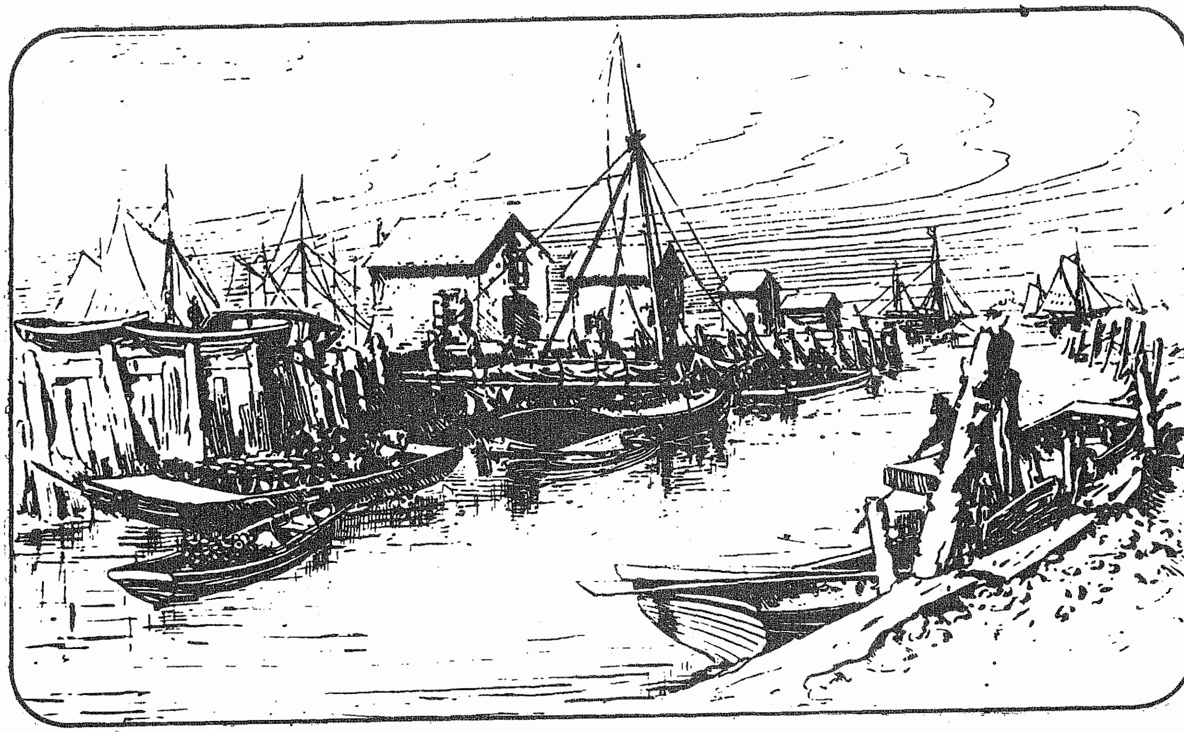
RARITAN BAY
ITS MULTIPLE USES AND ABUSES



Proceedings
of the
Walford Memorial
Convocation

1983

RARITAN BAY

ITS MULTIPLE USES AND ABUSES

PROCEEDINGS

OF THE

WALFORD MEMORIAL CONVOCATION

A Workshop Sponsored Jointly By

American Littoral Society
New Jersey Marine Sciences Consortium
National Marine Fisheries Service, Sandy Hook Laboratory
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Anthony L. Pacheco, Proceedings Editor

Sandy Hook Laboratory

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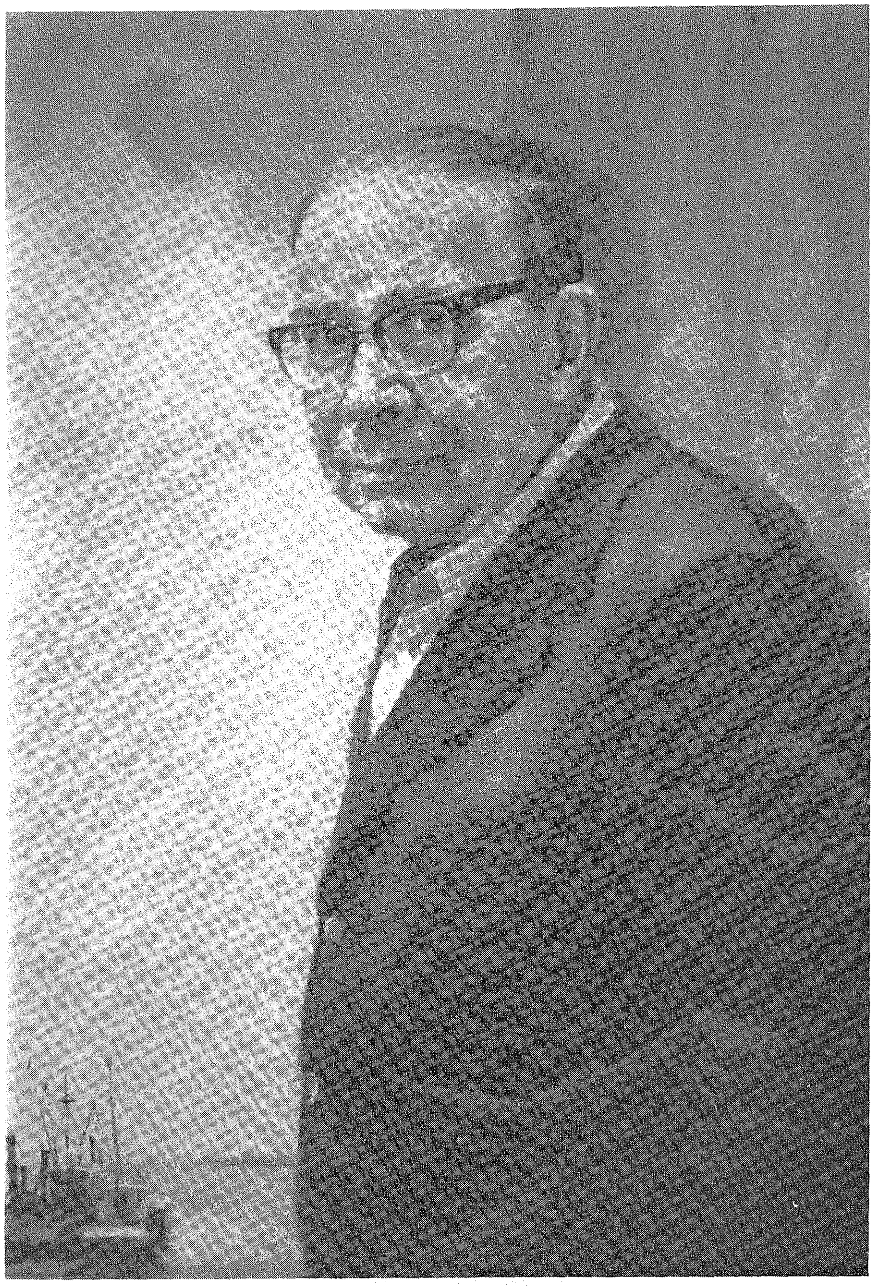
"Seriously, Roy," said Mr. Zimmer, "don't you think the water's getting cleaner?"

"Of course it isn't," said Mr. Poole. "It's getting worse and worse. Everything is getting worse everywhere. When I was young, I used to dream the time would come when we could bed oysters in the harbor again. Now I'm satisfied that that time will never come. I don't even worry about the pollution any more. My only hope, I hope they don't pollute the harbor with something a million times worse than pollution."

............From "The Bottom of the Harbor" by Joseph Mitchell.



LIONEL A. WALFORD

1905 - 1979

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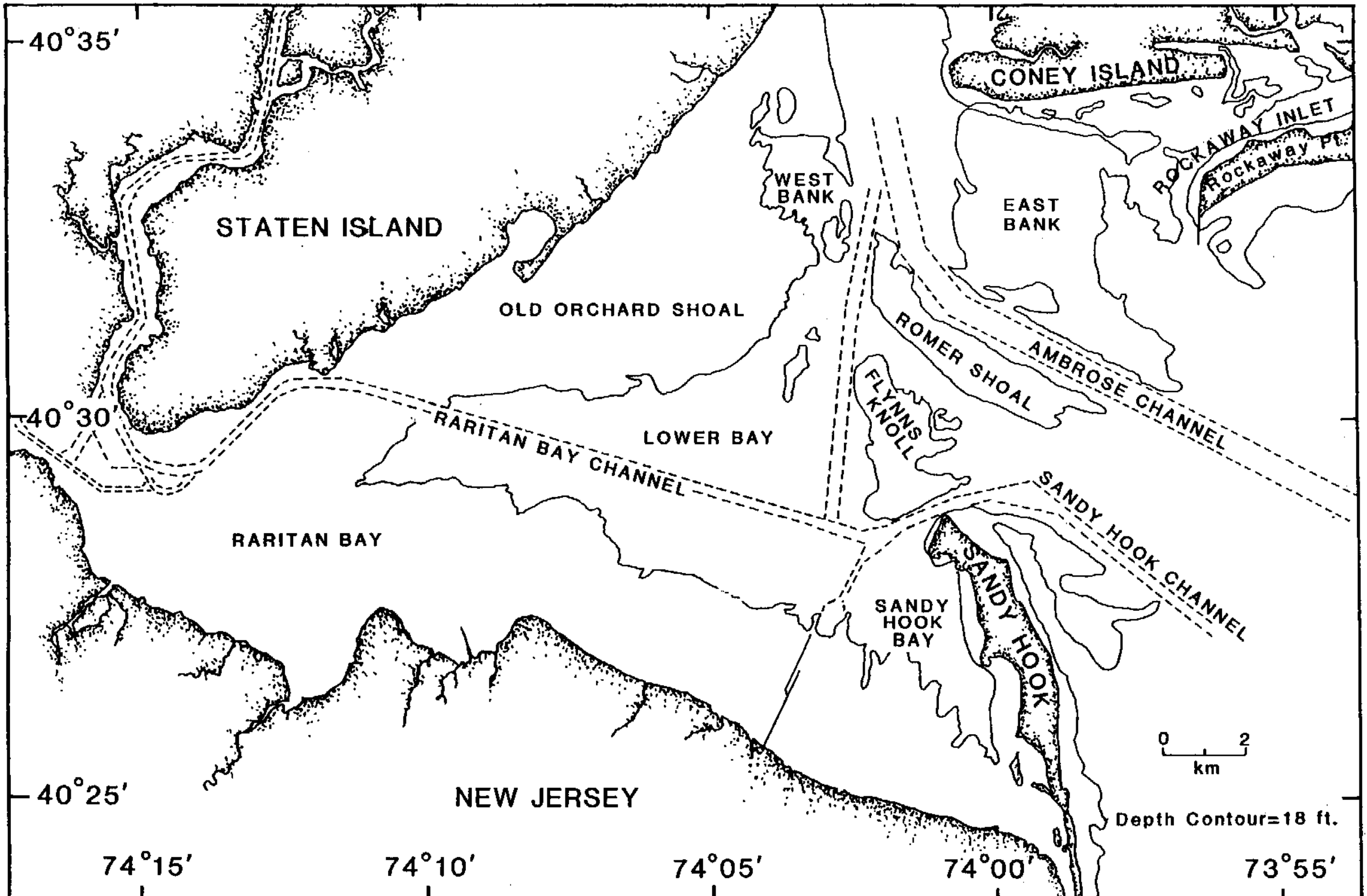
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FOREWORD

The Raritan Bay Workshop was sponsored by three institutions making up the marine science complex of Sandy Hook. Each of the institutions is involved in its unique way with maritime issues.

- The National Marine Fisheries Service is concerned with living marine resources and the possible pollution impacts on fish and shellfish stocks, as well as their habitats.

- The New Jersey Marine Sciences Consortium provides an educational program, university research support, and advisory services that broaden public awareness and interest in marine resources, commercial and recreational.

- The American Littoral Society is a non-profit organization of amateur and professional naturalists encouraging the study and conservation of marine life, particularly close to shore where productivity is concentrated. It fosters public awareness in coastal issues and needs for conservation action.

We have had in the past at Sandy Hook a number of lectures and public meetings focusing on marine science and coastal problems. To broaden the participation from all interested groups (public, private, governmental and university), it seemed reasonable to try a workshop format.

This first workshop concerned Raritan Bay...an important and abused body of water. I hope we can move on, in subsequent workshops, to other bodies of water and other issues in a continuing series honoring a man, Dr. Lionel Walford, who was instrumental in the founding of all three host institutions.

The workshop had at least two purposes--a forum for exchange of information and ideas, and preparation of a Raritan Bay volume which reflects the discussions and summarized proposed action plans.

Carl J. Sindermann
Director, Sandy Hook Laboratory

INTRODUCTION

THE RARITAN: A BIG BAD BAY IN Need OF FRIENDS[1]

D. W. Bennett
Executive Director, American Littoral Society

The sampling area this day is Raritan Bay. THe trawl goes over the stern of the research vessel Kyma, the wooden doors spread the net and soon it is dragging over the bottom of the bay.

In exactly 12 minutes (for these are scientific samples), the trawl is hauled back. Soon, as the net comes over the stern, two people lift it on to the deck and spill the contents. During the day, nine stations in the bay are sampled.

The catch--summer and winter, morning and afternoon--is always interesting and often diverse. From this first haul on a sunny but chilly May day, the catch is light. Three eels squirm toward the scuppers and a half-dozen big, slow rock crabs move away from the mass of fish.

There are 11 species worth putting into buckets, all to be counted and weighed.

Two kinds of sea robins with wings and feet.

A two-inch-long sculpin, which is called a grubby and nicknamed "Buzz Bomb." (It is like a cross between a bumblebee and a rocket, and it can spread its gill rakers, making itself unattractive for larger fish to swallow).

Almost two buckets of slimy squirrel hake or ling -- "mud-bellies" to some -- with whiskers to search the bottom for food.

A few dozen translucent windowpane flounders, as well as winter flounders, the bay's prime commercial and sports fish.

Two kinds of herring, one the true sea herring and the other an alewife, which migrates into fresh water to spawn.

A brace of horseshoe crabs.

A few pugnacious blue crabs.

A cupful of mud shrimp.

One small anchovy.

[1]A similar article by DWB appeared in the New York Times, July 10, 1983.

Also in the net are a cluster of blue mussels, some mud, a few shreds of plastic, a can or two and some sodden driftwood.

The fish are quickly weighed and counted. Some go on ice for later examination, many go back into the bay alive and a few, too bruised to survive, are tossed into the murky water to float down current until herring gulls swallow them.

The discolored water, the amount of trash in the net and the live creatures (about 100 pounds in this haul) spell out the contrasts of Raritan Bay: It is a multistressed estuarine environment, yet one full of marine life ranging from microscopic plankton to big fish that use the bay as a summering or feeding ground, a spawning area or a place to spend the winter. This contrast--a big, dirty, bountiful body of water--is what brings the _Kyma_, a vessel of the National Marine Fisheries Service, here. The bay, as polluted as it is, is still a vital habitat and the home of a thriving commercial and recreational fishery that is available to the nation's most-concentrated urban population.

The question being asked is: Can this body of water serve many functions -- sewer sump, dumping ground, harbor, sand mine and recreational area? The answer may be yes, but most of its functions are threatened, one way or another.

The Raritan Bay can be thought of as a big bad bay in need of friends. Such friends may be organizing, for the Sandy Hook laboratory of the Fisheries Service, the New Jersey Marine Sciences Consortium and the American Littoral Society have formed a Raritan Bay Workshop to start bringing together what is known of the bay and to suggest ways to protect it.

Raritan Bay is bounded on the north by Coney Island, the Verrazano-Narrows Bridge and Staten Island, among other landmarks, and on the south by New Jersey (from South Amboy on the western end to Sandy Hook at the eastern). Fresh water enters it from the Hudson and Raritan Rivers, while ocean waters come in with the tide across the Sandy Hook-Rockaway transect.

The bay is about 80 square miles of relatively shallow water with lots of shoals less than 12 feet deep. The deepest spot, 91 feet, is right near the Verrazano Bridge. The bay is cut by major shipping channels; for example, Ambrose Channel, which is dredged to 40 feet, comes into it from the ocean and leads up into New York Harbor. Sandy Hook Channel, also 40 feet deep, hugs the tip of The Hook and then runs almost due west to the southwest corner of Staten Island before bearing sharply north and up into the Arthur Kill to the refineries and ports of Carteret, Woodbridge, Elizabeth and Newark.

The channels, the fresh-water flows, the ocean water, the winds and the shorelines all make for complicated currents in the bay; in general, however, it is a sluggish counter-clockwise system with much back-and-forth movement. Fresh water entering the bay from either the Raritan or Hudson Rivers has a net movement toward the ocean of about 500 yards a day, and so it takes 16 to 21 days for the bay to flush itself. Tide range is about five feet.

The fresh-water contribution brings with it one of the world's most exotic brews of pollutants, ranging from heavy metals (mercury, cadmium and lead) to hydrocarbons from petrochemical plants and refineries, the runoff from the streets of New York and New Jersey, paper and plastic, dog feces, rubber particles from tires, and oil drippings. You name it.

Also dumped are the failed concoctions of thousands of aspiring organic chemists working on new fabrics, cures, or dyes in the industrialized waterfronts of Hudson and Middlesex Counties, to say nothing of the silt and sand that swirls down the rivers, especially during spring runoff.

Raritan Bay has been called the world's most polluted estuary. Lead and copper head the list of heavy-metal contaminants, copper registering higher than in any other estuary in the world. Hydrocarbons are about the same as in Boston Harbor and Tokyo Harbor and greater than at the entrance to San Francisco Bay.

PCB (polychlorinated biphenol, among the nastiest of organic pollutants) is found in the bay's water and sediments; it also has been found in dangerous levels in various species of fish caught in the bay--weakfish, bluefish, eels, striped bass, catfish and white perch.

Very often, scientists are not needed to prove that the water is unclean. On sampling trips into the bay, one can only be impressed by the filth encountered: logs, plastic bags, dead birds, a surface sheen of oil, an almost granular feel to the water and a murkiness that bespeaks the untreated and semitreated sewage coming from big pipes, runoff from streets, and explosion of floatables from the Great Kills landfill on Staten Island (the world's largest), a steady input of tampon inserters from overburdened sewage-treatment plants, oil from marshes and rotting algae, also from Staten Island.

The loading of nutrients into the bay from sewage--phosphates, nitrates and carbons--brings enormous blooms of microscopic floating plants (phytoplankton). Think of Raritan Bay as a rich organic stew laced with toxics, sloshing back and forth as it moves slowly to sea.

Nearly 20 million people live near, use, travel through or eliminate into Raritan Bay. In a very real way, they compete for its values. Sand miners see the bay as a rich resource to dredge for fill and other construction purposes. About 90 million cubic yards of sand were dredged between 1950 and 1975, some of it destined for the Meadowlands Race Track and parts of the New Jersey Turnpike. Miners want at least eight million yards more a year if they can get permits.

Boat traffic in and out of Raritan Bay is immense. Big tankers lighter offshore and then come in, half-loaded, to Staten Island. Other big ships hug the tip of Sandy Hook before heading due west for the Arthur Kill. Container ships steam in for Port Elizabeth and Port Newark, while garbage scows, sludge barges, dredgers and acid-waste barges go both ways. Smaller barges laden with petroleum products--gasoline, kerosene and fuel oil--head out of the harbor and up and down the coast.

All this heavy traffic needs good, predictable deep channels, so channel-dredging is a regular activity.

Smaller vessels far outnumber the larger ones, especially from April to October, for that is the prime sportsfishing season in Raritan Bay. Party and charter boats ply the waters for winter flounder, fluke, weakfish, bluefish and striped bass. Occupants of little rowboats venture out for fishing and crabbing, while the big charter boats head out of Perth Amboy, Keyport, Keansburg, Highlands, and Atlantic Highlands, going outside the bay and offshore for bigger fish.

Sailboat traffic reaches panic proportions in the summertime. In Horseshoe Cove, in behind Sandy Hook, there can be 100 sailboats and as many powerboats, all anchored and nested for simmering weekends of swimming, fishing and fantail picnics (it is a practice of the local citizenry to avoid swimming in Horseshoe Cove on Mondays or after any holiday. The garbage and sewage from the boats take a tide or two or more to slop out of the cove and into the bay proper).

Commercial fishing is big business in Raritan Bay. Lobster pots can be found as far as the Verrazano Bridge and off the eastern shore of Staten Island. Big fish traps, called pound nets, reach out from the shoreline behind Sandy Hook and along the bay's south shore. In the 1920's, there were 130 such pound nets in the bay; today, there are about a dozen, but they catch daily loads of menhaden, fluke, weakfish and flounder.

The bay teems with useful worthwhile fish and shellfish. In one sampling series in 1975-76, some 63 species of fish were collected. Killies, blueback herring, alewife, anchovy and sand lance led the list, along with American eel, shad, silver hake, silversides and fingerling striped bass. Pound nets can land 40,000 pounds of weakfish in one set, fish that can be in the Fulton Fish Market the following morning. Illegal night trawling for fluke is a money-maker for risk takers.

Shellfish in Raritan Bay are common enough to bring tears to old-time (and younger) clammers because they are as polluted as they are numerous and cannot be harvested. In the late 19th century, the nation's most valuable oyster beds were concentrated in the western bay, close to Perth Amboy, Keyport and two rivers, the Navesink and Shrewsbury, that feed Sandy Hook Bay. About 200,000 acres of the bay bottom were suitable for oyster cultivation, although far fewer were needed to provide a steady cash crop.

Today, the oyster business is dead, a victim of silt and pollution. The beds are covered with soft silt, which is unsuitable for the setting of oyster larvae, and the waters are so grossly polluted that anyone eating a raw clam or oyster from the bay challenges great odds for contracting a hideous list of infections from bacteria and viruses.

Hard clams (quahogs in New England) pave parts of the bay bottom, but they, too, are off limits. Soft clams are more creatures of the shallows; a soft-clam industry exists in Sandy Hook Bay and some rivers, but they must go to a plant for purification before they can be marketed.

Given its location near population centers and as the entrance to one of the world's great natural seaports, Raritan Bay has suffered all sorts of indignities in the name of progress. Its channels are dredged almost continuously for commerce; it is a close, cheap dumping ground for wastes and, now that the mainland is so built up, it has even become a place to try to create "new land."

A map of planned dredging or filling sites laid out in the early 1970's shows nearly a third of Raritan Bay either buried or deeply disturbed. Among the grandiose plans were:

Recap Island, an artificial island made out of municipal refuse.

A six-square-mile stretch dredged for a deepwater port.

Several thousand acres dredged for construction fill.

Hoffman and Swinburne Islands connected with spoil and refuse.

Two big landfills, one on each side of the entrance to Great Kills.

The Richmond County land extension, six miles along the eastern shore of Staten Island and a mile or more out into the bay.

More recently, the Earle Naval Ammunition Depot announced a big dredging project near its existing mile-long pier, and the Corps of Engineers would be happy to dispose of polluted dredge spoils in existing dredge holes in the bay.

Raritan Bay invites this kind of thinking--dredging, dumping and sculpting--because it is polluted, its bottom is foul, its shellfish beds are closed and it appears so devoid of hope that some believe it should be allowed to succumb to the hydraulic engineers and their new projects.

But at the same time, it harbors living riches pursued by anglers, and its broad surfaces and good summer and fall winds attract sailboats to cruise and race.

One of the jobs of the Raritan Bay Workshop--and of the two states bordering the bay--is to develop ways to permit some of the present multiple uses of its waters and discourage those one-shot consumptive uses that attract the hit-and-run speculators and short-term planners.

The last station of this sampling day is an old dredge hole about three miles due east of Great Kills Harbor on Staten Island. The hole, some 40 feet deep, is ringed with lobster pots, and scuba divers explore its edges routinely for fish and lobsters. The Corps of Engineers would like to use it to dump harbor dredgings from slips around New York and the Arthur Kill.

The Corps has theorized that this deep hole is either lifeless or unimportant, but when the net is hauled on deck--by winch this time, because it is so full--the fish tumble out in an impressive pile; hundreds of ling, a dozen or so foot-long silver hake, several species of flatfish, herring, shad, blackfish and cunner. It is the largest haul and also contains the widest variety of species.

In 12 minutes, the net has proved with emphasis that the bay lives.

On the trip back, a single common loon dives for fish near the Staten Island shoreline. While most waterfowl have left to nest in the north, they will be back by Christmas. Raritan Bay is a prime wintering area for broadbills, a handsome bay duck that sometimes rafts by the hundreds of thousands within site of the Verrazano, where just a few months later big, ripe striped bass, sturgeon and shad will move upriver to spawn.

FISH AND FISHING

CHAIRMAN

Mr. Bruce Freeman
Administrator, Marine Fisheries
New Jersey Division of Fish, Game and Wildlife
Department of Environmental Protection
Trenton, New Jersey

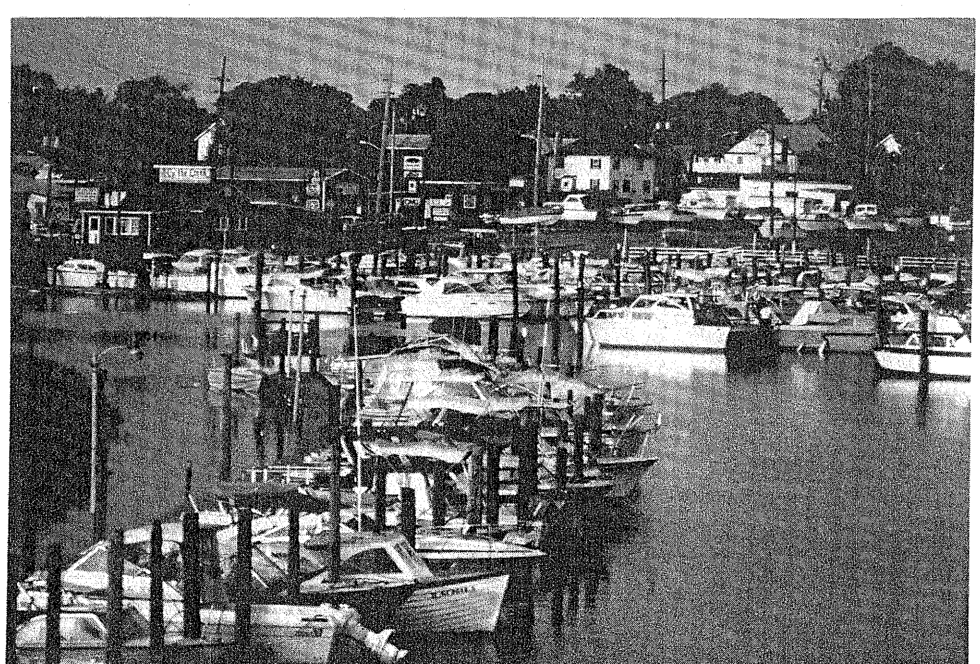
THE PANEL

Dr. J.L. McHugh
Professor, Emeritus
Marine Science Research Center
State University of New York
Stony Brook, New York 11794

Mr. Stuart Wilk
Deputy Chief, Environmental Assessment Division
NMFS, Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, New Jersey 07732

Mr. Peter Barrett
Managing Editor
New Jersey Fisherman
339 Herbertsville Road
Bricktown, New Jersey 08723

Mr. Lou Figurelli
President
Natural Resources Protective Association
of Staten Island, Inc.
P.O. Box 306, Great Kills
Staten Island, New York 10308



FISH AND FISHING PANEL SUMMARY[1]

...Our panel began with an introduction to Raritan Bay, its history and the goals of the Workshop by Bruce Freeman, followed by a detailed report from Dr. McHugh on the different types of net operations that affect Raritan Bay. The most detailed report came from Stu Wilk who has probably studied Raritan/Sandy Hook Bays over the last fifteen years more than any other individual.

Stu's presentation documented the value of the Bay as a nursery area for juvenile fish, many of which become the larger gamefish of tomorrow such as weakfish, red and silver hake, flounder, fluke and bluefish. He outlined how Raritan Bay was unique in comparison to other bay systems along the Atlantic coast since Raritan Bay has such a diversity of fish. Few other bay areas have the numbers of fish, or the variety of fish that inhabit Raritan.

...My own presentation centered on outlining the history of recreational fishing in Raritan which goes back to the early 1800's, tracing how it progressed over the last 200 years, and what its economic value is today. Our brief research on the Bay showed an economic impact on the local New Jersey area of over $30 million spent by sport anglers. That figure can probably be tripled when you take into account Staten Island and the Rockaway/Sheepshead Bay areas.

The main problems of Raritan Bay, from a sport fisherman's viewpoint, center around four points; pollution, lack of access, loss of species habitat and commercial fishing pressure.

Pollution can take several forms, not just the technical scientific aspect. To a fisherman visible pollution such as trash, garbage and oil slicks, are just as important as chemical pollution that contaminates the fish he seeks but which is commonly invisible to the eye.

Strict enforcement of pollution and dumping laws are essential to a healthy Raritan Bay. It has been rumored that a dumping "island" might be constructed in the Bay--this should be opposed. Dredging of high ground areas such as Romer Shoal destroyed good fishing grounds and cause siltation and a muddying of the Bay waters.

Lack of access may eventually hurt the fishing industry more than any other factor on the Bay because it prevents the people from using the Bay for fishing purposes. If you can't get to the Bay, you can't fish. Real estate is becoming so valuable that waterfront properties that previously emphasized boating and fishing are now being developed for housing and business, causing the loss of many boat slips and beach access.

Over the last 25 years more than a dozen small launch ramps have been lost to landfills, housing development, commercial building or construction of bulkheads.

[1]Excerpted from an article by Peter Barrett appearing in "The Fisherman" [11 (42) Oct. 20-26, 1981)]

...Loss of species habitat is like an unseen cancer to the sport fisherman. Despite new coastal zone regulations that are supposed to protect these critical areas it seems that each year the marshes and natural areas around the Bay shrink and slowly disappear. Still the landfills operate, the offices and factories go up.

...Commercial fishing pressure can also have an adverse effect on sport fishing and should be restricted. For instance, commercial operations that fish heavily for summer flounder (fluke) can overfish Raritan Bay so that the fish are temporarily "extinct" from the area, causing a tremendous loss of business to the recreational fishing industry.

The emphasis here is not to eliminate commercial fishing, but to restrict the commercial catches to a reduced level to leave enough fish for sports anglers to support the fishery at a steady level high enough to provide reasonable catches for the angler.

Following my presentation Lou Figurelli of the Natural Resources Protection Association spoke. He talked about the effects of pollution on Raritan Bay and how the Association has been so successful in battling the giants in industry and government to make Raritan Bay a cleaner, more productive fishing and boating area.

Perhaps the most valuable thrust of Lou's presentation was the hope and realization that the individual can do something about pollution and that as private citizens we do not have to sit back and take the abuse of areas like Raritan Bay without a fight. Get your facts together, fight hard, long and loud and you will eventually come out a winner.

THE INSHORE CATCH OF FOOD FISHES IN THE RARITAN BAY AREA[1]

J. L. McHugh
Marine Sciences Research Center
State University of New York at Stony Brook

INTRODUCTION

As Sindermann et al. (1982) have stated, in the general area of New York Bight catch statistics for commercially valuable species reveal few changes in abundance that can be directly attributed to pollution. All life history stages of fishes and shellfishes are susceptible to the effects of pollution, although it is the pre-adult stages that are most sensitive and therefore merit attention. It would seem that populations in contaminated waters should dwindle and disappear, yet this has not happened. Localized disappearance of species has been recorded only for severely degraded waters, and even there, other species remain, and in some instances are abundant. Many coastal fish species spend much of their early lives in waters that are to some extent contaminated. Death and disappearance may be criteria that are too extreme to determine harmful effects of pollutants, and sublethal effects may be more promising indicators.

