This document contains the National Chapter of the National Estuary Program Coastal Condition Report. The National Chapter contains statements and graphics depicting the overall condition of all the National Estuary Programs on a regional and national basis. The entire report can be downloaded from
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National Estuary Program Coastal Condition Report

Chapter 2: Condition of National Estuary Program Sites — A National Snapshot

June 2007

CHAPTER 2

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

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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

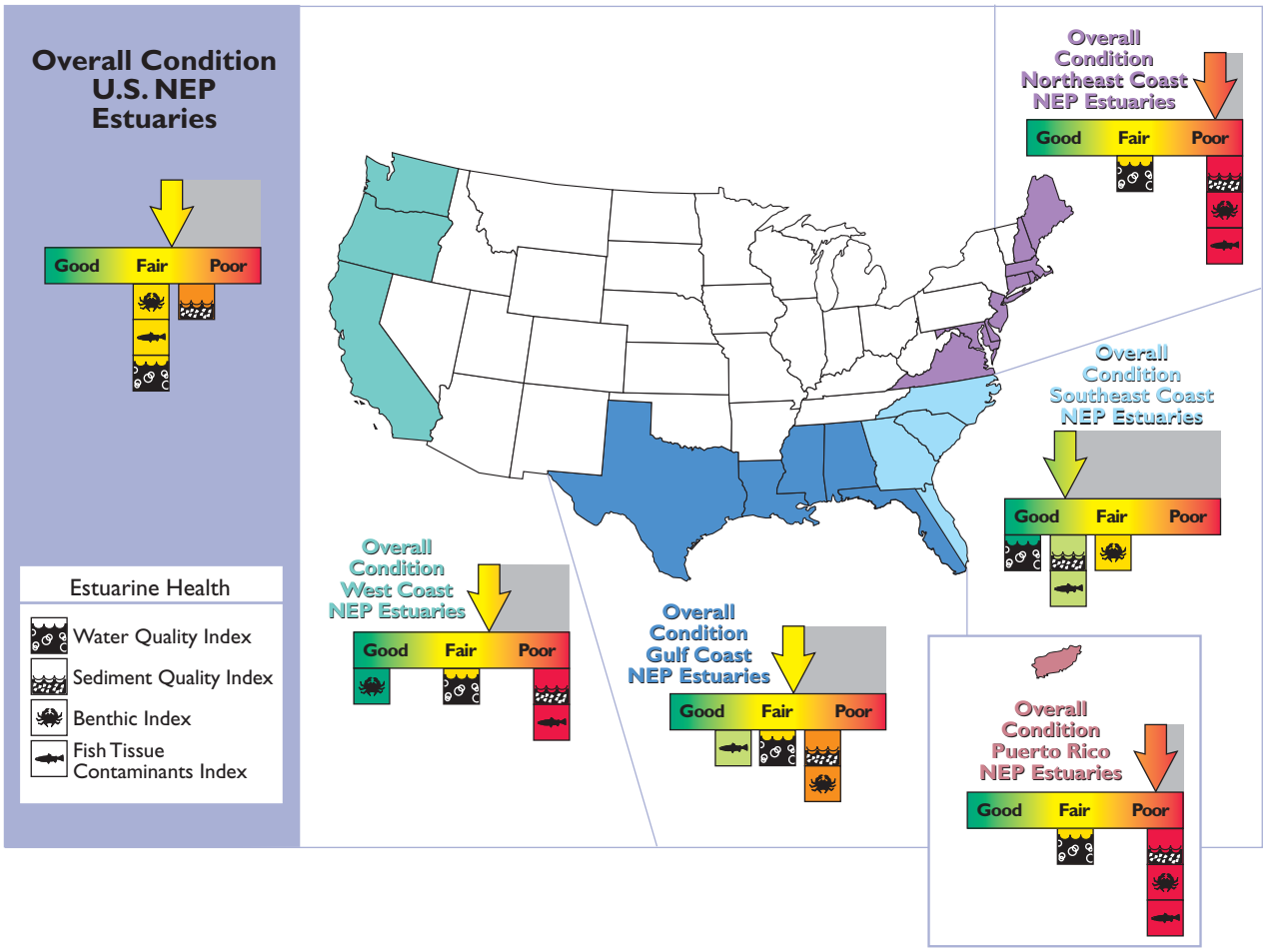

Figure 2-1. National and regional overall condition ratings for the nation's NEP estuaries (U.S. EPA/NCA).

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.

