' Laboratory in Milford, Conn. (Loosanoff and Davis, 1963), as well as from several other groups. Production capacities of the various shellfish hatcheries have ranged from several to 20 billion setting-sized larvae/year. The goal is hatchery production of all the seed the industry needs to eliminate dependence on natural reproduction (Lindsay and Simons, In Press).

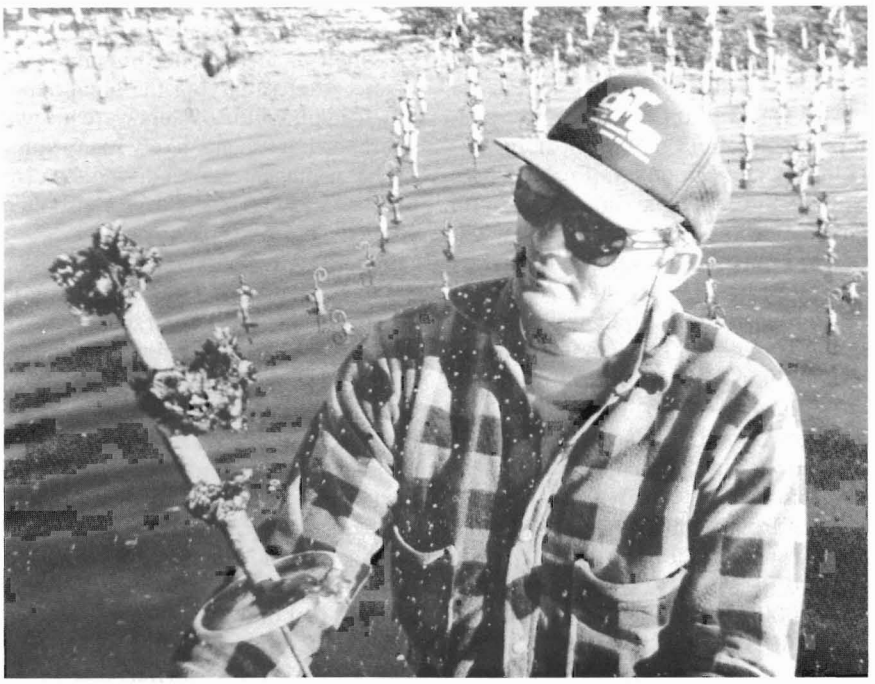


Figure 114.—Modern oyster culture in Washington. NOAA photograph.

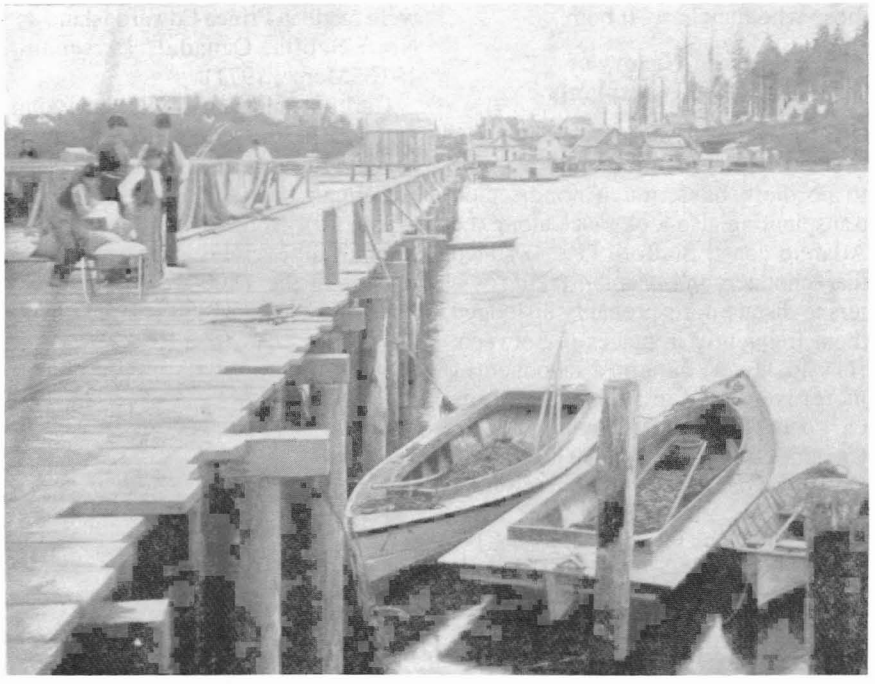


Figure 115.—The dock at Bay Center, Wash., the center of the Willapa Bay oyster fishery in the 1890's.

