



This document contains the regional discussion of the Northeast estuaries, from the National Estuary Program Coastal Condition Report. The entire report can be downloaded from
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National Estuary Program Coastal Condition Report

Chapter 3: Northeast National Estuary Program Coastal Condition, Regional Discussion

June 2007

CHAPTER 3

NORTHEAST NATIONAL ESTUARY PROGRAM COASTAL CONDITION



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Background

The Northeast Coast region extends from Maine southward to Virginia and contains the largest number of NEP estuaries (12) per region in the United States (Figure 3-1). Tides throughout the Northeast Coast region occur twice a day and range from highs of 18 feet in areas of northern Maine to 10 feet in southern Maine, diminishing to less than 3 feet in southern Virginia (NOAA, 1985).

Within the Northeast Coast region, there are two distinct and unique geological areas. The first area, referred to as the Gulf of Maine, extends from the

Canadian border south to Cape Cod, MA. Estuaries in the Gulf of Maine were formed by ancient glaciers that scoured much of the soil cover from the land, leaving rocky shorelines, thin soils, and deeply carved channels through which rivers today flow out to the ocean. These estuarine systems are similar in many ways to fjords. As a result of the strong tidal flows and the shape of the basins in the Gulf of Maine estuaries, circulation within these systems is tidally dominated (NOAA, 1985).

The Northeast Coast region's second geological area extends from Cape Cod, MA, south to Virginia. The topography of this area was less affected by ancient glaciers; rather, rising sea level resulting from melting glaciers drowned the mouths of ancient rivers flowing across the continental shelf, which created coastal plain estuaries. In these coastal plain estuaries, the volume of water introduced by tidal action is large compared to freshwater river inflow, with tides in the estuaries serving as the dominant force influencing circulation (NOAA, 1985). In addition to its basin and coastal plain estuaries, the Northeast Coast region also has several shallow lagoon systems where circulation is largely wind-dominated (Day et al., 1989).

The 12 Northeast Coast NEP estuaries are very different in their geological and physical characteristics. On average, water depth is greater than 56 feet from Maine to New York, but only 20 feet from New York to Delaware. Light can penetrate to 33 feet or more in the northern waters of the region, where there is less suspended sediment, but to less than 7 feet south of New Jersey, where thicker soils in the mid-Atlantic contribute greater amounts of sediment to coastal waters. As a result, seagrass communities in the southernmost waters of this region are often light-limited and more sensitive to human development (Thayer et al., 1984; Roman et al., 2000).

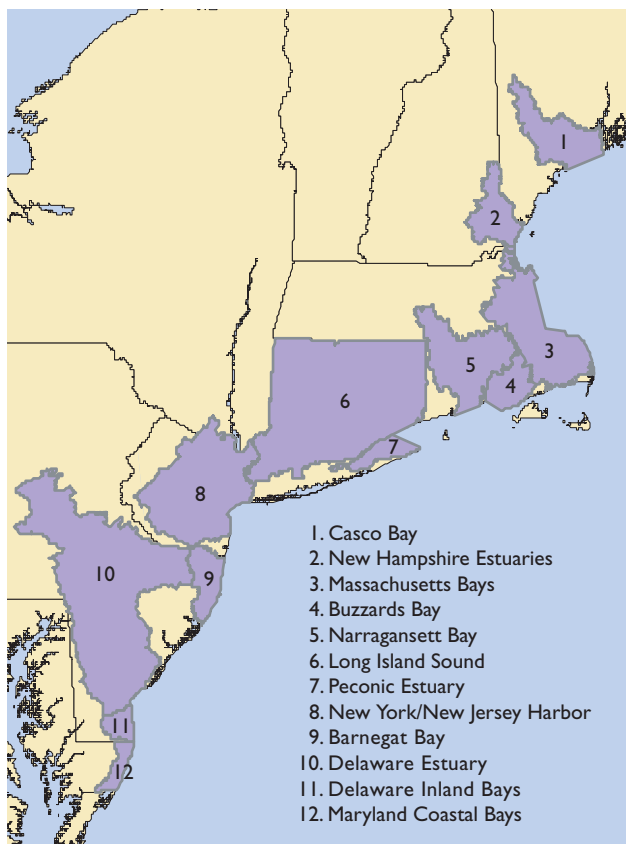


Figure 3-1. The Northeast Coast region is home to 12 NEP estuaries.

Freshwater inflows into the Northeast Coast NEP estuaries typically carry low amounts of sediment because of the extensive stretches of heavy forest and the rocky nature of the soils that predominate in the region's estuarine drainage areas. Sediment loading to Northeast Coast estuaries increases southward as the coastal plain widens and agricultural activity increases. Precipitation patterns also influence freshwater input from rivers flowing into these estuaries, and annual precipitation (averaging 40 to 44 inches) increases only slightly from north to south. Freshwater inflows to the Northeast NEP estuaries tend to coincide with variations in winter snow melt, with high-flow periods occurring from March through May in the northern portions of the region and slightly earlier in the year in the central and southern portions of the region. Freshwater inputs to the NEP estuaries throughout the region are lowest from July through September. Along the East Coast, the Northeast NEP estuaries contribute about 65% of all freshwater discharges to coastal waters (NOAA, 1985).

