This document contains the Introduction of the National Estuary Program Coastal Condition Report. The Introduction contains a statement of the objectives of the report, a description of the environmental indices used to evaluate the condition of the estuaries of the National Estuary Program and the criteria used to develop these indices. The entire can be downloaded from ***http://www.epa.gov/owow/oceans/nepccr/index.html***

National Estuary Program Coastal Condition Report

Chapter 1: Introduction

June 2007

CHAPTER 1 | INTRODUCTION

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The *National Estuary Program Coastal Condition Report* (NEP CCR), a comprehensive report on the condition of the nation's National Estuary Program (NEP) waters, is a collaborative effort among the individual NEPs and the U.S. Environmental Protection Agency's (EPA's) National Coastal Assessment (NCA), Office of Wetlands, Oceans and Watersheds (OWOW), and Office of Research and Development (ORD).

The first *National Coastal Condition Report* (NCCR I) (U.S. EPA, 2001) assessed the condition of the nation's coasts using data from 1990–1996 that were provided by several existing coastal programs, including EPA's Environmental Monitoring and Assessment Program (EMAP), the U.S. Fish and Wildlife Service's (FWS's) National Wetland Inventory (NWI), and the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends (NS&T) Program. The second in this series of reports, the *National Coastal Condition Report II* (NCCR II) (U.S. EPA, 2004a), assessed coastal condition using data from 1997–2000 that were provided by the NCA and the NWI. The NEP CCR is similar to the NCCR series in structure, but instead of assessing national coastal condition, it focuses specifically on the condition of the 28 NEP estuaries using NCA data collected from 1997 through 2003. The NEP CCR also presents recent monitoring data collected and analyzed by the individual NEPs for a variety of estuarine indicators. Figure 1-1 shows the study areas assessed for all 28 NEP estuaries of the conterminous 48 states and Puerto Rico.

In addition to serving as important wildlife habitat, estuaries perform valuable services that benefit human communities (John Theilgard).

Why Are Estuaries Important?

Estuaries Are Valuable and Productive Natural Ecosystems

Estuaries are bodies of water that receive both fresh water and sediment influx from rivers and tidal influx from the ocean, thus providing transition zones between the fresh water of rivers and the saline environment of the sea. This interaction produces a unique environment that supports diverse habitats for a wide variety of living resources, such as fish and wildlife, and contributes substantially to the economy of coastal areas.

Estuaries are critical for the survival of a number of species. Many fish and shellfish species, including most commercially and recreationally important species, rely on the sheltered waters of estuaries as protected places to spawn and for their offspring to grow and develop (giving estuaries the nickname "nurseries of the sea"). Estuarine waters also serve as habitat and breeding areas for hundreds of species of birds and other wildlife, including marine mammals such as manatees, seals, sea lions, otters, porpoises, and whales.

Figure 1-1. A map of the study areas for each of the 28 NEP estuaries.

Estuaries Have Many Human Uses

In addition to serving as important habitat for wildlife, estuaries perform valuable services that benefit human communities. Tourism, fisheries, and other commercial activities thrive on the wealth of natural resources supplied by estuaries. The many commercially important fish and shellfish that depend on estuaries include striped bass, shad, salmon, sturgeon, shrimp, crabs, lobster, clams, oysters, mussels, and bay scallops. Estuaries also supply water for industrial uses; lose water to freshwater diversions for drinking and irrigation uses; serve as the critical terminals for the nation's marine transportation system and the U.S. Navy; provide a point of discharge for municipalities and industries; and are the downstream end of non-point source runoff, serving as filters for pollutants and sediments carried in water flowing from upstream. Wetland plants along the edge of estuaries act as a natural buffer between the land and the ocean, absorbing flood waters, dissipating storm surges, and helping to prevent erosion by stabilizing the shoreline.

Estuaries also provide community benefits, such as recreation, scientific knowledge, education, and aesthetic values. They are often the cultural centers of coastal communities, serving as the focal point for local commerce, recreation, celebrations, customs, and traditions. Boating, fishing, swimming, surfing, and bird watching are just a few of the numerous recreational activities that people enjoy in estuaries.

Population Pressures Affecting the NEPs

The coastal areas surrounding estuaries are among the most populated areas in the nation. Although the nation's narrow fringe of coastal land represents only 13% of the total contiguous land area of the United States, it is home to roughly 43% of the U.S. population (Figure 1-2).

A comparison of U.S. population data (1960–2000) for the nation and various geographic areas (e.g., all non-coastal counties, all coastal counties, and all NEP-coincident coastal counties) reveals that the largest percentage of the U.S. population (57%) lived in non-coastal counties in 2000 (Figure 1-3). Of the 43% of the U.S. population living in NOAA-designated coastal counties in 2000, almost 69% lived in NEP-coincident coastal counties, which represent less than 6% of the coastal land area of the contiguous United States (Cuilliton et al., 1990; U.S. Census Bureau, 1991;

Certain aspects of the nation's economic activity depend on estuaries and other coastal waters:

- Estuaries provide habitat for more than 75% of U.S. commercial fish catch and for 80% to 90% of the recreational fish catch. Estuarine-dependent fisheries are among the most valuable within regions and across the nation.
- Commercial and recreational fishing, boating, tourism, and other coastal industries provide more than 28 million jobs nationwide and generate $54 billion in goods and services each year.
- There are 25,500 recreational facilities along the U.S. coasts and almost 44,000 mi^2 of outdoor public recreation areas. The average American spends 10 recreational days on the coast each year. More than 180 million Americans—nearly 70% of the U.S. population—visit ocean and bay beaches annually, and coastal recreation and tourism generate $8 to $12 billion in annual revenue.

Sources: NOAA, 1990; NRC, 2000.

Figure 1-2. Population distribution in the United States in 2000 (U.S. Census Bureau, 2001).

2001). It should be noted that these calculations include only marine NOAA-designated coastal counties for the lower 48 states. For the purposes of this report, the populations of the counties bordering the Great Lakes were processed as non-coastal counties. This topic, along with a discussion of NEP-coincident counties, can be found in Appendix A of this report.

Figure 1-4 shows the population densities for these same geographic areas during this same time period (1960–2000). Although the rate of increase in population density is relatively constant, there is clearly great variability (a 10-fold difference) between the population density of non-coastal counties versus NEP-coincident coastal counties. For example, the population density in the NEP-coincident coastal counties in 2000 was highest at almost 500 persons/mi^2, whereas the population density in the conterminous 48 states was about 100 persons/mi^2 and in non-coastal counties was a mere 60 persons/mi^2. The population density in all U.S. coastal counties in 2000 was about 300 persons/mi^2. As shown in Table 1-1, the population growth rate for all U.S. coastal counties from 1960 to 2000 was 70%, compared to 48% for non-coastal counties and 57% for the nation. The population growth rate for this same period within NEP-coincident coastal counties was 59%, slightly more than the national population growth rate (U.S. Census Bureau, 1991; 2001).

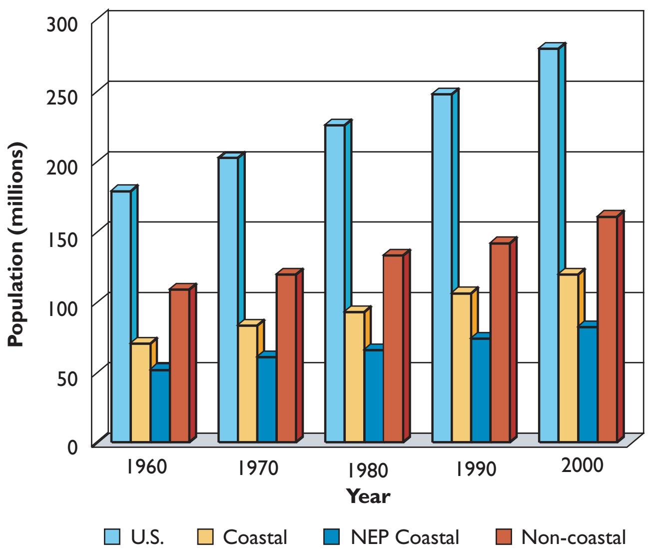


Figure 1-3. Total population data for the United States from 1960 to 2000 (U.S. Census Bureau, 1991; 2001).