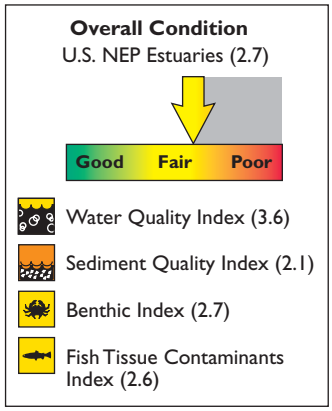

Figure 2-2. The overall condition of the nation's NEP estuarine area is fair (U.S. EPA/NCA).

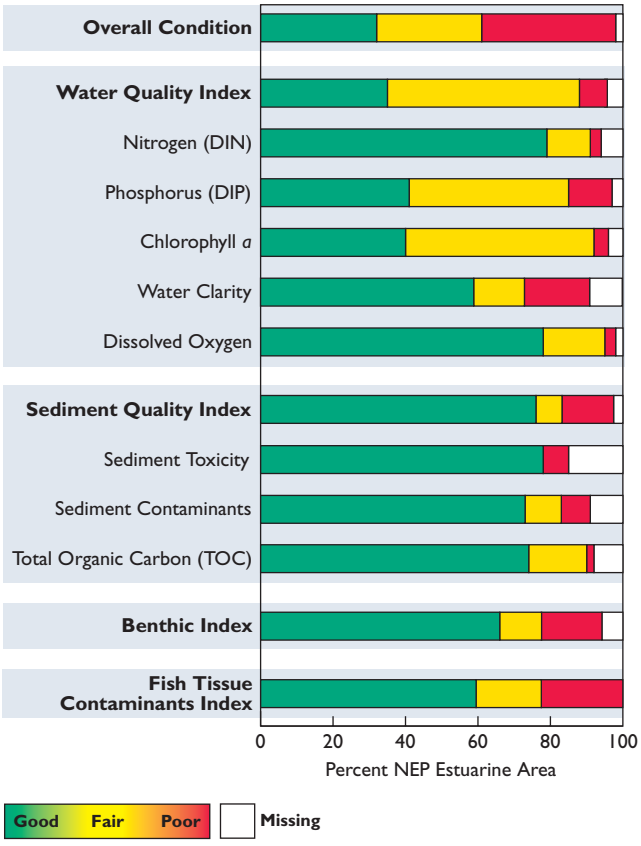

Figure 2-3. Percentage of estuarine area achieving each rating for all indices and component indicators – U.S. NEP estuaries (U.S. EPA/NCA).

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.

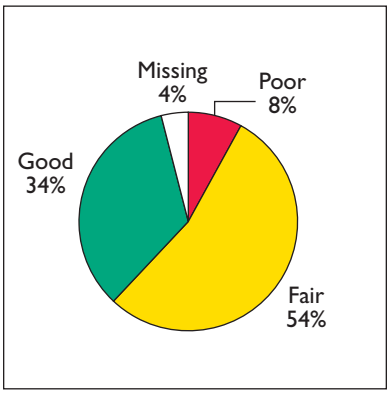

Figure 2-4. Water quality index data for U.S. NEP estuaries (U.S. EPA/NCA).

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.

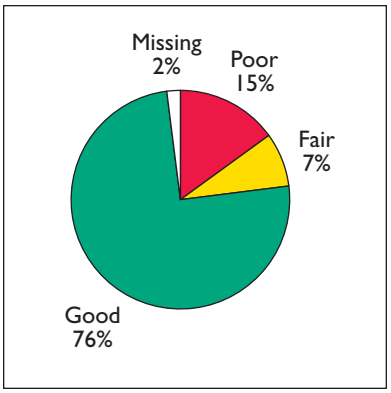

Figure 2-5. Sediment quality index data for U.S. NEP estuaries (U.S. EPA/NCA).

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.

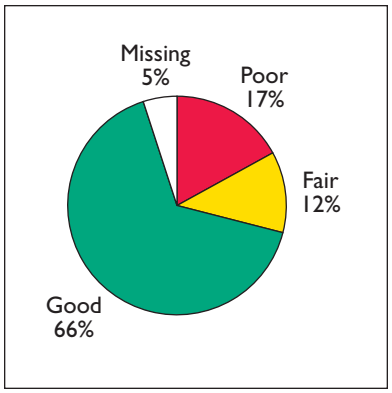

Figure 2-6. Benthic index data for U.S. NEP estuaries (U.S. EPA/NCA).

