

History of the Fisheries of Raritan Bay, New York and New Jersey

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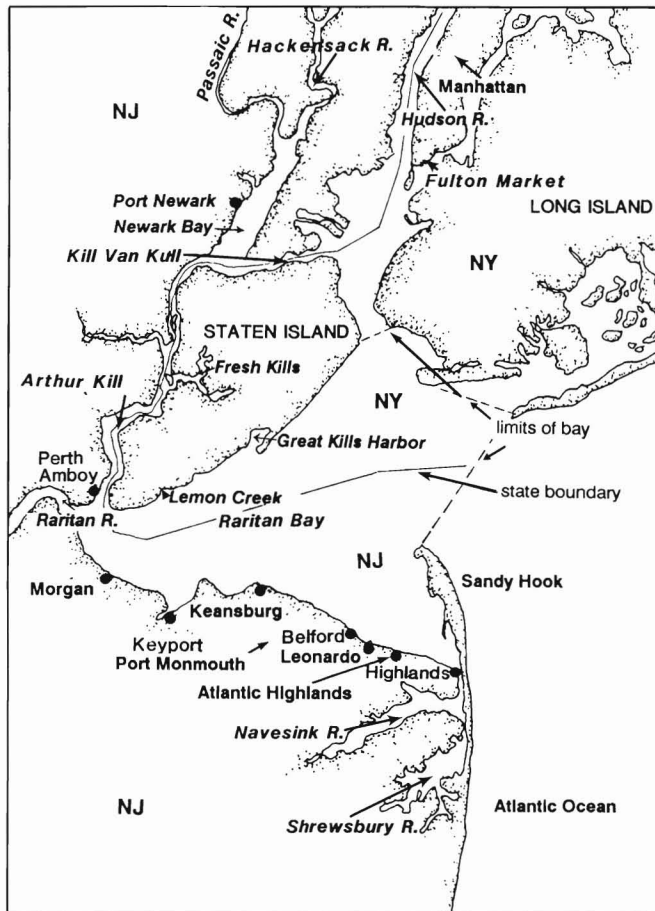
Introduction

Raritan Bay is the body of water bounded by New York and New Jersey and lying immediately south of New York City (Fig. 1). It has close proximity to the most concentrated urban and industrial area in the United States. Its history has been one of extensive multiple use by the surrounding human population. Dating from the precolonial and colonial periods, people have employed many types of gear to catch and gather its once abundant fishes and shellfishes. Its beaches were once popular for sun bathing and swimming, but after the 1940's they were essentially abandoned because the water became too polluted. Another large use has been for pleasure boating and the transit and dockage of merchant, passenger, and military vessels. Channels and basins were dug in the bay, bulkheads and jetties were constructed along its shores, and it was a donor source of sand and gravel for construction projects. It has also been a receptor for large quantities of domestic and industrial wastes and, mainly for this reason, it is one of the most deteriorated estuaries in the United States.

The earliest descriptions of fisheries in or near the bay are included in Pearson's (1972) collections of reports about fishing methods by Indians and European colonists from the early 1600's through the 1700's. Next is Akerly's (1843) report about Staten Island fisheries. In the

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Figure 1.—The Raritan Bay area.



late 1800's, the U.S. Bureau of Fisheries published several monographs which described the fisheries of North America, including some of those of Raritan Bay (Goode, 1880; Ingersoll, 1881, 1887; Rathbun, 1887; True, 1887; Hall, 1894). The monographs contained descriptions of fishing and marketing methods supported by illustrations of boats, gear, and

ports. Since then, little has been written about Raritan Bay fisheries, aside from a few published and unpublished documents and observations in local newspapers about their status. As in other localities, its fisheries have developed, changed, and, to various degrees, declined or disappeared without any formal records of this history. The reasons for

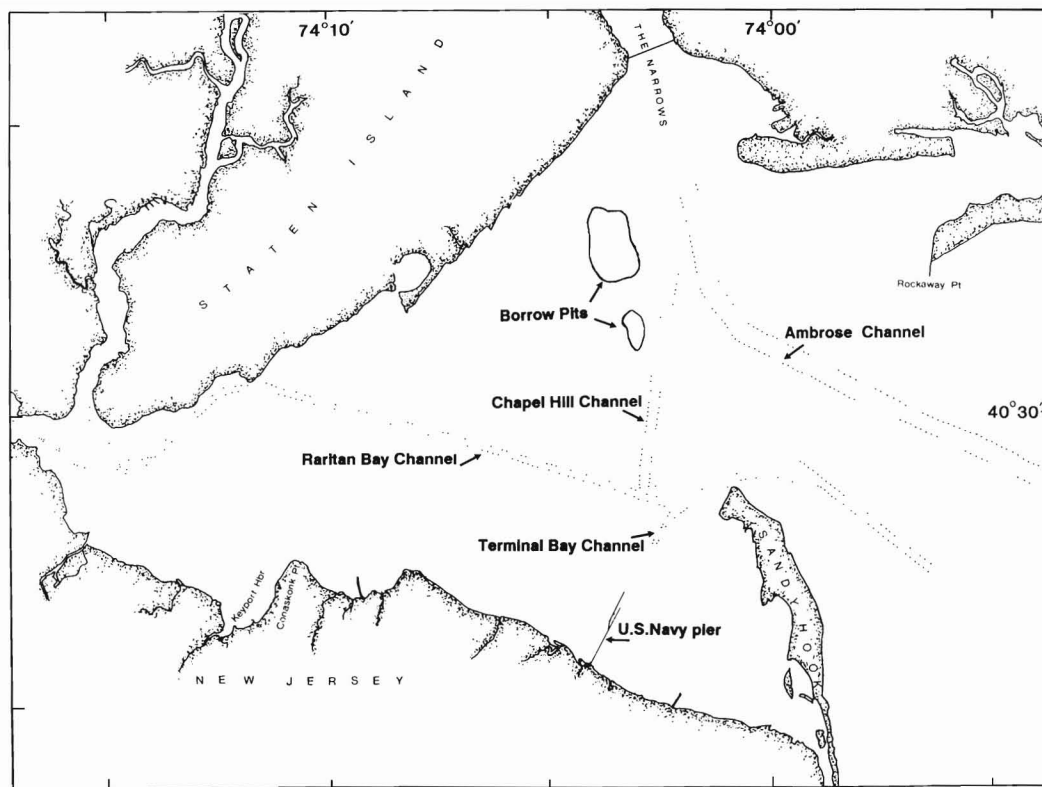


Figure 2.—Locations of channels, borrow pits, and the U.S. Navy pier. Most channels were dug from 1890 to 1905. The borrow pits were dug in the 1960's. The Navy pier was constructed in 1942-43.

declines and disappearances have been, at most, only scantily analyzed.

The purposes of this paper are to: 1) Describe the history of each fishery, suggesting how deterioration of the bay's environment, declines in fish and shellfish abundances, competition with other users, market conditions, economics, and other factors affected them, and 2) record the types of boats, gears, and methods used and sizes of the fisheries. The Bureau of Fisheries monographs and other early papers provided the historical baseline, and fishermen interviews and some documents and newspaper reports were used to trace developments from the early years of this century. Such information may provide environmental managers and fishery biologists a perspective from which to preserve and study existing fisheries, fishes, and shellfishes.

Methods

Information was obtained from docu-

ments and newspapers in the libraries of the Sandy Hook Laboratory of the NMFS Northeast Fisheries Center, Highlands, N.J.; Staten Island Institute of Arts and Sciences, Saint George, Staten Island, N.Y.; Richmondtown Restoration, Staten Island Historical Society; Monmouth County Historical Association, Freehold, N.J.; Keyport Historical Society Steamboat Dock Museum, Keyport, N.J.; and several city libraries.

Descriptions of fishery histories after 1900 were obtained also from taped interviews¹ I made of 70 active or former fishermen whose ages ranged from 55 to 104; each interview lasted 1.5 to 2.5 hours. Specific topics were discussed independently with 5-10 fishermen to obtain corroborating statements. Additional information was obtained during trips I made in the 1980's on pound-net, eel,

¹Footnote 1 identifies the information obtained by the author from fisherman interviews.

sportfish, lobster, and blue-crab boats in Raritan Bay.

Landings statistics of fishes and shellfishes from Raritan Bay were generally unavailable. Commercial landings data from the bay have been obtained by the National Marine Fisheries Service and its predecessor agencies, but they were grouped into larger statistical reporting units. Thus it was only rarely possible to present annual landings data for bay species.

Description of Raritan Bay

Raritan Bay is nearly triangular (Fig. 1) and has an area of about 210 km². Its main sources of fresh water are the Raritan River in the west and Hudson River in the northeast; the Arthur Kill in the west is an unimportant source (Jeffries, 1962). In the 1980's, bottom salinities at the end of the ebb current averaged about 18⁰/₀₀ in the Raritan River mouth and about 32⁰/₀₀ near Sandy Hook.

Water temperatures range from about 2°C in late January to 26°C in late August (MacKenzie, 1984). The mean tidal amplitude is 1.7 m (Jeffries, 1962). The bay has four major channels dredged to depths of 9-10.5 m. (Fig. 2).

Before the bay became deteriorated, it was an excellent habitat for fishes and shellfishes and had high biological productivity. Its edges consisted of wide shallows which had beds of eelgrass, *Zostera marina*, serving as nursery areas for juvenile fishes. Its bottom slopes gradually from its shores to about a 7.5 m depth in its broad central area, where the water remains cool enough for some fishes to remain in midsummer. In addition, the bay receives the effluents of five rivers, the Hudson, Hackensack, Passaic, Raritan, and Navesink, which provide nutrients to the bay and spawning areas for anadromous fishes.

On hydrographic charts, the bay is divided into three areas: Raritan Bay, Lower Bay, and Sandy Hook Bay. For simplification, these three "bays" are collectively called Raritan Bay in this paper.

Fishes and Shellfishes

Fishes

Raritan Bay is used as a spawning area, nursery area, part-time residence, or all three, for a number of commercial and sport fishes. These include Atlantic menhaden, *Brevoortia tyrannus*; bluefish, *Pomatomus saltatrix*; scup, *Stenotomus chrysops*; summer flounder, *Paralichthys dentatus*; weakfish, *Cynoscion regalis*; and winter flounder, *Pseudopleuronectes americanus*. In addition, such fishes as alewife, *Alosa pseudoharengus*; American shad, *Alosa sapidissima*; blueback herring, *Alosa aestivalis*; and striped bass, *Morone saxatilis*, have traversed the bay en route to spawning in the Hudson, Raritan, and Navesink Rivers, while maturing American eels, *Anguilla rostrata*, leave the tributary rivers and traverse the bay in the opposite direction toward their spawning area in the Sargasso Sea (Esser, 1982). Various fishes are available to sportfishermen throughout much of the year, except for January and February (Table 1).

At times, two typically southern fishes, Atlantic croaker, *Micropogonias undulatus*, and Spanish mackerel, *Scomberomorus maculatus*, were abundant enough to be important in commercial catches. Atlantic croaker was landed in quantity in the 1910's, 1920's and also the late 1930's and early 1940's, but has since been scarce (McHugh, 1977). Data on Spanish mackerel are known only from newspaper accounts (*Red Bank Register*, various articles); it was caught in commercial quantities in the 1880's and 1890's, but is scarce now.

The following fishes have declined substantially in abundance also: Alewife, butterfish, *Peprilus triacanthus*; eel, kingfish, *Menticirrhus saxatilis*; menhaden, mullet, *Mugil cephalus*; scup, sharks (various species), sheepshead, *Archosargus probatocephalus*; silver hake, *Merluccius bilinearis*; spot, *Leiostomus xanthurus*; the now-endangered shortnose sturgeon, *Acipenser brevirostrum*; and also the threatened loggerhead turtle, *Caretta caretta*. As an example, in 1885, pound nets were making such immense hauls of alewives that the fish reduction factories wanted to process them into scrap for use as fertilizer (*Red Bank Register*, 29 April). During each April in the 1980's, however, only a few bushels a day were caught by the pound nets. Currently, it is illegal to land shortnose sturgeon or loggerhead turtles because they are protected by the Federal Government.

Other species have been relatively abundant. For instance, in nearly all of the 1980's, summer flounder and winter flounder were abundant in the bay. From

1962 to 1975 and in 1989, summer flounder were relatively scarce¹, however, but apparently from causes not associated with the bay's environment.

Possible Causes of Fish Declines

Heavy Fishing

Undoubtedly, the principal cause of declines in some species, such as bluefish, butterfish, menhaden, scup, silver hake, spot, and weakfish, was heavy fishing by commercial and sport fishermen in the ocean before they entered the bay. Sportfishermen caught far more bluefish, an equal number of weakfish, but fewer scup than commercial fishermen (McHugh, 1990). Since the 1960's heavy fishing has reduced the numbers of menhaden along the entire U.S. Atlantic Coast (Ahrenholz et al., 1987). From 1960 to 1966, landings of scup fell by 54 percent, and an increasing proportion of the catch was small fish. Smith and Norcross (1968) attributed the decline in scup to heavy fishing in their overwintering grounds near the edge of the continental shelf by eastern European trawlers. The scup population has not recovered; landings remain low and available scup are smaller than they once were, most weighing less than a pound.

Heavy fishing in the bay did not appear to cause the decline in eels. Fishing effort was relatively light while the eels became scarcer¹.

The numbers of sturgeon along the Atlantic coast declined from heavy fishing, construction of dams, and pollution (Vladykov and Grey, 1963). Many were

Table 1.—Numbers of fish caught by sportfishermen in the Hudson-Raritan Estuary in 1979 (Smith et al., 1983).

Species	Sportfish caught					Total	Std. error of the estimate
	Mar.-April	May-June	July-Aug.	Sept.-Oct.	Nov.-Dec.		
Summer flounder		258,066	4,454,830	7,212		4,720,100	(2,614,000)
Winter flounder	1,338,940	205,207	3,377	11,912	485,453	2,044,900	(847,800)
Bluefish			732,264	776,664		1,508,900	(504,900)
Scup		948	21,925	548,865		571,700	(323,800)
Cunner	26,486	34,776	32,918	275,395	29,996	399,600	(218,500)
Weakfish		34,993	94,102	687		129,800	(76,500)
Tautog		50,377	7,233		13,332	70,900	(33,100)
Eel		21,871	9,410		1,538	32,800	(23,900)
Menhaden		9,479	14,466			23,900	(17,300)
Puffer				13,549		13,500	(13,500)
All others		14,783	70,970		6,922	92,700	
Totals	1,365,426	630,500	5,441,495	1,634,285	537,241	9,608,800	

caught in shad nets before they became mature and the number of spawners became small (Leland, 1968). Sturgeon mature at age 9 (Grey, 1937).

Biologists believe that the number of loggerhead turtles declined because: 1) Their breeding sites on beaches have been substantially deteriorated by man and 2) people have taken females and their eggs from beaches where they breed in the southeastern United States and Caribbean Sea.

Silt and Eutrophication

No one has shown whether the large increase in turbidity caused by silt and eutrophication in the bay was partly responsible for the decline in abundance of fishes. Studies in other locations, however, have shown that high turbidity did reduce abundances of fishes (Miller, 1974; Muncy et al., 1979).

Chemical Pollution

Likewise, no one has determined whether chemical pollution of water and sediments by heavy metals and other pollutants has affected fish abundances or their behavior and growth in the bay (Esser, 1982; Werme and Breteler, 1983). In the 1960's and 1970's, however, a variety of fishes in the bay had fin necrosis, possibly associated with chemical pollution (Mahoney et al., 1973; Ziskowski and Murchelano, 1975).

Studies in other locations have shown that: 1) Fishes in streams exhibit avoidance responses to heavy metal concentrations (Sprague, 1964; Atchison et al., 1987), 2) heavy metals interfere with fishes' chemoreception (Rehnberg and Schreck, 1986), 3) heavy metals affect fishes' activity patterns, swimming performance, respiration, and perhaps vulnerability of juveniles to adult predators (Rehnberg and Schreck, 1986; Atchison et al., 1987), and, 4) in areas heavily contaminated with PAH's, adult fish had a variety of maladies, including liver disease and lesion formation (Hargis et al., 1984; Huggett et al., 1987), and biological activity was suppressed (Helz and Huggett, 1987). In the Hudson River, tomcod, *Microgadus tomcod*, developed neoplasms; PCB's were the suspected pollutant causing them (Couch and

Harshbarger, 1985). These studies suggest that the elevated concentrations of pollutants in Raritan Bay have had negative effects on adult fishes, perhaps reducing their abundances. They have neglected the effects of pollutants on viability of fish eggs, and growth and survival of juvenile fishes, however, an important aspect in Raritan Bay, because, as noted, it is a spawning and nursery area for fishes.

Dams and Other Changes in Streams

Construction of dams or other physical modifications in the Hackensack, Passaic, Raritan, and Matawan Rivers reduced the stocks of alewives, shad, and other anadromous fishes there and in Raritan Bay. Installation of a dam on the Navesink River led to the loss of a striped bass population by making upstream spawning and nursery areas inaccessible.

Loss of Eelgrass

In the 1930's eelgrass died in the bay. The effect of its loss on the bay's fishes was never studied, but it may have been harmful, because many investigators have shown that eelgrass beds are nursery areas for juvenile fishes (Kikuchi, 1980). (See also the eelgrass section below.)

Motor Boat Noise

Sonic effects of motors on fishes have never been studied. It is possible that engine noise from the many boats in the bay in summer, however, affects behavior and reduces residency times of some fishes.

Shellfishes

Occurrences and causes of any declines in the following species are discussed here: Oyster, *Crassostrea virginica*; hard clam, *Mercenaria mercenaria*; soft clam, *Mya arenaria*; bay scallop, *Argopecten irradians*; American lobster, *Homarus americanus*; blue crab, *Callinectes sapidus*; horseshoe crab, *Limulus polyphemus*. (The effects of chemical pollution (heavy metals and organics) on shellfishes are not considered in this paper.)

Oysters

In the colonial period, an oyster bed, about 1.6 km in diameter, known as the

"Great Beds," was present just beyond the mouths of the Arthur Kill and Raritan River at the western end of Raritan Bay. Another oyster bed, several acres in size, at Keyport was known as the "Chingarora Bed." The remainder of the bay had relatively few oysters. Peripheral oyster beds to the bay were present in southern Newark Bay, the Arthur Kill, and Raritan, Navesink, and Shrewsbury Rivers (Hall, 1894).

Probably, silt from the Raritan River settled on oysters on the Great Beds. Siltation was likely heavy during and after the colonial period of forest cutting and farming. If so, it would have diminished productivity of the oyster beds, because silt covers available shell surfaces for settling oyster larvae and also smothers oysters at the bottom of clusters.

In the 1700's and early 1800's, siltation was not recognized as a factor in the decline in oyster production on the Great Beds, but it probably played a major role, along with heavy harvesting. My surveys in the 1970's showed that the bottom where the Great Beds were and the channel bottoms in that region were covered by large quantities of mud. Ingersoll (1881) and Lockwood (1883) believed that silt had killed many oysters in the Hudson River. No reference is available concerning the fate of the Chingarora Bed; it was probably depleted by heavy fishing. After 1825 the quantities of oysters in the bay were enhanced many times by the importation of seed oysters from other areas, as is described in a later section.

Hard Clams

Surveys conducted in 1962 and 1982 showed that hard clams were abundant off the shores of Staten Island (DeFalco, 1967) and from Keansburg to Sandy Hook (McCloy, 1984; Fig. 3). In 1963 the estimated quantity of hard clams in the bay was 4.8 million bushels (3.4 million bushels in New York and 1.4 million bushels in New Jersey) (Campbell, 1967). Evidence that their abundance declined from earlier periods is lacking.

Soft Clams

Before the 1940's soft clams were

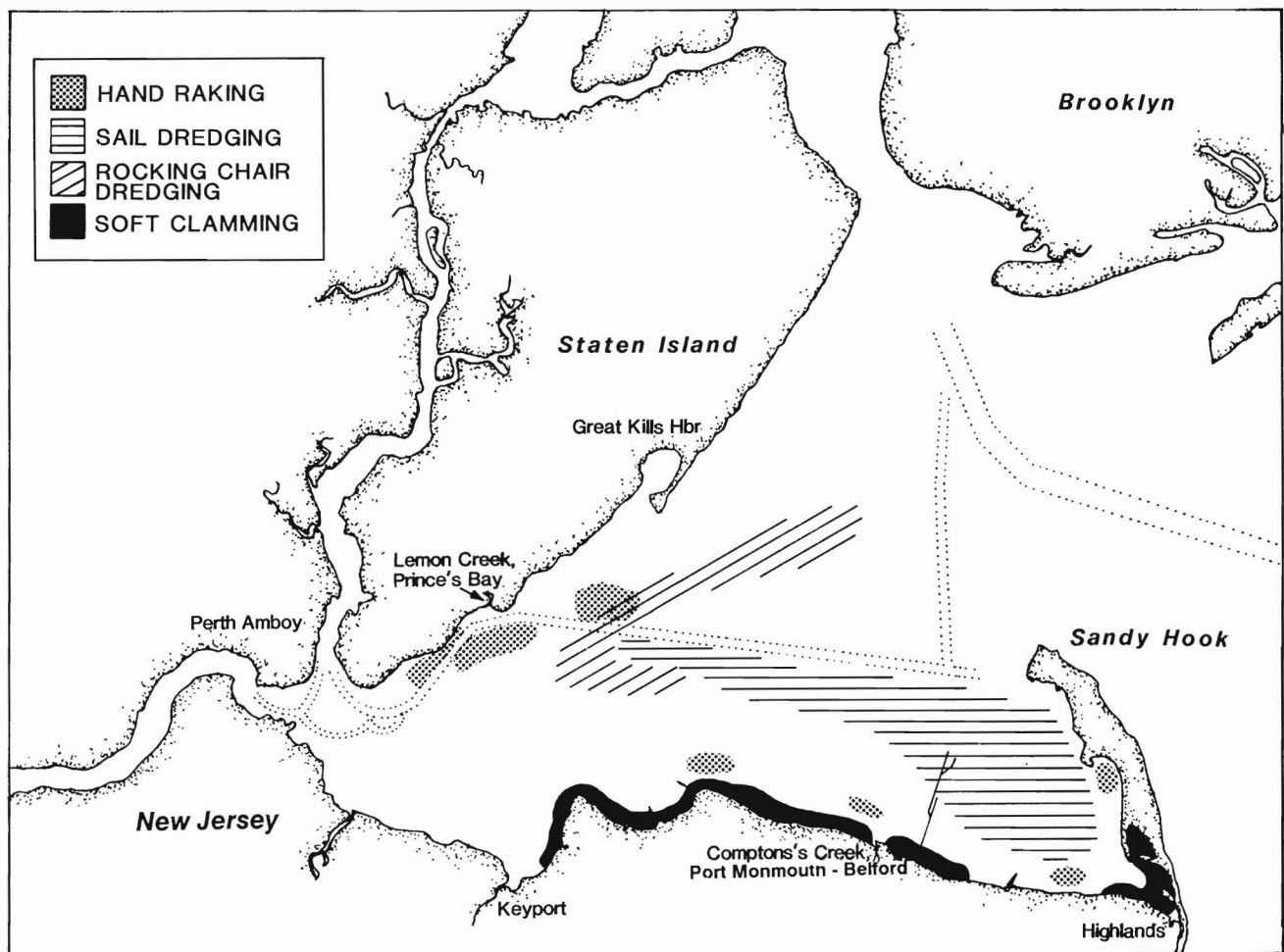


Figure 3.—Principal hard clamming and soft clamming areas. Source: Fishermen interviews.

abundant in wide, intertidal flats from Keyport to Atlantic Highlands and in extensive shallow areas around Highlands (Fig. 3). The disappearance of eelgrass in the 1930's, however, apparently led to the disappearance of soft clams in most intertidal flats (MacKenzie and Stehlik, 1988). The eelgrass had absorbed energy from waves generated by northerly storms; the small resulting waves did little scouring of the flats and did not affect survival of clams growing on them.