Esser (1982) and Murchelano (1982) agree that natural fluctuations in abundance of fishes makes the detection of pollution effects very difficult. Esser showed that American shad (Alosa sapidissima), sturgeons (Acipenser oxyrhynchus and A. brevirostrum), rainbow smelt (Osmerus mordax) and alewives (Alosa pseudoharengus and A. aestivalis), being anadromous species (i.e., spawning and living their early lives in fresh or brackish water and in bays or estuaries), are especially susceptible in water pollution, and have declined in abundance in New York Bight. Striped bass (Morone saxatilis), also an anadromous species, on the other hand, has if anything increased in abundance in the area. Thus, the effects of water pollution are by no means clear, and overfishing and other environmental effects play a larger part also. Murchelano found that the only pollution-associated diseases numerically prevalent in the New York Bight area were shell disease, "black gill" disease, and fin rot, but fin rot in fishes has not been associated with a specific level of mortality.

Pearce (1979) noted that Raritan Bay has provided a significant quantity of commercial fishes and continues to be a principal area for recreational fishing. It provides a summer residence for red hake (Urophycis chuss), bluefish (Pomatomus saltatrix), scup (Stenotomus chrysops), weakfish (Cynoscion regalis), butterfish (Peprilus triacanthus), summer flounder (Pseudopleuronectes americanus). Some investigators have reported severely diseased fishes from Raritan Bay and vicinity. Mahoney et al. (1973) reported

[1]Contribution 386 of the Marine Sciences Research Center of the State University of New York, Stony Brook, New York 11794-5000

extensive fin erosion disease in 22 species of fishes from the area, and Ziskowski and Murchelano (1975) found 15 percent prevalence of fin erosion in winter flounder from Raritan Bay compared with only 2.2 percent from Great Bay, farther to the south. Thus, there are deleterious effects on fishes, although these are not always clearly associated with mortality.

It must also be emphasized that the benthic fauna in Raritan Bay is impoverished compared with other similar temperate estuaries (McGrath 1974). Oysters (Crassostrea virginica) once were abundant in the area, but are now completely gone (Wallace 1971). Franz (1982) showed that industrial and sewage pollution were the major causes of destruction of oyster beds in harbor waters. The final blow came with linkage of typhoid to sewage-contaminated oysters from the waters of New York and New Jersey, including Raritan Bay.

Thus, in spite of the aforementioned uncertainties, there is clearly a serious pollution problem in the vicinity of Raritan Bay. In fact, of all the major embayments of the northeastern United States, Raritan Bay is deemed to be the most heavily polluted (Pearce 1979).

PRINCIPAL FOOD FINFISH GEARS IN THE AREA

From federal statistics of food fish catches (Pileggi and Thompson 1980; U. S. Dept. Commerce 1980) it is impossible to pinpoint catches from Raritan Bay alone. However, statistics for New York and New Jersey are available, and they give a history of the evolution of the various types in the general area. Food finfish catches in the area have been taken mainly by four gears: pound nets, gill nets, and haul seines in the coastal zone; and otter trawls mostly farther offshore. Since 1921 the numbers of pound nets licensed have fallen off rather rapidly, from a maximum of over 700 in 1921 to a minimum of less than 100 in 1974 (Figure 1). The numbers of gill nets and haul seines also have dropped off since 1921, gill nets from over 5,000 in 1921 to between 200 and 300 now, and haul seines from over 300 in 1921 to less than 40 today. Otter trawls, on the other hand, have increased since 1921 to a maximum of about 400 in 1953, declined to about half that amount in 1973, and since have risen slightly.

Pound nets, gill nets, and haul seines are fished mostly close to shore. Pound nets are tied to stakes, and thus must be fished in shallow water. They have a long leader, which is set in toward shore, and migrating fishes, coming in contact with the leader, move offshore toward the pound. It is easy to enter the funnel-shaped opening, but difficult to escape again, and the fishes mill around inside the pound until the bag is lifted. Gill nets rely on fishes swimming into the meshes until the body is held, then find it impossible to back out because the gill covers become entangled in the meshes. Gill nets are either tied to stakes, allowed to drift, or set in a circle around fishes. Haul seines are set parallel to shore, lines at each end are run into shore, and the nets are hauled on to shore, either by hand or by power. All three nets rely upon fishes migrating in to them.

Otter trawls, on the other hand, are towed along the bottom, and take out fishes wherever they are. The mouth of the net is held open with "otter boards", heavy doors that ride along the bottom. Otter trawls also can be

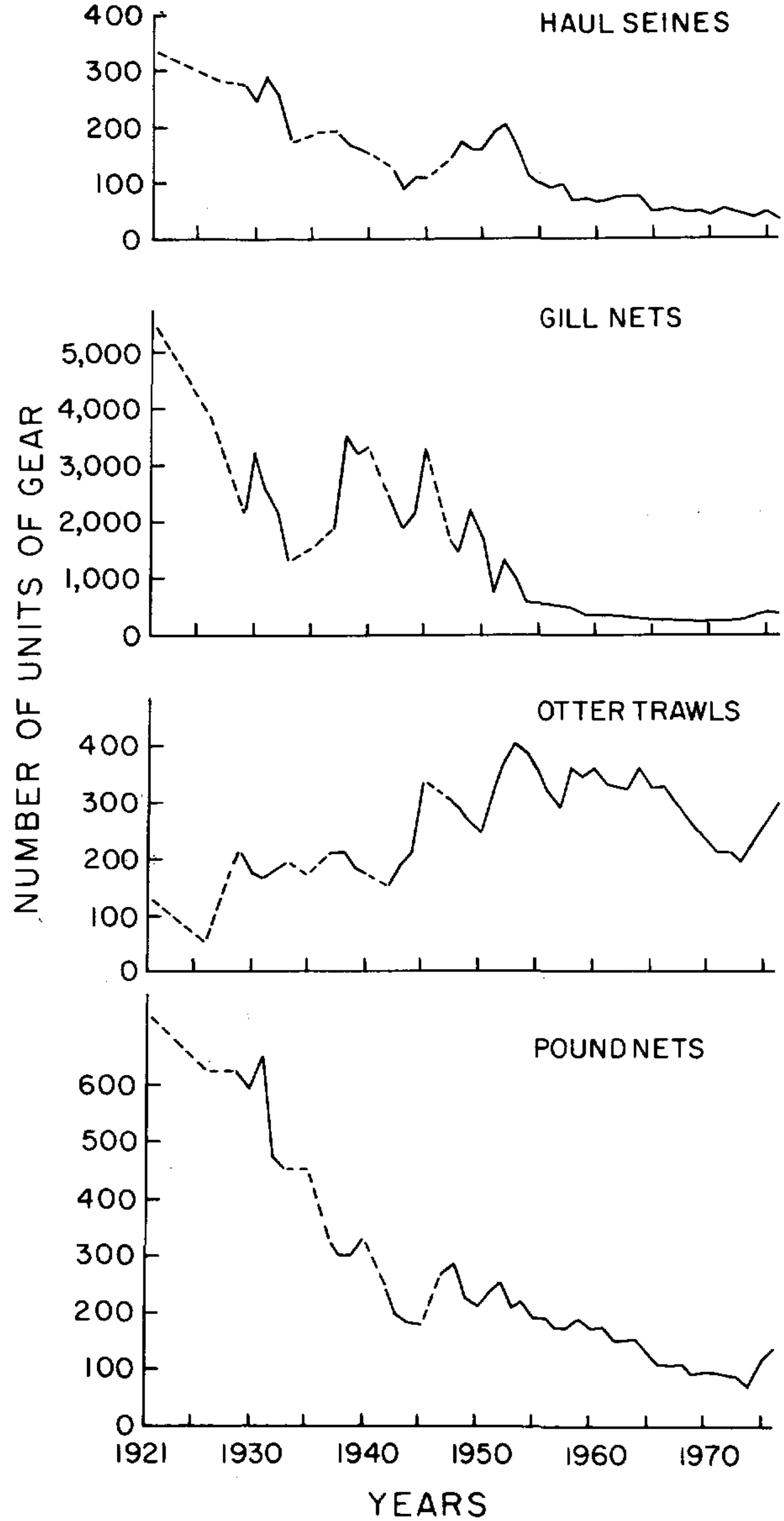


Figure 1. Numbers of pound nets, otter trawls, gill nets, and haul seines licensed from 1921 to 1976 in New York and New Jersey. Note the changing scale for units of gear.

rigged to fish above the bottom. Otter trawls came into use after power was available to drive vessels, and they did not begin to compete seriously with inshore gears until the 1920s. They can be fished in relatively shallow water near shore, but are also effective offshore, and can be used to follow and catch fishes as they migrate inshore and offshore, north and south, with the seasons. Because they are more efficient than other gears, laws restricting their use in inshore waters were passed fairly soon, but that has not prevented their use in deeper waters. They were soon catching a large part of the total foodfish catch, close to 80 percent before 1960.

The greatest catch of food finfishes by pound nets was in 1939, when about 34 million pounds were taken in New York and New Jersey. In 1921 pound nets were taking almost 53 percent of the total catch of food finfishes (Figure 2). The greatest catch by gill nets was in 1944, when a little over 8 million pounds were taken. In that year gill nets took a little over 9 percent of the total food finfish catch (Figure 3). The greatest catch by haul seines was taken fairly recently, in 1973, when the total was a little over 3 million pounds, and this was somewhat over 7 percent of the total food finfish catch (Figure 4). The greatest catch by otter trawls was in 1943 and 1960, when about 50 million pounds were taken in both years. The greatest percentage of the total food finfish catch was taken in 1969, at almost 80 percent of the total (Figure 5). The total catch of all foodfishes by all gears was taken in 1943, when about 98 million pounds were taken in New York and New Jersey (Figure 6). This fell off to about 33 million pounds in 1969, and has since risen to about 67 million pounds in 1979.

SPECIES COMPOSITION OF THE TOTAL CATCH OF FOOD FINFISHES

The composition of the total catch of food finfishes in New York and New Jersey has changed substantially from the peak in 1943 to the low point in 1969. Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), haddock (*Melanogrammus aeglefinus*), Atlantic bonito (*Sarda sarda*), American shad, alewives, Atlantic cod (*Gadus morhua*), black sea bass (*Centropristis striata*) and Atlantic mackerel (*Scomber scombrus*) were relatively less important in 1969 than in 1943; and yellowtail flounder (*Limanda ferruginea*), striped bass and bluefish were much more important. From the beginning of the period (1921) to the end (1979) spot, alewives, Atlantic croaker, Atlantic bonito, Atlantic cod, butterfish, black sea bass, American shad, and weakfish were relatively less important; and Atlantic mackerel, haddock, striped bass, red hake, silver hake or whiting (*Merluccius bilinearis*), and tilefish (*Lopholatilus chamaeleonticeps*) were much more important. Especially noticeable was the drop in American shad and alewife landings, and the increases in landings of silver and red hake.

PRINCIPAL SPECIES IN MAJOR GEARS

The principal species taken in pound nets in New York and New Jersey are weakfish, scup, butterfish, silver hake, bluefish, flounders, Atlantic mackerel, and northern puffer (*Sphoeroides maculatus*). Northern puffer was a somewhat special case, for it grew into popularity only in the 1950s and by

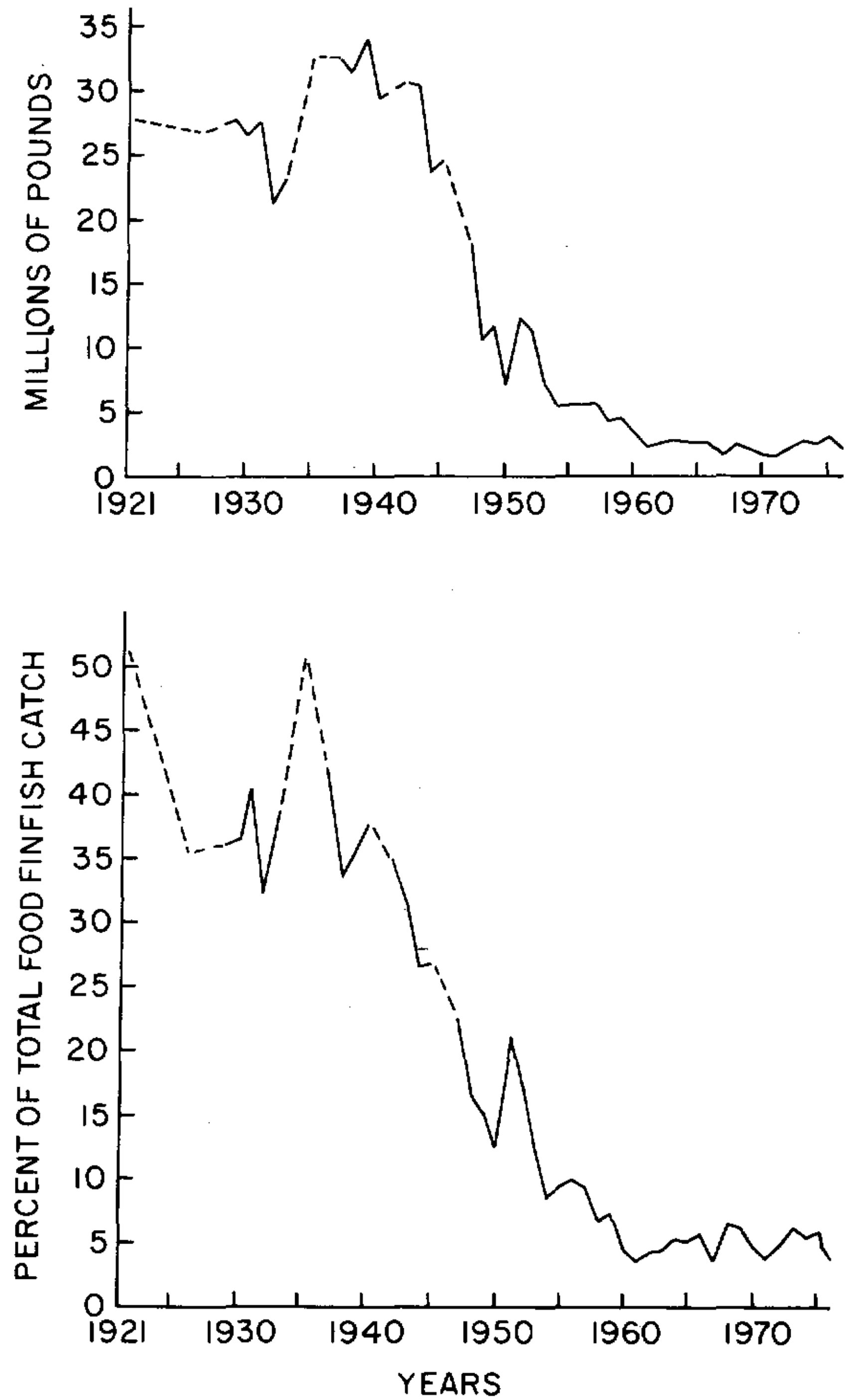


Figure 2. Percentage of total food finfish weight taken by pound nets in New York and New Jersey from 1921 to 1976, and the total weight of food finfishes taken by pound nets for the same period.

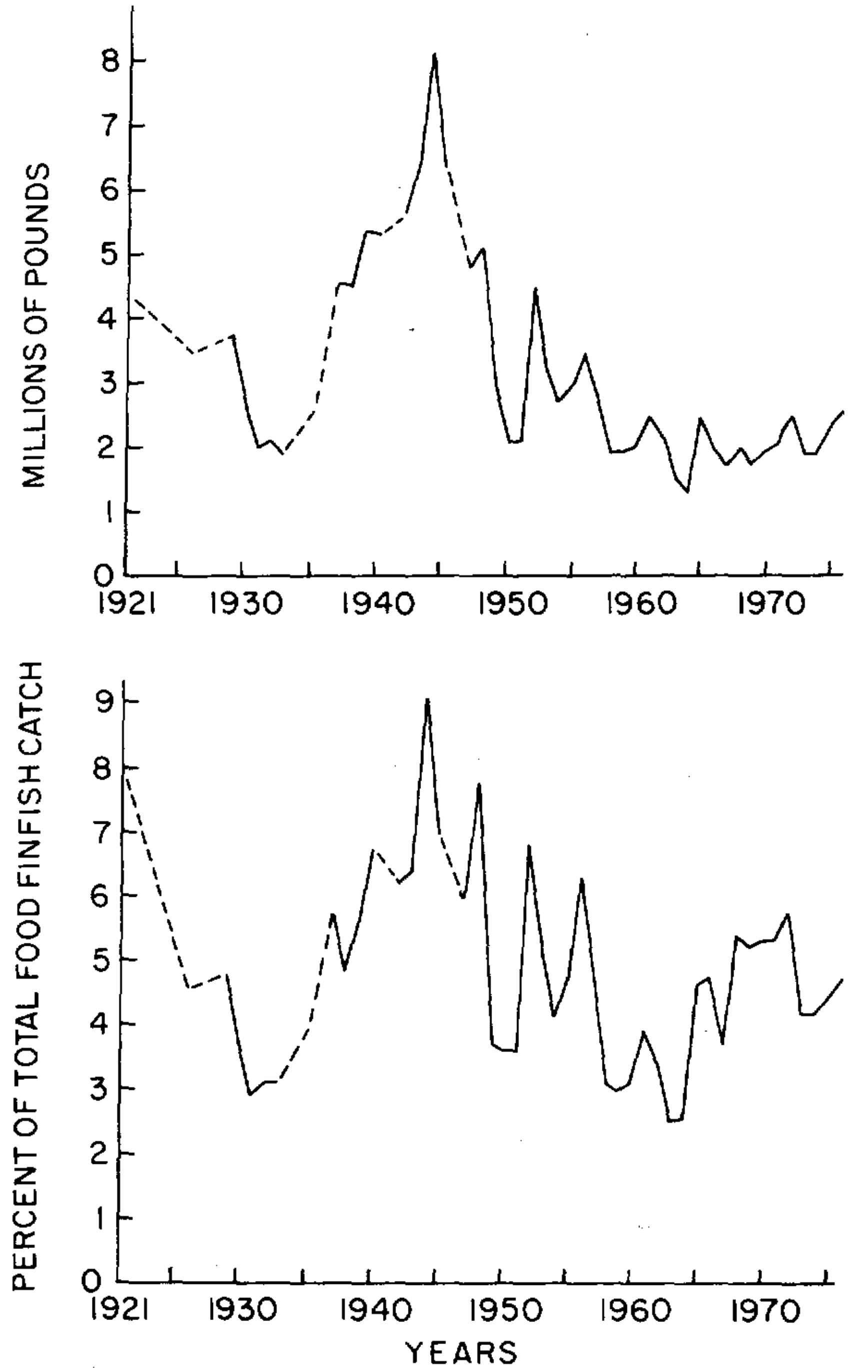


Figure 3. Percentage of total food finfish weight taken by gill nets in New York and New Jersey from 1921 to 1976, and the total weight of food finfishes taken by gill nets for the same period.

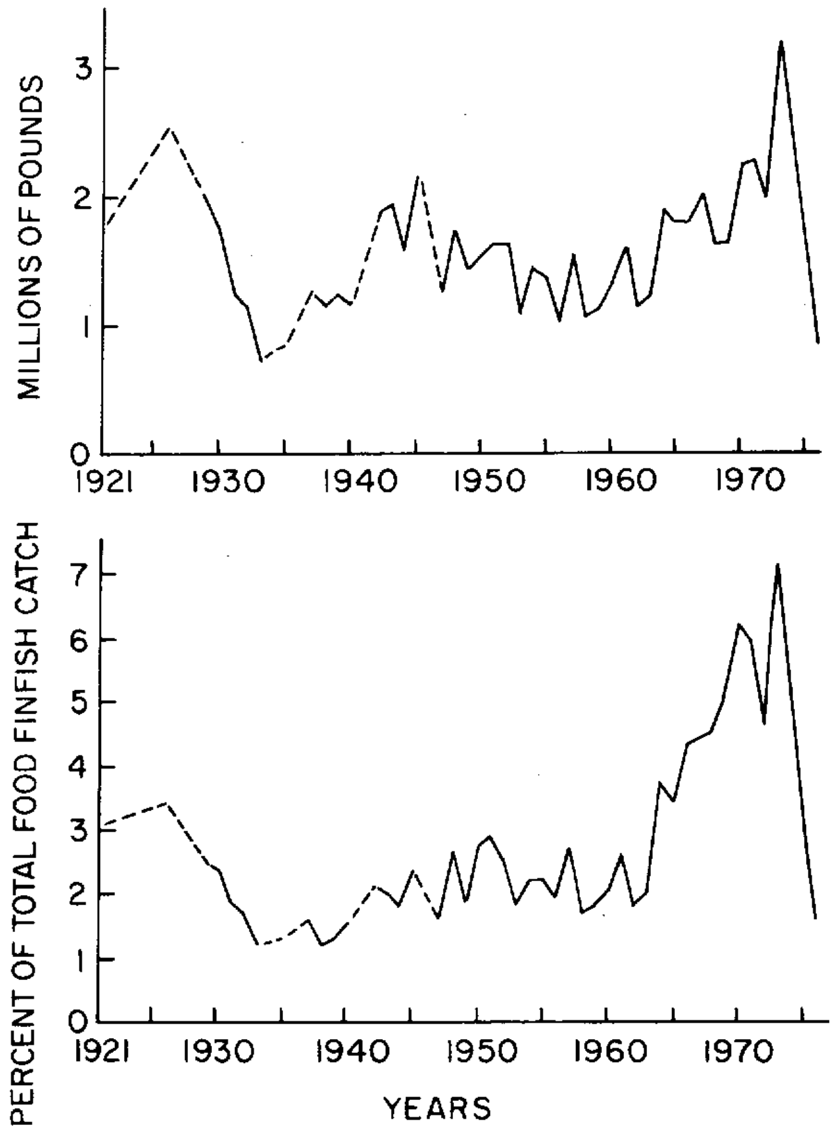


Figure 4. Percentage of total food finfish weight taken by haul seines in New York and New Jersey from 1921 to 1976, and the total weight of food finfishes taken by haul seines for the same period.

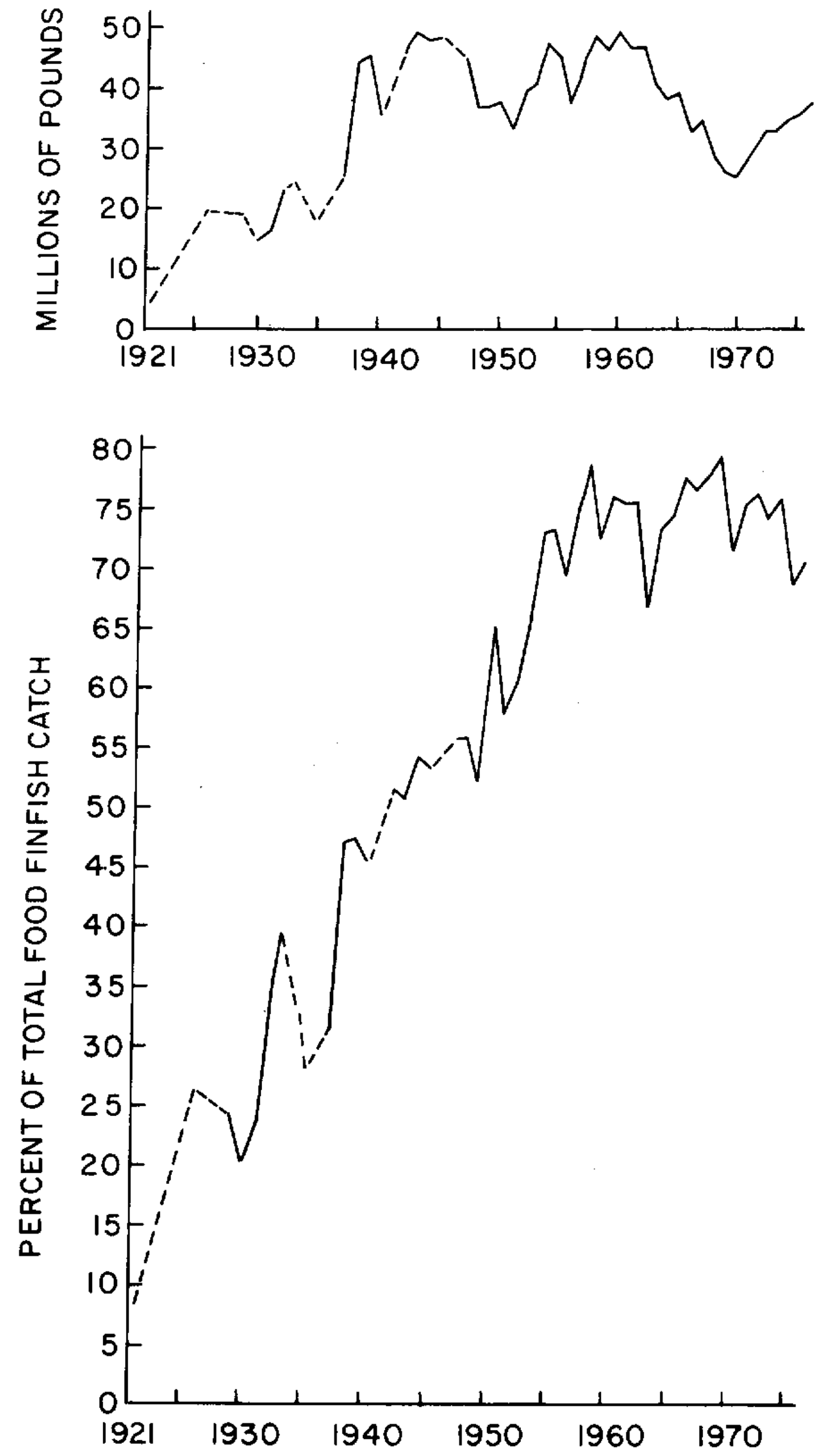


Figure 5. Percentage of total food finfish weight taken by otter trawls in New York and New Jersey from 1921 to 1976, and the total weight of food finfishes taken by otter trawls for the same period.

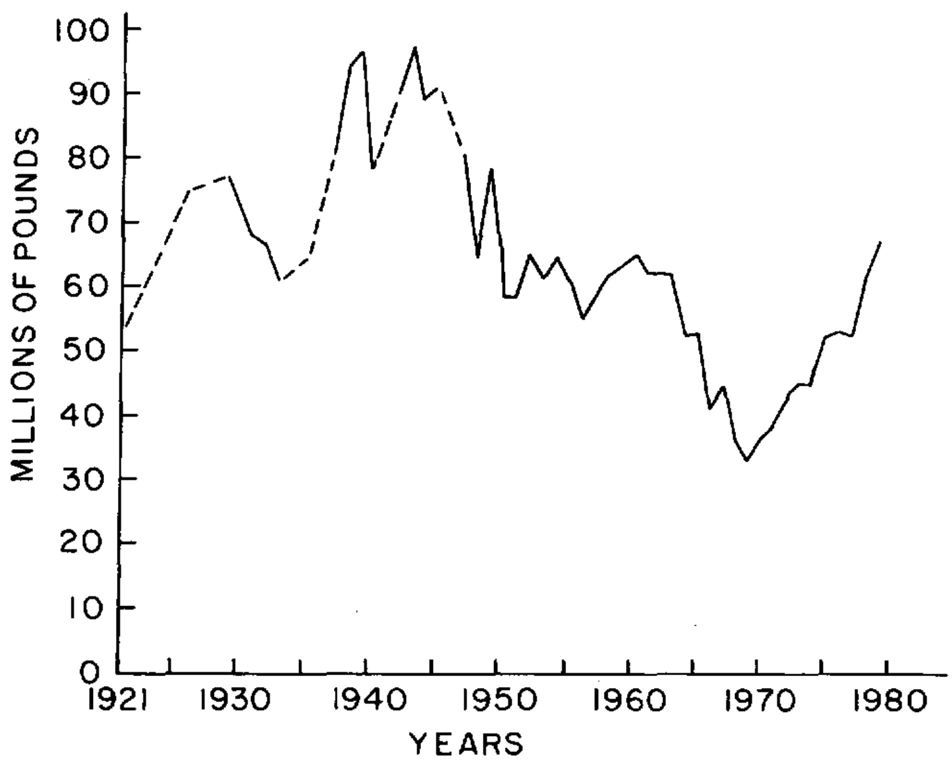


Figure 6. Total weight of food finfishes taken by all gears in New York and New Jersey from 1921 to 1979.

the 1970s it was either overfished, or had declined to do a change in the environment, or both. The principal species in gill nets were American shad, bluefish, weakfish, Atlantic mackerel and striped bass. The principal species taken in haul seines were striped bass, weakfish, alewives, common carp (Cyprinus carpio), white perch (Morone americana), and American shad. Haul seines have changed their strategy more noticeably than other gears, because in the early days the principal species were alewives, American shad and weakfish, whereas now they are white perch, striped bass, and carp.

In the otter trawl fishery, flounders as a group have always been important. Flounders were not listed separately prior to 1938. After that, the principal species were summer flounder, yellowtail flounder, and winter flounder, usually ranked in that order. Haddock was important until the end of the second world war, then dropped off very rapidly to minor importance. Scup became important in the 1940s and reached greatest importance in the 1950s and 1960s. In the late 1950s and early 1960s, especially in New York, the otter trawl fishery shifted to catching a variety of species for industrial use, and for a few years unclassified fishes used mainly for reduction to meal dominated the catch. In the late 1960s and the 1970s silver hake became increasingly important, and the otter trawl fishery in New York and New Jersey became more an opportunistic fishery, seeking out whatever species of value were in the general area. The major species were silver hake, summer flounder and scup, but many others were taken from time to time.

The mainstay of the pound net fishery has been silver hake, weakfish, butterfish and scup. Silver hake were taken mostly in the early days of the fishery, when more nets were fished on the outer coast. At present weakfish and scup are the principal species. American shad and alewives, although not among the major species, were taken mostly before or during the second world war.

Major species taken in gill nets were Atlantic shad, weakfish, Atlantic mackerel, and bluefish. Atlantic shad were taken mostly before and during the war, and declined rapidly after 1945. At present weakfish and bluefish are the principal species.

The dominant species in haul seines have been weakfish, alewives, scup and striped bass. Alewives were most important before the war, and now are a minor species. Striped bass were the dominant species from the 1950s to the early 1970s, but have fallen off since that time and now are minor. At present the major species in haul seines are weakfish and bluefish. River fishes like sturgeon, carp and suckers have declined since the early days.

Thus, river fishes and anadromous species obviously have declined the most, and the causes are probably several, including overfishing, water pollution, and dams and other blocks to migration. Despite these hazards, however, some continue to migrate upriver, spawn, survive to catchable size, and be caught. Other species, that migrate in from the sea at certain seasons, like weakfish, butterfish, Atlantic mackerel, bluefish, and others, fluctuate widely from time to time from unknown causes in the marine environment. They apparently are not affected greatly by stressful conditions in bays and estuaries related to man's activities. To a considerable extent, the decline of catch of these species in inshore gears like pound nets, gill nets, and haul seines have been made up by larger catches in otter trawls, by larger numbers of some species taken by recreational fishermen, and until recently by large numbers taken by foreign fishermen. The remarkable thing is that, by and large, except for American shad, alewives, sturgeon, striped bass, and some others, fishes continue to be caught in Raritan Bay in large numbers.