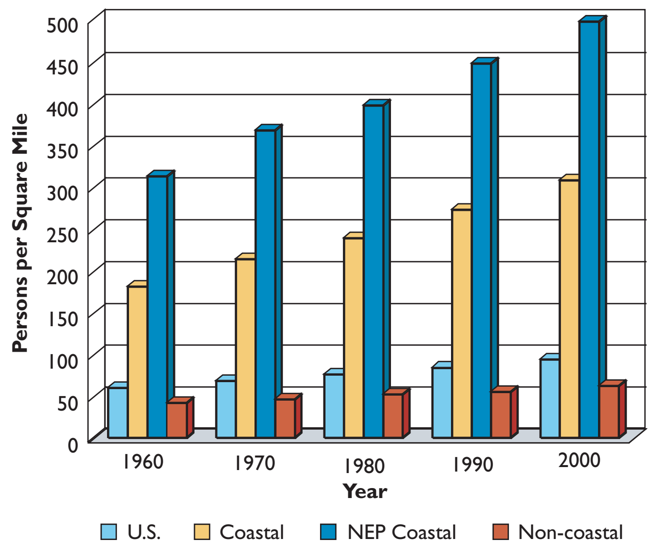


Figure 1-4. Population density data for the United States from 1960 to 2000 (U.S. Census Bureau, 1991; 2001).

Table 1-1. Comparison of U.S. Total Population, Population Density, and Population Growth Rate for the Nation, Coastal Counties, NEP-coincident Coastal Counties, and Non-coastal Counties* (U.S. Census Bureau, 1991; 2001)

	Total population, 2000 (millions)	Population density, 2000 (persons/mi^2)	Percent population growth rate, 1960–2000	Land area (mi^2)
United States	280	94	57	2,959,060
Coastal counties	119	308	70	387,470
NEP-coincident coastal counties	82	498	59	164,380
Non-coastal counties	160	62	48	2,571,590

*Excludes population and land area from Alaska, Hawaii, and U.S. Territories.

Why Be Concerned About the Health of Estuaries?

The economy of many coastal areas is based primarily on the natural beauty and bounty of estuaries, and the livelihoods of the people who live and work in these areas are affected when these estuaries are imperiled. Because a disproportionate percentage of the nation's population lives in coastal communities, the increased activities of municipalities, commerce, industry, and tourism in these areas have created environmental pressures that threaten coastal resources. These pressures include increased solid waste production; higher volumes of urban non-point source runoff; loss of green space and wildlife habitat; declines in ambient water and sediment quality; and increased demands for wastewater treatment, irrigation and potable water, and energy supplies. In addition, residential and commercial development continue to destroy estuarine wetlands and alter the quantity and timing of freshwater flow, which is critical to river and estuarine function. In effect, the same human uses that are desired of coastal waters also have the potential to lessen their value. This report not only discusses indices of estuarine condition that gauge the extent to which NEP habitats and resources have been altered, but it also addresses connections between estuarine condition and the ability of estuaries to meet human expectations for their use.

The National Estuary Program

As the U.S. population grows and the demands imposed on our nation's natural resources increase, so too does the importance of protecting these resources for their natural, economic, and aesthetic values. It is the mission of EPA's NEP to restore and protect America's nationally significant estuaries. Through its approach of inclusive, community-based planning and action on the watershed level, the NEP is an important initiative in conserving U.S. estuarine resources and an effective model for the protection and management of other coastal areas.

Established as part of the 1987 amendments to Section 320 of the Clean Water Act, the NEP promotes comprehensive planning efforts to help protect nationally significant estuaries judged to be threatened by pollution, development, or overuse. Section 320 requires the development of a Comprehensive Conservation and Management Plan (CCMP) for attaining or maintaining water quality in each NEP estuary. Aspects of water quality addressed by the CCMPs include the protection of public water supplies; the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife; and the maintenance of recreational opportunities, both in and on the water. The objective of each individual NEP is to create and implement a CCMP that addresses the entire range of environmental problems facing an NEP

The NEP promotes comprehensive planning efforts to help protect nationally significant estuaries judged to be threatened by pollution, development, or overuse (John Theilgard).

estuary, as well as to maintain the estuary's economic and social value; therefore, NEPs are required to monitor the effectiveness of their CCMPs to achieve measurable results. By providing grants and technical assistance, EPA helps state and local governments achieve these goals and share "lessons learned" among the individual NEPs and with other coastal communities.

Although EPA administers the national-level NEP, program decisions and activities for the 28 individual NEPs are carried out by committees of local government officials, private citizens, and representatives from other federal agencies, academic institutions, industry, and estuary user-groups. Estuaries are selected for inclusion in the NEP through a nomination process, with nominations submitted to EPA during designated nomination periods by the Governor of the state where the estuary is located. Table 1-2 provides a current list of the nation's NEP estuaries, as well as the year these estuaries received NEP designation.

Once selected for inclusion in the national program, each individual NEP must create decision-making committees comprised of relevant stakeholders to identify and prioritize the problems in their estuary. Most NEPs choose a management framework that includes a Management Committee to oversee the routine operation of the program; a Policy Committee comprised of high-level representatives from federal, state, and local government agencies; a Technical Advisory Committee to guide technical decisions; and a Citizens' Advisory Committee to represent the interests of estuary user-groups and the public. Together, these committees develop the CCMP to protect the NEP estuary and its resources.

The flexible and collaborative nature of the NEP has allowed the 28 individual NEPs to develop many innovative approaches to address local problems; approaches uniquely tailored to local environmental conditions and to the needs of local communities and stakeholders. At the same time, the national structure

Table 1-2. U.S. Estuaries in the National Estuary Program (U.S. EPA, 2006d)

Northeast Coast	Year of Entry	Puerto Rico	Year of Entry
Casco Bay, ME	1990	San Juan Bay Estuary, PR	1992
New Hampshire Estuaries, NH	1995		
Massachusetts Bays, MA	1990	**Gulf Coast**	
Buzzards Bay, MA	1987	Charlotte Harbor, FL	1995
Narragansett Bay, RI and MA	1987	Sarasota Bay, FL	1988
Long Island Sound, CT and NY	1987	Tampa Bay, FL	1990
Peconic Estuary, NY	1992	Mobile Bay, AL	1995
New York/New Jersey Harbor, NY and NJ	1988	Barataria-Terrebonne Estuarine Complex, LA	1991
Barnegat Bay, NJ	1995	Galveston Bay, TX	1988
Delaware Estuary, NJ, PA, and DE	1988	Coastal Bend Bays, TX	1992
Delaware Inland Bays, DE	1988		
Maryland Coastal Bays, MD	1995	**West Coast**	
		Puget Sound, WA	1987
Southeast Coast		Lower Columbia River Estuary, WA and OR	1995
Albemarle-Pamlico Estuarine Complex, NC and VA	1987	Tillamook Bay, OR	1994
Indian River Lagoon, FL	1990	San Francisco Estuary, CA	1987
		Morro Bay, CA	1995
		Santa Monica Bay, CA	1988

facilitates the sharing of successful management approaches, technologies, and ideas. Effective projects and innovative programs carried out by an individual NEP often serve as models for similar initiatives for other NEPs and coastal areas.

Although environmental results are often slow to be realized, positive signs of improving environmental conditions are already emerging from the activities of the individual NEPs. The NEPs have worked hard to monitor, conserve, protect, and restore important habitats (e.g., submerged aquatic vegetation [SAV], wetlands) in their study areas, including restoring and/or protecting more than one million acres of habitat since 2000 (U.S. EPA, 2006b). They are also demonstrating success in finding effective institutional arrangements from which to manage their estuaries, including securing and leveraging funds and improving public education and citizen participation through outreach efforts.

