This document contains the Front Matter, Executive Summary, Chapter 1: Introduction and Chapter 2: National Discussion of the National Estuary Program National Coastal Condition Report. The entire report can be downloaded from ***http://www.epa.gov/owow/oceans/nepccr/index.html***

National Estuary Program Coastal Condition Report

Front Matter, Executive Summary and Introduction and National Chapter

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National Estuary Program Coastal Condition Report

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Appendix A

Acronyms

ADEM	Alabama Department of Environmental Management
AET	Apparent Effects Threshold
ALAMAP	Alabama Monitoring and Assessment Program
AMRAT	Alabama-Mississippi Rapid Assessment Team
APNEP	Albemarle-Pamlico National Estuary Program
BB NEP	Buzzards Bay National Estuary Program
BBNEP	Barnegat Bay National Estuary Program
BMP	best management practice
BOD	biological oxygen demand
BTNEP	Barataria-Terrebonne National Estuary Program
BYPP	Backyard Planting Program
CAFOs	confined animal feeding operations
CBB	Coalition for Buzzards Bay
CBBEP	Coastal Bend Bays and Estuaries Program
CBEP	Casco Bay Estuary Partnership
CCMP	Comprehensive Conservation and Management Plan
CCRWQCB	Central Coast Regional Water Quality Control Board
CDS	continuous deflective separation
CHNEP	Charlotte Harbor National Estuary Program
CIB	Center for the Inland Bays
CISNet	Coastal Intensive Sites Network
CLPS	Critical Lands Protection Strategy
CPF	Community Preservation Fund
CPUE	catch per unit effort
CRSSA	Center for Remote Sensing and Spatial Analysis
CSO	combined sewer overflow
CT DEP	Connecticut Department of Environmental Protection
CTR	California Toxic Rule
CZM	Coastal Zone Management
DDD	p,p'-dichlorodiphenyldichloroethane
DDE	p,p'-dichlorodiphenyldichloroethylene
DDT	p,p'-dichlorodiphenyltrichloroethane
DEP	Department of Environmental Protection
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorus
DMF	Division of Marine Fisheries
DNA	deoxyribonucleic acid

DNR	Department of Natural Resources
DNREC	Department of Natural Resources and Environmental Control
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DRBC	Delaware River Basin Commission
DSHS	Department of State Health Services
DWQ	Division of Water Quality
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
EQB	Environmental Quality Board
ERDG	Ecological Research & Development Group
ERL	effects range low
ERM	effects range median
FDA	U.S. Food and Drug Administration
FDEP	Florida Department of Environmental Protection
FIPS	Federal Information Processing Standards
FWS	U.S. Fish and Wildlife Service
FYN	Florida Yards and Neighborhoods
GAO	U.S. Government Accountability Office
GBEP	Galveston Bay Estuary Program
GCRL	Gulf Coast Research Laboratory
GIS	geographic information systems
GLO	General Land Office
GPS	Global Positioning System
HAB	harmful algal bloom
HCDOP	Hood Canal Dissolved Oxygen Program
HEP	Harbor Estuary Program
HRI	Habitat Restoration Initiative
IEC	Interstate Environmental Commission
IEP	Interagency Ecological Project
IRLNEP	Indian River Lagoon National Estuary Program
kg/yr	kilograms per year
LCREP	Lower Columbia River Estuary Partnership
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
LIDAR	LIght Detection And Ranging
LISS	Long Island Sound Study
LTEIP	Long-Term Environmental Indicator Program

MAC	Manatee Awareness Coalition
MAIA	Mid-Atlantic Integrated Assessment
MAR	multiple antibiotic resistance
Massachusetts CZM	Massachusetts Office of Coastal Zone Management
MassWildlife	Massachusetts Division of Fisheries and Wildlife
MBP	Massachusetts Bays Program
MCBP	Maryland Coastal Bays Program
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
MDPH	Massachusetts Department of Public Health
MFRMR	Maritime Forest Ridge and Marsh Restoration
mg/kg	milligram per kilogram
mg/L	milligram per liter
mi^2	square miles
mL	milliliter
Mobile Bay NEP	Mobile Bay National Estuary Program
Morro Bay NEP	Morro Bay National Estuary Program
MWRA	Massachusetts Water Resources Authority
NASA	National Aeronautics and Space Administration
NBEP	Narragansett Bay Estuary Program
NCA	National Coastal Assessment
NCCR I	National Coastal Condition Report
NCCR II	National Coastal Condition Report II
NCDENR	North Carolina Department of Environment and Natural Resources
NCDOT	North Carolina Department of Transportation
NEP	National Estuary Program
NEP CCR	National Estuary Program Coastal Condition Report
NERR	National Estuarine Research Reserve
NFWF	National Fish and Wildlife Foundation
NHCP	New Hampshire Coastal Program
NHEP	New Hampshire Estuaries Project
NJDEP	New Jersey Department of Environmental Protection
NJHDG	New Jersey Harbor Discharges Group
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NRCS	U.S. Natural Resource Conservation Service

NRDA	Natural Resource Damage Assessment
NS&T	National Status and Trends
NWI	National Wetland Inventory
NYCDEP	New York City Department of Environmental Protection
NYC DOHMH	New York City Department of Health and Mental Hygiene
NYSDEC	New York State Department of Environmental Conservation
ODEQ	Oregon Department of Environmental Quality
OEHHA	California Office of Environmental Health Hazard Assessment
ORD	Office of Research and Development
OWOW	Office of Wetlands, Oceans and Watersheds
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDE	Partnership for the Delaware Estuary
PEP	Peconic Estuary Program
PIVOT	Performance Indicators Visualization and Outreach Tool
POTWs	publicly owned treatment works
ppm	parts per million
ppt	parts per thousand
PSAT	Puget Sound Action Team
PVSC	Passaic Valley Sewerage Commissioners
RAM	Rapid Assessment Method
RIDEM	Rhode Island Department of Environmental Management
RMP	Regional Monitoring Program for Trace Substances
SAV	submerged aquatic vegetation
SBEP	Sarasota Bay Estuary Program
SCCWRP	Southern California Coastal Water Research Project
SCDHS	Suffolk County Department of Health Services
SCWRRP	Southern California Water Resources Research Project
SET	surface elevation table
SFEI	San Francisco Estuary Institute
SFEP	San Francisco Estuary Project
SFRWQCB	San Francisco Regional Water Quality Control Board
SFWMD	South Florida Water Management District
SJBEP	San Juan Bay Estuary Partnership
SJRWMD	St. Johns River Water Management District
SMBRC	Santa Monica Bay Restoration Commission
SMBRP	Santa Monica Bay Restoration Project
SPMD	semipermeable membrane device

STAC	Scientific and Technical Advisory Committee
STOP	Stop Throwing Out Pollutants Program
STP	sewage treatment plant
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management
TAC	Technical Advisory Committee
TAT	Tributary Action Team
TBBI	Tampa Bay Benthic Index
TBEP	Tampa Bay Estuary Program
TBI	The Bay Institute
TBT	tributyltin
TCEQ	Texas Commission on Environmental Quality
TEP	Tillamook Estuaries Partnership
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TPWD	Texas Parks and Wildlife Department
ug/kg	microgram per kilogram
ug/L	microgram per liter
uM	micromolar
UNH	University of New Hampshire
URI	University of Rhode Island
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VIMS	Virginia Institute of Marine Studies
VMP	Volunteer Monitoring Program
VOC	volatile organic compound
WCI	Water Clarity Index
WDNR	Washington Department of Natural Resources
WDOH	Washington Department of Health
WHAT	Wetland Health Assessment Toolbox
WQI	Water Quality Index
WRP	Wetlands Restoration Program
WSDE	Washington State Department of Ecology
WWTP	wastewater treatment plant

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Estuaries are bodies of water that provide transition zones between the fresh water from rivers and the saline environment of the ocean. The various interactions that occur between fresh water and salt water in estuaries result from the specific physical and hydrological characteristics of these waterbodies. These characteristics produce unique environments that support wildlife and fisheries and contribute substantially to the economy of the United States.

The nation's estuaries are a subset of U.S. coastal waters and encompass a wide variety of coastal habitats, including wetlands, salt marshes, coral reefs, mangrove and kelp forests, seagrass meadows, tidal mudflats, and upwelling areas. These estuarine habitats provide spawning grounds, nurseries, shelter, and food for fish, shellfish, and other wildlife species, as well as nesting, resting, feeding, and breeding habitat for 75% of waterfowl and other migratory birds.

As part of the 1987 amendments to the Clean Water Act, the Section 320 National Estuary Program (NEP) promotes comprehensive planning efforts to help protect nationally significant estuaries in the United States that are deemed to be threatened by pollution, development, or overuse. Since the inception of the program, 28 estuaries have been nominated by their respective state Governors and officially designated as NEP estuaries, and in 2007, the NEP will celebrate 20 years of restoring and protecting these nationally significant estuaries. As one of the U.S. Environmental Protection Agency's (EPA's) most successful watershed programs, the NEP demonstrates the effectiveness of a stakeholder-driven, collaborative process to address water quality problems and to target habitat restoration.

Individual NEPs are required to monitor the effectiveness of their management activities to address estuary-specific priority actions. The Clean Water Act also requires that EPA report periodically on the condition of the nation's estuarine waters. Coastal states provide EPA with valuable information about the condition of their estuarine resources; however, because the individual states and the NEPs and their partners use different approaches for data collection and the evaluation of estuarine condition, it has been difficult to compare this information among states, NEPs, or on a regional or national basis.

To better address questions about the condition of the nation's estuaries, EPA, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the U.S. Department of the Interior (DOI), and the U.S. Department of Agriculture (USDA) agreed to participate in a multi-agency effort to assess the condition of all U.S. estuaries, including the NEP estuaries. To minimize the problems created by compiling data collected using different sampling methods, the collaborating agencies chose to assess estuarine condition using nationally consistent monitoring surveys, the results of which are compiled periodically into a series of reports called the *National Coastal Condition Reports*.

Published in 2001, the first *National Coastal Condition Report* (NCCR I) reported that the nation's collective estuarine resources were in fair condition. This assessment was based on available data, collected from 1990 through 1996, that were used to characterize about 70% of the nation's estuarine resources. Agencies contributing data to the NCCR I included EPA, NOAA, DOI, and USDA. The second *National Coastal Condition Report* (NCCR II), published in 2004, was based on available data from 1997 to 2000 that were representative of 100% of the estuarine area of the conterminous 48 states and Puerto Rico. These data show that the nation's estuaries continue to be rated in fair condition. Agencies contributing to the NCCR II included EPA, NOAA, the U.S. Fish and Wildlife Service (FWS), and USGS, as well as several state, regional, and local organizations that provided information on the current condition of the nation's coastal waters.

The objective of this *National Estuary Program Coastal Condition Report* (NEP CCR) is to report on the condition of the nation's 28 NEP estuaries. The NEP CCR presents two major types of monitoring data for each NEP estuary: (1) data collected as part of EPA's National Coastal Assessment (NCA) and (2) data collected by the individual NEPs or by the NEPs in partnership with interested stakeholders, including state environmental agencies, universities, or volunteer monitoring groups. Together, these data paint a picture of the overall condition of the coastal resources of the nation's NEP estuaries.

The ratings developed in this report are based solely on NCA monitoring data and not the data collected by the individual NEPs. The NCA data—the most comprehensive and nationally consistent data available related to estuarine condition—were collected from 1997 through 2003 for four primary indices of estuarine condition (water quality index, sediment quality index, benthic index, and fish tissue contaminants index). These indices were assigned a good, fair, or poor rating for each NEP estuary according to the rating criteria presented in Table ES-1. These ratings were then used to create overall condition ratings for the collective NEP estuaries of each coastal region (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, and Puerto Rico) and the nation (Figure ES-1). The overall condition rating for the nation's collective NEP estuaries is based on a weighted average of the regional index scores. More detailed information on the component indicators for water quality and sediment quality, when available, is also presented throughout this report.

In addition to the NCA-based assessments, this report provides individual profiles of the 28 NEP estuaries that describe the indicators each NEP uses to address specific environmental concerns, including water and sediment quality, habitat quality, living resources, and environmental stressors, as appropriate. Each profile includes background information on the NEP estuary discussed, maps of the NEP study area, and data on the population pressures that affect the study area, including the total population (2000), population density (2000), and population growth rate (1960–2000) in NOAA-designated coastal counties that are within or transect the boundaries of the study area (i.e., NEP-coincident coastal counties). A short discussion of an individual NEP's current projects, accomplishments, and future goals is also provided in each profile, as well as a Highlight article, developed by the individual NEP, that describes a representative species, program, or activity for the NEP. These profiles are not meant to be exhaustive or comprehensive reports, but are included to provide the reader with a perspective about the variety of habitats and species that each NEP estuary shelters, the salient or unique aspects about the nature of the estuary, the problems of most concern to local stakeholders, and the ongoing and planned initiatives to continue monitoring and managing the environmental health of the estuary. The monitoring data derived from the NEPs will be used to develop an effective management plan for protecting and improving the condition of the nation's NEP resources.

Estuaries are critical for the survival of a number of species, including the Brown Pelican, which nests and breeds along the nation's coasts (John Theilgard).

Describing Estuarine Condition

This report presents two types of monitoring data to provide a perspective on the condition of the nation's NEP estuaries: data collected by the NCA and data collected by the individual NEPs and their partners.

National Coastal Assessment (NCA) Monitoring Data

The monitoring data derived from EPA's NCA are used exclusively in this report to develop indices of estuarine condition for the 28 NEP estuaries and to calculate regional and national ratings of NEP estuarine condition. The NCA survey was designed to assess the percentage of the nation's estuaries and coastal waters exhibiting poor, fair, or good condition using consistent and comparable environmental indicators, and data from this survey was used for the NCCR series, which includes this NEP CCR. The probability survey design, indices, and component indicators of the NCA survey are appropriate to assess estuarine condition at state, regional (e.g., Gulf Coast), or national scales. When probability survey designs incorporate geographic areas smaller than a state, as in the case of the NEPs, assessments can be made of the condition of each strata, provided a sufficient number of samples were taken to achieve the desired confidence level.