Population Pressures

The population of the 75 NOAA-designated coastal counties coincident with the NEP study areas of the Northeast Coast region increased by 24% during a 40-year period, from 30.5 million people in 1960 to 37.9 million people in 2000 (Figure 3-2) (U.S. Census Bureau, 1991; 2001). This increase resulted in a population density of 1,055 persons/mi² in 2000 for these coastal counties; however, the population densities of the region's individual NEP study areas varied considerably in 2000, from a high of 3,097 persons/mi² for the New York/New Jersey Harbor to a low of 98 persons/mi² for the Maryland Coastal Bays (U.S. Census Bureau, 2001). The population density of the Northeast Coast region was much higher than the densities exhibited the Southeast Coast (168 persons/mi²), Gulf Coast (287 persons/mi²), and West Coast (421 persons/mi²) regions. Development and population pressures are especially strong surrounding most of the Northeast NEP estuaries, which are close to some of the oldest cities in the United States. These cities—located

along the nation's most heavily populated corridor between Washington, D.C., and Boston, MA—are historic and current centers of commerce and industry, and the nearby NEP estuaries are popular areas for commercial and recreational fishing and other activities for city residents.

NCA Indices of Estuarine Condition—Northeast Coast Region

Based on data collected for the NCA, the overall condition of the collective NEP estuaries of the Northeast Coast region is rated poor (Figure 3-3). EPA summarizes conditions in the 12 Northeast Coast NEP estuaries, and these statistical summaries facilitate coastal condition comparisons among different NEP estuaries within the region. As part of the NCA, more than 550 Northeast sites were assessed during 2000 and 2001, and 18 sites in the Peconic Estuary were also surveyed in 2002. Each site was visited once during the summer season; therefore, the picture that emerges from the NCA study is a “snapshot” rather than a description of long-term conditions. The NCA approach provides an accurate assessment of conditions in the relatively stable realm of the sediments and biological communities; however, it does not address short-term water

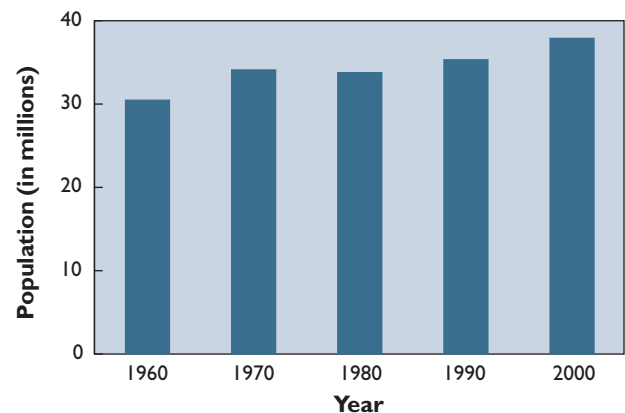


Figure 3-2. Population of NOAA-designated coastal counties of the Northeast Coast region's NEP study areas, 1960–2000 (U.S. Census Bureau, 1991; 2001).

quality conditions, such as changes in the water column that may occur weekly or daily during the summertime survey period.

EPA assessed the Northeast Coast NEP estuaries using four indices that respectively evaluate water quality, sediment quality, benthic condition (i.e., the status of the invertebrate community that lives in or on the sediments), and fish tissue contaminant levels. These indices were rated good, fair, or poor based on the criteria outlined in Chapter 1 (Tables 1-24, 1-25, and 1-26), and a category of missing was applied when data were unavailable. Figure 3-4 shows the percent of NEP estuarine area in the Northeast Coast region rated good, fair, poor, or missing for each parameter considered. For all parameters except the fish tissue contaminants index, results were expressed as the percentage of estuarine area falling within a category for each NEP. The fish tissue contaminants index was not weighted by area, but was reported as the percentage of fish analyzed.

The water quality index for the collective NEP estuaries of the Northeast Coast region is rated fair, and the sediment quality, benthic, and fish tissue contaminants indices for this region are rated poor based on the criteria used in this report. These regional-scale ratings facilitate comparisons among NEP estuaries in different regions of the country.

Natural and anthropogenic features and pressures in the Northeast Coast region strongly influence the manner in which pollutants accumulate and are processed in estuaries, as well as the structure and condition of estuarine fish and benthic communities. The major estuaries of the Northeast Coast region—those associated with the Connecticut, Hudson, and Delaware rivers—have watersheds that are relatively small compared with estuaries along the Southeast Coast and Gulf Coast regions; therefore, estuaries of the Northeast Coast are more affected by local sources of pollution and stresses than estuaries in the other regions. In addition, NEP estuaries in the Northeast Coast region are situated along the most densely populated coastline in the country (U.S. Census Bureau, 2001). Estuarine sediment contamination levels tend to be highest where sediments deposit near urban centers, and nutrient concentrations in developed areas are

greater than in pristine areas. In New England, the dominant nutrient input is from WWTPs in urban centers and from atmospheric deposition of nitrogen for non-urban sites. In the mid-Atlantic, agricultural runoff and animal operations are important sources of nutrients, in addition to atmospheric deposition and urban sources.