RECENT SURVEYS IN RARITAN BAY

Recent surveys in the Raritan Bay area by Wilk and Silverman (1976), Wilk et al. (1977) as reported in Brinkhuis (1980), Conover et al. (1983) and Pacheco (1983) reported on the abundance of fishes (mostly young collected in small-mesh trawls) in the area of Raritan Bay. They found a variety of species, dominated by anchovies, winter flounder, American shad, river herrings, red hake, butterfish, weakfish, silver hake, windowpane flounder (*Scophthalmus aquosus*), and scup. The numbers of individuals and of species were surprisingly large, and no abnormalities were noted. In fact, one observer (Smith 1976) stated that despite the uses and abuses of the Hudson River estuary, there were more species in these waters now than when Henry Hudson arrived in 1609. It is not certain that this was a valid observation, however, because in the 1600s very little was known about the fishes of the area. Especially noteworthy was the relative abundance of American shad and river herrings in these local catches, despite the overall reduction in abundance of these species.

SUMMARY

Thus, from examination of statistics on commercial fishery landings, from recent surveys of abundance of fishes in the area, and from what is known about recreational fishery catches, the fishes of Raritan Bay have shown remarkable resistance to water pollution. Although landings in pound nets, gill nets, and haul seines in New York and New Jersey are all down substantially, they have been balanced at least partially by increasing otter trawl landings from farther offshore. If the foreign catch and recreational catches are added to the total, there appears to be little evidence from statistics on landings that deterioration of quality of the waters of Raritan Bay has affected the abundance of oceanic fishes, and only indirect evidence that anadromous fishes have suffered from pollution. Fishes have a remarkable capacity to tolerate pollution or to avoid it, without noticeable effects on their abundance. In view of the wide fluctuations that occur from time to time in abundance of most species from natural factors in the environment, it is virtually impossible to separate out the effects of pollution alone.

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FINFISH RESOURCES OF THE SANDY HOOK-RARITAN-LOWER BAY COMPLEX --

A REVIEW OF RESEARCH FINDINGS

Stuart J. Wilk
U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Fisheries Service
Sandy Hook Laboratory
Highlands, New Jersey 07732

INTRODUCTION

Historically, the Sandy Hook-Raritan-Lower Bay complex has supported commercial fisheries since the early days of settlement in the United States (Fig. 1). However, within the past half century water quality has deteriorated sufficiently from sewage and waste contamination to render most of the bay unfit for shellfish harvest. There are seasonal commercial fisheries for clams (soft and hard), lobsters and blue crabs. At present time, only a few pound nets and purse seines are operated in the bay for harvesting finfish; however, a year-round and seasonally intensive recreational fishery has developed using private-, rental-, and party-boats as well as along the shores. The recreational effort continues to expand.

I will address those questions regarding finfish resources of the bay most often asked of fishery scientists. These include: What species of finfish can be found in the Bay? What is the seasonality of each species in the Bay? How is each species distributed within the confines of the bay? How abundant are the various species in the Bay? And, how important is the Bay relative to these species? I will attempt to provide answers to these questions using as a basis, two independent research studies conducted by the National Marine Fisheries Service's Sandy Hook Laboratory during 1970 and between 1974 and 1976.

PURPOSE

The purpose of the 1970 survey was to define, enumerate, and generally to gather information on the finfish resources associated with Sandy Hook Bay during the height of the recreational and limited commercial fisheries effort. This effort generally takes place mostly from May until October, and subsequently dwindles with the advent of fall cooling and the onset of winter weather.

The 1974-76 survey was part of a more extensive study which extended from within the bay seaward to the edge of the continental shelf and southward from eastern Long Island to the offing of Chesapeake Bay. Generally speaking, this survey was designed to build a synoptic as well as a statistically sound data base necessary to detect areal and temporal changes in distribution, abundance, and species composition of the various finfish which utilize or inhabit the Mid-Atlantic Bight during phases of their life cycle. In addition it was also designed to collect information on various life history features (i.e., age and size composition, reproductive stages and condition) of the more important recreational and commercial species.

METHODS

Both surveys were conducted in the 1970s, but were accomplished in two different manners. For the 1970 study, because of the relatively confined nature of Sandy Hook Bay we divided the area into 18 sampling blocks (Fig. 2). Except where interrupted by land, each block measured 1° of latitude x 1° of longitude, i.e., 1.8 km x 1.4 km (1.0 x 0.75 nm). All 18 blocks were sampled, as close to biweekly as possible, during 2-day cruises when weather conditions and vessel scheduling permitted.

For the 1974-76 survey we divided the total bay into 103 sampling blocks as described above (Fig. 3). Because of the larger area to be surveyed, and the longer sampling period (30 months), we selected randomly between 18 and 20 stations for sampling purposes each month. Figure 4 illustrates a typical monthly array of stations.

At each station we lowered a 30' wide otter trawl over the side of the research vessels, towed it over the bottom at a prescribed, usually 3 to 3-1/2 knots for a standard period of time, usually 15 min. The trawl was then retrieved and the fish emptied onto a sorting table aboard the vessel. The fish were identified, enumerated, and weighed. In addition, to this, during all of this survey work, we took observations of water temperature and salinity.

The 1970 survey was conducted over 3-1/2 months during which time 112 stations were sampled. During the 1974-76 survey, we sampled 408 stations over a 30-month period.

RESULTS AND CONCLUSIONS

One of the environmental variables significant to fish is temperature. We found no real differences in the annual patterns among the three years observed (Fig. 5) in the bay. A second factor which can affect fish distribution is salinity. Normal seasonal variations were noted, but salinities were generally more stable than temperature.

A relatively small number of species composed most of the finfish catch, both in number and weight. Of the 59 species captured during the 1974-76 survey, 20 species made up 99 percent by number and 27 species made up 99 percent of the catch by weight. Principal species were either permanent residents of the bay or entered seasonally in large numbers.

Seasonally the bay serves different roles for fish. In the spring, it is an area where anadromous fish, such as shad and river herring congregate and pass on their way to riverine spawning grounds. Other species present in spring, some of which may be considered residents, are winter flounder,

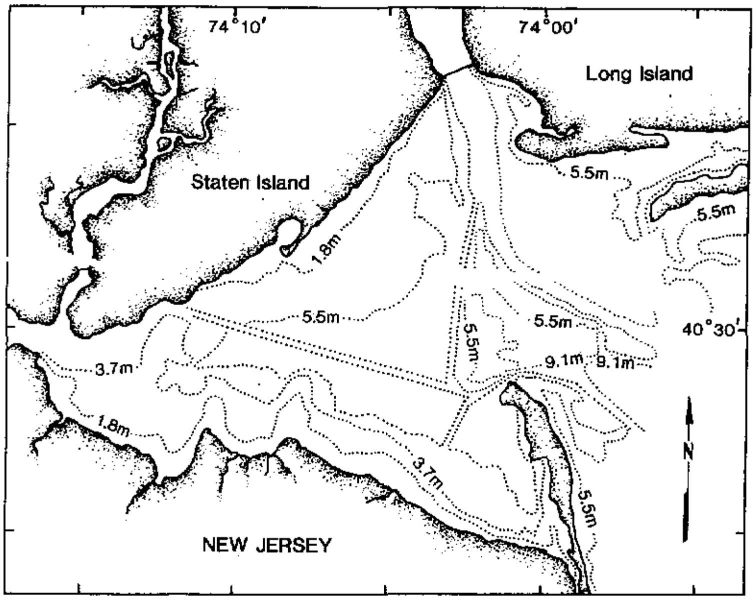
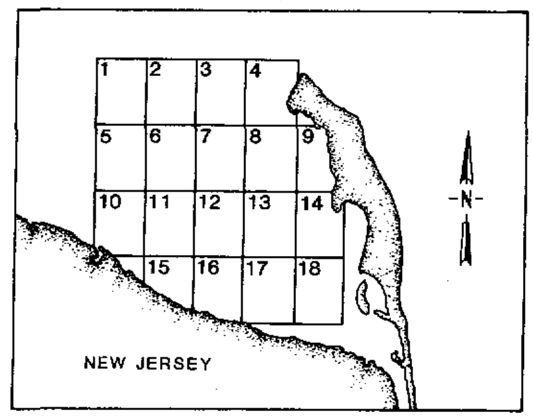


Figure 1. The Sandy Hook-Raritan-Lower Bay complex. Depth contours and major channels indicated by dotted lines.

Figure 2. The 1970 Sandy Hook Bay survey grid.



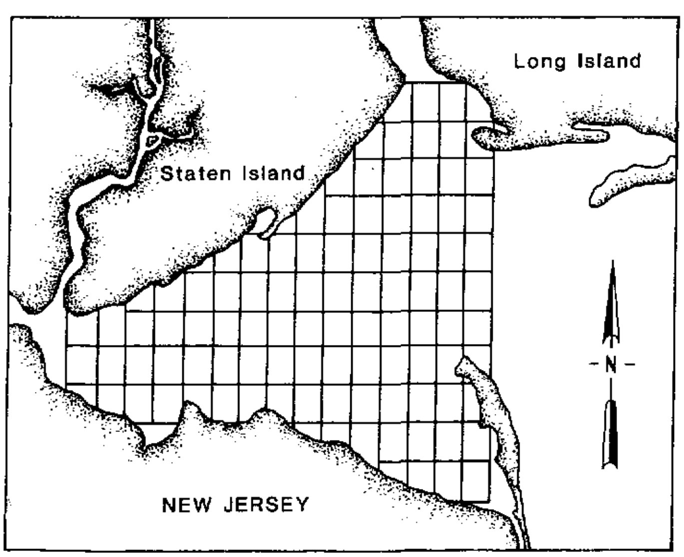


Figure 3. The 1974-76 Bay complex survey grid.

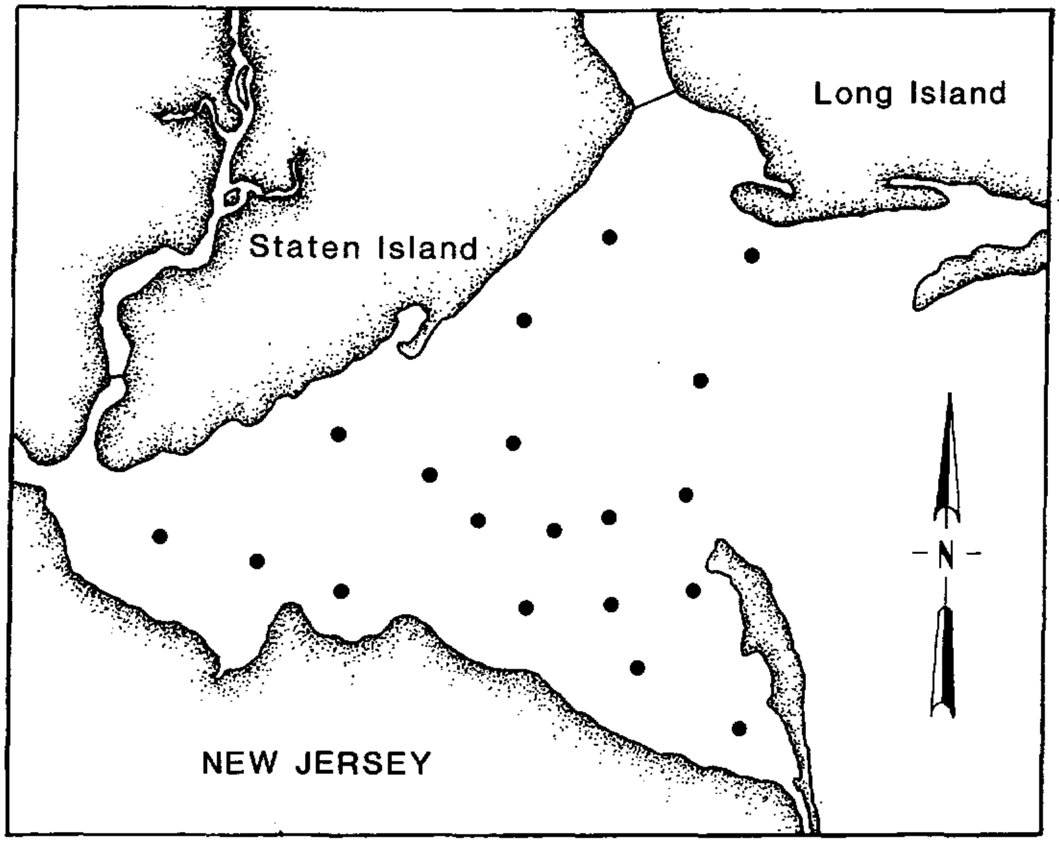


Figure 4. A typical station pattern of the 1974-76 survey.

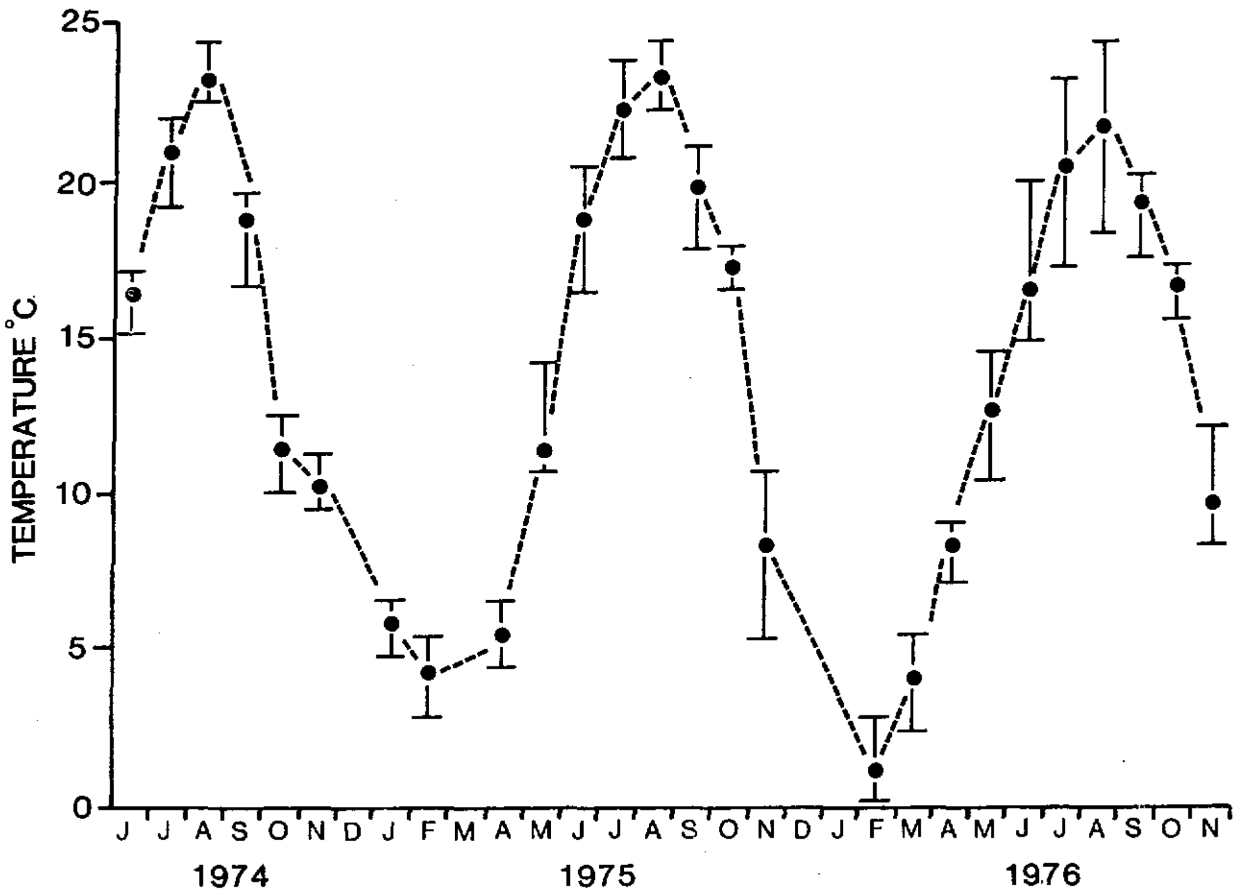


Figure 5. Trend of surface water temperatures in the Raritan Bay complex. Mean (solid circles) and range (bars).

windowpane flounder, and red and spotted hake. Depending on their size, some of these species move out of the bay seasonally.

During summer and fall, species composition is similar. Predominant fish include scup (porgy), summer flounder (fluke), two species of sea robins (striped and northern), bay anchovy, winter flounder, three species of hakes (red, silver and spotted), butterfish, bluefish, windowpane flounder and weakfish. During the 3-1/2 months of the 1970 survey, essentially with the summer sampling, nearly 70 percent of the total weight consisted of sea robins, winter flounder, spotted hake, red hake, and windowpane flounder.

Summer catches held a certain fascination because of the diversity of species in the catches. From the 1974-76 survey we captured 59 species of fish which included some tropical strays during the late summer months. Besides numbers of fish, there is also a considerable biomass. For example, in the 1974-76 surveys we captured over 200,000 individuals which weighed some 7,000 pounds. This amounted to an average of some 500 specimens per haul; however, most of the catch consisted of small fish. A significant conclusion was that the area is an important nursery for a number of species. This is illustrated in the length-frequency distribution of sizes (Tables 6, 7, 8).

The dynamics and stability of the bay's fish population are worthy of mention. The variations in monthly weights and numbers of species for the 30-month period is shown in Figure 9. There was a periodicity in 1974 and 1975 which broke down in 1976. The increased catch and weight of 1976 reflect a response of fish to development of a hypoxic (low oxygen) nearshore condition. Fish moved into the bay to avoid suffocation. Normally, however, the bay seems to maintain a fairly constant carrying capacity for a given biomass which repeats seasonally.

Factors which induce environmental stresses result in shifts in the distribution of fishes. In 1976, when the nearshore area was no longer a viable environment, abnormal numbers of fish retreated into the bay (Fig. 10). Rather than have a predominance of young-of-year and yearling fish, more older age groups were apparent in the catch (cf. winter flounder, Fig. 8).

As seen from the observations depicted in the figures, some characteristics of the bay's fish population are relatively constant and repetitious. In a broad sense, we can characterize areas of the bay utilized by various species for given periods of time because seasonal movements create recombinations of species and availability of different age groups.

We must, however, document the significance of the bay stock to future fisheries. Certain questions are still not clear. What are primary and alternate components of the various food chains? What is the effect of contaminants? Although the young-of-year and yearling fish exist as prerecruits to the local fisheries and are the potential future harvest the effects of disease, parasites and predation in these early years still are not clearly measured.

The National Marine Fisheries Service has experienced a renewed interest in the role of estuaries in nearshore fish production. In cooperation with coastal states, I expect estuarine surveys of fishery resources, descriptions

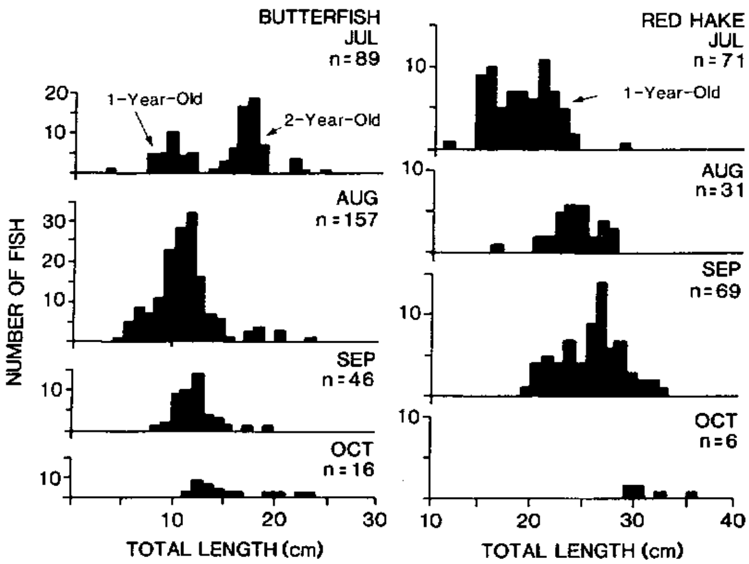


Figure 6. July-October length frequency distributions of butterfish and red hake.

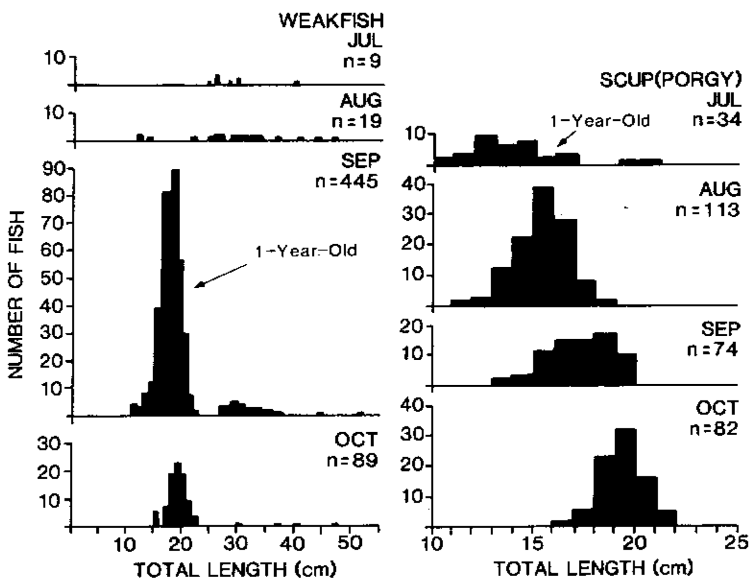


Figure 7. July-October length frequency distributions of weakfish and scup.

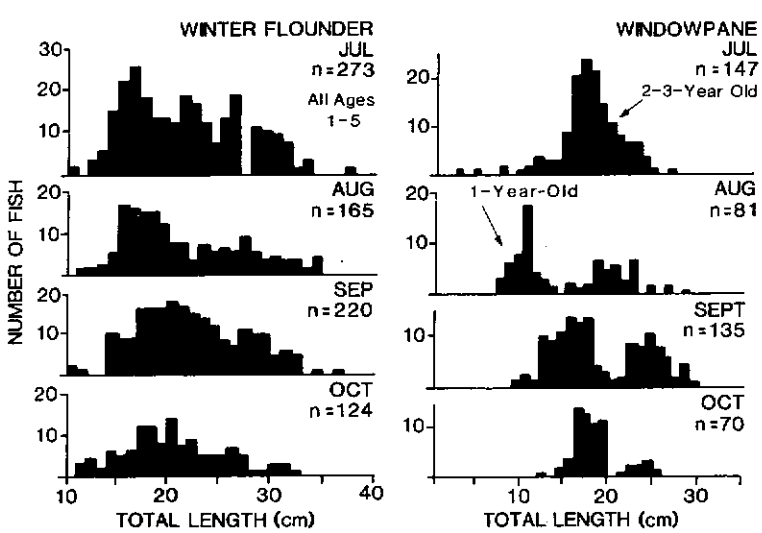


Figure 8. July-October length frequency distributions of winter and windowpane flounder.

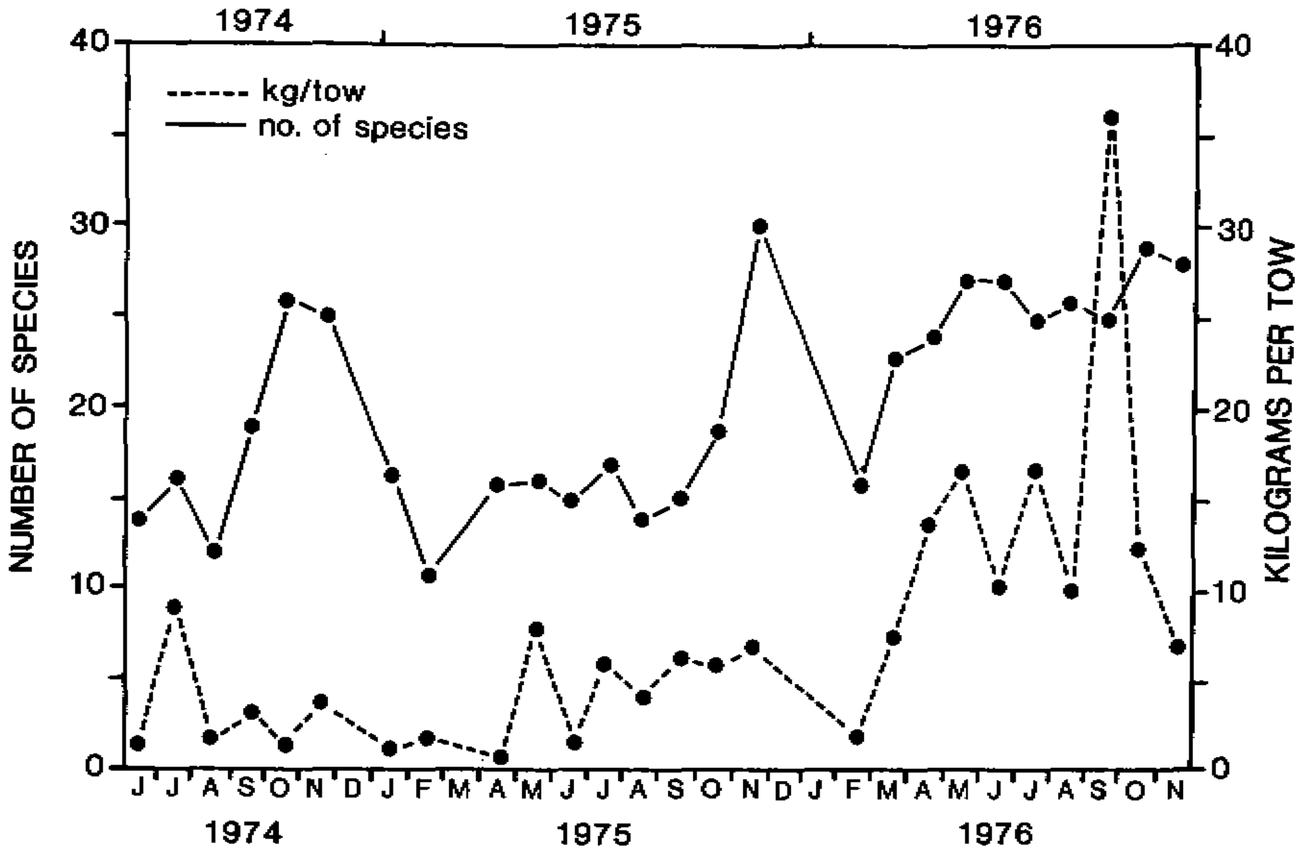


Figure 9. Trends in species count and weight/tow, 1974-1976.

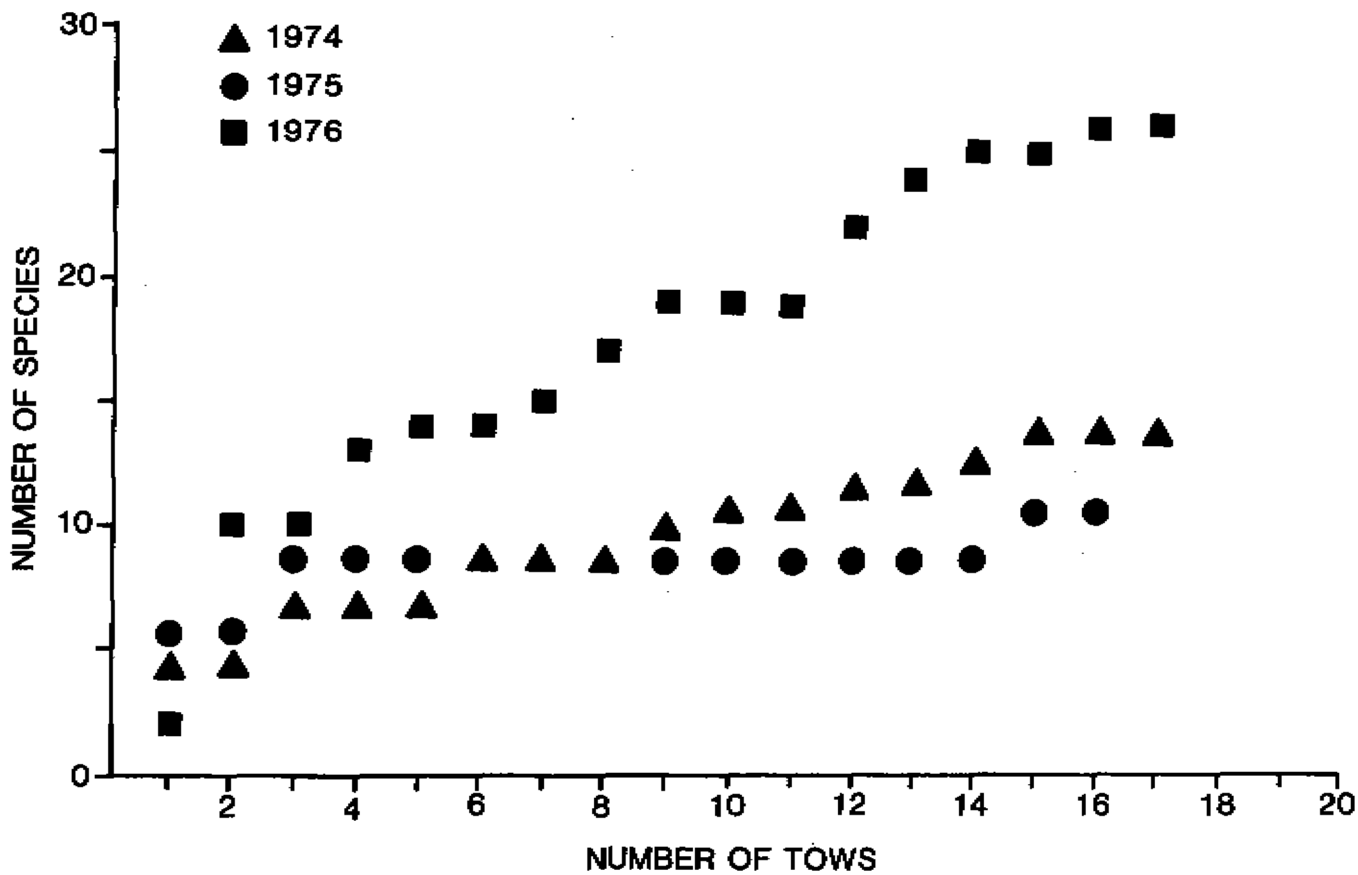


Figure 10. Trends of species frequency/tow, 1974-1976.

of environmental characteristics and analyses of their interactions will develop. With a broad and appropriately designed sampling program we should be able to answer questions on effects of pollution and from the distributions of size and numbers of fish be able to forecast trends in nearshore fishery harvests.