Every summer since the eelgrass disappeared, however, storm-produced waves wash out any sets of juvenile clams and cast them ashore where they die. Moreover, adult soft clams cannot inhabit these sands because they shift during storms.

By the late 1980's the flats had largely disappeared as a result of the rising water level and erosion. Some soft-clam beds were lost in Atlantic Highlands and Highlands when they were dredged to construct boat basins and channels. In the 1970's and 1980's soft clams were scarce in the bay, but usually they were abundant enough to support commercial digging in the nearby Navesink and Shrewsbury Rivers.

Bay Scallops

Bay scallops once grew in small quantities in the bay, but probably not in sufficient abundance to be used as food by man (Ingersoll, 1887; Smith, 1890). In the 1980's they were rare, and only old

bay scallop shells commonly washed up on its shores.

American Lobsters

The lobster ranges from the coasts of Canada to North Carolina. Raritan Bay is the southernmost bay where it occurs, except for the extreme southeastern end of Delaware Bay. Southward, its distribution is entirely on the continental shelf. In Raritan Bay, lobsters inhabit the deeper areas in its eastern part (Fig. 4). No one knows whether they have declined because formal assessments of their abundances were never made. Apparently, their numbers have not declined in the nearby ocean recently, because commercial catches, though variable among

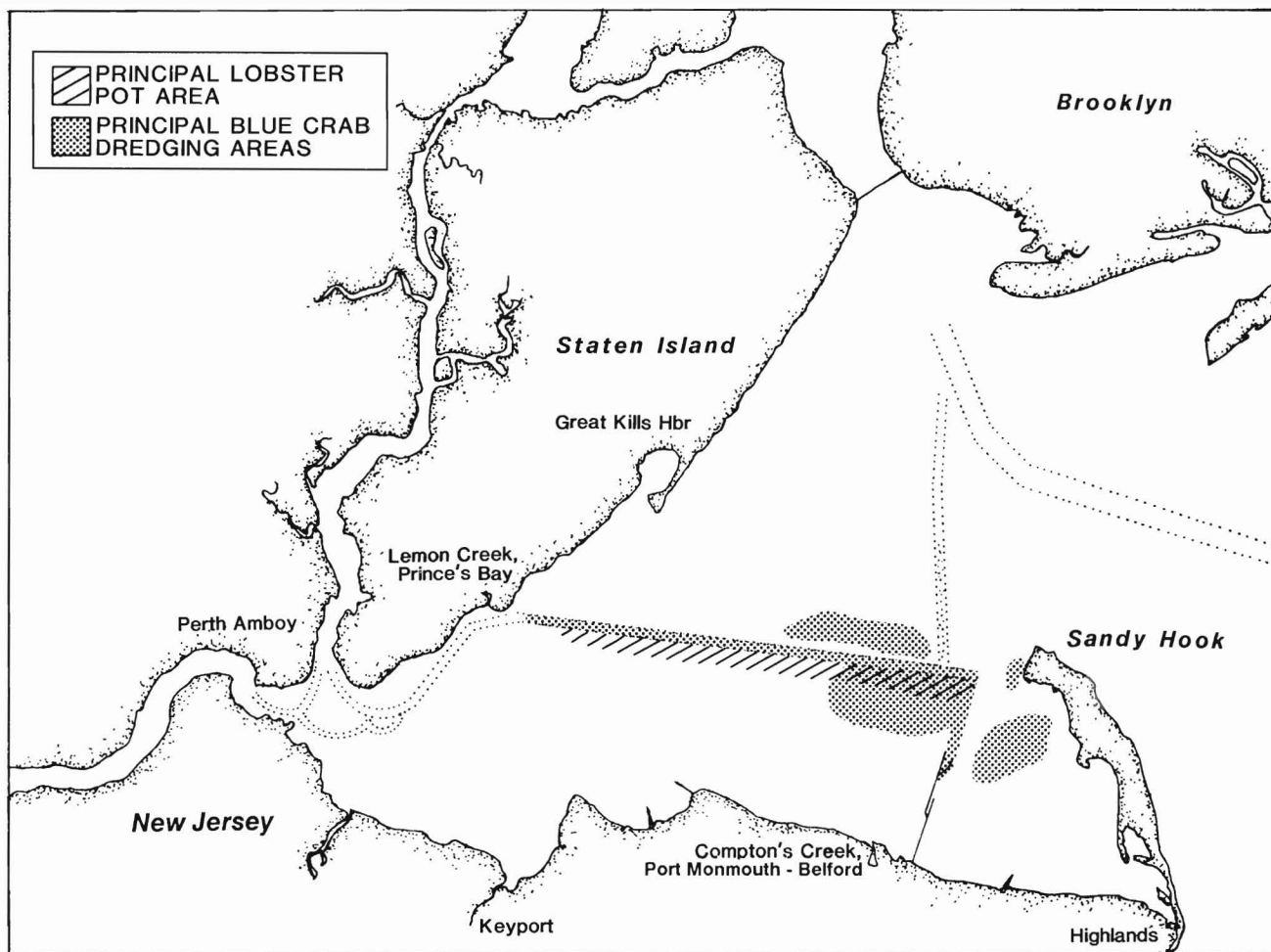


Figure 4.—Principal areas for potting lobsters and dredging blue crabs. Source: Fishermen interviews.

years, have not shown a downward trend¹. It may be only by chance that lobsters are abundant in the bay in various years. For example, in 1985 they were extremely abundant there, whereas from 1986 through 1989 they were much scarcer. In the ocean, however, they were abundant from 1985 through 1989¹.

Blue Crabs

Raritan Bay is the northernmost bay along the Atlantic coast which supports a regular commercial dredge fishery for blue crabs in winter. It is unique in supporting commercial populations of lobsters and blue crabs. These crabs summer in tributary rivers and creeks and shallow areas and then migrate to deep areas in the eastern part of the bay in fall. In

the late fall and winter, when the water chills, they become dormant and can be gathered by fishermen using dredges (Fig. 4).

Elderly fishermen related that blue crabs were scarcer in the 1970's and 1980's than they were in earlier periods, but in the 1988-89 dredging season they were relatively abundant¹. The exceptionally warm years of 1987 and 1988 may have enhanced their survival. In Atlantic coast estuaries, abundance of blue crabs did not decline in the years from the 1930's to 1950's when eelgrass was absent (McRoy and Helfferich, 1980). Apparently then, the eelgrass disappearance in the bay was not a factor in the perceived decline in blue crab abundance.

Horseshoe Crabs

Apparently these "crabs" are scarcer than they once were in the bay. In the 1980's mating pairs were present on beaches every spring, but elderly fishermen relate that in the early 1900's they were more abundant¹.

Other Species

Worms

Since the 1940's, sandworms, *Nereis virens*, and bloodworms, *Glycera* sp., found in the intertidal zone, and nemertean "tapeworms," *Cerebratulus lacteus*, found there and subtidally, have become relatively scarce in the bay. Before that, these worms were abundant

enough to be dug commercially as bait for sportfishing¹.

The causes of declines in bay scallops, horseshoe crabs, and worms are unknown. The possibilities include: 1) Loss of eelgrass (a) which may have served as a nursery for bay scallops, (b) which protected intertidal zones from wave action, and (c) whose decaying blades added organic matter to sediments; 2) recurrent oil spills in the 1940's, 1950's and 1960's, which saturated intertidal zones with oil; and 3) polluted water and sediments from urban and industrial discharges.

Benthic Invertebrates

A 1973-74 survey revealed that 156 species of benthic invertebrates, representing most major taxa, grew in the bay. The average number of individuals was 660/m². The invertebrate community structure was not considered as degraded as had been reported and, in many ways, was similar to those in less-deteriorated estuaries on the mid-Atlantic coast (Steimle and Caracciolo-Ward, 1989), but comparisons with invertebrates before the bay became deteriorated cannot be made.

Eelgrass and Sea Lettuce

Eelgrass was once abundant in the bay. It grew off the Staten Island coast and in a wide band from Morgan to Highlands. It disappeared from the bay and nearly everywhere else along the Atlantic coast in the 1930's (Thayer et al., 1984). Eelgrass has never returned to the bay, except for a small area near Sandy Hook, because the bay has been turbid (MacKenzie and Stehlik, 1988). Sea lettuce, *Ulva lactuca*, grew along nearly the entire shoreline of the bay in the 1980's, but its abundance was much lower than it once was, also because the bay was turbid.

Fishing and Shellfishing, Pre-1800's

This section summarizes fishing and shellfishing practices in and near Raritan Bay, based mostly on compilations by Pearson (1972) and Ingersoll (1881).

Indians consumed fish, such as alewives, shad, and striped bass extensively in the warm months. They caught



Figure 5.—Part of an exposed Indian shell midden on the southwestern shore of Staten Island, 1913. Source of photograph: Staten Island Institute of Arts and Sciences.

striped bass with seines as long as 146 m and made of reeds. Seines had stones tied along their bottoms as weights and sticks attached along their tops as floats. And they caught fish in weirs 11-13 m long and 1.8-2.3 m deep. To preserve fish for consumption in winter, Indians dried them in the sun on tree bark and stored them in deerskin bags. They fertilized their agricultural crops with menhaden, mussels, and seaweed (probably *Ulva lactuca*).

Oysters, hard clams, and soft clams were staple foods of Indians also (Smith, 1890; Kalm, 1937). In their festivals, hard clams were the featured food. To preserve shellfish, they strung the meats on reeds, hung them in the sun to dry, and stored them in deerskin bags also. At least four oyster shell middens were present on the shores of western Raritan Bay (Fig. 5), and, in the 1900's, bayshore farmers found oyster and clam shells and arrowheads, all left by Indians, in their fields¹ (MacKenzie, 1984).

Dutch and English colonists of the 1600's and 1700's described large schools of alewives, menhaden, and shad and numerous sturgeon in and near the

bay. They caught these fishes, along with striped bass, and ate all, except menhaden, fresh and smoked. As Indians had done, farmers used menhaden for fertilizer.

Oysters were abundant and available to the colonists who ate them raw, broiled on coals, boiled in fat, and preserved in vinegar. In addition, colonists ate hard clams, soft clams, and lobsters, which were often pickled in vinegar.

Colonists gathered oysters from the beds by hand and with tongs and primitive dredges towed from sloops. Oyster shells were baked into lime in kilns, for use in farm fields and house construction. By the early 1700's oysters had become scarcer. Citizens of New York and New Jersey tried to conserve them by enacting laws which restricted oystering to specific seasons and to residents of their own states. Nevertheless, by the early 1800's, oysters on the Great Beds were depleted. This led to the importation of seed oysters from other areas, mostly Chesapeake Bay, to be planted on leased beds, and the creation of a substantial oyster industry.

Fisheries, 1800's to the Present

Raritan Bay has supported 23 known types of fisheries, most of which were developed in the 1800's. Thirteen have since disappeared, mostly from 1925 and 1961 (Table 2).

The total number of commercial fishermen working in the bay is known only for 1950 and 1960. In 1950, 501 full-time and 463 part-time fishermen worked on boats and ashore. In 1960, comparable figures were 668 full-time and 227 part-time fishermen (DeFalco, 1967). Undoubtedly, the number was substantially larger from the 1870's to early 1900's, when at least 600 men were engaged in oystering alone (see also the later section, The Shellfishing Ports).

Fishermen could not concentrate on one fishery for support, because each was seasonal and some were undependable. Instead, most worked in a few fisheries each year. For instance, a fisherman might work with a pound-net crew from spring to midsummer, set his own lobster pots from then until fall, and rake hard clams, dig soft clams, dredge blue crabs, or spear eels, or do all of them, in late fall and winter¹.

Finfisheries

Fishermen began finfishing in the bay with primitive gear and slowly introduced more efficient gear through the years. Considering food fishes, they used the hand line, haul seine, and fyke net in most if not all of the 1800's and undoubtedly caught only a small portion of the fish available. In the later half of the 1800's they introduced the gill net and pound net, and, since these caught more fish, the first three gears became less important. Finally, in the 1940's they introduced the otter trawl which has since made the pound net somewhat obsolete. In the 1980's fishermen used the otter trawl almost entirely in the ocean and, along with a large sportfishing effort, it was catching so many fish that fewer were available to enter the bay. The boats employed with these and other gears varied and changed over time (Table 3).

The Finfishing Ports

Since at least the 1870's, Compton's

Table 2.—Duration of the principal fisheries in Raritan Bay. Possibly some of the fisheries listed as beginning in the 1800's actually began in the 1700's.

Fishery	When it began	Status
Hand lining	1800's	Ended in 1950's
Haul seining	1800's	Ended in 1940's, except for baitfish
Fyke netting	1800's	Ended in 1950's
Gill netting	1800's	Ended in 1946 ¹
Eel potting	1800's	Still exists
Pound netting	1855	Still exists
Purse seining	1800's	Still exists
Otter trawling	1945	Ended in 1963
Sportfishing	1700's	Still exists
Oystering		
Natural beds	1700's	1820's (?)
Industrial	1825	Ended in 1925
Hard clamming		
Scratch raking	1800's	Ended in 1940's
Sail dredging	1863+	Ended in 1961
Rocking chair dredging	1946	Ended in 1961
Hand raking	1863	Ended in 1961 ²
Soft clamming		
Dragging and churning	1800's	Ended in 1961, moved to rivers
Outboard motoring	1920's-1940's	Ended in 1950's
Lobstering	1800's	Still exists
Blue crabbing	1800's	Still exists
Bait fisheries	1800's	Still exists
Horseshoe crabbing	1800's	Ended in 1930's, except for bait
Recreational lobstering	1950's	Still exists
Recreational crabbing	Early 1900's	Still exists

¹Reinstated for shad in 1981.

²The hand raking fishery for hard clams began again in 1983, but the clams have to be depurated.

Table 3.—Boats used for commercial fishing in Raritan Bay.

Boat	Length (m)	Uses ¹	Period used
Bateau	4.3-6	1, 3, 5, 11	1800's-1950's
Rowboat	7.6-8.5	2	1800's-1940's
Catboat	5.5-7.6	4, 5, 10, 11, 13	1800's-early 1900's
Tonging skiff	5.5-6	10, 11	1800's-early 1900's
Sloop	10.6-12.2	6, 7, 10, 11, 14	1800's-1950's
Schooner	18.3-21.3	10, 11	1800's-1950's
Pound boat	11	6	1800's-present
Dredge boat	15-18	10	1905-1925
Nova Scotia-type lobster boat	12.2	11, 13	1945-present
Seine boat	42.7-61	7	1930's-1980's
Sea skiff	5.5-7	1, 4, 5, 11, 13	Early 1900's-1940's
Dragger	16.8-21.3	8	1946-1963
Maycraft	6.7-8.5	9	1946-1963
Outboard motor boat	6	5, 11	1950's-present

¹Usage key:

- | | |
|-------------------------------|---------------------------|
| 1. Hand lining | 8. Purse seining for scup |
| 2. Haul seining | 9. Trawling for scup |
| 3. Fyke netting | 10. Oystering |
| 4. Gill netting | 11. Hard clamming |
| 5. Eel potting | 12. Soft clamming |
| 6. Pound netting | 13. Lobstering |
| 7. Purse seining for menhaden | 14. Blue crabbing |

Creek in Port Monmouth-Belford has been the principal finfishing port in the bay (McCay, 1984; Fig. 1). The port was once only a minimally developed marshland creek used for the transport of agricultural produce and some fish from the local region to New York City. In the early 1870's four companies constructed and operated factories there for canning menhaden for food, but they closed after only a few years. In the late 1800's and early 1900's the port expanded as immigrants, mostly from Germany and Scandinavia, settled there to work in menhaden reduction factories and catch fish with hand lines, haul seines, fyke nets, pound nets, and eel pots, gather hard clams and soft clams, and catch lobsters and blue crabs. Pound netting was the largest fishery, sometimes employing as many as 300 men. The creek was widened and deepened to hold more and larger boats as the fisheries grew. Nearly every year, menhaden, always predictable, abundant, and a reliable money-maker, constituted over 90 percent of the port's landings by weight. Since about 1970, a number of trawlers berthed at the port have fished in the ocean primarily for silver hake in winter (McCay, 1981).

The other finfishing ports were Keyport, where fishermen used fyke nets, gill nets, and eel pots, and Highlands, where they used hand lines, fyke nets, and eel pots. Haul seining was practiced at several sites along the Staten Island and New Jersey shores.

Nondirected Finfisheries, by Gear

Haul Seining

In the 1840's haul seines were used for catching fish on Staten Island and probably New Jersey. In spring they were used to catch, first, shad and then menhaden. The menhaden were sold for 75 cents per thousand fish to farmers for fertilizer (Akerly, 1843). Presumably, other fishes were caught also.

In the 1890's about five crews were haul seining in the bay (Stevenson, 1899), and in the 1920's and 1930's about seven crews were engaged in this fishery, all in New Jersey¹ (Breder, 1922; Fig. 6). Most seines were about 700 m long and had a stretched mesh size of 64 mm. The

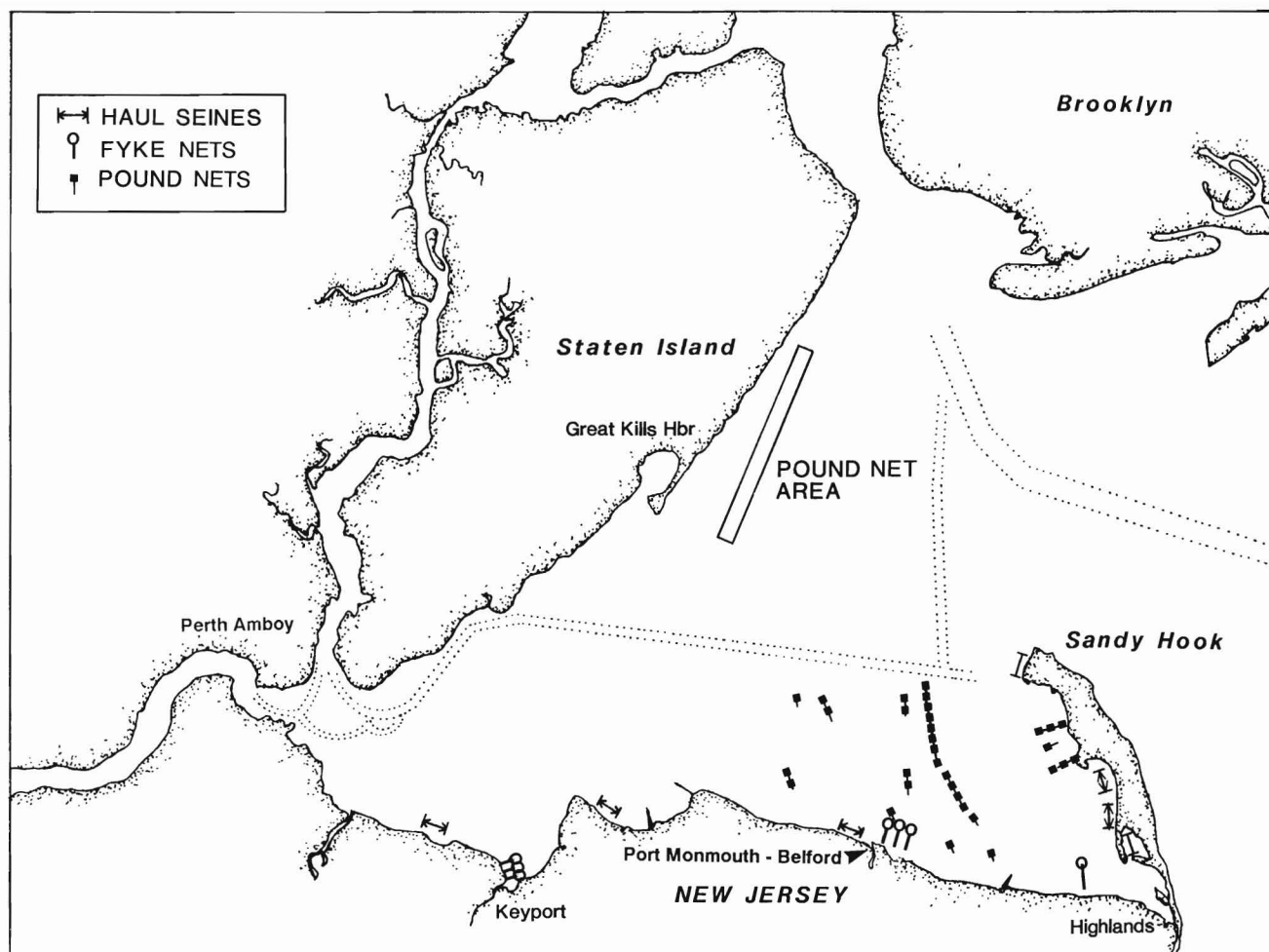


Figure 6.—Locations of haul seines, fyke nets, and pound nets in the 1920's and 1930's (from Breder, 1922, and fishermen interviews). The rectangular area east of Great Kills Harbor denotes where pound nets for shad were located in the 1940's and early 1950's.

longest seine was about 2 km long. Each crew consisted of about eight men. Once a day, at high tide and slack current, they rowed out the net using a boat about 8.5 m long (Fig. 7; Table 3). The net was hauled ashore by hand or horse. The usual catch was 8-10 bushels of fishes, including alewives, bluefish, flounder, menhaden, mullet, shad, striped bass, and weakfish. Blue crabs and horseshoe crabs were an incidental part of the catch¹.

