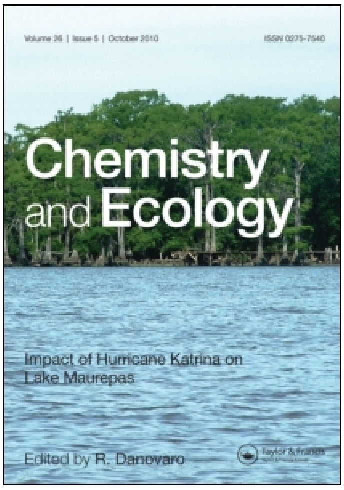


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# USE IMPAIRMENTS AND ECOSYSTEM IMPACTS OF THE NEW YORK BIGHT

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The New York Bight is perhaps one of the most used and abused coastal areas in the world as a consequence of urbanization and the disposal of the waste of some 20 million people who reside by its shores and surrounding bays and estuaries. A variety of sources, including those associated with sewage wastes, industrial wastes, contaminated dredged material, urban runoff, and atmospheric fallout contaminate these coastal waters. Many of the stresses of excess population and industrialization as measured by pollutant loadings and ecosystem impacts can be crudely quantified in terms of use impairments—use impairments that have measurable social and economic relevance. Five broad categories of impairment attributed to pollution in the Bight that are causing significant losses of ecological, economic, or social values are: beach closures, unsafe seafoods, hazards to commercial and recreational navigation, loss of commercial and recreational fisheries, and declines in birds, mammals and turtles. These impairments are generally caused by floatable wastes, nutrients, toxicants, pathogens and habitat loss. Measures of such impairments are not standard, nor in many cases totally quantifiable. We have examined specific subsets of these impairments in terms of their spatial and temporal changes and as a first approximation determined the economic and social significance of these changes. The cost of these impaired uses of the Bight are measured in terms of billions of dollars annually for New York and New Jersey.

KEY WORDS Coastal ocean, Pollution, Floatables, Sewage, Beach closures, Unsafe seafoods, Loss of fisheries, Social and economic impacts



## INTRODUCTION

East of New Jersey and south of Long Island, the continental shelf spreads into the rolling sand plain of the New York Bight. The floor of the Bight slopes—about 30 meters in a hundred kilometers—toward the edge of the shelf from an apex at the mouth of the Hudson River (Figure 1). A wide, shallow valley, cut by the Hudson River during the last ice age, crosses the shelf and terminates in the Hudson Canyon. Bight waters which cover this section of the continental shelf are subjected to external forces and processes that in many ways control the consequences of anthropogenic interactions with this marine ecosystem. Driving forces such as the northwestern Atlantic circulation, meteorological and climatological conditions, and the influence of the Hudson–Raritan Estuary and back bays of New York and New Jersey are among the most dominant.

The Bight is perhaps one of the most used and abused coastal areas in the world as a consequence of urbanization and the disposal of the waste of some 20 million people who reside by its shores and surrounding bays and estuaries. A variety of sources, including those associated with sewage wastes, industrial wastes, contaminated dredged material, urban runoff, and atmospheric fallout, contaminate these coastal waters. These sources discharge wastes indirectly to the Bight via the inflowing Hudson–Raritan Estuary and coastal inlets, as well as directly from coastal runoff and sewage outfalls. Much of the area's muncipal wastes have been taken by barge out into the Bight for nearly a century. Legal dumping of garbage and trash ceased in 1934 but, as late as 1987, some 7.6 million wet tonnes of sewage sludge and 4.6 million cubic metres of contaminated dredged material were dumped into the ocean waters 10 to 180 km offshore† (Figure 2).

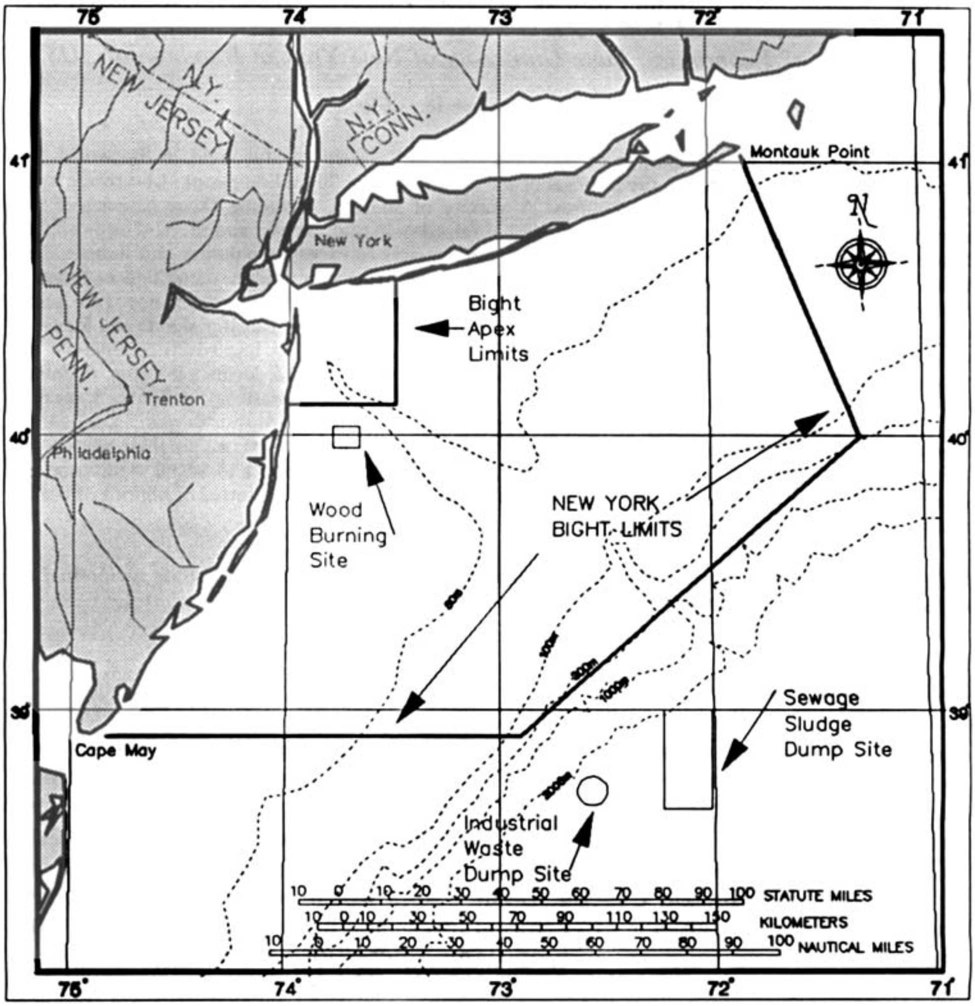


**Figure 1** New York Bight and approaches.

† Sewage sludge was ocean dumped at a site approximately equidistant from and 20 km off the New York and New Jersey coast from 1924 through 1986. In 1987 sewage sludge dumping was phased out of this near coastal site to the 106-mile site some 250 km east of Cape May, New Jersey. All sludge dumping at the near-shore site ceased in December 1987.

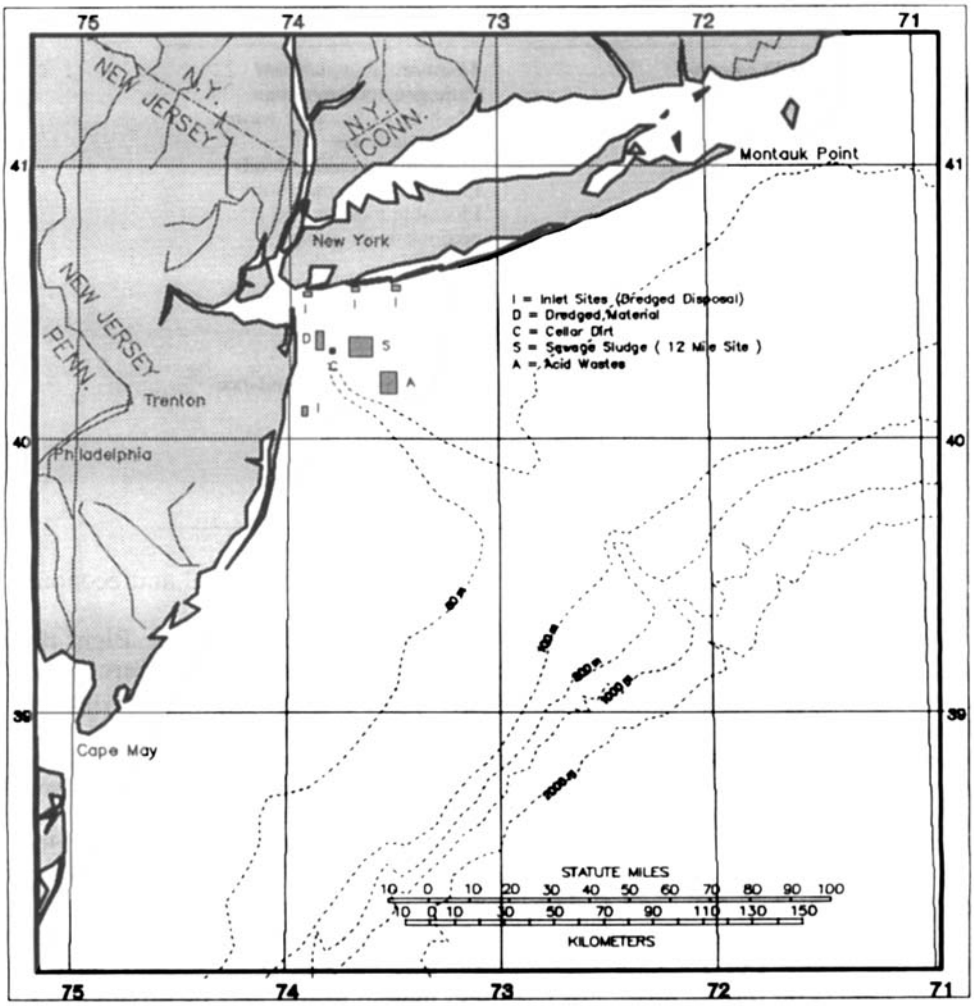


**Figure 2** New York Bight apex and disposal sites.

The Bight still provides important resources for its millions of users. There are offshore fisheries in these waters, and wildlife inhabit the less populated shores. The Gateway National Recreation Area borders the Bight and provides marine recreational opportunities in a relatively natural environment. The Bight is a major sea lane for marine commerce, and its resources include sand and gravel and perhaps other untapped resources.