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

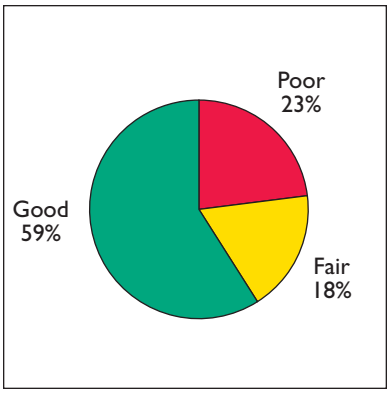

Figure 2-7. Fish tissue contaminants index data for U.S. NEP estuaries (U.S. EPA/NCA).

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).

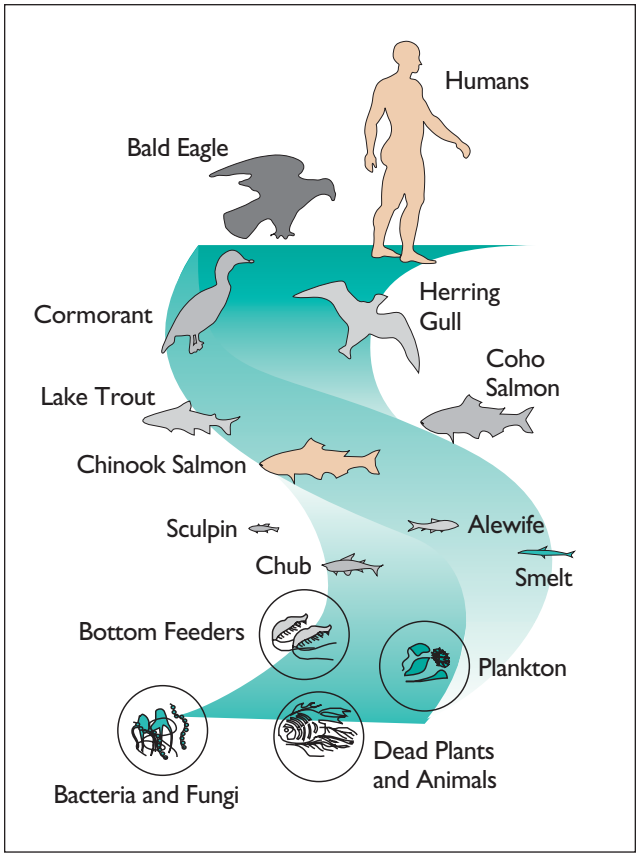

Figure 2-8. Bioaccumulation process (U.S. EPA/NCA).

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).

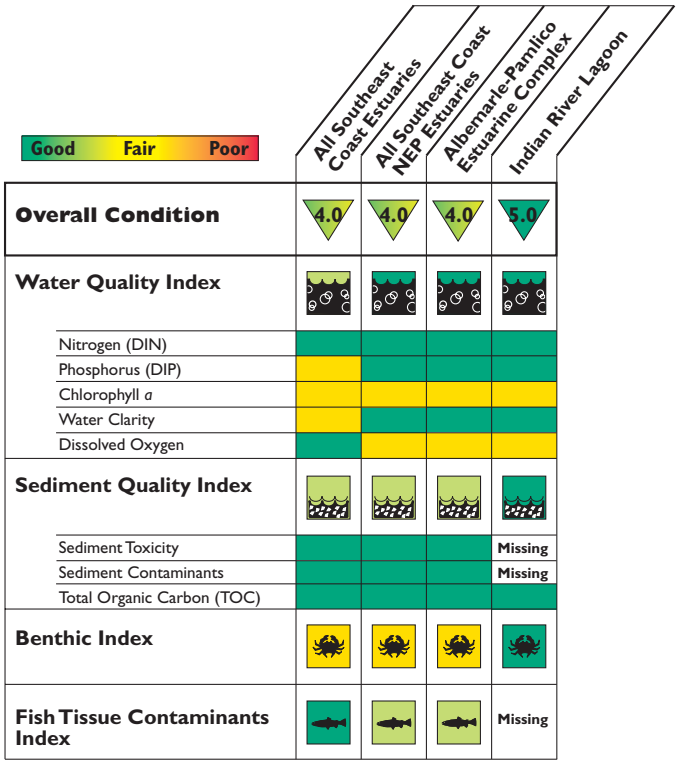

Figure 2-10. Comparison of NCA results for Southeast Coast NEP estuaries and all Southeast Coast estuaries (U.S. EPA/NCA).