In the early 1940's fishermen gave up haul seining because they had found more lucrative jobs in factories and other shore-based industries¹. In the 1980's fish were too scarce in the bay for commercial haul seining. Minor haul seining,

using nets about 15 m long, was practiced then by sportfishermen to catch bait, e.g., silversides, *Menidiemenidia*, and mummichogs, *Fundulus heteroclitus*, and sometimes blue crabs.

Fyke Netting

In much of the 1800's the fyke net was the principal commercial finfishing gear used in the bay. Fyke nets were installed along the shores of Raritan Bay. They were cylinders, about 9 m long and 1.2-1.9 m in diameter, whose shape was held by four or five wooden hoops spaced about 2.4 m apart. Net funnels aiming toward the head of the fyke were attached to each hoop. The head had an opening for

removing fish. A net leader, about 12 m long and 1.7 m high, was positioned directly in front of the mouth extending perpendicularly to the shore to intercept the fish, and two heart-shaped nets were positioned in front of the fyke's mouth, one on each side, to direct fish toward it. The netting had a mesh size of only about 15 mm to retain eels. Fykes were held in position by poles (Fig. 8). Fishermen tended fykes in rowboats called bateaux¹ (Table 3).

Fishermen installed fykes only in spring, beginning in March, and fall, but not in summer when fishes remained in deeper water and the netting would become extremely "dirty" with growth of

various organisms. In the 1840's farmers, whose land bordered on the eastern and southern shores of Staten Island, each had at least one fyke installed. They removed fish from them at low tide in daytime. Whenever they caught more fish than they could consume, they shipped the surplus to New York City for sale. These catches often brought them more money than their agricultural crops (Akerly, 1843). In the 1890's Staten Island had 18 fyke fishermen and 215 fykes, Gravesend Bay had 34 fykes and Monmouth County had 53 fyke fishermen and 213 fykes (Smith, 1894a; Stevenson, 1899). Counting those in Gravesend Bay, Raritan Bay probably had more than 200 fykes, while some were in Arthur Kill, Kill Van Kull, Navesink River, Shrewsbury River, and other areas.

By the 1920's and 1930's the number of fykes in the bay had fallen to about 25 (Fig. 6). Three fishermen in Keyport and three in Port Monmouth-Belford had three to four fykes each; fishermen in Highlands had a few fykes along Sandy Hook. The fishes caught were alewives, bluefish, croakers, eels, flounder, mullet, and weakfish, besides horseshoe crabs. Each fisherman obtained 50-100 pounds of fishes a day from all his fykes. The fyke fishermen potted eels also¹. After the mid-1950's fyke netting disappeared because a scarcity of fish made it uneconomical¹.

Pound Netting

In 1855 George Snediker of Gravesend, Long Island, introduced pound nets to New Jersey. They were smaller than those currently used and were set in Raritan Bay near Sandy Hook (Smith, 1894b). Before 1873 they had not come into regular use, and in 1880 the bay had only a few of them (True, 1887).

Since at least 1900, the design of pound nets has not changed. They consist of four sections: 1) A pocket which measures about 13 × 16 m and holds the fish, 2) a net leader about 165 m long, 3) a curved big heart, and 4) a curved small heart (Fig. 9). Their overall length is about 230 m and it is held in place by about 70 poles set in the bottom.

Before the late 1940's, pound nets were

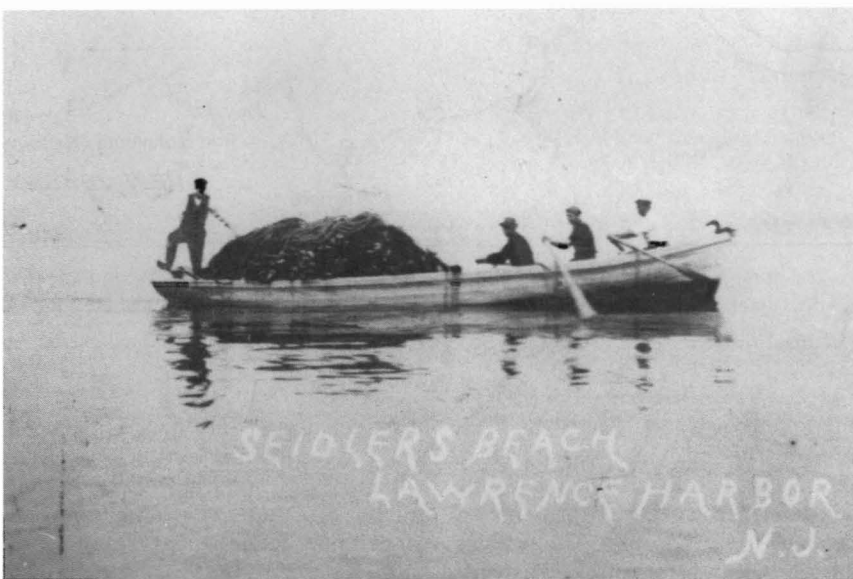


Figure 7.—Loading a haul seine on a rowboat (top) and rowing out a haul seine (bottom), about 1900. Source of photograph: L. Booz.

made of cotton twine. Fishing crews had two sets of nets for each of their pound nets; one was installed in the bay, while the other set was in a local field where the crew dried, cleaned, repaired, and finally dipped it in tar. About every 2 weeks in spring and fall and once a week in sum-

mer, crews had to remove nets from the bay and replace them with cleaned, tarred alternates, or they would rot and disintegrate. In addition, the nets collected large quantities of fouling organisms and mud; if left in the bay, currents would tip them over. After the late 1940's, crews

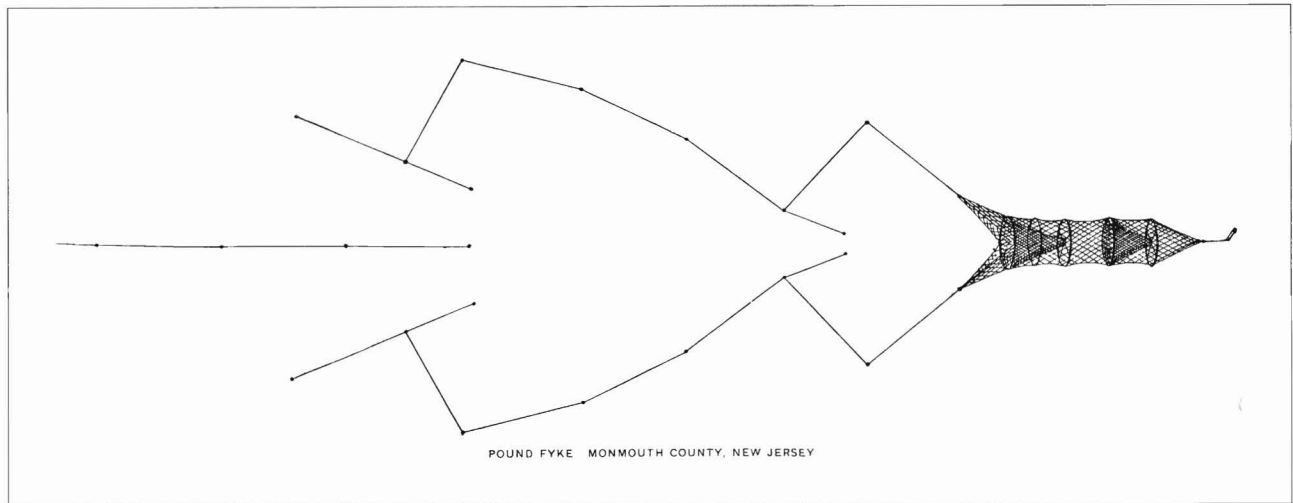


Figure 8.—The design of the fyke net used in Raritan Bay in the late 1800's (Smith, 1894a). In the 1900's the number of hearts was only two.

continued to have two sets of nets, but they were made of nylon and were tarred only once a year in spring. Crews still had to remove them as frequently as the cotton nets, however, for cleaning and repairing.

Before 1900 the pound boats were sloops, about 11 m long, which could carry about 300 bushels of fish (Frye, 1978; Table 3). Crews poled them out of Compton's Creek, Port Monmouth-Belford, the only port for pound boats, to the pound nets, most of which were then installed in shallow water nearby (Fig. 6). Crews sailed or, with no breeze, rowed their sloops to the pound nets installed at Sandy Hook, a distance of 4.8 km¹.

Since the turn of the century, pound boats have been about the same size, 11 m long and 3 m wide, but engine-powered (Table 3). They have a small pilothouse aft and an open hold in their midsection which carries 250-300 bushels of fish. Crews use a boom and brail net to transfer fish from the pound-net pockets to the hold of their pound boats (Fig. 10).

For many years, crews lifted brail nets by hand. In the mid-1930's Arnold Pedersen, a fisherman of Highlands, introduced the motorized winch to fishing boats in the bay. Afterwards, fishermen used winches to lift brail nets, eel and lobster pots, and crab dredges.

Figure 9.—The design of the pound net used in Raritan Bay. The depth of a net ranged from 6 to 9 m. Source: Fishermen interviews.

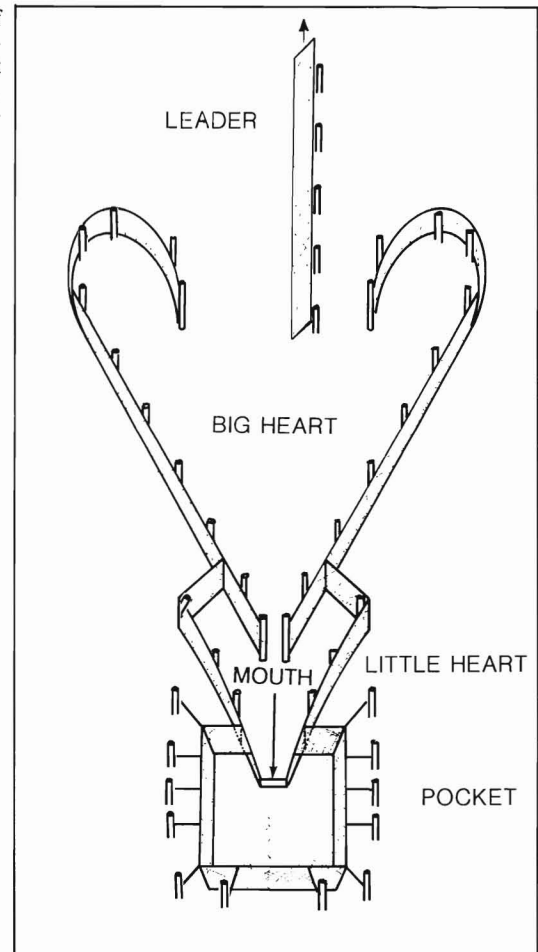




Figure 10.—Transferring fish in a brail net from a pound-net pocket to a pound boat, 1950's. Source of photograph: Monmouth County Historical Association.

In the 1890's, about 37 pound nets were installed in the bay; 28 boats tended them (Stevenson, 1899). In the early 1900's, the number of pound nets increased to about 50 (*Red Bank Register*, 8 March 1911), but in the 1930's it fell off to about 25 (Fig. 6). During World War II, when market demand and prices for fish rose substantially, the number increased sharply to about 150 pound nets and 30 pound boats; 100 pound nets were in the New York half of the bay, 50 in the New Jersey half¹. In 1950, 76 pound nets were installed in the bay and in 1960, 68 (DeFalco, 1967). The number of pound nets declined steadily afterward, and from 1974 to 1989 it ranged from 9 to 13.

For a long time, pound netters were divided into two groups based on the length of their fishing seasons. One group fished only from April until early July, primarily for menhaden, although they caught food fish also. The other group fished for the entire season through October. This second group began the season with three pound nets, but could han-

dle only two from July through October because the nets became "dirtier" then and had to be changed once a week as noted. In recent years, all pound nets have been installed for the entire season¹.

Each morning, except on Sundays, pound-net crews left Port Monmouth-Belford to lift their nets just before dawn. They arrived at the first nets at dawn, drew up the pockets, brailed out the fish, spent about 20 minutes mending holes in the pockets, and then reset them. Then they went to their other nets and did the same. They returned to port about 2½ hours after leaving, unloaded the menhaden at a fish factory and put the food fish on a freight boat destined for the Fulton Fish Market in New York City or sold them to peddlers. They spent the remainder of the day, until about 1:00 p.m., working on their alternate sets of pound nets in local fields¹.

The composition of fishes caught in pound nets varied seasonally. In March and April, they caught mostly alewives and shad. In April and May, they caught

some sturgeon. And in about a five-week season extending from mid-April through May, they caught huge quantities of menhaden. Though far fewer menhaden went into pound nets from June to October, their quantity still consistently exceeded those of food fishes. Pound nets caught bluefish from May into October, and scup and weakfish from July into October. Pound-net catches also included small numbers of black drum, *Pogonias cromis*, sharks as long as 4.9 m, striped bass, summer flounder, loggerhead turtles and others¹. In the late 1980's crews had to release all striped bass that were under New Jersey's minimum length limit (34 inches [86 cm] in 1988 through 1989; then 36 inches [91 cm]). In 1950, pound netters marketed 37 species of fishes (McCay, 1984).

The usual annual catch of menhaden by each pound-net crew was from 20,000 to 30,000 bushels, and, in especially good seasons, as many as 50,000-60,000 bushels. From mid-April through May, menhaden were so numerous that each pound net could be emptied as many as four times a day. Pound boats made from one to four trips a day, carrying 200- to 300-bushel loads of menhaden each time, to the J. Howard Smith fish factory, known after 1971 as the Seacoast Products, Inc., fish factory. And crews hired hard-clam sloops and fishing draggers to help them carry the menhaden. Crews of these boats installed boards around their decks, making bins which held 500-550 bushels. To load, they tied alongside pound-net pockets and brailed out the menhaden. Each pound-net crew obtained from 1,000 to 2,000 bushels of menhaden a day from its three pound nets¹.

After menhaden, scup were the fish caught in the largest quantity. Before the 1940's scup brought the least money per bushel or box of any food fish, however, and landed prices were so low that fishermen often released them. Nevertheless, because these two fishes were so abundant, pound-net crews made most of their money on them, with menhaden providing far more than scup. Usually, the next most abundant fishes were bluefish and weakfish.

Through the years, all food fishes have

fluctuated in abundance. In the mid to late 1940's, bluefish were scarce; in the 1950's and 1960's, weakfish were scarce; since 1963, scup have been scarce (McHugh, 1977).

Driftwood hazards

A major hazard for pound-net crews was drifting logs of various sizes which tangled in their nets almost every day. Logs were abundant in the bay and came from greater New York City. Fishermen had to remove them regularly or the nets would be torn in heavy winds¹. In recent years, the situation has much improved because far fewer logs have been discarded into the water and the U.S. Army Corps of Engineers (COE) has operated boats to remove large drifting material from New York Harbor.

Submarine net

During World War II, the U.S. Government installed a metal net between Staten Island and Long Island to prevent German submarines from approaching New York City. New Jersey fishermen anticipated that shad, on their spring spawning migration up the Hudson River, might be deflected toward Staten Island by the submarine net, and, in the early 1940's, installed a few pound nets off the island's southeastern shore. Indeed, large quantities of shad were caught in a season lasting about 5 weeks. Within a year or two, fishermen had installed about 100 pound nets there. New York authorities made the fishermen take out the nets by the 15th of each May, however, to prevent the taking of any "good" fish, such as bluefish, striped bass, and weakfish. When the submarine net was removed after the war, catches dropped. For this reason and because prices for shad were low, fishermen abandoned the practice of putting pound nets there soon afterward¹.

Conflicts with anglers and pleasure boaters

In the first few decades that pound nets were installed, sportfishermen encouraged politicians to have them banned. From the late 1800's to the 1950's, besides those in Raritan Bay, pound nets were installed in the ocean along the

Atlantic coasts of New Jersey and Long Island. Sportfishermen believed that those in the ocean were catching most of the fish as they migrated toward the bay and then those in the bay were taking most of the remainder, leaving them with too few fish to catch. No legal action was ever taken, however, to reduce the number of pound nets in the New Jersey half of the bay (*Red Bank Register*, various articles).

In the 1980's, relations between sportfishermen and pound netters were good. Pound nets caught only small quantities of summer flounder, the principal species sought then by sportfishermen, and most of the menhaden which pound nets caught were sold to sportfishermen for bait.

Especially since the 1940's, large numbers of pleasure boats have traversed the bay. Every few years, one of them runs into a pound net at night and damages the netting and breaks poles. Fishermen have a legal right to place pound nets in designated areas, their positions are marked on navigation charts, and their end poles are lighted. The pleasure boats are at fault, but they are gone when crews lift their pound nets, and thus crews cannot collect money for the damage. Owners of pleasure boats view the pound nets as a hazard to boating¹.

Lack of labor

In the 1950's and 1960's, most pound-net owners sold their gear because capable crewmen had found more lucrative or easier jobs ashore and were increasingly unavailable. Thus it was difficult, if not impossible, for them to operate.

Directed Finfisheries, by Gear

Hand Lining for Bluefish

On a small scale, commercial fishermen from mainly Port Monmouth-Belford and Highlands, caught bluefish in channels at the eastern end of the bay and in the nearby ocean using hand lines. It was mainly a night fishery from dusk to dawn, but crews sometimes fished by day also. Usually, the fishery was composed of four or five regular boats and, at times, about an equal number of part-time boats. The most common boats used were bateaux and sea skiffs (Table 3). Each had two or three men. The boats were

equipped with a grinder to mince menhaden used as chum. Fishermen used hooks without barbs so they could unhook fish quickly. This fishery was first recorded in the 1840's (Akerly, 1843) and again in the early 1900's, when catches of 43, 110, 446, and 539 bluefish per boat were reported (*Red Bank Register*, 15 September 1909). In the 1930's and early 1940's, when bluefish were abundant, each crew typically caught 800-1,000 pounds a night¹. Crews gutted the bluefish while returning to port.

The total fleet of commercial hand liners for bluefish in the nearby ocean was relatively large. The port for the remaining fleet was New York City (see the later section, Processing and Marketing Menhaden).

In the late 1950's, the fishery ended when increasing numbers of sportfishermen were catching bluefish and selling them at low prices. They reduced the market price of bluefish so low that commercial hand liners were forced to quit.

Stake and Anchor Gill Netting for Shad

Stake gill nets were used to catch shad from February to early May, and the main shad run lasted about 5 weeks. The nets were made of cotton or linen and were about 122-153 m long, 4.5-5.5 m deep, and had a mesh size of 13 cm. They were tied to a series of oak poles set in the bottom about 6 m apart and across the current. Each day, fishermen removed the nets with the fish enmeshed and replaced them with alternate nets which, during the previous day, had been dried and cleaned of collected material, mainly tiny sticks, on racks ashore. In the late 1800's, the type of boat used for gill netting was the catboat (Fig. 11) and in the 1900's, the sea skiff¹ (Fig. 12; Table 3).

In 1895, a census of the numbers of shad nets set and of shad caught in the New Jersey half of the bay revealed the following distribution of effort and catch (Anonymous, 1896):

Location	Gill nets	No. of shad caught
Keansburg	83	34,986
Port Monmouth	17	8,143
Belford	103	40,900
Highlands	11	22,130



Figure 11.—These boats in Port Monmouth-Belford are catboats, used for gill netting, eeling, hard clamming, and lobstering, and sloops used for hard clamming and blue crabbing, about 1900. Source of photograph: K. A. Norton.

The numbers of various types of nets which caught shad along with other fishes in the 1940's were (Mansueti and Kolb, 1953):

<i>Net type</i>	<i>Number</i>
Stake gill net	61
Anchor gill net	6
Drift gill net	50
Pound net	53

In 1950 the number of gill nets set was 94 and in 1960, 14 (DeFalco, 1967).

Gill nets collected sticks, driftwood and, in recent years, plastic bags, which were a hazard (Fig. 13). The objects put pressure on nets, reduced their fishing efficiency, and some were difficult to remove.

After the 1940's, gill netting for shad declined because market demand for them fell and they became scarcer. Shad was once one of the most popular food fishes of the Atlantic coast (McHugh,



Figure 12.—A sea skiff of the style used for multipurpose commercial fishing and shellfishing from the early 1900's to the 1940's. Photograph by the author, 1988.

1977). In recent years, the following conditions have weakened shad fishing in Raritan Bay: 1) Demand for them has been poor during the major run, 2) local consumers resist buying them because

they fear they are contaminated by pollutants, and 3) landed prices for them have been as low as \$0.10-0.25 per pound.

In the 1980's only one or two fishing crews set out anchored gill nets for shad

Table 4.—Landed prices of some fishes and shellfishes in Raritan Bay (1885-1899 and 1900-1930), New Jersey (1940), and U.S. east coast (1987). Prices of fishes are for pounds unless otherwise indicated; prices of menhaden, clams, and blue crabs are for bushels. (—) shows that value is unknown.

Species	1885-99 ¹	1900-30 (not 1917-18) ¹	1940 ²	1987 ³
Alewives	1¢ ea.	3¢	—	—
Bluefish	4¢	12¢	8¢	24¢
Butterfish	—	6¢	3¢	70¢
Eels	—	—	8¢	—
Flounders (mixed)	4¢	8¢	6¢	65¢
Menhaden	12-25¢	12.5-20¢	60¢ in 1960's	—
Scup	—	50¢/bu.	\$4.50-9.60/box ⁴	—
Shad	♀25¢ ea., ♂15¢ ea.	♀45¢ ea., ♂35¢ ea.	8¢	—
Silver hake	—	\$3-\$4/bu.	1¢	45¢
Sturgeon	5¢	17¢	10¢	—
Weakfish	—	2.5-7¢	3¢	\$1.03
Oysters	\$1.00/bu.	\$1.15-1.40/ gal. shucked	—	—
Hard clams	\$1.25-1.40	\$1.25	\$1.50	—
Soft clams	35-80¢	\$1.40-2.20	\$1.15	—
Lobsters	—	—	20¢	\$3.10
Blue crabs	—	75¢ (1930s)	\$17-40 (1980's)	—

¹Source: *Red Bank Register*, N.J.