Purpose and Format of This Report

The purpose of this NEP CCR is to present a broad baseline picture of the condition of the nation's NEP estuaries from 1997 through 2003, as well as additional information about the specific conditions and challenges of each NEP estuary. This report uses currently available data to compare the condition of the nation's NEP estuaries to each other, as well as regionally and nationally; however, it is not intended to be a comprehensive literature review of estuarine information. Instead, this report uses NCA data on four primary indices of estuarine condition and data collected by individual NEPs on a variety of site-specific indicators to provide insight into current estuarine condition. This report also presents data gaps and other issues that environmental managers focus on to make more reliable assessments as to how the condition of the nation's NEP estuaries may be changing with time. This NEP CCR will serve as a continuing benchmark for analyzing the progress of the NEPs and is expected to be followed in subsequent years by reports on more specialized estuarine issues.

Chapter 2 of this report presents available NCA data on a national scale for the 28 NEP estuaries in the conterminous 48 states and Puerto Rico. These data are then broken down and analyzed for the NEP estuaries of five geographic regions: Northeast Coast (Chapter 3), Southeast Coast (Chapter 4), Gulf Coast (Chapter 5), West Coast (Chapter 6), and Puerto Rico (Chapter 7). These chapters include a regional overview of NEP estuarine condition and profiles of the individual NEPs in that region. Each NEP profile presents information on the specific indicators used by an NEP to evaluate water and sediment quality, habitat quality, living resources, and other environmental stressors in their estuary, as well as an overview of the current projects, accomplishments, and future goals of the individual program. The NEPs were also asked to provide a short Highlight article for each profile describing either a specific aspect of their estuary or an exemplary program developed at the local estuary level to address site-specific environmental concerns. These articles are intended to illustrate the unique living resources of the estuary, as well as innovative monitoring methods, successful restoration/remediation efforts, or novel decision-making and management efforts undertaken at the local level. The diversity of the subjects described in the Highlight articles speaks to the wide spectrum of programs and monitoring approaches that exist among the 28 NEP estuaries.

Chesapeake Bay Program

Why Isn't the Chesapeake Bay in the National Estuary Program?

The largest estuary in the United States, the Chesapeake Bay, is protected under its own federally mandated program that is separate from, but related to, the NEP. In fact, the approach and methods of the NEP were developed from the foundation laid by earlier efforts to protect Chesapeake Bay. Chesapeake Bay was the first estuary in the United States to be targeted for restoration and protection. In 1983, the Governors of Maryland, Virginia, and Pennsylvania; the Mayor of the District of Columbia; and the EPA Administrator signed the Chesapeake Bay Agreement, committing their states, the District of Columbia, and EPA to prepare plans for protecting and improving water quality and living resources in Chesapeake Bay. The Chesapeake Bay Program evolved as an institutional mechanism to restore the Bay and to meet the goals of the Chesapeake Bay Agreement. This program guides and coordinates multi-state and multi-agency activities.

The Chesapeake Bay Program raised awareness of the need to establish federal-state partnerships to protect estuaries threatened by pollution, development, and overuse. The NEP was established in response to the recognition of a need to protect not only the Chesapeake Bay but also the many other nationally significant estuaries throughout the country.

Approaches Used to Measure Estuarine Condition

There are two major approaches presented in each chapter of this report for evaluating estuarine condition. The first approach uses unbiased, quality-assured monitoring data collected nationally by the EPA NCA to make consistent comparison ratings of four primary indices of estuarine condition (water quality index, sediment quality index, benthic index, and fish tissue contaminants index) among the NEP estuaries. The resulting ratings for each index are then used to calculate an individual NEP rating, a regional NEP rating, and a national rating of NEP estuarine condition. Using the NCA approach, estuarine condition for the individual NEP estuaries and regions can be expressed in terms of the percent of estuarine area in good, fair, or poor condition and can be compared nationally. The overall condition and index ratings for the nation's collective NEP estuaries are based on an areally weighted mean of the regional overall condition and index scores. NCA sampling for each estuary is typically conducted at sites during a one-day period over the summer months for one to two years; therefore, the NCA data present only a "snapshot" of what is occurring in the estuary at that time.

The second approach presented in this report uses estuary-specific monitoring data collected by the individual NEPs and their partners in support of local problem-solving efforts. For some NEP estuaries, monitoring data have been collected continuously for more than a decade, and some estuarine indicators may be monitored on an hourly, daily, weekly, monthly, quarterly, or yearly basis. These monitoring data can provide a more detailed view of the various cyclic changes that may occur daily or seasonally in an estuary to evaluate long-term changes in an indicator; however, because the individual NEPs use a variety of approaches and methods for data collection and evaluation, it is often difficult to compare this information among estuaries or on a national basis. Table 1-3 compares some of the differences in temporal and spatial monitoring between the two monitoring approaches presented in this report.

Each of the two approaches has strengths and weakness, but the resulting information taken together paints a more precise picture of the overall condition of the resources of the NEP estuaries than can be gleaned from either program approach individually. The two monitoring approaches are described in the following sections.

National Coastal Assessment (NCA) Monitoring Data

EPA's NCA provides representative data on four indices of estuarine condition (water quality index, sediment quality index, benthic index, and fish tissue contaminants index) for the 28 NEP estuaries. These four primary indices were selected because of the availability

Table 1-3. Monitoring Approaches of the NCA and NEP

Parameter	NCA Approach	Individual NEP Approach
Indicators monitored	Water quality index Sediment quality index Benthic index Fish tissue contaminants index	Highly variable, but may include some or all of the four NCA indices, as well as a variety of other site-specific indicators
Selection of sampling sites	Randomized spatially throughout the estuary	Randomized spatially and/or targeted to monitor a specific area of the estuary that is known to be contaminated or degraded
Sampling frequency	One day during the summer sampling period (July–August), which is considered to be the most stressful period of the year; therefore, monitoring is able to capture evidence of degradation	Variable, but may be hourly, daily, weekly, monthly, quarterly, or annually, depending on the indicator being monitored
Sampling period	1997–2003 (The years of sampling differ slightly, depending on the specific NEP estuary, but fall within this time interval)	Historic data may be available for 20 years or more

of relatively consistent data for these indices for most of the nation's estuaries. The indices do not address all characteristics of estuaries that are valued by society, but they do provide information on both the ecological condition and the effects of human use on estuaries.

Characterizing the NEP estuaries using each of the four indices involves two steps. The first step is to assess condition at individual monitoring sites within an NEP estuarine area for each index and component indicator. The site-condition rating criteria for each index and component indicator are determined based on existing criteria, guidelines, or interpretation of scientific literature. For example, dissolved oxygen conditions (a component indicator of the water quality index) are considered poor if dissolved oxygen concentrations are less than 2 mg/L. This value is widely accepted as representative of hypoxic conditions; therefore, this benchmark for poor condition is strongly supported by scientific evidence (Diaz and Rosenberg, 1995; U.S. EPA, 2000a).

The second step is to assign index ratings for each NEP estuary and region based on the condition of the monitoring sites within an NEP estuary or region. For example, for an estuary or region to be rated poor with regard to dissolved oxygen concentrations, more than 15% of the NEP estuarine area must have concentrations measured at less than 2 mg/L. The criteria boundaries for the NEP estuary and the regional ratings (i.e., percentages used to rate each index of estuarine condition) were determined as a median of the responses provided through a survey of environmental managers, resource experts, and the knowledgeable public. The following sections provide detailed descriptions of each index and component indicator, as well as the criteria for determining the ratings for the four primary indices by site, NEP estuary, and region as good, fair, or poor.

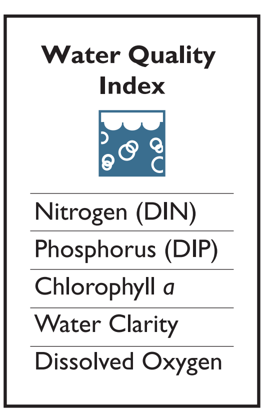


Figure 1-5. Component indicators of the water quality index.