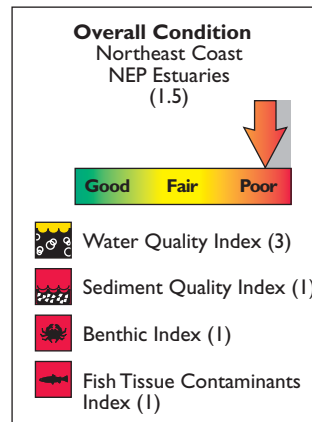


Figure 3-3. The overall condition of the Northeast Coast NEP estuarine area is poor (U.S. EPA/NCA).

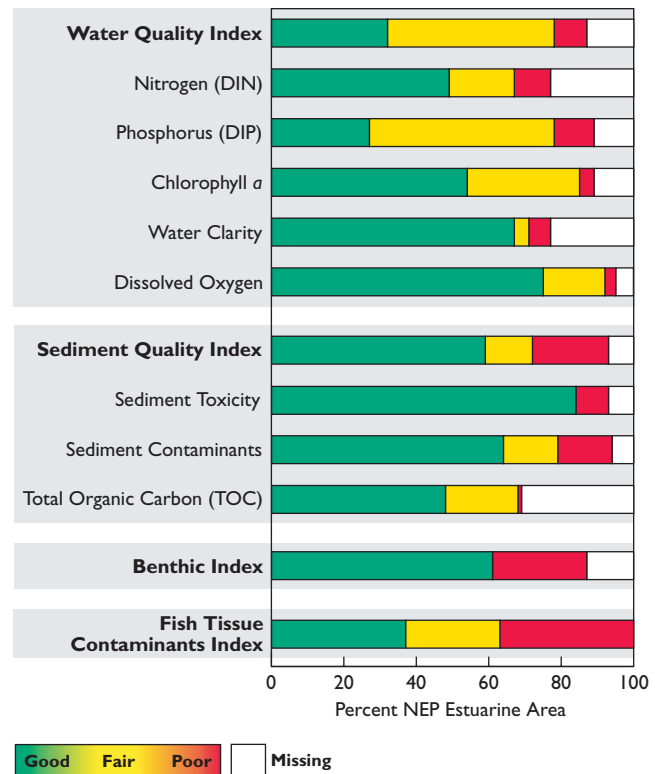


Figure 3-4. Percentage of NEP estuarine area achieving each rating for all indices and component indicators — Northeast Coast region (U.S. EPA/NCA).



Water Quality Index

The water quality index for the collective NEP estuaries of the Northeast Coast region is rated fair (Figure 3-5). The index was based on five component indicators measured in the NCA: three indicators that estimate the extent of estuarine eutrophication (DIN, DIP, and chlorophyll *a* concentrations) and two that evaluate conditions that are key to estuarine health (water clarity and dissolved oxygen concentrations). Generally, there was a north to south pattern in the Northeast region’s water quality index, which degraded southward.

Dissolved Nitrogen and Phosphorus | The Northeast Coast region is rated fair for both DIN and DIP concentrations. Based on the thresholds indicating impairment, 10% of the Northeast Coast NEP estuarine area was rated poor for DIN concentrations, and data were unavailable for 23% of the estuarine area. A north to south gradient was generally evident in the DIN data, with large areas of the Delaware Estuary, Delaware Inland Bays, and Maryland Coastal Bays exhibiting poor or fair condition for this component indicator.

Eleven percent of the Northeast Coast NEP estuarine area was rated poor for DIP concentrations, and data for this component indicator were unavailable for 11% of the estuarine area. More than 62% of the region had poor or fair DIP levels; however, there was no clear pattern with latitude for DIP. There are important questions regarding the process by which nutrients cause phytoplankton blooms and what levels of these nutrients are detrimental in estuaries; however, neither the frequency nor the location of measurements in the NCA survey were sufficient to address these questions.

Chlorophyll *a* | The Northeast Coast region is rated good for chlorophyll *a* concentrations. Only 4% of the region’s NEP estuarine area was rated poor for this component indicator, and 31% of the area was rated fair. Chlorophyll *a* data were unavailable for 11% of the Northeast Coast NEP estuarine area. The north to south gradient observed for DIN data was also generally evident in the chlorophyll *a* data, with large areas of the Delaware Estuary, Delaware Inland Bays, and Maryland Coastal Bays exhibiting poor or fair condition for this component indicator.

This report discusses two different approaches for characterizing estuarine condition:

Approach 1 – The NCA provides unbiased, quality-assured data that can be used to make consistent “snapshot” comparisons among the nation’s NEP estuaries. These comparisons are expressed in terms of the percent of NEP estuarine area in good, fair, or poor condition.

Approach 2 – Each individual NEP collects site-specific estuarine data in support of local problem-solving efforts. These data are difficult to compare among NEPs, within regions or nationally, because the sampling and evaluation procedures used by the NEPs are often unique to their individual estuaries. However, these evaluations are important because NEP-collected data can evaluate spatial and temporal changes in estuarine condition on a more in-depth scale than can be achieved by the NCA snapshot approach.