²Source: Fishery statistics of the U.S., U.S. Dep. Inter. 1940. Stat. Dig. 4.

³Source: Fisheries of the U.S., 1987. Curr. Fish. Stat. 8700. U.S. Dep. Commer., Wash., D.C.

⁴Source: Fishery statistics of the U.S., 1950-59. U.S. Gov. Print. Off., Wash., D.C.

in the New Jersey half of the bay. The nets, of synthetic plastic fiber, were set in the late afternoon and lifted the next morning¹.

Drift Gill Netting for Bluefish and Weakfish

Drift gill netting for bluefish and weakfish in the bay dates back to at least the 1890's (Smith, 1894b). Drift gill nets were made of cotton or linen and were about 365 m long and 6 m deep; stretched mesh sizes were 8 1/2 cm and 14 cm. Each crew had two or three nets—one in use, another drying on shore (Fig. 14), and often a third stored at home. The nets had to be dried every day to last a season, or they would rot within a month¹.

As in stake and anchor gill netting for shad, in the 1800's the type of boat used for drift gill netting was the catboat (Fig. 11) and, in the 1900's, the sea skiff (Fig. 12; Table 3). Each had a crew of two.

In the 1920's and 1930's, the number of crews drift gill netting from New Jersey ports was about as follows: Perth Amboy, 2; Keyport, 15-16; Morgan, 5-6; Port Monmouth-Belford, 12; and



Figure 13.—Scene of high tide line of Raritan Bay beach, showing extraordinarily large amount of decaying cordgrass, *Spartina alterniflora*, and plastic bottles and sheets, 1987. The grass and plastic blows and drifts into the water and catches in boat propellers and in gill nets installed for shad. Photograph by the author.

Highlands, 3. Since drift gill netting was not permitted in the New York half of the bay, no crews fished with drift gill nets from Staten Island ports¹.

Each year, fishermen began drift gill netting in May and caught bluefish from then into October. From July into October they caught many weakfish also. Along with these two fishes, they caught croakers, spot, and others in the nets. Each day crews made their first sets around dawn and continued until mid-afternoon. The gill nets were set out in a

straight line or a circle. If set in a circle, crews ran their boats inside and splashed the water to drive the fish toward the nets. Most fish were gilled within a meter of the bottoms. Crews retrieved the nets about 10 minutes after setting them and took out the fish as they came aboard. Each crew was able to make five or six sets a day. Typical daily catches for a crew ranged from 200 to 400 pounds of fish; infrequently, catches ranged up to 1,500 pounds¹.

In the 1940's, pound netters were



Figure 14.—Fishermen drying gill nets on a rack in Keyport, about 1910. Source of photograph: Keyport Historical Society, Steamboat Dock Museum.

becoming increasingly hostile towards drift gill netters. Pound netters believed that gill netters had an unfair advantage over them because they could move their nets around, and they were angered because the gill netters often set their nets close to the pound nets, perhaps reducing their catches¹. In 1948 they convinced New Jersey legislators to ban the use of drift gill nets in the bay thereafter.

Eeling

The U.S. government fishery monographs of the late 1800's did not mention an eel fishery in Raritan Bay, but it is believed from fisherman interviews and also Sim (1975) that one existed in the 1800's.

Potting

In the 1800's, eel pots used in New Jersey were cylindrical, about 92 cm long and 23 cm in diameter. They were made of woven oak splints and had two funnels, one at an end and another in the middle. The opposite end had a wooden door to

empty out the eels (Sim, 1975). Since the early 1900's, the dimensions of pots used in the bay have remained about the same, but the outside has been made of mesh wire having 19 mm square openings. Since the 1940's the funnels have been made of cotton or nylon mesh. Fishermen attached from 5 to 15 eel pots to trot lines, strung them along the bottom, and anchored their ends. Fishermen have always used horseshoe crabs, chopped in halves or quarters, and broken soft clams for bait, while in the 1980's they also used surf clams, *Spisula solidissima*¹.

From the 1800's to the early 1900's, full-time eel fishermen used catboats (Fig. 11) for potting, and until the 1950's, sea skiffs (Fig. 12). Since the 1950's they have used outboard motorboats (Table 3). Part-timers, mainly soft-clam fishermen from Highlands, commonly used bateaux. In the 1920's and 1930's, about two fishermen potted eels from Lemon Creek, eight from Keyport, eight from Port Monmouth-Belford, and 12 from Highlands. The number declined after-

Table 5.—Comparison of the number of commercial fishing boats used by fisheries and listed in the ports of Port Monmouth-Belford and Highlands near the beginning and at the end of the 1980's.

Ports and fisheries	1979-81 ¹	1989 ²
Port Monmouth-Belford		
Menhaden purse seine	4-7	1
Lobster	17	21
Trawl ³	13 ²	21
Crab	10	10
Eel	10	1
Pound net	5	4
Gill net	1	0
Highlands		
Soft clam	30	0
Lobster	9	6
Eel	6	3
Gill net	3	1
Totals	109-112	68

¹Source: Caruso (1982).

²Source: Fishermen interviews.

³Some of these trawl boats were converted for lobstering in the warmer months.

wards, and, in the late 1980's, only four fishermen potted eels in the bay¹ (Table 5).

Before the 1940's each full-time fisherman tended up to 100 pots, part-timers as few as 15. Before the mid-1930's fishermen retrieved the pots by hand; from then to the early 1970's those with motorboats used a motorized winch. Since then, they have used a hydraulic hoist. In the 1980's one eeler using a fast boat and a hydraulic hoist was able to tend as many as 300 pots.

The potting season for eels extends from April to early November. In April, pots are placed close to shore in 30-45 cm of water at low tide. As water temperatures rise with the advance of spring, the fishermen move their pots into deeper water following the seasonal movements of the eels. By mid-summer, most eels are in the shipping channels. More eels are caught on muddy than sandy bottoms.

Eel fishermen lift their pots daily, until the last weeks of the season when catches fall and then they lift them every other day. In the 1980's, the eeler with 300 pots averaged 200-250 pounds of eels a day, with largest daily catches ranging from 700 to 1,000 pounds¹.

Spearing

In winter, while standing on ice, many fishermen speared eels laying dormant in muddy bottoms. If ice did not form, they speared from bateaux in the same areas on a much more limited basis. The spear was from 3.7 to 5.5 m long. Its head had three or four barbed prongs on each side of a flattened prong in the center. Fishermen used an axe to cut holes in the ice and a potato or onion sack to carry the eels.

In the bay, the most favored locations for spearing were Keyport Harbor, a muddy area about 1.5 km east of Port Monmouth-Belford and a site near Sandy Hook. Fishermen from the bayshore speared eels in Great Kills Harbor and Fresh Kills on Staten Island, and in the Navesink and Shrewsbury Rivers also¹ (Fig. 1). Spearing was common in the 1800's and 1900's until the 1950's, but continued afterwards on only a limited basis into the 1970's. Daily catches of eels by each fishermen ranged from 12 pounds in poor years (*Red Bank Register*, 22 January 1930) to 175-200 pounds in years of extraordinarily high eel abun-

dance (*Red Bank Register*, 4 January 1945).

Bobbing

In the early spring, usually in March, when the eels first became active, some fishermen caught them using a fist-size bob of sandworms as bait. Bobs were made by running a string lengthwise through about 30 worms and rolling them into a ball. Just after dark, fishermen, alone in bateaux, lowered two bobs on lines to the bottom and caught eels for about 4 hours. Each landed as many as 100 pounds of eels a night, but about 80 percent were undersized and released. Each year, from about 1900 to 1940, as many as 20 fishermen bobbed for eels in the bay and nearby waters¹. By the 1980's eel spearing and bobbing had disappeared.

Factors affecting eeling

In mid-summer eels are concentrated in the shipping channels of the bay. Probably, before the channels were dug, eels were in the deepest areas of the bay, but dispersed. Thus, channel construction may have concentrated them, benefitting the fishery. Fishermen catch more eels in the channels whenever the COE dredges accumulated mud from them. Eels seem to be most abundant in the roiled water¹; perhaps they feed on polychaetes and crustaceans made available by the dredging.

The potting, spearing, and bobbing of eels declined in part because the market for eels became limited. In addition, eels became scarcer.

In 1976, beginning about the first of July and ending in October, an 8,600 km² zone of ocean bottom water off the coast of New Jersey had extremely low concentrations of oxygen (Sindermann and Swanson, 1979). In that period, fishermen reported that catches of eels in the bay were unusually high. For instance, one fisherman who had about 50 pots caught about 2,000 pounds of eels a week, much higher than his usual catches¹. Apparently, eels in the ocean fled from the low-oxygen zone back to Raritan Bay and probably other bays.

In the 1980's eel fishermen did not put their pot lines everywhere they desired in

the channels because sportfishermen would constantly hook them. Instead, they put them in several small areas, usually opposite channel buoys, which sportfishermen had learned to avoid. In addition, eel fishermen set the pot lines without buoys and towed a grapnel to lift them, a tactic to prevent sportfishermen from taking the pots.

Scup Fishery

As noted, before the 1940's the market for scup had been limited; in the 1920's and 1930's pound netters often received only about \$0.50 a bushel (60 pounds) for them. In the 1940's, however, the demand for them increased sharply and remained good. From the 1940's through the early 1960's, prices ranged from \$4.50 to \$9.60 per 100-pound box (Anonymous, 1945-62). The sharp increase in price spurred the development of a substantial fishery for scup which began in 1946 and peaked from 1950 to the early 1960's. Fishermen caught scup with otter trawls (Fig. 15), purse seines, and drift gill nets, besides pound nets. Their port was Port Monmouth-Belford. The fishery operated when scup were in the bay from July through most of October. The trawling and seining crews prospered¹.

Otter trawling

Fishermen used "Maycraft" boats, 6.7-8.5 m long, for otter trawling scup (Table 3). The trawling fleet consisted of 20-23 of these boats, each with a crew of four. They fished mostly in the bay and also in the ocean up to 35 km away. Crews retrieved the otter trawls by hand. Because scup were abundant in the bay, boats often had to make only one or two half-hour tows to catch a full load of about 60 boxes¹.

Purse seining

The number of purse-seine boats in this fishery ranged from 12 to 18; they fished in the bay but mostly the ocean. There were two types. The larger was a dragger, 18-21 m long, with a crew of seven. The smaller type was the pound boat, about 11 m long (Table 3), with a crew of four. Purse boats used with these boats were about 11 m long also. After the mid-

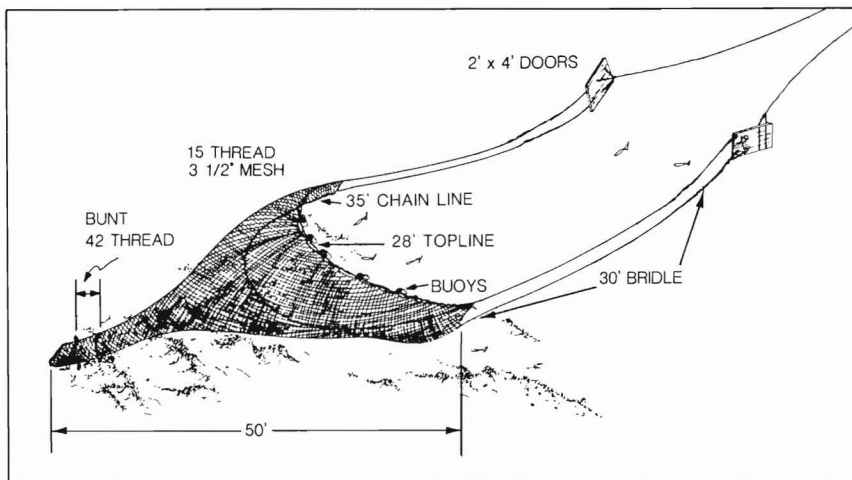


Figure 15.—The design of the otter trawl used for catching scup in Raritan Bay.
Source: Fishermen interviews.

1950's the seine boats used depth recorders to find scup. Often, seine boat crews got 200-1,000 boxes per set. Each was limited to a 100-box daily quota, however, since the port could handle only 2,500 boxes of scup a day. Crews with over 100 boxes gave the remainder to other boats to make up their quotas¹.

Drift gill netting

A fleet of about 12 sea skiffs used drift gill nets to catch scup. Crews had to fish at night because scup would not gill themselves by day. Nightly catches ranged from 5 to 50 boxes per sea skiff¹.

Since 1920, otter trawling had been illegal in the bay (McCay, 1984), and in 1948 bay scup fishing with purse seines and also drift gill netting, as noted, were declared illegal (Backus, 1955). Fishermen asked New Jersey authorities to make these methods legal and establish a daily catch limit on each boat, but the law was not changed. Nevertheless, fishermen continued to pursue the fishery while dodging wardens¹.

In 1963 the fishery ended because scup became scarce¹. It will be recalled that heavy fishing of scup on the continental shelf in winter was largely responsible for their depletion.

Purse Seining for Menhaden

Purse seining for menhaden in Raritan

Bay dates from the mid-1800's when sloops, 10.5-13.7 m long, and small schooners (Table 3) caught them for reduction and canning factories in and near Port Monmouth-Belford. In the early morning darkness, the vessels sailed into the bay and nearby ocean and waited for the menhaden schools to become visible after dawn. When a vessel's crew spotted a school, it rowed two purse-seine boats, each carrying half of the net, around the school, encircling it with the net. The crew drew in the net tightly and, using scoops holding about a peck, transferred the menhaden to the vessel hold (Goode, 1880).

In 1911 the J. Howard Smith fish factory, which processed menhaden for oil and meal, began operating in Port Monmouth-Belford. In its first years, pound nets in the bay supplied most of its menhaden. The other supply source was independent purse-seine sloops, most still under sail, but some using primitive engines as power (Frye, 1978). Gradually, the factory acquired about 12 boats, 43-61 m long, with motors for seining menhaden (Fig. 16; Table 3). These boats supplied this factory and others the company owned at various sites along the Atlantic coast¹. At times during the 1950's, the seine boats were catching menhaden in the bay (DeFalco, 1967). They caught menhaden in coastal New

Jersey, New York, Connecticut, Massachusetts, and Maine. In a typical year, from the early 1930's to the 1970's, about 90 percent of the menhaden which the factory processed came from its seine boats, the remainder from pound nets in Raritan Bay¹. After 1920 purse seiners were not allowed to catch food fishes in Raritan Bay (McCay, 1981).

Gradually, the seine boats became more efficient. They converted to diesel from steam power, some newer boats had steel instead of wooden hulls and were equipped with refrigerated holds, menhaden schools were eventually spotted from small aircraft rather than from crow's nests on the vessels, and aircraft pilots directed the sets by radio. Moreover, in purse boats, engines replaced rowing and hydraulic blocks hauled in the seines (Frye, 1978).

Fishery conflicts

The first of many protests against the menhaden seiners was made in the late 1800's. Sportfishermen claimed that the seiners depleted the bay of bluefish and weakfish, and oyster planters claimed they disturbed the oyster beds by dragging their nets over them. As a result, menhaden seining was banned temporarily, at least in New York waters of the bay (*New York Times*, 30 June 1886). After that, sportfishermen voiced sporadic protests, claiming that the seiners took many sport fish (Frye, 1978). Subsequently, impartial studies showed that only trivial quantities of food fish were taken. Sportfishermen countered that removal of menhaden removed a food supply for sport fish which made them emigrate.

Restrictions and scarcity

After the early 1970's, a major problem for the menhaden fishery was increasingly restrictive laws for seining. New York and Connecticut authorities placed limits on where boats could seine, leaving many inshore waters off-limits (Frye, 1978). Since 1979, New York waters of Raritan Bay have been off-limits to menhaden seining. In addition, menhaden became scarcer (Ahrenholz et al., 1987). Seining crews believed that the use of aircraft to spot schools made



Figure 16.—Boats for purse seining menhaden at the J. Howard Smith fish factory, 1950's. Source of photograph: Monmouth County Historical Association.

their seining too efficient because far more schools were seined, leading to overfishing¹.

Purse seining by vessels owned by the J. Howard Smith fish factory, then under the name of the Seacoast Products, Inc. fish factory, ended when the factory closed in 1981 (see Processing and Marketing Menhaden section, p. 22-23). Since then, the only purse seining in the bay has been by one boat which sells menhaden to the fishermen's cooperative in Port Monmouth-Belford, which in turn sells them to tackle shops as bait.

Bait Fisheries

Bait fisheries were most active along the south shore of Staten Island and around Highlands¹, and date from at least as early as the 1890's (*Red Bank Register*, 15 October 1890). Sportfishermen in the bay have used sandworms, bloodworms, nemertean tapeworms, shrimp, and mummichogs for bait. During the warmer months, the fishery to

supply these was active, and in the 1920's and 1930's it supported at least 100 commercial fishermen¹.

Fishermen obtained the baits in intertidal and shallow zones of the bay. Sandworms were most abundant in the sloping part of the intertidal zone between the cordgrass, *Spartina alterniflora*, and the flat. Each fisherman dug as many as 1,200 sandworms on a low tide, using a four-tine garden fork. Fishermen found tapeworms on the flats and in shallow areas, mostly associated with soft clams, and dug them with stone forks having 10 or 11 tines. They seined shrimp and mummichogs along shallow shorelines. Mummichogs were caught with wire pots similar to eel pots and also baited with soft clams. Fishermen sold the baits to boat liveries and tackle shops¹.

In the 1940's, the worms became much scarcer and commercial worm digging ended. The worms have remained scarce. In the 1980's the only commercial bait fishing was for mummichogs on a small

scale. Sportfishermen still bought worms, but they were imported from New England.

Marketing Practices for Food Fish

The principal market for Raritan Bay fish and shellfish was Fulton Market in Manhattan, New York City (Fig. 1). By water, Port Monmouth-Belford was only 33 km away. The fish and shellfish shipped there daily from the bay were the freshest the market received. In 1831, Fulton Market was first established as an independent market. In the 1820's some dealers had sold fish and others sold produce along Fulton Street in lower Manhattan.

Early landings data for food fish from the bay are rare. In the 1890's the annual catch of shad in Raritan Bay was about 50,000 fish. In 1896, 61 percent were taken in pound nets, 36 percent in stake nets, 2.3 percent in haul seines, and 0.7 percent in fyke nets (Stevenson, 1899).



Figure 17.—Freight boat, which transported food fish daily from Port Monmouth-Belford to Fulton Market, is being loaded as it crosses Raritan Bay. The boats adjacent to it are pound net boats, 1920's. Source of photograph: K. A. Norton.

In 1910, the average catch of food fish for each of the bay's 50 pound nets was 157,500 pounds, for a total of about 8 million pounds for the year. The fish were sold to commission merchants for an average of 3.5 cents a pound during the year (*Red Bank Register*, 8 March 1911).

In 1988, landings data for the ten pound nets in the bay show that fewer food fish were available. The average catch per pound net was 48,450 pounds of food fish, for a total of 484,500 pounds. The average catch per pound net for menhaden was 89,000 pounds, for a total of 890,000 pounds².

²G. LoVerde, Statistics Branch, NMFS, NOAA, Point Pleasant, NJ 08742. Personal commun.

Shad, Bluefish, Weakfish, and Others

From at least the late 1800's to the late 1930's, about 90 percent of the food fish caught by commercial fishermen in the bay was shipped to Fulton Market on freight boats which left from Port Monmouth-Belford. Before 1900 the fish were transported on sloops in spring and fall and on a passenger-freight steamer in summer. Beginning just after 1900, two motorized freight boats delivered the fish during the entire season¹.

Fishermen brought their fish to Port Monmouth-Belford and packed them in boxes on the motorized freight boats. These boats left Port Monmouth-Belford

around 9:30 a.m. to arrive in Fulton Market before noon. Any late fishing boats transferred their catches in the crossing (Fig. 17). Commission merchants in the market took out 12.5 percent of the sale price as payment for handling the fish, paid the boat operator for freighting out of the sale money, and mailed the remainder to the fishermen. In the late 1930's, the last remaining freight boat lost its business when trucks took over the freighting of fish from Port Monmouth-Belford to Fulton Market and other points¹.

Often on Mondays, when pound-net crews had extra-large loads of food fish (not having lifted on Sunday), they carried the fish in their pound boats directly



Figure 18.—Pound net boat unloading food fish at Port Monmouth-Belford. Fish peddlers with horses and wagons on the dock wait to purchase the fish. Ice cakes at right had been obtained from nearby ponds in winter, around 1900. Source of photograph: K. A. Norton.

to Fulton Market to avoid the freight charge. Such a round trip took about 5 hours.

At least as early as the 1880's, fishermen sold the remaining 10 percent of the food fish they caught to local peddlers (Fig. 18) and markets. In the 1920's and 1930's three peddlers sold fish in southwestern Staten Island, while Port Monmouth-Belford had seven to ten, and others sold in Perth Amboy and Keyport. Each bought 200-300 pounds of fish a day, put them on ice in his vehicle and sold them along regular routes, house to house. Before the 1930's, most peddlers delivered in horse-drawn covered wagons, and thereafter they used automobiles and trucks. In the early 1970's fish peddling ended¹.

From the 1950's onward, commercial fishermen lost some markets for blue-

fish because sportfishermen were catching and selling large quantities of them, saturating markets and depressing prices. Commercial fishermen felt this competition was unfair because they had relied on bluefish sales for part of their livelihood¹.

Eels

From the 1800's through the 1930's, most eels were shipped live on freight boats to Fulton Market. The remainder were sold locally, fresh or smoked after being gutted and skinned. In the past few decades, the demand for eels in the U.S. has been weak, but in some foreign countries it is strong. Five large buyers of eels along the U.S. Atlantic Coast airfreight nearly all the eels, including some from Raritan Bay, live to markets in Europe and Japan.