Between 1937 and 1989, Washington oyster production ranged from 458,000 to 1,553,000 gallons of Pacific oyster meats (a bushel of Pacific oysters yields about 1 gallon of meats) (Lindsay and Simons, In Press). Puget Sound and Willapa Bay along with Grays Harbor, Wash., now ranks second to Louisiana, currently the leading U.S. oyster producing state. Washington's 1994 oyster output was about 9 million pounds of meat compared with 11.3 million pounds of meat produced in Louisiana.[11]

Puget Sound also supports a small recreational oyster fishery, with about 90% of those harvests (Pacific oysters) coming from public tidelands in Hood Canal (Sterritt[18]). Recreational harvests ranged generally between about 1,000,000 and 2,000,000 oysters between 1990 and 1995 (Table 9). Because data on the recreational effort is collected during aerial surveys, state officials are unable to distinguish between clam and oyster harvesters or those who may harvest both.

Brief History of Oyster Transplants

Besides the directed transplanting of oysters especially from Chesapeake Bay to northern bays, much nondirected transplanting also took place along the Atlantic coast. Stafford (1913) stated that schooners and steamers taking oysters to distant ports probably dislodged them frequently in places in-between. He said, "Every autumn a schooner (or more) is awaited in Montreal with its cargo of Caraquets (oysters from Caraquet Bay, New Brunswick, Can.). On several occassions such vessels have been forced by the unexpected arrival of winter to seek shelter in Gaspe bay where, after satisfying the local appetite, the bulk of the oysters were thrown overboard." It seems likely many similar happenings occurred during the century or more that oysters were transported along the Atlantic coast by vessels.

In the late 1800's and into the 1930's, the owners of freighting schooners and sloops used to have contracts to sail to distant ports to load and return with such materials such as bricks, stone, or lumber. If the vessels were to travel to the ports empty, the captains often tried to obtain a load of freight, such as oysters from a local bed, to sell while picking up the primary cargo. If they could not sell the oysters, they were often spread on a local bottom. Some captains used to boast that they started oyster beds in many new places, such as Martha's Vineyard, Mass., by such means. In the early 1900's (1912, 1913, and other years), several plants of eastern oysters from Cape Cod and Long Island Sound were made in Prince Edward Island and Nova Scotia, Canada[19] (Arsenault, 1916; Morse, 1971).

Carlton and Mann (1996) have summarized the history of transplants of eastern oysters to Europe, the North American Pacific coast, and Hawaii (Table 10). None of the transplants to grounds in several European countries, mostly in the 1800's, became established. In the late 1800's, large quantities of eastern oysters were transported to the Pacific coast, mainly to California. At times, eastern oysters spawned and set in San Francisco Bay, but not in commercial quantities. The only eastern oyster population that has sustained itself on the west coast is in the Nicomekl River in Boundary Bay, British Columbia. Introductions to Pearl Harbor in Hawaii have also sustained themselves, and living populations remain. Besides transfers of eastern oysters from Chesapeake Bay to more northern grounds, small quantities of oysters were transplanted from South Carolina and North Carolina to Chesapeake Bay.

The transplanting of eastern oysters has unfortunately introduced associated invertebrates as well as the diseases MSX and Dermo to estuaries where they were planted. At least four bivalve species (softshell, *M. arenaria*; ribbed mussel, *Geukensia demissa*; amethyst gemclam, *Gemma gemma*; and false angelwing, *Petricola pholadiformis*) and six gastropod species (Atlantic oyster drill, *U. cinerea*; convex slippersnail, *Crepidula convexa*; eastern white slippersnail, *C. plana*; common Atlantic slippersnail, *C. fornicata*; eastern mudsnail, *Ilyanassa obseleta*; and channeled whelk, *Busycotypus canaliculatus*), along with several other taxa associated with oysters on the Atlantic coast, are now established in Pacific coast bays. The Atlantic oyster drill and Atlantic slippersnail now are serious pests in Europe after being introduced with eastern oysters (Carlton and Mann, 1996).

[18]Dave Sterritt, Fish Biologist, Washington Department of Fish and Wildlife, Brinnon, Wash. Personal commun., 23 October 1996.

[19]Annual reports of the Canadian Fisheries Branch, Department of Naval Service, on file at the Ellerslie Fisheries Station, Prince Edward Island.

Table 9.—Estimated recreational Pacific oyster harvest for Hood Canal, 1990–95.

Year	Total users[1]	No. of oysters
1990	183,679	986,251
1991	234,911	1,910,246
1992	186,645	2,161,721
1993	164,602	1,669,740
1994	141,327	1,525,282
1995	140,240	1,356,904

[1] Includes both clam and oyster harvesters.

Table 10.—Successes and failures in establishing populations of eastern oysters from introductions around the world (from Carlton and Mann, 1996).