Water Quality Index

The water quality index is made up of five component indicators: dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), chlorophyll *a*, water clarity, and dissolved oxygen (Figure 1-5). Some nutrient inputs to estuaries (such as DIN and DIP) are necessary for a healthy, functioning estuarine ecosystem; however, when nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, the concentration of available nutrients can increase beyond natural background levels. This increase in the rate of supply of organic matter is called eutrophication and may result in a host of undesirable water quality conditions (Figure 1-6). Excess nutrients can lead to excess plant production (phytoplankton or algae) and to increased chlorophyll *a* concentrations that can decrease water clarity and lower concentrations of dissolved oxygen.

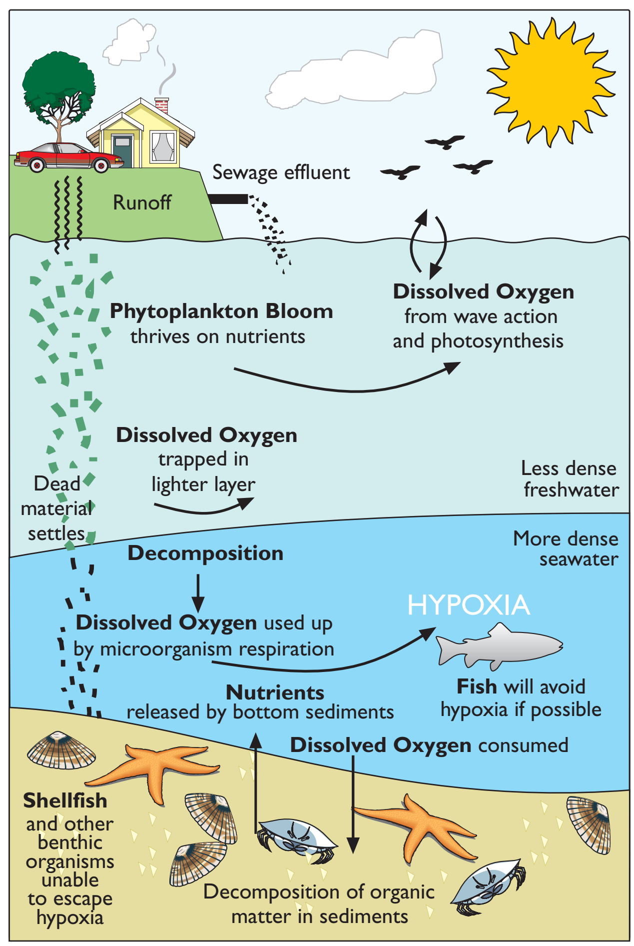


Figure 1-6. Eutrophication can occur when the concentration of available nutrients increases beyond normal levels.

The water quality index used in this report is intended to characterize acutely degraded water quality conditions and does not consistently identify sites experiencing occasional or infrequent hypoxia, nutrient enrichment, or decreased water clarity. As a result, a rating of poor for the water quality index means that the site is likely to have consistently poor condition during the monitoring period. If a site is designated as fair or good, the site did not experience poor condition on the date sampled, but could be characterized by poor condition for short time periods. In order to assess the level of variability in the index at a specific site over time, increased or supplemental sampling is needed.

Dissolved Nitrogen and Phosphorus | DIN and DIP are necessary and natural nutrients required for the growth of phytoplankton, the primary producers that form the base of an estuary's food chain; however, excessive DIN and DIP can result in large, undesirable phytoplankton blooms. For this report, DIN and DIP were determined chemically through the collection of filtered surface water at each site. NCA surveys were conducted in late summer—not the most likely period for maximal nutrient values in East Coast and Gulf Coast estuaries, but the period of expected peak concentrations for West Coast estuaries.

NCA monitoring sites were rated good, fair, or poor for DIN and DIP using the criteria shown in Tables 1-4 and 1-5. These ratings were then used to calculate DIN and DIP ratings for each NEP estuary and region.

Chlorophyll a | For this report, the surface concentrations of chlorophyll *a* were determined from a filtered portion of water collected at each site. Surface chlorophyll *a* concentrations at a site were rated good, fair, or poor using the criteria shown in Table 1-6. These ratings were then used to calculate chlorophyll *a* ratings for each NEP estuary and region.

Water Clarity | Clear waters are valued by society and contribute to the maintenance of healthy and productive ecosystems. Light penetration into estuarine waters is important for the healthy growth of SAV, which serves as food and habitat for the resident biota. The NCA estimates water clarity using specialized equipment that compares the amount and type of light reaching the water surface to the light at a depth of 1 meter, as well as by using a Secchi disk. Water clarity varies naturally among different parts of the nation; therefore, the water clarity index (WCI) is based on a ratio of observed clarity to regional reference conditions: WCI = (observed clarity at 1 meter/regional reference clarity at 1 meter). The reference conditions for the NEP estuaries and regions were determined by examining available data for each of the regions. Conditions

Table 1-4. Criteria for Assessing Dissolved Inorganic Nitrogen (DIN)

Area	Good	Fair	Poor
East/Gulf Coast sites	< 0.1 mg/L	0.1–0.5 mg/L	> 0.5 mg/L
West Coast sites	< 0.5 mg/L	0.5–1.0 mg/L	> 1 mg/L
Puerto Rico sites	< 0.05 mg/L	0.05–0.1 mg/L	> 0.1 mg/L
NEP Estuary or Region	Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.	10% to 25% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.	More than 25% of the NEP estuarine area is in poor condition.

Table 1-5. Criteria for Assessing Dissolved Inorganic Phosphorus (DIP)

Area	Good	Fair	Poor
East/Gulf Coast sites	< 0.01 mg/L	0.01–0.05 mg/L	> 0.05 mg/L
West Coast sites	< 0.01 mg/L	0.01–0.1 mg/L	> 0.1 mg/L
Puerto Rico sites	< 0.005 mg/L	0.005–0.01 mg/L	> 0.01 mg/L
NEP Estuary or Region	Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.	10% to 25% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.	More than 25% of the NEP estuarine area is in poor condition.

Table 1-6. Criteria for Assessing Chlorophyll *a*

Area	Good	Fair	Poor
East/Gulf/ West Coast sites	< 5 µg/L	5–20 µg/L	> 20 µg/L
Puerto Rico sites	< 0.5 µg/L	0.5–1 µg/L	> 1 µg/L
NEP Estuary or Region	Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.	10% to 20% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.	More than 20% of the NEP estuarine area is in poor condition.

were set at 10% of incident light available at a depth of 1 meter for areas with normal turbidity (most of the United States), 5% for areas with naturally high turbidity (Alabama, Georgia, Louisiana, South Carolina, and parts of Delaware), and 20% for areas with significant SAV beds or active programs for SAV restoration (southern Laguna Madre, the Big Bend region of Florida, the region from Tampa Bay to Florida Bay, the Indian River Lagoon, and portions of the Chesapeake Bay). Table 1-7 summarizes the rating criteria for water clarity for each monitoring site and for the NEP estuaries and regions.

Table 1-7. Criteria for Assessing Water Clarity

Area	Good	Fair	Poor
Individual sampling sites	WCI ratio is greater than 2.	WCI ratio is between 1 and 2.	WCI ratio is less than 1.
NEP Estuary or Region	Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.	10% to 20% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.	More than 25% of the NEP estuarine area is in poor condition.

Dissolved Oxygen | Dissolved oxygen is necessary for all estuarine life. Many states use a dissolved oxygen threshold average concentration of 4 to 5 mg/L to set their water quality standards, and concentrations below approximately 2 mg/L are thought to be stressful to many estuarine organisms (Diaz and Rosenberg, 1995; U.S. EPA, 2000a). Low oxygen levels (hypoxia) or a lack of oxygen (anoxia) most often occur in bottom waters and affect the organisms that live in the sediments. These conditions often accompany the onset of severe bacterial degradation, sometimes resulting in the presence of algal scums and noxious odors; however, in some estuaries, low oxygen levels occur periodically or may be a part of an estuary's natural ecology. Therefore, although it is easy to show a snapshot of the conditions of the nation's estuaries concerning oxygen concentrations, it is difficult to interpret whether this snapshot is representative of all summertime periods (such as representative of the variable daily conditions in Narragansett Bay) or the result of natural physical processes.