Scup

It will be recalled that from the late 1940's through the early 1960's, fishermen landed substantial quantities of scup in Port Monmouth-Belford. They were shipped by trailer trucks to wholesalers in New York City, Philadelphia, and Hampton, Va.¹

Sturgeon

Each year, from at least the early 1900's and through the 1960's, one or two fishermen in Port Monmouth-Belford prepared caviar from the eggs of sturgeon, caught mostly in pound nets, and sold it in New York City. The fishermen caught some sturgeon themselves and bought some from others. In the 1950's, two or three roe sturgeon were caught per week, some 30 to 40 during the



Figure 19.—Menhaden fish factory in Port Monmouth-Belford. Bags of dried fish scrap and barrels of fish oil are visible, 1890's. Source of photograph: K. A. Norton.

season, which peaked in April and May. They yielded a total of about 300 pounds of caviar. Carcasses of the sturgeon were shipped to Fulton Market where they were sold as steaks¹.

The Fishermen's Cooperative in Port Monmouth-Belford

In 1953, the fishermen of Port Monmouth-Belford established a cooperative to sell their fish. Facilities at the cooperative include ice machines, ice storage units, fork lifts, box assembly machines, and also a retail fish market which sells only whole fish. Before the cooperative, all fish had been shipped to commission merchants at Fulton Market or other points on consignment. The cooperative has insisted, however, that wholesalers in New York City, Philadelphia, Baltimore, and Washington, D.C., and other localities quote prices of fish before shipment. By selling to those who offer the highest prices, it has provided fishermen with more income. Another advantage of the cooperative has been that fishermen's supplies, such as nets, can be purchased

in bulk quantities more cheaply. However, a fishermen's cost is involved in selling through the cooperative, as 15 percent of the sale price of fish is deducted for paying operating expenses.

Processing and Marketing Menhaden

Before 1850, menhaden were used only as fertilizer and as bait to catch Atlantic mackerel, *Scomber scombrus*, and cod, *Gadus morhua*, in the ocean (Goode, 1880). Probably in the 1850's or 1860's, extraction of oil from menhaden in factories began (Bayles, 1887). Farmers continued to buy menhaden for fertilizer, but as meal which remained after the oil was extracted and the bodies dried. In the 1870's, four companies in Port Monmouth-Belford built factories to can menhaden for human consumption. The product was similar to canned sardines, but the fish were larger (Goode, 1880). The canning companies operated only a few years, but they were immediately replaced by menhaden reduction factories. Around 1900, Port Monmouth-

Belford had three small menhaden reduction factories (Fig. 19) and Atlantic Highlands had one¹.

Early methods of oil extraction by the factories consisted of three steps: 1) Menhaden were boiled in a cooking vessel which held about 50 bushels, the oil floated to its surface and was scooped by hand into barrels, 2) the remaining oil in the fish was squeezed out in a press, similar to an apple press (Goode and Clarke, 1887), and 3) the oil and gurry water were run into vats; when the oil floated to the surface, it was scooped into barrels also³. A thousand menhaden yielded 5-5.5 gallons of oil (*Red Bank Register*, 27 August 1890). Each factory processed about 35,000 menhaden a day (Frye, 1978). Factories dried the fish scrap remaining from the extraction on wooden platforms and sold it to farmers.

As noted, the J. Howard Smith fish fac-

³Murphy, M.H. N.d. Unpublished manuscript, in 27 chapters, chronicling the life memories of the author, in custody of Barbara Eigenrauch, Red Bank, N.J.

tory for processing menhaden was constructed in Port Monmouth-Belford in 1911. This factory bought one of the small reduction factories and soon the others went out of business. From then on, the menhaden fishery and processing by this factory constituted the largest fishery in the bay, replacing oystering. In years of average menhaden abundance, the factory processed about 200 million fish, and in exceptional years, 350-400 million fish. With a processing capacity of 5 million fish daily, the factory was the largest menhaden reduction factory in the United States (Frye, 1978).

Menhaden yielded more oil in some years than others, probably as their plankton diet varied. The factory used an improved oil removal process that was better than what the small factories had used, and it obtained 12-18 gallons/thousand fish. The yield of scrap was 350 dry tons/million fish. The oil was used in the manufacture of cosmetics, linoleum, paint, and soap, and in leather tanning and steel tempering¹. In the 1870's and 1880's, some of the oil produced by the small factories had been sold as cod liver oil (*Red Bank Register*, 28 March 1883). From the 1930's to the 1970's, the J. Howard Smith fish factory sold most of its scrap to poultry growers as a feed supplement¹.

From the late 1800's until 1981, pound-net fishermen sold nearly all their menhaden to the reduction factories. Annually, the pound nets supplied the J. Howard Smith fish factory with 20-40 million menhaden. In 1911, the factory paid pound-net fishermen \$0.12½-0.15 a bushel for them; it sold oil for \$0.40 a gallon and fish scrap for \$36 a ton (*Red Bank Register*, 3 May 1911). In the 1920's and 1930's, the factory paid about \$0.20 a bushel for menhaden, gradually increasing until the 1960's when it paid about \$0.60 a bushel¹ (Table 4).

In the late 1800's, pound-net fishermen also sold menhaden to crews on fishing smacks for use as bait. The crews of a fleet of about 80 smacks, whose port was near Fulton Market, caught bluefish and cod in the ocean using hand lines. Each day, they obtained about 500 bushels of menhaden from the pound nets (*Red Bank Register*, 2 July 1890). In the early

1900's, they paid about \$0.25 a bushel for them, or about twice as much as fishermen were receiving from reduction factories and farmers (*Red Bank Register*, 7 June 1911).

In addition, from the late 1800's to about 1950, pound-net fishermen sold menhaden to lobstermen for baiting their pots. Each morning, the crews of lobster boats waited at several pound nets on the way to their pots to purchase about 5 bushels of menhaden each when the nets were lifted¹.

In the 1980's, pound-net fishermen sold nearly all their menhaden to the fish cooperative, which in turn sold them to tackle shops for sale as bait. The fishermen received about \$4 a bushel for them. In 1988 and 1989, lobstermen again bought some for bait, however, because flounder frames, the preferred bait, had become scarce. Both markets were limited, and pound netters often removed only the quantity of menhaden from their pound nets that they could sell.

Odor From Fish Factories

From the mid-1800's to 1981 the odor emanating from the menhaden reduction factories was a prominent feature of living near Raritan Bay in New Jersey, from mid-April to early November. When farming and fishing were the principal occupations in the area, residents rarely objected to it. As other people moved to the area in substantial numbers beginning in the 1950's, however, many complained about the odor to local health authorities and politicians¹.

Closure of Fish Factory

In 1981 the Seacoast Products, Inc., fish factory closed permanently, because: 1) Demand for menhaden oil had declined (soybean oil was cheaper and took over much of the market), 2) operations were more expensive on the Atlantic coast than in the Gulf of Mexico¹, and 3) according to Ahrenholz et al. (1987), heavy fishing by Atlantic coast fleets reduced the numbers of menhaden available.

Fish Prices

Until about 1940, fish prices were relatively stable, but afterwards they

Table 6.—Number of sportfishing trips by 2-month sampling periods for three eastern United States estuaries in 1979 (Smith et al., 1983).

Dates	Narragansett Bay	Hudson/Raritan Estuary	Delaware Bay
March-April	16,686	277,155	14,938
May-June	194,713	175,059	326,747
July-Aug.	493,692	1,281,711	183,325
Sept.-Oct.	62,652	135,763	399,746
Nov.-Dec.	2,333	124,600	5,339
Total	770,076	1,994,300	930,100
SE ¹	±288,500	±624,500	±167,000

¹Standard error of the estimate.

began to increase sharply. By 1987 most prices had increased by about an order of magnitude over those around 1940 (Table 4).

Sportfishing

The Hudson-Raritan Estuary has been one of the most important areas for sportfishing in the northeastern United States (Table 6). Its popularity is a reflection of the large human population in the vicinity and the good fishing provided. The fishes sought have been the same as those landed by commercial fishermen.

Sportfishing contrasts with commercial fishing in that the fishermen seek recreation, under pleasant conditions on the water, and most sportfishing is done on weekends rather than during the week. Anglers may justify expenses (purchases of small gear, bait, gasoline, or trip on a head (party) boat) by the value of their catch, although there are other non-monetary benefits involved.

In Raritan Bay, sportfishing was practiced as early as the 1700's, but it became substantial only after the Civil War. Large sailing boats took fishermen from such sites as Manhattan, Hoboken, Jersey City, Newark, Elizabeth, Staten Island, Perth Amboy, and Highlands to fish in the bay and nearby ocean. In the late 1880's these boats began to convert to engine power. Some converted boats were at least 60 m long and had as many as three decks; they were often crowded with fishermen (Barrett, 1985).

In the late 1800's, people hired rowboats from liveries and also used piers and beaches from which to catch fish (*New York Times*, 13 March 1892). The daily



Figure 20.—Sportfishermen at a rowboat livery in Prince's Bay on Staten Island, 1920's. Source of photograph: P. Glismann.

cost of hiring rowboats was \$1.00, and for some piers it was \$0.25, while most were free (Emmons, 1907). People fished from small sailboats also (Zeisel, 1988). The fishes caught included bluefish, croakers, eels, flounder, kingfish, scup, shad, sheepshead, spot, weakfish, and an occasional Atlantic salmon, *Salmo salar*. Usually, fishermen lured bluefish to their boats by chumming with minced menhaden (*New York Times*, 4 March 1878; 1 July 1888). They caught weakfish by trolling small spoons or sandworms hooked onto spinners (Zeisel, 1988). Two sportfishing clubs, the Excelsior and the Walton, based on Staten Island, had many active members, who stayed overnight in the clubs' buildings when they were on fishing weekends (*New York Times*, 4 March 1878; 1 July 1888).

From 1900 to the end of World War II, most sportfishing continued to be from rowboats, piers, and beaches. Several rowboat liveries, typically having about

40 rowboats each, were located in various bay ports (Fig. 20). In the 1930's, however, the bay had only three head boats, about 20 m long, and a small number of small sportfishing boats. The head boats were busy taking people out "meat fishing." Each carried about 10,000 fisherman a year, charging each \$2.00 a day. Being out of work and with little money for purchasing food, fishermen caught mostly scup in the bay in summer and red hake, *Urophycis chuss*, in the ocean in winter for food¹.

Soon after World War II, the number of sportfishermen increased sharply as people had more leisure time, the coastal population increased, and fishing equipment improved. Improvements included: 1) The fiberglass rod which replaced steel and bamboo rods, 2) an improved spool for the fishing reel, 3) stronger, more durable monofilament line to replace cotton and linen line, and 4) the aluminum or fiberglass motorboat, 5.5-6 m long, which could be transported on

trailers towed by automobiles and which replaced wooden boats, and 5) inexpensive outboard motors which replaced the labor of rowing (Fig. 21). In addition, the number of head boats increased to meet the demand. In 1949 as many as 18 head boats fished in the bay at times; they were busiest from April to October (Redfield and Walford, 1951). In the 1980's about 12 of these boats fished in the bay regularly¹.

In the 1960's, the number of pleasure boats which berthed in Raritan Bay was about 9,200: 5,800 outboard-motor and sail boats and 3,400 large inboard boats; the totals included a small number of boats in the Arthur Kill. About 6,000 of the boats were used for sportfishing. The smaller boats fished in the bay while the large inboard boats fished mainly in the ocean (DeFalco, 1967).

In 1963, the total sportfishing use of the bay was about 355,000 fisherman days, 25,000 in the New York half and 330,000 in the New Jersey half. The total in the



Figure 21.—Fiberglass boats with sportfishermen, 1980's. Photograph by the author.

New Jersey half represented a 30 percent increase over 1953 (DeFalco, 1967).

Since about 1963, when the commercial fishery for scup ended, sportfishermen have landed more food fish than commercial fishermen, at least in years when summer flounder have been abundant. Probably, the quantity of menhaden landed by commercial fishermen, however, still exceeds the quantity of food fish landed by sportfishermen. In the 1970's and 1980's, beginning in March and April and continuing all summer and into fall, the number of people sportfishing exceeded 1,000 per day on weekends during good weather. The most important fishing period, by far, was July-August, followed by September-October, and then March-April (Table 1). Summer flounder, winter flounder, and bluefish, in that order, were the fishes caught in the largest numbers (Smith et al., 1983; Fig. 22). In the 1960's, black sea bass, *Centropristis striata*; kingfish, northern puffer, *Sphoeroides maculatus*; scup, striped bass, tautog, *Tautoga onitis*; and weakfish were commonly caught also (DeFalco, 1967).

Current Problems for Sportfishermen

The problems for sportfishermen were listed and assessed by Barrett (1985) as:

1) Pollution, 2) lack of access, and 3) competition from commercial fishing.

Pollution

Fish caught in some tributaries near the bay have body burdens of PCB's. For this reason, in 1976 the New York State Department of Environmental Conservation issued a ban on eating certain fishes caught in New York waters. The sale of striped bass and eels from the Hudson River, Upper New York Bay, Newark Bay, tidal portions of the Passaic and Hackensack Rivers, Kill Van Kull, and Arthur Kill was banned also. In the late 1980's the ban remained in effect.

In the 1980's, New Jersey authorities issued an advisory, for the same reason, on eating large bluefish (at least 6 pounds or 24 inches), striped bass, white catfish, *Ictalurus catus*; and white perch, *Morone americana*, caught in Raritan Bay. People were advised to limit consumption of the fishes (Ruppel and Sarner, 1988).

Lack of access

Real estate on the bayshore has increased steadily in value. As a result, since 1960 some marinas and public docks previously used for sportfishing and more than 12 small ramps for launching boats in and near the bay have been lost to land filling and bulkheads, hous-

ing development, and commercial building. Thus, access to the bay for trailered boats has become less available and more expensive. Some head boats have had to relocate to less desirable docking sites.

Commercial fishing competition

At times, sportfishermen find that the numbers of fish available are too small. They believe that if commercial catches were controlled, larger numbers would remain for them.

Ecological Impact of Sportfishermen

Sportfishermen using small boats add to the pollution of estuaries. The pollution consists of: 1) Sanitary wastes, 2) solid wastes (cans, bottles, paper, and plastic), and 3) petroleum products (unburned fuel and lubricants) (Jensen, 1978).

Shellfisheries

Most likely, in the early 1800's shellfishing consisted of tonging and dredging oysters by hand and gathering hard clams in wading depths and soft clams in intertidal zones with metal rakes. Probably, lobstering existed at that time also. Sometime after the mid-1800's, improved gears for gathering hard clams and soft clams were developed, and lobstering

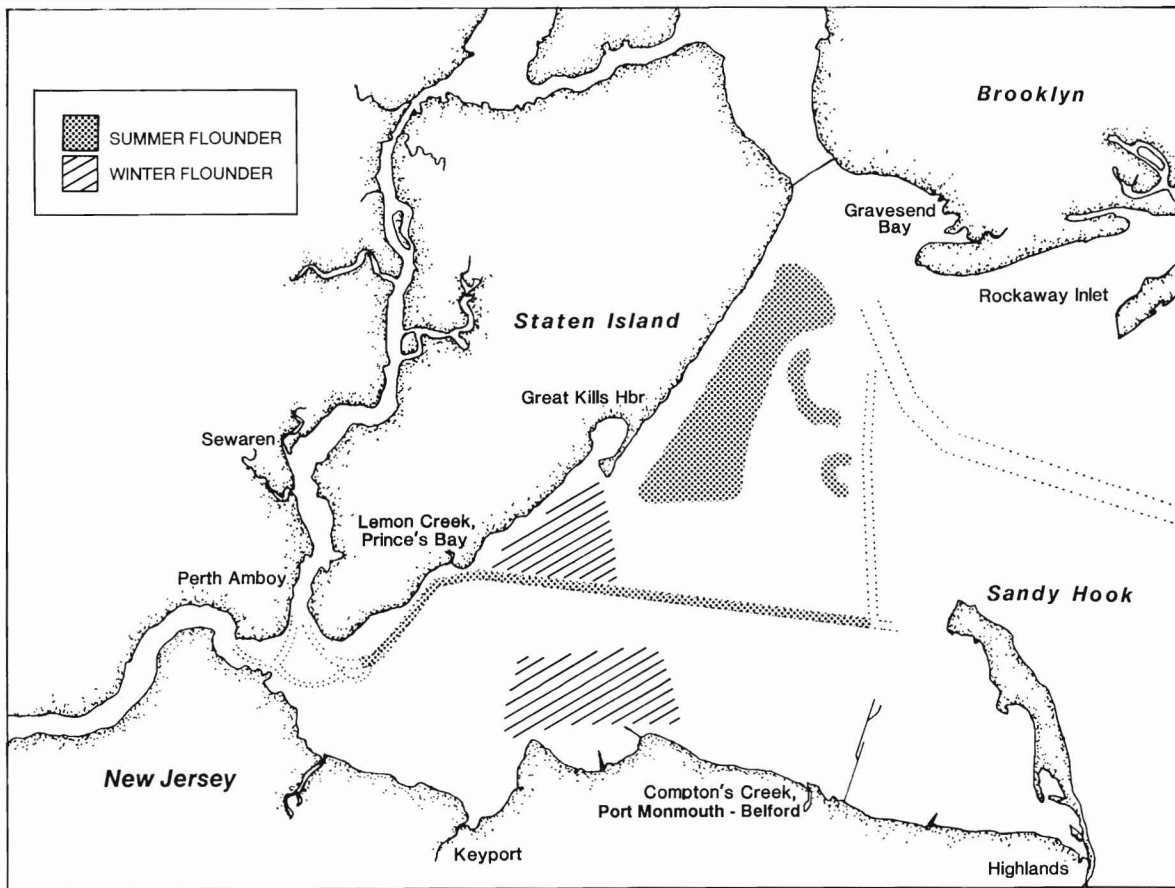


Figure 22.—Principal areas for catching summer flounder and winter flounder. Both fishes are distributed over larger areas of the bay in certain times of the year. Source: Fishermen interviews.

and blue crab dredging were documented.

The Shellfishing Ports

The ports used for oystering were in the western part of the bay. In 1834, oystering was the largest industry in Perth Amboy (Gordon, 1973). Hard clamming was practiced from all bay ports. Port Monmouth-Belford was the most important one for hand raking. The sail dredging fleet was based mainly at Keyport and Port Monmouth-Belford, but also at Perth Amboy and Highlands, and the rocking-chair fleet was based mainly at Port Monmouth-Belford. The principal port for soft clamming was Highlands (Fig. 23), but soft clamming was practiced from Keyport to Port Monmouth-Belford also. Lobstering was practiced

from all ports. Until the 1920's the port for blue crabbing was Keyport and, since then, Port Monmouth-Belford.

Oystering

The industrial oyster fishery lasted from about 1825 to 1925. It was the largest fishery in the bay until perhaps 1915 when it began to decline sharply from pollution. The industry operated by importing seed oysters, mostly from Chesapeake Bay, growing them to market size on leased beds in the bay, and selling them in New York City, the midwest, far west, and Europe. Thus, it was linked to the general oyster industry along the east coast of the United States involving common sources of seed and markets. Heavily dependent on the oyster industry in the bay were boat yards, blacksmiths,

basket factories, lime kilns, freight boats, and railroads. In the 1800's, the boats used for oystering were tonging skiffs, catboats, sloops, and schooners (Ingersoll, 1881); after 1900, motorized dredge boats were used mostly (Table 3).

In the spring of 1825, a crew sailed a schooner from Virginia with the first imported seed oysters and planted them on Round Shoal (Ingersoll, 1881; Fig. 24). By the following fall, they had grown and were harvested and sold as market oysters in New York City. Other crews sailed for seed oysters from Chesapeake Bay the next year and, some years later, as many as 300,000 bushels were being imported from there and spread over leased beds every spring (Ingersoll, 1881). The seed was 5-6.4 cm long; 400-500 were in a bushel. A bushel of

seed cost \$0.35-0.45 and the charge for transporting it to Raritan Bay was an additional \$0.10 a bushel¹.

A substantial number of schooners and some sloops were employed for transplanting the seed oysters from Chesapeake Bay. A typical schooner carried about 3,000 bushels of oysters, which filled about 4 acres of bay bottom, i.e., 750 bushels an acre. The oysters were left to grow from spring to fall-winter and then marketed.

Planters also obtained seed locally. About a quarter of the seed planted on beds, in some years as much as 100,000 bushels, was from Newark Bay, the Arthur Kill, and the Raritan and Hudson Rivers. Crews sailed sloops to these areas to purchase the seed from tongers, paying them about \$0.35 a bushel (Ingersoll, 1881). Northern seed was smaller than Chesapeake seed, however, and had to be grown in the bay for 2 or 3 years before being marketed (Hall, 1894). At times, oyster plantings filled nearly all the leased beds (Ingersoll, 1881).

When the planting of seed oysters began, no system of leasing bottoms existed. A planter marked the boundaries of plots with poles and claimed the oysters within were his. Such claims were often disputed and brought to county courts to be settled. The courts awarded planters formal leases to the bottom (Ingersoll, 1881). Eventually, two areas were leased to planters; one was about 17 km long and 8 km wide off Staten Island (Ingersoll, 1881), and the other covered about 1,600 acres off Keyport (Hall, 1894; Fig. 24). Water depths in the leased areas were mostly 2.4-7.6 m. In the 1800's, the bay had many planters, and most leases were less than 10 acres.

Oysters had enemies. Oyster drills, *Urosalpinx cinerea*, and drumfish killed some, and, at times, blue mussels, *Mytilus edulis*, set on the beds, making the oysters thin by competing for food or killing them by overgrowth (Ingersoll, 1881; Lockwood, 1883). Starfish, *Asterias forbesi*, were not an important predator (Ingersoll, 1881), though, because water temperatures became too warm for them (MacKenzie, 1984).

In the 1800's, workers using tongs or rakes in skiffs harvested most market



Figure 23.—Scenes in Highlands, N.J., 1880's (then called Parkertown): a, pulling clam boat into water; b, raking hard clams; c, beach where soft clams were landed (note boats, wheelbarrow for carrying clams up beach, shucking shanty, and fishermen—vests on the fishermen were typical from the 1800's through the 1940's); d, houseboat, a type of dwelling for some clambers and eelers. Source: G. Kobbe, 1982. The New Jersey coast and pines. Walking News, Inc. P.O. Box 352, New York, NY 10013.