In order to conserve and hopefully rehabilitate the Bight, it is important to understand ecological processes in the Bight and the impact of anthropogenic activities on the marine ecosystem. To acquire and allocate resources for rehabilitation, it is useful to understand impacts in terms of economic costs and benefits. Many of the stresses of excess population and industrialization as measured by pollutant loadings and ecosystem impacts can be specified in terms

**Table 1.** Use impairments and adverse ecosystem impacts

| *Use impairment* | *Measures of impairment* |
|---|---|
| Beach closures | Pathogen contamination<br>Wash-up of floatable waste<br>Algae wash-ups |
| Unsafe seafoods | Toxicants in marine foods<br>Pathogen contamination |
| Commercial navigation and recreational boating | Floatable hazards and noxious water quality features |
| *Ecosystem health and productivity impacts* | |
| Commercial and recreational fisheries | Disease<br>Distribution and abundance<br>Fish kills |
| Birds, mammals, and turtles | Habitat loss<br>Human conflicts<br>Toxicants<br>Floatable wastes |

of use impairments—use impairments that have measurable social and economic relevance.

Five broad categories of impairment attributed to pollution in the Bight that are causing significant losses of ecological, economic, or social values are: beach closures, unsafe seafoods, hazards to commercial and recreational navigation, losses of commercial and recreational fisheries, and possible impacts on some marine animals. These impairments are generally caused by floatable wastes, nutrient loading, toxicants, pathogens, and loss of habitat. Measures of such impairments are not standardized, nor in many cases, totally quantifiable. We have examined specific subsets of these impairments (Table 1) in terms of their spatial and temporal changes, when available, and as a first approximation determined the economic and social significance of these changes.

In some cases, there may be overlap when an impairment is caused by more than one agent. For some of the impairments, the causal agent may have an indirect effect on the resource. For example, human health may be threatened by toxicants via eating contaminated fish. The direct effect of the toxicant may jeopardize the health of the fish (lower reproductive capacity), while the indirect effect is on public health.

The procedures that we adopted to quantify the extent of the impairments are discussed in the following section on methods.

## METHODS

### *Beach Closures*

The economic consequences of beach impairments from algae, pathogens, and floatables are based on beach use which can be measured in user days; however, there is no single or comprehensive source from which these data can be derived

(Kahn, in press).† The extent to which beach use has decreased at New York beaches as a result of pollution can be approximated by comparing beach attendance in 1976 (60 million user days) with either the baseline attendance figure (105 million) or attendance in peak years (150 million). Alternatively, for an extremely conservative assessment of the reductions in beach usage, one could assume that the 1976 level was the baseline, and measure a 25% to 50% reduction in use from that level. This reduction is based on reports of the New York State Department of Parks and Recreation of the effects of 1988 waste wash-ups on beach attendance. Using these assumptions, the reduction in beach use would be between 30 and 90 million user days in New York State. Comparable figures for New Jersey would be 6.7 to 37 million user days (based on an observed decline in beach attendance of 7.9% to 34% at beaches along the New Jersey shore in 1987–1988).

A beach pollution event has three major economic impacts. First, there is a reduced level of expenditures‡ on beach activity, which has negative effects in many sectors of the economy. Second, there are impacts on employment. Third, the people who use the beaches suffer a lower quality of life because of diminished recreational opportunities. The measures of the first two impacts are apparent to the non-economist. The third, measured by consumers' surplus, is not considered in this analysis.

Beach closures due to pathogens, while not appearing to have economic consequences as large as those due to floatables, do have significant economic impacts. The impacts of pathogen contamination is probably less because large-scale beach closures due to pathogens have not been necessary, pathogen contamination is better understood, and not nearly as visible. Beach attendance was again used to measure the impacts. Specifically, the average yearly attendance at New York State Park beaches in the 1970s (excepting 1976, a year of pronounced floatable wash-ups) was computed and compared to average

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† Some institutions such as the Long Island Region of the New York State Department of Parks and Recreation compile annual attendance figures from the per-vehicle admission fee records. At some beaches (particularly town beaches) admission is gained by having the appropriate annual sticker on the car, so there is no daily census. The only comprehensive annual attendance figure for New York is for 1976, a year associated with an unusually large number of beach problems (wash-ups of floatables and other wastes).

An estimate of total beach use was determined by assuming that attendance at New York State Park beaches is a constant fraction of total attendance. Based on these data, one could assume a baseline attendance at New York beaches of approximately 105 million user days (the average of the lower and upper bounds reported in a working paper prepared in connection with this report). This figure is representative of average attendance in years without a major pollution event. The comparable figure for New Jersey would be 93.6 million user days.

‡ Direct expenditures have been estimated by examining average per-trip expenditures in other studies—adapting those figures to 1987–1988. Direct expenditures do not take into account the additional expenditures generated as these dollars are respent. These indirect or "ripple effects" are determined through the application of a multiplier. Multipliers of 2 to 3 are generally employed in studies of this nature (Bell and Leeworthy, 1986 and New York State Department of Environmental Conservation, 1977).

It should be noted that this analysis does not consider that expenditures not made at the beach may be put back into the economy elsewhere such as at golf courses, mountain resorts etc. While this probably occurred and in a macroeconomic sense diminished the economic consequences of the floatable event, to those people and communities affected, the floatables event was significant.

attendance in the 1980s (excepting 1987 and 1988, characterized by high incidence of floatable wash-ups). The averaging process evened out the effects of weather on beach attendance, and it was assumed that the remainder of the difference was due to pathogens (or possibly other forms of chronic pollution).

The assignment of economic values is similar to those described above for floatables. Since comparable figures were not available for New Jersey, these values were assumed to be proportionate to the New York values. Estimates were based on the ratio of floatable impacts to pathogen impacts being the same for New York and New Jersey.

### *Unsafe Seafoods*

In addition to the effect on human health in those small segments of the population who are subsistence fishermen and who disregard health advice against consuming contaminated seafood, there are losses in economic benefits associated with reduced activity in the recreational and commercial fisheries. Recreational fishing, after beach use, involves the most people using the New York Bight. Roughly 2.5 million anglers (National Oceanic and Atmospheric Administration, 1980) for New York and New Jersey combined, derive enjoyment from recreational fishing and inject roughly $2 million yearly of direct expenditures into the region's economy (Kahn, personal communication).

There was a significant reaction by recreational fisherman to the 1988 medically related waste wash-ups. The wash-ups may have exacerbated existing negative reactions as the wash-ups came shortly after the considerable media coverage of the following events: closure of the New York striped bass fishery, the issuance of a New Jersey bluefish health advisory notice, and the unexplained deaths and wash-ups of dolphins and whales. This intense media coverage created the impression that local fishes are simply too contaminated to eat. Much of our information is based on informal survey data following the 1988 fishing season.

The economic multipliers or ripple effects for both the recreational and commercial fishery are estimated to be between 2 and 3. The impact of toxicants on commercial fishing markets was based on the catch of a prohibited species and the downward shift in demand that could have had effects on price and quantity of landings.

It is difficult to measure employment impacts in the commercial fishing industry that result from a reduction in demand since there are many part-time fishermen in the industry. Shocks of this nature usually affect the part-time fishermen first. It is also difficult to measure impacts on employment in the shellfishing industry as a result of closure of shellfish beds. Closures have been a problem for decades, so there are not the sudden and unexpected impacts that have characterized recreational fishing and beach use.

Still other important economic impacts are associated with the closure of shellfish beds and with pathogen contamination in general. Approximately 32% of the shellfish beds that once existed in the Bight and Hudson–Raritan Estuary are closed. The first costs are those associated with the lost potential production which could take place if the beds were open. Second are the costs associated with the human ingestion of pathogens, either from consumption of shellfish from beds that are contaminated but not yet closed, or from the consumption from illegal beds. The third group of costs are those associated with enforcing closures.

Finally, there are the lost economic benefits from declining demand for shellfish because people are afraid of ingesting pathogens. Our estimates were based primarily on lost potential production.

*Commercial/Recreational Navigation*

Our measures of costs of floatable hazards to commercial and recreational boating were limited to the costs of damage due to collision with floating objects and costs to remove floating hazards from waterways. They do not measure the economic damages generated from reduced aesthetic quality of the recreational boating experience.

*Commercial/Recreational Fisheries*

Changes in both abundance and distribution of fishes may have important impacts on the economy. The commercial catch has declined over time as has catch per unit effort. It is assumed that the recreational catch per unit effort has declined as well. One must use caution when discussing catch per unit effort in recreational fishing because the effort is the source of enjoyment. However, studies by Buerger and Kahn (1989) show that catch rates are an important determinant of the demand for recreational fishing.

If the demand declines as a result of the reduction in catch rates, then both the value to the anglers and the number of trips (and expenditures) will decline. Buerger and Kahn (1989) showed that the decline in striped bass populations resulted in a loss of economic benefits of $2 to $8 million alone. Changes in distribution of fishes may also increase the cost to anglers, lowering their number of trips and reducing their catch rates, which will further reduce their trips.

It was not possible to approximate the economic losses associated with changes in abundance and distribution in recreational fishing due to pollution. It is difficult to determine how much of the decline in abundance and distribution was due to overfishing and how much was due to pollution. It is probably safe to assume that the effect of pollution was greater for estuarine and anadromous species than for offshore marine species. It could also be argued that the estuarine and anadromous species were subject to more fishing pressure than offshore species, particularly with respect to the recreational catch. Since the data do not exist to estimate this relationship properly, we have assumed that for every 1% increase in recreational fishing activity, direct expenditures would increase by $20 million, total expenditures by $40 million to $50 million, net economic benefits by $10 million, and employment by roughly 900 jobs. It is possible that the recreational fishing benefits of reducing pollution and increasing fish abundance could be negated if the response of commercial fishing to the increased stock is an increase in fishing effort which would result in lower stocks.

The above analysis for recreational fishing can be extended to commercial fishing. Fish kills and fish disease are likely to have small negative impacts on the economic benefits derived from commercial fishing, with the exception of shellfish. Given that the total value of landings for shellfish in New Jersey and New York is approximately $70 million annually, it appears that the annual damages for a shellfish kill of large magnitude could approximate this amount.

Stock reductions from overfishing are likely to have a significant impact on the fishery, but the stock reduction from pollution could not be inferred from existing data. However, for each one percent increase in commercial fishing activity, direct expenditures would increase by $1.2 million dollars, total expenditures by $2.4 million to $3.6 million and net economic benefits by $1.2 million. Employment impacts are difficult to determine due to the presence of part-timers in the industry.