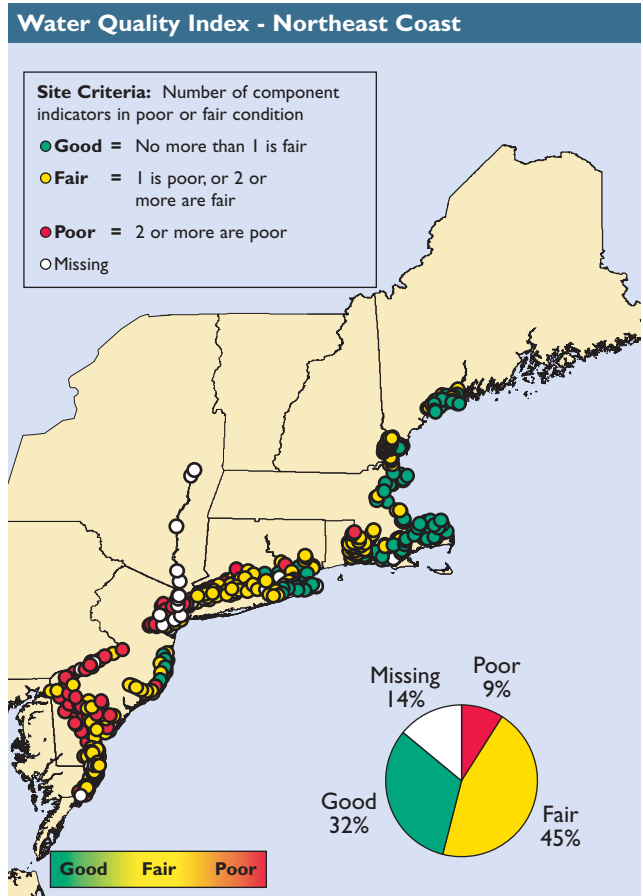


Figure 3-5. Water quality index data for the Northeast Coast NEP estuarine area (U.S. EPA/NCA).

Water Clarity | The Northeast Coast region is rated good for water clarity. NCA data show that poor water clarity occurred in only 6% of the Northeast NEP estuarine area; however, data from 23% of the area were unavailable. Poor water clarity was prevalent only in the more southernly NEP estuaries of the Northeast Coast region, including Barnegat Bay, Delaware Estuary, the Delaware Inland Bays, and the Maryland Coastal Bays. Diminished water clarity is commonly observed in these estuarine systems, to some extent because of natural processes such as tidal resuspension of fine sediments.

Dissolved Oxygen | The Northeast Coast region is rated good for dissolved oxygen concentrations. Seventy-five percent and 17% of the region's NEP estuarine area were rated good and fair, respectively, for dissolved oxygen concentrations, and only 3% of the estuarine area was rated poor. Depleted dissolved oxygen concentrations were measured in portions of Long Island Sound, Narragansett Bay, New York/New Jersey Harbor, and Buzzards Bay.



Sediment Quality Index

Sediment quality for the Northeast Coast region was calculated using three component indicators of sediment condition measured by the NCA: sediment toxicity, sediment contaminants, and sediment TOC. The sediment quality index for the collective estuaries of the Northeast Coast region is rated poor (Figure 3-6), primarily because 21% of the NEP estuarine area monitored was rated poor due to sediment toxicity or sediment contaminants concentrations.

The Northeast Coast NEP estuaries with the poorest sediment quality condition were generally situated near major urban centers (e.g., New York/New Jersey Harbor, western Long Island Sound, upper Narragansett Bay, and the waters of the Delaware Estuary in the vicinity of Philadelphia). At these locations, impaired ratings were usually triggered by sediment contamination, such as high concentrations of metals, PCBs, and/or DDT.

Sediment Toxicity | The Northeast Coast region is rated poor for sediment toxicity because 9% of the region's NEP estuarine area was rated poor. Eighty-four percent of the area was rated good for this component

indicator, and NCA data on sediment toxicity were unavailable for 7% of the Northeast Coast NEP estuarine area.

Sediment Contaminants | The Northeast Coast region is rated fair for sediment contaminant concentrations because 15% of the region's NEP estuarine area was rated poor for this component indicator. In addition, 15% of the area was rated fair, and 64% of the area was rated good. NCA data on sediment contaminant concentrations were unavailable for 6% of the Northeast Coast NEP estuarine area.

Total Organic Carbon | The Northeast Coast region is rated good for sediment TOC. Only 1% of the Northeast Coast NEP estuarine area was rated poor for TOC concentrations, whereas 48% of the area was rated good and 20% of the area was rated fair. NCA data on TOC concentrations were unavailable for 31% of the estuarine area.