Unless otherwise noted, the dissolved oxygen data presented in this report were collected as part of the NCA survey. Table 1-8 summarizes the dissolved oxygen rating criteria for the individual monitoring sites and for the NEP estuaries and regions.

Table 1-8. Criteria for Assessing Dissolved Oxygen

Area	Good	Fair	Poor
Individual sampling sites	> 5 mg/L	2–5 mg/L	< 2 mg/L
NEP Estuary or Region	Less than 5% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.	10% to 20% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.	More than 15% of the NEP estuarine area is in poor condition.

Calculating the Water Quality Index

Once DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen were assessed for a given site, a water quality index rating was calculated for the site based on these five component indicators. Table 1-9 summarizes the rating criteria for developing a water quality index for an individual sampling site. The water quality index was then calculated for each NEP estuary and region using the criteria in Table 1–10.

Table 1-9. Criteria for Determining the Water Quality Index Rating by Site

Rating	Criteria
Good	A maximum of one component indicator is rated fair, and no component indicators are rated poor.
Fair	One of the component indicators is rated poor, or two or more component indicators are rated fair.
Poor	Two or more of the five component indicators are rated poor.
Missing	Two component indicators are missing, and the available component indicators do not suggest a poor or fair rating.

Table 1-10. Criteria for Determining the Water Quality Index Rating by NEP Estuary or Region

Rating	Criteria
Good	Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair	10% to 20% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor	More than 20% of the NEP estuarine area is in poor condition.

Sediment Quality Index

Another issue of major environmental concern in estuaries is the contamination of sediments with toxic chemicals. A wide variety of metals and organic substances, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides, are discharged into estuaries from urban, agricultural, and industrial sources in a watershed. These contaminants adsorb onto suspended particles and eventually accumulate in depositional basins, where they can disrupt the benthic community of invertebrates, shellfish, and crustaceans that live in or on the sediments. To the extent that the contaminants become concentrated in the organisms, they pose a risk to organisms throughout the food web—including humans.

Several factors influence the extent and severity of sediment contamination. Fine-grained, organic-rich sediments are efficient at scavenging pollutants and are likely to become resuspended and be transported to distant locations. Thus, silty sediments high in total organic carbon (TOC) are potential sources of contamination. Conversely, organic-rich particles bind some toxicants so strongly that the threat to organisms can be greatly reduced.

Physical and chemical characteristics of surface sediments are the result of interacting forces controlling chemical input and particle dynamics at any particular site. When assessing estuarine condition, researchers measure the potential for sediments to affect bottom-dwelling organisms. The sediment quality index is based on three component indicators of sediment condition: direct measures of sediment toxicity, sediment contaminant concentrations, and the sediment TOC concentration (Figure 1-7).

The NCA survey measured the concentrations of 91 chemical constituents in sediments to determine the sediment contaminants component of the index. Sediment toxicity was evaluated by measuring the survival of the marine amphipod *Ampelisca abdita* following 10-day exposure to the sediments under laboratory conditions. The sediment TOC concentration was measured on a dry-weight basis. The results of these evaluations may be used to identify the most polluted areas and may provide clues regarding the sources of contamination.

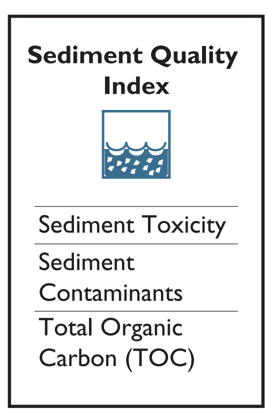


Figure 1-7. Component indicators of the sediment quality index.

Sediment Contaminant Criteria (Long et al., 1995)

ERM (Effects Range Median)—Determined for each chemical as the 50th percentile (median) in a database of ascending concentrations associated with adverse biological effects.

ERL (Effects Range Low)—Determined for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

Some researchers and managers would prefer that the sediment triad (sediment contaminants, sediment toxicity, and benthic communities) be used to assess sediment condition (poor condition would require all three elements to be poor), or that poor sediment condition be determined at least based on the joint occurrence of elevated sediment contaminant concentrations and high sediment toxicity (see text box–*Alternative Views for a Sediment Quality Index*). However, benthic community attributes are included in this assessment of estuarine condition as an independent variable (see the *Benthic Index* section in this chapter), rather than as a component of sediment quality.

In this report, the focus of the sediment quality index is on sediment condition, not just sediment toxicity. Attributes of sediments other than toxicity can result in unacceptable changes in biotic communities. For example, organic enrichment through wastewater disposal can have an undesired effect on biota, and elevated contaminant levels can have undesirable ecological effects (e.g., changes in benthic community structure) that are not directly related to acute toxicity (as measured by the *Ampelisca* test). For these reasons, the sediment quality index used in this report combines sediment toxicity, sediment contaminants, and TOC to assess sediment condition. The condition of estuarine sediment is assessed as poor (high potential for exposure effects on biota) if any one of the component elements is rated poor; assessed as fair if the sediment contaminants indicator is rated fair; and assessed as good if all three component indicators are at levels that would be unlikely to result in adverse biological effects due to sediment quality.

When assessing estuarine condition, researchers measure the potential for sediments to affect bottom-dwelling organisms (Morro Bay NEP).

Alternative Views for a Sediment Quality Index

Some resource managers object to using ERM and ERL values to calculate the sediment quality index because the index is also based on actual measurements of toxicity. Because ERMs are acknowledged to be no greater than 50% predictive of toxicity, these managers believe that the same weight should not be given to a nontoxic sample with an ERM exceedance as is given to a sample that is actually toxic. O'Connor et al. (1998), using a 1,508-sample EPA and NOAA database, found that 38% of ERM exceedances coincided with amphipod toxicity (i.e., were toxic); 13% of the ERL exceedances (no ERM exceedance) were toxic; and only 5% of the samples that did not exceed ERL values were toxic. O'Connor and Paul (2000) expanded the 1,508-sample data set to 2,475 samples, and the results remained relatively unchanged (41% of the ERM exceedances were toxic, and only 5% of the nonexceedances were toxic). As a result, these researchers and managers believe that the sediment quality index used in this report should not result in a poor rating if sediment contaminant criteria are exceeded, but the sediment is not toxic.

Sediment Toxicity | Researchers applied a standard direct test of toxicity at thousands of sites to measure the survival of amphipods (commonly found, shrimp-like benthic crustaceans) exposed to sediments for 10 days under laboratory conditions. As in all tests of toxicity, survival was measured relative to that of amphipods exposed to uncontaminated reference sediment. The criteria for rating sediment toxicity based on amphipod survival for each sampling site are shown in Table 1-11, and Table 1-12 shows how these site data were used to evaluate sediment toxicity by NEP estuary or region. It should be noted that for this component indicator, unlike the others, only a good or poor rating is possible—there is no fair rating.

Table 1-11. Criteria for Assessing Sediment Toxicity by Site

Rating	Criteria
Good	The amphipod survival rate is greater than or equal to 80%.
Poor	The amphipod survival rate is less than 80%.

Table 1-12. Criteria for Assessing Sediment Toxicity by NEP Estuary or Region

Rating	Criteria
Good	Less than 5% of the NEP estuarine area is in poor condition.
Poor	5% or more of the NEP estuarine area is in poor condition.

Contaminants that absorb onto suspended particles can disrupt the benthic community of invertebrates, shellfish, and crustaceans that live in or on the sediments (Morro Bay NEP).