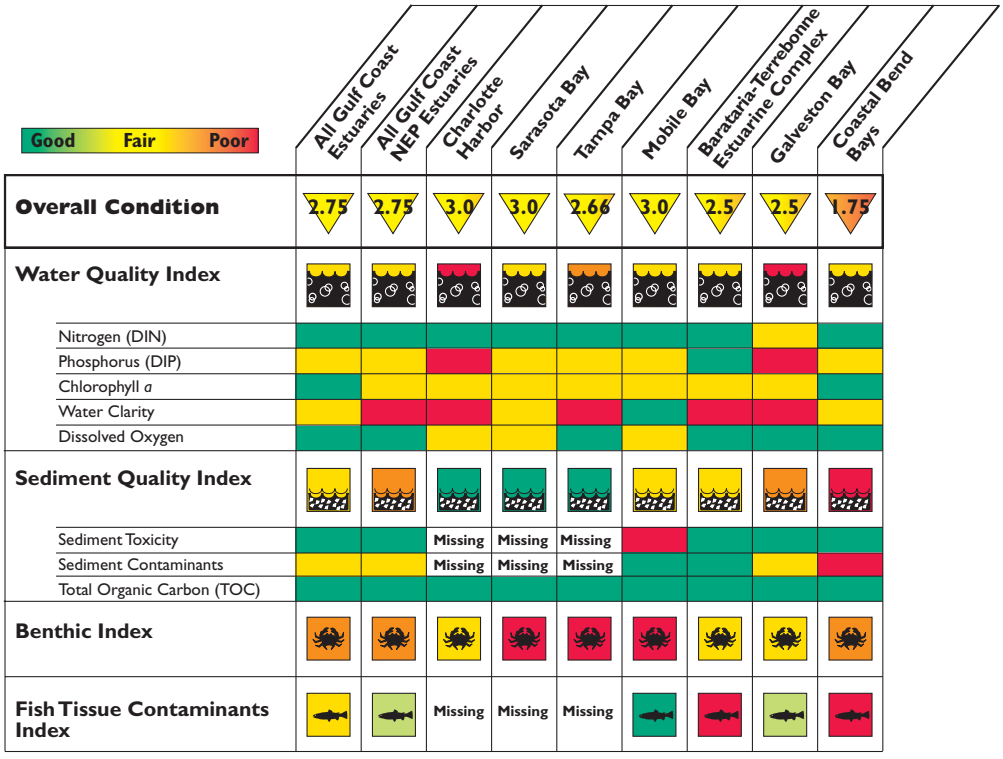

Figure 2-11. Comparison of NCA results for Gulf Coast NEP estuaries and all Gulf Coast estuaries (U.S. EPA/NCA).