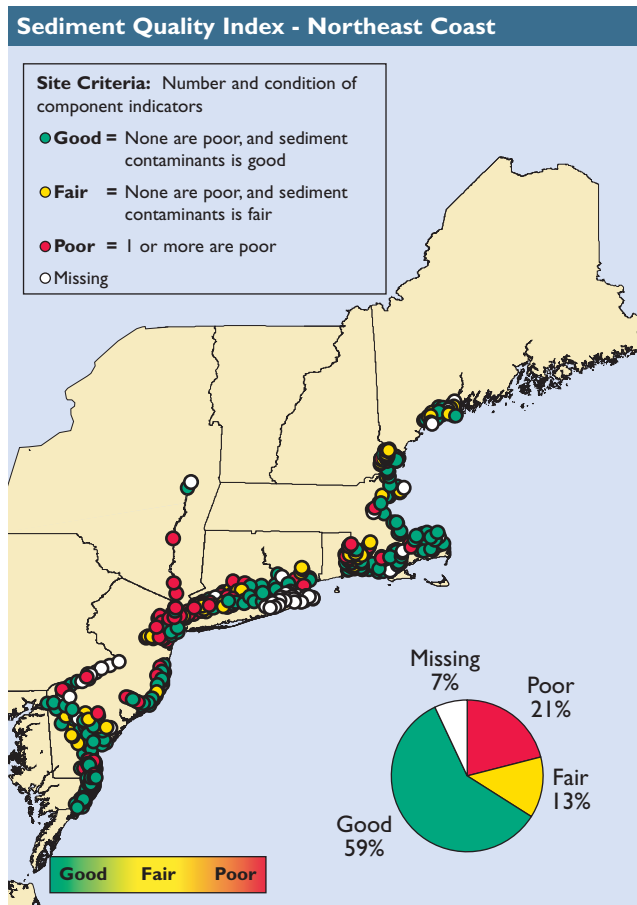


Figure 3-6. Sediment quality index data for the Northeast Coast NEP estuarine area (U.S. EPA/NCA).



Benthic Index

Sixty-one percent of the Northeast Coast NEP estuarine area exhibited acceptable benthic condition, but 26% did not; therefore, the benthic index for the collective NEP estuaries of the Northeast Coast region is rated poor (Figure 3-7). The extent of impairment was relatively uniform at all NEP sites, slightly exceeding a third of the estuarine area only in Long Island Sound, New York/New Jersey Harbor, and the Delaware Inland Bays. The benthic index for the Northeast Coast region was calculated by two methods: an established benthic index created specifically for the Virginian Province was used to evaluate conditions south of Cape Cod (Paul et al., 2001), whereas the Shannon-Weiner Diversity Index was used to evaluate locations north of Cape Cod. By both measures, greater diversity is indicative of a healthier community. Currently, a new benthic index for the waters north of Cape Cod is being developed that will account for the effects of natural habitat variations that affect species diversity.



Fish Tissue Contaminants Index

The fish tissue contaminants index for the collective NEP estuaries of the Northeast Coast region is rated poor (Figure 3-8). Thirty-eight percent of all fish samples analyzed had concentrations of chemical contaminants that exceeded EPA Advisory Guidance values for fish consumption; another 25% of the fish samples analyzed were rated fair for fish tissue contaminant levels; and only 37% were rated good. In addition, wide differences in contaminant levels were noted among the individual NEP estuaries. All of Narragansett Bay and New York/New Jersey Harbor achieved a poor or fair rating for fish tissue contaminant concentrations, as did large portions of the New Hampshire Estuaries, Buzzards Bay, Massachusetts Bays, and Delaware Estuary. In contrast, nearly all of the Delaware Inland Bays and Maryland Coastal Bays were rated good for this index, and NCA data were unavailable for Casco Bay. These results reflect concentrations in whole fish; whereas the EPA Advisory Guidance refers to edible portions of fish. Contaminant levels in whole fish can

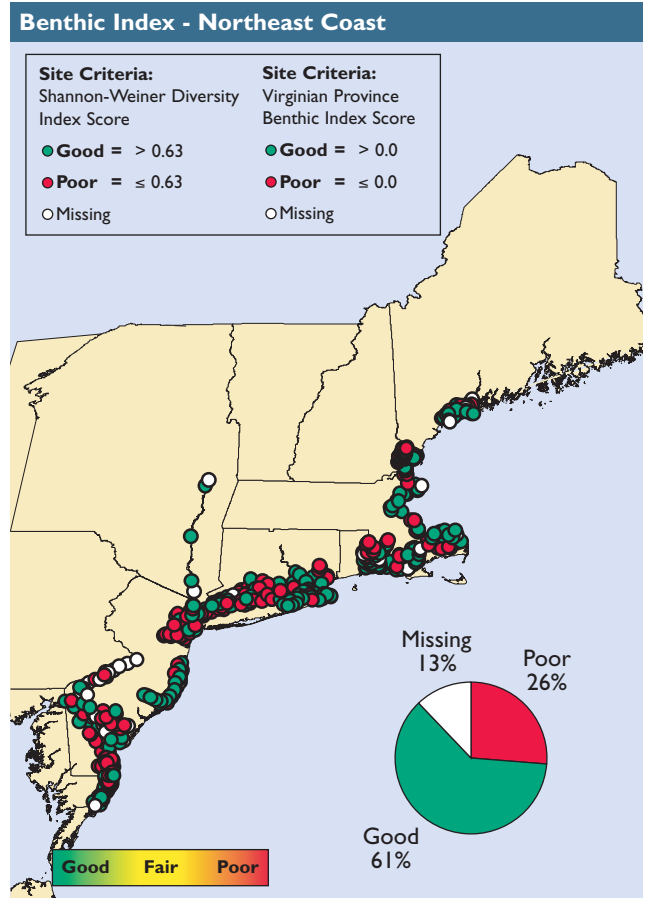


Figure 3-7. Benthic index data for the Northeast Coast NEP estuarine area (U.S. EPA/NCA).



In some areas of the Northeast, lobster tissue was analyzed for contaminants (NOAA).

