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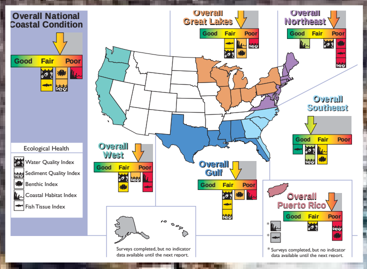
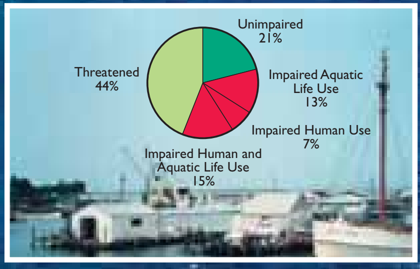
National Coastal Condition Report II





Lighthouse cover photo by Kim Ferguson, Waynesville, North Carolina

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Contents

Executive Summary

Coastal waters in the United States include estuaries, coastal wetlands, coral reefs, mangrove and kelp forests, seagrass meadows, and upwelling areas. Critical coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. The nation's coastal resources also provide nesting, resting, feeding, and breeding habitat for 85% of waterfowl and other migratory birds. Estuaries are bodies of water that provide transition zones between the fresh water from rivers and the saline environment of the ocean. This interaction produces a unique environment that supports wildlife and fisheries and contributes substantially to the economy of the United States.

Section 305(b) of the Clean Water Act requires that the U.S. Environmental Protection Agency (EPA) report periodically on the condition of the nation's waters. As part of this process, coastal states provide valuable information about the condition of their coastal resources to EPA. However, because the individual states use a variety of approaches for data collection and evaluation, it is difficult to compare this information between states or on a national basis.

To better address questions about national coastal condition, EPA, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of the Interior (DOI), and the U.S. Department of Agriculture (USDA) agreed to participate in a multiagency effort to assess the condition of the nation's coastal resources (U.S. EPA, 1998). The agencies chose to assess condition using nationally consistent monitoring surveys in order to minimize the problems created by compiling data collected using multiple approaches. The results of these assessments are compiled periodically into a National Coastal Condition Report.

The first National Coastal Condition Report (NCCR I), published in 2001, reported that the nation's estuarine resources were in fair condition. The NCCR I used available data from 1990 to 1996 to characterize about 70% of the nation's estuarine resources. Agencies contributing these data included EPA, NOAA, the U.S. Fish and Wildlife Service (FWS), and USDA. This second National Coastal Condition Report (NCCR II) is based on available data from 1997 to 2000. These data are representative of 100% of estuarine acreage in the conterminous 48 states and Puerto Rico, and they show that the nation's estuaries continue to be in fair condition. Agencies contributing data to this report include EPA, NOAA, FWS, and the U.S. Geological Survey (USGS). Several state, regional, and local organizations also provided information on the current condition of the nation's coasts.

With each National Coastal Condition Report, the collaborating agencies strive to provide a more comprehensive picture of the nation's coastal resources. The NCCR II builds on the foundation provided by the NCCR I, and efforts are under way to assess even more areas using comparable and consistent methods. Although the NCCR II provides some condition data for Alaska, Hawaii, U.S. island commonwealths and territories, and the Great Lakes, these data are not comparable with data provided for other regions. Current monitoring efforts in Alaska, Hawaii, and the island commonwealths and territories, however, will allow comparisons in future National Coastal Condition Reports.

The NCCR II presents three main types of data: (1) coastal monitoring data, (2) offshore fisheries data, and (3) assessment and advisory data. The ratings of coastal condition in the report are based primarily on coastal monitoring data because these are the most comprehensive and nationally consistent data available related to coastal condition. One source of coastal monitoring data is obtained through EPA's National Coastal Assessment (NCA) Program, which provides information on the condition of coastal estuaries for most regions of the United States. The NCCR II relies heavily on NCA estuarine data in assessing coastal condition and uses NCA and other data to evaluate five indicators of condition—water quality, sediment quality, benthic community condition, coastal habitat loss, and fish tissue contaminants—in each region of the United States (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Great Lakes, and Puerto Rico). The resulting ratings for each indicator are then used to calculate both the overall regional ratings and an overall national rating of coastal condition. This national assessment applies to 28 coastal states (20 ocean states, 6 Great Lakes states, and 2 ocean/Great Lakes states) and Puerto Rico (Figure ES-1).

In addition to rating coastal condition based on coastal monitoring data, the NCCR II summarizes available information related to offshore fisheries and