Introduced to:	Years	Results
Europe		
England: Essex and Kent	1871 to 1939	Not established
Wales: Menai Straits	pre-1896	Not established
Ireland	pre-1939	Not established
France: Archachon	1860's to 1870's	Not established
Netherlands: Oostende	1939 to 1940	Not established
Denmark: Aro	1880, 1884	Not established
North America: Pac. coast		
British Columbia	1880's to 1930's	Established
Washington	1874 to 1940's	Population now extinct
Oregon	1870's; 1896 to 1940	Reproduced but not established
California	1869 to 1940	Reproduced but not established
Baja California	Planted	Not established
Hawaii		
Oahu: Pearl Harbor	1866; 1883 to 1949 and perhaps later	Established

Bay anemones, widespread in Chesapeake Bay oyster beds also inhabit Delaware and Raritan Bays oyster beds but not Connecticut oyster beds. It is yet unknown whether the anemone's range was extended to these bays by the transfers of oysters from Chesapeake Bay.

According to Buesa (In Press), seed eastern oysters were also planted in Cienfuegos Bay on the southern coast of Cuba in the 1920's. The oysters survived, and a small population developed that endured until at least the 1970's.

Discussion

The Past

After over two centuries of increased use and study, we have learned much about the oyster—its desirability, food value, life history, habitat needs, and its vulnerability to pollution, new diseases, and the like. In addition, research and regulation has shown how to grow healthy, nutritious oysters and to protect consumers from contaminants by using standardized safety and sanitation methods in oyster harvesting, preserving, and sales.

From the time 200 years ago when oyster harvests were small and local, we have progressed through several decades of increasingly greater harvest and use a century later, to the recent era of lower demand and consumption and fewer oysters. The industry still has potential for growth, however, and not just in the eight important estuaries described in this paper.

Oyster studies began in the 1870's with W. K. Brooks whose papers describe the oyster's anatomy, fertilization of its eggs, and development of its larvae (Ingersoll, 1881). Thereafter, much research on oyster biology was conducted and culminated in the massive 480-page volume by Galtsoff (1964); that benchmark volume was recently superseded by the 734-page multiauthored volume edited by Kennedy et al. (1996).

Much of the oyster research has been "theoretical" rather than "applied" and some questions remain about oysters in their environment. For instance, little research has been conducted on the precise roles of silt, anemones, tunicates, and xanthid crabs on oyster productivity, and no one has, as yet, determined whether presence of the spawners (or how many of them) on a shell bed actually enhances spat settlement. Additionally, more research is needed to find ways to cure or combat the diseases MSX and Dermo, as well as to improve hatchery work and to develop disease-resistant oysters. Nevertheless, we have a firm foundation upon which to base future programs to improve oyster production and management.

North America's eight greatest oyster-producing estuaries have some common features. They have large areas hospitable to oysters, the seed is from naturally occurring spat in seven of them (the exception is estuaries in Washington where production now is from hatchery-reared Pacific oyster seed), and annual setting of spat in commercially usable quantities is fairly regular. Whenever setting is light for a year or two, which is especially common in the northeast estuaries, some oysters from previous sets remain on the beds for harvesting, thus stabilizing production.

The length of oyster setting periods is much shorter in the northern Atlantic estuaries than farther south and especially in the Gulf of Mexico. In Bedeque Bay, the period may last about 3 weeks, whereas in the Gulf of Mexico it can last at least 7 months, though sets may be intermittent.

Another feature common to most of the estuaries is the practice of planting large quantities of shell as cultch for oyster larvae to maintain or increase seed abundance. Perret et al. (1991) believed the consistently high oyster production in Louisiana had been due to the state's large planting program on public seed grounds.

Provincial and state agencies also have become deeply involved in controlling harvests from the public seed beds using seasonal restrictions and in some instances daily catch limits. Government agencies have also developed public health regulations related to both production and marketing. Without such public involvement, the industries would have declined much more sharply with consequent loss of employment and with fewer oysters reaching markets.

Two management systems have been used in the oyster estuaries. In one, some beds in parts of upper New Haven Harbor, Delaware Bay, James River, and Louisiana have been used for producing seed to be transplanted to other beds for faster growth, growth of the more acceptable oval shapes, and for producing fatter, tastier meats. In the second type, such as in most Maryland estuaries, Apalachicola Bay, and, currently, most of the James River, oysters at least 3 inches (7.6 cm) long are harvested directly for market from their original beds. Bedeque Bay oysters are harvested at market length, but have to be transplanted for depuration. Oyster growth in Prince Edward Island is not typical. Bedeque Bay oysters grow relatively fast, 25–40 mm/season, but are transplanted to beds of higher salinity, mainly in Malpeque Bay, where their growth is much slower, 3–6 mm/season.