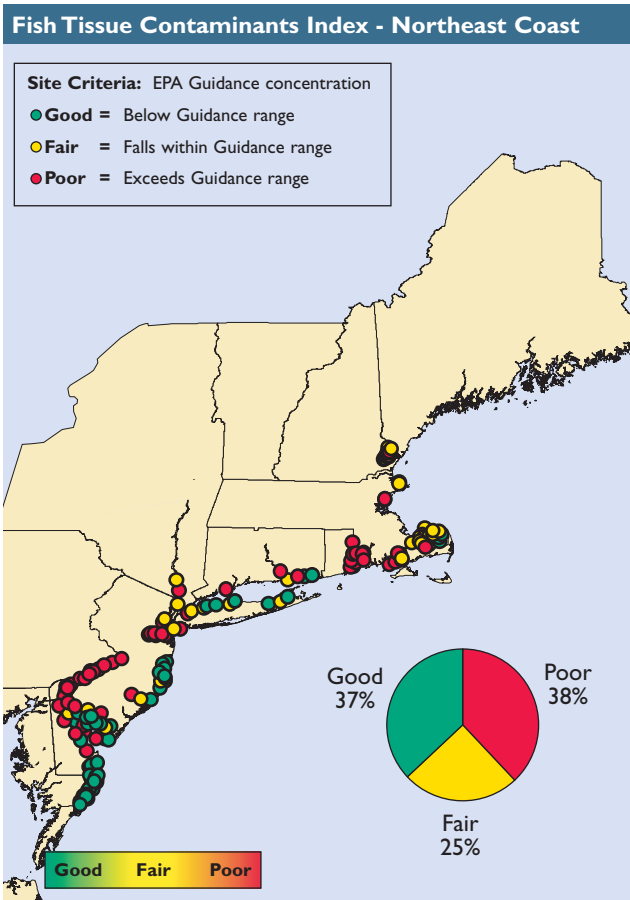


Figure 3-8. Fish tissue contaminants index data for the Northeast Coast NEP estuarine area (U.S. EPA/NCA).

be higher or lower than levels in fillets, depending on the fish species and contaminant assessed; however, the guidelines used for this report are appropriate for some populations that consume whole fish.

NEP Estuaries and the Condition of the Northeast Coast Region

The purpose of the NEP is to identify, restore, and protect the nationally significant estuaries of the United States. Most of the 12 NEP estuaries of the Northeast Coast region need this extra protection, in part because their size and societal significance have led to intense human development and a diversity of uses, including industrial and agricultural production and international commerce and shipping, resulting in associated environmental concerns throughout their watersheds. Does the condition of the Northeast Coast NEP estuaries

accurately reflect the condition of all Northeast Coast estuaries (both NEP and non-NEP)? Based on the NCA survey results, the collective Northeast Coast NEP estuaries and all Northeast Coast estuaries combined are both rated poor for overall condition, with the group of NEP estuaries receiving an overall condition score of 1.5, just slightly higher than the overall condition score of 1.25 for all Northeast Coast estuaries (Figure 3-9). Both groups of estuaries also have similar regional ratings for most of the NCA estuarine indices and component indicators.

A comparison of the NCA data shows that the collective Northeast Coast NEP estuaries are rated fair for the water quality index and poor for the sediment quality, benthic, and fish tissue contaminants indices. The group of all Northeast Coast estuaries combined are rated fair to poor for the water quality index and poor for the sediment quality, benthic, and fish tissue contaminants indices. The two groups of estuaries are rated comparably for a number of the water and sediment quality component indicators, with both groups rated good for sediment TOC concentrations, fair for DIN and sediment contaminant concentrations, and poor for sediment toxicity. However, the collective NEP estuaries are rated good for water clarity and chlorophyll *a* and dissolved oxygen concentrations and rated fair for DIP concentrations, whereas the group of all Northeast Coast estuaries are rated poor for water clarity, fair for chlorophyll *a* and dissolved oxygen concentrations, and good for DIP concentrations. Based on these ratings, the condition of the Northeast Coast NEP estuaries is relatively representative of the condition of all Northeast Coast estuaries, with the exception of water quality condition, where the group of NEP estuaries received better or equal ratings for the index and most of the component indicators.

With respect to the individual Northeast Coast NEP estuaries, 11 of the 12 estuaries received higher or comparable overall condition scores than the overall condition score for than the collective Northeast Coast NEP estuaries (1.5, rated poor). Casco Bay (5.0) and Peconic Estuary (4.33) are both rated good for overall condition; the New Hampshire Estuaries (3.5), Barnegat Bay (3.5), the Maryland Coastal Bays (3.5), Buzzards Bay (3.25), the Delaware Inland Bays (2.5),