As with recreational fishing benefits, the commercial fishing benefits of reducing pollution will be dissipated if the response to less pollution is more intense fishing, which ultimately reduces stocks and catch. It is essential that fishery management policy be coordinated with environmental policy to avoid this.

*Birds, Mammals, and Turtles*

Marine mammals and turtles are not commercially and recreationally exploited. However, marine birds, such as ducks and geese, are hunted in some cases. Economic impacts of impaired uses were therefore difficult to quantify. Some estimates might have been made by examining sales receipts from whale watching excursions, visitations to wildlife refuges, and memberships in wildlife clubs. Although assigning a value to these resources is difficult, birds, turtles, and mammals are nonetheless aesthetically and ecologically important.

Three levels of impairments need to be examined. At the lowest level are impairments that reduce the regional population of a species. The second level is the endangerment (or extinction) of a species in the region. At the third level, regional endangerment (or extinction) leads to global endangerment (or extinction in the wild). For most species in the New York Bight area, the first and second levels are the most relevant.

Since the reduction in habitat for certain endangered birds and sea turtles may have a critical effect on their reproduction (birds) or development (turtles), continued loss of habitat in addition to anthropogenic mortality in the New York Bight region may threaten their existence. Fisher and Krutilla (1985) documented the economic importance of preventing species extinction. They also demonstrated that when faced with an irreversible environmental change such as the loss of critical habitat or extinction of a species, one should avoid these irreversible consequences even if the immediate costs of doing so seem to exceed the benefits.

The reduction in abundance of these animals leads to social losses in a variety of ways. First, the sighting of these animals leads to increased enjoyment during a variety of other activities. For example, the highlight of a recreational fishing trip might not be the fish the angler catches, but the sighting of a whale, eagle, or osprey. Large nesting populations of birds add enjoyment to beach trips. Second, the existence of healthy numbers of these species is taken by many people as an important indicator of the quality of the environment and the quality of life. When individual or large numbers of organisms die from oil spills, entanglement or other anthropogenic causes, people hold themselves responsible as members of a society that allowed the tragedy to take place.

The importance of marine mammals in this regard cannot be understated. Many members of society feel a warmth towards marine mammals that does not extend to other members of the animal kingdom. This may be because of the superior intelligence of these animals, their size, grace or other factors. The source of this enchantment is not as important as its existence, and there is ample evidence to suggest that it exists. Such evidence includes the widespread contributions to the "Save the Whales" campaign, the passage of the Marine Mammal Protection Act, the attention given to the wash-up of dead porpoises in the Mid Atlantic Bight area, and the $5.8 million international effort (Rose, 1989) to save three California Gray whales trapped in Arctic ice.

While it is difficult to quantify the losses from pollution-induced reductions in populations of birds, marine mammals, and sea turtles, the losses do exist and are important. In any overall comparisons of the costs and benefits of reducing pollution in the New York Bight, these values should not be ignored.

## USE IMPAIRMENTS

### *Beach Closures—Pathogenic Contamination*

Particular pathogenic bacteria and viruses excreted by man can cause gastrointestinal tract diseases: typhoid, paratyphoid, dysentery, diarrhoea, cholera, polio, and hepatitis. Beach closures in the Bight are not based on the presence of the actual pathogens, a determination that is costly and slow. Closures are based instead on the presence of total and fecal coliform bacteria—presumptive evidence that pathogens are present. Since *Escherichia coli* is an intestinal bacterium, its presence in a water sample suggests faecal contamination.



The criteria for beach closures based on coliform concentrations are different for the states of New York and New Jersey. The differences in the standards for the two states may account for some of the discrepancy in numbers of beach closures in New Jersey (more restrictive in recent years) versus those in New York. Despite these differences it is likely that fewer ocean beaches closed in New York because there are fewer sources of faecal coliform in inshore waters—fewer storm sewers and only two sewage treatment plant outfalls along the coast.

*Areal extent.* In New Jersey, between 1985–1988, there were 86 ocean beach closures due to pathogens. Closures occurred in all the coastal counties, although the greatest impacts cover the 45 km of beaches from Sandy Hook to Manasquan. The periods of closures have generally been on the order of days with several instances of closures in excess of a month. Information for beach closures in New York due to high coliform counts was lacking for years prior to 1987. In 1987, no ocean beaches in New York were closed due to pathogens, but one ocean beach (Quoque) was closed in 1988.

*Causes of impairment.* Certain pathogenic bacteria and viruses excreted by man may be contained in the greater than 8.7 billion litres of wastewater (primary and secondary treatment) effluents that are delivered to New York harbour daily (HydroQual, 1989). Storm water via combined sewer overflows (CSOs) also delivers raw effluent to the Harbour. A portion of this water mixes with the water at various New York and New Jersey beaches.

*Problems associated with the impairment.* Certain pathogens may cause gastrointestinal tract diseases. Coliforms serve as a surrogate for their presence. Based on the few incidents of disease outbreaks reported, the public has been well protected over the years by the coliform standards, a measure of the standards' effectiveness. Although chlorination and other treatments may kill off faecal coliforms, other problem organisms such as viruses may survive the treatments. Faecal coliform standards alone may now be giving a false sense of public health status.

*Economic and social impacts.* The most significant social impacts of beach closures due to pathogens are the lost opportunities for recreation. The major economic loss for New Jersey in 1988, estimated at $390 million, was from decreased revenues resulting from actual beach closures. However, based on press accounts and personal interviews, the general public's perception that beaches are unhealthy also resulted in decreased beach use. In New York the economic loss was approximately $200 million (Table 2). New Jersey's user days also decreased by eight million during 1987 as a result of coliform-caused closures.

For New York, there was one beach closure due to coliforms, although the general perception that beaches and water quality were poor apparently culminated in decreased beach use. New York's user days in 1987 decreased by 20 million.



### *Beach Closures—Wash-up of Floatable Waste*

Floatable wastes are waterborne materials and debris that are buoyant. These include debris (wood and beach litter such as cans, bottles, styrofoam cups, sheet plastic, balloons, straws, and paper products); sewage-related wastes (condoms, sanitary napkins, tampon applicators, diaper liners, grease balls, tar balls, and faecal material); fishing gear (nets, floats, traps, lines); and medically related wastes (hypodermic needles, syringes, bandages, red bags, enema bottles).

*Areal extent.* In the period 1980–1988, there were on the order of 100 beach closures around the New York Bight due to floatable wastes. Until 1989, the

**Table 2.** Use impairments: beach closures

| *Use impairments* | *Factors causing impairment* | *Ecological significance of impairment* | *Spatial and temporal extent of impairment* | *Annual economic impact 1987 dollars* |
|---|---|---|---|---|
| *Beach Closures* | | | | |
| • Pathogens | Pathogens | Little | approx. 100 beach closures in 1980s in New Jersey's Records not comparable in New York | $590 million |
| • Floatables | Floatables | Little | up to 100 km closed at one time or another over short periods in each state | $1.0–5.4 billion in 1988. Much less in most years |
| • Algae | Nutrients | Little | limited | small |

criteria for closing beaches because of floatable wastes were not consistent from beach to beach. Water quality (as measured by the coliform indicator) has generally not been a factor in closing beaches during a floatable wash-up. Rather, closures have depended on subjective criteria such as the look or smell of the material or on expectations of public perception—to avoid a possible public outcry. Most closures occurred for hours—rarely more than a day. More consistent beach closure guidelines by local and state agencies are now in use (Marine Sciences Research Center, 1989).

In New Jersey, the area closed on numerous occasions during May 1987 due to floatables included 40 km of beaches; in August 1987, the area closed comprised 80 km of beaches (Figure 3). Few beaches were closed because of floatable wastes in 1988. In New York in 1976, sewage-related floatable wastes were responsible

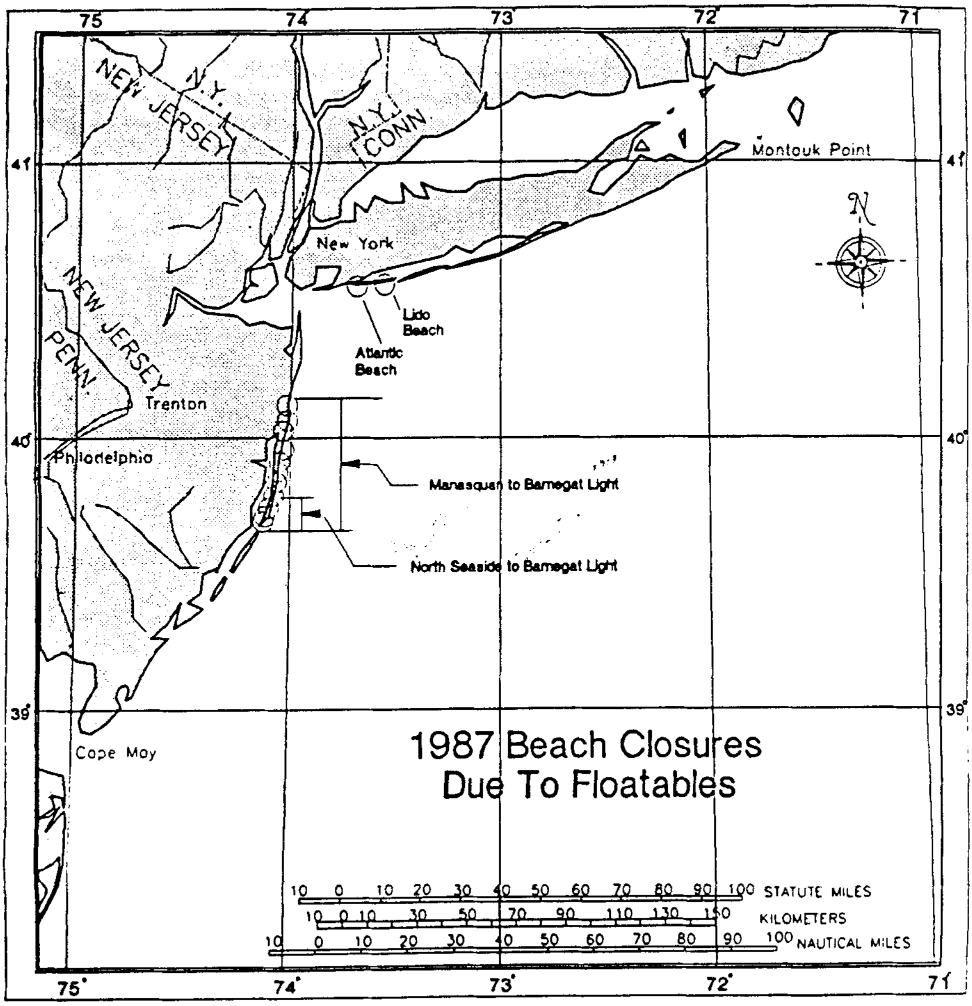


**Figure 3** 1987 Beach closures due to floatables.

for closing 93 km of beaches. There were 2.4 km of beaches closed in 1987; and in July, 1988, 93 km of beaches were closed due to medically related and other floatable wastes (Figure 4).