The estuaries all have predators that limit oyster distribution and abundance. Predators include starfish in Bedeque Bay, New Haven Harbor, and lower Delaware Bay, and boring gastropods and crabs in all but Bedeque Bay. Ingersoll (1881) discussed predator control, describing dredges, trawls, and mops to control starfish. Mops remain an effective method in Connecticut areas where starfish are not overly abundant.

Ingersoll (1881) also discussed controlling oyster drills by 1) culling them from oysters being transplanted, 2) using a fine-mesh dredge to remove them from the bottom, and 3) destroying their egg cases. Another method tried later was to attempt to remove them from the bottom with wire mesh bags baited with seed oysters (drill traps). Such methods have been impractical and abandoned. The most effective control method for oyster drills has been to remove them from grounds with suction dredges as is now done in Long Island Sound. The two species do not have pelagic larvae, and when grounds are so cleaned their numbers can remain low for several years. Oyster drills are not controlled in other estuaries. In the Gulf of Mexico, the most effective practice has been to avoid grounds where the rocksnails are abundant. The rocksnails have pelagic larvae which can invade oyster beds in

large numbers in a period of weeks where salinities exceed about 15‰.

The types of oyster harvesting gear have been tongs, apparently first used in the 1700's, and dredges, apparently first used in the early 1800's. Hand tongs have been used exclusively in Bedeque Bay, James River seed beds, and Apalachicola Bay ever since. Hand tongs, patent tongs, and dredges have been used in Maryland's estuaries, while dredges have been used much of the time in New Haven Harbor, Delaware Bay, most Louisiana estuaries, and Puget Sound.

Many authors have attributed the huge decline in oyster production along the Atlantic seaboard after 1900 to excessive harvests which outstripped nature's capacity to supply oysters (e.g., Haven et al., 1978; Rothschild et al., 1994), and while that has been an important factor, it is not the only one. Earlier, an unknown New Jersey author (Anonymous, 1888) reviewing the oyster situation in Newark Bay aptly outlined the reasons why the beds exist and decline: "Suitable objects, such as stones, to which the young oyster could fasten, were present on the bottom, and when once 'set' has been made, the shells of preceding generations serve as collectors for the succeeding ones. If from any cause, as from excessive tonging, the oysters be taken away and no new ones appear naturally in their places, the bed, as an oyster-bed, ceases to exist."

He stated further that the reasons grounds were not stocked with oysters was because no suitable collectors for the spat were present, and clearly, if shells were placed in such situations, a bed would be established. The author added that the seed supply was scarcer in his area in 1888 than in 1886 because there had not been a set in the bay and the shells had not been stirred up enough by tongers to keep them bright. This suggests that even then silt accumulations on the shells prevented much setting of oyster larvae.

My professional experience has included examining oyster beds visually using scuba gear in Prince Edward Island, Long Island Sound (Connecticut and New York), Delaware Bay (New Jersey and Delaware), Chesapeake Bay (Maryland and Virginia), and Mississippi Sound during the summer oyster setting period, and in Long Island Sound in every month of the year. My findings agree with those outlined by the Anonymous (1888) New Jersey author that intense oyster harvesting often stripped the beds of not only oysters but also of shells, leaving the beds with less cultch each year on which oyster larvae could set. But a heavy rain of silt (an unseen destroyer of oyster seed beds[20]) collected on seed beds and partially or entirely covered the cultch shells and oysters, and severely limited or prevented oyster setting. Had adequate cultch always remained on every segment of bottom suitable for oysters and had it remained clean, the supply of oysters would not have declined as much before the more recent disease period (since the late 1950's). The two procedures that have been successful in maintaining and increasing seed abundance have been spreading clean shells (Fig. 116) and washing silt (mud) off shells already in place (Fig. 117) on beds. Silt remains "fluffy" on the bottom, can be lifted into the water easily, and then can be removed by water currents.

In the mid-1960's, the oyster industry in northeastern North America was severely depressed. Little was left of the Connecticut industry, and the industry in Prince Edward Island had declined for nearly 20 years and its 200 fishermen had critically low incomes. In the late 1960's, the two principal oyster companies remaining in Connecticut began an industry upswing by simultaneously controlling oyster drills and starfish and by earlier transplants which reduced mortalities of seed caused by smothering in silt in the spring. They had collected the seed by spreading about 200,000 bushels of shells each year (MacKenzie, 1970, 1981). The oysters increased in quantity so quickly that the remaining oyster vessels had trouble handling them, and the companies had difficulty selling the sudden large crops of oysters available in the late 1960's and early 1970's. In the 1980's and 1990's, oyster abundance and production surged further when the Tallmadge Co., the only large company

[20]When a vessel dredges shells covered with silt from a bed, the silt washes out of the dredges before they reach the surface, and the boat crews, observing clean shells in the dredges, nearly always assume that little or no silt exists on the bed. The silt can be as deep as perhaps 4 cm over the shells and still wash out.