The NCA sampled a minimum of 20 (typically 35–50) monitoring sites to assess the condition of each NEP estuary. Twelve hundred and thirty-nine NCA sites were sampled in the NEP estuarine areas. In addition, the NCA was designed to assess condition during the summer season, when estuaries are expected to be the most stressed (i.e., highest water temperature). These data are also used to determine reference conditions to assess ecological responses to stressors and to set state criteria and standards.

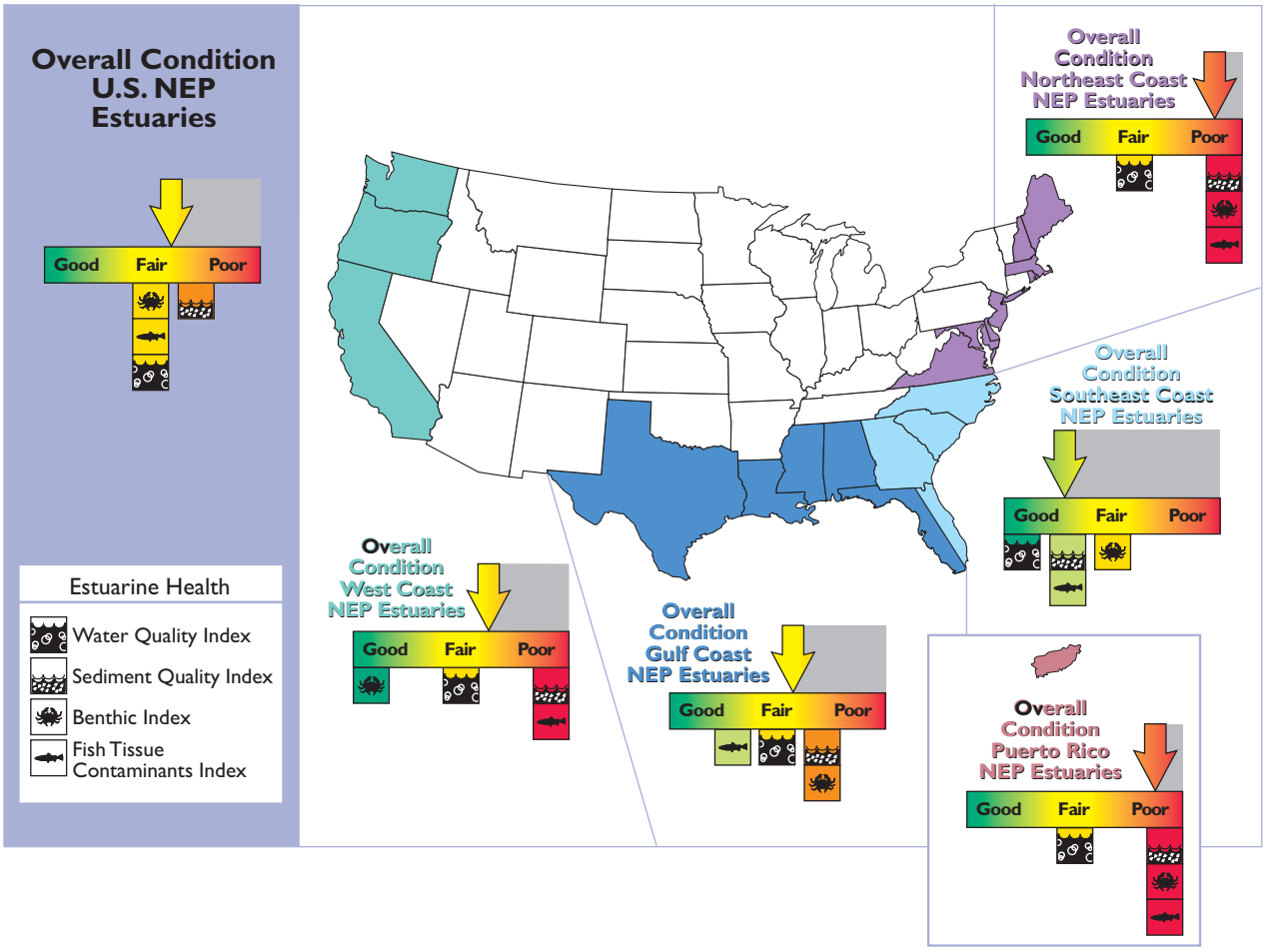

Figure ES-1. National and regional overall condition ratings for NEP estuaries based on NCA results (1997–2003).

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

Icon		
 Water Quality Index	**Water Quality Index**—This index is based on five water quality component indicators (dissolved inorganic nitrogen [DIN], dissolved inorganic phosphorus [DIP], chlorophyll *a*, water clarity, and dissolved oxygen).	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good: No component indicators are rated poor, and a maximum of one component indicator is rated fair.	**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: One component indicator is rated poor, or two or more component indicators are rated fair.	**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.	**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 total organic carbon [TOC]).	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good: No component indicators are rated poor, and the sediment contaminants indicator is rated good.	**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.	**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.	**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.	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good, **fair**, and **poor** were determined using regionally dependent benthic index scores.	**Good:** 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.	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good: For all chemical contaminants listed in Table 1-21 (Chapter 1), composite fish tissue contaminant concentrations are below the EPA Advisory Guidance* concentration range.	**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: For at least one chemical contaminant listed in Table 1-21, composite fish tissue contaminant concentrations are within the EPA Advisory Guidance concentration range.	**Fair:** 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.	**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.

*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, Chapter 1).

Given the parameters of the NCA methodology, the NEP CCR is not designed to assess the temporal variability or extent (i.e., how often within a summer these conditions exist or the area affected) of highly variable water quality parameters (e.g., nutrient, chlorophyll *a*, or dissolved oxygen concentrations). In addition, the report does not provide the specific location of poor, fair, or good conditions, but rather the proportion of a larger area that exhibits such conditions, nor does it answer local estuary-specific management questions regarding the location, temporal extent, or frequency of degraded conditions for rapidly changing parameters.

This report is appropriate for defining the percentage of the nation's NEP waters (nationally, regionally, and on an individual estuary basis) that exhibit poor, fair, or good conditions for fairly stable summer characteristics, such as sediment contaminant levels and benthic condition, which often reflect conditions integrated over months or even years. However, to maintain NCA monitoring at a reasonable cost, measurements were taken one time per sampling site during the summer over a modest number of sites; therefore, the resulting NCA survey data provide a less accurate view of the ephemeral conditions associated with an estuary's water column, where water quality conditions may change weekly, daily, or even hourly during a summer sampling period.

National Estuary Program (NEP) Monitoring Data

To assess the overall condition of each NEP estuary, the NCA data should be evaluated in addition to data collected locally by the NEPs over a longer time period and at more sampling locations. For example, degraded benthic condition may not necessarily be caused solely by the high sediment contaminant levels measured by the NCA, but may also be caused by short-term stresses, such as sporadic hypoxia or algal blooms. The NCA "snapshot" approach may not capture these stresses because they occur outside the summer diurnal sampling period; therefore, an assessment of NEP-specific data is necessary.

The NEP monitoring data are derived from the individual NEPs and are discussed in this report to provide information on NEP monitoring methods and indicators developed to address site-specific estuarine concerns. Because these data are collected using methods unique to each individual NEP, they generally cannot be used to make comparisons among estuaries at the regional or national level. A summary of the data is provided in the individual NEP profiles in the hope that information about the types of indicators that have been developed, implemented, and found to be effective in assessing spatial and temporal trends for one NEP estuary will also prove useful to other NEPs.

Boating, fishing, swimming, and bird watching are just a few of the numerous recreational activities that people enjoy in estuaries (Toni Droscher, PSAT).

To find out if there is an NEP in your coastal area and to obtain detailed environmental monitoring data for the 28 NEP estuaries, please visit www.epa.gov/owow/estuaries, www.nationalestuaries.org, or www.epa.gov/emap.

Summary of Findings

With this NEP CCR, the collaborating agencies and the individual NEPs strive to provide a benchmark of estuarine condition that paints a comprehensive picture of the nation's NEP estuaries. The report indices are based on the large amount of NCA monitoring data collected from 1997 through 2003 on the condition of the nation's NEP estuaries. NCA rating scores for estuarine condition are based on a 5-point system, where a score of less than 2.0 is rated poor; 2.0 to less than 2.3 is rated fair to poor; 2.3 to 3.7 is rated fair; greater than 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

The major findings of this report are as follows:

- An assessment of the ecological monitoring data shows that the overall condition of the nation's NEP estuaries is generally fair (2.7), but that regionally, the Puerto Rico (1.5) and Northeast Coast (1.5) regions are rated poor, the Gulf Coast (2.75) and West Coast (2.5) regions are rated fair, and the Southeast Coast region is rated good to fair (4.0) for overall condition (Table ES-2). The overall condition ratings for the nation's NEP estuaries are based on four primary indices of estuarine condition—a water quality index, sediment quality index, benthic index, and fish tissue contaminants index.
- The **water quality index** for the nation's collective NEP estuaries is rated fair (3.6), with the Northeast Coast (3.0), Gulf Coast (3.0), West Coast (3.0), and Puerto Rico (3.0) regions rated fair and the Southeast Coast region (5.0) rated good for this index. Water quality data, including data on the five component indicators (DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen), were available for all NEP estuaries of the United States.
- The **sediment quality index** for the nation's collective NEP estuaries is rated fair to poor (2.1), with the Northeast Coast (1.0), West Coast (1.0), and Puerto Rico (1.0) regions rated poor; the Gulf Coast region (2.0) rated fair to poor; and the Southeast Coast region (4.0) rated good to fair for this index. Sediment quality index ratings were based on three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. For some NEPs, two of the three component indicators for assessing sediment quality were not monitored, and the sediment quality index was based solely on the measurement of one component indicator. Typically, sediment TOC

Table ES-2. Regional and National Rating Scores[a] for Indices of Estuarine Condition and Overall Condition for the Nation's NEP Estuaries

Index	Northeast Coast	Southeast Coast	Gulf Coast[b]	West Coast	Puerto Rico[c]	United States[d]
Water Quality Index	3	5	3	3	3	3.6
Sediment Quality Index	1	4	2	1	1	2.1
Benthic Index	1	3	2	5	1	2.7
Fish Tissue Contaminants Index	1	4	4	1	1	2.6
Overall Condition	**1.5**	**4.0**	**2.75**	**2.5**	**1.5**	**2.7**

[a] Rating scores are based on a 5-point system, where a score of less than 2.0 is rated poor; 2.0 to less than 2.3 is rated fair to poor; 2.3 to 3.7 is rated fair; greater than 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

[b] This rating score does not include the impact of the hypoxic zone in offshore Gulf Coast waters.

[c] This rating score includes only San Juan Bay Estuary, Puerto Rico.

[d] The U.S. score is based on an areally weighted mean of the regional index scores.

was more consistently monitored among sites than sediment toxicity or sediment contaminant concentrations. The NCA did not evaluate the Peconic Estuary for sediment quality, and only sediment TOC data were available for the four NEP estuaries located in Florida (Indian River Lagoon, Charlotte Harbor, Sarasota Bay, and Tampa Bay).

- The **benthic index** for the nation's collective NEP estuaries is rated fair (2.7), with the Northeast Coast (1.0) and Puerto Rico (1.0) regions rated poor, the Gulf Coast region (2.0) rated fair to poor, the Southeast Coast region (3.0) rated fair, and the West Coast region (5.0) rated good for this index. Benthic indices were developed for the NEP estuaries of the Northeast Coast, Southeast Coast, and Gulf Coast regions, and benthic community diversity was used as a surrogate indicator of biological condition for the West Coast and Puerto Rico regions. No assessment was possible using the benthic community diversity indicator for three West Coast estuaries (Lower Columbia River Estuary, Morro Bay, and Santa Monica Bay).
- The **fish tissue contaminants index** for the nation's collective NEP estuaries is rated fair (2.6), with the Northeast Coast (1.0), West Coast (1.0), and Puerto Rico (1.0) regions rated poor, and the Southeast Coast (4.0) and Gulf Coast (4.0) regions rated good to fair for this index. NCA data for the fish tissue contaminants index were not available for several of the NEP estuaries, including Casco Bay, the Indian River Lagoon, Charlotte Harbor, Sarasota Bay, and Tampa Bay.
- Nationally, 37% of the NEP estuaries are in poor overall condition (Table ES-3, Figure ES-2). Regionally, roughly 100% of Puerto Rico's NEP estuary (San Juan Bay Estuary) is in poor overall condition, and 46% of the Northeast Coast, 46% of the Gulf Coast, 36% of the West Coast, and 23% of the Southeast Coast NEP estuaries are in poor overall condition.

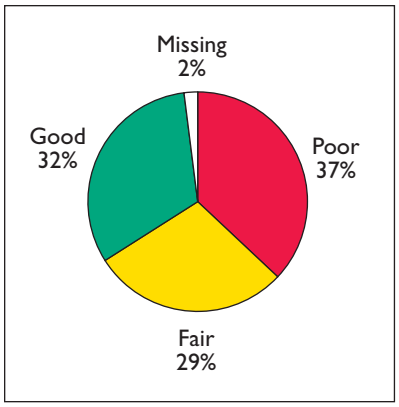

Figure ES-2. Overall condition data for U.S. NEP estuaries (U.S. EPA/NCA).

Comparison of NEP Estuaries with All U.S. Estuaries

A primary goal of the NCCR series is to provide a benchmark of estuarine condition to measure the success of estuarine programs over time. To achieve this goal, the conditions reported in the NCCR series and the NEP CCR need to be comparable. Comparing data between the NCCR II (inclusive of both NEP and non-NEP estuaries) and the NEP CCR is complicated because, in some cases, common indicators were not available for both reports. For example, the NCCR II used five environmental indices to determine coastal condition—water quality, sediment quality, benthic

Table ES-3. Percent of NEP Estuarine Area in Poor Condition by Index and Region

Index	Northeast Coast	Southeast Coast	Gulf Coast	West Coast	Puerto Rico	United States
Water Quality Index	9	4	13	4	8	8
Sediment Quality Index	21	6	15	17	33	15
Benthic Index	26	15	20	4	65	17
Fish Tissue Contaminants Index	38	10	12	32	40	23
Overall Condition	**46**	**23**	**46**	**36**	**100**	**37**

condition, fish tissue contaminant concentrations, and coastal habitat condition; however, information on coastal habitat condition was not available for the current NEP CCR. To facilitate a comparison between the two reports, the rating scores for the NCA indices reported in the NCCR II were recalculated, to the extent possible, using the methods followed in the NEP CCR. The coastal habitat index and its effect on regional and national ratings were excluded from the NCCR II scores presented in this report. Table ES-4 summarizes the rating scores by index and region, comparing the NCCR II and the NEP CCR results.