*Temporal changes.* From the late 1800s through the 1930s, garbage, paper bottles, metal, and dead animals were discarded into New York Bight and New York harbour waters. During the 1940s–1950s, the floatables problem was probably held somewhat in check with the end of refuse dumping at sea and introduction of sewage treatment plants. During the 1960s and 1970s, styrofoam cups, disposable plastic diapers, plastic tampon applicators and PET (polyethylene teraphthalate) bottles increased the floatables load, and in 1987 and 1988, some medically related wastes were found with the typical floatables.

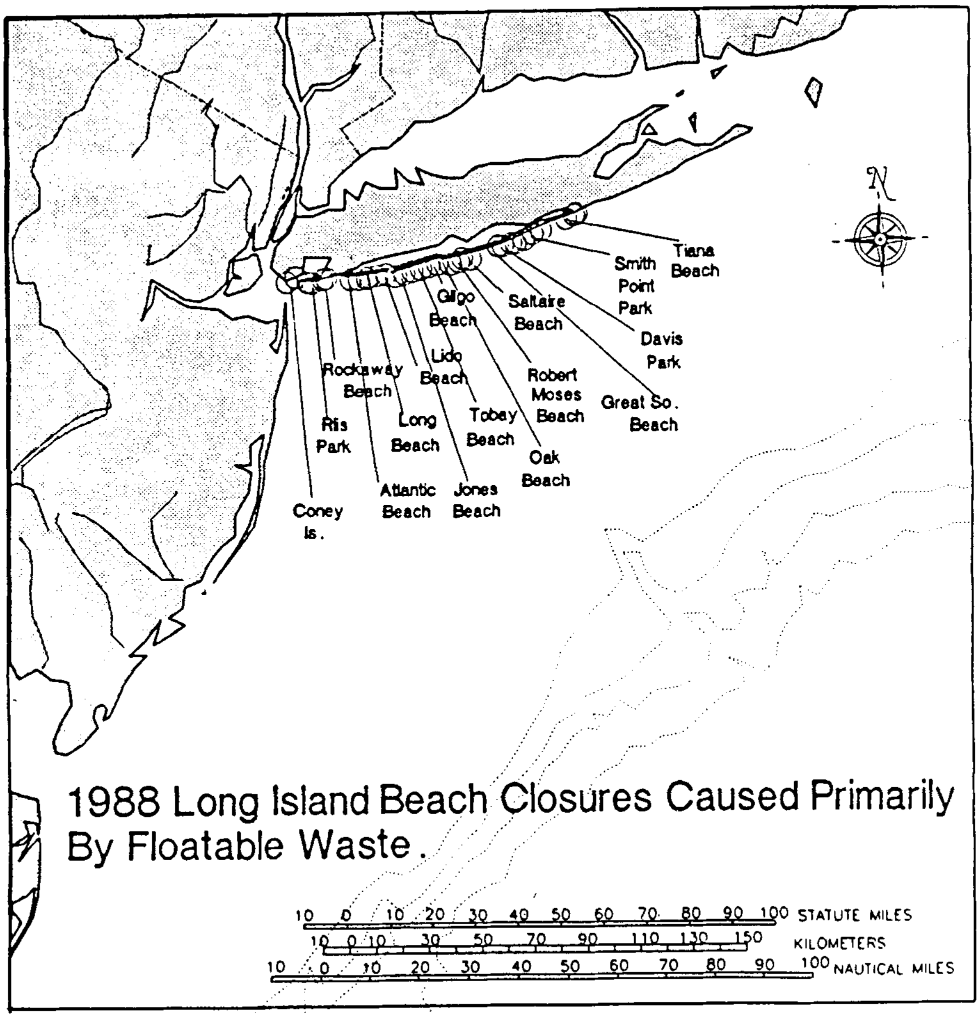


**Figure 4** 1988 Long Island beach closures caused primarily by floatable waste.

*Causes of impairment.* The sources for the majority of the floatable wastes are located along the periphery of the Hudson–Raritan Estuary, and much of these wastes are flushed out into the Bight during the spring freshet (Swanson and Zimmer, 1990). The intensity of the freshet dictates the size and distribution of the summer-time floatable load. The peak of floatable waste input from the freshet is at or near the start of the beach season.

During the summer, rainfall causes bypassing of sewage treatment plants, delivering floatable wastes to the receiving waters from combined sewer overflows. Garbage and trash reach marine waters through poor solid waste handling in the metropolitan area and from storm sewers, particularly along the New Jersey coast. Illegal disposal is probably a minor source. Sea breezes may wash ashore debris accumulated along oceanic fronts and convergences and in Langmuir circulation cells. Long Island is particularly vulnerable to wash-ups of floatable wastes because of the prevailing summer winds in the area (Swanson *et al.*, 1978, Swanson and Zimmer, 1990).

*Problems associated with the impairment.* Floatable materials on beaches and in our coastal waters are mainly an aesthetic problem for the public. There is a perception that contact with floatable material poses a major public health threat; however, there is no evidence to support that supposition. Public safety (injury from cuts, bruises, punctures) may be a more significant threat. The fear of exposure to AIDS made the medical wastes found in the floatable material a major concern in the 1987 and 1988 wash-ups. These fears are unfounded. The chance of acquiring AIDS in this manner is close to zero (Green, in press). Also, the risk of acquiring Hepatitus (B and non-A/non-B) from a needle that has washed ashore is extremely low (Bell *et al.*, 1989).

There are also detrimental impacts on marine birds, turtles, fishes, and other marine animals from floatable wastes which may result in death: entanglement in plastic objects and in fishing line and ingestion of plastic objects that are mistaken by animals for prey food. Some of the impacted marine animals have been designated as endangered or threatened species, underscoring the ecological significance of this impairment.

*Economic and social impacts.* For New York the loss in total expenditures is estimated to be between $750 million and $1.8 billion for 1988. The New Jersey loss in total expenditures is estimated to be between $600 million and $3.6 billion. Our estimates for losses in beach user days in 1988 range from 6.7–30 million in New Jersey and 30–91 million in New York as compared to estimates of baseline attendance. The reasons for the difference in the estimates of losses for the two states is not clear. However, it must be kept in mind that the character of the ocean beach areas of the two states is considerably different (much more commercial in New Jersey). Also the manner of generating attendance figures is completely different. New Jersey of course experienced major floatable problems in 1987 so that frequenters of the New Jersey shore were reacting in 1988 to a problem over two summers.

In an independent analysis, R. L. Associates (1988) report a reduction in user days of 1.9 million in 1988 relative to 1987 along the New Jersey coast. They also report a reduction of $700 million in expenditures in 1988 relative to 1987.

In a study for the Long Island Tourist and Convention Commission, Fey (in press) estimated that the net loss of expenditures on Long Island in 1988 was $700 million. In this estimation, the Commission considered that the loss in beach related expenditures of $1.4 billion was partially returned to other parts of the economy and that the Island had been experiencing a 5.6% growth rate in the tourist industry since 1978. The actual loss in expenditures in 1988 relative to 1987 was $900 million.

In an effort to reduce the impact of floatables, the U.S. Environmental Protection Agency (EPA) in cooperation with the U.S. Army Corps of Engineers (COE), the U.S. Coast Guard, the states of New York and New Jersey, and New York City implemented a short-term floatables action plan. The plan supplements the COE program of skimming New York Harbour of debris that might pose a hazard to navigation. The effort, implemented in 1989 at an additional cost of $1 million, consists of reducing the mesh size of the existing nets in order to pick up much of the floating debris.†

*Beach Closures—Algae*

Algal blooms—green and red tides—have occurred throughout the Bight, particularly off the New Jersey coast, but have rarely caused ocean beaches to close. Blooms may be enhanced by the introduction of certain nutrients that enter the Bight in the effluent from sewage treatment plants (point sources along the New Jersey coast), from the Hudson–Raritan Estuary, and direct runoff from the land (non-point sources), especially from agricultural runoff. Nutrients are also transported on to the continental shelf from slope waters and to some degree from atmospheric fallout.

*Problems associated with the impairment.* Algal blooms are aesthetically displeasing and disconcerting because they often look and smell like sewage. There are no known health risks associated with blooms occurring in the Bight, although in 1972 blooms of *Prorocentrum micans* were associated with complaints by swimmers of respiratory discomfort (Olsen, 1989). Beach closures in New Jersey (near Atlantic City) in 1984 and 1985 resulted from blooms of the non-toxic dinoflagellate *Gyrodinium aureolum*, but these beaches closed as a precautionary measure.

*Economic and social impacts.* Economic impacts affect many communities that are economically dependent on beach users. The dollar amount is unknown, but assumed to be relatively small.

*Ecological significance.* Very dense algal blooms are known to cause a reduction of dissolved oxygen (DO) in the water column. Low DO in certain areas—usually enclosed or restricted areas having limited flushing with oxygenated waters—has resulted in kills of marine animals, particularly benthic fauna. In the Bight

† The floatable problem was not nearly as bad in 1989 and 1990 as compared to the previous two years. This can be attributed to the fact that the short-term floatable action plan is working well and also to the fact that the meteorological conditions did not favour wash-up of debris.

proper, there are very few areas subject to these conditions; therefore, the ecological impacts resulting from algal blooms are negligible. Recent reports of kills in the Bight have been of very few fishes and of a very localized and sporadic nature, mainly in several places along the New Jersey coast. An exception was the anomalous 1976 widespread bloom of *Ceratium tripos,* which contributed to a major faunal kill extending over some 8600 $km^2$ (Swanson and Sindermann, 1979). In most of the localized kills, DO had not been measured; therefore low DO has not unambiguously been determined as the cause of the recent fish kills in the Bight. However, these episodes along with direct measurements of general hypoxic conditions and phytoplankton bloom events along much of the New Jersey shore may indicate chronic, increasing coastal eutrophication. The dolphin strandings which occurred off the New Jersey shore in 1987 have recently been indirectly tied, through the food chain, to a bloom of *Ptychodiscus brevis,* a species not found in the New York Bight.