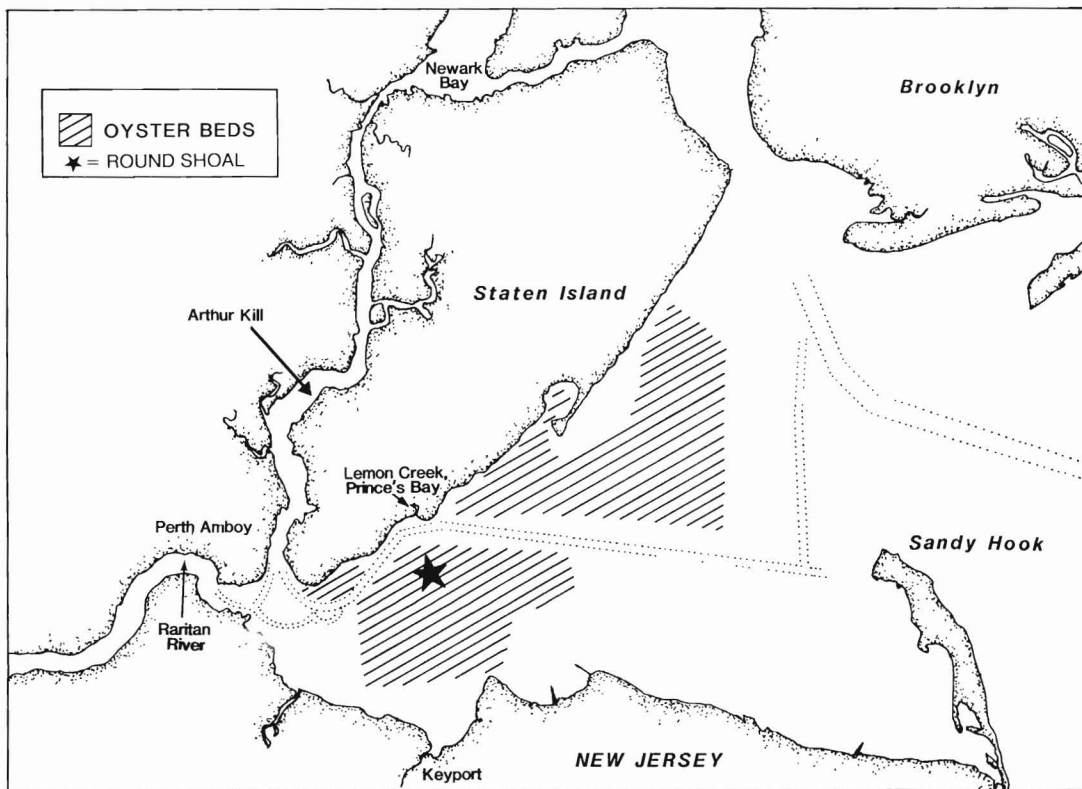


Figure 24.—Leased oyster beds, mid-1800's to early 1900's. Source: New York State Department of Environmental Conservation and fishermen interviews.

oysters from planter's beds. They transferred the oysters to sloops whose crews brought them to port. When the oysters became too scarce for these workers, sloops towed dredges, which were hand-retrieved, to harvest the remainder.

In the late 1800's and early 1900's, the ports being used and the number of oystermen in each were: Lemon Creek, about 50; Tottenville, 75 (Ingersoll, 1881); Perth Amboy (Figs. 25, 26), 220 (Hall, 1894); and Keyport, 250 (*Red Bank Register*, 23 December 1914).

Soon after 1900, the harvesting of oysters became more efficient. Planters installed motors, motorized winches, and dredges, which held about 8 bushels, in their sloops. These dredge boats harvested the oysters then (Fig. 25). In another change, the larger planters acquired most of the leases and combined them into large leases, enabling the dredge boats to harvest more easily. The oyster beds were divided into 18 holdings of which only five were under 10 acres; the others ranged from 18 to 328 acres



Figure 25.—Unloading oysters from a dredge boat onto scows, Keyport, about 1910. Source of photograph: Keyport Historical Society, Steamboat Dock Museum.

(McCay, 1984). Yet another change was in the source of seed oysters. Most came from Connecticut, while the remainder came from Chesapeake Bay and local

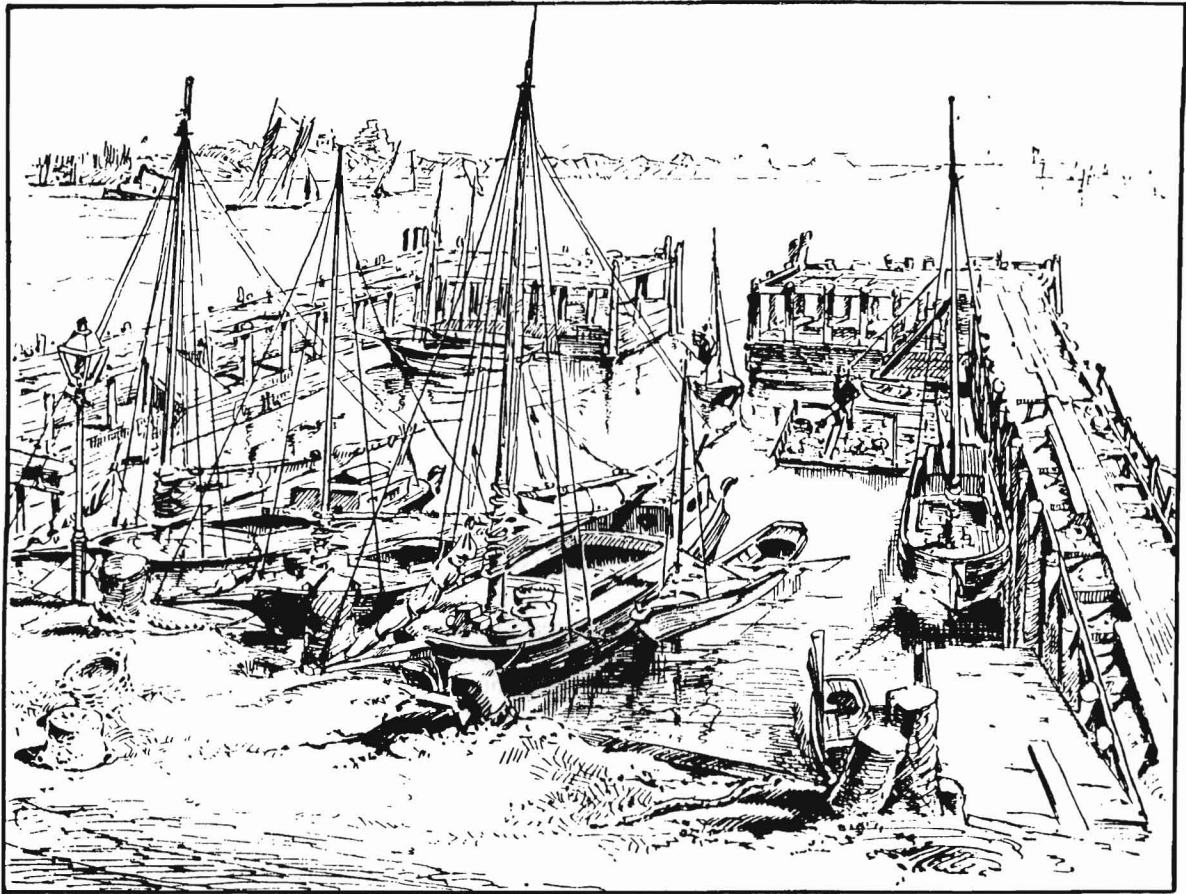


Figure 26.—At top is an oyster compound with oyster sloops, tonging skiffs, and floats in Perth Amboy, N.J., 1870's (Ingersoll, 1881). At bottom is the same location and time of year, now used for storing pleasure boats, 1985. Photograph by the author.

areas (*Red Bank Register*, 23 December 1914).

Biological Effects of Oyster Plantings

Undoubtedly, the extensive plantings of oysters in the 1800's and early 1900's had an effect on the remaining fauna in the bay. Oyster clusters projected 5-10 cm above the bottom, and thus the surface area for settling organisms was substantially increased by their presence. Moreover, the new substrate being shell, rather than sand or silt, provided habitat for encrusting invertebrates. Oysters provided cover for hard clams, crabs, polychaetes, and others. More fish are attracted to oyster beds than to otherwise barren bottoms (MacKenzie, 1981), and thus the oyster beds in the bay may have attracted fish. Oysters removed much phytoplankton from the water also.

Factors Detrimental to Oystering

Shipping channels

In the 1890's, the Raritan Bay channel, which runs east and west, was dug through the bay (Fig. 2). It went through some oyster beds but spared most as it went inshore of Round Shoal and then offshore avoiding other beds before it aimed toward Perth Amboy. Some channel dredging in the western end of the bay, however, eliminated good oyster beds.

Early lack of navigation buoys

In 1872, the bay had only eight navigational aids to mark channels, and, as a result, captains not familiar with the bay ran vessels aground on shallow beds and destroyed some oysters frequently (Ingersoll, 1881). By 1896, the Federal Government had installed additional buoys in the bay to mark the channels⁴, and the problem was eliminated.

Competition for bottom with hard clammers

In the 1800's and early 1900's, hard

clammers complained that bottoms with clams were being leased to oyster planters. Clammers were given permission by the courts to remove clams from leased oyster beds, with the proviso that they leave the oysters there. However, this resulted in many infractions and court cases as late as 1919 (*Red Bank Register*, 24 September 1919). Authorities did not lease most of New Jersey's bottom, retaining it for clammers, though much of it was good for growing oysters (Hall, 1894).

Lemon Creek shoaling

A small number of oyster sloops and skiffs moored in this port. They delivered oysters to houses in the creek where they were packed for shipment to New York City and Europe. By the 1890's, Lemon Creek had shoaled to such an extent that sloops could no longer reach the packing houses. Moreover, in storms, oystermen had to move them to the Arthur Kill for shelter. The U.S. Government dredged the creek in 1896 and 1902, but by 1912 it had shoaled to its original condition, and access to it was difficult again⁵.

Pollution

In the 1890's, the creeks used for "drinking" oysters (holding them in brackish water for cleansing and absorbing brackish water—see later section, Marketing Shellfish: Oysters) in the western part of the bay and the Arthur Kill began to become contaminated with human pathogens. In 1895, the first report of human illness attributed to eating local oysters was issued. The oysters had been held overnight in a creek on Staten Island. Thereafter, the creek was condemned as a site for "drinking" oysters (*The Staten Islander*, 16 March 1895).

After 1915, the oyster industry declined steadily as newspapers reported human illnesses from typhoid fever, especially in Chicago, traced to Raritan Bay oysters. By 1925, the negative publicity had forced planters to abandon the oyster industry permanently.

Hard Clamming

Hard clamming was an important fishery in the bay from the 1860s to 1961, when pollution nearly ended it. In 1863, hand raking for hard clams from boats in areas beyond wading depths began when George Eldridge, of Highlands, constructed a rake with a long handle (Leonard, 1923).

Ingersoll (1887) reported that in the 1880's hard clams were gathered by: 1) Treading, 2) short handle raking in wading depths, 3) hand raking from small boats, and 4) sail dredging from sloops. Thus, in a span of less than 20 years after Eldridge constructed his rake, hand raking had become a regular practice, and a new method, sail dredging, which involved use of ropes to tow modified hand rakes, had been developed. After 1900 the major implements used for hard clamming were: 1) The hand rake, 2) the sail dredge, and 3) the rocking-chair dredge.

Hand raking

Hand rakes were about 75 cm wide and had about 30 teeth and an adjustable wooden handle about 7 m long. Burlap bags or onion sacks were used to hold the clams. Fishermen raked from bateaux, oyster tonging skiffs, and, at times, sea skiffs (Table 3).

Hand rakers dug hard clams where waters were 3-6 m deep in the sediment transition zone (between sand in shallower water and mud in deeper water) and where sail dredgers and rocking-chair dredgers did not work (Fig. 3). Hand rakers worked mainly from spring through fall. In 5-6 hours on the water, each could gather 6-10 bushels of hard clams, a mixture of littlenecks (small), cherrystones (medium), and chowders (large)¹.

In the mid-1920's, when the oyster industry was closed by pollution, New York authorities had prohibited all further clam fishing in its half of the bay because they feared that the hard clams and soft clams were polluted also. At the time, only about 12 fishermen hand raked in New Jersey, because: 1) The supply of hard clams was relatively small, 2) jobs ashore were plentiful, and 3) some former hard clammers worked as rum

⁴R. Anderson, U.S. Coast Guard, Governors Island, N.Y. Personal commun.

⁵Powell, H. 1976. Prince's Bay, Lemon Creek and the oyster industry. Staten Isl. Inst. Arts Sci., St. George, Staten Isl. Unpubl. manuscr., 30 p.

runners.

In the economically-depressed 1930's, however, hard clamming became much more important. In 1930 or 1931, seed hard clams had set abundantly in many large areas, and because little work was available ashore then, the number of hand rakers in New Jersey increased sharply to gather them. Taking these clams, though smaller than littlenecks, was not prohibited by New Jersey statutes. At times, the number of bateaux and sea skiffs with fishermen hand raking hard clams reached nearly 700¹. Some sea skiffs carried as many as three rakers. The total number of fishermen hard and soft clamming was estimated to be about 1,000 (*Red Bank Register*, 3 October 1935).

To collect seed hard clams, fishermen put screens in their rakes and each gathered several bushels, and at times as many as 12 bushels, a day. Most were sold to leaseholders in Chincoteague Bay, Maryland and Virginia, and Barnegat Bay, N.J., for rebedding and additional growth, for \$1.00-1.50 a bushel. In winter, many were sold also to coal truckers from Pennsylvania, who returned with the clams for sale to retail outlets¹. From 1933 to 1938, hard clam landings rose about twelvefold as a result of the abundant set and a large raking effort (Fiedler et al., 1934; Fiedler, 1940).

In the late 1930's, Staten Island fishermen persuaded New York authorities to reopen the clam beds there, when it was shown that the hard clams were actually not polluted. From 30 to 100 fishermen from Lemon Creek and Great Kills Harbor hand raked annually off Staten Island from then until 1961¹.

Sail dredging

Sail dredging for hard clams is believed to have been unique to Raritan Bay. It involved the use of sail power to pull dredges through clam beds. Fishermen sail dredged mostly from spring through fall, but continued into winter when blue crabs were scarce¹.

The "dredges" used were actually rakes similar in design to, but about four teeth wider than, hand rakes. Each had a stout wooden handle about 1.5 m long and was towed by an 18 mm diameter rope (Fig. 27).



Figure 27.—Sail dredging for hard clams, 1940's. Most sloops towed four dredges (top). Source of photograph: Monmouth County Historical Association. Fisherman holding clam "dredge" (bottom). Source of Photograph: W. Thompsen.

The boats used for sail dredging were sloops, catboats, and small schooners (Table 3). The number of boats in the fleet from 1915 to 1925, the earliest period for which a figure is available, was about 40; after that, it declined, and in the 1950's and early 1960's, when about half of the fleet had converted to rocking-chair dredging, it consisted of about 14 boats¹.

The sail dredgers worked in 6-9 m of water in the middle and southeastern areas of the bay, where the bottom is mud and hard clammers using other gear did not work (Fig. 3). The boats were positioned crossways to the wind and most towed four dredges along their windward side (Fig. 27). Most boats were manned by a captain and a mate, the remainder by one man. In two-man boats, each fisherman hand-pulled two of the four dredges, alternating one with the other. A typical drift was about 1.7 km long and lasted about an hour, but on small beds drifts were much shorter. Depending on wind conditions, sail dredgers worked as long as 8 hours a day. Each boat gathered from 10 to 30 bushels of hard clams a day, the highest reported total being 53 bushels¹.

Rocking-chair dredging

In 1946, Willie Alexander, a fisherman of Belford, purchased a rocking-chair dredge from Rhode Island, where this type dredge was being used and, with a motorized sloop, began gathering hard clams with it in Raritan Bay. The dredge has a large backboard (Fig. 28), and, as it is towed, the teeth move up and down in the bottom in a rocking motion, hence the name. Within a few months, more fishermen obtained these dredges, and by 1950 about 20 boats were using them for gathering hard clams (Table 3). Each was manned by a captain and two deckhands. Fishermen liked rocking-chair dredging because it required only light labor, and wages were good¹.

The dredging area for this gear was in the north-central part of the bay, where the bottom is mud-sand and where hard clammers using other gear could not work (Fig. 3). Fishermen could dredge only from November through February when the clams were dormant. During the warmer months, when the clams were open and pumping, the dredging forced



Figure 28.—A rocking chair dredge for hard clams, 1988. Photograph by the author.

mud and sand into them and thus they were not marketable. From July into October, these fishermen caught scup¹.

Boats with rocking-chair dredges could gather as many as 60 bushels of hard clams a day. The fishermen agreed among themselves, however, to limit catches to about 40 bushels a day as a conservation measure¹.

Conflict with state regulation

After a few years, New Jersey and New York authorities ruled that use of rocking-chair dredges was illegal in the bay. Nevertheless, the fishermen continued to dredge, mostly at night to avoid wardens¹.

Other hard clamming methods

Some hard clams were gathered with tongs and short-handle rakes, and, in

summer, by barefoot treaders. Tongers and short-handle rakers could gather 3-9 bushels a day; treaders, two to three bushels a day. The treaders included women and school-age boys¹.

Biological effects of hard clamming

When fishermen dug hard clams with hand rakes, they lifted some polychaetes and other invertebrates out of the bottom. Fishes, such as summer flounder, followed the rakes and fed on the invertebrates. As a consequence, sportfishermen caught more fish near the rakers¹.

Factors Affecting Hard Clamming

Shipping channels maintenance

Much of the bottom alongside the shipping channels consists of sand. Hard

clams occurred there, but the bottom was too firm for sail dredgers to gather them. Whenever mud was removed from the channels by dredging by the COE, some of it spilled and accumulated on the bottom alongside. The mud forced the hard clams to ascend through it to reach water. Sail dredgers found that they could gather commercial quantities of hard clams, which were then partially in mud, alongside the channels for at least a week after the maintenance dredging had ended¹.

Installation of U.S. Navy pier

In 1942-43, the U.S. Navy constructed a 5 km pier off Leonardo (Fig. 2). The piles for the pier were driven 24 hours a day for an 8-month period. The resulting vibrations made hard clams in sand bottoms move partially out of the bottom, and, as a consequence, sail dredgers gathered clams in areas where they could not before. The effect was manifested within about 3.5 km of the pier. The pier went across a clam bed, however, eliminating it from the fishery¹.

Passenger ships

From the 1880's to the early 1940's, passenger ships ran between Manhattan and Atlantic Highlands four or five times a day in summer. Travelling at high speeds, they produced large waves which were a stability problem for hard clambers. Hand rakers had to be careful how they held the handles of their rakes, and sail dredgers had to lower their sails and secure the gaffs and booms each time the ships passed; otherwise, the rake handles and boats' riggings could be broken¹.

Pollution

As noted, in the mid-1920's, New York authorities prohibited further clam fishing in their half of the bay because they feared that the clams were polluted. In the late 1930's, local fishermen persuaded the state authorities to reopen the beds for marketing hard clams, using evidence from a bacteriologist who found that the clams had coliform counts below minimum standards. The beds remained open until 1961, when the authorities had to close them again because they had become polluted.

Before 1942, nearly the entire New

Jersey portion of the bay was open to hand raking and sail dredging for hard clams. After that date, however, the history of hard clamming was one of decreasing area open as pollution spread (DeFalco, 1967). In 1942, authorities closed about 60 percent of the hard clamming area because the water was rated as polluted. Gradually, pollution worsened, and by 1960 the entire bay was closed, except for about two-thirds of its eastern end. In 1960-61 many people contracted infectious hepatitis from eating hard clams from the bay, forcing a total closure of hard clamming and soft clamming on 1 May 1961. Thereafter until the early 1970's, authorities opened small areas temporarily, and a small number of hand rakers and sail dredgers gathered hard clams.

Since the early 1970's, the entire bay has been closed to direct marketing of hard clams and soft clams, but New York and New Jersey authorities have allowed fishermen to gather and sell polluted hard clams under the condition that they be depurated before being sold to the public. From 1979 to 1983, a depuration plant for hard clams operated in Great Kills Harbor, and from 1983 to mid-1988 a similar plant for hard clams operated in Highlands. From 15 to 20 fishermen dug hard clams daily for each plant. The plant in Great Kills Harbor closed because it was unprofitable; state authorities closed the Highlands plant for failing to follow their prescribed procedures.

Beginning in 1983 New Jersey authorities allowed fishermen to gather hard clams from the eastern end of the bay for transplanting to unpolluted leases in Barnegat Bay, N.J., where they had to remain for at least 30 days before being sold to the public. About 15 fishermen were involved in the relaying, which continued on a limited basis in the late 1980's. In 1988 and 1989, New York authorities allowed fishermen to dig and relay hard clams from the New York half of the bay to Peconic Bay, Long Island, N.Y., where they were held for at least 21 days for depuration and then marketed. On most days, 50-100 fishermen were digging; each dug 10-15 bushels a day and received about half the eventual market price for them. In 1989 they dug 55,639 bushels of hard clams in Raritan Bay.

Soft Clamming

During the 1800's and until the 1940's, soft clamming was an unimportant fishery around Staten Island, but it had importance in the New Jersey half of the bay. Soft clamming was practiced mostly in fall, winter, and spring from Keyport to Atlantic Highlands and throughout the year in Highlands, where most of the clams were dug. Each year, from the early 1900's through the 1930's, as many as 315 people in Highlands were engaged in soft clamming, mostly as diggers and shuckers¹. During and after the 1940's, the soft clams became scarcer and, by then, some of the beds had become polluted; by the 1960's all had to be closed because they were polluted.

Ingersoll (1887) described the soft-clam fishery in Raritan Bay in the 1880's as follows. Soft clams were dug along the New Jersey shore from the Raritan River to Sandy Hook in the colder months of the year (Fig. 1). Strong northwesterly winds, combined with full moons, produced extra low tides and exposed wide flats bearing the clams. At these times, hundreds of men and boys dug clams as fast as they could before the tide rose. Fishermen brought the clams home where they, their children, and wives opened them and packed the meats in quart jars. Afterwards, the clams were peddled locally for \$0.12½ a quart. Some clambers picked discarded oysters from shell piles in Keyport and peddled them with the clams.

After 1900, four gears were used for soft clamming: 1) The drag, 2) the churning hoe, 3) the fork, and 4) motor-driven propellers. Undoubtedly, the first three types were used in the 1800's also.