Sediment Contaminants | There are no absolute chemical concentrations that correspond to sediment toxicity, but ERL and ERM values are used as guidelines in assessing sediment contamination (Table 1-13). ERM is the median concentration (50th percentile) of a contaminant observed to have adverse biological effects in the literature studies examined. A more protective indicator of contaminant concentrations is the ERL

Table 1-13. ERM and ERL Guidance Values in Sediments (Long et al., 1995)

Metal[a]	ERL	ERM
Arsenic	8.2	70
Cadmium	1.2	9.6
Chromium	81	370
Copper	34	270
Lead	46.7	218
Mercury	0.15	0.71
Nickel	20.9	51.6
Silver	1	3.7
Zinc	150	410
Analyte[b]	**ERL**	**ERM**
Acenaphthene	16	500
Acenaphthylene	44	640
Anthracene	85.3	1,100
Fluorene	19	540
2-Methyl naphthalene	70	670
Naphthalene	160	2,100
Phenanthrene	240	1,500
Benz(a)anthracene	261	1,600
Benzo(a)pyrene	430	1,600
Chrysene	384	2,800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5,100
Pyrene	665	2,600
Low molecular-weight PAH	552	3,160
High molecular-weight PAH	1,700	9,600
Total PAHs	4,020	44,800
4,4'-DDE	2.2	27
Total DDT	1.6	46.1
Total PCBs	22.7	180

[a] units are µg/g dry sediment, equivalent to ppm
[b] units are ng/g dry sediment, equivalent to ppb

criterion, which is the 10th percentile concentration of a contaminant represented by studies demonstrating adverse biological effects in the literature. Ecological effects are not likely to occur at contaminant concentrations below the ERL criterion. The criteria for rating sediment contaminants at individual sampling sites are shown in Table 1-14, and Table 1-15 shows how these data were used to create ratings for the NEP estuaries and regions.

Table 1-14. Criteria for Assessing Sediment Contaminants by Site

Rating	Criteria
Good	No ERM values are exceeded, and less than five ERL values are exceeded.
Fair	Five or more ERL values are exceeded.
Poor	An ERM value is exceeded for one or more contaminants.

Table 1-15. Criteria for Assessing Sediment Contaminants by NEP Estuary or Region

Rating	Criteria
Good	Less than 5% of the NEP estuarine area is in poor condition.
Fair	5% to 15% of the NEP estuarine area is in poor condition.
Poor	More than 15% of the NEP estuarine area is in poor condition.

Total Organic Carbon | Sediment contaminant availability or organic enrichment can be altered in areas where there is considerable deposition of organic matter. Sediment toxicity from organic matter is assessed by measuring the sediment TOC. The criteria for rating TOC concentrations at individual sampling sites are shown in Table 1-16, and Table 1-17 shows how these data were used to create ratings for the NEP estuaries and regions.

Table 1-16. Criteria for Assessing TOC by Site (concentrations on a dry-weight basis)

Rating	Criteria
Good	The TOC concentration is less than 2%.
Fair	The TOC concentration is between 2% and 5%.
Poor	The TOC concentration is greater than 5%.

Table 1-17. Criteria for Assessing TOC by NEP Estuary or Region

Rating	Criteria
Good	Less than 20% of the NEP estuarine area is in poor condition.
Fair	20% to 30% of the NEP estuarine area is in poor condition.
Poor	More than 30% of the NEP estuarine area is in poor condition.

Calculating the Sediment Quality Index

Once all three sediment quality component indicators (sediment toxicity, sediment contaminants, and sediment TOC) were assessed for a given site, a sediment quality index rating was calculated for the site. The sediment quality index was rated good, fair, or poor for each site using the criteria shown in Table 1-18. The sediment quality index was then calculated for each NEP estuary and region using the criteria shown in Table 1-19.

Table 1-18. Criteria for Determining the Sediment Quality Index by Site

Rating	Criteria
Good	None of the component indicators are rated poor, and the sediment contaminants indicator is rated good.
Fair	None of the component indicators are rated poor, and the sediment contaminants indicator is rated fair.
Poor	One or more of the component indicators are rated poor.

Table 1-19. Criteria for Determining the Sediment Quality Index by NEP Estuary or Region

Rating	Criteria
Good	Less than 5% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair	5% to 15% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor	More than 15% of the NEP estuarine area is in poor condition.

Benthic Index

The worms, clams, and crustaceans that inhabit the bottom substrates of estuaries are collectively called benthic macroinvertebrates, or benthos. These organisms play a vital role in maintaining sediment and water quality and are an important food source for bottom-feeding fish, shrimp, ducks, and marsh birds. Benthos are often used as indicators of disturbances in estuarine environments because they are not very mobile; thus, they cannot avoid environmental problems. Benthic population and community characteristics are sensitive indicators of chemical contaminant and dissolved-oxygen stress, salinity fluctuations, and sediment disturbance and serve as reliable indicators of estuarine environmental quality. To distinguish degraded benthic habitats from undegraded benthic habitats, EMAP and NCA have developed regional (Northeast, Southeast, and Gulf coasts) benthic indices of environmental condition for estuaries that reflect changes in the diversity and population size of indicator species (Engle et al., 1994; Weisberg et al., 1997; Engle and Summers, 1999; Van Dolah et al., 1999; Paul et at., 2001). These indices reflect changes in benthic community diversity and the abundance of pollution-tolerant and pollution-sensitive species. A high benthic index rating means that samples taken from an estuary's sediments contain a wide variety of species, a low proportion of pollution-tolerant species, and a high proportion of pollution-sensitive species. A low benthic index rating indicates that the benthic communities are less diverse than expected, are populated by more pollution-tolerant species than expected, and contain fewer pollution-sensitive species than expected. The benthic condition data presented throughout this report were collected by the NCA unless otherwise noted. Indices vary among the regions because species assemblages depend on prevailing temperatures, salinities, and the silt-clay content of sediments. A benthic index was rated poor when the index values for the Northeast, Southeast, and Gulf coasts' diversity or species richness, abundance of pollution-sensitive species, and abundance of pollution-tolerant species fell below a certain threshold. It should be noted that the benthic indices used in the Northeast are designed to discriminate between good and poor categories; a fair category does not exist.

Not all regions included in this report have developed benthic indices. Indices for the New England Coast north of Cape Cod (Acadian Province), the West Coast, and Puerto Rico are being developed and are not available for reporting at this time. The benthic index used in the Northeast region south of Cape Cod (Virginian Province) was developed by EMAP and NCA; however, EPA used the Shannon-Weiner Diversity Index to evaluate the benthic community for the NEP estuaries of the Acadian Province because the index used for the Virginian Province did not produce good results for these estuaries. In the West Coast and Puerto Rico regions, benthic community diversity was determined for each site as a surrogate for the benthic index. Values for benthic community diversity were examined regionally to determine if diversity varied directly with either salinity or sediment silt-clay content (the two natural variables most likely to influence

The abundant population growth in U.S. coastal areas increases the demands imposed on the natural, economic, and aesthetic value of estuaries (John Theilgard).

estuarine benthic diversity). If there was no significant relationship between diversity and these natural gradients in a region (as in Puerto Rico), then a surrogate benthic index was used based on the lower 95% confidence limit for the mean benthic diversity measures. If there was a significant relationship between diversity and either of these natural gradients in a region (as in the West Coast NEP estuaries), then a surrogate benthic index was used based on the ratio of observed to expected diversity. Expected diversity was determined based on the statistical relationship of site diversity to site salinity (or silt-clay content). Poor condition was defined as less than 75% of the expected benthic diversity at a particular salinity (expected diversity was determined by a regression between diversity and salinity). Table 1-20 shows the good, fair, and poor rating criteria for sites in the different regions of the country, which were used to calculate an overall rating for each NEP estuary and region.

The relationship between poor benthic condition (poor benthic index values) and environmental stressors (e.g., water quality and sediment quality indices and their component indicators) is examined using the co-occurrence of these factors in each region. In all regions, some sites with poor benthic community condition did not co-occur with high levels of environmental stressors measured by the NCA. The sites that do not co-occur with the poor water quality and sediment quality indices may be the result of physical habitat degradation (a parameter not measured by the NCA).