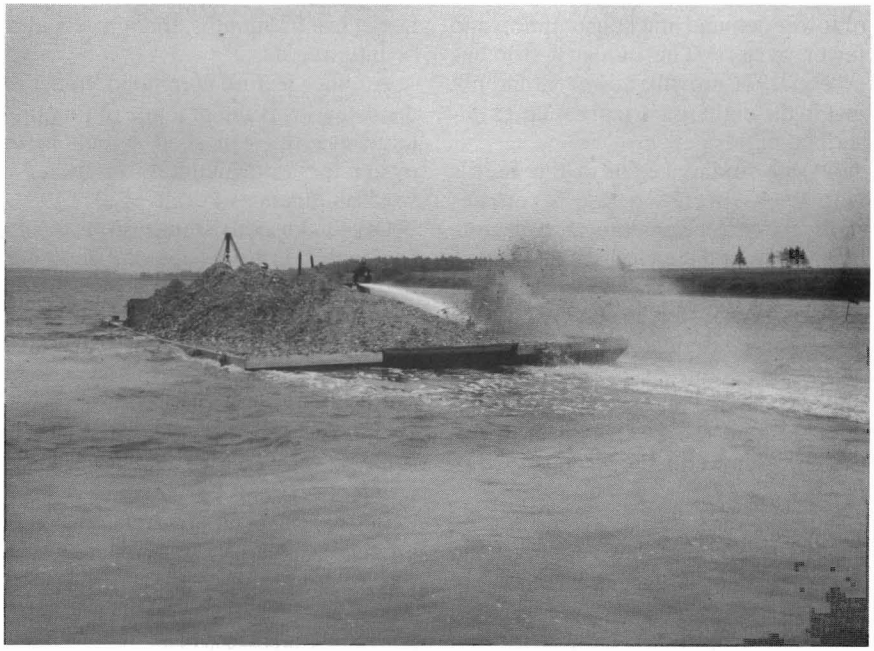


Figure 116.—Spreading shells on a bed to collect seed oysters. Photograph by A. Morrison.

remaining, and the State of Connecticut each spread about 1 million bushels of shells/year on beds in many years. The quantity of shell spread was about two-thirds of the 3 million bushels spread in the bigger production years in the early decades of this century.

In view of the short time and relative ease required to produce the large increase in Connecticut oyster production, I believe the Connecticut oyster companies would have found ways to maintain large oyster supplies and production throughout the 1900's had they been able to make good profits from selling oysters. My scuba observations of the beds during 1966–72 helped make culture actions more efficient then, but the earlier companies still could have done it. With rising production costs, a light demand, and nearly level prices for oysters, the companies were making little money in the early decades of the 1900's, and they could afford to make only modest attempts to produce oysters. Most eventually failed in business.

The Prince Edward Island industry had never been enhanced by shelling beds or transplanting seed before 1972. In that year, the industry began to improve when a government-sponsored program spread shells on some beds, washed silt off other beds, and transplanted oysters from a deep channel and from a large intertidal flat to harvesting beds (MacKenzie, 1975). In the late 1970's, 1980's, and 1990's, oyster production has been from two to three times higher than in 1972. Again, production was increased with relative ease.

The Present and Future

In recent years, oyster habitats in nearly all estuaries have been threatened by outside development. Oystermen have claimed that "oystering and civilization do not mix well," because they have seen their oyster stocks decline or become tainted when various types of development impinged on their oyster estuaries. Diverse interests have wanted to use the rivers leading into estuaries, the shores, and the estuaries for various purposes, including developing recreational areas (by damming rivers), constructing residential housing, laying pipelines, developing shipping (by dredging bottoms and constructing wharves), and disposal of domestic and industrial wastes. Such developments can alter the salinity, destroy the beds, and pollute the oysters. The presence of oystering in the estuaries has helped to contain many developments.

The prospect of growing large quantities of oysters on the beds of Delaware and Chesapeake Bays where the diseases MSX and Dermo have killed most oysters in recent years seems dim, unless the diseases were to disappear as mysteriously as they appeared or unless disease-resistant oysters are developed. The oyster interests in Delaware Bay have decided to modify the management used for most of this century. From September 6 to November 1, 1996, the oystermen harvested oysters, at least 3 inches (7.6 cm) long, from the former up-river seed beds, where mortality from diseases usually is only slight, and marketed them, leaving undersized oysters and shell behind on the beds. Each vessel was allowed to harvest 2,000 bushels of oysters for the season. About 17 vessels dredged on any one day (Courier-Post 1996). This is the oystering practice that prevailed throughout most of the 1800's, except that no limits on quantities harvested were set then. Measures to enhance setting sites for oyster larvae, such as spreading additional shell and desilting cultch, may be needed to the increase oyster abundance.