Table ES-4 shows that the overall condition score for the nation's collective NEP estuaries is 2.7 (rated fair) and that this score is slightly higher than the NCCR II score of 2.6 (rated fair) for overall condition for all U.S. estuaries (both NEP and non-NEP estuaries). On a national basis, it appears that the collective NEP estuaries score slightly higher for two of the four indices (water quality index and benthic index) than the scores for all U.S. estuaries, comparably for the fish tissue contaminants index, and slightly lower for the sediment quality index.

Regionally, the rating results are somewhat mixed when comparing NEP estuaries to all U.S. estuaries, although the regional overall condition scores are not appreciably different between the two groups (within 0.25 points or less of the corresponding score). For example, the regional overall condition scores for the NEP estuaries are higher for the Northeast Coast and West Coast regions, comparable for the Southeast Coast and Gulf Coast regions, and lower for Puerto Rico than the regional overall condition scores for all estuaries (both NEP and non-NEP).

It is noteworthy that the most complete data set collected in the NCA was for the water quality index, whereas data for the sediment quality index (predominately for the sediment toxicity and sediment contaminants component indicators), benthic index, and fish tissue contaminants index were missing for some NEPs. In addition, EPA's *Clean Water State Revolving Fund Programs 2005 Annual Report* noted that $53 billion in funding has been spent over the past 18 years to rebuild and upgrade wastewater treatment plants (WWTPs), resulting in expanded capacity for secondary and tertiary treatment of wastewater to remove nutrients, heavy metals, and organic contaminants. These strides, coupled with more stringent water quality standards for industrial dischargers, have resulted in water quality improvements in many areas; however, the legacy of contamination remains in the sediments of many estuaries as byproducts of the Industrial Revolution and years of discharging without the protective mandates of the Clean Water Act. This residual contamination may result in reduced benthic community health and in the bioaccumulation of chemical contaminants in fish and shellfish tissues.

Table ES-4. Regional and National Rating Scores* by Index for All U.S. Estuaries (NCCR) and for NEP Estuaries

	Northeast Coast		Southeast Coast		Gulf Coast		West Coast		Puerto Rico		United States	
Index	**NCCR**	**NEP**	**NCCR**	**NEP**	**NCCR**	**NEP**	**NCCR**	**NEP**	**NCCR**	**NEP**	**NCCR**	**NEP**
Water Quality Index	2	3	4	5	3	3	3	3	3	3	3.0	3.6
Sediment Quality Index	1	1	4	4	3	2	2	1	1	1	2.6	2.1
Benthic Index	1	1	3	3	2	2	3	5	1	1	2.2	2.7
Fish Tissue Contaminants Index	1	1	5	4	3	4	1	1	NA	1	2.6	2.6
Overall Condition	1.25	1.50	4.0	4.0	2.75	2.75	2.25	2.50	1.67	1.50	2.6	2.7

* Rating scores are based on a 5-point system, where a score of less than 2.0 is rated poor; 2.0 to less than 2.3 is rated fair to poor; 2.3 to 3.7 is rated fair; greater than 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

Population Pressures Affecting the NEPs

Population pressures on coastal counties coincident with the individual NEP study areas or collectively on NEP-coincident coastal counties within a specific region were evaluated with respect to both temporal and spatial perspectives using total population (2000), population density (2000), and percent population growth rate (1960–2000). Total population provides a perspective of the total number of individuals using the various resources within the NEP-coincident coastal counties at any point in time, and population density provides a measure of how saturated the associated NEP-coincident coastal counties are with respect to human development. The population growth rate over a specific time interval provides an indication of how quickly human development in an area occurs and the coinciding infrastructure development that would be needed to provide for the associated residential and commercial development and services. When assessed collectively, these population measures provide information about the pressures exerted by society on the NEP coastal ecosystems.

Regionally, the NEP-coincident coastal counties of the Northeast Coast region contained the highest total population in 2000 (38 million), followed by the West Coast (30 million), Gulf Coast (11 million), and Southeast Coast (3 million) regions. Population density values also showed that the NEP-coincident coastal counties of the Northeast Coast region have the highest regional density (1,055 persons/mi^2), followed by the West Coast (421 persons/mi^2), Gulf Coast (287 persons/mi^2), and Southeast Coast (168 persons/mi^2) regions. By comparison, Puerto Rico had the highest population density in 2000 of any NEP region (5,055 persons/mi^2). In contrast, population growth rates for these same regional areas show a different pattern, with the Gulf Coast region having the highest growth rate (133%), closely followed by the Southeast Coast (131%) and West Coast (100%) regions, and lastly by the Northeast Coast (24%) region.

Estuarine waters serve as habitat and breeding areas for hundred of species of birds and other wildlife (John Theilgard).

Correlation Between NEP CCR Index Scores and Population Pressures

Population data reveal some patterns for both total population and population density with respect to population pressures within the NEP-coincident coastal counties. As shown in Table ES-5, when the population in the coastal counties is greater than 2 million people, as it is for 11 NEPs, the overall condition scores for these NEPs range from 1.0 (rated poor) to 3.0 (rated fair), with a mean score of 2.26 (rated fair to poor). For the 8 NEPs with populations between 1 to 2 million people, the overall condition scores range from 1.5 (rated poor) to 5.0 (rated good), with a mean score of 3.30 (rated fair). For the 9 NEPs with populations less than 1 million people, the overall condition scores range from 1.75 (rated poor) to 5.0 (rated good), with a mean score of 3.45 (rated fair). Although it is clear that the NEPs with the highest populations (> 2 million) showed the lowest overall condition scores, as well as scores with the smallest range of values, the overall condition scores for the other two population groups varied widely; however, the mean overall condition scores tended to be slightly higher in the NEPs with the lowest total population.

The population density results (Table ES-6) are very similar to the total population results. For the 5 NEPs with population densities greater than 1,000 persons/mi^2 in NEP-coincident coastal counties, the overall condition scores range from 1.0 (rated poor) to 4.33 (rated good), with a mean score of 2.16 (rated fair to poor). For the 8 NEPs with population densities ranging from 500 to 1,000 persons/mi^2, the overall condition scores range from 1.75 (rated poor) to 3.5 (rated fair), with a mean score of 2.58 (rated fair). Finally, for the 15 NEPs with the lowest population densities (less than 500 persons/mi^2), the overall condition scores range from 1.75 (rated poor) to 5.0 (rated good), with a mean score of 3.39 (rated fair). A slight difference among the three population density groups shows an increase in the mean overall condition scores as the population density decreases.

Although the mean overall condition scores based on total population and population density within the NEP-coincident coastal counties appear to exhibit some patterns, it should be noted that within any of the total population groups (Table ES-5) or population density groups (Table ES-6), there is a high degree of variability in the overall condition scores for the individual NEPs that can be inconsistent with the patterns exhibited in the mean overall condition scores.

Table ES-5. Comparison of Total Population of NEP-Coincident Coastal Counties with the NCA Mean Overall Condition Scores for the NEP Estuaries

Total Population of NEP-Coincident Coastal Counties	Range in NCA Overall Condition Scores Observed	NCA Mean Overall Condition Score	Number of NEP Estuaries
> 2 million	1.0–3.0	2.26	11
1–2 million	1.5–5.0	3.30	8
< 1 million	1.75–5.0	3.45	9

Table ES-6. Comparison of Population Density of NEP-Coincident Coastal Counties with the NCA Mean Overall Condition Scores for the NEP Estuaries

Population Density of NEP-Coincident Coastal Counties	Range in NCA Overall Condition Scores Observed	NCA Mean Overall Condition Score	Number of NEP Estuaries
> 1,000 persons/mi^2	1.0–4.33	2.16	5
500–1,000 persons/mi^2	1.75–3.5	2.58	8
< 500 persons/mi^2	1.75–5.0	3.39	15

NEP Environmental Concerns

The NEP estuaries have been affected by a wide variety of environmental concerns, several of which have been adopted by the NEPs as priority management activities for their respective estuaries. For this report, more that two dozen major environmental concerns were identified by the NEPs, including the following:

- Habitat loss/alteration
- Declines in fish and wildlife populations
- Excessive nutrients
- Toxic chemical contaminants
- Pathogens
- Alteration of freshwater flows
- Introduction of invasive species.

Some environmental concerns have commonality in many NEPs, whereas others are more NEP-specific because they relate to the unique climactic, hydrologic, geologic, or geomorphologic conditions associated with an individual estuary. Figure ES-3 shows a variety of environmental concerns identified by the 28 NEPs.

Shortcomings of Available Data

This NEP CCR provides estimates of estuarine condition on a national, regional, and individual scale for the 28 NEP estuaries. These estimates are based on nationally consistent and comparable NCA data on four primary indices of estuarine condition. For about one-third of the NEP estuaries, however, complete data on all four NCA indices were not available. As a result, an NEP estuary and its respective region may have received either a higher or a lower overall condition score and rating than would have been achieved if the missing data were available for use in the analysis of estuarine condition. This report makes the best use of the available NCA data to characterize and assess the condition of the nation's NEP estuaries; however, it cannot represent all individual NEP estuarine systems at all of the appropriate temporal and spatial scales necessary to assess the overall condition of the these estuaries.

In addition to the NCA data presented in this report, the individual NEPs have also been mandated the responsibility of monitoring environmental conditions in their individual estuaries to assess whether the

U.S. coastal areas are home to roughly 40% of the U.S. population (John Theilgard).

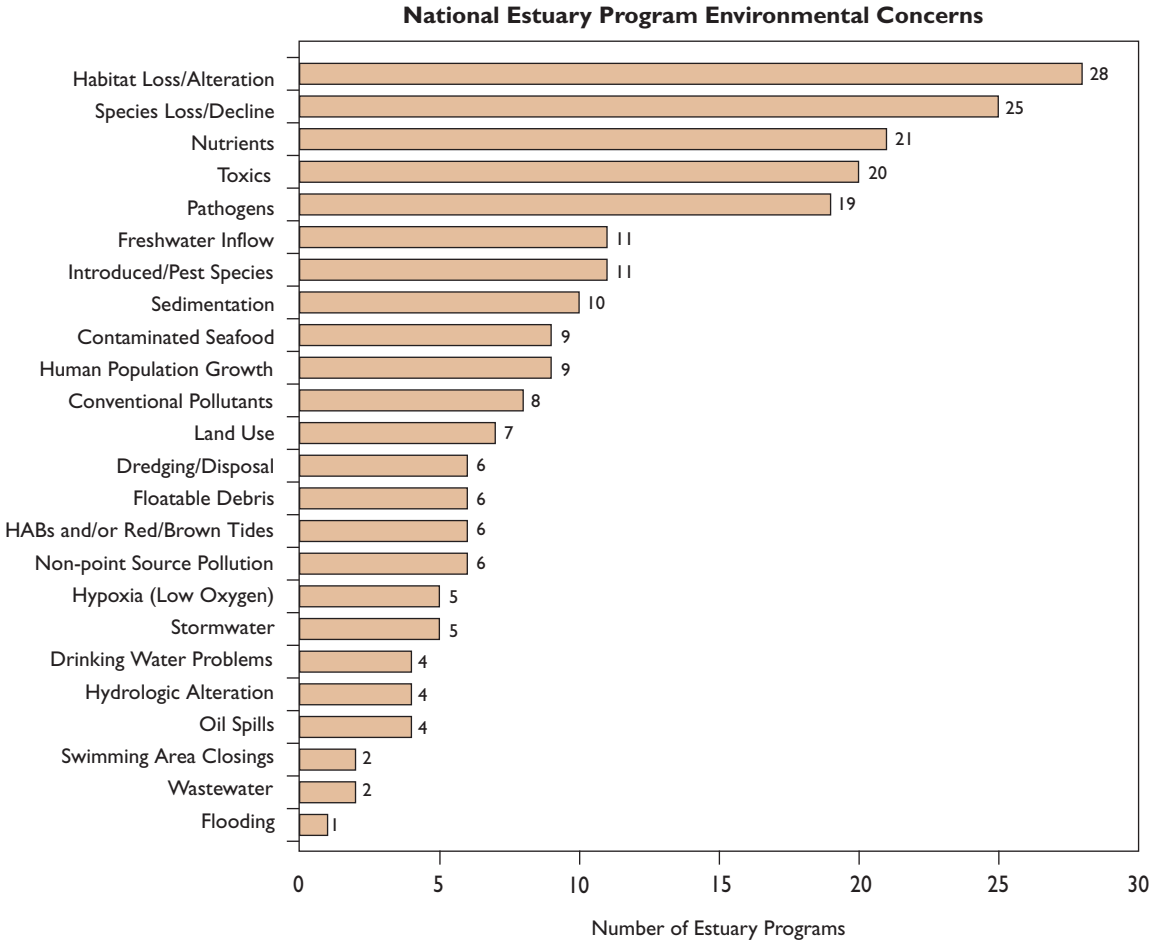

Figure ES-3. List of environmental concerns of the nation's 28 individual NEPs.

environmental health of the estuary is degrading and, if possible, to help restore ecological condition. Because each NEP estuary's suite of environmental concerns are site-specific, each state, NEP, and its stakeholders have often developed monitoring and assessment methods that are unique to their estuary. Individual NEP monitoring may not be randomized spatially (as was done for the NCA) because NEP monitoring may target specific areas to ascertain specific sources of contamination or to obtain more detailed information about a particular environmental concern relevant to the NEP estuary.