Fish Tissue Contaminants Index

Chemical contaminants may enter a marine organism in several ways: direct uptake from contaminated water, consumption of contaminated sediment, or consumption of previously contaminated organisms. Once these contaminants enter an organism, they tend

Table 1-20. Criteria for Assessing Benthic Condition

Region	Good	Fair	Poor
Northeast Coast sites			
Acadian Province	Shannon-Weiner Diversity Index is greater than 0.63	NA*	Shannon-Weiner Diversity Index is less than or equal to 0.63
Virginian Province	Benthic index score is greater than 0.0	NA*	Benthic index score is less than 0.0
Southeast Coast sites	Benthic index score is greater than 2.5	Benthic index score is between 2.0 and 2.5	Benthic index score is less than 2.0
Gulf Coast sites	Benthic index score is greater than 5.0	Benthic index score is between 3.0 and 5.0	Benthic index score is less than 3.0
West Coast sites (compared to expected diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of expected mean diversity for a specific salinity	Benthic index score is between 75% and 90% of the lower limit of expected mean diversity for a specific salinity	Less than 75% of observations had expected diversity
Puerto Rico sites (compared to upper 95% confidence interval for mean regional benthic diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of mean diversity in unstressed habitats in Puerto Rico	Benthic index score is between 75% and 90% of the lower limit of mean diversity in unstressed habitats in Puerto Rico	Benthic index score is less than 75% of the lower limit of mean diversity for unstressed habitats in Puerto Rico
NEP Estuary or Region	Less than 10% of the NEP estuarine area has a poor benthic index score, and more than 50% of the NEP estuarine area has a good index score	10% to 20% of the NEP estuarine area has a poor benthic index score, or more than 50% of the NEP estuarine area has a combined fair and poor benthic index score	More than 20% of the NEP estuarine area has a poor benthic index score

* By design, these indices discriminate between good and poor conditions only.

to remain in the animal's tissues and may build up with subsequent feedings. When fish consume contaminated organisms, they may "inherit" the levels of contaminants in the organisms they consume. This same inheritance of contaminants occurs when humans consume fish with contaminated tissues. Contaminant residues can be examined in the fillets, whole-body portions, or specific organs of target fish and shellfish species and are compared with risk-based EPA Advisory Guidance criteria for fish contaminants (U.S. EPA, 2000b).

For the NCA surveys, target fish were collected from all stations where fish were available, and whole-body contaminant burdens were determined. No EPA Advisory Guidance criteria exist to assess the ecological risk of whole-body contaminants for fish, but EPA Advisory Guidance (U.S. EPA, 200b) can be used as a basis for estimating advisory determinations, even if the data are based on whole-fish or organ-specific body burdens (Table 1-21). The whole-fish contaminant information collected by the NCA for U.S. NEP estuaries was compared with risk-based thresholds based on the consumption of four 8-ounce meals per month for selected contaminants (approach used by many state advisory programs) and assessed for non-cancer and cancer health endpoints (U.S. EPA, 2000b). Table 1-22 shows the rating criteria for the fish tissue contaminants index for each site, and Table 1-23 shows how these data were used to create ratings for the NEP estuaries and the regions.

Table 1-21. Risk-based EPA Advisory Guidelines for Recreational Fishers (U.S. EPA, 2000b)

Contaminant	Concentration Range[a] (mg/L)	Health Endpoint
Arsenic (inorganic)[b]	3.5–7.0	non-cancer
Cadmium	0.35–0.70	non-cancer
Mercury	0.12–0.23	non-cancer
Selenium	5.9–12.0	non-cancer
Chlordane	0.59–1.2	non-cancer
DDT (total)	0.059–0.12	non-cancer
Dieldrin	0.059–0.12	non-cancer
Endosulfan	7.0–14.0	non-cancer
Endrin	0.35–0.70	non-cancer
Heptachlor epoxide	0.015–0.031	non-cancer
Hexachlorobenzene	0.94–1.9	non-cancer
Lindane	0.35–0.70	non-cancer
Mirex	0.23–0.47	non-cancer
Toxaphene	0.29–0.59	non-cancer
PAH (Benzo[a]pyrene)	0.0016–0.0032	cancer[c]
PCB (total)	0.023–0.047	non-cancer

[a] Range of concentrations associated with non-cancer and cancer health endpoint risk for consumption of four 8-ounce meals per month
[b] Inorganic arsenic estimated as 2% of total arsenic
[c] A non-cancer concentration range for PAHs does not exist

Table 1-22. Criteria for Determining the Fish Tissue Contaminants Index by Monitoring Station

Rating	Criteria
Good	For all chemical contaminants listed in Table 1-21, the measured concentrations fall below the range of the EPA Advisory Guidance* criteria for risk-based consumption associated with four 8-ounce meals per month.
Fair	For at least one chemical contaminant listed in Table 1-21, the measured concentration falls within the range of the EPA Advisory Guidance criteria for risk-based consumption associated with four 8-ounce meals per month.
Poor	For at least one chemical contaminant listed in Table 1-21, the measured concentration exceeds the maximum value in the range of the EPA Advisory Guidance criteria for risk-based consumption associated with four 8-ounce meals per month.

*The EPA Advisory Guidance concentration is based on the non-cancer ranges for all contaminants except PAH (benzo(a)pyrene), which are based on a cancer range because a non-cancer range for PAHs does not exist (see Table 1-21).

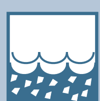
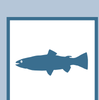
Table 1-23. Criteria for Determining the Fish Tissue Contaminants Index by NEP Estuary or Region

Rating	Criteria
Good	Less than 10% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition, and more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in good condition.
Fair	10% to 20% of the fish samples analyzed (Northeast Coast region) or monitoring stations where fish were caught (all other regions) are in poor condition, or more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in combined poor and fair condition.
Poor	More than 20% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition.

Summary of NCA Rating Criteria

The rating criteria for the NCA survey data used in this report are summarized in Table 1-24 (primary indices) and Tables 1-25 and 1-26 (component indicators).

Table 1-24. NCA Indices Used to Assess Estuarine Condition

Icon	Index	Rating	Ecological Condition by Site	Ranking by NEP Estuary or Region
 Water Quality Index	**Water Quality Index**—This index is based on five water quality component indicators (DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen).	**Good:**	No component indicators are rated poor, and a maximum of one component indicator is rated fair.	Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
		Fair:	One component indicator is rated poor, or two or more component indicators are rated fair.	10% to 20% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
		Poor:	Two or more component indicators are rated poor.	More than 20% of the NEP estuarine area is in poor condition.
 Sediment Quality Index	**Sediment Quality Index**—This index is based on three sediment quality component indicators (sediment toxicity, sediment contaminants, and sediment TOC).	**Good:**	No component indicators are rated poor, and the sediment contaminants indicator is rated good.	Less than 5% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
		Fair:	No component indicators are rated poor, and the sediment contaminants indicator is rated fair.	5% to 15% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
		Poor:	One or more component indicators are rated poor.	More than 15% of the NEP estuarine area is in poor condition.
 Benthic Index	**Benthic Index** (or a surrogate measure)—This index indicates the condition of the benthic community (organisms living in estuarine sediments) and can include measures of benthic community diversity, the presence and abundance of pollution-tolerant species, and the presence and abundance of pollution-sensitive species.	**Good:**	**Good**, **fair**, and **poor** were determined using regionally dependent benthic index scores.	Less than 10% of the NEP estuarine area has a poor benthic index score, and more than 50% of the NEP estuarine area has a good benthic index score.
		Fair:		10% to 20% of the NEP estuarine area has a poor benthic index score, or more than 50% of the NEP estuarine area has a combined poor and fair benthic index score.
		Poor:		More than 20% of the NEP estuarine area has a poor benthic index score.
 Fish Tissue Contaminants Index	**Fish Tissue Contaminants Index**—This index indicates the level of chemical contamination in target fish/shellfish species.	**Good:**	For all chemical contaminants listed in Table 1-21, composite fish tissue contaminant concentrations are below the EPA Advisory Guidance* concentration range.	Less than 10% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition, and more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in good condition.
		Fair:	For at least one chemical contaminant listed in Table 1-21, composite fish tissue contaminant concentrations are within the EPA Advisory Guidance concentration range.	10% to 20% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition, or more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in combined poor and fair condition.
		Poor:	For at least one chemical contaminant listed in Table 1-21, composite fish tissue contaminant concentrations are above the EPA Advisory Guidance concentration range.	More than 20% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition.