SHELLFISHERIES

CHAIRMAN

Dr. Harold Haskin
Professor, Rutgers University
Department of Biology
New Brunswick, New Jersey 08903

THE PANEL

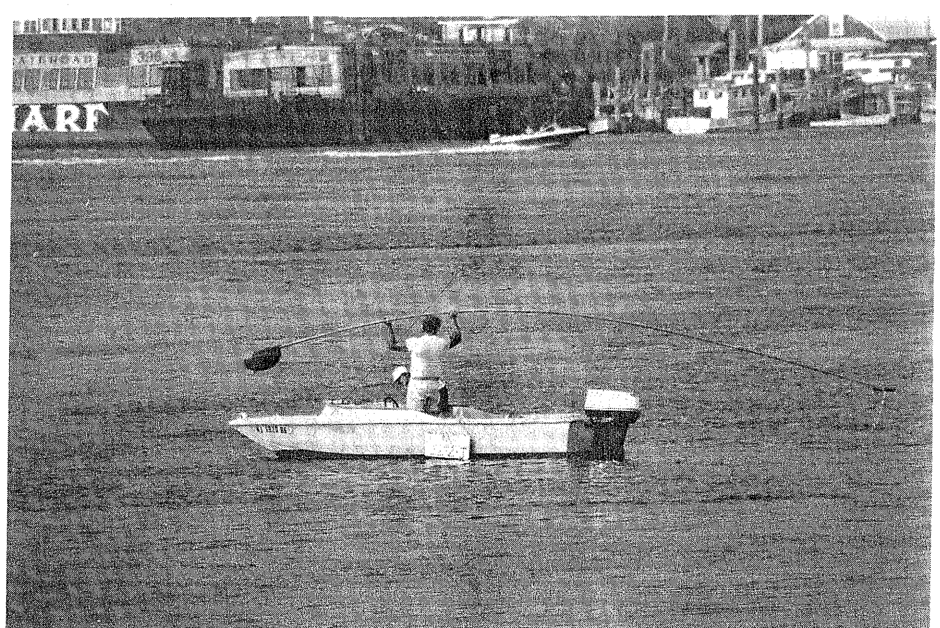
Dr. David R. Franz
Professor, Biology Department
Brooklyn College, City University of New York
Brooklyn, New York 111210

Mrs. Gail Critchlow
Chief, New Jersey Bureau of Shellfish
Division of Fish, Game and Wildlife
Department of Enviromental Protection
Trenton, New Jersey 08645

Mr. Austin Farley
Fishery Research Biologist
NMFS, Northeast Fisheries Center
Oxford Laboratory
Oxford, Maryland 21654

Mr. Clyde MacKenzie
Fishery Research Biologist
NMFS, Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, New Jersey 07732

Mr. Jason Harvey
Manager, Jersey Shore Shellfish, Inc.
76 Fifth Street
Highlands, New Jersey 07732



THE SHELLFISH PANEL SUMMARY

Dr. Haskin introduced the topic with an historical overview of Raritan Bay's shellfish resource and fishery. In the heydays of the late 1890's Monmouth County, for example, harvested from 39 to 80 thousand bushels of oysters from some 1600 acres of Raritan beds. A considerably smaller clam fishery was conducted in the remaining 23,800 acres of bay waters inside of Sandy Hook. Even by this time local seed beds were already depleted or damaged by sedimentation and the dumping of refuse and sewage. By the 1920's petroleum flavors were detectable in oysters, reducing their marketability. By the late 40's only 14 vessels were clamming in Sandy Hook Bay. In the late 50's hepatitis outbreaks in the Tottenville area resulted in the nearly complete closure of bay waters to shellfishing. The constancy of chemical and industrial pollution, dredging, illegal dumping, and problems caused by pathogens (associated with sewage pollution) all conspired to devastate the Raritan shellfish industry.

Dr. Franz summarized the changes in benthic faunal assemblages which occurred when sediment composition shifted from coarse sands and gravels to silts and muds. Compared to muddy/sand assemblages at several other locations he concluded that the bay is impoverished. There are four molluscan species in the Raritan compared to 14 in Central Long Island Sound and 24 in Fishers Island Sound.

Mrs. Critchlow described the mission of the Bureau of Shellfisheries, Division of Fish, Game and Wildlife as one of making the Raritan shellfish resources useful. She cited data from a hard clam survey which estimated a population of 12 million harvestable clams in the Bay. These are order-of-magnitude differences from Rutgers estimates conducted in the 60's which were of approximately 2 million. Shellfish stocks appear to be at least stabilized. Depuration and relaying represent viable strategies for resource utilization at the present time.

Mr. Farley presented observations of pathological characteristics of oyster tissue. At the present time there is a low incidence of oyster parasites on traditional Raritan oystering grounds and earlier observations from the Navesink indicate higher parasite densities existed in the past. He suggested that oysters may be considered to depurate overwinter. Oysters may be highly tolerant of certain metals and some high metal levels may not be toxic to them. Levels of 29,000 ppm Cu and even higher levels of Zn were recorded in the '20's. Present metal levels in Barnegat shellfish are not significantly different from the Raritan.

Mr. MacKenzie pointed out that the traditional Raritan oyster beds were depleted in the early 1800's and the industry was rejuvenated by developing a seed-planting technology. Before the Civil War, Chesapeake Bay seed was imported, and during that war local beds in Newark Bay, Kill van Kull and western Long Island Sound were used to supplement the seed stock of the Raritan. For a number of reasons, including the damage to beds by siltation resulting from land development, as well as public health considerations, oystering had all but ended by 1922.

Mr. Harvey reflected on the needs of those interested in redeveloping the Bay shellfishery. He reviewed the gaps in knowledge and bureaucratic impediments affecting the depuration strategy for producing marketable clams. He concluded that definitive guidelines for operations are necessary for a viable industry to develop.

A HISTORY OF OYSTERING IN RARITAN BAY, WITH ENVIRONMENTAL OBSERVATIONS

Clyde L. MacKenzie, Jr.
U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, New Jersey 07732

INTRODUCTION

Oystering in Raritan Bay was practiced by the Indians who colonized its shores hundreds of years ago, and by the European colonists and their descendants who eventually depleted the oyster beds. A commercial oyster industry began in 1825 and lasted until about 1925; this is the main topic of the paper. The oyster industry in the bay was part of a much larger oyster industry which extended along the east coast of North America from the Maritime Provinces of Canada to Texas. During that time, oysters were a more important part of the diet of Americans than in the early 1980s. About 30 million bushels of oysters a year were produced from Rhode Island to Chesapeake Bay in 1890 and about 25 million bushels in 1900 (Lyles 1969). The population of the entire United States was about 75 million and most people worked in farming or fishing in 1900 (Hindley 1959). By the early 1980s, annual oyster production from the same area of Rhode Island to Chesapeake Bay area was about 5 million bushels (MacKenzie 1983) while the population of the United States was slightly above 230 million. Thus, the population is 3.3 times larger but consumes only one-fifth as many oysters; the per capita consumption of oysters is about one-seventeenth of what is was. During the late 1800s and early 1900s, many families had two oyster dinners a week, one nearly always on Sunday. Shucked oysters were peddled from horse-drawn carts on the streets of eastern cities for about 25 cents a quart. In sections of the cities, oyster and clam bars operated on almost every block, much as small restaurants do now, and oysters were commonly eaten in saloons. Oysters were frequently sold by name according to their source: Malpeques, Cotuits, Robbins Islands, Blue Points, Rockaways, Sounds, Prince's Bays, Shrewsburys, Maurice River Coves, Bombay Hooks, Potomacs, Rappahannocks, Chincoteagues, etc. The largest oyster markets were Boston, New York, Philadelphia, Baltimore, Norfolk and New Orleans. Luxury liners on international cruises carried oysters for passengers. The Raritan Bay oyster industry produced roughly 2 percent of the total oyster crop in the northeastern United States.

The colonists of Massachusetts, Rhode Island, New York and New Jersey gathered local oysters as one of their foods. As populations increased the supplies of oysters dwindled, seed oysters from Chesapeake Bay were transplanted to Wellfleet (Massachusetts), Narragansett Bay, Long Island Sound, Raritan Bay and Delaware Bay in the spring and harvested in the fall to meet the demand for oysters. The earliest European settlers of New York City area had gathered local oysters for consumption, but eventually depleted the supply. Afterwards, supplies of market oysters to the city were imported from various estuaries along the Atlantic coast. The oysters were transported mostly by schooners, which carried a substantial amount of freight--agricultural produce, coal, lumber, brick, stone and other commodities--, besides oysters, along the eastern seaboard. The schooners and sloops also dredged many of the oysters. The operations of boats were subject to the whims of the weather.

Production of oysters was labor intensive when compared with present standards in crop production. A large amount of labor was involved in building schooners, sloops, skiffs, tongs, rakes, dredges, anchors, baskets, floats and oars, cutting and hauling stakes out of woods and then setting them in place with cement buoy stones to mark the corners of lease boundaries, making ropes, sails and knives, waterproofing the outer clothing of boat crews with linseed oil, shucking and cleaning oysters, and obtaining ice to preserve them. On the beds, tongs were operated by hand, dredges were hauled by hand and oysters were shoveled into baskets and the baskets were hand carried; oyster skiffs were rowed. The reputations of men were based on their strength and the work they could perform; captains had higher status than deck-hands on boats. Oysters were abundant in most estuaries, though, which helped to compensate for the labor expended. One common saying was: "Who is going to eat all these oysters?"

ORIGINAL DISTRIBUTION OF OYSTERS IN RARITAN BAY

The distribution of oysters in Raritan Bay in the precolonial period is incompletely known. A huge bed, later known as the Great Beds (Fig. 1), occurred at the western end of the bay just beyond the mouths of the Raritan River and the Arthur Kill. Oysters grew along the Raritan River from its mouth to five miles upriver (Hall, 1894). Oyster beds also occurred along the entire length of the Arthur Kill and to an extent in the Kill Van Kull. Another natural bed, known as the Chingarora Bed, occurred at Keyport. Mitchell (1961) states that a chain of beds extended from Sandy Hook across New York Harbor, up the Hudson River to Ossining, New York. (The locations of these beds in Raritan Bay are not certain.) Oysters grew along the shores of Jersey City, Manhattan, and Brooklyn and Wards, Ellis, and Bedloe's islands.

OBSERVATIONS ABOUT OYSTERS, 1748-51 (KALM, 1770)

The following observations made about oysters near the present location of New York City probably apply to the Raritan Bay as well. The Indians used oysters and other shellfish (clams and mussels) as one of their chief foods and were active in gathering them. The shellfish were eaten fresh and also preserved for later consumption by being strung dried and then smoked. They sold a portion of their shellfish to other Indians further inland. Large piles of oyster and mussel shells existed where the Indians had their huts. (Note: piles of oyster shells made by Indians existed in the early 1900s at Perth Amboy and Union Beach, New Jersey, and other localities.)

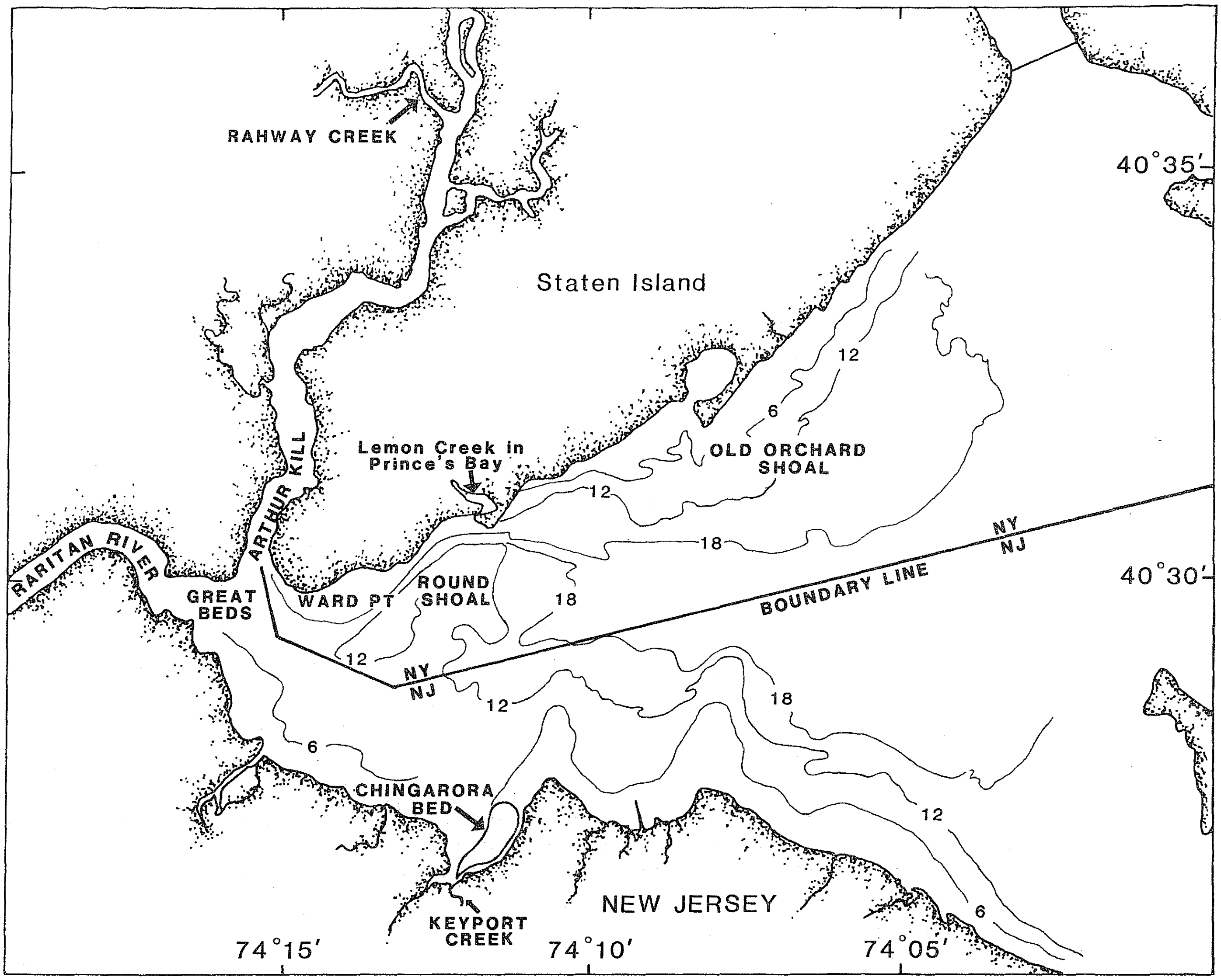


Figure 1. Some of the principal oyster beds, the creeks where oysters were floated, the location of the boundary line between New York and New Jersey and the water depths at various locations in Raritan Bay.

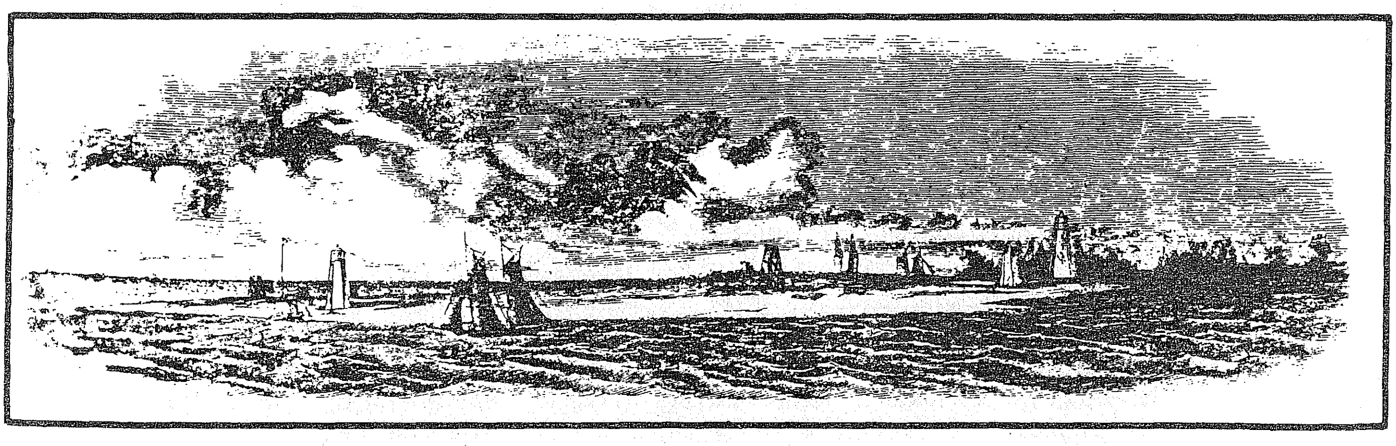


Figure 2. A schooner rounding Sandy Hook, New Jersey, heading to Virginia to buy seed oysters for planting on Raritan Bay oyster beds (from: Frank Leslie's Illustrated Newspaper 1857). The transplanting of seed from Chesapeake Bay to Raritan Bay took place during March and April each year.

The colonists gathered quantities of oysters as food. They used the shells to make lime for mortar used in construction of stone houses, and also scattered them over their farm fields, presumably to correct soil acidity.

The observations below are summarized from the writings of Ingersoll (1881) and Hall (1894), both employed by the Federal Government to study the oyster industry; Kochis (1975), who summarized reports from a number of newspapers, journals and books from that period; the Staten Island Historian (a quarterly periodical), historical newspaper articles about oystering; and interviews with people familiar with the oyster industry (see ACKNOWLEDGMENTS). Investigative reporters during the 1800s had to make some estimates concerning quantities of oysters planted and harvested and the numbers of oystermen and boats. The statistics relating to these items vary somewhat among the reporters and should be considered as estimates.

OYSTERING ON THE NATURAL BEDS

In the early 1700s, many colonists gathered oysters for consumption from natural beds in western Raritan Bay, Arthur Kill and Raritan River. Because the salinity was relatively low in the Arthur Kill and Raritan River, the oysters there remained small and thus were much less desirable as food than those in Raritan Bay (eventually, oysters in the Kill and river were gathered as seed to be spread on leased beds in Raritan Bay). Some oysters were consumed immediately and some were stored in cellars for eating during winter. It is not recorded how the oysters were taken; probably, some were gathered by hand at low tide, some with tongs (invented by the Indians) and some dredged from sailing boats. The first dredges consisted of a wooden crossbar with iron teeth to which a rope mesh bag was attached. After the Civil War, an improved dredge was developed with the frame and bag made of iron. People from other areas also sailed into the bay to take oysters. After a period of years, the oysters became relatively scarce, and restrictions were imposed in an effort to preserve them: oysters could be taken only between September 1 and May 1, and only by local people; the Indians did not have to abide by the restrictions. Nevertheless, the oysters became depleted. (The Indians along the New Jersey coast ceded their lands to the State and were moved to the Oneida Reservation in New York by 1802.)

THE COMMERCIAL OYSTER INDUSTRY, 1825 TO ABOUT 1925

Importing Seed Oysters

Because oysters represented an important source of protein, the local people began to import seed oysters from other areas by sailboat for planting on Raritan Bay beds, allowing them to grow to market size and then selling them. The first imported oysters came from Chesapeake Bay (Virginia), in the spring of 1825, and were spread on Round Shoal, which had been barren of oysters, off the town of Prince's Bay, Staten Island. Apparently, the oysters did well and the planter recovered a large portion of them the next fall, because in the ensuing years, more planters did the same. Quantities of oysters were imported from Virginia, mostly from the James, York and

Rappahannock rivers. The oysters were transplanted to Raritan Bay during March and April.

Eventually, a large number of schooners (most had two masts but a few had three or four masts) and some sloops were employed for transporting the oysters (Fig. 2). The schooners had a captain (45 to 70 years old) and a crew of four young men. Onboard, they subsisted on salted and smoked meats, and canned and dry foods. It took a schooner 35 to 40 hours to sail from Raritan Bay to Chesapeake Bay, two days to load with from 2,500 to 3,500 bushels of oysters, and another 35 to 40 hours to return to Raritan Bay. Sailing was done by day and night. If the local tongers were unable to work because the weather was bad, the schooners had to remain longer in the rivers. During such delays the crew watered the seed to keep it alive.

In Chesapeake Bay, the seed oysters were gathered by men in boats using tongs. The tonging boats had a crew of two. Usually, the two gathered about 125 bushels of rough culled seed (it was mixed with small quantities of shells) in six to seven hours on days with good weather.

When a schooner from Connecticut, Raritan Bay, Delaware Bay or another northern locality sailed into a river, such as the James, its crew dropped the anchor and, if the schooner was unknown to the tongers, raised an empty basket up the mast as a signal that it wanted to buy seed. As many as 20 boats tied up alongside the schooner to sell seed. The schooners had four loading sites; each was termed a fall. A boom and bushel container was lowered from each fall to the tonging boats for transferring seed to the schooner. The bushels were tallied as they were dumped on deck; the tongers received about 15 cents in the early years and 35 cents in the later years per bushel for the seed oysters, and they were 'paid on the spot'. A schooner which carried 3,000 bushels of oysters bought about 24 loads (assuming each consisted of 125 bushels) from the tonging boats. When the schooner was loaded, the anchor and sails were raised and the captain headed for Raritan Bay. The oysters were known as 'Virginia seed', 'Chesapeakes', 'soft' and 'fresh' oysters.

Some seed from northern estuaries was also imported to Raritan Bay. Most of it was gathered by men in skiffs using tongs.

The principal ports for oyster boats in Raritan Bay were Prince's Bay, and Perth Amboy and Keyport, New Jersey (Fig. 3). In addition, coastal towns on Staten Island, such as Tottenville, Chelsea, Mariners Harbor and Port Richmond had fleets of boats; Mariners Harbor had about 100 boats.

Bedding the oysters

When a schooner arrived in Raritan Bay, the captain headed for a designated bed to plant the oysters. The schooner sailed back and forth over the bed while the oysters were being shoveled overboard to spread the oysters as evenly as possible. Probably, the planters experimented with different planting rates. Taking a typical spreading density used currently of about 750 bushels of seed per acre, a schooner-load of 3,000 bushels of seed would cover four acres of bottom. The Virginia seed was left on the beds for one growing season. On most beds, the entire quantity of oysters was harvested and sold each fall. Thus, the beds were clean for a new crop of seed the following spring. Any plantings of small northern seed were left on the beds for an extra year or two, however, to allow them to grow. Usually, planters

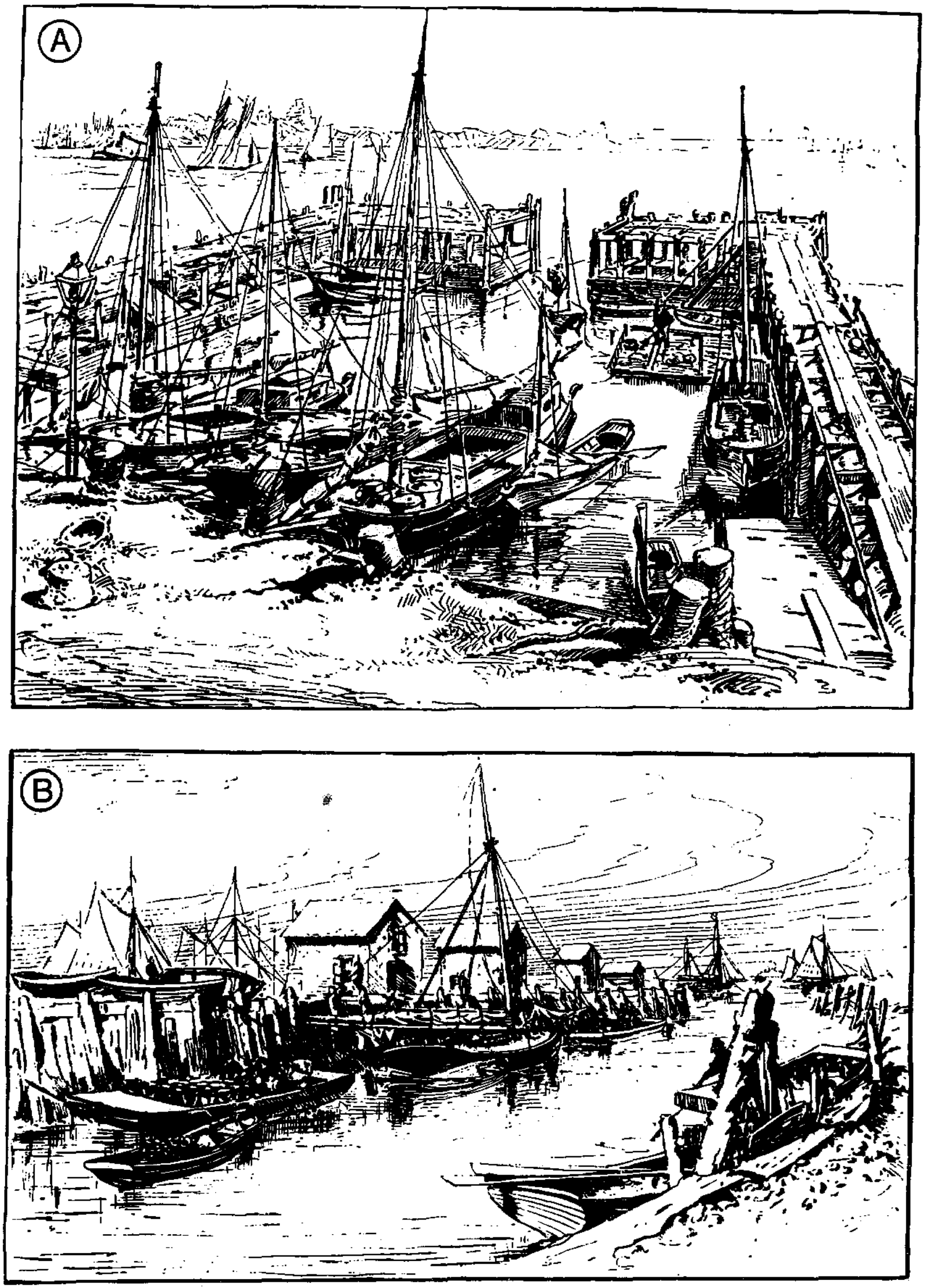


Figure 3. (a) Enclosed boat basin at Perth Amboy, New Jersey. The cluster of boats at upper right, probably represents a group of men tonging oysters from skiffs at Ward Point. (b) The creek at Keyport, New Jersey. The illustrations show sloops, skiffs and oyster floats (from Ingersoll 1881).

spread the small northern seed over the beds with relatively soft bottoms and later transplanted it to beds which had hard bottoms for the final growing season. The Virginia oysters were planted on the hard bottoms. One report stated that a planting of Virginia oysters increased 40 percent in volume from planting to harvesting (average yields were probably at least 1 to 1, i.e., one bushel of seed yielded at least one bushel of market oysters). Another report stated that a company in Keyport bought Virginia seed one spring for $150,000 and sold the harvested oysters resulting from it during the subsequent fall for $500,000. During the season of 1879-80, oyster production from Raritan Bay was estimated at 430,000 bushels.

When the bedding of oysters began, no system of leasing bottoms existed. In the beginning, a planter staked the boundaries of a plot with hemlock poles (many poles were later anchored in place with 200-pound cement stones) and claimed that the oysters which he had planted on it were his. Such claims were often disputed, and they were brought to the courts to be settled. The courts ruled that if a person staked a plot and planted oysters on it, his claim would be upheld. The claim system gradually evolved into a formal granting system, under which individuals had the legal right to hold oysters on designated sections of bottom. Leases ranged from a fraction of an acre to about 100 acres (Fig. 4). Planters who held a lease at Ward Point had to pay $1.00 a year for it, because the bottom there was especially good (hard) for oysters; however, planters holding leases in other locations did not have to pay for them.

Eventually, two Raritan Bay areas were leased to planters; one was in New York and extended about 10 miles long and five miles wide off the Staten Island coast at depths of mostly 8 to 25 feet, and the other was off Keyport (Fig. 5). Oystering became a large commercial industry and many individual planters formed companies. Some companies held a number of leases, and companies which held leases in other states, such as Connecticut, also held leases in Raritan Bay. As many as 1,000,000 bushels of oysters were spread over the beds each spring (more typical quantities may have been closer to 300,000 to 500,000 bushels). Some of the beds with soft, muddy bottoms were not planted. The setting of oyster spat on the imported oysters was sparse, and did not contribute much to the quantity of oysters produced. Probably, the Chesapeake Bay oysters did not spawn in the colder waters. Spat setting may have been denser than believed; much of the spat could have been killed by oyster drills and rock crabs before it was noticed. Starfish (*Asterias forbesi*) which cause much damage to oysters in Connecticut are scarce in Raritan Bay, and apparently did little damage to the oysters. Temperatures above 73°F have an adverse effect on starfish (MacKenzie 1970), and in Raritan Bay temperatures rise above that in midsummer (see Fig. 6).

Some hazards threatened the oyster plantings. A summer with several major storms and large freshets seemed to produce thinner oysters than a calm summer. Severe easterly storms buried some of the oysters. Old Orchard Shoal was the most exposed to storms and thus the most dangerous ground on which to plant oysters. In the early 1900s, one company planted only four-year-old oysters brought from Milford and New Haven, Connecticut to Raritan Bay; they were planted in the spring and harvested in September before storms could bury them. At times, schools of black drum (*Pogonias cromis*) entered the bay and ate some oysters. Some poaching of the oysters occurred and public fishermen tried to dig clams on the oyster leases. To protect their oysters, the

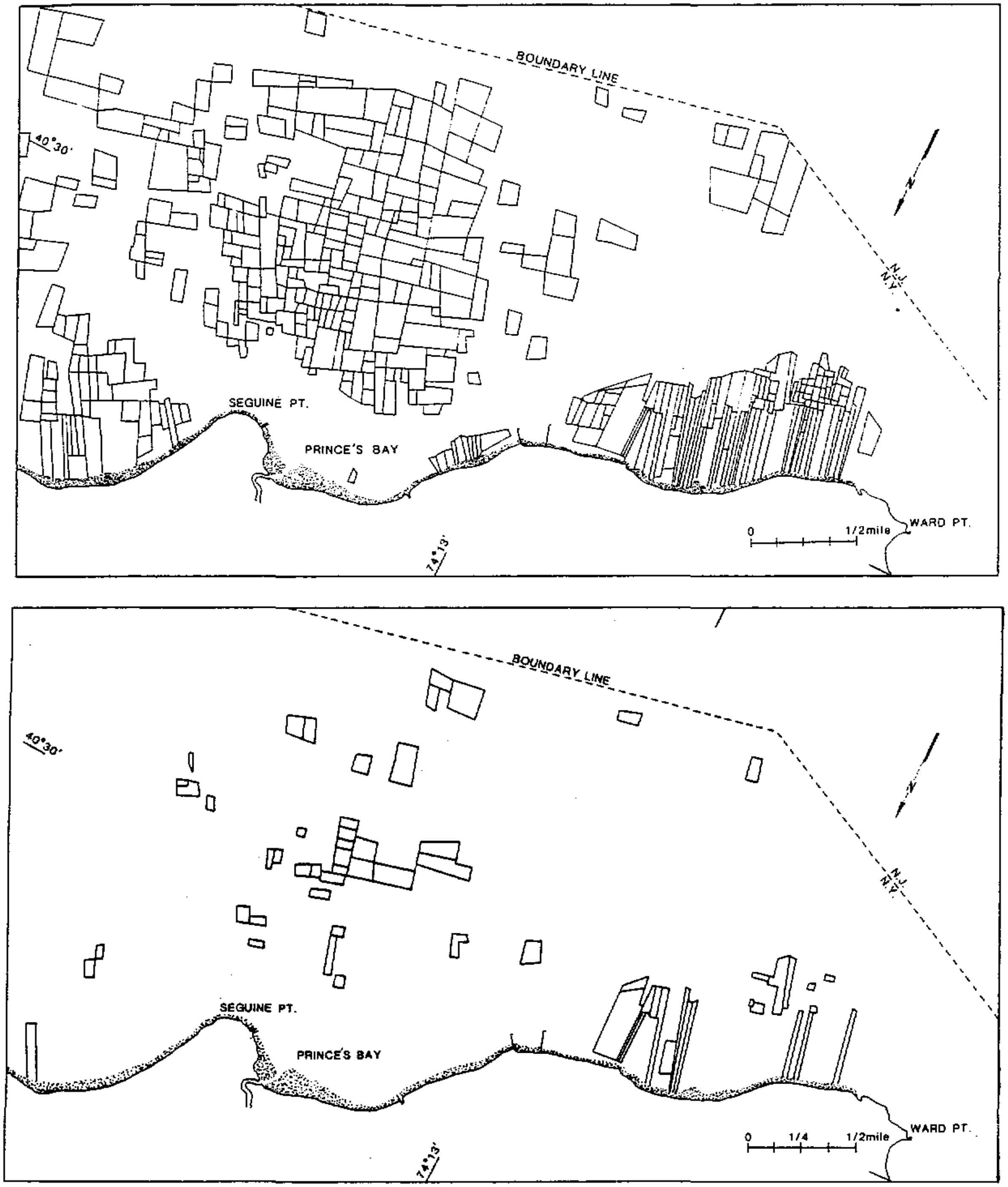


Figure 4. (a) Leased beds off Prince's Bay (Round Shoal) and Ward Point, Staten Island, in Raritan Bay in 1917. (b) Same area as (a) in 1937 after the industry was closed down because the water was polluted.