It is important that the users of this report realize the shortcomings and limitations of the data presented, both from the NCA and from the individual NEPs. Both of these data sources taken together can often show very different results for the same estuarine index or component indicator. For example, although the NCA survey data may indicate that dissolved oxygen concentrations in the water column are in good condition, this assessment is based on monitoring conducted in an estuary during daylight hours only for a one-day period in the summer season during a given year. In contrast, the individual NEP monitoring data may indicate that dissolved oxygen levels at the same site are poor based on hourly monitoring conducted over a 24-hour monitoring cycle, including hours after dark when oxygen concentrations often drop due to plant respiration. Both of these data collection methods are correct within the limitations of the conditions under which the monitoring was conducted and the analysis used to evaluate the data.

Conclusion

There was no consistent and comparable NCA estuarine survey at the inception of the NEP. However, based on the probabilistic sampling results collected by the NCA from 1997 through 2003, the NEP estuaries scored equal to or higher than all U.S. estuaries combined.

During the past 20 years, population pressures along the coasts have increased. By 2000, more than two-thirds of the coastal population lived in NEP-coincident counties, which comprise less than 6% of the coastal land area. Since 1987, as NEPs have attempted to address their individual environmental concerns, they have made many improvements to areas that are assessed by NCA. For example, work by the individual NEPs and their partners to make improvements in WWTPs, assist with the implementation of stormwater management plans, or identify primary sources of non-point source pollution may result in better ratings for water quality parameters in the NEP estuaries. The NEPs have also directed resources towards addressing some environmental concerns that are not directly assessed by the NCA. For example, habitat loss and alteration is listed as an environmental concern for all 28 NEP estuaries, and the individual NEPs have worked hard to monitor, conserve, protect, and restore important habitats (e.g., SAV, wetlands) in their study areas, including restoring and/or protecting more than one million acres of habitat between 2000 and 2006.

Tourism, fisheries, and other commercial activities thrive on the wealth of natural resources supplied by estuaries (John Theilgard).

CHAPTER 1 | INTRODUCTION

CHAPTER 1 | INTRODUCTION

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.

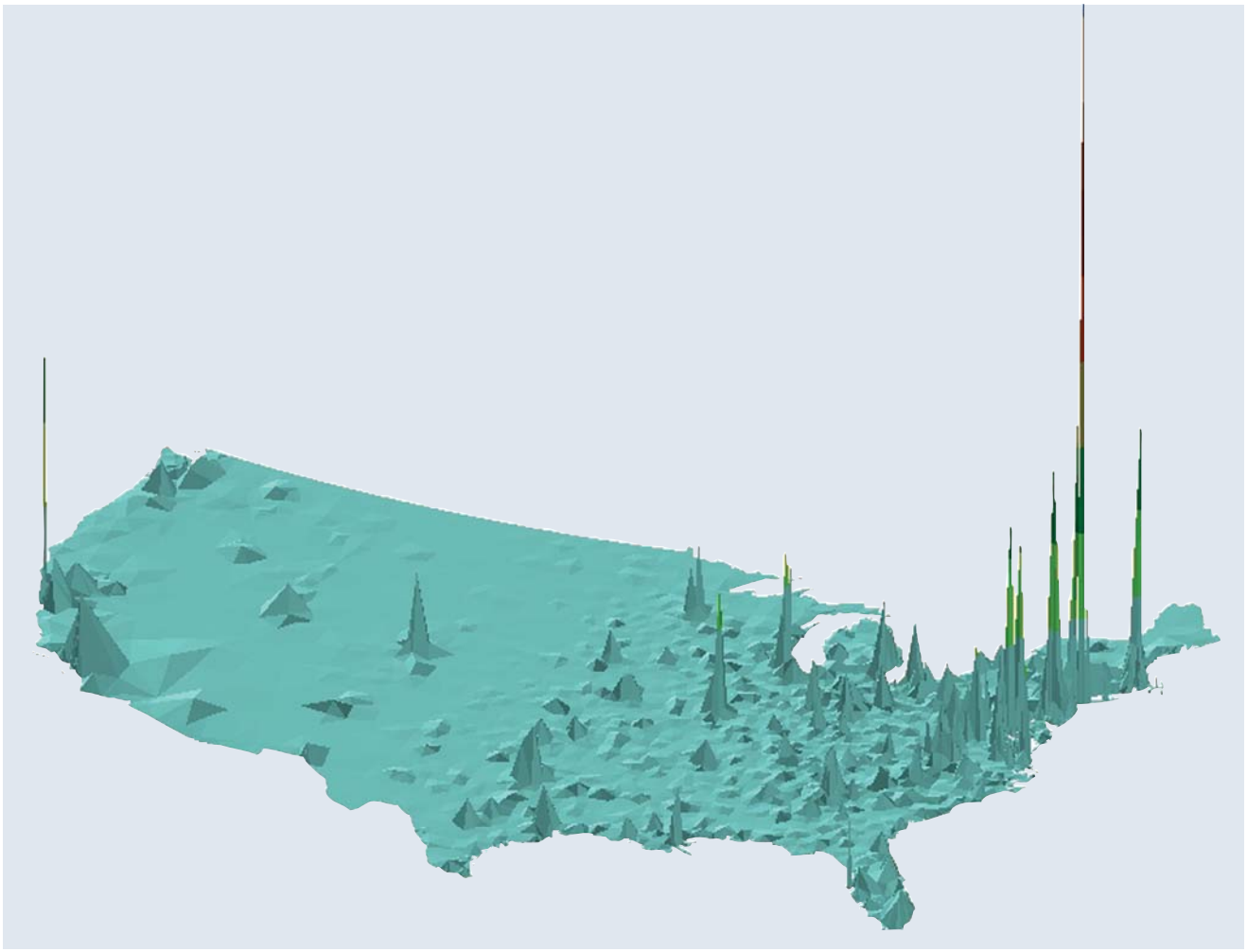

Figure 1-2. Population distribution in the United States in 2000 (U.S. Census Bureau, 2001).

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).

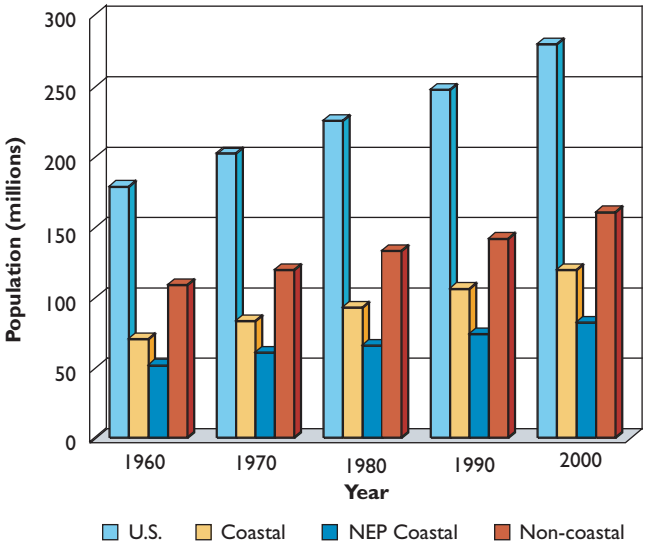

Figure 1-3. Total population data for the United States from 1960 to 2000 (U.S. Census Bureau, 1991; 2001).

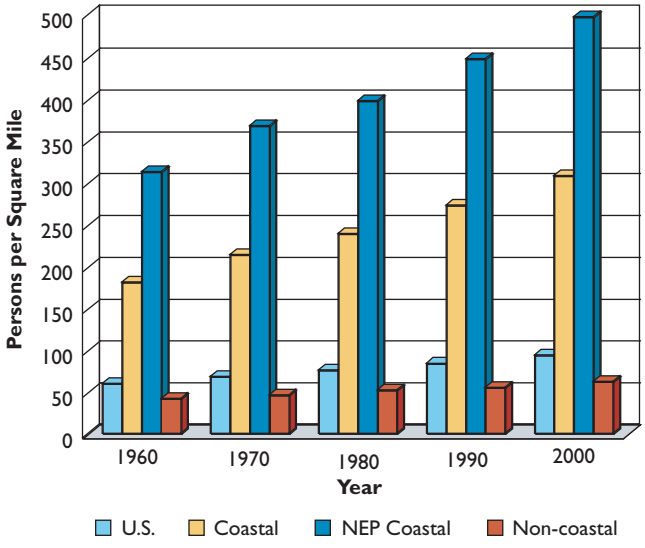

Figure 1-4. Population density data for the United States from 1960 to 2000 (U.S. Census Bureau, 1991; 2001).

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
Casco Bay, ME	1990
New Hampshire Estuaries, NH	1995
Massachusetts Bays, MA	1990
Buzzards Bay, MA	1987
Narragansett Bay, RI and MA	1987
Long Island Sound, CT and NY	1987
Peconic Estuary, NY	1992
New York/New Jersey Harbor, NY and NJ	1988
Barnegat Bay, NJ	1995
Delaware Estuary, NJ, PA, and DE	1988
Delaware Inland Bays, DE	1988
Maryland Coastal Bays, MD	1995
Southeast Coast	
Albemarle-Pamlico Estuarine Complex, NC and VA	1987
Indian River Lagoon, FL	1990

Puerto Rico	Year of Entry
San Juan Bay Estuary, PR	1992
Gulf Coast	
Charlotte Harbor, FL	1995
Sarasota Bay, FL	1988
Tampa Bay, FL	1990
Mobile Bay, AL	1995
Barataria-Terrebonne Estuarine Complex, LA	1991
Galveston Bay, TX	1988
Coastal Bend Bays, TX	1992
West Coast	
Puget Sound, WA	1987
Lower Columbia River Estuary, WA and OR	1995
Tillamook Bay, OR	1994
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.

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.

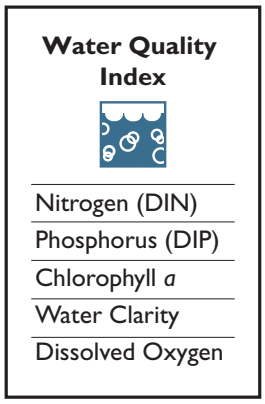

Figure 1-5. Component indicators of the water quality index.

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.

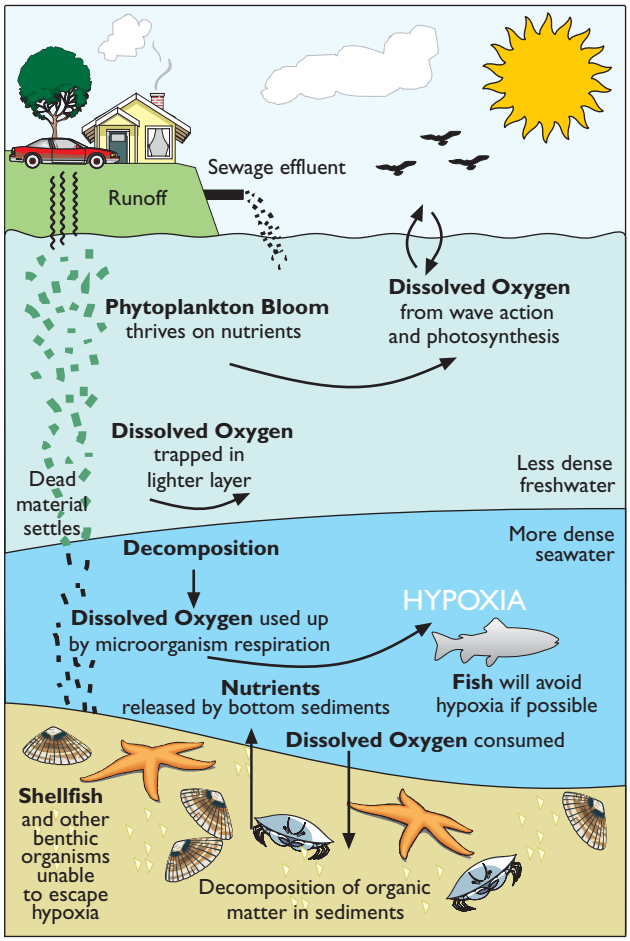

Figure 1-6. Eutrophication can occur when the concentration of available nutrients increases beyond normal levels.

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.

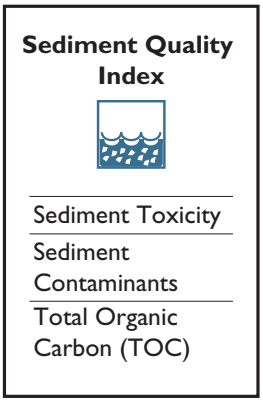

Figure 1-7. Component indicators of the sediment quality index.

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		
 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).	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good: No component indicators are rated poor, and a maximum of one component indicator is rated fair.	**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: One component indicator is rated poor, or two or more component indicators are rated fair.	**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.	**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).	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good: No component indicators are rated poor, and the sediment contaminants indicator is rated good.	**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.	**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.	**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.	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good, **fair**, and **poor** were determined using regionally dependent benthic index scores.	**Good:** 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.	
	Ecological Condition by Site	**Ranking by NEP Estuary or Region**
	Good: For all chemical contaminants listed in Table 1-21, composite fish tissue contaminant concentrations are below the EPA Advisory Guidance* concentration range.	**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: For at least one chemical contaminant listed in Table 1-21, composite fish tissue contaminant concentrations are within the EPA Advisory Guidance concentration range.	**Fair:** 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.	**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.

*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

Ecological Condition by Site	Ranking by NEP Estuary or Region
Dissolved Inorganic Nitrogen (DIN)	
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.

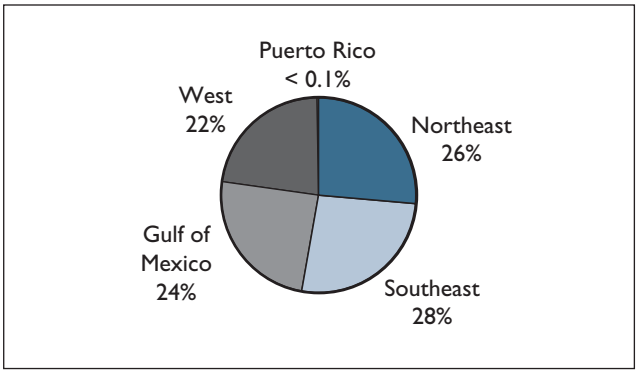

Figure 1-8. Percentage of NEP estuarine area contributed by each geographic region assessed in this report.