*Unsafe Seafoods—Toxicants*

The types of toxicants in edible marine species of the Bight include the organic compounds: polychlorinated biphenyls (PCBs), DDT, and polyaromatic hydrocarbons (PAHs); and the metals: mercury, cadmium, lead, and silver.



*Areal extent.* In general, toxicants mainly affect inshore species because toxicant concentrations are greater near the sources of pollution along the coast and in estuaries.

*PCBs*—In general, concentrations of PCBs are below the Food and Drug Administration (FDA) action limits (2.0 mg/kg) (Mearns, *et al.*, 1988), except in large, fatty species of fishes. PCB concentrations are generally higher in fishes than in shellfish.

*DDT*—The average concentrations all fall well below the 5.0 mg/kg FDA limit (National Oceanic and Atmospheric Administration, 1986).

*Other toxicants*—Data are very limited, but generally these toxicants fall below FDA action levels (National Oceanic and Atmospheric Administration, 1986).

*Temporal changes.* Comparisons over time are difficult to make because measurements of contaminants historically have been made from different tissues within the same species and among different species. However, for PCBs there is a decreasing trend exemplified by the PCB content in menhaden populations along the New Jersey coast between 1969 and 1975 (Mearns *et al.*, 1988). DDT levels have decreased eighty to one hundred-fold nation-wide since the mid-1960s. For dieldrin, there is some evidence of a nation-wide decrease in shellfish contamination, but the national trend in marine fishes is not apparent (Mearns *et al.*, 1988).

*Social and economic impacts.* The most immediate impact to the public is issuance of health advisory notices limiting or prohibiting ingestion of fishes or actual fishing for certain species. In both New York and New Jersey, these warn the public to limit consumption of striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*) and American eel (*Anguilla rostrata*) (Belton, 1985; Halgren, personal communication).

In the longer term, risk analysis studies indicate there may be an increased incidence of cancer from ingestion of contaminated seafood. Although the indication of increased cancer risks is speculative, a recent study (National Oceanic and Atmospheric Administration, 1986) determined that only that part of the population that consumes large quantities of contaminated fishes may be at an unacceptable risk. However, the lifetime cancer risks of anyone who eats carcinogen-contaminated fishes are increased in proportion to the amount of the carcinogen consumed.

The major economic impact is from a decrease in fish consumption due to fears that the food may be harmful. Based on anecdotal information, some of the public still avoided seafood in January 1989 as a result of the floatable medically related waste wash-ups of the summer of 1988. Dilernia and Malchoff, (in press) found a 25–50% decline in consumption relative to 1987 based on a survey of fishermen on party boats from New York City and Long Island. These vessels ply the near-shore waters where the impact of the floatables problem was most evident.

The offshore charter boat fleet was not so much impacted by the floatable problem as by adverse stock abundance and distribution. In 1988 this was apparently related to unusual water temperatures, not pollution. While the local commercial sales of fisheries products was down, the price the fisherman received at the dock did not seem to be affected. Fishermen were able to sell their catch to foreign markets. Ofiara and Brown (in press) found a 20–50% decline in the number of fishing trips in a survey conducted in New Jersey of party boats and charter boats. New York and New Jersey recreational fishing experienced a loss in total expenditures of $1.25 billion (Table 3). New York and New Jersey commercial fisheries suffered a loss in total expenditures of $60 million.



### *Pathogens in Shellfish*

Filter-feeding bivalves can collect and concentrate bacteria and viruses of anthropogenic origin. Therefore, health risks to consumers are increased by the practice of eating raw or partially cooked shellfish.

*Areal and temporal extent.* Typhoid fever outbreaks associated with shellfish were common until the mid-1920s (Lumsden, 1925). An infectious hepatitis epidemic was linked to contaminated Raritan Bay hard clams in 1960–61 (Ringe *et al.*, 1962; Mason and McClean 1982). In 1986 about 25% of the nearly 4047 km$^2$ of shellfishing grounds in the New York Bight and bordering shallow bays and lagoons were closed to shellfishing (Figure 5). The Hudson–Raritan Estuary has

**Table 3.** Use impairments: unsafe seafoods

| *Use impairments* | *Factors causing impairment* | *Ecological significance of impairment* | *Spatial and temporal extent of impairment* | *Annual Economic impact* |
|---|---|---|---|---|
| • Toxicants | Toxicants | Little | Inshore | $1.3 billion |
| • Pathogens | Pathogens | Little | 825 km$^2$ | $73–109 million |

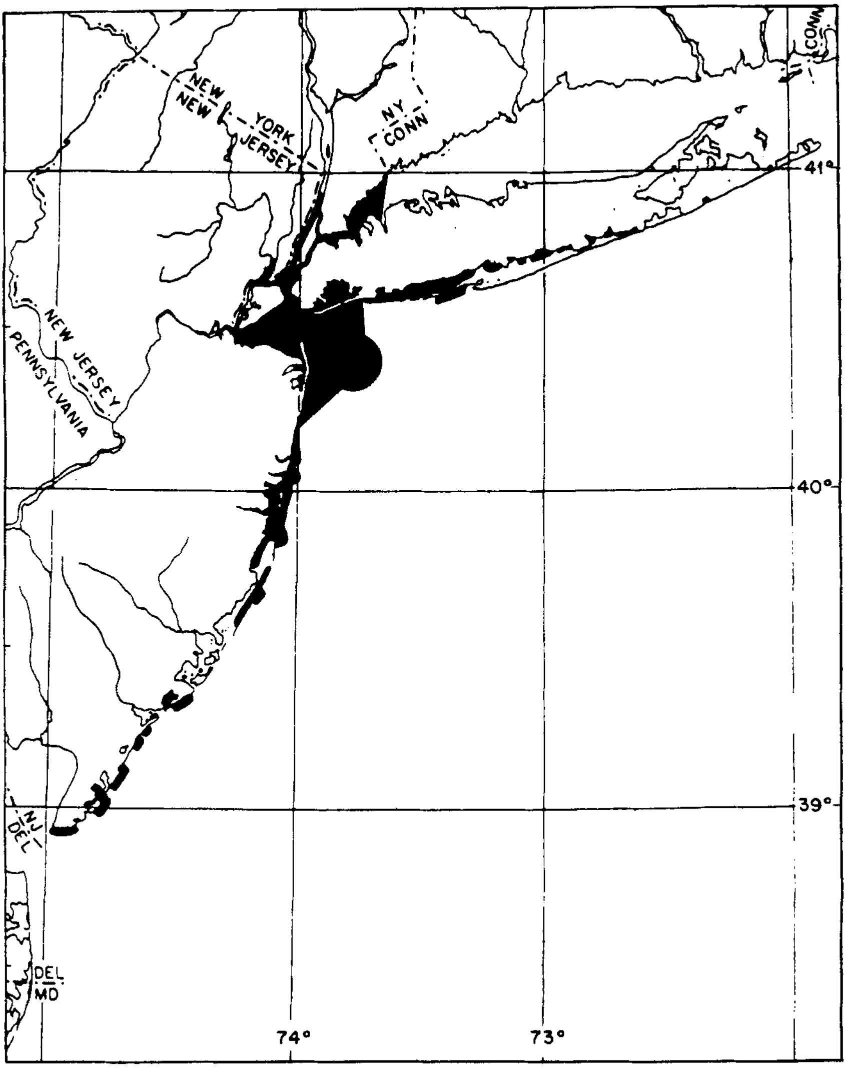


**Figure 5** Shellfish closure areas of the New York Bight region in 1986.

been closed for over 60 years. The total closed area in the Bight apex is approximately 825 km$^2$.

*Causes of impairment.* As is the case with beach closures due to pathogens, coliform bacteria are the indicator organisms used to assess the water quality of shellfish beds. New York and New Jersey monitioring standards are much more stringent for closing shellfish beds than for closing beaches. The sources of the coliform, however, are the same—sewage effluent (treated and untreated), ocean dumping of sewage sludge and contaminated dredged material, effluent from the

Hudson–Raritan Estuary, stormwater runoff, combined sewer overflow, and sewage discharge from boats.

*Economic and social impacts.* The estimated potential production in dollars, if closed shellfish beds were open, is $36 million annually. This estimate is based on the assumption that all beds have equal productivity and that an increase in production does not reduce the price of shellfish.

Costs associated with human ingestion of pathogens and the costs associated with enforcing closures are not known, but probably are significant. Also unknown is the cost in lost economic benefits from declining demand for shellfish because people are afraid of ingesting pathogens. The total annual economic impact from this impairment is estimated at $73–109 million.

*Ecological impact.* The ecological consequences of pathogens in shellfish are believed to be insignificant. In fact, closures of beds to shellfishing probably result in overall increased shellfish populations, since the closed beds serve as seed populations. Shellfish populations appear to thrive in nutrient-enriched waters, despite toxicant content, and in some instances are safe for ingestion using current relaying and depuration techniques.

*Commercial and Recreational Navigation—Floatables and Noxious Conditions*

*Areal extent.* Floating debris, particularly driftwood, poses some hazards to boating in the Bight, but the number of boats damaged is not known. The greatest impact to navigation is in or just outside the Hudson-Raritan Estuary, for which the greatest amount of data exists. The drift collection program of the COE is carried out in the harbour proper; however, the Bight is directly affected by the program since whatever driftwood is eliminated from the harbour lessens the amount entering the Bight. As one moves progressively farther away from the Harbour along the southern coast of New Jersey and Long Island, the reports of drift-related accidents decreases dramatically. Much of the driftwood that is collected is burned at an EPA designated site some 32 km east of Pt. Pleasant, NJ (Figure 1).

*Causes of impairment.* Much of the driftwood is carried downstream in the Hudson during high river stages. A significant contribution is also made from abandoned and disintegrating piers, boats, sheds, and other structures around the harbour, as well as intentional and unintentional dumping of dunnage, crates, and other unwanted materials from vessels and docks into the harbour. In 1987, 17,500 $m^3$ of drift was collected compared to the average annual $14{,}077 \pm 452$ $m^3$ for the period 1967–86.