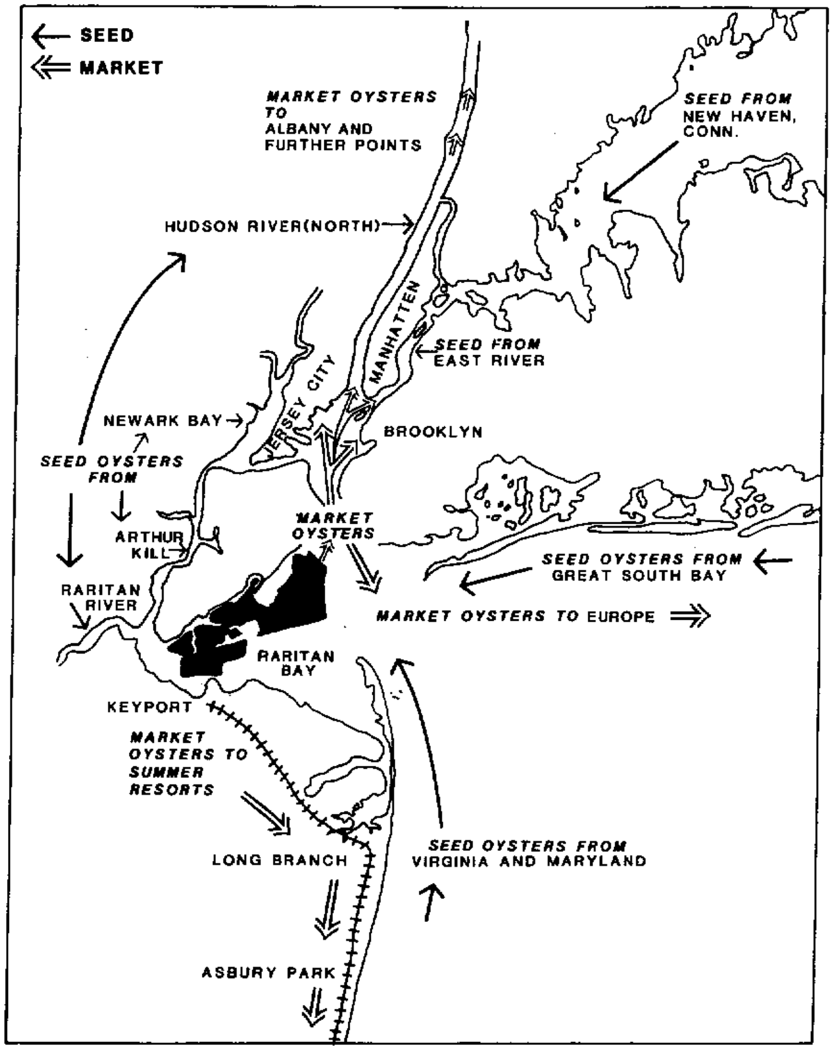


Figure 5. Locations of leased oyster beds (shaded areas) in Raritan Bay. Sources of seed oysters for the leased beds (single arrows) and marketing routes (double arrows) in the late 1800s.

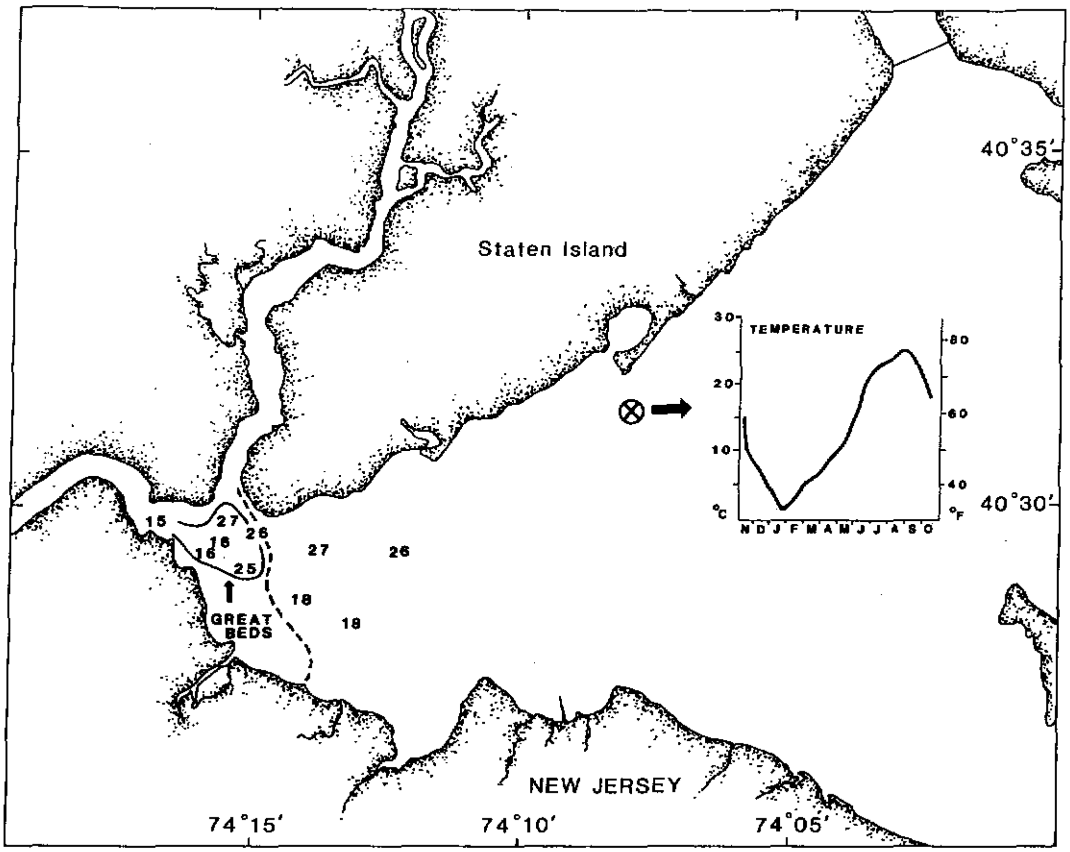


Figure 6. Salinities and temperatures in Raritan Bay. Arrow points to the limits of the Great beds. Dashed line is hypothetical 15 ppt line at the end of the ebb current in late March-early April in the pre-colonial period. The numbers correspond to bottom salinities at the end of the ebb current in late March 1984. The graph shows bottom temperatures, monthly, for a year. (Temperature data provided by A. L. Pacheco).

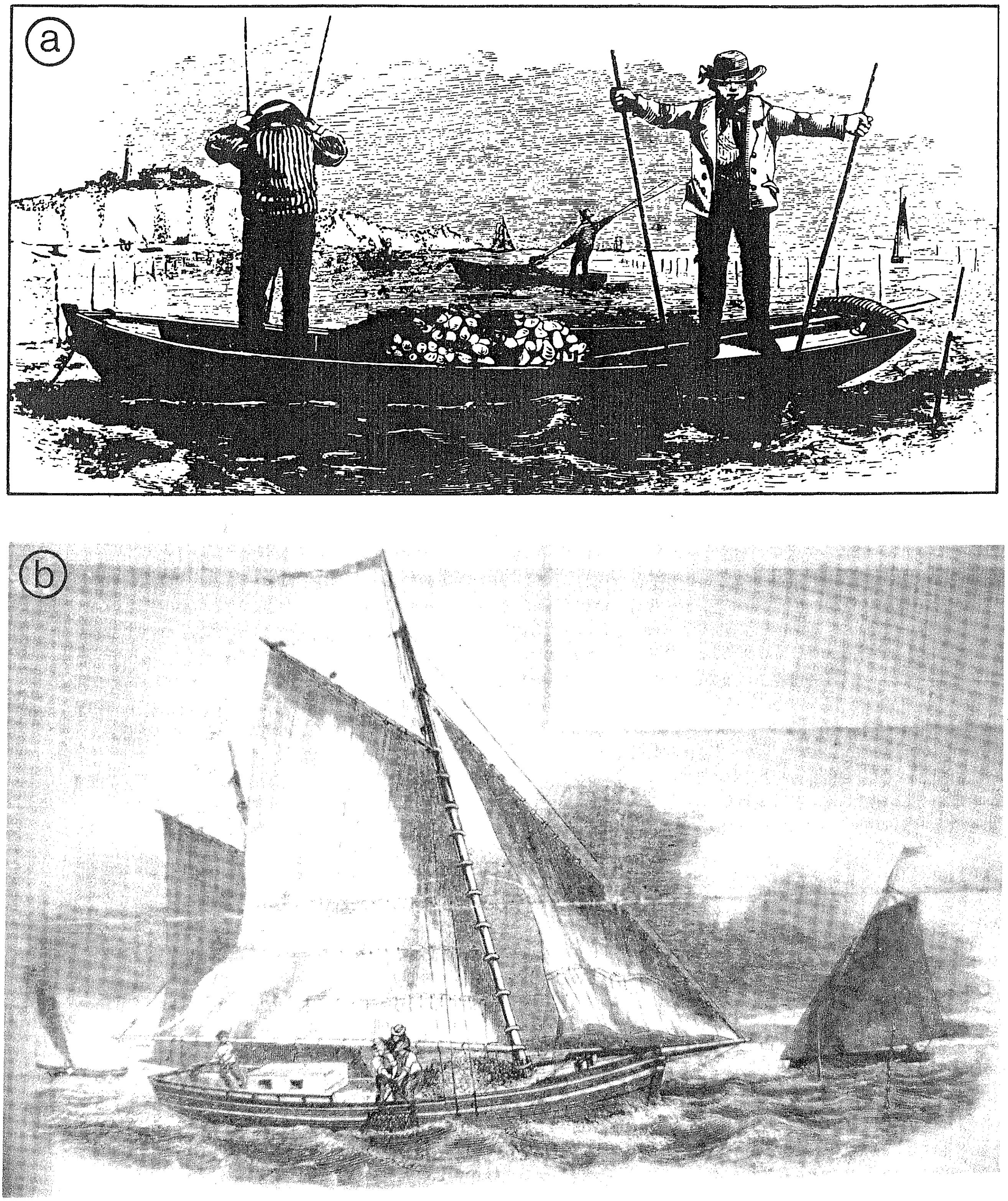
leaseholders founded oyster planting associations on Staten Island and Keyport in the 1870s and 1880s. The associations hired watch boats to patrol the beds at night.

Use of Chesapeake Bay and Northern Seed

During the Civil War, schooners were restricted from sailing to Chesapeake Bay because it was feared they might carry messages or otherwise aid the southern military forces. Thus, the oyster planters had to obtain seed oysters in the North. Following the war, the importation of Chesapeake Bay seed was resumed and thereafter about three-fourths of the seed came from Virginia and Maryland. Sources included Hampton Roads, the James, York, Rappahannock, and Choptank rivers, Tangier Sound, and Chincoteague Bay, etc., and came from public and private beds. The seed varied in price from 15 to 60 cents per bushel. In addition, the planter paid about $300 for each boat load, of perhaps 3,000 bushels, for transportation, and about $48 more for spreading the oysters on the beds. The remaining fourth of the seed, which sometimes totalled about 250,000 bushels, was from northern areas: the Raritan River, Arthur Kill, Newark Bay, the Hudson River (then known as the North River) and the East River and sold for about 50 cents a bushel. Northern seed was also imported from Great South Bay on Long Island and Connecticut (Fig. 5). The Connecticut seed was transplanted with engine-powered boats after 1900. Connecticut had imported most of its seed from Chesapeake Bay but became a seed producing area when it was discovered that spat would set in quantity on beds after the shells of Chesapeake Bay oysters were spread over the bottom. Seed was also imported from Delaware Bay in small amounts. In March and April, hundreds of men in skiffs tonged or raked up seed oysters in the Arthur Kill and Newark Bay for planting in Prince's Bay and other parts of Raritan Bay. The boats employed in transporting oysters from the Hudson River and Newark Bay to Raritan Bay were captained by the proprietors of leased beds and usually had three deckhands. The northern seed grew into superior shipping oysters and these were the oysters selected for shipments to the Midwest and Europe.

Marketing the Oysters

The principal oyster marketing season began on September 1 and ended around Christmas. Most oysters were harvested by tonging from skiffs (Fig. 7a), near a sloop anchored on the beds. The tonging skiffs were 21-26 feet long and 5-6 feet wide. Rakes with long slender handles, similar to the bull rakes used now for clamming, were also used to harvest the oysters in relatively deep water. The tongers culled the oysters from shells and refuse and transferred them to the sloops. The sloop carried the men to and from the bed and along with the oyster catch (a sloop-load consisted of 200 to 800 bushels of oysters). When oysters became scarce, sloops dredged most of the remaining oysters off the beds. For a long time, the sloop's dredges were hauled arduously by hand; one-bushel dredges were hauled by one man, three-bushel dredges by three men (Fig. 7b). Eventually, some sloops were fitted with hand winders for pulling in the dredges, but winding was slower than hand hauling, and some vessels retained the hand hauling method. One practice was to allow men, called gleaners, to tong and dredge up any oysters that remained on the beds on 50:50 shares. Usually, gleaners had two to three weeks of work, earning $4 to $5 a day. Later, the gasoline engine substantially improved the efficiency of boats. The first engine-powered oyster boat was built in 1896 and by 1910 every oyster company on Raritan Bay had at least one



DREDGING FOR OYSTERS, STATEN ISLAND — Gleason's Ill. News, 1853

Figure 7. Harvesting oysters in the 1850s. (a) Tonging for oysters in Prince's Bay. The rake in the skiff was used for harvesting oysters in deep water (from: Ballou's Pictorial Drawing-Room Companion 1855). (b) Hauling in a dredge full of oysters on a sloop (from: Gleason's Illustrated News, 1853).

engine-powered oyster boat equipped with dredges hauled in by power. Probably, most oysters were harvested by power boats after 1910.

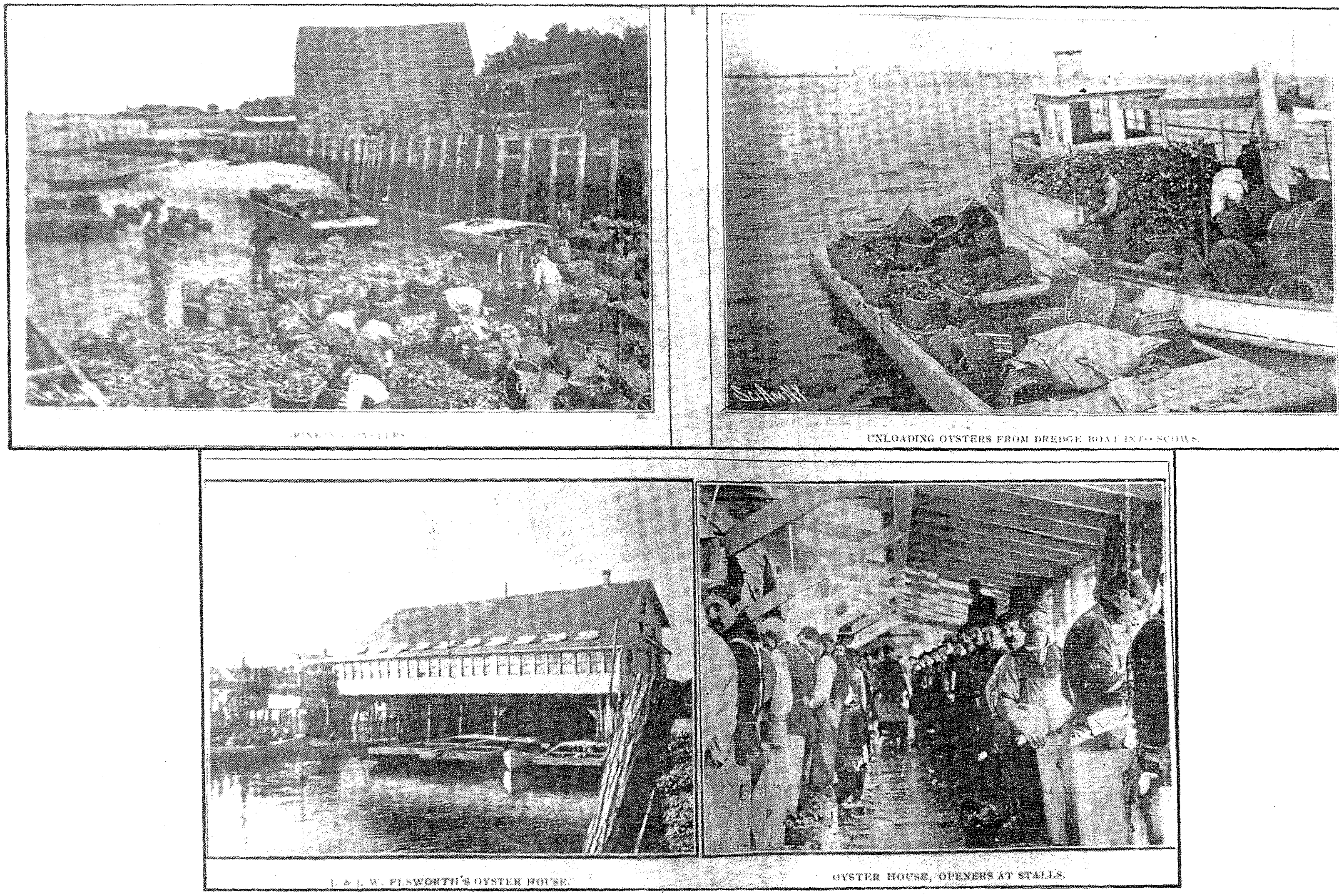
When the harvested oysters were brought ashore, they were put in floats in brackish water creeks and held there for a single change of high tide or overnight, 'to give the oysters a drink'. The floats were about 25 to 35 feet long, 20 feet wide and 16 inches deep (Fig. 8). In the floats, the oysters opened and flushed out any mud and sand; 'drinking' oysters made their flesh whiter, freshened their flavor and when shucked increased the volume of a gallon of oyster meats by about a pint. Oysters were 'given a drink' in Lemon Creek in Prince's Bay and on the flats off Mariners Harbor on Staten Island, in Keyport Creek and the Rahway River in New Jersey and probably other localities (Fig. 1). Oysters were held in the floats for a longer period if they did not whiten or the landing port had a temporary oversupply. (The practice of 'drinking' oysters in floats around Raritan Bay and New York was abolished during the period of the typhoid fever scares. Since then, oysters along the Atlantic coast have been washed in sterile stainless steel tanks containing fresh water. The tanks are called 'blowers' because air is forced into the bottom of the tanks to agitate the oyster meats.)

In Keyport, many of the oysters were shucked in three large oyster houses (Fig. 9), and each had a huge pile of oyster shells beside it. Some of the shells were spread on the beds in July to collect a set of spat. Shells were also used to make roads in Keyport and nearby towns, sold to the poultry industry, which crushed and fed them to chickens for hardening egg shells, and to make lime for farms (apparently, the inshore beds in Keyport collected some natural sets of spat, but the beds on the Staten Island side of the bay may not have collected much set because no reports mention the spreading of shells there to collect spat).

The oysters were taken from the floats, put in oak baskets, which the industry used by the thousands, loaded onto sloops or passenger steamers (Fig. 10) and taken to New York City and other markets (Fig. 5). (Usually, large schooners were used to transport seed oysters from Chesapeake Bay to Raritan Bay, while sloops were used to carry market oysters from the bay to New York.) The sloops heading for New York had to wait for the flood current in the Hudson River because they could not sail against the ebb. Any oversupplies of oysters brought to New York were also held in floats. Apparently, most Raritan Bay oysters were sold in Manhattan, where the sloops unloaded them onto oyster barges, scows and other oyster vessels at Broome Street in the East River, and Tenth Street and Charles Street in the Hudson River (Fig. 11). Oysters from other areas were received there also. On the barges, most oysters were packed whole for sale to the half-shell trade, but some were shucked. Oysters destined for the half-shell trade were graded into four sizes and sold to wholesalers. Landed prices received for oysters varied according to their sizes and to some extent their sources. In 1840, average prices received for Raritan Bay oysters of various sizes were:

-Extras	$15 to $25 per 1,000
-Box oysters	$7 to $10 per 1,000
-Cullens	$3.50 to $5 per 1,000
-The poorest	50 cents per bushel

Figure 8. Floats of the type used to clean, fatten and whiten Raritan Bay oysters after they were harvested. Photos taken in Bivalve (Delaware Bay), New Jersey (from: Undersail - the Dredge Boats of Delaware Bay [used with permission of Wheaton Village, Millville, New Jersey]).



UNLOADING OYSTERS FROM DREDGE BOAT INTO SCOWS.

J. & J. W. ELSWORTH'S OYSTER HOUSE.

OYSTER HOUSE, OPENERS AT STALLS.

Figure 9. View of the oyster industry at Keyport, New Jersey around 1910. Photo at upper right shows dredge boat with load of oysters being transferred to a scow for transport into Keyport creek. The dredge boat operated with an engine and the dredges (8 bushel capacity) were pulled in over rollers by engine. Note the post which replaced the mast. Photo at upper left shows the 'drinking' of oysters; apparently, the oysters were left in baskets for 'drinking'. Photo at lower left shows an oyster house; the oysters were lifted into the house through holes in the floor. Photo at lower right shows some of the shuckers in the oyster house; they opened 50-100 thousand gallons of oysters a year. The oyster house, which opened in 1900, discontinued operations in 1926. (Photo composite courtesy of Keyport Historical Society).

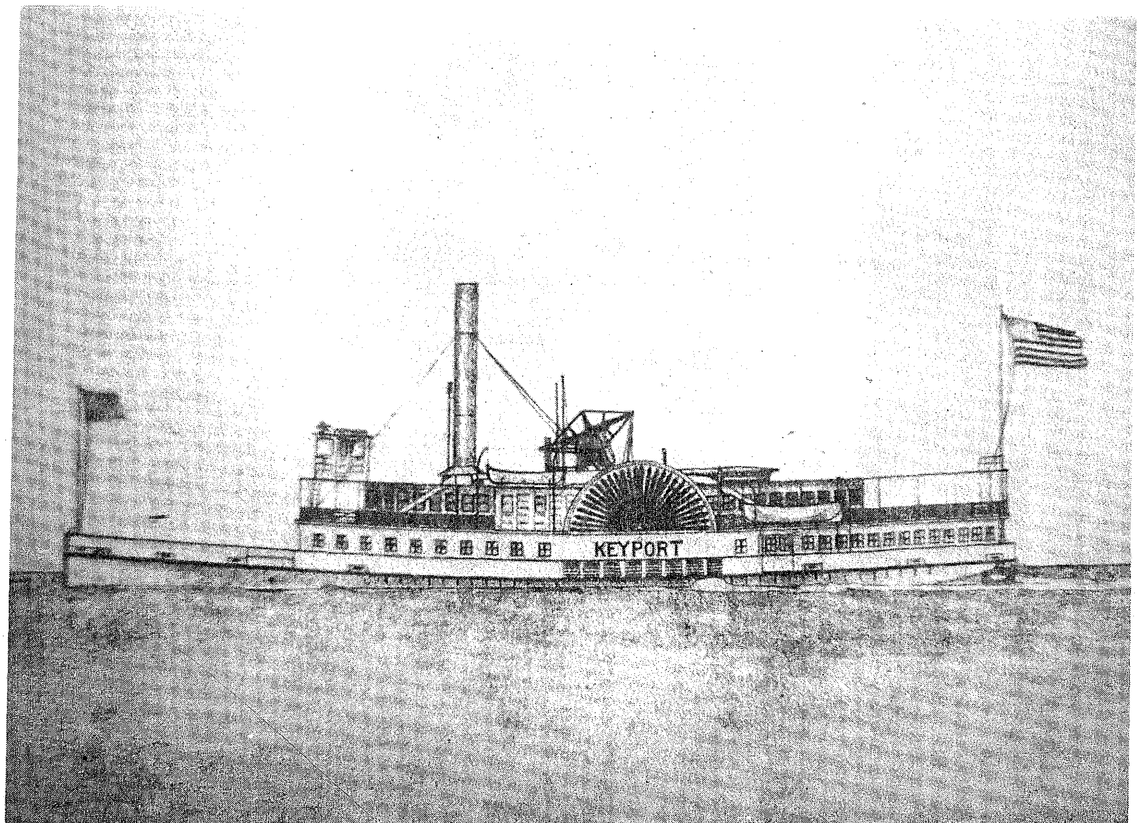


Figure 10. A steamer which transported passengers between Keyport, New Jersey and New York City also carried oysters to the city.

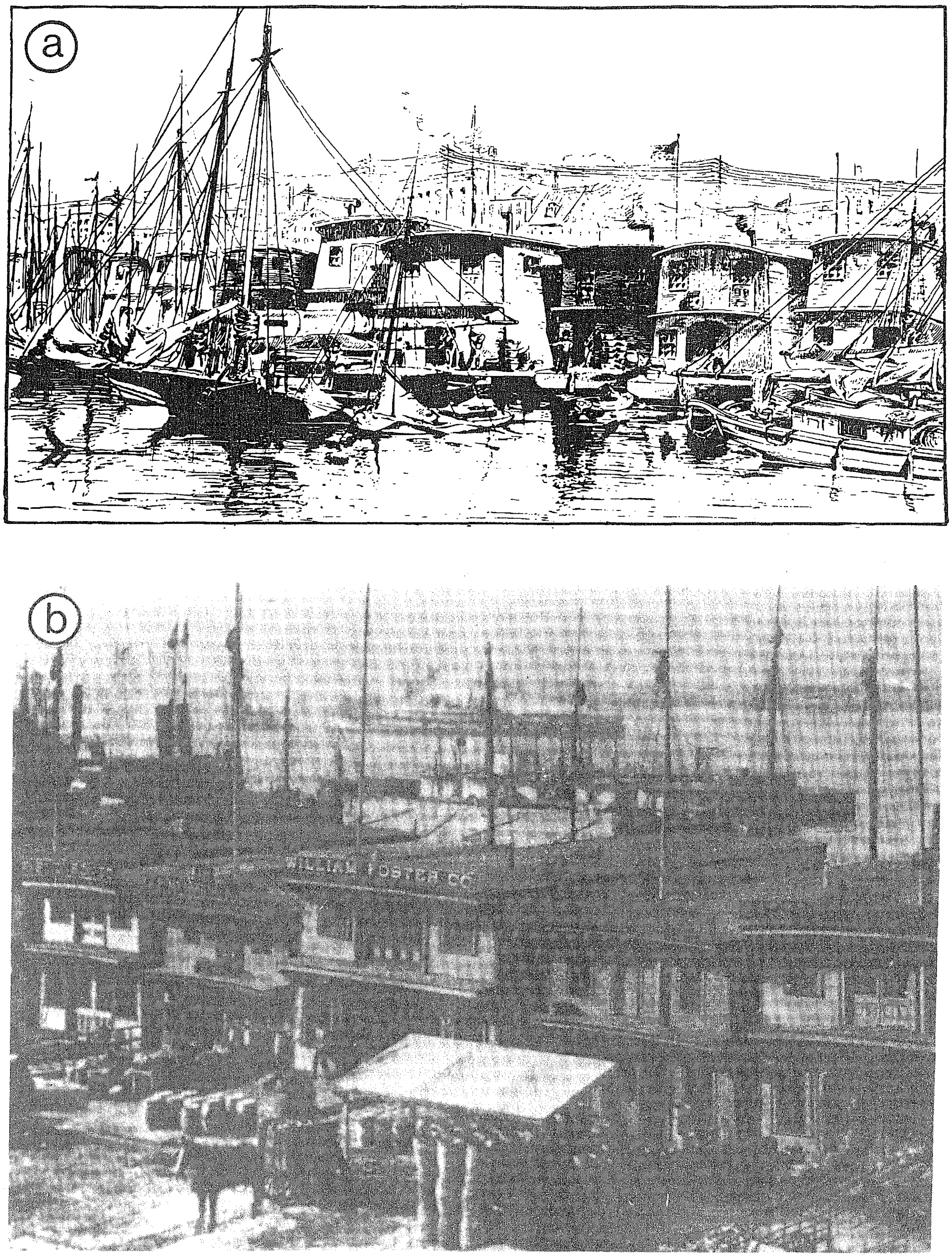


Figure 11. Oyster barges in Manhattan, New York City, where oysters were received from sloops, packed in barrels (some were shucked), and then put on horse-drawn wagons for delivery to points in the city. A barge could handle about 700 bushels of oysters a day. (a) The barges as seen from the river, showing the sloops which delivered the oysters (drawing from Ingersoll 1881). (b) The barges from land, showing a horse-drawn wagon and barrels of oysters (photograph from the Oysterman and the Fisherman 1912).

Oysters were also marketed at other locations along the Hudson River, including Jersey City, Brooklyn and towns above New York and Albany. Sometimes, as many as 40 sloops were tied up unloading oysters in Albany. Some oysters landed in Albany were taken by wagons and boats via the Erie Canal to Buffalo. Before the railroads came into being, oyster growers visited towns on the Hudson River early in the fall for orders which were filled before ice formed in the river. Quantities of Raritan Bay oysters were also shipped overland to the Midwest and West Coast and also Europe, mostly England.

During summer, some oysters were harvested to supply New Jersey tourists at sea coast resorts south of Sandy Hook, such as Long Branch and Ocean Grove. For this market, the oysters were landed at Keyport and delivered by rail. The oysters shipped by rail were packed in barrels (three-bushel capacity). Raritan Bay oysters were known as 'Sounds' (in the 1800s, the Arthur Kill was known as Staten Island Sound), 'Prince's Bays', 'Keyports' and 'Amboys'. They were relatively fat, and had excellent keeping qualities when stored out of water.