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.

CHAPTER 2

U.S. NATIONAL ESTUARY PROGRAM COASTAL CONDITION—A NATIONAL SNAPSHOT

CHAPTER 2

U.S. NATIONAL ESTUARY PROGRAM COASTAL CONDITION—A NATIONAL SNAPSHOT

EPA summarizes environmental conditions in the 28 NEP estuaries to allow for statistical comparisons of coastal conditions nationwide. As discussed in Chapter 1, assessments of estuarine condition were developed for each individual NEP estuary and for the collective NEP estuaries on a regional and national basis. This chapter presents the national estuarine condition ratings for the collective NEP estuaries, as well as information on the regional estuarine condition ratings for the five U.S. regions discussed in this report. More in-depth information on the estuarine condition of these regions and the 28 individual NEP estuaries is provided in the regional summary sections and NEP profiles presented in Chapters 3 through 7.

The overall condition of the NEP estuaries of the United States is rated fair, with the water quality index, benthic index, and fish tissue contaminants index each rated fair and the sediment quality index rated fair to poor at the national level. Figure 2-1 shows the overall condition and estuarine index ratings for the nation and for the five regions discussed in this report. These ratings are based on monitoring data collected as part of the NCA, which sampled 1,239 sites within U.S. NEP estuaries from 1997 through 2003, with the majority of

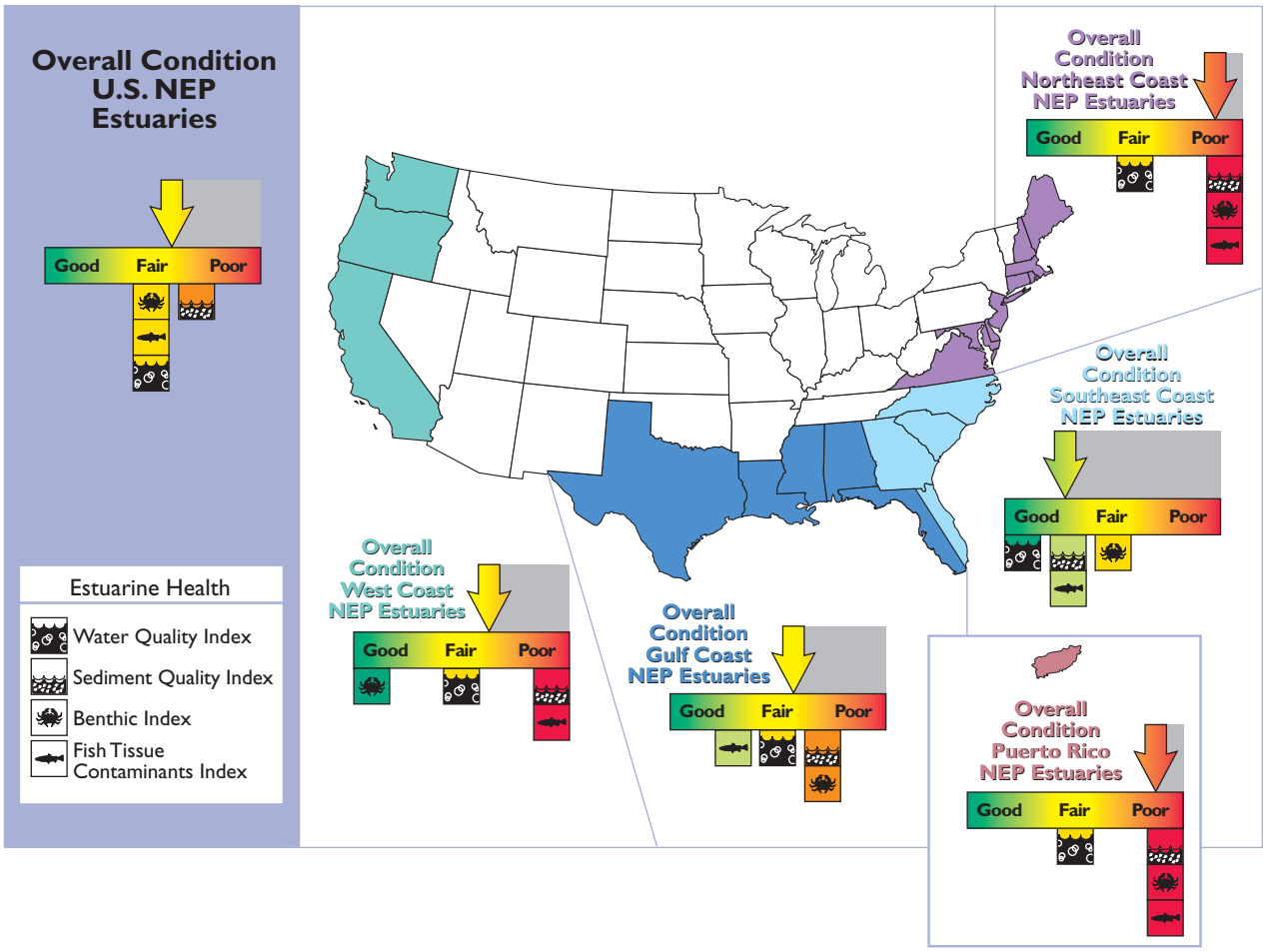

Figure 2-1. National and regional overall condition ratings for the nation's NEP estuaries (U.S. EPA/NCA).

the samples (95%) collected between 1999 and 2001. Of the four NCA indices rated for NEP estuaries nationwide, only the water quality index for the Southeast Coast region and the benthic index for the West Coast region were rated good.

The ratings for the individual NEP estuaries and the five geographic regions were based on the criteria outlined in Tables 1-24, 1-25, and 1-26 of this report, and overall condition ratings for each region were developed by averaging the four regional estuarine index ratings. Based on these calculations, the Northeast Coast region is rated fair for the water quality index; poor for the sediment quality, benthic, and fish tissue contaminants indices; and poor for overall condition. The Southeast Coast region is rated good for the water quality index; good to fair for the sediment quality index; fair for the benthic index; good to fair for the fish tissue contaminants index; and good to fair for overall condition. The Gulf Coast region is rated fair for the water quality index; fair to poor for the sediment quality and benthic indices; good to fair for the fish tissue contaminants index; and fair for overall condition. The West Coast region is rated fair for the water quality index; poor for the sediment quality index; good for the benthic index; poor for the fish tissue contaminants index; and fair for overall condition. Finally, the sole NEP estuary (San Juan Bay Estuary) in Puerto Rico is rated fair for the water quality index; poor for the sediment quality, benthic, and fish tissue contaminants indices; and poor for overall condition.

NCA Indices of Estuarine Condition—U.S. NEP Estuaries

This section presents EPA's NCA monitoring data, which were used to rate the four primary indices of estuarine condition discussed in this report. Based on NCA data, the overall condition of the nation's NEP estuaries is rated fair, with 37% of the nation's collective NEP estuarine area rated poor (Figure 2-2). The overall condition score was calculated by averaging the rating scores for the individual indices (water quality, sediment quality, benthic, and fish tissue contaminants). Figure 2-3 shows the percent of the nation's NEP estuarine area rated good, fair, poor, or missing for each of the parameters considered. Each NCA survey site was visited only once during the summer season; therefore, the results emerging from the NCA study form a "snapshot" of estuarine condition at a site, rather than a description of long-term conditions. This approach provides an accurate assessment of conditions in the relatively stable media of sediment and the associated benthic community, as well as of fish tissue contamination conditions that change relatively slowly over time; however, it provides a less accurate view of the ephemeral conditions associated with the water column, where water quality conditions may change weekly or even daily during a summer sampling period.

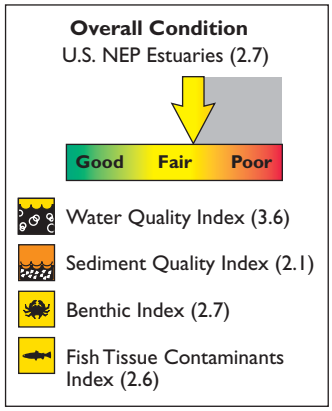

Figure 2-2. The overall condition of the nation's NEP estuarine area is fair (U.S. EPA/NCA).

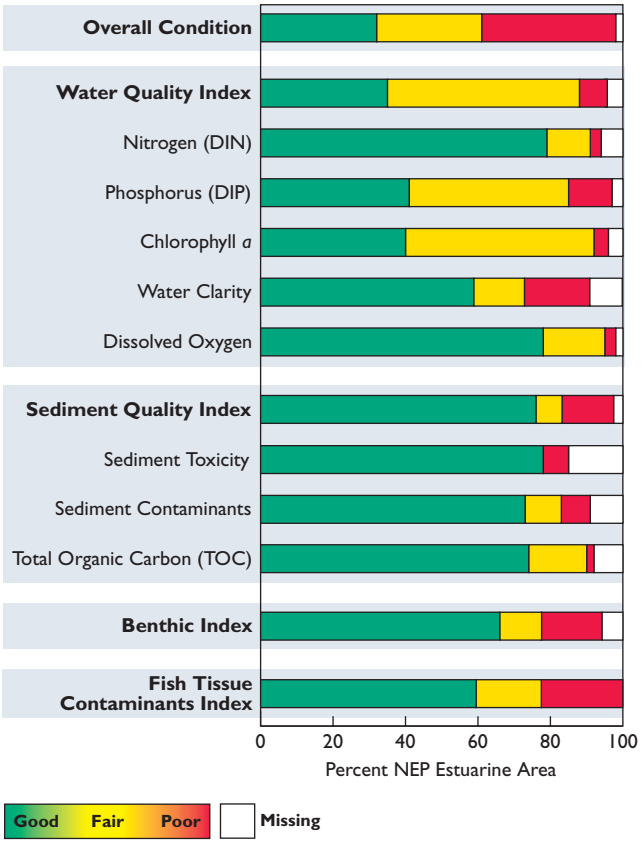

Figure 2-3. Percentage of estuarine area achieving each rating for all indices and component indicators – U.S. NEP estuaries (U.S. EPA/NCA).

Water Quality Index

Based on NCA data (representing five component indicators—DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen), the water quality index for the nation's collective NEP estuaries is rated fair. The index shows that 8% of the nation's NEP estuarine area is rated poor for water quality, and 54% of the area is rated fair (Figure 2-4). These categories combine to show that 62% ± 3% of the nation's NEP estuaries are experiencing a moderate to high degree of eutrophication. Poor water quality condition is generally characterized by degradation in the water quality variable (i.e., increased chlorophyll *a* concentrations and decreased dissolved oxygen concentrations). Moderate eutrophication shows some minor degradation in response variables, but poor water quality condition is more likely to be characterized by degradation due to environmental stressors, such as increased nutrient concentrations and reduced water clarity.

The Gulf Coast region shows the highest proportional area of NEP estuaries in poor condition (13%) for water quality, although the water quality index for this region is rated fair. NEP estuaries along the Northeast Coast, West Coast, and Puerto Rico also had water quality indices rated fair, with 9%, 4%, and 8% of NEP estuarine waters in these regions rated poor for water quality, respectively. The water quality index for the Southeast Coast region is rated good, with only 4% of this region's NEP estuarine area rated poor for water quality.

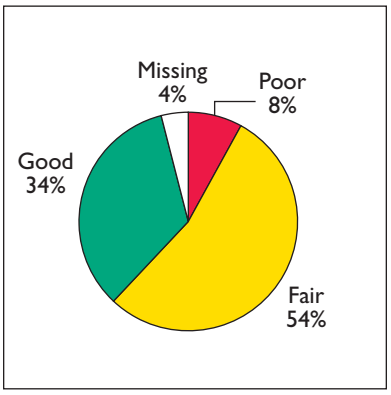

Figure 2-4. Water quality index data for U.S. NEP estuaries (U.S. EPA/NCA).

The sampling conducted by EPA's NCA is designed to estimate the percent of NEP estuarine area (nationally or regionally) in varying conditions; these estimates are displayed as pie diagrams. Many of the figures in this report illustrate environmental measurements made at specific locations (colored dots on maps); however, these dots (color) represent the value of the index specifically at the time of sampling. Additional sampling may be required to define variability and to confirm impairment or the lack of impairment at specific locations.

Dissolved Nitrogen and Phosphorus

Nutrient concentrations for summertime conditions in the nation's NEP estuaries are rated good for DIN concentrations and fair for DIP concentrations. Nutrient concentrations in summer are expected to be generally lower than at other times of year, except on the West Coast, where Pacific upwelling events often produce higher nutrient concentrations in the summer. Because of the expectation for lower nutrient concentrations, reference conditions were modified (reduced by 50%) for NEP estuaries of the Northeast Coast, Southeast Coast, and Gulf Coast regions.

DIN concentrations were uniformly low throughout the nation's NEP estuaries, with only 3% of the nation's NEP estuarine area characterized by poor conditions. Most DIN concentrations that exceeded reference conditions were in the NEP waters of the Northeast Coast (10%) and Puerto Rico (23%) regions. DIP concentrations exceeded the regional reference conditions in 12% of the nation's NEP estuarine area. Elevated summer DIP concentrations were observed in 10% to 20% of the area of most NEP regions (except for NEP estuaries of the Southeast Coast region, where only 6% exceeded these values). In addition, elevated DIN and DIP concentrations in the NEP estuaries of the Northeast Coast, Gulf Coast, and Puerto Rico regions correspond to elevated chlorophyll *a* concentrations in these estuaries.

Chlorophyll a | High concentrations of chlorophyll *a* in a waterbody indicate the potential for problems related to the overproduction of algae and increased eutrophic conditions. The collective NEP estuaries of the United States are rated fair for chlorophyll *a* concentrations, with 52% of the nation's NEP estuarine area rated fair and 4% of the area rated poor. The Gulf Coast, Southeast Coast, and Puerto Rico regions were also rated fair for this component indicator, whereas chlorophyll *a* conditions in the Northeast Coast and West Coast regions were rated good.

Water Clarity | Water clarity for the nation's NEP estuaries is rated fair. Three different regional reference conditions were established for measuring water clarity conditions (Table 2-1).