*Economic and social impacts.* Floating debris and slicks of pollutants are aesthetically displeasing to recreational boaters in the Bight. Noxious slicks of pollutants usually result in some inconvenience but rarely in expense to boaters having to clean their boats. Large economic losses, however, are frequently incurred when plastic is sucked into the engine via the water intake pump. There can be even greater economic losses when a boat strikes a partially sunken

**Table 4.** Use impairments: commercial and recreational navigation

| *Use impairments* | *Factors causing impairment* | *Ecological significance of impairment* | *Spatial and Temporal extent of impairment* | *Annual economic impact* |
|---|---|---|---|---|
| • Floatables | Floatables | Little | No data for Bight; data for harbour only | $500 million |
| • Noxious Conditions | Floatables, sewage | Little | — | $25 million |

drifting object large enough to damage the hull, propeller, or shaft. However, the amount of losses incurred by recreational boaters from these types of impacts is not known. According to insurance companies, many boating accidents that are actually due to poor navigation, are reported on insurance claims as the result of hitting drifting objects. Total estimated economic expenditures, including the program to collect and burn drift in the harbour, may amount to $500 million annually (Table 4).

In 1987, floating timbers washing ashore in the surf zone along the New Jersey coast, struck and injured two children. The timbers were alleged to have come from the EPA designated wood burning site. As a consequence new rules and regulations regarding use of the site were promulgated. An environmental impact statement on continued use of the site is now being developed.



## ECOSYSTEM HEALTH AND PRODUCTIVITY

### *Commercial and Recreational Fisheries—Disease*

The diseases that impact fisheries species in the Bight are mainly fin rot in fishes (Sindermann, 1988) and shell disease in crabs and lobsters. The prevalence of fin rot in the Bight has declined significantly between 1974 and 1983 (Table 5) for reasons that are not clear.

### *Areal and Temporal Extent of Impairment*

#### Fin rot

An outbreak of fin rot disease affecting several species was reported in the Bight in 1967. During 1967 there was an 8% prevalence in bluefish (*Pomatomus sultatrix*) and 4% in winter flounder (*Pseudopleuronectes americanus*), with a much larger prevalence (25%–70%) in adjacent rivers and bays. From 1973–74, 14.1% of winter flounder from the Bight apex were diseased, compared to 1.9% from control areas. From 1974–75, 3.9% of winter flounder from the Bight apex were affected by fin rot, while only 0.7% of winter flounder from outside the apex were affected. In 1983 the prevalence had decreased to about 1% in the Bight apex.

#### Shell disease

Epizootic incidents of 10–90% prevalence occur among stressed populations of crabs and lobsters; natural prevalence may be as low as 2%. In 1988, 30% of red

**Table 5.** Ecosystem health and productivity impacts: commercial and recreational fisheries

| *Use impairments* | *Factors causing impairment* | *Ecological significance of impairment* | *Spatial and temporal extent of impairment* | *Annual economic impact* |
|---|---|---|---|---|
| • Disease | Toxicants | unknown | Bight apex (prevalence of finrot decreased from 13% to 1% in winter flounder from 1974–83) | nms[1] |
| • Abundance and distribution | toxicants, overharvest, habitat loss | moderate | — | 1.3 billion in 1988 |
| • Episodic kills | nutrients, reduced circulation | unknown | small in extent, but occurring almost annually from 1974–88. 8600 $km^2$ in 1976 | nml[2] |

[1] nms—not measured but probably small.
[2] nml—not measured but probably large.



crabs from the Hudson Canyon (Figure 6) and several canyons farther north were moderately or severely diseased giving the appearance in different areas that the shell had been burned (Young, 1990). Young, however, notes that the disease prevalence was as high as 81% in 1884 from the same areas based on samples stored in the Smithsonian Institution. These latter samples were only slightly or very slightly diseased but can be considered to have been taken in non-polluted waters prior to impacts from the Industrial Revolution.

*Causes of impairment.* Both types of disease are non-specific (their etiology is not clear). However, according to some studies, they are associated with toxicants in polluted or degraded environments, including many major harbours around the world. However, the 1884 crab collections certainly indicate the occurrence of the shellburn disease prior to any contamination of the Bight. While microbial infections are thought to be responsible for fin rot, there is evidence that persistent exposure to toxicants in sediment and sea water promotes the condition. Thus, flat-fishes are especially prone to this disease because of their direct contact with sediments. Shell disease is thought to result from various chitin-consuming bacteria and fungi. There is some very limited evidence that sewage sludge and contaminated dredged material may promote the condition. It is not known if or to what extent these diseases cause a decline in the affected species.

*Economic and social impacts.* The economic losses to fishermen from these diseases are not known, but are probably small, since fishes with fin rot may still be sold as fillets in the market and are safe to consume. Crustaceans with shell burn disease are also considered safe to eat and their meat can be marketed as a processed product. With lobsters and crabs, however, their market value, at least in the U.S. market, is higher when sold whole, so there is some loss to fishermen

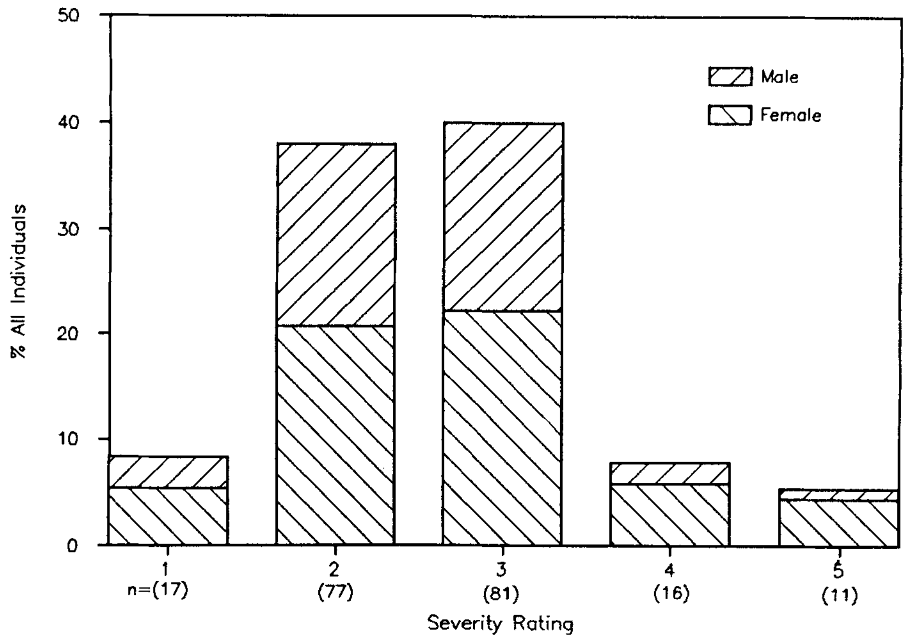


**Figure 6** Shell disease prevalence and severity in Hudson Canyon, June 1988.



marketing shell burn diseased crustaceans. Japanese fishermen apparently prefer some indication of shell disease as they associate the colouring of the diseased shell with the firmness of the meat (Young, 1990).

*Commercial and recreational fisheries—distribution and abundance areal and temporal extent of impairment.* Marine fish reproductive data are few, so information comes mainly from landings. There has been a distinct decline in abundance of fishes and shellfish in the past 100 years, judging by commercial landings (Figure 7). In 1957 there was a maximum of $3.2 \times 10^5$ tonnes landed. By 1987, that figure was down to $7.3 \times 10^4$ tonnes. Landings of major marine species have fluctuated over the years, even showing a slight increasing trend (McHugh and Hasbrouck, 1989). However, because the commercial fishing effort has increased substantially, the catch per unit effort has declined.

*Causes of impairment.* Overfishing is the chief factor responsible for the decline in fish abundance for commercial fisheries and probably for recreational fisheries, as well. Pollution has no doubt played a part in the decline of estuarine fisheries, since anadromous and estuarine stocks have declined much more than marine stocks (Mayer, 1982; Rose *et al.*, 1986; Summers *et al.*, 1987). Estuarine and anadromous species are vulnerable to pollution and loss of habitat because their critical developmental stages are spent in the sites closest to shore and are therefore subjected to the brunt of pollution and human intrusion. Whether these effects are reversible, or long-term damage has been done to any species, is not known.

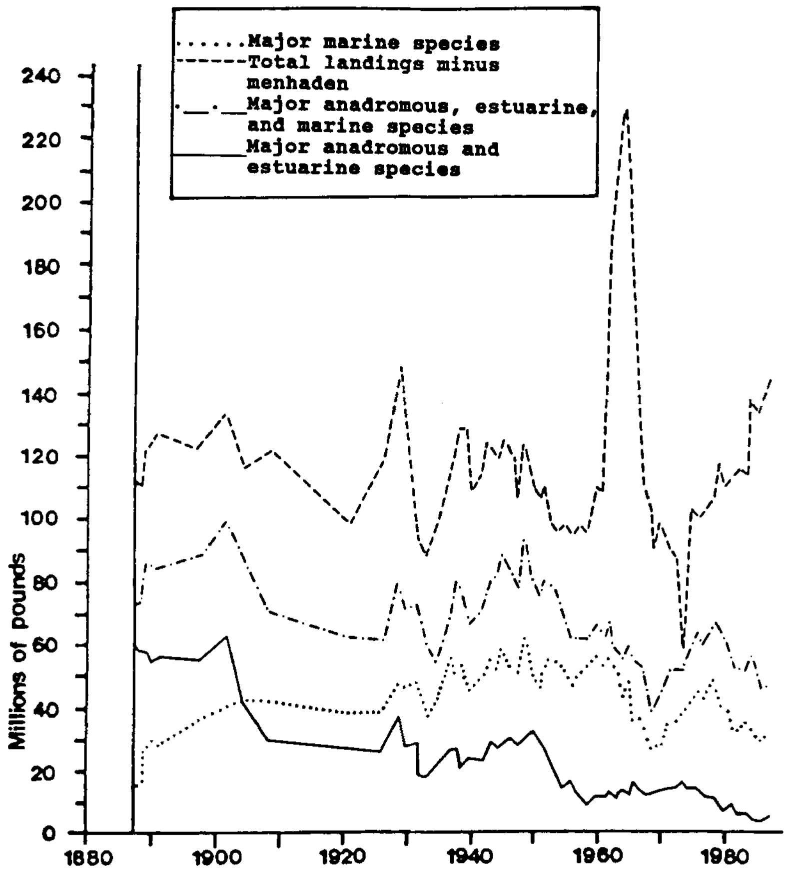


**Figure 7** Commercial fish landings in the New York Bight between 1880–1987.

*Economic and social impacts.* The estimated loss in total expenditures to recreational fishing in both states is $1.25 billion for 1988. This estimate takes into account the decrease in demand from the perceived contamination of fishes after the 1987 and 1988 floatable events. Commercial fishing losses in total expenditures were estimated at $24 million for New York and $36 million for New Jersey.