Most activity on the oyster beds occurred during the fall harvesting season, less during the spring planting season, and little in summer and mid-winter. In the fall, the western end of Raritan Bay was said to have an 'uncountable number of skiffs and sloops harvesting oysters from the beds amidst a forest of oyster stakes that were so numerous they were difficult to sail through'.

Effect of the Industry on Local Economies

The local economies of Raritan Bay were substantially fostered by the development of the oyster industry. Human populations on the northern and western sides of the bay grew along with the oyster industry. The population of Staten Island, which had been relatively small, grew considerably as a result of the work generated by the oyster industry. Nearly all families in the southern half of the island were involved in some phase of oystering, mostly handling oysters on the beds and ashore. But other phases existed. For example, Tottenville had a shipyard in which sloops and schooners were built. (Some engine-powered oyster boats also built there remain active in Long Island Sound in the 1980s.) Keyport had 23 planters and 89 men worked for them on the water. The workers tonged oysters on the beds and then handled oysters in floats and baskets in Keyport Creek. In addition, scores of men shucked oysters. Keyport had a factory which made baskets for the industry and two kilns for making lime from oyster shells for farms. Communities had blacksmiths who made gear for the oystermen and farmers. Grocery and hardware stores were supported in part by the trade of people in the oyster industry.

In the 1850s an estimated 1,000 to 3,000 people were supported by the industry and 400 ships and sloops worked on the beds. Investment capital was in the millions of dollars, and the richest Staten Islanders were oystermen. The Raritan Bay oyster industry did well economically because the bay had excellent hard bottom for raising oysters, large supplies of seed oysters were available for planting, oysters grew fast, yields were good, oysters became fatter than those in most other estuaries and large markets were nearby.

Pollution and the Demise of the Industry

The oyster industry in Raritan Bay prospered until about 1910, when the water in New York Harbor started to become polluted. Newspaper reporters traced cases of typhoid to Raritan Bay oysters and in 1918, a typhoid fever outbreak made more than 15,000 people sick and resulted in 150 deaths. The outbreak was traced to the consumption of shellfish, much of it from Raritan Bay. The bay was temporarily closed to oyster and clam harvesting. (Much of the contamination of oysters may have occurred while they were held in floats in Lemon, Keyport and Rahway Creeks, Mariners Harbor and alongside the oyster barges in New York.) The negative publicity caused the oyster wholesalers to abandon the Raritan Bay oyster industry since they were reluctant to assume the financial risk for building boats and buying Chesapeake Bay seed oysters. The industry limped along, threatened by pollution scares, until about 1925 when it more or less closed down.

Effect of the Closure on the Oystermen

The closure of the oyster industry plunged the oystermen into a depression. It was especially hard because the men had investments in their boats and gear which could not be used to any substantial extent for other purposes. Attempts were made to lift the closure (the oystermen who were having difficulty finding acceptable alternative employment got politicians to lend their help) and some were temporarily successful, but closures followed each time because more illnesses were traced to Raritan Bay oysters. Most men had to turn to other local jobs, or move elsewhere. Thus, the closures displaced many oystermen and their families, eliminated small family leaseholds and shore-based enterprises which had supported the oystermen, and diminished the quality of rural coastal life.

The larger oyster companies which had beds in other states were allowed to transplant their oysters from Raritan Bay to the other beds for cleansing. Most oysters were transplanted to Gardiners Bay in eastern Long Island and Narragansett Bay, Rhode Island. By that time a railroad ran from Greenport to New York City which transported market oysters to the city.

Effect of the Closure on Consumers

Since the Raritan Bay oyster industry produced only a small percentage of the total oysters at the time, the closure had only small effect on the oyster market. New York, its chief market, was already obtaining most of its oysters from other sources, i.e., Connecticut, Long Island, Delaware Bay and Chesapeake Bay. Probably, some people missed the locality names and the taste of Raritan Bay oysters.

During the 1880s and 1890s, the railroad industry developed refrigerated railroad cars, which made it possible to ship huge quantities of chilled beef and pork from the Midwest to eastern cities (Walsh 1982). The meats competed with oysters as a source of protein. Since about 1900, the decline in oyster production has been caused, in part, by a reduced demand. How much of the reduced demand resulted from a fear of disease is not known. In recent years, shellfish, including oysters, and fish have been shown to be more healthful than meats; they contain unsaturated fats and smaller amounts of cholesterol. Thus, the demand for seafood has risen in relation to meats.

ENVIRONMENTAL OBSERVATIONS

Effects of Oyster Plantings Upon the Environment

The plantings of oysters across the western and northern portion of Raritan Bay must have had an enormous effect upon the biota of the bay. The almost continuous populations of oysters resulted in a huge increase in the surface area of the bottom. Oyster clusters project as much as 6 inches above the bottom, each with a much larger surface area than the bottom below it. Moreover, the new substrate was shell rather than sand or mud. It provided a larger environment for such shell encrusting species as filamentous diatoms, sponges, bay anemones (Diadumene leucolena) (Fig. 12), bryozoans, slipper shells (Crepidula sp.), mussels (Mytilus edulis), barnacles (Balanus sp.), polychaetes and others. Beds of oysters also provided cover for mud crabs, hard clams (clams are most abundant under oysters which protect the seed from predation) and hake (Urophycis sp.). All of the associated species could occur in greater abundance after the oysters were present than they had on the sand bottom without oysters. Since many species are fish prey, more fish probably inhabited Raritan Bay. It has been shown in other areas that oyster beds contain a larger mass of invertebrates and fish, such as cunner (Tautogolabrus adspersus) and summer flounder (Paralichthys dentatus) than exists on sand bottoms nearby (Arve 1960; MacKenzie 1981). Probably, the invertebrates which require open, sandy bottoms declined in numbers where the oysters were planted. Most biota associated with the oysters were tonged or dredged up with the oysters and died during the fall, but new generations settled on the new crop of seed oysters during the following spring and summer.

The feeding by oysters and encrusted animals must have also had a substantial effect on other biota of the bay. They would have removed quantities of phytoplankton from the water; a large oyster, 4 to 5 inches long, for example, can transport from 9 to 48 quarts of water across its gills daily for feeding and respiration (Galtsoff 1964). Moreover, the quantities of feces and pseudofeces which they produced would have provided a rich environment for benthic bacteria, protozoans and other invertebrates.

The presence of oyster stakes attached to the cement stones which marked the corners of oyster beds provided a habitat of their own. A variety of encrusting organisms attach in a continuous layer to these substrates, and certain fish, such as the cunner, remain around such objects.

One can only speculate about other effects. Did the importation of oysters from Chesapeake Bay, Long Island Sound and other areas introduce any new species into Raritan Bay, and did the presence of oysters act to slow water currents in the bay?

Various Impacts upon the Oyster's Environment

The adverse impacts of man's activities upon the oyster environment can be considered in four categories. In the order of occurrence, the impacts were: 1) increased silt inflow, 2) dredging of channels, 3) increase in salinity and 4) water pollution. Some conclusions about impacts are speculative because until recently no quantitative records were available.

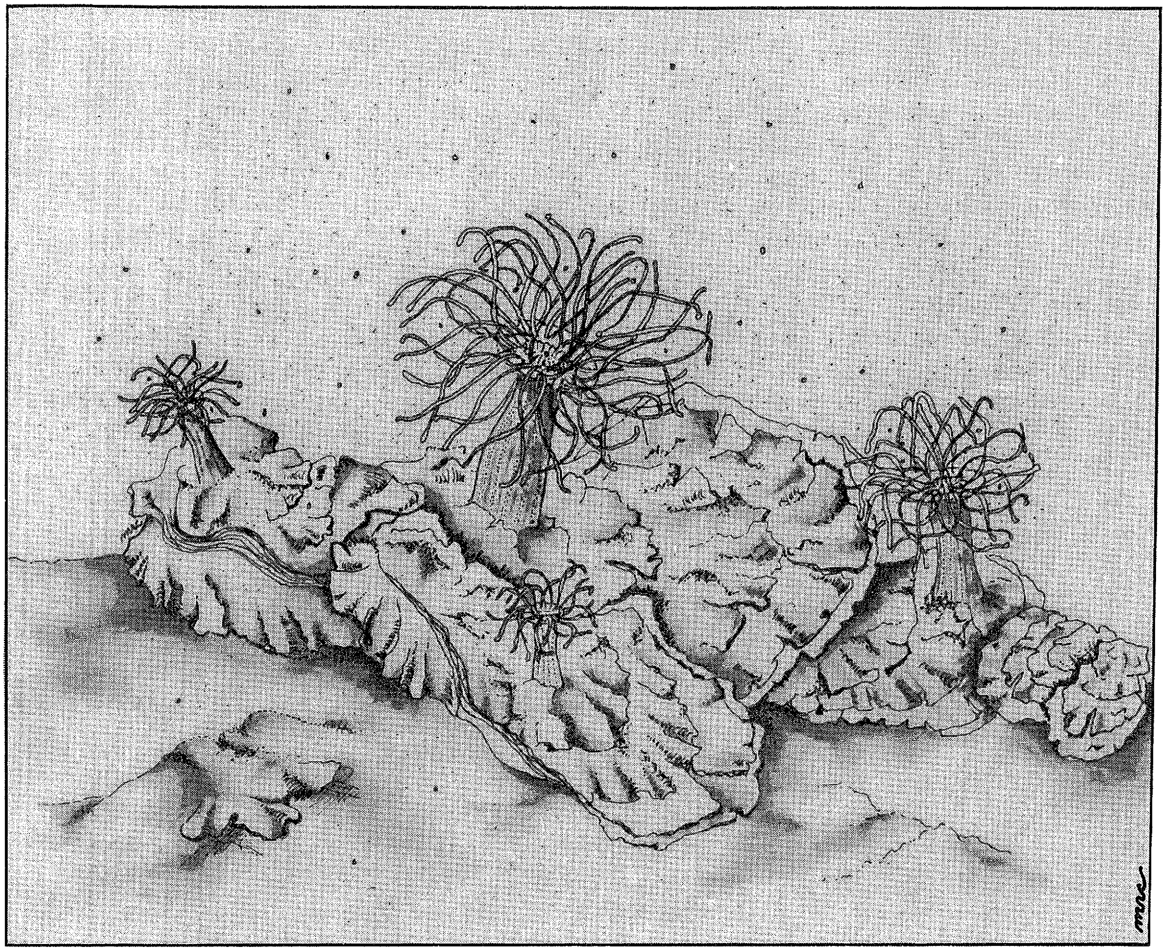


Figure 12. Bay anemones, which prey on the larvae of oysters and other invertebrates, are abundant in the western third of Raritan Bay.

1. Increased silt inflow

When colonists populated the drainage area of the Raritan River, they cut down trees and plowed land to establish farms. Thereafter, a great deal of erosion of sediment occurred. As sediments were carried into streams, the larger particles settled out early, but much of the silt and clay remained in suspension until it reached the mouth of the river and entered Raritan Bay. Here, the current flow was considerably reduced and much of the sediment settled to the bottom. The presence of oysters on the bottom tends to accumulate silt because the oysters act as baffles which interrupt and reduce the flow. As mentioned earlier, a natural chain of oyster beds extended from a point about five miles upriver from the mouth of the river to about a mile eastward from its mouth (the Great Beds). Undoubtedly, the entire stretch of oysters accumulated quantities of silt beginning during the colonial period and continuing afterwards. In addition, a channel was dug in the Raritan River from its mouth to New Brunswick in 1837, and one was dug in the Arthur Kill in the early 1890s. The digging, which was done with clamshell buckets, removed quantities of oysters, destroyed part of the oyster's environment (oysters cannot grow in a channel bottom overlaid with mud), and released quantities of silt into the water which would have settled on the remaining oyster beds along the river and the Great Beds (Fig. 13a).

Silt, if present in quantity, can have a substantial adverse effect on oyster abundance. It fills any oyster shells positioned cup-side-up, covers the outer surface of shells lying cup-side-down on the bottom and accumulates around oyster clusters, sometines leaving only a small portion of the oysters exposed to water (Fig. 14). Thus, the presence of silt substantially reduces the available shell area of the bed on which oyster spat can set and grow, and consequently reduces the recruitment of oysters. Wherever silt accumulates more than about 3 inches over the bottom, the habitat cannot support oysters. Siltation is not mentioned in the literature as a factor in the decline of oyster production from the Great Beds, but it probably played a major role. Surveys made in the late 1970s showed that the bottom where the Great Beds were and the channel bottoms in Raritan Bay are now covered by at least several inches of soft mud. Moreover, following a spring rain, the water is completely dark from a meter or so below the surface to the bottom in the area of the Great Beds (Fig. 13b). Silt has probably accumulated in other sections of Raritan Bay. The areas shown on present charts that have mud or soft bottoms may have been somewhat smaller in extent, and the mud layer thinner, during pre-colonial times.

2. Dredging of channels

Figure 15 shows the dates during which the various shipping channels were dug in Raritan Bay, Raritan River and Arthur Kill. Most channelling occurred from 1890 to 1910 and was done with clamshell buckets. The dredging in the western end of the Bay, the river and the Kill must have destroyed quantities of oysters and eliminated much good oyster bottom. As mentioned earlier, quantities of silt were released during the dredging. Any effects of the channels on salinities and currents are unknown.

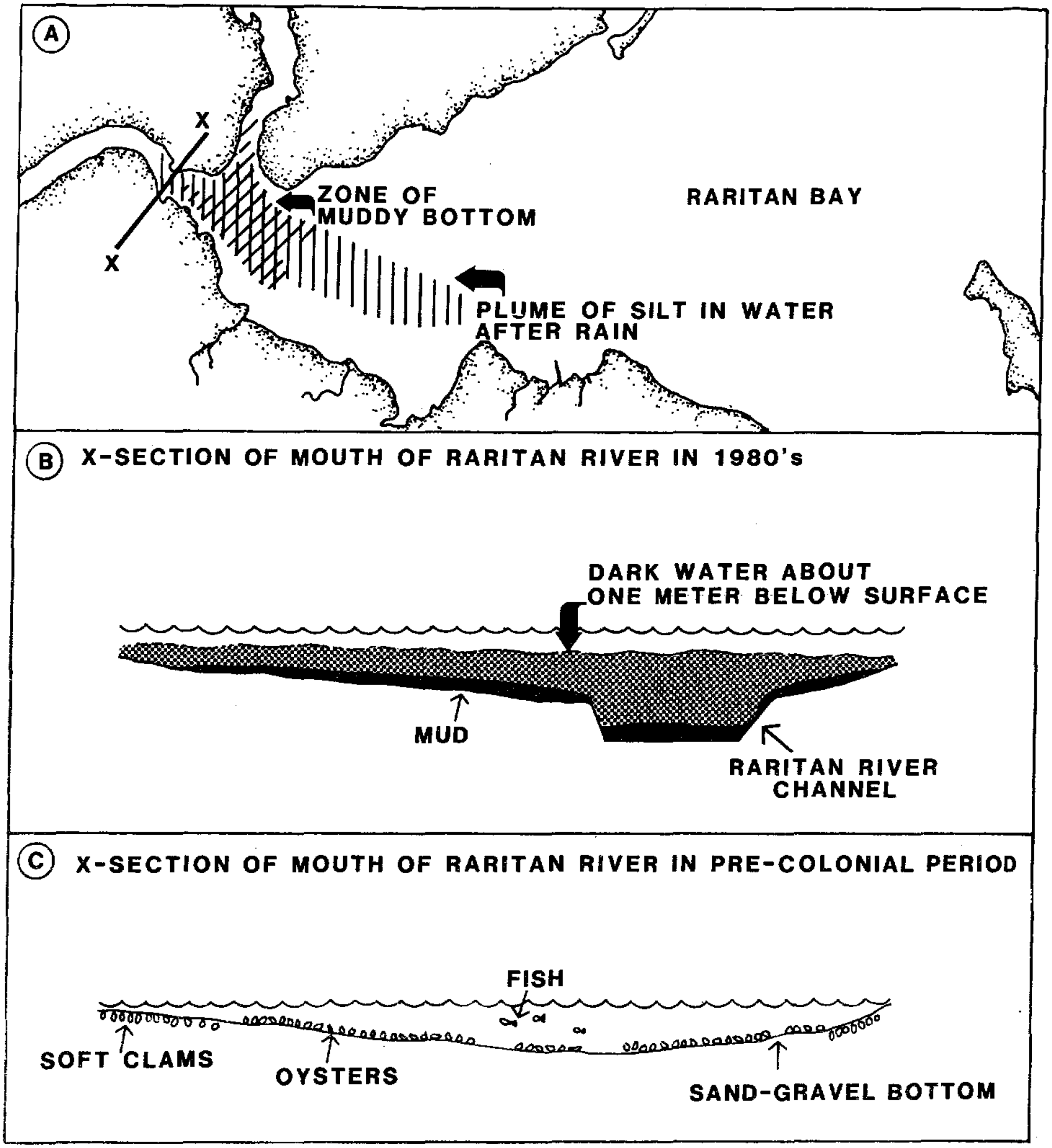


Figure 13. (a) Raritan Bay and surrounding area showing the present extent of muddy bottom just beyond the mouths of the Raritan River and Arthur Kill, and a plume of silt visible from the air following a rainstorm. (Note: such a plume varies in size and often covers most of the bay.) (b) view of the cross-section of the mouth of the Raritan River; a channel has been dredged, mud lies on the bottom, the water is dark, the salinity is higher, and the water and mud contain industrial wastes. The adverse environmental modifications in the Raritan River and Arthur Kill should be considered as a factor which reduced fish abundances in Raritan Bay. (c) probable view of the cross-section of the mouth of the Raritan River during pre-colonial times; oysters grew on the bottom in relatively clear water.

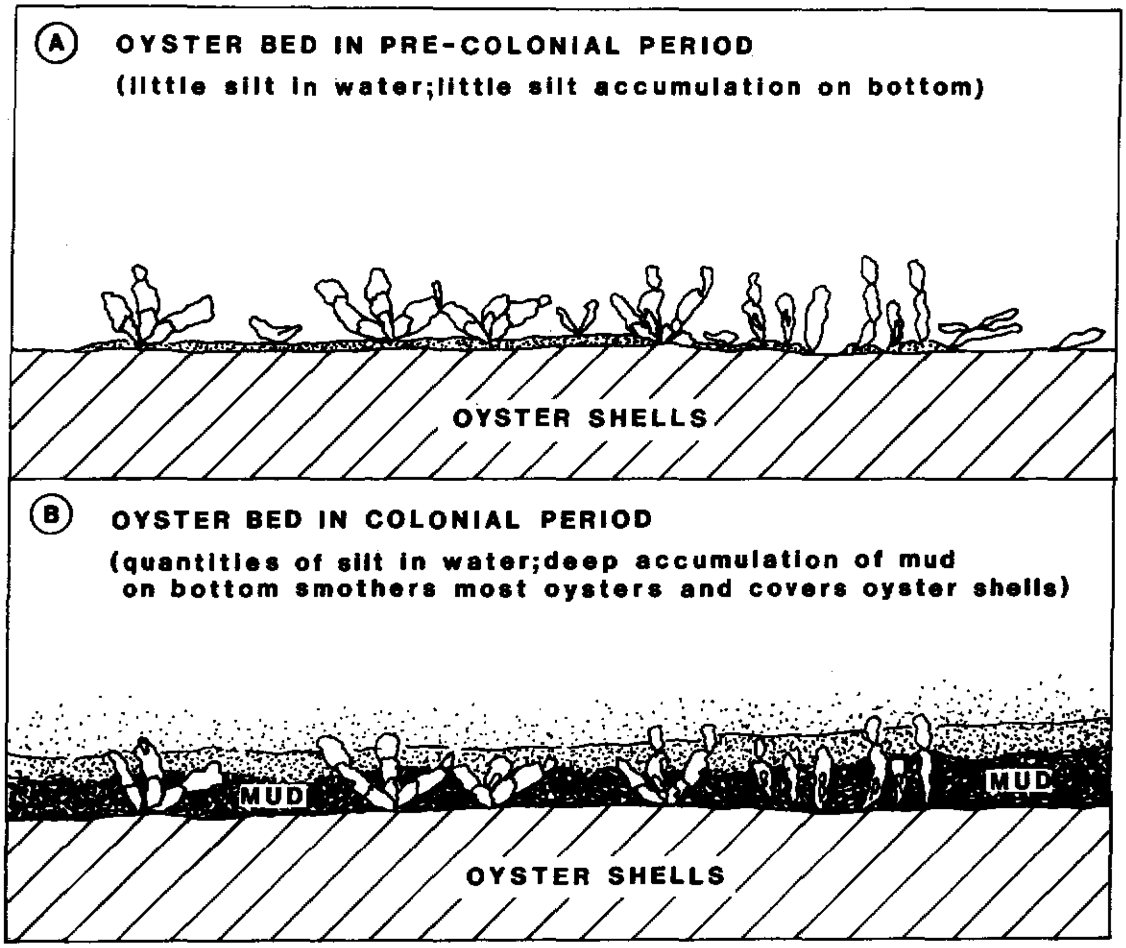


Figure 14. Probable appearance of a section of oyster bottom in the Great Beds, located immediately beyond the mouths of the Raritan River and Arthur Kill in the (a) pre-colonial period and (b) colonial period.

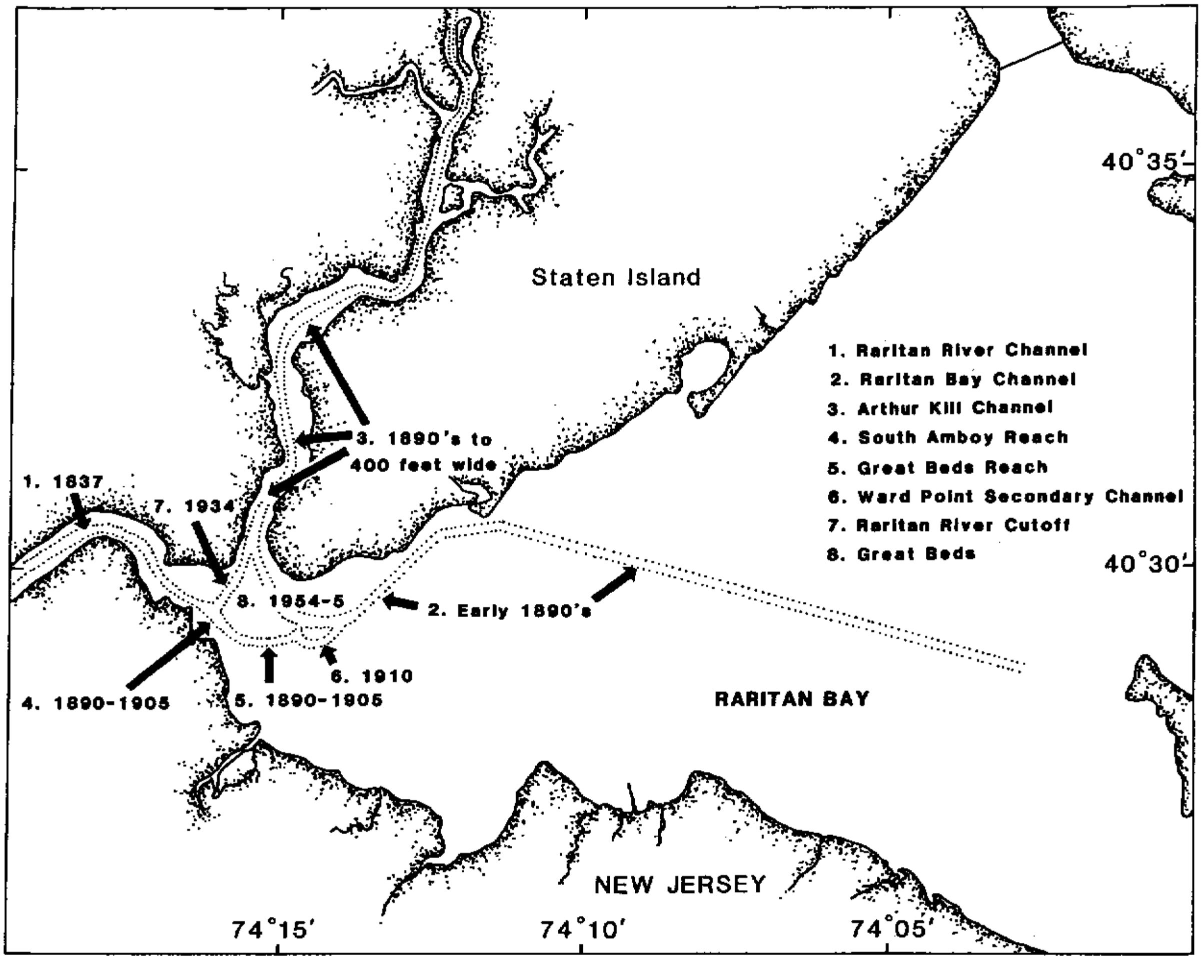


Figure 15. Maps of Raritan Bay, Raritan River and Arthur Kill listing the dates when the channels were dredged.

3. Increased salinity

Usually, natural oyster beds occur within a zone where the bottom salinity ranges from about 7 to 15 ppt at low tide. In such habitats, oyster shells remain nearly free of fouling organisms and predators of seed oysters are relatively scarce. The oyster cannot live at lower salinities. Larval and sedentary stages can live at higher salinities; oysters do not normally occur there, however, because a relatively dense array of organisms occurs which makes the environment much less suitable for survival. Normally, any shells or stones on which the larvae could set are covered with fouling organisms (diatoms, bryozoans, slipper shells [*Crepidula* sp.] and others). Since oyster larvae cannot set on them, settlement of oyster spat is sparse. Moreover, oyster drills and crabs, which destroy quantities of small oysters, are usually abundant. Thus, few of the spat which do set survive beyond a few months.

No record exists of the salinities in Raritan Bay before the early 1800s, when oysters grew on the Great Beds. I measured bottom salinities in the western end of the bay on March 28, 1984 at the end of the ebb current. Salinities on Great Beds ranged from 16 to 27 ppt. A reading of 15 ppt was recorded at a site about one-half mile west of the western extremity of Great Beds (see Fig. 6). A historical record exists of the flow of the Raritan River at Bound Brook, New Jersey, about 20 miles from the mouth of the river. The record extends from 1904 to 1908, with a break to 1945, and is continuous through 1982. The annual river flow at that site was 14.1 percent less (14,267 cubic feet per second) during 1945-72 period than during the 1904-08 period (16,606 cubic feet per second) (Table 1). Data for the recent period are highly variable, however; short periods within it are comparable with the 1904-08 period and thus it is not certain how much the river flow actually diminished. Presumably, river discharges during the pre-colonial period may have been even larger than during the 1904-08 period. Reduced river flows in the Raritan River produce higher salinities over the Great Beds.

What would reduce river flow in the Raritan River? According to the New Jersey Geological Survey, water is now removed from the drainage area of the Raritan River by municipalities. For example, the city of New Brunswick and the Duhernal Water Company at Old Bridge off South River remove more than 33 percent of the river's water during August when the river is low. Though nearly all is returned to the river as processed sewage water, some loss occurs, in part from leaky pipes and in part from water loss to the ground. Elizabethtown removes about 11 percent of the water from the Raritan River of which 30 to 50 percent returns as processed sewage water. The Delaware-Raritan Canal once emptied into the Raritan River. Towns take some water from the canal; estimated at 75 cfs in 1980. Probably, some of the water enters the Raritan River as processed sewage water. Although the diversions are believed to reduce total river flow, the diversions mentioned have taken place largely since the Great Beds were depleted of oysters; however, during the colonial period, farmers in the Raritan River drainage basin dammed a number of the creeks which led into the river. The dams would have reduced river flow and raised salinities over the Great Beds by a small amount.

4. Pollution

Raritan Bay lies 'downstream' from the largest population center in the United States: Greater New York City. Four rivers, the Raritan, Hackensack, Passaic and Hudson, which pass through this center, ultimately drain into Raritan Bay. In addition, the creeks where oysters were held in floats were not sanitary. It is not surprising that the oysters eventually became polluted and the oyster industry was forced to close.

Effects of the Impacts Upon Associated Species

The environmental changes described must have had an enormous effect on the indigenous invertebrates and fish which had populated those areas (Fig. 13b, c). An animal community had evolved to grow on and around oysters or on sandy bottom, and in water carrying less silt, with having a lower salinity and with no industrial wastes. Probably, few of the indigenous invertebrates are now abundant in the area; most numerous today are some mud-dwelling, pollution-tolerant species. The total number of individuals and species of invertebrates is reduced from the pre-colonial period.

Raritan Bay is a nursery area for the larvae of several fish species. Undoubtedly, the environmental modifications in the western end of the bay have reduced fish abundances. Muncy et al. (1979) state that entire aquatic communities including plankton and macroinvertebrates, as well as fish, are substantially modified by high turbidity; large concentrations of silt disrupt activity and respiratory patterns; reduce sight-feeding distances and change orientation patterns of some larval and juvenile fish species. Miller (1974) found that in Hawaiian waters, the number of fish larvae was about 75 percent lower in turbid water than in clear water; the number of fish species present was about 55 percent lower in the turbid water. The reason may be that in highly turbid water, fish larvae are unable to see their prey and cannot orient themselves to the current flow. The environmental modifications should be included as a factor which reduced fish abundances in Raritan Bay.

Pearce (1979) has reviewed quantitative studies, conducted mostly in the 1970s, of the contamination of biota and their environments and some effects of contaminants on invertebrates and fish in Raritan Bay. A feature of the bay which increases its pollution is that the water has a relatively long residence time. The flushing time of the bay is about 32 to 42 tidal cycles or 16 to 21 days (Jeffries 1962). Thus, any contaminant discharged into the bay will remain there for that time and will likely be picked up by the biota and sediments. The concentrations of six heavy metals in bay sediments were highest in the central muddy portions of the bay, but concentrations were also elevated in other portions of the bay. The concentration of copper in the water was 65 ppm (Waldhauer et al. 1978), the highest ever reported for any estuary. The concentration of hydrocarbons in the sediments of the bay was also elevated, especially in its central portion (Stainken 1979; Koons and Thomas 1979). Fish in the bay have body burdens of PCBs. Spot (*Leiostomus xanthurus*) had 0.53 ppm; small winter flounder (*Pseudopleuronectes americanus*), 0.37 ppm; larger winter flounder, 0.14 ppm; small bluefish (*Pomatomus saltatrix*), 3.09 ppm; medium size weakfish (*Cynoscion regalis*), 0.6 ppm, and eels (*Anguilla rostrata*), 1.4 to 3.32 ppm. The numbers and species diversity of invertebrates in Raritan Bay were much lower than in other temperate estuaries, and amphipods were absent from the western third of the bay, suggesting a large amount of pollution (McGrath 1974). The fish in Raritan Bay commonly have fin erosion disease; in a 1967 survey, 70 percent of individuals comprising 22 species of fish caught in Raritan, Lower New York and Sandy Hook bays and the New York Bight apex were diseased and the epizootic was centered in the estuaries (Mahoney et al. 1973). A subsequent study in Raritan Bay and nearby waters showed that 15 percent of winter flounder had fin erosion disease (Ziskowski and Murchelano 1975). A study of the oxygen consumption of the biota, sediment and water immediately above the sediment in Raritan Bay had values ranging from 0.11 to 0.89 ounces/yd^2/hr (3.9 to 31.4 ml O_2/m^2/hr); the rate is much elevated over pristine environments and undoubtedly results from the loading of sediments with organic material (Thomas et al. 1976). Raritan Bay has extremely high primary productivity--the annual value of 24 ounces C/yd^2/yr(817 g C/m^2/yr) is considered among the highest anywhere in the world (O'Reilly et al. 1976) (note: it is believed that much of the heavy metal loading of Raritan Bay began during World War II when industrial plants along the Raritan River and other coastal areas had to produce large quantities of goods for the war effort. During that war, people had little concern about water pollution and thus much of the industrial waste was emptied into the rivers. Many plants maintained this means of waste disposal after the war.)