Maryland's recent oyster management strategy has been to establish new seed beds and transplant seed to low-salinity growing areas. Maryland groups now want to enhance oyster abundance by planting disease-free oysters in quarantined areas and sanctuaries where salinities are too low for the disease. Perhaps some oysters will be reared in hatcheries (Krantz and Jordan, 1996; MacKenzie, 1996).

Oyster abundance could be increased somewhat in every estuary by spreading more shells and cleaning silt off existing bottom shell cultch. The advantages of doing it are that 1) natural habitats of estuaries would be restored, 2) fishermen could work in the estuaries where they enjoy working, and 3) many restaurants, looking to expand their menus, and families, seeking more variety in their meals, would have more oysters available to purchase when they are harvested.

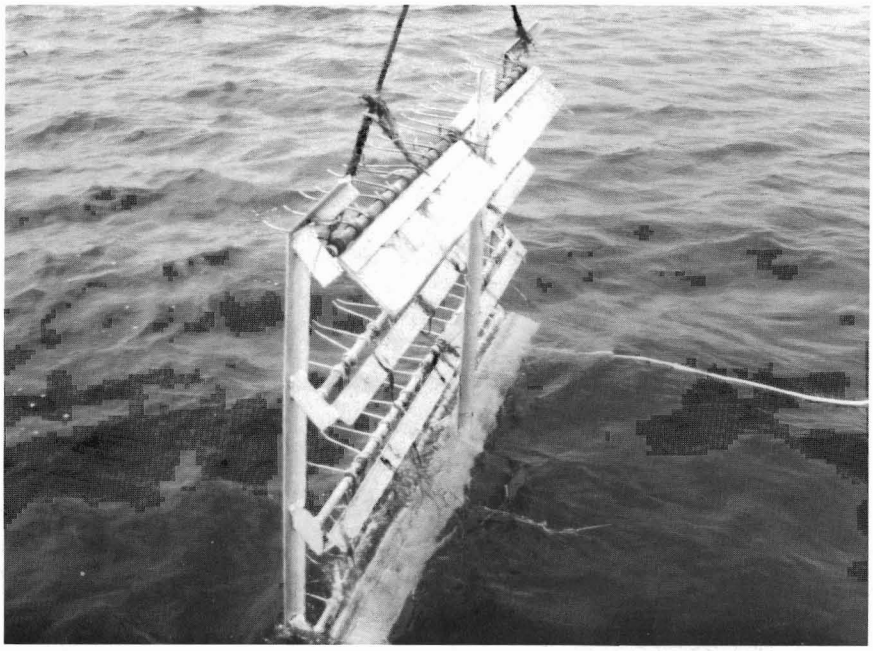


Figure 117.—A specially designed "board" used to remove silt from bottom shells to prepare them for collecting a set of seed oysters. Photograph by A. Morrison.

Since oyster beds are often in the public domain, management procedures on them are the concerns of fishermen, local residents, resource management agencies, environmentalists, and politicians. Fishermen are a key group. Throughout history, fishermen, processors, and local residents have viewed their oyster industry primarily as a means of employment rather than a means to provide food for others. Management initiatives to enhance oyster production will be most successful if they enhance gainful employment for fishermen, and they should also be developed in a way to gain the full support of the associated groups before implementation begins. Highly trained field scientists will be needed to develop effective procedures for specific beds (MacKenzie, 1989, 1996)

To increase abundance of seed substantially, local oystering groups may need more publicity. In the past, fishermen, including oystermen, have been reluctant to publicize their work because they like working in an atmosphere of freedom. They have found if they make things known to the public and public agencies, regulations which restrict their freedom may follow. But publicity keeps the public aware that 1) the beds are being used productively, 2) pollution needs to be controlled further, and 3) oysters are a wholesome food. Publicizing increased efforts to enhance oyster abundance makes it easier to justify the efforts to control various external degrading factors.

Market demand for oysters now is far less than it was in earlier periods, but the demand for protein foods such as oysters may be strong in the future. If oysters were to be produced in substantially larger quantities, their market prices might need to fall as they now are in the ultra-luxury category. Fishermen have received as much or more for oysters than beef and chicken sell for at retail: In 1992, the value of landed oysters ranged from $2.15/pound (Louisiana) to $6.60/pound (Connecticut) before shucking.[11] Consequently, people now purchase oysters only once in a while from supermarkets and fish markets. Oysters continue to be sold in a relatively small number of restaurants in Montreal, New York City, Philadelphia, and many other Atlantic and Gulf Coast cities and towns. On the half-shell, they usually sell for more than $1.00 each and often above $2.00 each in the northeastern United States. Some restaurants offer at least 15 varieties at a time (Fig. 118). Fishermen cannot receive much less for oysters and survive financially unless they can harvest larger quantities. Costs need to be lowered in the steps following harvest.