	All Northeast Coast Estuaries	All Northeast Coast NEP Estuaries	Casco Bay	NH Estuaries	Massachusetts Bays	Buzzards Bay	Narragansett Bay	Long Island Sound	Peconic Estuary	NY/NJ Harbor	Barnegat Bay	Delaware Estuary	Delaware Inland Bays	Maryland Coastal Bays
Overall Condition	1.25	1.5	5.0	3.5	2.5	3.25	1.75	1.5	4.33	1.0	3.5	1.75	2.5	3.5
Water Quality Index														
Nitrogen (DIN)	Good	Good	Good	Fair	Fair	Fair	Fair	Fair	Good	Poor	Good	Fair	Fair	Poor
Phosphorus (DIP)	Good	Good	Good	Fair	Fair	Fair	Fair	Fair	Good	Poor	Good	Fair	Fair	Poor
Chlorophyll <i>a</i>	Good	Good	Good	Fair	Fair	Fair	Fair	Fair	Good	Poor	Good	Fair	Fair	Poor
Water Clarity	Poor	Poor	Good	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor
Dissolved Oxygen	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Sediment Quality Index									Missing					
Sediment Toxicity	Poor	Poor	Good	Good	Poor	Poor	Poor	Poor	Missing	Good	Good	Poor	Poor	Good
Sediment Contaminants	Fair	Fair	Good	Fair	Fair	Fair	Fair	Fair	Missing	Poor	Good	Good	Good	Good
Total Organic Carbon (TOC)	Good	Good	Good	Good	Good	Good	Good	Good	Missing	Good	Good	Good	Good	Good
Benthic Index														
Fish Tissue Contaminants Index			Missing											

Figure 3-9. Comparison of NCA results for Northeast Coast NEP estuaries and all Northeast Coast estuaries (U.S. EPA/NCA).

and the Massachusetts Bays (2.5) are each rated fair; and Narragansett Bay (1.75), Delaware Estuary (1.75), and Long Island Sound (1.5) are each rated poor. Only one Northeast Coast NEP estuary, New York/New Jersey Harbor, received an overall condition score (1.0, rated poor) that is lower than the overall score for the collective Northeast Coast NEP estuaries.

A review of the NCA data for the water quality index and component indicators shows that this index is rated good for Casco Bay, the Massachusetts Bays, Buzzards Bay, and Peconic Estuary; good to fair for Barnegat Bay; fair for the New Hampshire Estuaries, Narragansett Bay, Long Island Sound, and Delaware Inland Bays; and poor for New York/New Jersey Harbor, Delaware Estuary, and the Maryland Coastal Bays. The poor water quality ratings were caused primarily by elevated DIN and/or DIP concentrations in all three estuaries and by degraded water clarity and elevated chlorophyll *a* concentrations in Delaware Estuary and the Maryland Coastal Bays. A north to south gradient was generally evident in the DIN data for the Northeast Coast NEP estuaries, with Casco Bay,

the New Hampshire Estuaries, the Massachusetts Bays, Buzzards Bay, Narragansett Bay, Long Island Sound, Peconic Estuary, and Barnegat Bay rated good for this component indicator; New York/New Jersey Harbor and the Delaware Inland Bays rated fair; and Delaware Estuary and Maryland Coastal Bays rated poor. No clear pattern was observed with latitude for DIP concentrations in the Northeast Coast NEP estuaries, with Casco Bay, the Massachusetts Bays, and Barnegat Bay rated good for this component indicator; the New Hampshire Estuaries, Buzzards Bay, Narragansett Bay, Long Island Sound, Peconic Estuary, Delaware Estuary, and the Delaware Inland Bays rated fair; and New York/New Jersey Harbor and the Maryland Coastal Bays rated poor. Casco Bay, the New Hampshire Estuaries, the Massachusetts Bays, Buzzards Bay, Long Island Sound, Peconic Estuary, New York/New Jersey Harbor, and Barnegat Bay are rated good for chlorophyll *a* concentrations. Narragansett Bay, Delaware Estuary, the Delaware Inland Bays, and the Maryland Coastal Bays are rated fair. None of the Northeast Coast NEP estuaries are rated poor for

chlorophyll *a* concentrations. A north to south gradient was generally evident in the chlorophyll *a* data, with large areas of Delaware Estuary, the Delaware Inland Bays, and the Maryland Coastal Bays exhibiting fair condition for this component indicator. Narragansett Bay was the only estuary rated fair for this component indicator that exhibited an exception to this latitudinal trend.

Although the water clarity rating is good for the Northeast Coast NEP estuarine area and for 9 of the 12 individual NEP estuaries, the Delaware Estuary is rated fair and Barnegat Bay and the Maryland Coastal Bays are rated poor for this component indicator. Poor water clarity was prevalent only in the more southernly NEP estuaries of the Northeast Coast region. Diminished water clarity is commonly observed in these estuarine systems, to some extent because of natural processes such as tidal resuspension of fine sediments. Accordingly, the reference levels used to rate water clarity are different for the naturally turbid Delaware Estuary, where greater turbidity was required to merit a fair or poor rating than the criteria for neighboring estuaries. An important determination involving water clarity is the level of turbidity due to excess soil erosion or phytoplankton blooms caused by human activity; however, the NCA data alone were not sufficient to answer this question. Dissolved oxygen concentrations are rated good for 11 Northeast Coast NEP estuaries, but are rated fair for Long Island Sound. Depleted dissolved oxygen concentrations were measured in areas of Long Island Sound, Narragansett Bay, New York/New Jersey Harbor, and Buzzards Bay.