The NCA estimates that 18% of the nation's NEP estuaries do not meet regional reference conditions for good water clarity. NEP estuaries with poor water clarity are distributed throughout the country, but the West Coast (35%), Gulf Coast (31%), and Puerto Rico (17%) regions have the greatest proportion of NEP waters not meeting the conditions for good water clarity.

Table 2-1. Reference Conditions for Water Clarity in the Nation's NEP Estuaries

Reference Condition (ambient surface light that reaches a depth of 1 meter)	Area Type
5%	Areas having high natural levels of suspended solids in the water (e.g., Delaware Estuary, Barataria-Terrebone Estuarine Complex, Mobile Bay) or extensive wetlands
20%	Areas having extensive SAV beds (e.g., Indian River Lagoon, southern Laguna Madre of the Coastal Bend Bays) or desiring to re-establish SAV (e.g., Tampa Bay)
10%	The remainder of the country

Interpretation of Instantaneous Dissolved Oxygen Information

Although NCA results do not suggest that low dissolved oxygen concentrations are a pervasive problem, the instantaneous measurements on which these results are based may have underestimated the magnitude and duration of low dissolved oxygen events at any given site. Long-term observations by other investigators have revealed increasing trends in the frequency and areal extent of hypoxic events in some coastal areas. For example, extensive year-round or seasonal monitoring data over multiple years in such places as Narragansett Bay in Rhode Island have shown a much higher incidence of hypoxia than is depicted in the present NCA data, indicating that although hypoxic conditions do not exist continuously, they can occur occasionally to frequently for generally short durations of time (hours).

Dissolved Oxygen | Dissolved oxygen condition for the nation's NEP estuaries is rated good; however, the majority of NEP estuaries are not located in areas where severe hypoxic and anoxic water conditions have occurred historically, such as the waters found offshore of the Mississippi Delta region in the Gulf of Mexico. In addition, NCA estimates do not reflect the dystrophic nature of some estuarine systems, where dissolved oxygen levels are acceptable during daylight hours but decrease to low levels during the night. Many of these systems and their associated biota are adapted to this cycle, which is common in wetland, swamp, and blackwater ecosystems; however, because all NCA survey measurements were taken during daylight hours, these dystrophic events would not be detected by the NCA surveys.

The reference value used in the NCA analysis for poor dissolved oxygen is less than 2 mg/L in bottom waters. This guideline was chosen because this concentration is clearly indicative of potential harm to estuarine organisms. Approximately 3% of the NEP estuarine area experienced dissolved oxygen concentrations less than 2 mg/L in bottom waters. Although most regions of the country were rated good for dissolved oxygen concentrations, the Southeast Coast and Puerto Rico regions were rated fair.

Sediment Quality Index

The sediment quality index for the nation's collective NEP estuaries is rated fair to poor. This index is based on an assessment of sediment toxicity, sediment contaminant concentrations, and the percentage of sediment TOC, and about 15% of the nation's NEP estuarine area displayed a poor rating for one of these component indicators (Figure 2-5). The largest proportion of NEP estuarine area in poor condition was found in the Puerto Rico (33%), Northeast Coast (21%), and West Coast (17%) regions. Poor sediment quality condition in these regions is primarily the result of high TOC and sediment toxicity levels (Puerto Rico), elevated contaminant concentrations (Northeast Coast), and a high percentage of toxic sediments (West Coast). The Gulf Coast region received a fair to poor rating for sediment quality because 15% of this region's NEP estuarine area was rated poor for sediment contaminant concentrations. The Southeast Coast region received a good to fair regional rating for this index, with only 6% of the NEP estuarine area found to be in poor condition.

Sediment Toxicity

The NCA determined sediment toxicity by exposing test organisms to sediments from each sampling site and evaluating the effects of these sediments on the survival of the exposed organisms. Sediment toxicity tests using the benthic organism *Ampelisca abdita* showed significant mortalities associated with sediments in 7% of the nation's NEP estuarine area; therefore, sediment toxicity for the nation's collective NEP estuaries is rated poor. Regionally, sediment toxicity was observed most often in the NEP estuaries of the Puerto Rico (29%), West Coast (18%), and Northeast Coast (9%) regions.

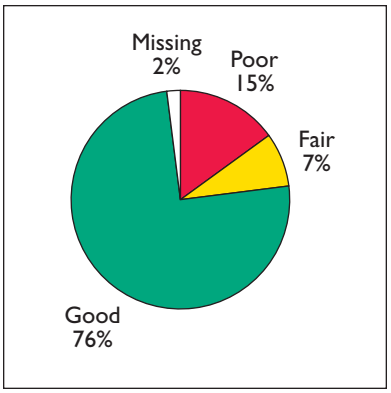

Figure 2-5. Sediment quality index data for U.S. NEP estuaries (U.S. EPA/NCA).

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.

Sediment Contaminants

The NCA analyzed collected sediments for nearly 100 chemical contaminants at each sampling site, including 25 PAHs, 22 PCBs, 25 pesticides, and 15 metals. ERM and ERL values were used as guidelines to ascertain sediment condition, and poor condition was determined as an exceedance of one or more ERMs. Sediment contamination for the nation's NEP estuaries is rated fair, with ERM values exceeded in sediments from 8% of the nation's NEP estuarine area. The highest proportion of sediments exceeding these guidelines occurred in the NEP estuaries of the Northeast Coast (15%) and Gulf Coast (11%) regions, which were both rated fair for sediment contaminants. The West Coast and Puerto Rico were also rated fair for this component indicator, with 5% of each region's NEP estuarine area rated poor. Only the Southeast Coast region was rated good for sediment contaminant concentrations, with none of its estuarine area rated poor.

Total Organic Carbon

TOC in estuarine sediments is often a source of food for benthic organisms; however, high levels of sediment TOC can result in significant changes in an estuary's benthic community structure and the predominance of pollution-tolerant species. The nation's collective NEP estuaries were rated good for sediment TOC, with only 2% of the U.S. NEP estuarine area rated poor for this component indicator. In addition, all five NEP regions outlined in this report received good regional ratings for sediment TOC.

Benthic Index

As shown in Table 2-2, the criteria used to assess benthic condition differed for the various geographic regions of the United States. The benthic index for the nation's NEP estuaries is rated fair, with the index showing that 17% of the nation's NEP estuarine area supports benthic communities in poor condition (Figure 2-6). Benthic communities that are rated poor are characterized by lower-than-expected diversity and a high population of pollution-tolerant species, or they contain fewer-than-expected pollution-sensitive species, as measured by multimetric benthic indices. The Northeast Coast and Puerto Rico regions are both rated poor for the benthic index, with 26% and 65% of NEP estuarine area in those regions rated poor, respectively. The Gulf Coast region is rated fair to poor for this index, with 20% of the NEP estuarine area rated poor and an additional 27% rated fair for benthic communities. The Southeast Coast region is rated fair for benthic condition, with 15% of its NEP estuarine area rated as having poorer-than-expected benthic communities. Finally, the West Coast region is rated good for this index, with only 4% of the region's NEP estuarine area characterized as poor.

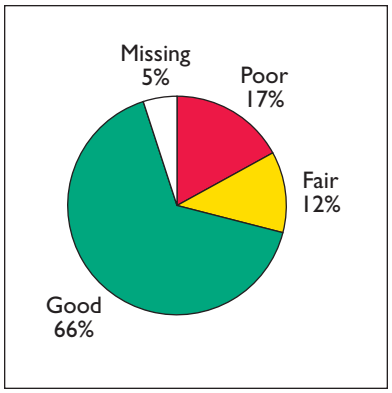

Figure 2-6. Benthic index data for U.S. NEP estuaries (U.S. EPA/NCA).

Table 2-2. Regional Criteria for Assessing Benthic Condition

Region	Good	Fair	Poor
Northeast Coast sites			
Acadian Province	Shannon-Weiner Diversity Index score is greater than 0.63	NA*	Shannon-Weiner Diversity Index score 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 for unstressed habitats in Puerto Rico	Benthic index score is between 75% and 90% of the lower limit of mean diversity for 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 benthic 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 poor and fair 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.

Fish Tissue Contaminants Index

Based on a weighted average of the regional scores, the fish tissue contaminants index for the nation's NEP estuaries is rated fair. Nationally, the index shows elevated levels of chemical contaminants in fish/shellfish tissues from 23% of the stations where fish were caught (Figure 2-7). The NCA collected fish for analysis of whole-body burdens of chemical contaminants (i.e., contaminants from the entire fish—fillets, head, skin, and organs), with the exception of a few stations that examined both edible fillets and whole-body burdens. The NCA examined samples (5–10 fish of a target species per station) from 330 stations throughout the nation's NEP estuarine waters and performed chemical analysis for about 90 specific contaminants.

The percentage of stations where fish were caught with elevated contaminant concentrations may have been increased in part due to the use of juvenile fish rather than fish of commercial size. The use of juvenile-sized fish could increase the likelihood of obtaining higher whole-body concentrations of contaminants, especially for those contaminants not found in muscle tissue. EPA Advisory Guidance describing risk-based concentrations of contaminants of concern for recreational and subsistence fishers (few contaminant guidelines exist for wildlife protection) applies to fillet, whole-body, and organ-specific concentrations (U.S. EPA, 2000b). Whole-body concentrations for many chemical contaminants (e.g., dioxins, PCBs, organochlorine pesticides) are higher than the concentrations found in muscle tissue (fillets); however, mercury concentrations can be severely underestimated using whole-body concentration data because mercury is concentrated primarily in the muscle tissue. Although

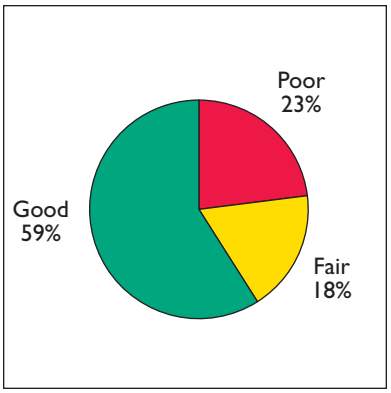

Figure 2-7. Fish tissue contaminants index data for U.S. NEP estuaries (U.S. EPA/NCA).

In the bioaccumulation process, chemical contaminants bioaccumulate in the tissues of aquatic organisms to concentrations many times higher than those found in seawater. In addition, these tissue concentrations in fish and other aquatic organisms may be increased at each successive level of the food web (Figure 2-8). As a result, top predators in a food web may have concentrations of chemical contaminants in their tissues at levels a million times higher than the concentrations found in seawater. A direct comparison of fish advisory contaminants and sediment contaminants is not possible because states often issue advisories for groups of chemicals; however, five of the top six contaminants most often associated with fish advisories (e.g., PCBs, DDT, dieldrin, chlordane, and dioxins) are among the contaminants most often responsible for a Tier 1 National Sediment Inventory classification (i.e., associated adverse effects to aquatic life or human health are probable) of waterbodies based on potential human health effects (U.S. EPA, 1997).

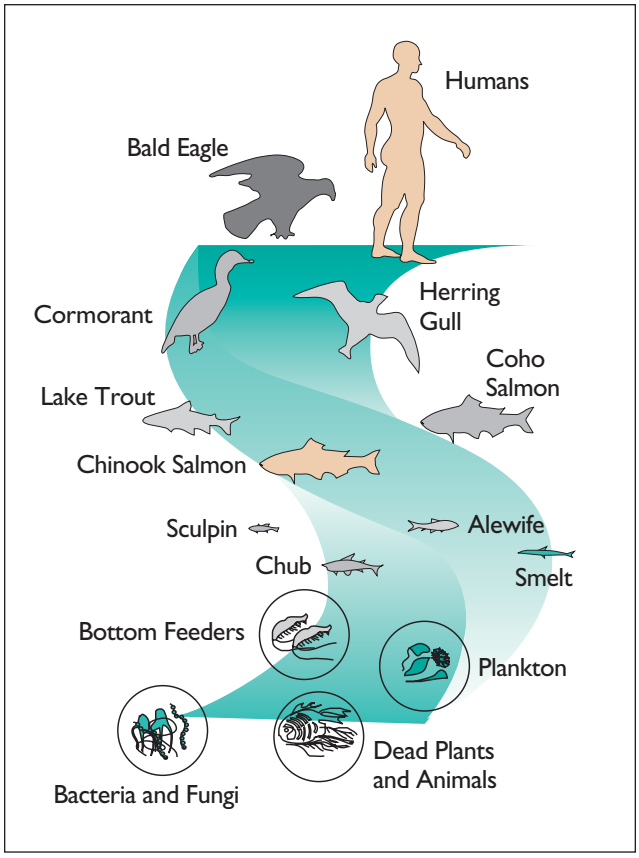

Figure 2-8. Bioaccumulation process (U.S. EPA/NCA).

mercury concentrations can be three to five times more concentrated in muscle tissue than in whole-body samples, about one-third of the coastal states often use whole-body concentrations to set fish advisories for waters where consumer groups eat whole fish.

The West Coast and Puerto Rico regions are rated poor for fish tissue contaminants in their NEP estuaries, with 32% and 40% of stations sampled, respectively, showing above-Guidance concentrations for at least one chemical contaminant. The Northeast Coast region is also rated poor, with 38% of the samples analyzed rated poor. Chemical contaminants detected in fish tissues generally included total PCBs, DDT and its metabolites, total PAHs, and mercury. Twelve percent of stations sampled in Gulf Coast NEP estuaries and 10% of stations sampled in Southeast Coast NEP estuaries showed elevated tissue concentrations, and both regions are rated good to fair for this index.

Population Pressures—A National Perspective

Population pressures on the coastal counties coincident to an individual NEP study area, or collectively on coastal counties coincident to all NEP study areas in a specific region, must be evaluated not only as total population, but also with thought to population density and population growth rate; therefore, total population values need to be assessed from both a temporal and spatial perspective. Population density provides a measure of how saturated the associated NEP-coincident coastal counties are with respect to human development. In contrast, the population growth rate over a specific time interval provides an indication of how quickly human development in an area occurs, as well as the coinciding infrastructure development that would be necessary to provide such essentials as residential housing and commercial development, highways and other transportation facilities, safe drinking water, and municipal and industrial treatment of wastes. Explosive population growth may not provide adequate time for state, county, or local government planning to meet increased infrastructure needs; to adequately monitor environmental indicators to assess trends affecting water, sediment, and habitat quality and the health of living resources; or to take action to reduce ecosystem degradation when it is identified. When assessed collectively, these measures provide information about the pressures society is exerting on the NEP coastal ecosystems.