Other Estuaries

Many North American estuaries that have produced oysters are not included in this paper. Some have been or are substantial producers. The following estuaries which primarily received oyster seed for growth and subsequent marketing now produce few or no oysters: Narragansett Bay, R.I. (due to hurricane damage and no seed available); Peconic Bay, N.Y. (no seed available and "brown

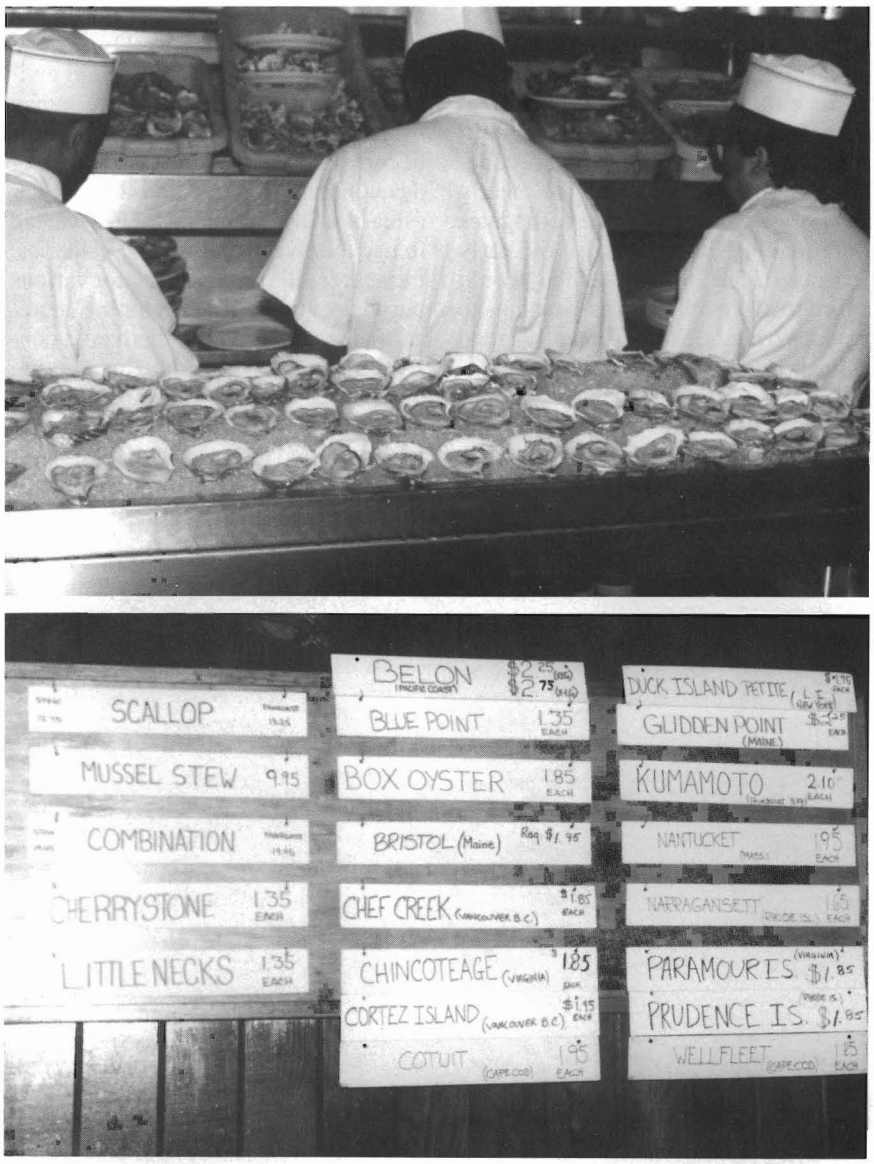


Figure 118.—A modern New York City oyster bar (top) and a price list (bottom); the two right columns list types and prices of oysters for sale on the half-shell. Photographs by the author.

tides" kill oysters); Great South Bay, N.Y.; Barnegat Bay, N.J.; Chincoteague Bay, Md. and Va.; Mobjack Bay and York River, Va., (oysters die from MSX disease); and Raritan Bay, N.Y. and N.J., and San Francisco Bay, Calif. (pollution).