Dragging

The drag was used on the intertidal flats from Keyport and Port Monmouth-Belford. It had four tines, 12.5-20 cm long, and a handle about 25 cm long (Fig. 29). The fishermen made bags from discarded pockets of pound nets and also used bushel baskets to hold the clams¹.

The number of diggers varied according to the tide. Many dug when extreme low tides left large areas of the flats bare, making offshore areas available where soft clams had higher abundance, but

few dug when the tides fell less than normally¹. In the early 1900's, the bare flats off Port Monmouth-Belford were about 300 m wide on a normal low tide and as much as 1.6 km wide on a "blow-

out" tide (*Red Bank Register*, 28 February 1912). Economic conditions affected the number of diggers also. For example, in the prosperous 1920's, each town had only five or six diggers, whereas in

the economically-depressed 1930's, the comparable number often reached 60¹.

The fishermen turned over the sediment with their drags and picked out the clams. Each dug 2-3 bushels of soft clams a day. On extreme low tides, if the clams were at least 7.5 cm long and abundant, however, a good fisherman could dig as many as 5-6 bushels a day. Along the off-shore edges of the flats, fishermen got some hard clams also¹.

Churning

Highlands did not have intertidal flats. Except for small soft clamming areas along narrow shorelines, all others were subtidal. The gear used for gathering clams was the churning hoe and the scap net (Fig. 30) or rake. The hoe had a metal blade which measured about 10 × 20 cm; its handle was about 1.8 m long. In the late 1800's and continuing through the 1930's, many fishermen churned soft clams from bateaux in water about 1.2-1.5 m deep (Table 3). Usually, one man was in a bateau but sometimes two. Fishermen worked their hoes a few inches into the bottom and then moved them rapidly up and down, mixing the sand and clams into the water as they stepped slowly backward, digging a "drill." The clams, being less dense than sand, settled on the sand and then were gathered with scap nets or rakes. Fishermen termed this practice "long-rigging." The quantity of clams gathered per bateau was as much as 12 bushels a day. The number of bateaux used for long-rigging varied with the economic conditions; when times were poor, the number was highest, as many as 50¹.

Fishermen gathered soft clams by "shoal-water clamming" also, i.e., churning the clams while wading in water at low tide. Fishermen churned as they stepped slowly backward. Usually, fishermen worked in pairs. One of the pair churned and the other, sometimes the fisherman's wife, gathered the clams with a scap net and put them in a floating basket; after the 1920's, usually the baskets were set in an inflated tire tube. Where clams were abundant, each pair could gather as much as 12 bushels a day also¹. In the late 1970's and most of the 1980's, clams continued to be gathered

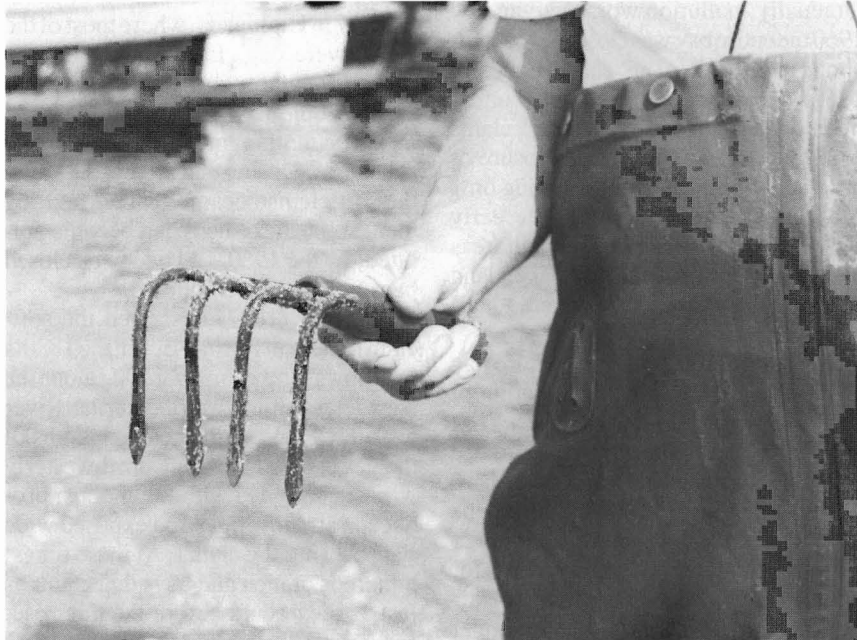


Figure 29.—Gathering soft clams. A drag (top) photographed by the author. Fishermen digging clams with drags at Leonardo, 1950's (bottom). Source of Photograph: J. Seminski.

by shoal-water clamming by fishermen from Highlands in the Navesink and Shrewsbury Rivers.

When ice formed on the bay in unusually cold winters, fishermen churned soft clams through slits they cut in the ice. They carried the clams ashore on sleds or discarded mattress springs, using a horse to tow them, or they put the clams in a bateau with runners attached and pushed it over the ice¹.

Forking

As noted, the taking of mollusks in Staten Island waters was forbidden by New York authorities from about 1925 through most of the 1930's. Nevertheless, in the 1930's, when people lacked sufficient food, they often dug soft clams for home consumption using four-tine garden forks. Wardens overlooked the state rule because people were not becoming ill from eating them, probably because the clams were cooked¹.

Washing out soft clams with boat propellers

In the 1920's and the 1940's, some Highlands fishermen used motor-driven propellers to gather soft clams. Where the water was 60-90 cm deep over the clam beds, fishermen anchored their boats at the stern, started their engines and swung them back and forth, washing out much larger quantities of clams than they had with churning hoes. They gathered the clams with scap nets. Use of boat propellers for soft clamming was not permitted by New Jersey authorities because they feared the clams would become depleted. Nevertheless, by dodging wardens, fishermen used them intermittently in each decade¹.

Factors Affecting Soft Clamming

Pollution

Similarly to hard clamming, the history of soft clamming in the 20th century was one of steadily declining areas open for digging as pollution spread and authorities had to close beds. In 1923, small beds in the eastern part of the bay near Highlands were closed by New Jersey authorities for soft clamming because they were



Figure 30.—A fisherman holds a churning hoe and a scap net, 1988. Photograph by the author.

polluted. In 1932 the authorities closed the flats from Keyport to Atlantic Highlands between the shore and 400 m offshore also for the same reason (State of New Jersey, Department of Public Health Reports). This should have eliminated the intertidal digging of soft clams, but the regulation was not enforced because it was recognized that local people needed the clams for food¹. In 1948, the authorities shortened the distance to 300 m (State of New Jersey, Department of Public Health Report). In the 1950's, soft clamming continued on a reduced scale in the bay, but in 1961 it ended.

In 1977, a depuration plant for soft clams opened in Highlands. New Jersey authorities allowed fishermen to gather soft clams in the Navesink and Shrewsbury Rivers for processing in this and two other Highlands plants, which opened subsequently, before they could be sold. In 1988, the three plants were closed.

Loss of eelgrass

As noted, the loss of eelgrass in the bay in the 1930's, resulting from disease and subsequent turbidity, led to a huge decline in abundance of soft clams.

The warm summer of 1948

The summer of 1948 was extremely warm, raising water temperatures too high in many areas of the bay for soft clams. Nearly all soft clams died except those at the mouths of small creeks where the water was cooler. No clamming was practiced by Highlands fishermen from 1948 to 1950, when the beds began to restock naturally¹.

Lobstering

The earliest report of commercial lobster fishing in Raritan Bay was in 1853 (Rathbun, 1887). This fishery has continued to the present time.

The type of lobster pot used in the bay is the same as used elsewhere in eastern North America, i.e., about 1 m long, made of tarred wooden lath; most are shaped like a half barrel, but some are square. In the 1800's, the pot had an exterior net funnel at each end and was open in between. From the 1920's until the 1960's, the pot had an exterior net funnel at one end only. It also had another funnel in its interior which divided it into two equal-size compartments, the "kitchen"

where fisherman put the bait and the "parlor." In the 1960's, the fishermen switched the end funnel to the side of the kitchen¹. Fishermen kept bricks, iron sash weights, or concrete in pots to stabilize them on the bottom. In recent years, use of plastic-coated wire pots has increased. In 1985, a Federal law was passed which made it mandatory for lobstermen to have a hatch, 44 × 152 mm, in pots for undersized lobsters to escape.

In the 1800's, the type of boat used for lobstering was the catboat. From the early 1900's to the mid-1940's, lobstermen used the sea skiff and, since then, the Nova Scotia style boat¹ (Table 3). In the 1920's and 1930's, the number of lobster boats from each port was about as follows: Two from Great Kills Harbor, one from Lemon Creek, six from Keyport, ten from Port Monmouth-Belford, and 20-25 from Highlands. From world War II to the early 1960's, however, only about three boats potted lobsters in the bay because lobstermen had switched to fishing for scup which was more profitable¹.

In the early 1960's, when the fishery for scup ended and hard clamming was curtailed substantially, many fishermen went back to lobstering. The number of lobster boats increased to nearly 30 and has remained at about that number¹. In 1989, the number of boats from Great Kills Harbor was two, from Port Monmouth-Belford, about 21, and from Highlands, six (Table 5). Fishermen concentrated their potting effort in the nearby ocean.

During most of this century, New York and New Jersey have had a law requiring that lobsters below a certain size be released. Nevertheless, before the early 1980's, lobstermen illegally sold all the undersized lobsters, termed shorts, which they caught, enforcement being rare. At times, about 90 percent of the lobsters landed were shorts; a typical daily catch for a boat was about 50 dozen. Fishermen claimed they would not have earned sufficient money lobstering had they not sold them¹. Ever since, the states and Federal Government have enforced the laws prohibiting the taking of shorts, however, and the practice ended. In the late 1980's, New Jersey, in

concert with other states, raised the minimum carapace length of lobsters, by annual increments of 1/8 inch each year. In 1989 the minimum length was 3 3/16 inches.

Lobstering methods

Lobstermen had always used menhaden for baiting their pots, but in the 1950's they began using fish frames (the skeletons of filleted fish, mostly flounder). In the late 1980's, lobstermen mixed menhaden with fish frames as their bait. Infrequently, red hake, cunner, *Tautoglabrus adspersus*, and tautog caught in the lobster pots were used as bait also¹.

From the 1800's to the mid-1940's, lobstermen used longlines and tied 30-35 pots to each. The ends of each line were anchored and marked with a wooden buoy or bamboo flag. The lines were laid out end to end and left in the same place during the entire season. In the bay, lobstermen placed pot lines near the edges of shipping channels, principally Raritan Bay Channel (Fig. 4), and, later, also in borrow pits constructed in the 1960's from sand mining. Lobstermen were not allowed to set pots in the channels because the lines could entangle the propellers of passing vessels. Most lobstermen had about 150 pots, and, if weather permitted and lobsters were abundant, they lifted them 7 days a week. When lobsters were relatively scarce, however, pots were lifted every other day. A few fishermen had about 280 pots and lifted half each day, alternating one group with the other¹.

In May and June, most lobstermen set their pots in the bay and then shifted them out to the ocean where catches were higher. Some moved their pots to the ocean then anyway because in the bay they became heavily fouled with algae and bryozoans in summer¹.

Lobstermen hauled their pot lines over a roller at the bow of the boat by hand. In the bay, where the water was only 4.5-6 m deep, the work was not difficult. In the ocean where the water was 18-30 m deep, however, the work was laborious¹.

When catches were highest, usually from mid-July through October, lobstermen averaged about one keeper lobster per pot in their 150 pots and landed

perhaps 175 pounds of lobsters a day. Before the late 1930's, lobstermen did not immobilize the claws of the lobsters. From then until the 1950's, they used wooden plugs and, since then, heavy rubber bands to do this, to prevent the lobsters from damaging each other and make them easier to handle. In the sea skiff, keeper lobsters were held in a flow-through water well and shorts in a bur-lap bag. In the Nova Scotia style boat, lobsters have been kept in barrels and iced¹.

Improved equipment

Beginning in the mid-1930's, fishermen began gradually to use improved equipment, which made lobstering easier and enabled each boat crew to handle many more pots and eventually double its catches. These improvements included: 1) The motorized winch in the mid-1930's, 2) the Nova Scotia style boat in the mid-1940's, 3) the hydraulic hoist in the early 1970's, 4) mesh bags in the mid-1970's, and 5) loran in the late 1970's¹.

Introduction of the motorized winch on boats constituted a major development because it made the lifting of pots much easier and faster, allowing lobstermen to increase the number of pots set (Fig. 31). After that, most lobstermen have fished exclusively in the ocean, lifting as many as 300 pots a day. Initially, each lobsterman had 600 pots and lifted half each day. When lobstermen switched to the Nova Scotia style boat from the sea skiff, they abandoned the practice of anchoring pot lines. They reduced the number of pots on a line to 25, stacked these on their boat after lifting them and then reset them. After several years, they went to a schedule of 3-day lifting with about 900 pots¹.

In the mid-1970's, they converted to using mesh bags from heavy copper wires for holding the bait. In the ocean, bait in the bags remains good for 4 days, in contrast to 3 days when the wires were used. Then fishermen were able to go to a system of 4-day lifting with about 1,200 pots. When lobsters were relatively abundant, daily catches were about 300 lobsters or 360 pounds. After adopting the 4-day system, fishermen became more prosperous even when they could not land

shorts any more¹. The introduction of loran as a navigational aid helped lobstermen find their pot lines in the ocean more efficiently. Before that, they ran a compass course and timed their boat run from Sandy Hook to the lines¹.

Factors Affecting Lobstering

Shipping channels

It will be recalled that nearly all lobsters in the bay have been caught along the edges of the dredged channels or in the borrow pits. Thus, construction of the channels and pits may have aided lobstering by creating additional habitat and concentrating the lobsters.

Pot losses

In a typical year, lobstermen lose about 10 percent of their pots, but annual losses range from none to 30 percent. Nearly all losses have been from vessel traffic which snags the pot buoys; the remainder are from storms¹.

Effective management

Despite the increase in effort by fishermen, stocks of lobsters do not appear to have declined. Undoubtedly, this is a result of effective management by state and Federal authorities, which prevents fishermen from landing berried females and, in recent years, shorts. The minimum size of lobsters to be landed was increased also, allowing more to reproduce. In the future, stock stability should continue because shorts are not killed after entering pots, as juvenile finfishes are in otter trawls.

Blue Crabbing

Dredging

The U.S. Government fishery monographs published in the late 1800's did not mention a dredging fishery in Raritan Bay for blue crabs. The first record of this fishery was a newspaper article in 1889 (*Red Bank Register*, 4 December), which stated that many Keyport sloops were in the southeastern part of the bay crabbing. The fishery has remained active ever since.

Blue crab dredging has never been a reliable source of winter income for fish-

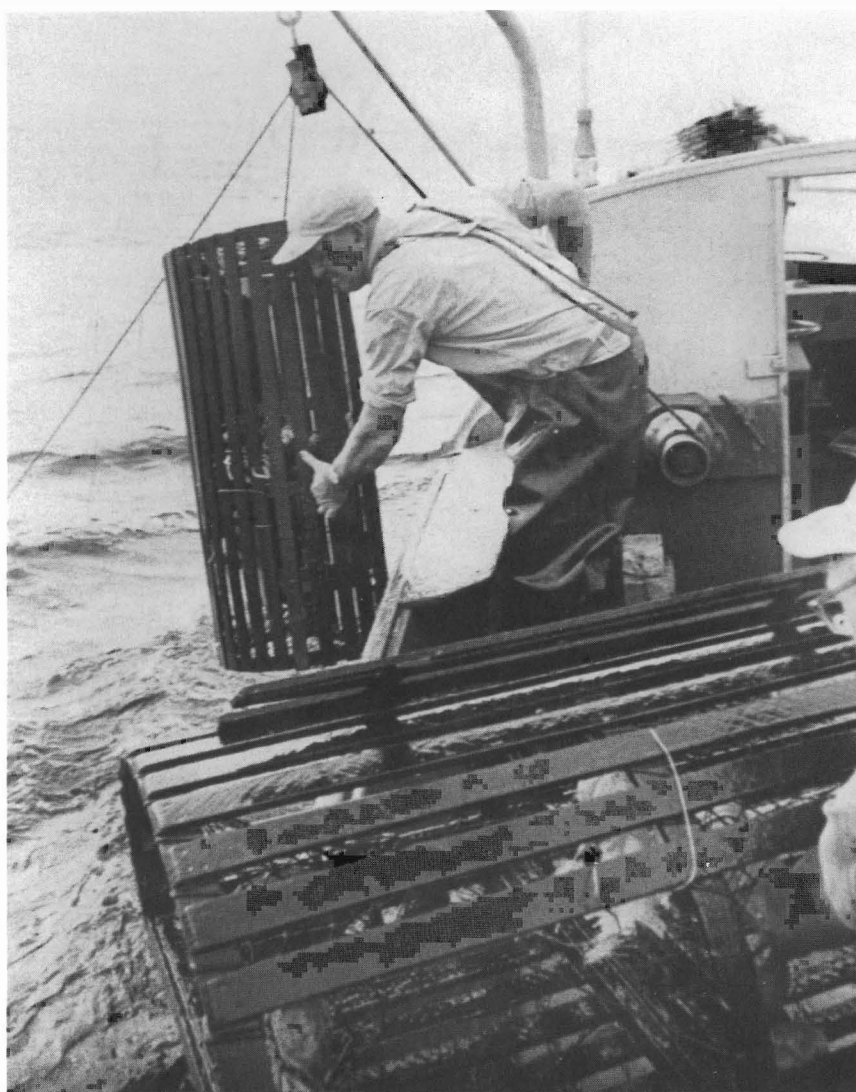


Figure 31.—A lobsterman uses a winch to lift his lobster pot in the 1950's. Source of photograph: W. Richardson.

ermen, because in some years the crabs have been scarce. In the poor years, commercial catches have lasted only 2 or 3 weeks at the beginning of a season; on the other hand, in the very best years, catches have lasted all season. Usually, the weather is suitable for dredging crabs only about 4 days a week. Moreover, in extraordinarily cold winters, an ice cover on the bay makes dredging impossible and nearly all blue crabs die¹, presumably from thermal stress.

New York has had a year-round open season for dredging blue crabs and it

allowed New Jersey fishermen to dredge blue crabs in its waters after they purchased a New York license. The legal season for dredging blue crabs in New Jersey has varied from 1 November to 15 December through 31 March (MacKenzie, 1988).

From the beginnings of the fishery to the mid-1930's, crab dredges consisted of an iron frame about 90 cm wide with a net bag holding about a bushel of material; teeth on dredges were 12-15 cm long. Boats under sail power each towed 8-12 dredges off their windward side.

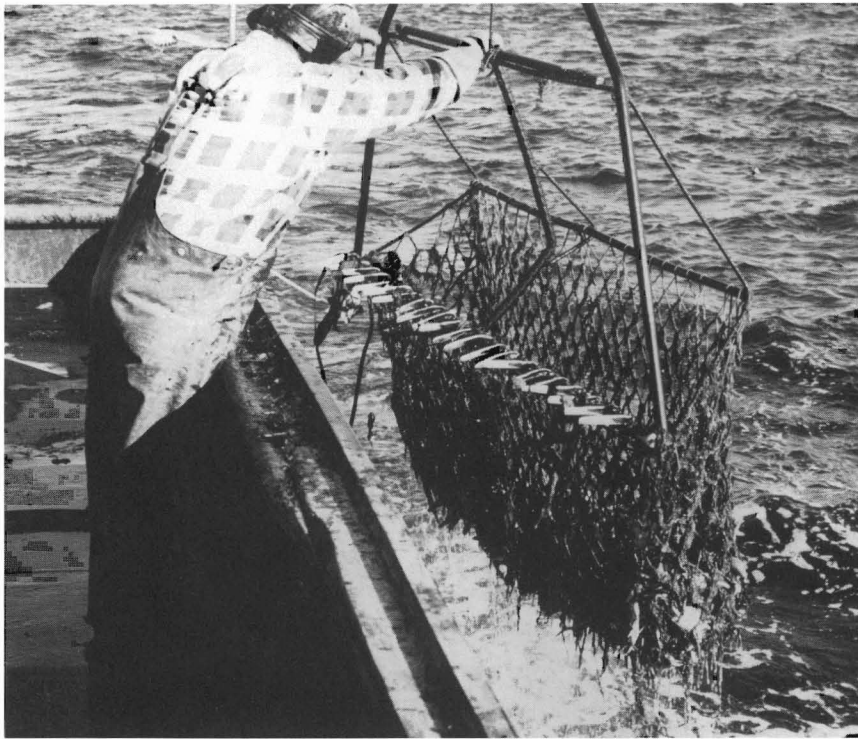


Figure 32.—A blue crab dredge is lifted onto a crab boat, 1986. Photograph by the author.

When they were converted to engine power, boats towed eight or nine dredges from both sides and the stern. Fishermen retrieved the dredges by hand¹.

After fishermen put power winches on their boats in the mid-1930's, they redesigned the dredges, making them 1.5-1.8 m wide; by New Jersey State law, their width could not exceed 75 inches (1.9 m) and their weight 110 pounds. The dredges resembled oyster dredges, except that they had teeth 12-15 cm long (Fig. 32). They held about 15 bushels. Most boats towed four dredges.

The first dredging boats were sailing sloops and schooners. Since the early 1900's, the crab boats have been engine-powered (Table 3). In the 1930's, the crab fleet consisted of about 40 boats¹. In 1950, the number of boats was 38 and in 1960, 23; they included converted sloops and one-man garveys (DeFalco, 1967). In the 1970's and 1980's, the usual number of boats crabbing in any one day ranged from 5 to 15. A captain and a mate

manned most, a single fisherman the remainder.

The bay's crab dredging fleet has always operated mostly from New Jersey ports, but in recent years, at least, about six boats from Great Kills Harbor and Brooklyn have dredged crabs in the northeastern part of the bay.

In good years in the 1920's and 1930's, typical daily catches were 20-30 bushels of crabs per boat. The highest reported catch was 150 bushels. Since then, the abundance of blue crabs has apparently fallen. In the 1970's and 1980's, typical daily catches have been 10-14 bushels¹.