For example, the NEP-coincident counties of the Northeast Coast region contained the highest total population in 2000 (38 million), followed by the West Coast (30 million), Gulf Coast (11 million), and Southeast Coast (3 million) regions (Table 2-3). Population density values also show that the NEP-coincident counties of the Northeast Coast had the highest regional density (1,055 persons/mi^2) in 2000, followed by the West Coast (421 persons/mi^2), Gulf Coast (287 persons/mi^2), and the Southeast Coast (168 persons/mi^2) regions; however, the NEP study area of San Juan Bay Estuary (Puerto Rico) had the highest population density in 2000 of any of the five regions (5,055 persons/mi^2). In contrast to total population and population density, population growth rates (1960–2000) for these same regions show a different pattern, with the Gulf Coast having the highest growth rate (133%), closely followed by both the Southeast Coast (131%) and the West Coast (100%), and lastly by the Northeast Coast (24%) region (Culliton et al., 1990; U.S. Census Bureau, 1991; 2001).

With respect to individual NEP study areas, there is a wide difference in total population, population density, and population growth rate, as well as in the size of the land area of NEP-coincident coastal counties.

Researchers assess population pressures to determine how increased population affects estuarine condition (John Theilgard).

Table 2-3. Total Population, Population Density, and Population Growth Rate for NEP-coincident Coastal Counties (U.S. Census Bureau, 1991; 2001)

NEP Estuarine Area	Land Area (mi^2)	Population for NEP-coincident Counties, 2000 (millions)	Population Density, 2000 (persons/mi^2)	Percent Population Growth Rate, 1960–2000
Northeast Coast	**35,894**	**37.876**	**1,055**	**24**
Casco Bay	4,671	0.646	138	48
New Hampshire Estuaries	2,002	0.433	216	148
Massachusetts Bays	2,829	4.224	1,493	23
Buzzards Bay	1,714	1.245	726	72
Narragansett Bay	5,001	4.922	984	28
Long Island Sound	6,750	14.647	2,170	14
Peconic Estuary	911	1.419	1,558	113
New York/New Jersey Harbor	5,470	16.943	3,097	13
Barnegat Bay	1,921	1.550	807	132
Delaware Estuary	12,138	9.376	772	35
Delaware Inland Bays	942	0.157	166	114
Maryland Coastal Bays	475	0.047	98	96
Southeast Coast	**18,963**	**3.192**	**168**	**131**
Albemarle-Pamlico Estuarine Complex	14,452	1.804	125	71
Indian River Lagoon	4,511	1.388	308	327
Gulf Coast	**39,482**	**11.334**	**287**	**133**
Charlotte Harbor	9,719	2.976	306	251
Sarasota Bay	1,320	0.590	447	304
Tampa Bay	5,214	3.339	640	190
Mobile Bay	2,827	0.540	191	49
Barataria-Terrebonne Estuarine Complex	8,824	1.627	184	28
Galveston Bay	6,720	4.376	651	182
Coastal Bend Bays	10,374	0.548	53	36
West Coast	**70,043**	**29.504**	**421**	**100**
Puget Sound	20,118	4.114	205	121
Lower Columbia River Estuary	11,875	1.644	138	78
Tillamook Bay	1,101	0.024	22	28
San Francisco Estuary	10,357	8.740	844	96
Morro Bay	3,308	0.247	75	204
Santa Monica Bay	26,794	14.828	553	99
Puerto Rico	**233**	**1.177**	**5,055**	**NA**
San Juan Bay Estuary	233	1.177	5,055	NA

NA = not available

For example, the total population in 2000 for coastal counties coincident to NEP study areas ranged from 24,000 (Tillamook Bay) to 16,943,000 (New York/New Jersey Harbor)—almost a 1,000-fold difference. Population density also varied in the NEP-coincident coastal counties, ranging from 22 persons/mi^2 (Tillamook Bay) to 5,055 persons/mi^2 (San Juan Bay Estuary)—a more than a 200-fold difference. Finally, population growth rates from 1960 to 2000 varied widely and ranged from a low of 13% (New York/New Jersey Harbor) to a high of 304% (Sarasota Bay). In addition, the land areas of NEP-coincident coastal counties range in size from 233 mi^2 (San Juan Bay Estuary) to 26,794 mi^2 (Santa Monica Bay). The evaluation of these parameters is important in assessing population pressures on an individual estuary or coastal region.

Correlation between NEP CCR Index Scores and Population Pressures

The NCA data reveal some patterns with respect to an individual NEP study area's total population and population density and its overall condition score and rating. Mean overall condition improves with decreasing population, although the ranges vary widely. As shown in Table 2-4, for the 11 NEPs with populations greater than 2 million people, the overall condition scores range from 1.0 (rated poor) to 3.0 (rated fair), with a mean overall condition score of 2.26 (rated fair to poor). For the 8 NEPs with populations between 1 to 2 million people, the overall condition scores range from 1.5 (rated poor) to 5.0 (rated good), with a mean score of 3.30 (rated fair). For the 9 NEPs with populations less than 1 million people, the overall condition scores range from 1.75 (rated poor) to 5.0 (rated good), with a mean score of 3.45 (rated fair). Although it is clear that the NEPs with the greatest populations (> 2 million) show the lowest overall condition scores, as well as scores within the smallest range of values, the overall condition scores for the other two population ranges (1–2 million, < 1 million) vary widely. In addition, the mean overall condition score for the group of NEPs with the lowest overall population (< 1 million) is only slightly higher as compared to the score for the intermediate population group (1–2 million).

As shown in Table 2-5, the overall condition scores with respect to population density are very similar to those found with respect to total population. For the 5 NEP study areas with population densities greater than 2,000 persons/mi^2, the overall condition scores

Environmental degradation has led to major declines in native fish that depend upon estuaries for their existence (Jim Ramaglia).

Table 2-4. Comparison of Total Population of NEP-Coincident Coastal Counties with NCA Mean Overall Condition Scores

Total Population of NEP-Coincident Coastal Counties	Range in NCA Overall Condition Scores Observed	NCA Mean Overall Condition Score	Number of NEP Estuaries
> 2 million	1.0–3.0	2.26	11
1–2 million	1.5–5.0	3.30	8
< 1 million	1.75–5.0	3.45	9

range from 1.0 (rated poor) to 4.3 (rated good), with a mean overall condition score of 2.16 (rated fair to poor). These estuaries include San Juan Bay Estuary (5,055 persons/mi^2), New York/New Jersey Harbor (3,097 persons/mi^2), Long Island Sound (2,170 persons/mi^2), Peconic Estuary (1,558 persons/mi^2), and the Massachusetts Bays (1,493 persons/mi^2). It should be noted that although the Peconic Estuary had the highest overall condition score (4.33), no data were collected for a sediment quality index for this estuary; therefore, this score does not reflect an assessment of sediment toxicity, sediment contaminant concentrations, or sediment TOC. If the Peconic Estuary is not used in the population density analysis, then the overall condition scores of the other 4 NEPs range from 1.0 (rated poor) to 2.5 (rated fair), and the mean overall condition score drops from 2.16 (rated fair to poor) to 1.63 (rated poor). For the 8 NEPs with population densities ranging from 500 to 1,000 persons/mi^2, the overall condition scores range from 1.75 (rated poor) to 3.5 (rated fair), with a mean score of 2.58 (rated fair). Finally, for the 15 NEPs with the lowest population densities (less than 500 persons/mi^2), the overall condition scores range from 1.75 (rated poor) to 5.0 (rated good), with a mean score of 3.39 (rated fair). As shown for total population, there is a slight increase in the mean overall condition scores for these groups as the population density decreases.

Although the mean overall condition scores based on total population and population density for the NEP-coincident coastal counties appear to exhibit some patterns, it should be noted that within any of the total population groups (Table 2-4) or population density groups (Table 2-5), there is a high degree of variability in the range of overall condition scores for the individual NEPs because unmeasured indices or component indicators may exert effects on an estuary's overall condition score.

For example, one confounding issue is that for 9 of the 28 NEP estuaries (almost a third), component indicator data were not collected for one or more of the primary indices of estuarine condition. In the Northeast Coast region, NCA data for the fish tissue contaminants index and the sediment quality index were unavailable for Casco Bay and the Peconic Estuary, respectively. In the Southeast Coast region, NCA data for the fish tissue contaminants index and two components of the sediment quality index (sediment toxicity and sediment contaminant concentrations) were not available for the Indian River Lagoon. In the Gulf Coast region, data from the three Florida NEP estuaries were missing for evaluating the fish tissue contaminants index and two components of the sediment quality index (sediment toxicity and sediment contaminant concentrations). Finally, a benthic index could not be calculated for three of the West Coast region's seven estuaries (the Lower Columbia River Estuary, Morro Bay, and Santa Monica Bay). If data had been collected and/or applicable for these indices and component indicators, the overall condition scores for the individual NEP estuaries may have been considerably different from those developed using less than a full suite of data.

Table 2-5. Comparison of Population Density of NEP-Coincident Coastal Counties with NCA Mean Overall Condition Scores

Population Density of NEP-Coincident Coastal Counties	Range in NCA Overall Condition Scores Observed	NCA Mean Overall Condition Score	Number of NEP Estuaries
> 1,000 persons/mi^2	1.0–4.33	2.16	5
500–1,000 persons/mi^2	1.75–3.5	2.58	8
< 500 persons/mi^2	1.75–5.0	3.39	15

The previous sections of this chapter have discussed the national and regional ratings for the NEP estuaries, which are based on NCA scores for four primary indices of estuarine condition (water quality index, sediment quality index, benthic index, fish tissues contaminants index). The NCA results for the nation's 28 individual NEP estuaries for these four indices, as well as for the component indicators for the water and sediment quality indices, are shown in Figures 2-9 through 2-12. These figures provide an easy way to compare the various ratings and scores for each index and component indicator among the individual NEP estuaries, as well as regionally and nationally. The figures also show where data were unavailable to assess an index or component indicator for an individual estuary. The index ratings for the five NEP regions outlined in this report will be discussed further in the regional summary sections of Chapters 3 through 7.

Good Fair Poor

	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)														
Phosphorus (DIP)														
Chlorophyll *a*														
Water Clarity														
Dissolved Oxygen														
Sediment Quality Index									Missing					
Sediment Toxicity									Missing					
Sediment Contaminants									Missing					
Total Organic Carbon (TOC)									Missing					
Benthic Index														
Fish Tissue Contaminants Index			Missing											

Figure 2-9. Comparison of NCA results for Northeast Coast NEP estuaries and all Northeast Coast estuaries (U.S. EPA/NCA).

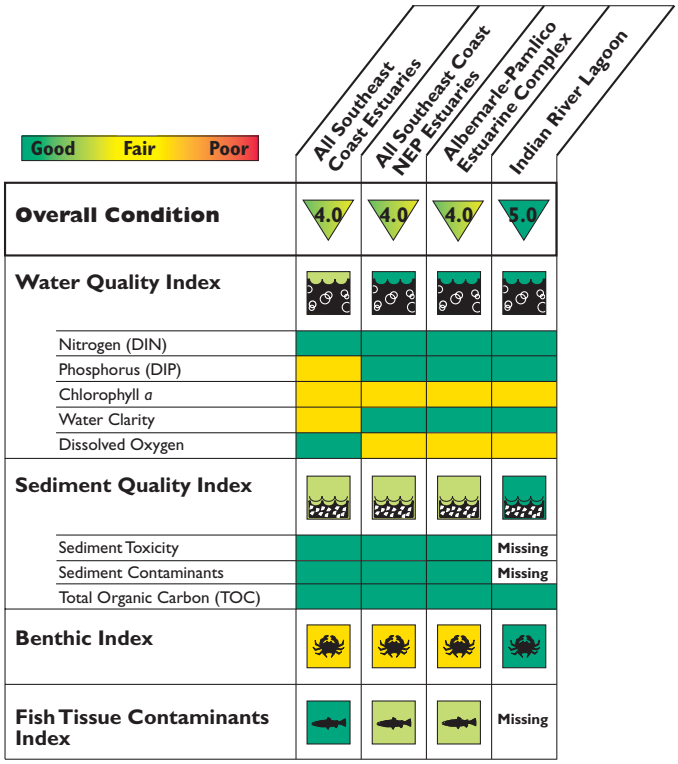

Figure 2-10. Comparison of NCA results for Southeast Coast NEP estuaries and all Southeast Coast estuaries (U.S. EPA/NCA).