The following continue to produce oysters: Caraquet Bay, New Brunswick; East and West Rivers and Malpeque Bay, P.E.I., Can.; Wellfleet Harbor, Mass.; western Long Island Sound (Norwalk to Milford); Oyster Bay and Northport Harbor, N.Y.; Rappahannock River, Va.; Pamlico Sound, N.C.; Mobile Bay, Ala.; Mississippi Sound, Miss.; Galveston, Matagorda, and San Antonio Bays, Tex.; Drakes Estero and Humboldt Bay, Calif., Grays Harbor, Wash.; and some estuaries in British Columbia. Some less prominent estuaries also have produced oysters. Many could benefit from the methods suggested for improving their oyster output.

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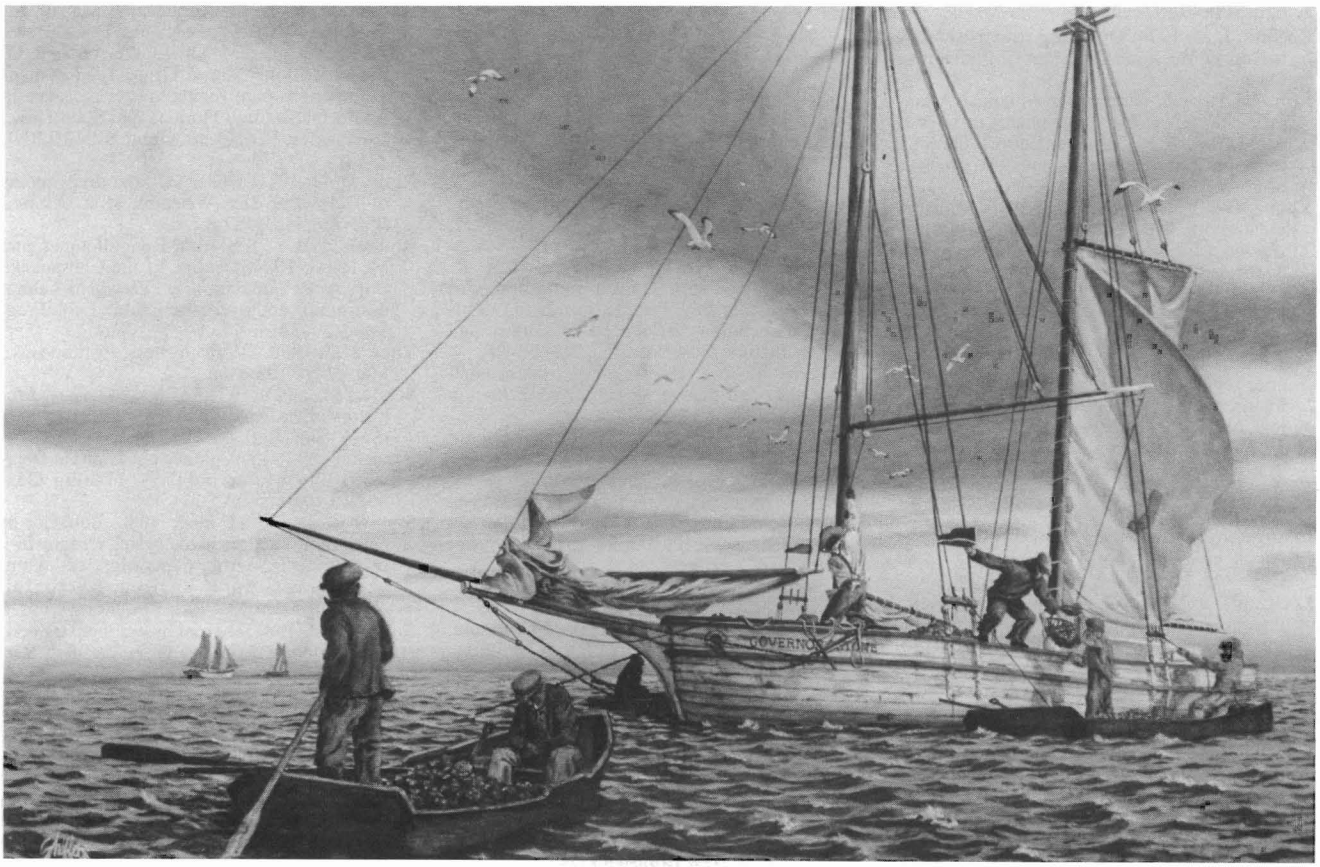

The Governor Stone collecting oysters from tonging skiffs in Mobile Bay, Ala., ca. 1900. Built in 1887, she is retired from the oyster fishery but now plys the waters of Apalachicola Bay, Fla., with sightseers and tourists. Courtesy of the Apalachicola Maritime Museum.