### *Commercial and Recreational Fisheries—Episodic Fish Kills*

*Areal and temporal extent of impairment.* In the 1970s and 1980s, periodic localized fish kills, generally of low numbers, have been reported in the New York Bight, particularly near the New Jersey coast. An anomalous benthic faunal kill in 1976, due to anoxic conditions over a 8600 $km^2$ area, resulted in mass mortalities of surf clam *Spisula solidissima* (62%), ocean quahog *Arctica islandica* (25%), and sea scallop *Placopecten magellanicus* (9–13%) (Sindermann and Swanson, 1979). Finfishes generally avoid areas of low DO, so the impact is not known, but it may be limited to reduced spawning and to associated mortality of eggs and larvae.

*Causes of impairment.* Hypoxic or anoxic conditions in the 1976 event were attributed to early and extreme spring warming, a deep pycnocline and, persistent southwesterly winds leading to onwelling of offshore waters and reversal of sub-surface currents (Swanson and Sindermann, 1979). There were few storm events during that year to circulate the water, and a bloom of phytoplankton (*Ceratium tripos*) consumed the oxygen supply that was already limited as a consequence of physical processes.

The causes of the other fish kills are unknown, but low DO is the suspected cause. Algal blooms are an annual phenomenon along the New Jersey coast, and concomitantly low DO is probably a factor in these fish kills. These yearly algal blooms may be associated with eutrophication; and organic carbon and nutrient input to coastal waters of the Bight is certainly a contributing factor.

*Ecological significance of impairment.* It is unknown whether kills of marine organisms are on the rise or whether the reports of these kills are increasing. However, if the kills are increasing, the impacts are not significant at present. These events are localized and sporadic, and the affected species seem to recover from them when the chemical and physical conditions rebound. It is unlikely that any long-term impact on the affected species would result from fish kills in the open Bight where even short-term effects are less profound than in more enclosed areas.

*Economic and social impact.* Recovery of a species is dependent on recruitment time. Sea scallops and ocean quahogs have much longer recruitment times than do surf clams, for example. However, recovery is also dependent on other factors; for example, predator decline and lack of fishing pressure on a diminished species will allow that species to recover sooner. In the 1976 mass benthic mortalities, both of these factors aided the fast recovery of surf clams in the Bight. The economic impact of this event was originally estimated to cost in excess of $500 million, probably an overestimate (Swanson and Sindermann, 1979). No other data on economic loss from fish kills exist.



### *Birds, Mammals and Turtles—Abundance and Distribution*

*Extent of the impairment.* Birds, mammals and turtles are found seasonally throughout the Bight. Several species of endangered or threatened birds and turtles use parts of the Bight for critical or developmental stages of life. Data are generally not available on pollutant effects on population over time in this area, with the exception of effects of DDT and possible PCBs on birds. The peak of these effects was in the 1950s and 1960s, but since the banning of DDT, there has been a steady rebound of affected bird populations from their previous steep declines. In 1985 and continuing through 1987, there was about a fivefold increase over the previous five years in the number of marine turtle strandings on New York beaches. For New Jersey, the increase jumped significantly in 1987 (by a factor of four) compared to the years 1979 through 1986.

*Causes of impairment.* Toxicants, entanglement in plastic litter, and disturbance by man are the three most prevalent causes of endangerment to marine animals as a whole (Table 6). Boat hits are the major cause of mortality to turtles in the

**Table 6.** Ecosystem health and productivity impacts: birds, mammals, and turtles

| *Ecosystem impact* | *Factors causing impairment* | *Ecological significance of impairment* | *Spatial and temporal extent* | *Annual economic impact* |
|---|---|---|---|---|
| • Abundance and Distribution | Floatables, toxicants and human use conflicts, habitat loss | Large for endangered or threatened species; less so for others | — | nml |

Bight. Turtles historically have only rarely laid eggs on Bight beaches, so reproduction is not jeopardized by toxicants in the Bight. However, toxicants are a major threat to bird reproduction in the Bight. Habitat loss, modification and disturbance along the coastal fringe have an even greater impact on bird populations in the Bight. Birds, turtles, and mammals are particularly vulnerable to entrapment and entanglement in plastic waste such as six-pack rings, fishing line, and nets. Turtles and mammals are vulnerable to ingestion of plastic bags and balloons that are mistaken for squid, jellyfish, and other prey food items. The consequence of ingestion is often death.

The degree of impairment from toxicants is not known, but it is likely that the general health and reproductive success of birds, mammals, and turtles that inhabit polluted areas may be compromised. Frequently turtles and occasionally mammals are stranded on New Jersey and New York beaches from unknown causes. It may be that, like seal deaths in the North Sea, animals' immune systems are compromised by pollution.



*Ecological significance of impairment.* The ecological significance is great when endangered or threatened species are involved. Among the four species of turtles that are found in the Bight, there are two on the endangered list (leatherback and Ridley) and two on the threatened list (loggerhead and green) (Mager, 1985). There are four New York State designated endangered species of birds (peregrine falcon, roseate tern, least tern and piping plover) and three New York State designated threatened species (osprey, northern harrier and common tern) that use the coastal areas of the Bight (Buckley and Buckley, 1978).

*Economic and social impacts.* Economic losses are undeterminable; however, social consequences can be significant. The perceived degradation of the region's waters is especially amplified when mammals die in large numbers, such as occurred in the summer of 1987. The public's sense of aesthetics about the place where they live is also compromised when once thriving marine animals are threatened or no longer found in the region.

## CONCLUSIONS

Some 20 million people live, work and recreate along the coastal waters of the New York Bight. Population densities vary from 2700 $km^{-2}$ for New York City as a whole to approximately 80 $km^{-2}$ at the eastern end of Long Island and southern New Jersey. Historically, it was the attraction of "The Great Port" that contributed to the development of the region and the associated degradation of much of the nearby coastal waters. The waterways were logical conduits for transport and dispersion of all types of wastes including domestic, industrial and even those of bone rendering facilities. Even though New York City was at the forefront of sewage treatment technology in the early to mid-twentieth century, waste disposal traditionally has been an afterthought in the metropolitan area (Squires, 1981).

Today, coastal waters of the Bight, which are geographically removed from the Hudson–Raritan Estuary, experience downstream effects of the estuary and its attendant pollution problems. The closure of shellfish beds at the mouth of the Hudson–Raritan Estuary, floatable debris on beaches, and the possible increase in hypoxia or eutrophication in the New York Bight and western Long Island Sound are but a few examples. Even the impacts of ocean-dumped sewage sludge and dredged materials and atmospheric fallout of pollutants originate with activities adjacent to the estuary.

Poorly controlled coastal development along New Jersey and Long Island portend the continuing deterioration of New York Bight resources even if conditions in the estuary are improved.

The population immediately surrounding the New York Bight will be in excess of 20 million by the year 2000. This is an increase of only about 5% over the period dating from 1985. However, it is perhaps the redistribution of the population that is more important with regard to marine water quality. Development will apparently continue to shift mainly away from the central city into the suburban counties, particularly into coastal areas. These predictions are paramount considerations for the development of any long-term management plan addressing the quality of coastal waters.



Identification of the important components of the Bight ecosystem that can or even should be restored and the means to do so are to be accomplished by the EPA's New York Bight Restoration Plan. Planning restoration of the Bight based on current understanding of the ecosystem is intriguing but frustrating: an appropriate approach to achieve positive and measurable results is not evident. We have examined impaired uses of the Bight—identifying those uses that are recognized as important to our health and well-being, aesthetic sensibilities and livelihoods. On some levels, these use impairments can be measured and quantified. Some aspects of the impairments remain very difficult, if not impossible to assess. The impaired uses that can be identified as significant in terms of social or economic values can be targeted for restoration. If the resources and technologies are committed and the citizenry is willing to modify its behavior, it is possible to implement actions to restore many of these uses. The success of these actions can be measured.

It is argued with increasing conviction that by targeting economically or socially significant impairments, the overall health of the ecosystem is ignored (Sagoff, 1988). In fact, if significant strides can be made toward restoring uses, the overall health of the ecosystem is bound to improve as well. The converse, however, is not evident. Even if a few measures of the overall health of the ecosystem were to be greatly improved, it is not evident that specific uses would be recovered.

The numbers generated for the economic part of this study are not precise. They cannot be derived directly from Bureau of Labor Statistics data, and very often the primary data upon which they are based are imprecise. However, we are confident that whenever we have ventured to provide numerical estimates, they are of the right order of magnitude.

The compartmentalization of the study into various impairments of specific uses excludes from consideration many economic damages from pollution. The quality of life is an important factor in business and industry decisions concerning where to locate their economic activity. Unfortunately, along with the additional economic activity generated by business and industry, they have also generally contributed to eventual environmental degradation. Witness the coastal area of the New York Bight that has many negative associations with air pollution, population congestion, and crime. A better marine environment can offset some of these negative features and make the region a more attractive place for families and businesses.

The information in Tables 2–6 is indeed alarming. Considering beach impairments, pathogens in shellfish and toxicants in marine foods, the total annual expenditures lost amount to somewhat less than $3 billion to $7.3 billion in 1988. Similarly, the jobs lost could be in the range of 46,000–100,000. On an annual basis these estimates are probably high because of the numerous unusual pollution problems of that year.

Nevertheless, lost revenue and jobs on this scale typically would generate considerable political attention and perhaps trigger extensive remediation programs with considerable tax-supported assistance. Societal targets are diffuse in this situation; where the uses have become gradually impaired over many decades, the need for attention has not been so obvious. However, it would appear that now there are significant benefits to be derived from an improved marine environment.

Interestingly, the greatest identified economic loss is associated with the floatables problem, yet this loss can be alleviated easily but not necessarily inexpensively. The sources of the problem are well known and the solutions to the problems have been identified.

There are already some programs and activities under way, particularly targeted towards the estuary, that will have beneficial effects on the quality of the Bight. The upgrading of sewage treatment plants, appropriate chlorination of sewage effluent, introduction of industrial pre-treatment programs, upgrading of combined storm sewer systems and the continued move of industry from the city should cause marked improvements in the water quality of the Upper and Lower Bays and the East River.

Perhaps as a result of these measures, we can anticipate the opening of several beaches in the estuary and shellfishing areas in the estuary and the Bight that are now closed. The reduction of toxins (dioxins, furans, dieldrin, lead and cadmium) in these waters may lead to lower concentrations of some of the contaminants in marine organisms. However, it is likely that bans and public health advisory notices will still be issued. These toxins persist in the marine sediments which serve as a continuing long-term repository of substances toxic to marine organisms. It is also possible that the EPA, state or FDA standards will become more restrictive as more is learned about the harmful effects of consuming contaminated seafood.