OYSTER RESOURCES IN THE 1980S

The bottoms of most oyster beds, such as Ward Point, Round Shoal, Old Orchard Shoal and the Chingarora Bed, remain in good physical condition and have oyster shells on them. Ward Point and Round Shoal contain small numbers of oysters; oyster setting occurs on the two beds in some years but it is sparse. The bottom of the Great Beds has been destroyed as an oyster habitat because it has been partially dredged and is covered with soft mud; the bottoms of the Raritan River and Arthur Kill have been channelled and probably are covered with mud.

COULD THE OYSTER INDUSTRY OPERATE AGAIN?

In the early 1980s, according to officials in the New York State Department of Conservation and New Jersey Department of Marine Fisheries, fecal coliform and heavy metal quantities in Raritan Bay are far above the maximum allowable for safe shellfish harvesting directly to the market. However, even if they were brought down to safe quantities, the potential for problems is large; a sewage plant breakdown or excessive rainfall could recontaminate the shellfish. Much of the contamination comes from non-point urban areas, such as city streets during rainfalls. To clean up the waters of the bay enough to allow direct consumption of shellfish would at least require that the old cities near Raritan Bay, such as New York, Jersey City and Brooklyn install separate systems for sewage and rainwater runoff. This is an enormous and unlikely undertaking. In addition, manufacturing plants would have to reduce their discharges of pollution into the rivers.

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"INDUSTRIAL USES OF THE BAY"

ORGANIZER

Dr. John L. Buzzi
President, Kupper Consultants
Piscataway, New Jersey 08854

CHAIRMAN

Mr. Alfred Hammon
Supervisor, Harbor Planning
Port Authority of New York and New Jersey
New York, New York 10048

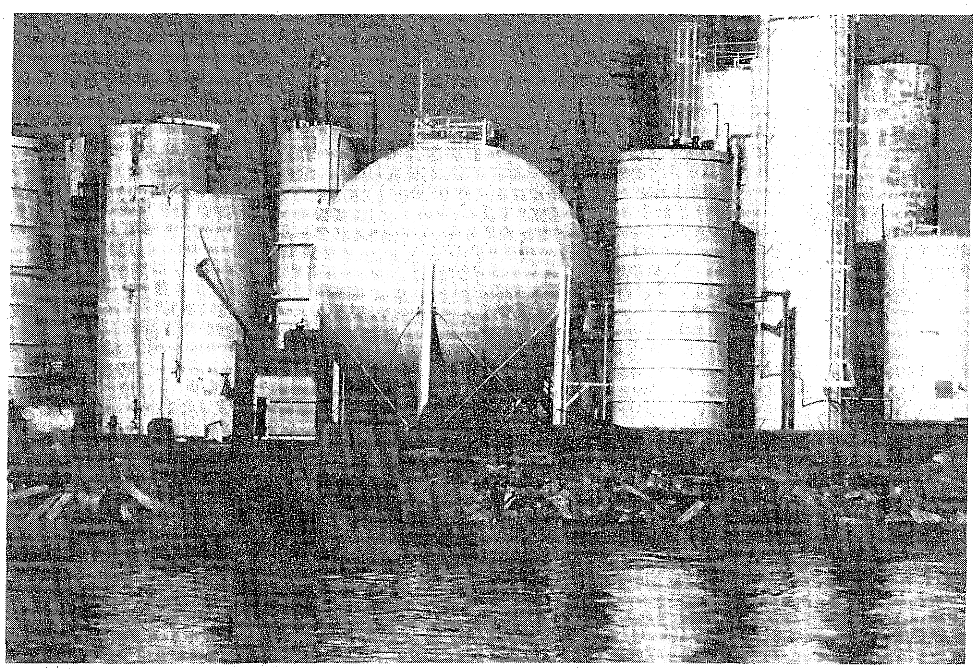
THE PANEL

Mr. Joseph T. Grossi, Maritime Coordinator
New Jersey Department of Commerce and Economic Development
Office of Business Advocacy
Trenton, New Jersey 08625

Mr. Frederick H. Kurtz
Chairman, Middlesex County Utilities Authority
Parlin, New Jersey 08859

Mr. Richard S. Roche, Captain
United New York and Sandy Hook Pilots Association
Garden City, New York 11530

Mr. Harold M. Stanford
Manager, NOAA Ocean Assessment Division
Stony Brook, New York 11794



INDUSTRIAL USES OF THE BAY - PANEL SUMMARY

The panel on commercial and industrial uses of the Bay recognized that as part of the New York-New Jersey metropolitan complex such uses act to improve the quality of life for people throughout the area.The chairman emphasized that commercial and industrial users must be able to plan in a predictable atmosphere. They must be able to count on a general set of criteria which if followed in good faith will permit them to plan their future commitments. When a serious effort is being made to follow established criteria, commercial and industrial users, and those charged with monitoring and managing the Bay to make it useable must be able to rely on special interests, such as environmental groups, likewise to follow established rules and criteria.

Rhetorical questions were posed: When and under what circumstances can the general public, commerce and industry, and public entities which serve the general public, count on environmental groups to act according to the same criteria? What must be done to prevent a small group from interfering with what has been determined to be best for the most people? Can the public count on the whole spectrum of environmental interests to stand up for them when faced with special interests who attempt to thwart the established criteria in the name of a particular environmental interest?

Mr. Grossi emphasized the commercial viability of Raritan Bay, vis-a-vis the Port of New York and New Jersey, as significantly contributing to the economic well-being of the people in the area. From the 568 overseas companies located in New Jersey, there were 35,000 jobs directly dependent and 30,000 jobs indirectly dependent upon export trade. The export business depending on New York Harbor is a $3 billion per year industry.

Mr. Hammon pointed out that Raritan Bay serves a specialized but vital role for the Port of New York and New Jersey, particularly with regard to transportation safety and cost. Raritan Bay is a large estuary which includes Lower New York and Sandy Hook bays, which together constitute the major seaward entrances to the Port, via the 2,000-foot wide and 45-foot deep Ambrose Channel into Upper New York Bay, and via the 600-foot wide, 35-foot deep Sandy Hook Channel in Raritan Bay.

Raritan Bay is characteristic of what most port areas refer to as an "outer harbor." This means that it contains very few onshore deepwater port cargo facilities, but essentially provides protected water access to the "inner harbor" where such facilities are located. The two major onshore port facilities on the Bay are a coal loading facility at South Amboy, New Jersey, and a naval weapons loading facility at Leonardo, New Jersey.

As an inner harbor access route, the Bay is part of a 35-foot deep federal channel system known as the New York and New Jersey Channels, which starts at the western terminus of the Sandy Hook Channel and runs from 31 miles around southern, western, and northern Staten Island, where it finally joins the Anchorage Channel in Upper New York Bay. It also connects with the Newark Bay, Hackensack and Passaic River Channels and the Raritan River Channel. In Raritan Bay, the channel is about 600 feet wide, and has a mean tidal range of 5.1 feet off Perth Amboy.

The Sandy Hook-Raritan Bay Channel is the sea access for petroleum and other terminals on the Raritan River. Large ocean going vessels, however, are limited by the 25-foot channel depth in the Raritan River, and by the clearance dimensions of the Victory and New Jersey Transit movable bridges across the lower River. The Sandy Hook-Raritan Bay Channel also serves the Arthur Kill and its concentration of petro-chemical terminals, being particularly attractive as a route to the lower reaches of the Arthur Kill. The Channel serves as a second entrance and exit to this area, and thus eases heavy traffic in the New York and New Jersey Channels, which in 1982 totaled nearly 113,000 shallow and deep-draft vessel movements carrying close to 1.3 billion ton miles of cargo. About 5,600 vessel movements took place in the Raritan River. As a southerly, second New York and New Jersey Channels entrance, the Sandy Hook-Raritan Bay Channel also relieves heavy traffic congestion off the area of St. George, Staten Island, near which the Anchorage, New Jersey Pierhead, Kill van Kull, Buttermilk, and Bay Ridge- Red Hook Channels all meet amidst deepwater anchorages in Upper New York Bay. However, a small supplemental anchorage to serve the nearby Raritan River-lower Arthur Kill areas is found in Raritan Bay off Staten Island. This anchorage has also been used in more recent years to "top off" colliers loaded with export coal moving through the South Amboy facility.

Thus, Raritan Bay, much like Long Island Sound, serves a specialized but vital role for the Port of New York and New Jersey in the matter of transportation safety and cost. It has not been the site of a significant number of onshore port facilities, and among the reasons for this is its limited railroad and highway access, the considerable shallow water dredging that would be required between most of the Raritan River Channel and the shoreline, and, for some trades, its more considerable distance from the Port's business center.

Mr. Kurtz was pleased to have sewage treatment recognized as an industry. His remarks included the fact that the Middlesex County Utilities Authority experienced a reduction in total flows over the past five years, dropping from 95 MGD in 1978 to less than 80 MGD in 1983. During this same period of time, the Authority effectuated a vast improvement in the water quality of its discharge to Raritan Bay. Loadings of BOD alone decreased from a reduction of 62% in 1978 to 92% in 1983.

He cited examples of attempts to reduce ocean dumping and improve the quality of effluent into Raritan Bay. In 1979-1980 the Authority sought approval to construct a codisposal facility which, while incinerating sludge with garbage or solid waste, would produce enough electricity to operate its energy intensive treatment process. The effort drew little support from the private sector and ultimately a denial from them. Unable to produce unqualified approvals from the State Department of Environmental Protection, due to the tremendous testing costs involved, the Authority lost a $95,000,000 federal grant in favor of a privately financed proposal to burn garbage alone.

In spite of the reams of federal and state rules, regulations, guidelines and orders, the potential for industrial uses in Raritan Bay is locked in a battle between inoperable legislation, randomly applied, and the basic failure of government to support openly a direction for large authorities to pursue. At the moment, there are industries located in communities offering only primary treatment because the cost of relocating to municipalities requiring higher treatment levels has negative impacts on operating budgets. While special interest groups fight the ocean dumping of sewage sludge, primary effluent continues to add to loadings in our rivers and bays. While we barge our sludge to the 12-mile or 106-mile sites, others continue to use the waterways as a direct, inexpensive conduit for wastes.

If we are to ever realize the full economic value of the Raritan Bay, we must come together with antagonists and legislators to develop a plan which is applied equally to all. The role of the scientist must be elevated, at least to the level of politician. The idea that progress means moving the problem further out to sea must be buried with its shortsightedness.

The point can be best illustrated with a true, short story. In 1980 the Middlesex County Utilities Authority was encouraged by the New Jersey Department of Environmental Protection to consider carefully the composting of sewage sludge. After two visits to the famous "Blue Plains" facility, with representatives of the New Jersey Department of Environmental Protection, we actively pursued composting as a possible alternative to ocean dumping. After a long, expensive series of analyses, tests and emergency reports which included testing by the state university, we sought in-state markets for our "soil additive." Incidentally, laboratory tests showed our finished product to be lower in content of heavy metals than the heavily used "Milorganit" fertilizer imported from a mid-western sewage agency. Word reached the then head of the New Jersey Department of Environmental Protection that the Middlesex County Utilities Authority was seeking a market for its compost. I was advised that New Jersey would not tolerate the use of sewage sludge products on its land and to look to other states for a suitable disposal site.

We have a long way to go in this industry of sewage treatment. The Middlesex County Utilities Authority continues to hope that codisposal remains a viable alternatative to ocean disposal. We would like to return our 80,000,000 MGD of effluent in the form of industrial process water to existing and future industries in our Raritan Valley.

The industrial use of Raritan Bay is dependent upon, in large measure, the success or failure of our goals. We believe that technology exists which will allow us to dispose of our waste responsibly; however, we find that government has been neither responsive nor supportive in overcoming political obstacles.

Captain Roche brought out several points on maintenance dredging of the Raritan Bay and its contiguous system of channels as it relates to safe navigation. As an example, Ambrose Channel, through which ships transit to and from the Port of New York and New Jersey, is maintained at a depth of 45 feet at low water. At this time, 80,000 dead weight ton tankers can enter the port on the high water with a draft of 46 feet, 6 inches by taking advantage of the average 4.5 feet rise. On a ship of this size, one foot of draft means about 2,400 tons of cargo.

While a shoaling channel does not necessarily mean that the ship will go aground, it can cause the vessel to handle in a sluggish manner as a result of hydraulic pressures which develop when the keel is near the bottom. It is possible these conditions could produce a casualty which would not occur when the channel is maintained to its mandated depth.

It is also vital that the docks where the vessels berth should have timely maintenance dredging. Not only does extreme shoaling present a danger to a ship when it is maneuvering in and out of its berth, but a loaded vessel could be severely damaged while alongside if an unpredicted, unusually low tide occurs. The increased size of ships of all types has only tended to exacerbate the problem because hydraulic forces are accentuated as vessels get larger.

Maintenance dredging should be done in a timely manner, without the seemingly endless delays that have characterized the past few years. Halting or deferring such dredging has a direct effect on the safe passage of vessels. This is just as true with tugs and barges that navigate narrow, shallow creeks and canals as it is for loaded tankers which may have only a few feet under the keel when they enter the channel at high water.

Mr. Stanford addressed the topic of pollution sources of Raritan Bay. He presented a series of graphs and tables (shown below) summarizing current levels and origin of standard parameters, organics, and metals. He compared total mass pollutant loads of the Hudson-Raritan drainage between 1970-1974 and 1979-1980 and the wastewater loads among several portions of the system.

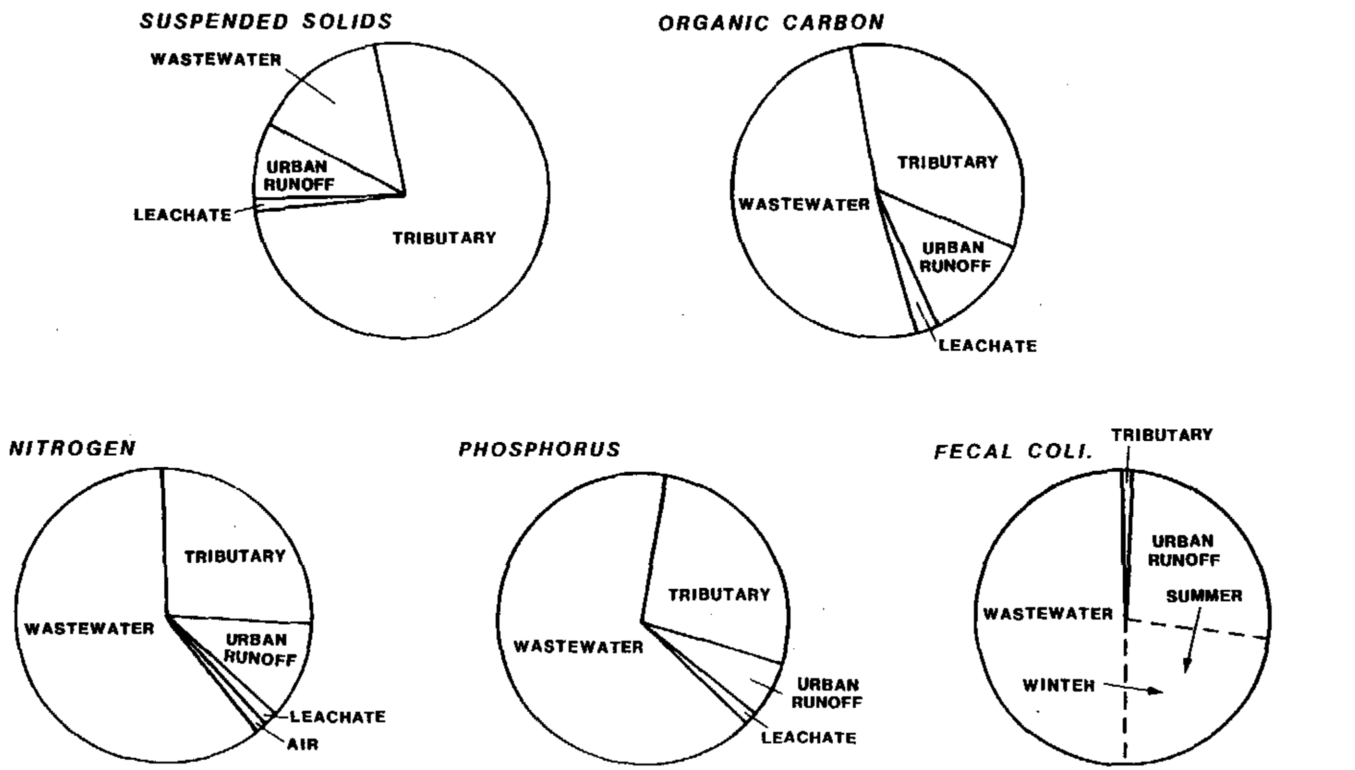
HUDSON-RARITAN ESTUARY TOTAL MASS LOADS[a]--STANDARD PARAMETERS

PARAMETER	TOTAL MASS LOAD (m.t./dy)	% CONTRIBUTED BY EACH SOURCE					
		WASTEWATER	TRIBUTARIES	URBAN RUNOFF	ATMOSPHERIC	ACCIDENTAL SPILLS	LANDFILL LEACHATE
FLOW(m^3/s)	1000	13	78	6.9	2.5	-	0.04
SS	5000	14	77	9.7	-	-	0.2
BOD	1000	71	9.7	18	-	-	0.9
TOC	1400	51	34	13	-	-	2.2
TOTAL-P	41	66	27	7.1	-	-	0.05
OIL & GREASE	350	48	12	34	-	6[b]	0.4

(a)Dashes indicate no data available,except for wastewater where constituents detected less than 90% of the time were excluded.

(b)Petroleum hydrocarbons.

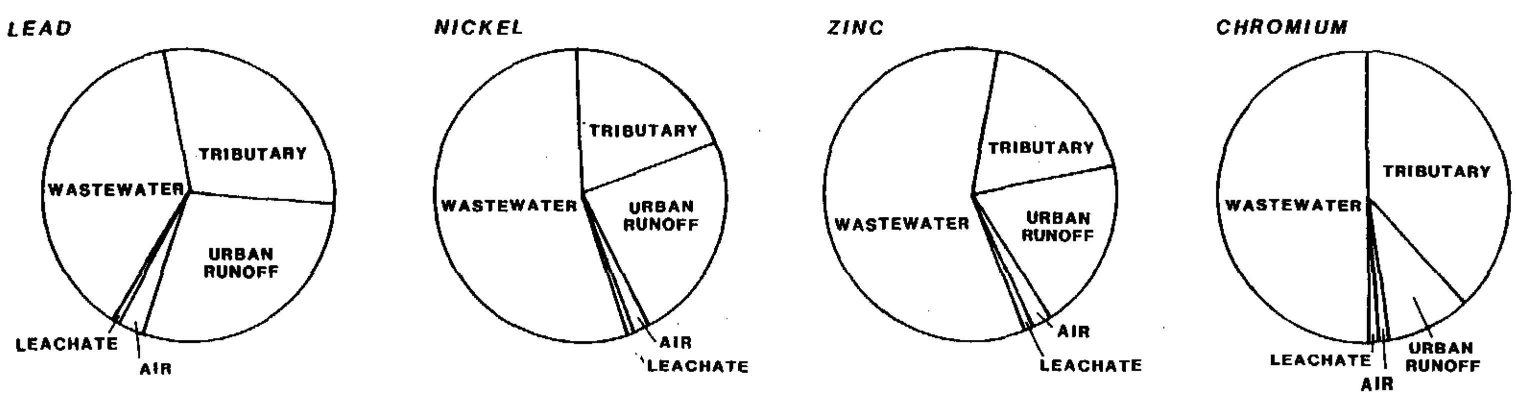
DISTRIBUTION BY SOURCE OF HUDSON-RARITAN ESTUARY CONVENTIONAL POLLUTANT MASS LOADS



HUDSON-RARITAN ESTUARY TOTAL MASS LOADS --METALS

PARAMETER	TOTAL MASS LOAD (kg/dy)	% COTRIBUTED BY EACH SOURCE					
		WASTEWATER	TRIBUTARIES	URBAN RUNOFF	ATMOSPHERIC	ACCIDENTAL SPILLS	LANDFILL LEACHATE
ANTIMONY	1100	100	—	—	—	—	—
ARSENIC	190-210	51-47	49-51	—	0.1-1.4	—	0.2-1.2
BERYLLIUM	41-43	96-91	3.7-8.9	—	—	—	0.25-0.23
CADMIUM	130-190	56-38	12-39	30-22	1.6-1.1	—	0.7-0.5
CHROMIUM	2020-2040	50	37	12	0.5	—	0.2
COPPER	3400	52	28	20	—	—	0.19
CYANIDE	900	100	—	—	—	—	0.20
LEAD	2800	39	29	29	3.5	—	0.26
MERCURY	62-92	89-60	8.9-37	2.6-3.2	—	—	0.3-0.2
NICKEL	1700	55	20	23	1.2	—	0.3
SELENIUM	120-160	65-49	34-51	—	—	—	0.4-0.3
SILVER	65-78	95-80	4.8-19	—	—	—	0.2-1.2
THALLIUM	350	100	—	—	—	—	—
ZINC	9400	60	19	19	2.1	—	—

DISTRIBUTION BY SOURCE OF HUDSON-RARITAN ESTUARY METALS MASS LOADS



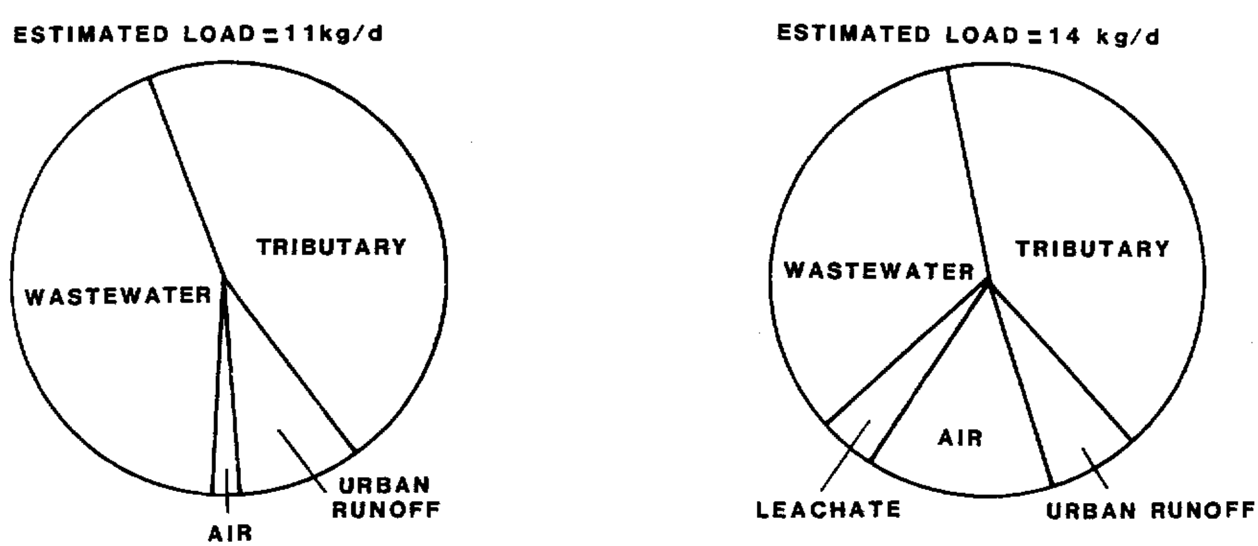
POLLUTANT MASS LOADS TO THE HUDSON-RARITAN ESTUARY--1979-1980

PARAMETER	MUNICIPAL WASTEWATER (metric tons/dy)	INDUSTRIAL WASTEWATER (metric tons/dy)[a]	TOTAL (metric tons/dy)
FLOW(m^3/sec)	120	12	130
SS	700	8.0	710
BOD	730	3.0	730
TOC	700	4.0	700
TOTAL-P	27	0.02	27
OIL & GREASE	170[b]	0.73	170
1,1,1-TRICHLOROETHANE(kg/dy)	370	2.5	370
CHLOROFORM(kg/dy)	130	3.3	130
ANTIMONY(kg/dy)	1100	0.05	1100
ARSENIC(kg/dy)	97	0.46	97
CADMIUM(kg/dy)	69	1.2	70
CHROMIUM(kg/dy)	1020	1.7	1020
COPPER(kg/dy)	1800	5.5	1800
CYANIDE(kg/dy)	990	1.3	900
LEAD(kg/dy)	1100	1.0	1100
MERCURY(kg/dy)	55	0.02	55
NICKEL(kg/dy)	930	2.3	930
SILVER(kg/dy)	61	1.0	62
ZINC(kg/dy)	5600	19	5600

(a)Excludes cooling water

(b)Data indicate that 30% of oils and greases are petroleum hydrocarbons

DISTRIBUTION BY SOURCE OF HUDSON-RARITAN ESTUARY PCB MASS LOADING-RANGE OF ESTIMATES



POLYCHLORINATED BIPHENYLS

HUDSON-RARITAN ESTUARY TOTAL MASS LOADS --ORGANICS

PARAMETER	TOTAL MASS LOAD (kg/dy)	% CONTRIBUTED BY EACH SOURCE					
		WASTEWATER	TRIBUTARIES	URBAN RUNOFF	ATMOSPHERIC	ACCIDENTAL SPILLS	LANDFILL LEACHATE
BENZENE	170	96	—	0.6	—	—	3.6
1,1,1-TRICHLOROETHANE	370	100	—	—	—	—	0.1
CHLOROFORM	140	92	—	4.4	—	—	3.9
1,2-DICHLOROBENZENE	49	100	—	—	—	—	0.1
1,1-DICHLOROETHYLENE	15	100	—	—	—	—	0.1
1,2-TRANSDICHLOROETHYLENE	21	100	—	—	—	—	0.1
ETHYLBENZENE	66	96	—	—	—	—	3.8
METHYLENE CHLORIDE	930	99	—	0.6	—	—	0.4
DICHLOROBROMOETHANE	3.2-3.3	97-99	—	—	—	—	3-1
NAPTHALENE	35	49	—	—	—	51	—
PENTACHLOROPHENOL	26	100	—	—	—	—	—
PHENOL	70	80	—	11	—	—	9
BIS(2-ETHYLHEXYL)PHTHALATE	350-355	77-76	—	23	0.1-1.4	—	—
BUTYL BENZYL PHTHALATE	41	73	—	27	—	—	—
DI-N-BUTHYLPHTHALATE	56-61	89-82	—	11-10	0.35-8.2	—	—
DIETHYLPTHALATE	20	80	—	20	—	—	—
PHENANTHRENETE	20.5	12	—	88	—	—	—
TRACHLOROETHYLENE	530	100	—	—	—	—	0.2
TOLUENE	280	88	—	3.5	—	3.3	5.3
TRICHLOROETHYLENE	300	95	—	—	—	3.6	1.1
GAMMA-BHC(LINDANE)	0.46-4.3	57-6.0	*	—	43-94	—	—
CHLORDANE	0.13-0.33	77-30	*	—	23-61	—	0-9
PCB	11-14	44-34	45-41	8.9-6.8	1.9-14	—	0-4.1

*Negligible or zero loads were estimated from sediment data. Water column data were not available.

COMPARISON OF 1970-1974 LOADS WITH 1979-1980 LOADS

PARAMETER	MUNICIPAL WASTEWATER (metric tons/dy)		INDUSTRIAL WASTEWATER (metric tons/dy)		TOTAL (metric tons/dy)	
	1970-74	1979-80	1970-74	1979-80	1970-74	1979-80
FLOW(m^3/s)	110	120	11	12	120	130
SS	830	700	52	8.0	880	710
BOD	960	730	48	3.0	1010	730
TOC	700	700	-	4.0	700	700
NH_3-N	110	100	5.4	-	120	100
ORGANIC-N	80	90	3.9	-	84	90
NO_2-N	6.2	0.95	0.3	-	6.5	0.95
TOTAL-N	190	210	9.6	-	200	210
TOTAL-P	44	27	1.8	0.02	46	27

(a)Mueller,et al.(1976)

(b)Excludes cooling water

PERCENTAGE OF TOTAL WASTEWATER CONTAMINANT LOADS TO RECEIVING WATERS

PARAMETER	HUDSON RIVER	EAST RIVER	UPPER NY BAY	LOWER RARITAN AND SANDY HOOK BAYS	RARITAN RIVER
FLOW	14	39	13	4.3	0.40
SS	15	24	41	2.9	0.20
BOD	15	20	42	2.2	0.47
TOC	15	30	24	7.0	0.40
TOTAL-N	15	34	18	6.3	0.37
TOTAL-P	18	30	21	4.1	0.70
CADMIUM	11	27	36	5.8	0.60
CHROMIUM	7.8	18	59	1.2	0.10
COPPER	11	44	22	6.5	0.63
CYANIDE	11	63	13	2.2	1.1
LEAD	4.7	8.8	62	2.5	0.21
MERCURY	2.0	4.2	91	0.18	0.02
NICKEL	6.2	28	47	1.6	0.13
ZINC	8.2	11	39	29	0.25

GOVERNMENT AND REGULATION

CHAIRMAN

Dr. James L. Verber, Chief, NE Technical Services Unit
United States Public Health Service
Food and Drug Administration, Shellfish Sanitation Branch
CB Center, Bldg. S-26
Davisville, Rhode Island 02854

THE PANEL

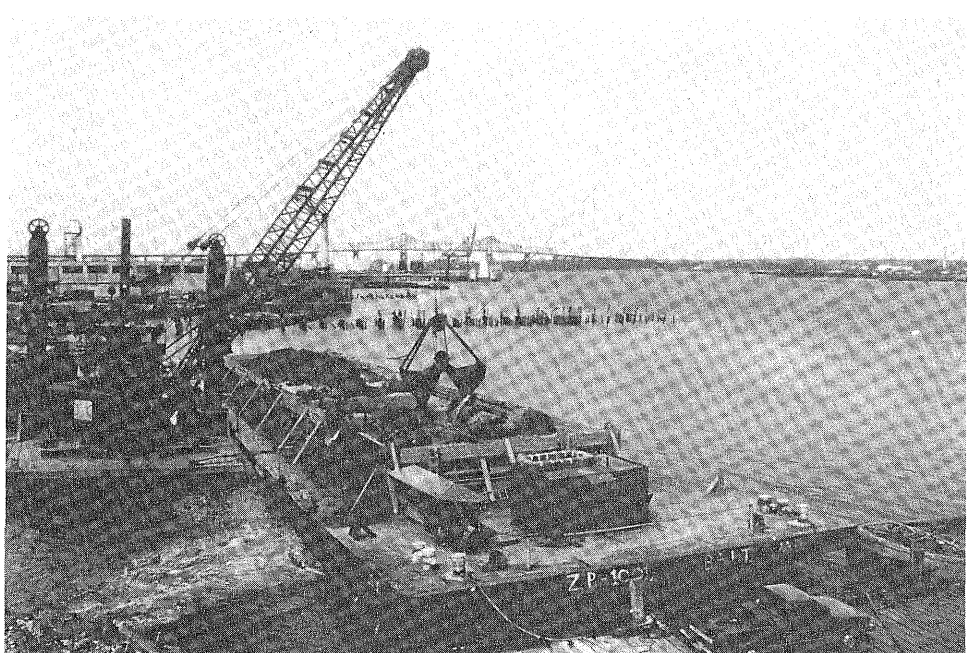
Mr. John Weingart
Director, New Jersey Division of Coastal Resources
Department of Environmental Protection
Cn 401, Trenton, New Jersey 08625

Mr. Robert E. Adamski, P.E.
Chief, Division of Operational Control
Department of Environmental Protection
Bureau of Water Pollution Control
Wards Island, New York 10035

Dr. Dennis Suszkowski, Chief
Regulatory Branch, New York District Corps of Engineers
26 Federal Plaza
New York, New York 10278

Lt. Cdr. Daniel Carney, Deputy Group Commander
United States Coast Guard, Sandy Hook Unit
Sandy Hook, New Jersey 07732

Dr. Barbara Metzger
Director, Environmental Services Division
Environmental Protection Agency, Region II
26 Federal Plaza
New York, New York 10007



GOVERNMENT AND REGULATION PANEL SUMMARY

The session was introduced by Dr. Verber. He noted that regulatory control for areas near Raritan Bay came into existence about 325 years ago when the Dutch Council of New Amsterdam passed an ordinance against the taking of oysters from the East River. This is only one river whose drainage influences the bay. Thus, the bay has had a tradition of degradation of habitat and resources in the intervening three centuries.