*The EPA Advisory Guidance concentration is based on the non-cancer ranges for all contaminants except PAH (benzo(a)pyrene), which are based on a cancer range because a non-cancer range for PAHs does not exist (see Table 1-21).

Table 1-25. NCA Criteria for the Five Component Indicators Used in the Water Quality Index to Assess NEP Estuarine Condition

Dissolved Inorganic Nitrogen (DIN)

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: Surface concentrations are less than 0.1 mg/L (NE, SE, Gulf), 0.5 mg/L (West), or 0.05 mg/L (tropical)*.	**Good:** Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair: Surface concentrations are 0.1–0.5 mg/L (NE, SE, Gulf), 0.5–1.0 mg/L (West), or 0.05–0.1 mg/L (tropical).	**Fair:** 10% to 25% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor: Surface concentrations are greater than 0.5 mg/L (NE, SE, Gulf), 1.0 mg/L (West), or 0.1 mg/L (tropical).	**Poor:** More than 25% of the NEP estuarine area is in poor condition.

Dissolved Inorganic Phosphorus (DIP)

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: Surface concentrations are less than 0.01 mg/L (NE, SE, Gulf), 0.01 mg/L (West), or 0.005 mg/L (tropical).	**Good:** Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair: Surface concentrations are 0.01–0.05 mg/L (NE, SE, Gulf), 0.01–0.1 mg/L (West), or 0.005–0.01 mg/L (tropical).	**Fair:** 10% to 25% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor: Surface concentrations are greater than 0.05 mg/L (NE, SE, Gulf), 0.1 mg/L (West), or 0.01 mg/L (tropical).	**Poor:** More than 25% of the NEP estuarine area is in poor condition.

Chlorophyll *a*

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: Surface concentrations are less than 5 µg/L (less than 0.5 µg/L for tropical ecosystems).	**Good:** Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair: Surface concentrations are between 5 µg/L and 20 µg/L (between 0.5 µg/L and 1 µg/L for tropical ecosystems).	**Fair:** 10% to 20% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor: Surface concentrations are greater than 20 µg/L (greater than 1 µg/L for tropical ecosystems).	**Poor:** More than 20% of the NEP estuarine area is in poor condition.

Water Clarity

Note: A water clarity index (WCI) is calculated by dividing observed clarity at 1 meter by a regional reference clarity at 1 meter. This regional reference is 10% for most of the United States, 5% for areas with naturally high turbidity, and 20% for areas with significant SAV beds or active SAV restoration programs.

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: WCI ratio is greater than 2.	**Good:** Less than 10% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair: WCI ratio is between 1 and 2.	**Fair:** 10% to 25% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor: WCI ratio is less than 1.	**Poor:** More than 25% of the NEP estuarine area is in poor condition.

*Tropical ecosystems in this NEP CCR include San Juan Bay Estuary, Puerto Rico.

Table 1-25. NCA Criteria for the Five Component Indicators Used in the Water Quality Index to Assess NEP Estuarine Condition (continued)

Dissolved Oxygen

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: Concentrations are greater than 5 mg/L.	**Good:** Less than 5% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition.
Fair: Concentrations are between 2 mg/L and 5 mg/L.	**Fair:** 5% to 15% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition.
Poor: Concentrations are less than 2 mg/L.	**Poor:** More than 15% of the NEP estuarine area is in poor condition.

Table 1-26. NCA Criteria for Measurements for the Three Component Indicators Used in the Sediment Quality Index to Assess NEP Estuarine Condition

Sediment Toxicity is evaluated as part of the sediment quality index using a 10-day static toxicity test with the amphipod *Ampelisca abdita*.

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: Mortality* is less than or equal to 20%.	**Good:** Less than 5% of the NEP estuarine area is in poor condition.
Poor: Mortality is greater than 20%.	**Poor:** 5% or more of the NEP estuarine area is in poor condition.

Sediment Contamination is evaluated as part of the sediment quality index using ERM and ERL guidelines.

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: No ERM values are exceeded, and fewer than five ERL values are exceeded.	**Good:** Less than 5% of the NEP estuarine area is in poor condition.
Fair: No ERM values are exceeded, and five or more ERL values are exceeded.	**Fair:** 5% to 15% of the NEP estuarine area is in poor condition.
Poor: One or more ERM values are exceeded.	**Poor:** More than 15% of the NEP estuarine area is in poor condition.

Sediment Total Organic Carbon (TOC) is measured as part of the sediment quality index.

Ecological Condition by Site	Ranking by NEP Estuary or Region
Good: The TOC concentration is less than 2%.	**Good:** Less than 20% of the NEP estuarine area is in poor condition.
Fair: The TOC concentration is between 2% and 5%.	**Fair:** 20% to 30% of the NEP estuarine area is in poor condition.
Poor: The TOC concentration is greater than 5%.	**Poor:** More than 30% of the NEP estuarine area is in poor condition.

*Test mortality is adjusted for control mortality.

How the NCA Indices Are Summarized

Overall condition for each region was calculated by summing the scores for the available regional indices and dividing by the number of available indices (i.e., equally weighted), where good = 5; fair = 4, 3, or 2 (based on position in percent range); and poor = 1.

The Southeast Coast, for example, received the following scores:

Index	Score
Water Quality Index	5
Sediment Quality Index	4
Benthic Index	3
Fish Tissue Contaminants Index	4
Total Score	**16**
Overall Condition	**16/4 = 4.0**

The national index scores and the overall condition score are calculated based on a weighted average of the regional scores for each index. The national ratings are assigned to each index score and overall condition score based on these regional scores, rather than on the percentage of area in good, fair, or poor condition. The indices were weighted based on the NEP estuarine area contributed by each geographic area, not the total estuarine area contributed by each region. For example, the weighted average for the water quality index was calculated by summing the products of the regional water quality index scores and the area contributed by the NEPs in each region (Figure 1-8). These weighting factors were used for all indices. The national overall condition score was then calculated by summing each national index score and dividing by four.

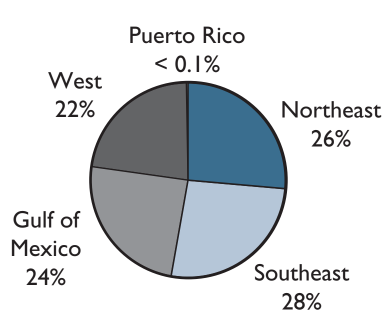


Figure 1-8. Percentage of NEP estuarine area contributed by each geographic region assessed in this report.

The NCA and the individual NEPs have the same goal of measuring estuarine condition, but these programs often use different monitoring methods and analysis procedures. Even when the indices used by these two programs seem to measure the same parameter, they may not be directly comparable because of differences in the methodology, time and spatial scales, and seasonality of the monitoring design. For instance, although the NCA may monitor chlorophyll *a* in an estuary over the course of a single week during the summer at randomly selected sites, an individual NEP may collect chlorophyll *a* samples every day, all year, but target the sampling to sites where nutrient inputs are anticipated to be high. Both types of information are important for learning about estuarine condition, but the information cannot be directly compared due to differences in methodology, time and spatial scales, and seasonality.

National Estuary Program (NEP) Monitoring Data

To measure the effectiveness of their CCMPs, each of the 28 individual NEPs develops a strategy for collecting and analyzing environmental monitoring data. Each program is also expected to develop indicators for measuring the change in estuarine conditions over time. In this report, indicator data have been collected from the individual NEPs to provide a specific picture of the conditions in each NEP estuary. Some of the more commonly assessed water quality indicators among the NEPs are nitrogen, chlorophyll *a*, and dissolved oxygen concentrations. Many NEPs are also concerned about habitat loss and have used a variety of methods, such as satellite imagery, geographic information systems (GIS) mapping, and aerial surveys, to track the changes in habitat coverage over time. Because the NEPs are able to choose the types of monitoring data and analytical methods that best fit their estuary's particular environmental conditions and concerns, the resulting data includes a variety of different measurements that are not readily comparable among the estuaries. This report takes advantage of region- and site-specific information from the individual NEPs to present a description of the condition of each NEP estuary, which is supplemented by the nationally consistent data provided by the NCA.