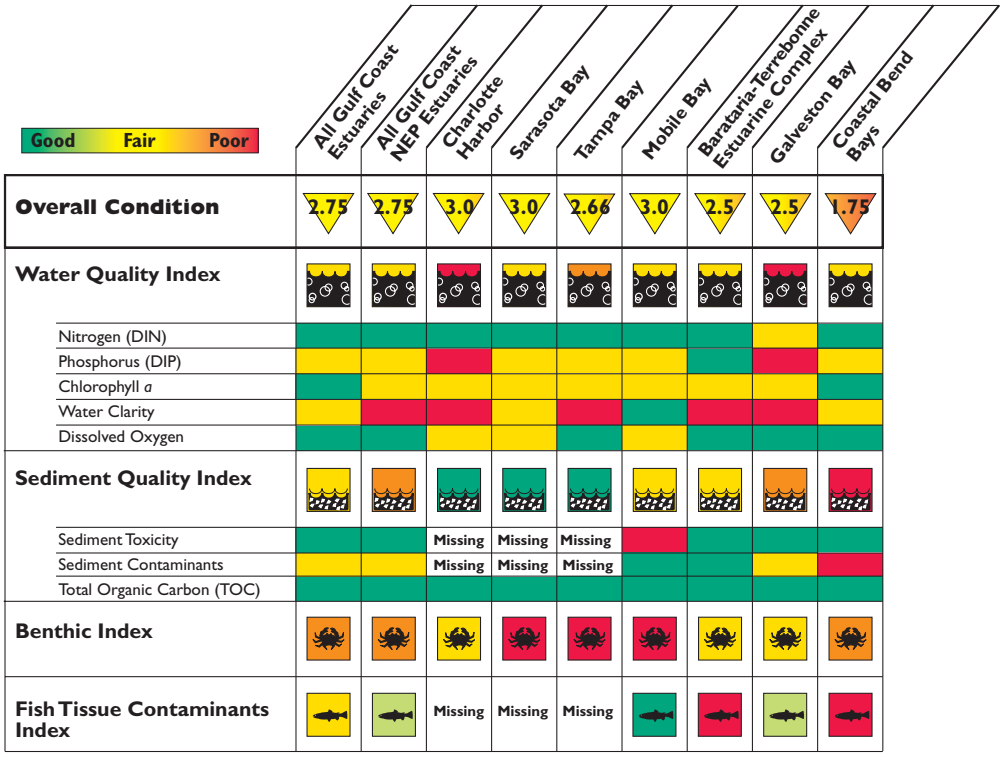

Figure 2-11. Comparison of NCA results for Gulf Coast NEP estuaries and all Gulf Coast estuaries (U.S. EPA/NCA).

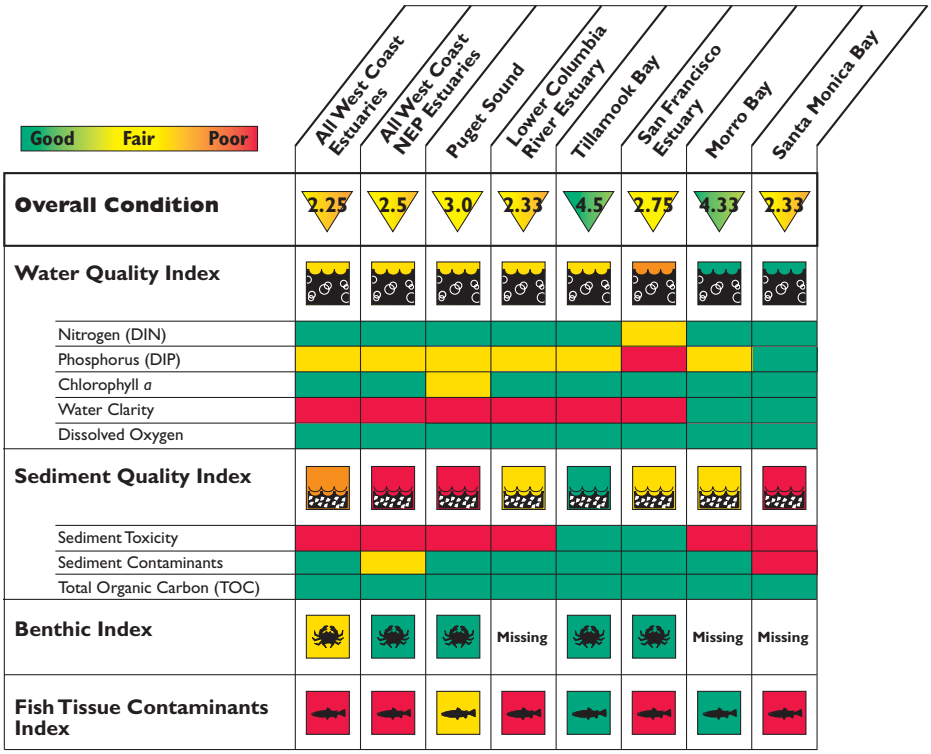

Figure 2-12. Comparison of NCA results for West Coast NEP estuaries and all West Coast estuaries (U.S. EPA/NCA).

The 28 NEPs identify habitat loss or alteration of habitat in the NEP estuaries as a primary environmental concern (Ed Garland).

NEP Environmental Concerns

There are a number of major environmental concerns that plague the nation's 28 NEP estuaries (ANEP, 2005; U.S. EPA, 2006d). As shown in Figure 2-13, several of these environmental concerns affect almost all of the NEPs, while others are a concern for a more limited number of NEPs and are related to site-specific differences in the climatic conditions, geology, or geomorphology of the individual estuaries. To address these issues, the 28 NEPs have made many of these environmental concerns the cornerstones of the priority management activities for their respective programs. The major environmental concerns for the NEP estuaries include those discussed below.

Habitat Loss/Alteration (28 NEPs)

All 28 of the NEPs identify habitat loss or alteration of habitat as a primary environmental concern. Estuaries are the transitional zones that provide high-quality habitat for a diverse array of organisms, including food, shelter, migratory corridors, and breeding and nursery areas for fish, shellfish, and waterfowl. Healthy estuaries and their associated wetlands and marshes protect water quality by sequestering toxicants, filtering nutrients from runoff and storing water, reducing flood potential, and protecting shorelines from erosion during hurricane and storm-related events; however, these areas are the habitats that are most affected by human development, including dredging and dredge-disposal activities; construction of groins, seawalls, and other hardened structures; and hydrologic modifications.

Declines in Fish and Wildlife Populations (25 NEPs)

Human population growth and the associated activities of residential and commercial development threaten the biological diversity, habitat quality, and productivity of our nation's estuaries. Environmental degradation associated with habitat loss, fragmentation or alteration, water pollution from toxic chemicals and nutrients, overexploitation of natural resources, and introduction of invasive species have all led to major declines in some of the native fish and wildlife populations that depend upon estuaries for their existence. In addition to the 25 NEPs that identify declines in fish and wildlife species as an environmental concern, 14 of these NEPs (~50%) identify that these declines have occurred in some recreationally or commercially valuable fish and shellfish species.

Excessive Nutrients (21 NEPs)

Nutrients such as nitrogen and phosphorus are naturally occurring and vital elements needed to support a healthy ecosystem; however, excessive amounts of nutrients can result in serious environmental problems. For example, algal blooms rob the water column of dissolved oxygen and diminish water clarity, reducing the growth of SAV (e.g., seagrasses). Loss of SAV acreage can result in loss of critical habitat needed to sustain healthy communities of fish and shellfish. From Delaware south to Florida's Atlantic and Gulf Coast estuaries, excessive nutrients have also been linked to fish kills by toxic algae such as *Pfiesteria piscicida* (N.C. Department of Health and Human Services, 2003). Nutrients can enter estuaries via runoff of agriculturally and residentially applied fertilizers and animal wastes, discharges from wastewater treatment plants (WWTPs), leaching from malfunctioning septic systems, and discharges of sanitary wastes from recreational boats. It is noteworthy that although excessive nutrients remain a concern in many estuaries, $53 billion in funding has been spent over the past 18 years to rebuild and upgrade WWTPs, resulting in expanded capacity for secondary and tertiary treatment of wastewater to remove nutrients, heavy metals, and organic contaminants (U.S. EPA, 2006a).

Toxic Chemical Contaminants (20 NEPs)

During the past 50 years, 70,000 synthetic chemicals have been released into the nation's estuarine and marine environments via stormwater runoff, industrial discharges, agricultural runoff, and deposition of toxicants from air pollution (ANEP, 2005). The chemical contaminants of major concern include metals (e.g., mercury), PCBs, PAHs, a variety of organochlorine pesticides (e.g., DDT, dieldrin, and chlordane), and herbicides. These chemicals may become adsorbed to estuarine sediments and affect the structure and diversity of benthic communities. In addition, they provide a conduit for chemical contaminants to move up the food chain because fish and other wildlife feed on benthic organisms living in areas with contaminated sediments.

Pathogenic Microorganisms (19 NEPs)

Pathogenic microorganisms (pathogens) include bacteria, viruses, and algae that produce diseases in plants, animals, and humans. In addition to human health risks from recreational contact with contaminated seawater and consumption of contaminated fish and shellfish, pathogen contamination in estuaries can result in economic losses due to shellfish-harvesting closures. Pathogens can cause disease conditions, such as gastroenteritis, salmonellosis, hepatitis A, and, in the case of the bacteria *Vibrio vulnificus*, can even cause death in some individuals (Rippey, 1994). Pathogen sources may include WWTP discharges, malfunctioning septic systems, land runoff from confined animal feeding operations (CAFOs) or concentrations of migratory waterfowl, and sanitary wastes from recreational boats.

Alteration of Freshwater Flows (11 NEPs)

In many parts of the United States, fresh water is an increasingly scarce natural resource. Human activities have altered the timing and volume of freshwater flows into some estuaries through dam construction and extensive withdrawals of water for irrigation or municipal drinking water use. Alteration in the timing and volume of freshwater flows can have devastating repercussions for estuarine plants and animals, especially in regions where rainfall is minimal. Alterations in freshwater discharges can result in changes in salinity, nutrient, and sediment levels in estuarine waters, which can affect seasonal fish-spawning activities, shellfish condition, avian nesting activities, and the health of wildlife that are dependent on the estuaries (ANEP, 2005).

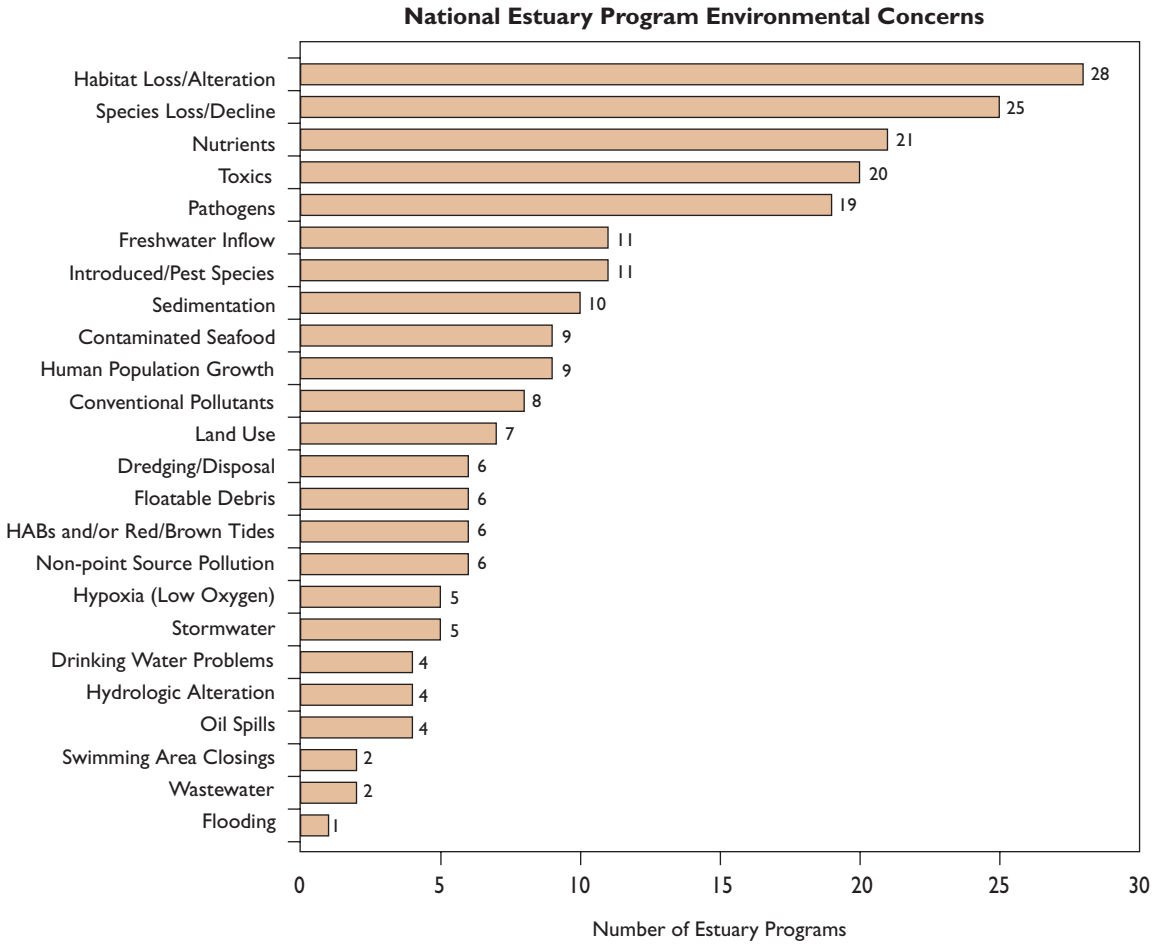

Figure 2-13. List of environmental concerns of the nation's 28 individual NEPS (U.S. EPA, 2006d).

Introduction of Invasive Species (11 NEPs)

Invasive species can be plants, animals, and other organisms such as microorganisms (e.g., bacteria, viruses, algae) that are typically introduced through human activities. An invasive species is one that is non-native to the ecosystem under consideration and whose introduction causes economic or environmental harm or human health concerns (USDA, 2006). The food webs of some NEP estuaries have been altered by the introduction of non-indigenous, exotic species, including both plants and animals. These invading, opportunistic species have, through predation of and competition with native species, led to the alteration or eradication of many native plants and animals. Invasive species can also affect commercial and recreational fishing, recreational boating, and beach ecology; interfere with industrial processes and navigation; cause wetlands loss; and modify nutrient cycling and soil fertility (ANEP, 2005). Many invasive species are transported by cargo ships, which discharge millions of gallons of ballast water at large commercial shipping ports in the United States. Other species are imported intentionally into the United States through the aquarium or water garden trade (USGS, 2006a). The European milfoil (*Myriophyllum spicatum*) is a prime example of an invasive SAV species that can become permanently established where it is introduced. In many estuarine rivers and bays along the Atlantic, Gulf, and Pacific coasts, water milfoil has thrived and has become the dominant SAV.

Although some environmental concerns are universal among the NEP estuaries, others are restricted to only a few NEPs. Each individual NEP must address, monitor, and effectively manage a slightly different suite of environmental concerns relative to their own estuary. Further information on some of the more important environmental concerns confronting each of the 28 NEP estuaries is described in the latter half of each NEP profile (Chapters 3 through 7) in the section entitled *Indicators of Estuarine Condition*.