It would be naive to believe that the New York Harbour area is going to revert to a desirable marine recreational area since many uncontrollable problems remain. For example, seepage of contaminants from landfills, intentional and accidental spills, urban runoff, poor control of marina operations, and poor management of wastes at the individual and small business level will continue to plague the metropolitan area. Operation and maintenance resources for the infrastructure needed to ensure water quality will probably lag far behind optimal levels.

The New York Bight apex will be a prime beneficiary of improvement to the harbour complex, which is a major source of contaminants to the Bight. However, continued coastal development on Long Island and in New Jersey will add stress to the bays and lagoons of these coastal areas. To relieve this stress, direct discharges from sewage treatment plants to the ocean offshore will probably increase. Given current trends in coastal development, we can probably anticipate that the rather steep gradient of water quality from extremely poor in the harbour to clean in the east and south will begin to level off. More frequent beach and shellfish bed closures might be expected. Nutrients stimulating phytoplankton blooms may also be expected to increase as sewage treatment systems come on line. Control of coastal development and effective land use planning are imperative if the present status of marine water quality along coasts to the south and east of the Bight apex is to be maintained.

Improvement in the water quality of the Bight apex may result from improvement in the water quality of the Hudson–Raritan plume and also from the cessation in 1988 of ocean dumping of sewage sludge at the 12-mile site. Perhaps the shellfishing closure area surrounding this site will be reduced to some degree as a consequence of these actions.

Concern must be expressed with regard to the potential long-term effects of ocean dumping of sewage sludge and industrial wastes at the 106 mile site, although legislation intended to terminate this practice by 31 December 1991 has already been signed (Ocean Dumping Ban Act of 1988). However, monitoring for long-term effects should be undertaken in case ocean dumping continues longer than has been legislated.

Overall, the quality of the waters of the New York Bight and particularly the Bight apex are probably typical of an over-populated and over-developed coastal region in the industrialized world. They can bear considerable improvement but there is room for conservative optimism. Technological solutions will only partially aid in reducing further degradation. More fundamental actions—reducing the production of pollutants or reducing population density—will be needed to restore uses and enhance ecosystem quality. These solutions will be costly and depend upon residents' willingness to modify some of their cultural habits. For example, limiting coastal development would probably be the greatest positive influence, but that has many implications regarding transportation, business, industry and the associated tax base. The opportunity for conserving and improving water quality and wisely using coastal resources depends upon the individual and collective will of society, business and industry and government. Extending the notion of improved U.S. competitiveness through better cooperation between business and government should perhaps be broadened to include environmental quality.



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## References

Bell, F. W. and Leeworthy, V. R. (1986). *An economic assessment of the importantce of saltwater beaches in Florida.* Florida State Univ., Tallahassee, 23 pp.

Bell, T. W., Schubel, J. R., and Swanson, R. L., editors (1989). *Floatable wastes and the region's beaches: answers to some common questions.* Marine Sciences Research Center, Special Report 85, State University of New York at Stony Brook. Stony Brook, NY, 114 pp.

Belton, T. J., Roundy, R., Ruppel, B. E., Lockwood, K., Shiboski, S., Bukowski, G., Weinstein, N., Wison, D., and Whelan, H. (1985). A study of toxic hazards to urban recreational fishermen and crabbers. *New Jersey Department of Environmental Protection. OSR.* 68 pp.

Buckely, P. A. and Buckley, F. G. (1978). In Noyes, J., editor. Human encroachement on barrier beaches of the northeastern U.S. and its impact on coastal birds. *Coastal recreational resources in an urbanizing environment.* Amherst, MA: Holdsworth Nature Resource Center, Planning and Development Series.

Buerger, R. and Kahn, J. (1989). The New York value of Chesapeake striped Bass. *Marine Resource Economics,* **6,** 19–25.

Dilernia, A. and Malchoff, M. (in press). 1989 Survey of Long Island and New York City charter and party boat businesses. In *Proceedings of the Conference of floatable wastes in the ocean: social, economic, and public health implications,* March 21–22, 1989 at SUNY–Stony Brook.

Fey, G. (in press). Impact of environmental issues on tourism. In *Proceedings of the Conference on floatable wastes in the ocean: social, economic, and public health implications,* March 21–22, 1989 at SUNY–Stony Brook.

Fisher, A. and Krutilla, J. (1985). *The economics of natural environments.* Johns Hopkins University Press, Baltimore, MD.

Green, W. (in press). "Manifest Waste: Will the Regulation of 'Medical Waste' Disposal Promote the Public Health and Protect the Public Shores?" In *Proceedings of the Conference on floatable wastes in the ocean: social, economic, and public health implications,* March 21–22, 1989 at SUNY–Stony Brook.

HydroQual, Inc. 1989. *Assessement of pollutant inputs to New York Bight.* Job No. DYNM0100. Dynamac Corporation. Rockville, MD.

Kahn, J. (in press). A general overview of the impacts of floatable wastes on fisheries, tourism, and marine recreation. In *Proceedings of the Conference on floatable wastes in the ocean: social, economic, and public health implications,* March 21–22, 1989 at SUNY–Stony Brook.

Lumsden, L. L. (1925). A typhoid fever epidemic caused by oysterborne infection. *Public Health Reports, supplement No. 50.*

Mager, A., Jr. (1985). Five year status review of sea turtles listed under the Endangered Species Act of 1973. *U.S. Department of Commerce, NOAA,* pp. 1–20; 36–55; 70–80.

Marine Sciences Research Center. (1989). *Floatables Management Plan.* Coast Institute. Waste Management Institute. State University of New York at Stony Brook. Stony Brook, New York, 40 pp.

Mason, J. R. and McClean, W. R. (1962). Infectious hepatitis traced to the consumption of raw oysters. *American Journal of Hygiene,* **75,** 90–95.

Mayer, G. F., ed. (1982). *Ecological stress and the New York Bigth: Science and management.* Estuarine Research Foundation, Columbia, S.C. 715 pp.

McHugh, J. L. and Hasbrouck, E. (1990). Fishery management in the New York Bight: Experience under the Magnuson Act. *Fisheries Research,* **8,** 205–221.

Mearns, A. J., Matta, M. B., Simecek-Beatty, D., Buchman, M. F., Shigenka, G., and Wert, W. A. (1988). PCB and chlorinated pesticide contamination in U.S. fish and shellfish: a historical assessment report. *NOAA/NOS Tech. Memo OMA-39.*

National Oceanic and Atmospheric Administration, National Marine Fisheries Service. (1980). Marine recreational fishery statistics survey, Atlantic and Gulf coasts, 1979. *Current Fishery Statistics,* Washington, D.C.

National Oceanic and Atmospheric Administration. (1986). *Report on the 1984–86 federal survey of PCB's in Atlantic coast bluefish.* Data report. 170 pp.

New York State Department of Environmental Conservation (1977). *New York State and outer continental shelf development: an assessment of impacts.* Albany, NY. pp 119–126.

Ofiara, D. and Brown, B. (in press). Marine pollution events of 1988 and their effect on travel, tourism, and recreational activities in New Jersey. In *Proceedings of the Conference on floatable wastes in the ocean: social, economic, and public health implications,* March 21–22, 1989 at SUNY–Stony Brook.

Olsen, P. (1989). Development and distribution of a brown-water algal bloom in Barnegat Bay, New Jersey. In E. M. Cosper, V. M. Bricelj and E. J. Carpenter, eds. *Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms.* Springer-Verlag, Berlin, pp. 189–212.

Ringe, M. E., Clem, J. D., Linker, R. E. and Shermer, L. K. (1962). A case study on the transmission of infectious hepatitis by raw clams. *U.S. Department of Health, Education and Welfare,* Public Health Service, Washington, D.C.

R. L. Associates. (1988). *The economic impact of visitors to the New Jersey shore the summer of 1988.* Princeton, New Jersey.

Rose, K. A., Summers, J. K., Cumins, R. A., and Heimbuch, D. G. (1986). Analysis of long-term ecological data using categorical time series regression. *Canadian Journal of Fisheries and Aquatic Sciences,* **43**(12), 2418–2426.

Rose, T. (1989). *Freeing the whales.* Carol Publishing Company. Secaucus, NJ.

Sagoff, M. (1988). *The economy of the earth.* Cambridge University Press, Cambridge University. 271 pp.

*Sindermann, C. J. 1988.* Fin erosion of striped bass. In Sindermann, C. J. and Lightner, D. P., eds. *Disease, diagnosis and control in North America marine aquaculture. Vol. 17. Developments in Aquaculture and Fishery Science.* Elsevier Science Publ. Co. NY. pp 360–361.

Sindermann, C. J. and Swanson, R. L. (1979). Historical and regional perspective. In Swanson, R. L. and Sindermann, C. J., eds. *Oxygen depletion and associated benthic mortalities in the New York Bight, 1976.* Professional Paper 11. National Oceanic and Atmospheric Administration, Rockville, MD. pp. 1–16.

Squires D. F. (1981). *The Bight of the Big Apple.* The New York State Sea Grant Institute, Albany, NY, 84 pp.

Summers, J. K., Polgar, T. T., Rose, K. A., Cummins, R. A., Ross, R. N. and Heimbuch, D. G. (1987). Assessment of the relationships among hydrographic conditions, macropollution histories, and fish and shellfish stocks in major northeastern estuaries. *NOAA Technical Memorandum, NOS OMA* 31. 223 *pp.*

Swanson, R. L. and Zimmer, R. L. (1990). Meterological conditions leading to the 1987 and 1988 washups of floatable wastes on New York and New Jersey beaches and comparison of these conditions with the historical record. *Estuarine, Coastal and Shelf Science,* **30,** 59–78.

Swanson, R. L. and Sindermann, C. J. (1979). Oxygen depletion and the future: an evaluation. In Swanson, R. L. and Sindermann, C. J., eds. *Oxygen depletion and associated benthic mortalities in the New York Bight, 1976.* Professional Paper 11. National Oceanic and Atmospheric Administration, Rockville, MD. pp. 335–345.

Swanson, R. L., Stanford, H. M., and O'Connor, J. S. (1978). June 1976 pollution of Long Island ocean beaches. *Journal of the environmental engineering division, ASCE, Proc. Paper 14238 (December),* 194, No. EE6, 1067–1085.

Young, R. R. (1990). Prevalence and severity of shell disease among deep-sea red crabs of the Middle Atlantic Bight in relation to ocean sludge dumping. Masters thesis. State University of New York at Stony Brook. Stony Brook, NY.