Primary jurisdiction in the area of pollution control rests with the U.S. Environmental Protection Agency. By virtue of the powers built into our democratic system of government, this agency can oversee cleanup of pollution sources. The Interstate Sanitation Commission of the states of New Jersey and New York establish the water quality goals for the waters under their jurisdiction, and the Environmental Protection Agency then supports or rejects these limits. If accepted, the states are expected to reach their established goals Overlapping jurisdictions, such as the role of the Corps of Engineers for dredge spoils, the US Coast Guard in a regulatory posture for control of oil or hydrocarbon spills, FDA for foods in interstate commerce; and state and local regulatory jurisdictions provide a multiplicity of regulation on the bay.

There is evidence that severe bay pollution existed before the turn of the century. The Public Health Service, in cooperation with states of New York and New Jersey and the City of New York published the study, "A report on the public health aspects of clamming in Raritan Bay" in 1941--the first involvement of the Public Health Service's Shellfish Branch in the bay. The latest study was dated September 1983, so the agency has been involved continuously in the bay over the past 40 years. Bacterial deterioration has been steady; and today there are only small zones of approved areas for shellfishing in existence. The Public Health Service/Food and Drug Administration, is an overseeing federal agency. It asserts most of its authority through state programs and utilizes the powers of the Federal Food, Drug, Cosmetic Act only where absolutely necessary.

Regulatory control, regulatory interference, and non-interference cross all social areas of activity, none less so than Raritan Bay. In the past few years, federal managers have frequently attended Environmental Protection Agency and Corps of Engineers public meetings as adversary agencies. Dr. Verber concluded that it is time these meetings were attended in a spirit of cooperation and unity, working together to solve a common problem.

Mr. Weingart indicated that State of New Jersey funds have been allocated to several cities bordering Raritan Bay. This is an effort to upgrade the waterfront and reduce pollution impact from municipalities on a continuing basis.

Mr. Adamski reviewed the discharges into the lower Hudson-Raritan system and the nature of water quality monitoring. He focused on the need for better agency coordination in monitoring efforts and detailed the long-term goals for upgrading New York's sewage treatment plants. Despite problems with funding a long-range plan for pollutant abatement is in place.

Dr. Suszkowski reviewed the regulatory authority of the Corps of Engineers, citing the Rivers and Harbors Act of 1899 re. construction permits in "navigational waters", The Clean Water Act re. discharges of dredged or fill material in "waters of the US" and the Ocean Dumping Act of 1972 re. transportation for purposes of dumping dredged material. The Corps' philosophy of planning involves a public interest review and its management plan considers utilization of protection of important resources. The agency has developed a considerable data base from managing the disposal of dredged materials taken from some 250 miles of federally maintained channels.

Lt. Commander Carney reminded the audience of the expanded Coast Guard role from its 1854 mission to "protect life and property from shipwrecks." Additionally, it is now charged with enforcing federal laws regarding marine environmental protection, interdiction of narcotics, fishery conservation, and maintaining security zones and navigational aids.

In the marine protection area, the Coast Guard through the Sandy Hook group and the Captain of the Port of New York, investigates, initiates cleanup (when the pollutor is unknown), and prosecutes all known individuals (companies) of petroleum and chemical spills in the bay. Cleanup efforts include containment, removal, and identification of responsible sources. Other Coast Guard activities which relate to adverse impacts are the monitoring of ocean dumping and enforcement of laws governing installation and upkeep of marine sanitation devices.

Dr. Metzger pointed out that EPA is primarily a regulatory agency and reviewed the suite of regulatory programs which relate to the bay: the National Pollutant Discharge Elimination System (NPDES) covers municipal and non-municipal discharges; SPCC is concerned with spill prevention control and countermeasures; the Resource Recovery and Conservation Act (RCRA) for hazardous waste disposal; the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) for pesticides and herbicides; and the Toxic Substances Control Act (TSCA) which relates primarily to PCBs, but also to a multiplicity of chemicals. The Marine Protection, Research and Sanctuaries Act (MPRSA) regulates the ocean dumping of sewage sludge and dredged materials, whereas discharge of dredged and fill material and all other disposal inside of the three mile limit is addressed by Sec. 404 of the Clean Water Act.

Most of these programs were originally carried out by EPA, however, other than TSCA and ocean disposal, the activities have been or can be delegated to states. When so delegated, EPA conducts only an oversight function. In earlier times, EPA was extremely active in management of resources as exemplified by the production of a series of basin plans. Currently EPA funds the states to carry out planning and management activities.

The chairperson concluded the session by stressing that no single agency, federal or state, is responsible for management of the bay. As indicated by panel members, the jurisdictions are fragmented and no agency exists to pull together the different governmental levels necessary in providing a comprehensive pollution control program for Raritan Bay.

Editor's note ...

Ocean science lost a friend on March 29, 1984 with the death of U. S. Representative Edwin B. Forsythe, the senior Republican member of the New Jersey Congressional delegation. At the time of his death he was Ranking Member of the House Merchant Marine and Fisheries Committee and the Subcommittee on Fisheries and Wildlife Management and the Environment. He was effective in fashioning workable legislation in the areas of fisheries development and protection, wildlife management and conservation, and environmental degradation.

Congressman Forsythe was a prime sponsor of the 200-mile limit, offshore fishing law enacted in 1976 and played a critical role in such important legislation as the National Environmental Protection Act, the Non-game Fish and Wildlife Act, the Alaskan Lands Act, the Endangered Species Act and the Marine Mammal Protection Act. He was instrumental in efforts to preserve the New Jersey Pinelands, to implement effective and fair management of the Bluefin Tuna, and to resolve the dumping of sludge in the Atlantic Ocean.

REMARKS OF THE

Honorable Edwin B. Forsythe

Chairman, House Committee on Merchant Marine and Fisheries

It is my privilege to address you this evening on the subject of Raritan Bay -- its multiple uses and abuses, and coordinated efforts to hasten its rehabilitation and restoration. I want to commend the American Littoral Society, the New Jersey Marine Sciences Consortium, and the Sandy Hook Lab of the National Marine Fisheries Service for sponsoring today's workshop.

When Bob Abel first approached me last summer about this conference, I was somewhat overwhelmed -- but very impressed -- by the enormity of your task. Restoration of the Bay -- the ultimate goal of each and everyone of us in this room -- will only occur with a concerted revitalization effort by all of the Bay's users. Such an effort is underway today. You all are to be congratulated.

We are all aware of the brutal facts:

-- the highest concentration of pollutants along the Jersey shore is in the Raritan Bay and that, of all the major bays in the Northeast, the Raritan is probably the most polluted.

-- the Hudson-Raritan estuary is the receiving body of water for a major portion of the waste products discharged into the environment from the New York metropolitan area.

-- there is a great stress to fish life in the Raritan Bay; and

-- the New Jersey-New York interstate waters are contained in fishing advisories issued by both states due to the presence of elevated PCB levels in different species of fish.

I am certain that much more distressing news about the state of the Bay has been shared during today's discussion. In fact, this sharing of information and research results is, I understand, a primary objective of today's meeting. Certainly, <u>recognizing</u> the reality of the environment is the first step toward <u>improving</u> that environment.

But not all of the news is bad news. We are also aware:

-- the Bay is -- and will continue to be -- of enormous importance to the commercial welfare of the surrounding region;

-- some scientists have noted that while the Bay is still considered to be degraded, it is believed that the pollutant load to the Bay is decreasing -- at least to the point that contaminant levels in fish and shellfish have stabilized over the past few years and restricted shellfish harvesting is again permitted; and

-- the commercial fishing industry seems to be reviving in the Bay.

So, we see that the news on Raritan Bay is not all doom and gloom.

We also read in newspapers, scientific journals, and government documents of the many but disjointed marine pollution abatement efforts in the Bay area. The most recent update by the National Oceanic and Atmospheric Administration (NOAA) on its Hudson-Raritan Estuary Project noted, and I quote:

> "The marine pollution problems of the project study are intricate because of -- and one of the five problems noted was -- the multiple and often uncoordinated efforts of Federal, state, regional, and local agencies."

Certainly, today's meeting is a giant stride toward addressing and licking the coordination problem. This, perhaps, is the best news of all.

My remarks this evening will be optimistic. While I admit to not looking at the Bay through rose-colored glasses, I am, nonetheless, aware of the commitment by Congress and by the Federal Government to working with state, local, public, and private interests to address coastal pollution and multiple-use problems -- problems that are epitomized right here in New Jersey in the Raritan Bay.

Let's explore the Congressional commitment in this area:

First, both the House and Senate Appropriations Committees have restored funds to continue NOAA's Hudson-Raritan/New York Bight and Northeast Monitoring Pollution programs -- at least through the end of next September. Without this action, these programs would have terminated today.

Work on the Hudson-Raritan Project involves:

-- quantifying the distribution and fate of key contaminants within the estuary and their flux to the New York Bight apex and western Long Island Sound;

-- assessing the extent to which the Hudson-Raritan pollution has reduced the abundance of fish and shellfish in the metropolitan area; and

-- developing alternatives to existing waste management practices that will enhance the use of polluted coastal and estuarine resources.

The other program for which funds are included in the House and Senate appropriations bills for the next year is the Northeast Monitoring Program (NEMP). It encompasses the waters of the northeast continental shelf from the Gulf of Maine to Cape Hatteras. This pilot program has as its goals:

-- to maintain an assessment of the health of the coastal marine ecosystem off the northeast United States; and

-- to provide timely information to protect human health.

Without intercession by Congress, NEMP was also slated for termination today.

On another front, last week the Senate Environment and Public Works Committee ventured on to new ground. The Committee adopted several changes to the Clean Water Act to help states address the elusive problem of nonpoint source pollution. Nonpoint source pollution -- the stuff that does not come through pipes and which does not have a discrete and identifiable source -- acounts for roughly 50 percent of the water pollution in this country. It is a major source of pollution to Raritan Bay.

The Senate amendments require states to identify their nonpoint source pollution problems and develop a plan to address these problems. Up to $46 million is authorized in 1985 to assist states in implementing their plans. Seven hundred thirty-six thousand dollars would go to the State of New Jersey were it to develop an approved plan. The Senate committee also set aside $23 million in 1985 to be distributed on a discretionary basis for acute nonpoint source pollution problems, including multistate problems.

I have cosponsored legislation in the House of Representatives to improve and strengthen the Clean Water Act. That bill does not, at this time, contain language addressing the nonpoint source problem. However, I understand that members of the House Public Works Committee are also considering amendments to the Clean Water Act to address this issue which I will be following closely with the intent to support -- if it is appropriate.

Two weeks ago, we had a victory on the House Floor for state and local oceans and coastal activities and programs. By an overwhelming vote -- 301 to 93 -- the House adopted the so-called Outer Continental Shelf (OCS) Revenue Sharing Program. I was pleased by the strength of this vote, since I was cosponsor of the bill and have worked hard on the legislation over the past months. The bill establishes a $300 million block grant fund. If appropriated, monies from the fund can be used by coastal states for coastal zone management, coastal energy impact, fisheries, and coastal natural resource-related programs. I estimate that New Jersey would receive $8.6 million annually -- of which roughly $600,000 would go to the state's Sea Grant Program.

In my mind, the OCS Revenue Sharing Program has great relevance to your efforts here today. From my reading of the legislation, much of your work in the area of Raritan Bay revitalization -- especially that which seeks to promote and establish an effective cooperative and consultative mechanism for resolving mutual problems with the Bay -- may be funded with OCS revenue sharing monies.

The Senate has not yet acted on its version of the revenue sharing bill. We are expecting Senate Floor action before Congress adjourns later this fall.

On a more personal note, I would like to share with you some of the other initiatives in which I am involved -- and which have direct bearing on the conference today and your goals for Raritan Bay.

Over the past months, I have been working with my New Jersey colleague, Bill Hughes, in devising a suitable legislative plan to address the pollution problem in the New York Bight -- specifically the problems of continued sewage sludge dumping. The proposal which we have put together addresses the need to permanently close the 12-mile sludge dumpsite. It also calls for a program to ensure the overall improvement of water quality in the New York Bight area, while promoting the development of suitable alternatives to ocean dumping.

Our proposal, which will soon be formally introduced as a Congressional bill, would:

-- provide for the complete phaseout of sludge dumping in the Bight apex by the end of 1986;

-- require EPA to undertake a "multimedia assessment" of potential environmental and health impacts of alternative disposal techniques for sewage sludge; and

-- require EPA to develop a "New York Bight Restoration Plan" to improve the overall water quality in the Bight area by addressing all of the various pollutant resources -- including treated and untreated sewage inputs, industrial wastes, agricultural and urban runoff, storm overflows, and contaminant inputs resulting from upstream sources and from the ocean and coastal disposal of other waste materials.

Municipalities that continue to ocean dump anywhere else after December 31, 1986, are required to be in compliance with the Clean Water Act's Pretreatment Program and to receive state certification that no suitable alternatives exist. The proposal also would provide for a general user fee to recover some of EPAs cost in running the Ocean Dumping Permit Program and bans the ocean dumping of certain hazardous wastes.

On the issue of dredge spoil disposal, I recognize that there is a legitimate need for dredging and dredge spoil disposal to enhance and maintain the commercial viability of the New York/New Jersey port complex in a highly competitive market. The economy of the entire region is certainly dependent upon adequate shipping capabilities.

However, I have some questions on the continued use of the "Mud Dump" site in the New York Bight. The lack of definitive scientifically derived data on the impacts of dredge spoil dumping and the uncertainty of "special care" techniques, such as capping of contaminated spoils with cleaner materials, are reasons enough to proceed with extreme caution.

If EPA decides to designate the site for continuing use, I suggest that the following steps must be taken:

-- environmental criteria must be reassessed, improved, and updated -- especially concerning PCB levels;

-- sufficient resources must be set aside to ensure timely development and implementation of proven, acceptable alternative disposal techniques for contaminated dredge spoils;

-- the period for designation of the site should be reduced by at least half, with alternative dumpsites designated and put in service as soon as possible, but in no event later than five years from now;

-- the permitting process for each application must be undertaken with full public involvement; and

-- sufficient resources must be set aside to carry out a program to effectively monitor the impacts at the site so that environmental insults are identified early enough to provide an adequate response and protection for our fishing and recreational resources.

Finally, other efforts under consideration on the Federal level which will help address the problems in Raritan and other seriously degraded bodies of water -- and which have my support -- include:

-- maintaining the requirement for pretreatment of toxic industrial wastes that are discharged into public sewage treatment plans, as opposed to amendments that would delay and relax pretreatment of toxic wastes and increase administrative costs of pretreatment programs;

-- strengthening the administrative procedures under the Section 404 Dredge and Fill Program to ensure that the views of the Federal natural resource agencies, like the National Marine Fisheries Service, get a better hearing, and that permit conditions are strenuously enforced;

-- tightening the provisions which allow municipalities a waiver from treatment requirements for marine discharges under the Clean Water Act. The Clean Water Act currently allows municipalities discharging to marine water to reduce their level of treatment from secondary -- required as a minimum for everyone else -- to nothing based on a showing that the discharge will not cause adverse impacts on the marine environment. The scientific methods for making this determination in advance are not foolproof. This waiver, which goes against the basic premise of equal treatment contained in the Clean Water Act, should be available only rarely and should never allow for treatment at less than primary levels, which removes most of the settleable and floatable materials, with some form of disinfection.

I believe that with the coordinated efforts of all users of the Bay -- and of all levels of government -- strides can be taken toward revitalizing this valuable body of water. The challenge is to maintain and <u>enhance</u> the commercial viability of the Bay, while at the same time addressing the Bay's environmental problems. We must coordinate our research efforts...and then our planning and economic development and pollution abatement activites. I am aware of proposals to create a Raritan Bay authority or commission to facilitate economic development and environmental planning in the area. Perhaps a strong interstate management authority to coordinate and address all of the Bay's interests and problems is worth further study. I am ready and willing to join you in future coordination and planning activities.

I agree with the words of Jack Pearce, as recently quoted in the <u>Newark Star Ledger</u>... and I quote...

"With the combined efforts of Federal, state, and local governments [and, I might interject with public and private non-governmental efforts as well] coastal water pollution can be ended. If I didn't believe that I would not sit here."

I would only add that with our combined talents, ideas, and resources, we will not only address the Bay's environmental problems...but we will also enhance its commercial and recreational potential.

Thank you.

CONCLUDING REMARKS

Dr. J. B. Pearce
U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Center
Sandy Hook Laboratory
Highlands, NJ 07732

Any workshop such as the one that was recently conducted at Sandy Hook is the product of many concerns. At the present time we view Raritan Bay as a body of water which has suffered numerous insults but is still reasonably productive biologically of many commercial and recreational species. From a historical viewpoint, however, Raritan Bay has been significantly degraded. At the turn of the century, The Bay was known to be a body of water that produced large quantities of shellfish, including the desirable oyster. It is known, however, that by the time of the First World War many of the oyster beds in Raritan Bay had declined to a relatively unproductive level. Scientists then at Rutgers University predicted if something was not done about the impact of industrialization and domestic sewage discharge, the oyster populations would disappear within a decade or so. By the time of the Second World War few oysters remained in Raritan Bay.

The historical suggestion of unreasonable degradation existed even before the turn of the century when Professor Goode noted that oysters and clams, as well as shad, taken from Newark Bay, could no longer be sold because they were tainted with coal oil (petroleum). His statements were made shortly after the Civil War.

In more recent years, scientists working in Raritan Bay have measured extremely high levels of contaminants in sediments and in the water of the Bay. Toxic trace metals such as lead, copper, mercury, cadmium, and zinc have been found in sediments throughout the Bay and large amounts of petroleum hydrocarbons and PCBs are measureable in water and sediment. It is also now known that the Bay has undergone eutrophication (increased richness in dissolved nutrients). Some of the highest levels of primary production and standing stocks of chlorophyll have been found in Raritan Bay. These measurements suggest that the Bay is in an advanced stage of eutrophication, or nutrient enrichment. The decline in habitat quality is coming to pass at the same time that our nation's leading fisheries agency, the National Marine Fisheries Service (NMFS), has set a goal to increase seafood production 40 percent by the end of the 1990s. Obviously, much of the suggested increase in such production will have to come from estuaries and coastal waters inasmuch as the offshore shelf fisheries are probably producing and yielding near their highest level.

To think about increasing the production of seafoods from an area such as Raritan Bay -- and it must be realized that Raritan Bay is fairly representative of many estuaries in the northeast -- it is obvious that these estuaries must be upgraded. To do this, we should begin to think in terms of the <u>multiple use</u> of marine waters. What does multiple use mean? It means, for one thing, that estuaries and coastal waters must be managed so the level of water quality maintained will make it possible for commercial and recreational species to be harvested from the waters and that these species can carry on a level of reproduction and survival sufficient to sustain the fisheries. Beyond this, the seafoods taken from such waters must be of a high enough quality to be regarded as wholesome for human consumption. Harvesting for human consumption must able to be done at the same time that these waters are also used for transportation, industrialization, domestic development, and other competing activities, including mining for a range of mineral resources. Finally, there is an obvious need to continue to dispose of many industrial by-products as well as effluents from our domestic sewage treatment systems. Thus, a body of water such as Raritan Bay will be used for many purposes but individual activities managed so that any one of them will not compromise the use of waters for other purposes.

Dr. Sindermann, in his introductory remarks, suggested that this Raritan Bay Workshop should lead to a series of recommended actions. One of the goals of the Workshop was to develop a list of actions that might be taken which would lead to an improvement in the water quality of the Bay so that multiple-use in its broadest sense could occur. Virginia Parrot presented a series of slides showing what Raritan Bay and its adjoining land masses looked like in recent months. One can see that the Bay does yield fish. One can also see that the Bay has been heavily developed with refineries, smelters, extensive piers, and docking facilities, and other activities which tend to degrade water quality. There are many things, however, that cannot be determined from such slides. Levels of petroleum hydrocarbons and trace metals mentioned earlier are not obvious. Samples must be taken by research vessels and sophisticated analyses performed in order to ascertain that there are levels of contaminants present which can impact upon marine life. The disappearance of bottom-dwelling species of marine resources is also difficult to observe from the surface or, sometimes, even from the contents of the fisherman's net.

When one is looking to the multiple use of estuaries and coastal waters, it becomes essential to understand (1) the <u>sources</u>, <u>fates</u>, and <u>effects</u> of a range of contaminants, and (2) processes which result in physical degradation. The latter includes mining for sands and gravels, dredging to deepen channels, ocean dumping to dispose of a range of wastes, point source discharge of domestic sewage, and to a large issue which is generally referred to as "nonpoint sources of pollution."

During one of the panels, we heard that EPA's 301 (h) waiver process will turn back progress that has been made in upgrading sewage treatment. Until recently, most cities were under a mandate to raise the level of treatment to the secondary or tertiary levels. Beyond this, most municipalities or regional water boards were under legislative direction to end ocean dumping. In recent months, however, the change in the economic climate has also resulted in a change in government attitude towards ending pollution and ocean dumping. Another panel traced the impact of pollution and man's effects back to the turn of the century. Dr. Haskin noted that in spite of massive pollution and physical degradation, many estuarine species persist. In fact, this is one of the hallmarks of estuarine animals; they have evolved through thousands of years by accommodating to natural changes in temperature, salinity, and turbidity. Since these animals were adapted to live in a fluctuating environment, many of the species have continued to prevail in spite of man's wide ranging effects on embayments such as Raritan Bay. The fact is, however, that many other estuarine species have been unable to survive unusual stresses. Important species of marine animals such as amphipods - a valuable forage species for many fish - have disappeared completely from Raritan Bay. Moreover, many of the organisms in the Bay are heavily tainted with PCBs, petroleum hydrocarbons, and other contaminants. Both finfish and shellfish panels stated strongly that while there were still species of valuable marine life in Raritan Bay, some benthic forms were no longer suitable for human consumption without expensive and energy consuming depuration or relaying. Many of the finfish were tained to the point where some contaminants could be tasted! The committees felt that it was important to increase the quality of waters so as to increase the yield of seafoods and to improve the quality of those seafoods.

The industrial panel felt that Raritan Bay was also extremely valuable as a center for transportation and industrial development. Companies engaged in overseas transportation number approximately 550. Industrialization is increasing in the New York metropolitan area because of the economic desirability of sea level shipping. It was noted that some 35,000 jobs in the Raritan Bay-Port Newark area result from various transportation endeavors that are ongoing in these waters. Discussions also indicated that people continue to move to this area in spite of the intensity of industrial and domestic development. Many communities have developed Green Acre programs which are thought to be important in luring new residents to Raritan Bay communities. Large, expensive condominium developments in Sea Bright and Atlantic Highlands testify to the view that these are still desirable places in which to live. It is important to recognize that one of the reasons that people are drawn to live near Raritan Bay is that there are excellent recreational facilities, and the possibility for increased recreation in the future. Numerous marinas provide berthing facilities for private boats and scores of party boats operate to take anglers to Raritan Bay and adjoining coastal waters.

While the various summaries provided by the panels indicate that there are, indeed, many competing demands on Raritan Bay and its resources, the regulatory or government panel indicated that there are numerous regulations, some of which go back almost 300 years. Unfortunately, it is obvious that these various regulations have not resulted in maintenance of water quality in Raritan Bay. As with various industries and development activities, the regulatory agencies have often been engaged in adversarial posturing. In many cases there are overlapping jurisdictions between state and federal agencies and even between agencies within individual states or agencies of the federal government. A representative of the United States Environmental Protection Agency (USEPA) asked, rhetorically, if anyone really cared about what happened in Raritan Bay. This same person also questioned whether USEPA continued to have a mandate to do something about such coastal waters. It was mentioned that the Interstate Sanitation Commission (ISC) could play a real role in terms of upgrading waters of the lower Hudson estury and Raritan Bay but, again, the question was asked, what is the ISC doing today?

Several panelists questioned whether one could possibly do anything about nonpoint sources of pollution? Nonpoint sources include the atmosphere, runoff from agricultural fields, runoff from fertilizers applied to private lands, and the effects of existing and developing roadways and rail transportation. Individuals who raised this concern within the various panels also asked where the funding would come from, noting that expectations of people often outstrip the resources of agencies in terms of mitigation and pollution abatement.

Other panelists also noted that many of the problems associated with harbor development, such as ocean disposal of dredged material, would pose no threat if nonpoint sources of pollutants did not impact upon our estuaries and coastal waters in the first place. If the human and industrial pollution from the New York metropolitan area did not accumulate in the lower Hudson and Raritan bays, then sediments would be relatively clean and, when dredged, could be disposed of almost anywhere in the offshore and upland environments as long as this disposal did not affect navigational activities.

Finally, persons on both the regulatory and industrial panels suggested the way forward would be to have an overall Raritan Bay commission or authority that would have responsibility for regulating activities in Raritan Bay so that one activity would not compromise another. It was noted that the Delaware Bay Commission can get into land affairs but only those which might affect water quality. There is precedent, therefore, for an authority or commission which would be able to regulate activities on the land in such a way that various watershed interests would not be compromised.

Any regulatory activity would have to result in the development of a series of water quality standards and criteria used to establish the violation of such standards. Terms such as unreasonable degradation would either not be usable in such a situation or limits must be established to define when too much pollution or development has occurred.

Finally, all of the panels indicated that far more communication and coordination is necessary to the implementation of those processes and steps necessary to improve water quality of Raritan Bay. Beyond this, it is absolutely essential to define clearly the various problems and issues at hand. The Workshop went a long way towards indicating some of these. By clearly defining the principal issues, multiple-use concepts and risk assessments can be developed to address them. By risk assessment I mean evaluating the actual effects of a particular activity on a range of living marine resources, including the economic consequences of these and alternative actions possible to avoid or mitigate adverse effects.

One thing is obvious -- Raritan Bay has been affected by man's past activities. If we have any hope of increasing the yields of seafood, improving recreational activities, and implementing other uses of Raritan Bay without compromising fishery production, it will be necessary to take stepwise actions, some of which have been suggested. Another thing is patently clear; if we allow the same activities that degraded Raritan Bay to continue in other embayments in New Jersey or other coastal areas of the northeast, such waters will certainly be degraded in the same way as those of Raritan and Delaware bays. As an example, recent measurements in relatively pristine estuaries along the Maine coastline, Penobscot and Casco bays, indicate that those areas have already been impacted upon. Raritan Bay should serve as a classic example of habitat mismanagement. This workshop has identified some of the historical problems and the groups presently responsible for management of Raritan Bay. Managers of other coastal waters should pay close attention.

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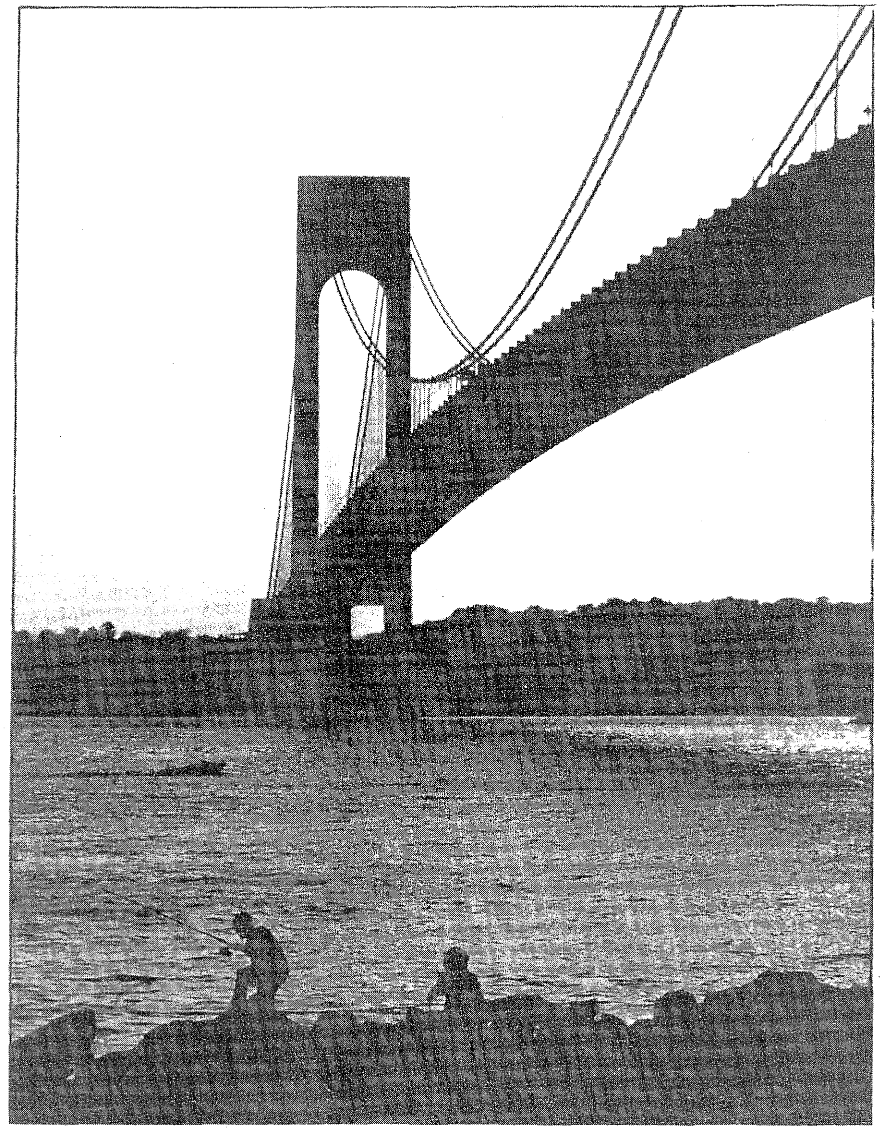

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Anthony L. Pacheco
Proceedings Editor