In recent years, a dredge boat makes about 10 tows a day, each lasting about 20 minutes. Besides blue crabs, the dredges gather lady crabs, *Ovalipes ocellatus*; rock crabs, *Cancer irroratus*; spider crabs, *Libinia emarginata*, horseshoe crabs, windowpane flounder, *Scophthalmus aquosus*, and shells of hard clams and blue mussels, along with such debris as beer and soda cans, bottles, and

fishing line (MacKenzie, 1988). After fishermen dump the dredges on deck, the mate picks out the blue crabs and places them dorsal side upward in bushel baskets. In this position, their gills remain moist longer and thus they live longer. The mate heaps 65-80 crabs in each basket and fastens a cover over it. One to two bushels of crabs per tow have been typical. On windy or freezing days or both, he puts the crabs in the boat's hold out of the wind.

Usually, female crabs comprise 70-80 percent of the catch. Females average 15.5 cm across the widest part of the carapace and males, 16.5 cm. Wholesalers buy both sexes but prefer males because they contain more meat and, in the 1980's, they brought as much as \$10 a bushel more than females when sold separately (MacKenzie, 1988).

Potting

In various summers, fishermen put crab pots in the bay to determine whether a fishery with this gear could be developed. However, catches have been invariably too small.

Factors Affecting Blue Crabbing

Shipping channels and borrow pits

Two important locations where fishermen dredge blue crabs are the shipping channels and borrow pits. Apparently, their construction aided crabbing by concentrating the blue crabs as it did eels and lobsters.

Pollution

It is impossible to assess whether the increase in pollution in the bay has affected abundance of blue crabs, because population assessments were never made. Fishermen state that blue crabs have become scarcer¹. In the winter of 1988-89, however, catches of crabs were larger than they had been for many years. Possibly, the warmer-than-average years of 1987 and 1988 contributed to the increase in their abundance.

Beverage cans

Large quantities of discarded beer and

soda cans litter the bottom of the bay. The cans are a minor hazard to fishermen who have to sort through them when picking up the blue crabs and then shovel them overboard.

Law prohibiting blue crab dredging

In 1984 an environmental group on Staten Island petitioned for legislation which prohibited further dredging for blue crabs in Richmond County (Staten Island) waters. The group claimed that the dredging deteriorated the bottom. The effect on the fishery was that about 40 percent of the crabbing area was eliminated, and fishermen could not dredge in the bay during strong northerly winds. During such winds, New Jersey waters were too rough for dredging, but crab fishermen had been able to dredge in Richmond County waters which remained relatively calm in the lee of Staten Island.

Horseshoe Crabbing

In the 1800's and continuing into the 1930's, farmers gathered horseshoe crabs, present by the thousands, along the shores of the bay in spring. Using horses and wagons, they brought them home, where they fed them to hogs and chickens and used some for fertilizer^{1,3}. In that period, fishermen also caught horseshoe crabs in haul seines and, until the 1950's, in fyke nets for use as eel bait. In the 1940's, gathering horseshoe crabs for feed and fertilizer ended when better feeds and artificial fertilizers became available.

Marketing Shellfish

Oysters

The oyster marketing season was from September 1st through the fall and early winter. In the 1879-80 season, production of oysters from Raritan Bay was estimated at 430,000 bushels (Ingersoll, 1881). In 1897, production was 558,000 bushels from Richmond County and Monmouth County, N.J. (Townsend, 1901); most of those oysters were grown in Raritan Bay.

During the 1800's, planters spread oysters in brackish creeks after harvesting them from the beds, to "give them a

drink." They kept them there for about 18 hours, from high tide one day to low tide the next, to allow them to pump out any mud or sand forced into their mantle cavities when they were tonged or dredged and to absorb the brackish water. Their meat volume swelled by about 30 percent and became whiter and less salty to the taste. For many years, oysters were spread on the bottom of the creeks (Fig. 33), but after 1865 most were held in them in wooden floats, which measured about $2.5 \times 7 \text{ m}^5$. The next step was to shovel the oysters into bushel baskets and ship them by sloop or passenger-freight steamers to southern Manhattan and other markets, including Albany and small towns along the Hudson River. When the oysters arrived in Manhattan, they were counted and sold in lots of 1,000 (Ingersoll, 1887). If sold by volume, many of the oysters would have been worth about \$1.00 a bushel. Most oysters were shucked on oyster barges tied along wharves in Manhattan.

Planters sold small quantities of oysters in summer also. Oysters were brought to Keyport and then shipped by rail to seacoast resorts in New Jersey, where they were served raw on the half-shell (Ingersoll, 1881).

After railroads developed refrigerated cars in the 1880's and 1890's, about two-thirds of Raritan Bay oysters, as shucked meats, were transported by rail to the midwest and far west from New York City. Most of the remaining oysters were consumed in the city, many eaten on the half-shell (*Red Bank Register*, 23 December 1914).

After 1900, some of the oyster shucking was transferred to Keyport, where the J. and J. W. Elsworth Oyster Company, by far the largest planter in the bay, employed about 250 men, 140 as shuckers. By then, the practice of "drinking" oysters had ended. The Elsworth company washed the oyster meats clean of mud and shell in tanks of fresh water after it shucked them; the meats swelled by about 30 percent also. In 1914, this company produced about 200,000 gallons of oyster meats from 275,000 bushels of oysters. Most oysters were shipped in 5-gallon cans packed in ice by railroad to the midwest and far west. The company

received \$1.15-1.40 a gallon for them (*Red Bank Register*, 23 December 1914).

Hard Clams

In the early 1880's, annual production of hard clams from the bay was estimated at 150,000 bushels (Ingersoll, 1887). In 1897 hard clam landings from Richmond County (mostly Raritan Bay) were about 12,000 bushels and in 1898, 10,000 bushels (Townsend, 1901). From 1897 to 1938, hard clam landings from Monmouth County (mostly Raritan Bay) ranged from 6,026 to 141,167 bushels (Townsend, 1901; Fiedler, 1940). From 1885 to 1940, landed prices of hard clams ranged from about \$1.10 to \$1.50 a bushel (Table 4).

Before the late 1930's, hand rakers temporarily stored their daily catches of hard clams in floating wooden cars in Keyport and Port Monmouth-Belford. Every week or so, they shipped the clams on freight boats, market sloops, and passenger-freight ferries to New York City and other markets¹. The sail dredgers sold their hard clams to market sloops which sailed down to Raritan Bay from New York City about twice a week (Ingersoll, 1887). Transfers of clams from the dredging sloops to these sloops were made in the bay. After the late 1930's, trucks took over the transport of hard clams to markets, including those of the rocking-chair dredgers¹.

Soft Clams

From 1897 to 1938, soft clam landings from Monmouth County (mostly Raritan Bay) ranged from 47,850 to 121,000 bushels (Townsend, 1901; Fiedler, 1940). In 1948, landings from the bay were estimated to be about 175,000 bushels (DeFalco, 1967). From 1885 to 1940, landed prices of soft clams ranged from \$0.35 to \$2.20 a bushel (Table 4).

Most soft clams were sold in New York City or seacoast resorts in New Jersey (*Red Bank Register*, 22 April 1896). In the late 1880's, the remainder were sold as bait to cod fishermen (*Red Bank Register*, 17 October 1888) or were eaten locally¹.

In Highlands, most soft clams were shucked and then shipped as meats by train to Fulton Market. From at least as



Figure 33.—Workers are gathering oysters from a brackish creek at low tide in Keyport, about 1910. Oysters were held in such creeks for about 18 hours before being sold. Source of photograph: Keyport Historical Society, Steamboat Dock Museum.

early as the 1850's (Ingersoll, 1887) and continuing into the early 1940's, most shucking of clams was done in shanties, about 12 in number. Each employed from five to ten women shuckers. The remainder of the clams were shucked in the homes of the clammers. The unshucked soft clams were shipped to Fulton Market, seacoast resorts in New York and New Jersey, and local clambakes to be eaten as "steamers."¹

From sometime in the 1800's (Ingersoll, 1887) to the early 1940's, many fishermen brought their soft clams home for shucking and enlisted their families' help in Highlands and in the area from Keyport

to Port Monmouth-Belford. In a typical home, the fisherman and perhaps an older son opened the clams in their kitchen. Then the younger children pulled the inedible skin off each clam neck, and, finally, the fisherman's wife packed the meats in quart Mason jars (Fig. 34). The family peddled most locally and kept some for themselves. In the 1920's and 1930's, these families sold clam meats for \$0.25-0.35 a quart¹.

Lobsters

From the early 1900's through the 1950's, each fisherman had five or six wooden cars for holding his daily catches

of lobsters. The cars consisted of a tarred wooden frame and lath and were weighted by bricks, similar to pots. They measured about 90 × 90 × 45 cm. Lobstermen anchored them on the bottom near their boat moorings¹.

From the late 1800's through the 1940's, most lobsters were sold in Fulton Market. They were delivered there on freight boats and trains, and occasionally fishermen delivered them in their boats. Fishermen sold the remainder to local restaurants and clambakes. From the 1950's through the 1980's, however, increasingly larger numbers of lobsters were sold locally to supply the bayshore



Figure 34.—Preparing soft clams in a fisherman's home. The fisherman and his son are opening the clams, one daughter is removing the skin from the neck of each clam, another daughter is carrying clam meats to her mother who is putting them into quart jars, 1930's. Source: Fishermen interviews.

population which had increased substantially especially in summer¹.

In the 1920's and 1930's, each fisherman sold 15-20 dozen short lobsters a day to local fish markets for about \$1.00 a dozen and kept the remainder in wooden cars temporarily. Every week, buy boats came to New Jersey ports from Staten Island and Brooklyn to buy the shorts for which fishermen were paid \$0.50-0.75 a dozen. From the 1950's through the 1970's, shorts were sold to fish markets and incidentally to sport-fish boats which

met the lobster boats near the tip of Sandy Hook¹.

Blue Crabs

From the late 1800's through the 1930's, crews delivered their catches of blue crabs to Fulton Market in their dredge boats. Daily catches were stored in holds of the boats and were taken to the market about every 3 days¹. Since then, fishermen have landed the blue crabs in Port Monmouth-Belford for transport by

truck to fish markets and taverns as distant as Pennsylvania¹.

Recreational Shellfishing

Before the bay's hard and soft clams became generally polluted, many vacationers and some local residents dug these two clams, as a pastime, especially in July and August. As recently as 1964, New Jersey authorities sold about 700 recreational clamming licenses for digging clams in unpolluted waters around Highlands (DeFalco, 1967).

Each summer since at least the early 1900's, a popular sportfishery for blue crabs has existed in creeks and shorelines around the bay. The crabs are on pilings and along the shallows where fishermen catch them with crab nets. Moreover, since the 1950's, some sportfishermen have caught lobsters by using scuba gear around the riprap of two lighthouses in the bay¹.

Status of Fisheries in the 1980's

In the 1980's, only Compton's Creek in Port Monmouth-Belford and Highlands remained as commercial fishing ports in Raritan Bay. During the decade, gillnet, eel, and pound-net fisheries diminished, while lobstering remained at the same status. The only fishery which grew was ocean trawling; the trawl boats used Port Monmouth-Belford as their port (Table 5).

In 1980, Port Monmouth-Belford had two commercial fishery organizations operating. One was the fishermen's cooperative which had 120 members and employed six full- and part-time dock personnel. The other organization was the Seacoast Products, Inc. fish factory which was serviced by from four to seven menhaden seine boats averaging about 53 m long. The menhaden fishery supported 68-120 fishermen (Caruso, 1982).

During the decade, the fishermen's cooperative remained active, but, at times, was stressed for lack of fish. And the port was and always has been unattractive and utilitarian¹. Buildings bordering on Compton's Creek belonging to independent fishermen were run down, docks were disheveled, roads to the docks were rutted, and one fish buyer used several tractor-trailer bodies as its base of operations. This port's appearance contrasted with the pleasant-looking fishing ports in most of New England.

In the 1980's, the property of the Seacoast Products, Inc. fish factory was purchased by a real estate developer who, in the early 1990's, plans to remove the factory buildings and construct luxury townhouses there in addition to a breakwater and a 1,000-slip marina in the bay. The development will change the port from being exclusively for commercial

fishing and somewhat private from outsiders, to one which includes upscale housing and expensive pleasure boats. Though the developer does not wish to interfere with the commercial fishermen, efforts by the new residents to make the area pretty, quiet, and odor-free, and also purchase some of the fishing boats for pleasure, may impinge on the commercial fisheries.

In 1980, the two dominant commercial fisheries in Highlands were soft clamming and lobstering, with smaller ones being gill netting and eeling. The port supported 117 full- and part-time fishermen along with 20 workers in two soft clam depuration plants and four lobster pounds (Caruso, 1982). By 1988, the two soft clam plants were closed, perhaps temporarily, because soft clams were scarce in the Navesink and Shrewsbury Rivers and problems arose with New Jersey authorities from inadequate depuration procedures. The number of lobster pounds declined to two (three were operating in 1989), and three of the port's lobster boats had been transferred to Port Monmouth-Belford (Table 5).

In Highlands, severe competition for waterfront space developed between commercial fishermen and pleasure and sportfishing boaters, and also between commercial fishermen and owners of restaurants, bars, and residential housing. The town tried to resolve the conflicts by zoning the waterfront for commercial fisheries, but the zoning decree was ignored and all ensuing development was restaurant construction. Moreover, the restaurants took over some commercial docks to provide moorings for their patrons with pleasure boats. No new commercial fishing docks were constructed. In addition, residents objected to odors and the early morning activities associated with fishing. Thus commercial fishermen had lost most of their docking space and were met with some hostility in the community (Caruso, 1982).

The former commercial fishing ports of Great Kills Harbor, Lemon Creek, Perth Amboy, Keyport, and Morgan were used only for pleasure sail, motor, and sportfishing boats (Fig. 26); as noted, Great Kills Harbor had two lobster boats also. Head boats used Great Kills Harbor,

Perth Amboy, Keyport, Atlantic Highlands, and Highlands as ports.

Before the 1940's commercial fishermen could catch fish and shellfish whenever and wherever they desired in the bay within liberal state-imposed limits. Wardens were present rarely, and few of the state rules were enforced stringently. Since then, commercial and sport fishermen have used much more efficient gear while the environment has deteriorated. The result has been that smaller exploitable fish and shellfish populations exist and conservation agencies have had to enforce rules to prevent depletion of stocks. Wardens, currently termed marine police, have become increasingly active. In the 1980's they boarded boats frequently to measure the lengths of flounder and lobsters to determine whether fishermen had violated regulations, and their activities also included determining whether fishermen were fishing after sunset or gathering clams in polluted waters. Violators were given tickets by the marine police and had to pay large fines. Being used to freedom of action, commercial fishermen felt harassed.

In recent years, New York and New Jersey authorities have spent increasing sums of money to administer and police their fisheries and shellfisheries. Much of the money has been obtained by making fishermen purchase licenses for commercial fishing. A negative aspect of the licensing has been that it bars boys from earning money after school or during vacations in low technology fisheries such as eeling, potting mummichogs, and soft clamming. Many of the veteran fishermen interviewed for this paper learned about fishing methods by working in these fisheries as boys when licenses were not required.

New Jersey authorities plan to support the construction of a depuration plant for hard clams in Highlands. If operated properly, it should provide employment for many clam fishermen.

Since the 1940's, articles in newspapers and magazines featuring the positive aspects of commercial fishing have not appeared as they commonly have in areas like Maine and Chesapeake Bay, where fishing is a larger component of the economy. In the 1980's, the articles

which did appear described illegal clamming in polluted beds and these downgraded the image of commercial fishing in the public's mind.

Status of the Environment, 1960's Through 1980's

In the 20th century, a major change has taken place in the use of Raritan Bay. Until the 1940's, most people around the bay derived a living by farming, fishing, and shellfishing, and were largely self-sufficient. Since then, however, the human population and industrialization have burgeoned, and the bay has been used for disposal of huge quantities of treated sewage and industrial wastes (Squires 1981, 1983). Four rivers—the Hudson, Hackensack, Passaic, and Raritan—run through and collect wastes from the surrounding area, including Greater New York City and other cities, and then flow into the bay. In 1980 the estimated annual pollutant loading to the Hudson-Raritan Estuary from all sources was: Suspended solids, 7.2×10^8 kg; oil and grease, 4.8×10^7 kg; trace metals, 5.8×10^6 kg; chlorinated hydrocarbons, 1.6×10^4 kg; and total petroleum hydrocarbons, 1.3×10^7 kg (Stanford and Young, 1988).

In addition, vessel traffic, which included container ships, garbage scows, dredges, and barges laden with sludge, acid-waste, and petroleum products, became heavy (Bennett, 1984). In the early 1980's, the various transportation endeavors ongoing in these and close-by waters provided some 35,000 jobs in the Raritan Bay-Port Newark area (Pearce, 1984). Frequently, commercial and sport fishermen had to abandon fishing and move their boats out of the way of passing vessels.

Studies of chemical pollution, in the bay were not made until the 1970's (Pearce, 1979). The concentrations of six heavy metals in sediments were elevated especially in the central muddy areas. The copper concentration in the bay water was 65 ppb (Waldhauer et al., 1978), the highest reported for any estuary.

Raritan Bay also had high concentrations of organic contaminants. At least several tons of PCB's were discharged

into the Hudson River from two General Electric capacitor-manufacturing plants on the Hudson River from 1930 to 1977 (Anonymous, 1981). Average PCB (Aroclor 1242) concentrations in bay sediments were about 0.4 ppm. Average concentrations in bay suspended matter were: PCB-1242, 0.47 ppb; and PCB-1254, 0.85 ppb. Concentrations of chlor-dane in bay sediments ranged from < 4 to 8.2 ppb, and in suspended sediments, 27 ppb. Concentrations of DDD in bay sediments ranged from < 1 to 35 ppb; in suspended matter they averaged 27 ppb. The concentration of DDT in suspended matter was 46 ppb (Olsen et al. 1984).

Nearly all samples of bay sediment that people examined were contaminated with petroleum hydrocarbons at concentrations from 26 to 3,872 ppb (Koons and Thomas, 1979). These originated from various sources, including recurrent oil spills in the 1940's, 1950's, and early 1960's.

A study of oxygen consumption of the biota, sediment, and water immediately above the sediment had values from 3.9 to 31.4 ml $O_2/m^2/h$; this elevated rate resulted from the loading of sediments with organic material (Thomas et al., 1976).

The bay had extremely high primary productivity—the annual value was about 680g $C/m^2/year$ and was considered among the highest for any estuary⁶.

Elevated concentrations of nitrogen and phosphorus made the bay highly eutrophic. Dense phytoplankton blooms, along with siltation, caused high turbidity. In 1971 Secchi disc readings ranged from only 0.8 to 2 m throughout the bay from April to September (Draxler et al., 1984). In the 1980's Secchi disc readings showed higher turbidity.

In the 1960's and 1970's, the COE granted permits to dig several sand and gravel borrow pits in the eastern part of the bay (Fig. 2). Most pits increased the original bottom depth to about 6-9 m from 3-4 m, while one pit had a depth of about 27 m.

In recent years, many proposals have been made by hydraulic engineers for

dredging and dumping in the bay. Added together, nearly one-third of the bay bottom would be altered. Most proposals have been defeated, but some people believe that the engineers should be allowed to implement them (Bennett, 1984).

In the 1980's, some effects of government actions to control pollution in the bay were evident. For instance, extensive oil slicks were seen rarely because after the early 1960's oil spillages decreased sharply. On the other hand, plastic materials, drifting, on the bottom and on shores, were widespread (Fig. 3).

Preserving the Future of Fisheries

In recent years, several Federal (National Marine Fisheries Service, Fish and Wildlife Service, and Environmental Protection Agency) and state agencies (units of the Department of Environmental Protection) and public interest groups (American Littoral Society, Clean Ocean Action, and Natural Resources Protective Association of Staten Island, Inc.) have tried to preserve living resources in Raritan Bay by preserving its environmental quality. They review proposed development projects and oppose or recommend substantial modifications in those which are likely to harm the bay.

Biological studies in the bay have been limited. In the future, biologists could aid bay fisheries by making studies to determine the specific environmental factors that control abundances of fishes and shellfishes, especially the fishes whose young stages use the bay as a nursery. Full-time bay residents needing similar study are commercial shellfish, various worms, and several small fishes used as forage by larger fishes. Studies of eelgrass and sea lettuce are also needed. If it can be shown that specific pollutants or some types of construction are harming any of these species, perhaps their effects could be lessened by controlling them and more organisms would survive. And, if the means could be found to reduce eutrophication, eelgrass might become re-established and its presence would improve the environment for fishes and soft clams as well as reduce shoreline erosion. Hard and soft clamming would be en-

⁶J. O'Reilly, Sandy Hook Laboratory, NMFS, NOAA, Highlands, NJ 07732. Personal commun.

hanced if bacterial pollution could be reduced. The knowledge required for implementing constructive environmental acts has been lacking.

Concern exists about overfishing in the bay and nearby ocean because, while abundances of many fishes have become relatively low, the demand for fishes in markets is high and commercial and sport fishing effort is substantial. Lyman (1986) believed that fishing effort needs continuous control to prevent overfishing. If fishermen could substantially reduce their catches of menhaden and scup, the two most abundant commercial fishes in the bay in the past, perhaps for a period of 5 years, their populations would rebound, no doubt, with resultant increases in future catches in Raritan Bay and other locations.

Commercial fisheries have always been laissez-faire industries, with little government help. Throughout the 20th century, other interests in the bay have ignored fishery interests and used it for their own purposes, resulting in much smaller commercial fisheries. If a public support group for fishermen had been present since the early 1900's, it might have been able to postpone the pollution of the oyster and clam beds and reduce some of the other negative effects on fisheries. Such a group needs to be established now.

Currently, an intense but largely unrecognized conflict is being waged between commercial fishermen, who wish to preserve their industry and retain their traditional way of life, and real estate interests, who wish to develop the bay's waterfront for residential and recreational uses. If fishermen lose, commercial fishing will become even smaller. The commercial fishing port in Port Monmouth-Belford would have a good chance of enduring if the appearance of its facilities could be substantially upgraded to make them compatible with the impending real estate development there. The remaining commercial facilities in Highlands might be saved if they were granted tax relief by state authorities. The media could help the fishing industry by giving some publicity to its positive aspects as a contributor to the culture, economy, and food production of the area through published articles.

Finally, the time has come for us to act on the concept that Raritan Bay remains an essential spawning, nursery, and feeding area for fishes and shellfishes, and also an important fishing area, and it should be nurtured and protected.

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