The sediment quality index and component indicator ratings for the individual Northeast Coast NEP estuaries range from good to poor. The sediment quality index is rated good for Casco Bay and the Maryland Coastal Bays; good to fair for the New Hampshire Estuaries, Barnegat Bay, and Delaware Estuary; fair for Buzzards Bay; and poor for the Massachusetts Bays, Narragansett Bay, Long Island Sound, New York/New Jersey Harbor, and the Delaware Inland Bays. Typically, sediment toxicity and/or sediment contaminant concentrations were responsible for a poor sediment quality index rating because all of the Northeast Coast NEP

estuaries are rated good for sediment TOC. None of the sediment quality component indicators were assessed for the Peconic Estuary.

The north to south pattern of degraded condition seen with some of the water quality component indicators was not apparent with the sediment quality component indicators. Rather, the NEP sites with the poorest condition were generally situated near major urban centers (e.g., New York/New Jersey Harbor, western Long Island Sound, upper Narragansett Bay, and the portion of Delaware Estuary near Philadelphia). At these locations, the impaired ratings were usually triggered by sediment contamination, most often high concentrations of metals (in particular, mercury, silver, and nickel), PCBs, and DDT. With respect to the sediment quality component indicators, sediment toxicity is rated good for Casco Bay, the New Hampshire Estuaries, Barnegat Bay, and the Maryland Coastal Bays and poor for the Massachusetts Bays, Buzzards Bay, Narragansett Bay, Long Island Sound, New York/New Jersey Harbor, Delaware Estuary, and the Delaware Inland Bays. Sediment toxicity was generally not observed in more than 11% of an NEP's estuarine area, with the exception of New York/New Jersey Harbor, where sediments were rated poor in 25% of the NEP estuarine area. The NCA survey did not assess sediment toxicity in the Peconic Estuary. Sediment contaminant concentrations are rated good for Casco Bay, the New Hampshire Estuaries, Barnegat Bay, Delaware Estuary, the Delaware Inland Bays, and the Maryland Coastal Bays; fair for the Massachusetts Bays, Buzzards Bay, and Narragansett Bay; and poor for Long Island Sound and New York/New Jersey Harbor. The NCA did not assess sediment contaminants in the Peconic Estuary. Finally, all of the Northeast Coast NEP estuaries are rated good for sediment TOC concentrations, although relatively large areas of Casco Bay and the New Hampshire Estuaries are rated fair for this component indicator. The northern NEP estuaries of the Northeast Coast region generally had the greatest occurrence of high TOC concentrations; however, some analysts caution that high TOC levels are not necessarily a definitive indication of sediment degradation. The NCA survey did not assess sediment TOC for the Peconic Estuary.

The benthic index ratings for the Northeast Coast NEP estuaries range from good to poor. The benthic index is rated good for Casco Bay; good to fair for Buzzards Bay; fair for the New Hampshire Estuaries, Peconic Estuary, Barnegat Bay, and the Maryland Coastal Bays; fair to poor for Narragansett Bay; and poor for the Massachusetts Bays, Long Island Sound, New York/New Jersey Harbor, Delaware Estuary, and the Delaware Inland Bays. Some of the estuaries north of Cape Cod (e.g., Acadian Province) did not score well based on the NCA method used to determine the health of benthic communities south of Cape Cod; therefore, the Shannon-Weiner Diversity Index of benthic community health was used for estuaries in the Acadian Province (see Chapter 1, *Benthic Index*)

The final estuarine index, the fish tissue contaminants index, is rated good for Peconic Estuary, the Delaware Inland Bays, and the Maryland Coastal Bays; good to fair for the New Hampshire Estuaries; fair for the Massachusetts Bays and Barnegat Bay; and poor for Buzzards Bay, Narragansett Bay, Long Island Sound, New York/New Jersey Harbor, and Delaware Estuary. NCA data were unavailable to evaluate fish tissue contaminant levels in Casco Bay.

The overall condition score for the collective NEP estuaries of the Northeast Coast region (1.5) was lower than the overall condition scores for the collective NEP estuaries of the Southeast Coast (4.0), Gulf Coast (2.75), or West Coast (2.5) regions and comparable to the score for Puerto Rico (1.5). This low overall condition score is not unexpected because many Northeast Coast NEP estuaries were designated to the program because of their societal importance to the nation as major centers of commerce and international trade and as commercial or recreational fishery areas since the 1700s. In addition, the counties surrounding the Northeast Coast NEP estuaries have some of the highest population densities in the country.

Population pressures, measured as population density (number of persons/mi²), correlated fairly well with the overall condition scores for the individual Northeast Coast NEP estuaries. For example, the study areas of the New York/New Jersey Harbor and Long Island Sound had the highest population densities of 3,097 and 2,170 persons/mi², respectively, and are both rated

poor for overall condition, receiving the lowest overall condition scores of 1.0 and 1.5, respectively. The three Northeast Coast NEP study areas with the lowest population densities—Maryland Coastal Bays (98 persons/mi²), Casco Bay (138 persons/mi²), and the New Hampshire Estuaries (216 persons/mi²)—are rated fair (3.5), good (5.0), and fair (3.5) for overall condition, respectively. However, Peconic Estuary, with a moderately high population density (1,558 persons/mi²), had one of the highest overall condition scores (4.3, rated good) for the Northeast Coast NEPs, although sediment quality was not evaluated for this estuary.



Slater Mill Pawtucket, RI, is considered the birthplace of the American industrial revolution (NBEP).