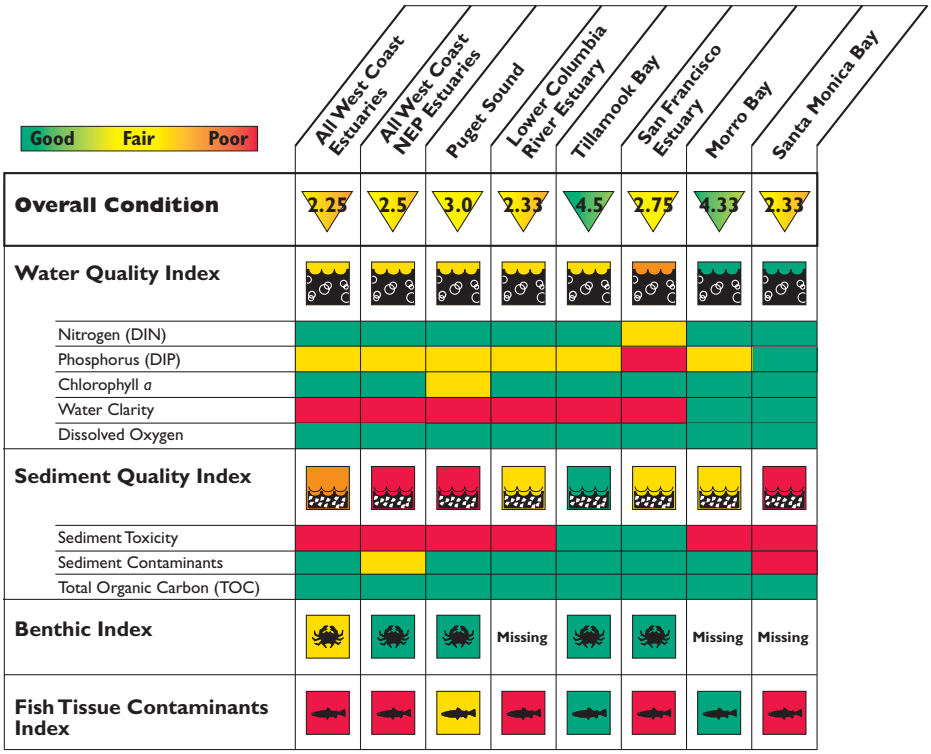

Figure 2-12. Comparison of NCA results for West Coast NEP estuaries and all West Coast estuaries (U.S. EPA/NCA).

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).

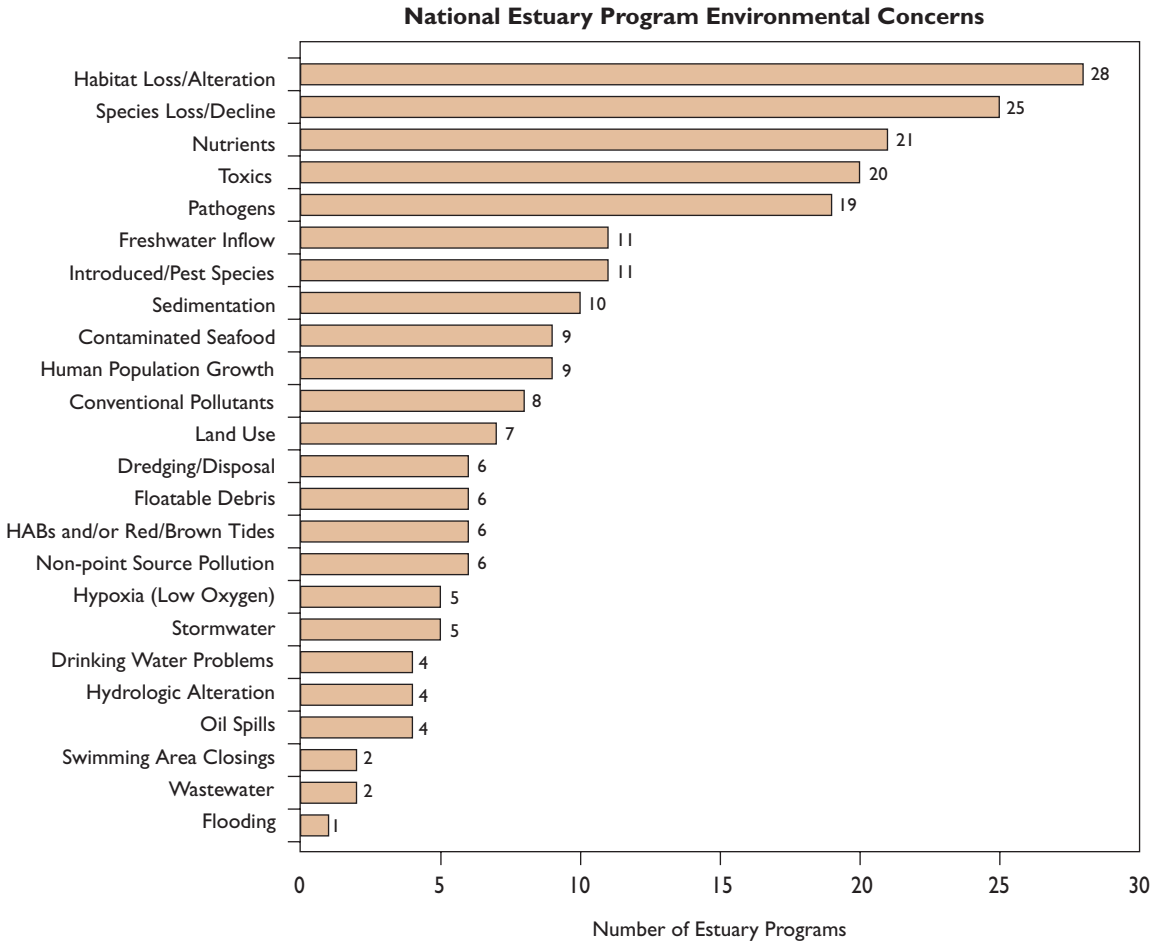

Figure 2-13. List of environmental concerns of the nation's 28 individual NEPS (U.S. EPA, 2006d).

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*.