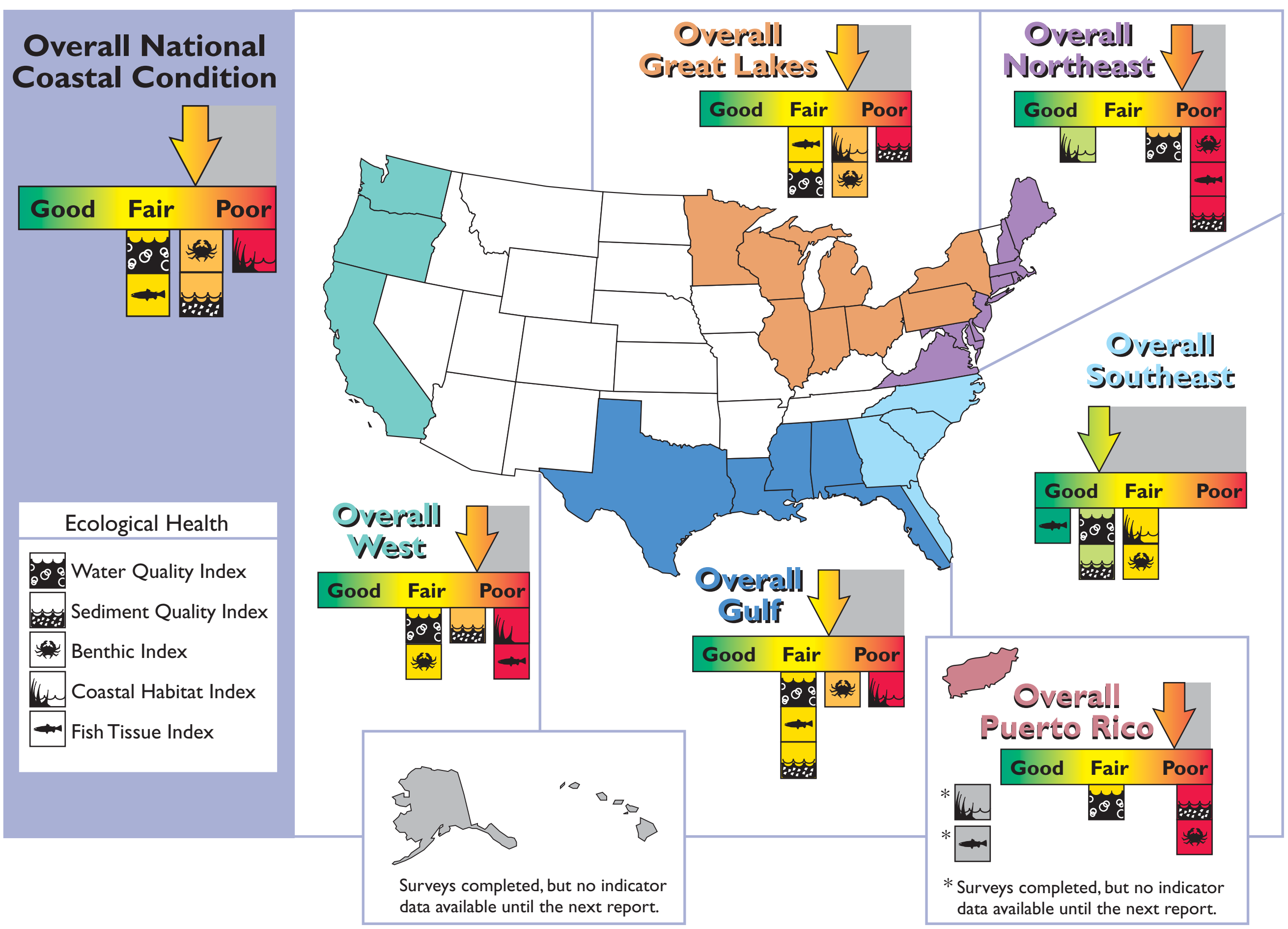


Figure ES-1. Overall national coastal condition based on results of the NCA Program, the Great Lakes State of the Lakes Ecosystem Conference (SOLEC) Program, and FWS's National Wetland Inventory (1997–2000).

beach advisories and closures. This information, together with descriptions of individual monitoring programs, paints a picture of the overall condition of coastal resources in the United States.

Summary of the Findings

This report is based on the large amount of monitoring data collected between 1997 and 2000 on the condition of the estuarine and Great Lakes resources of the United States. Ecological assessment of these data shows that the nation's estuaries are in fair condition, with poor conditions in the Northeast Coast and Puerto Rico regions and fair conditions in the Southeast Coast, Gulf Coast, Great Lakes, and West Coast regions. No overall assessments were completed of Alaska, Hawaii, Guam, American Samoa, the Northern Mariana Islands, or the U.S. Virgin Islands; however, surveys of Alaska and Hawaii have been completed, samples are being analyzed, and data will be available in 2004. New ecological monitoring programs will permit a comprehensive and consistent assessment of all of the nation's coastal resources by 2006.

The major findings of the 1997–2000 study period are as follows:

- Overall condition of the nation's estuaries is fair. This rating is based on five indicators of ecological condition: water quality index (including dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity), sediment quality index (including sediment toxicity, sediment contaminants, and sediment total organic carbon [TOC]), benthic index, coastal habitat index, and a fish tissue contaminants index.
- Twenty-one percent of assessed resources are unimpaired (good condition), whereas 35% are impaired (poor condition) and 44% are threatened (fair condition) for aquatic life use or human use.
- Twenty-five percent of estuarine waters are impaired for swimming, based on the water clarity data presented in this report. Water clarity represents the aesthetic component of this human use. The suitability of estuarine waters for swimming is best measured using microbial measures, which are not included in this report.
- Twenty-two percent of estuarine waters are impaired for fishing, based on the risk-based noncancer guidelines for moderate consumption. Suitability of waters for fishing is measured using the fish tissue contaminants index in this report.
- Twenty-eight percent of estuarine waters are impaired for aquatic life use. Suitability of waters for aquatic life use is measured using the water quality, sediment quality, benthic, and habitat loss indices in this report.
- The indicators that show the poorest conditions throughout the United States are coastal habitat condition, sediment quality, and benthic condition. The indicators that generally show the best condition are the individual components of water quality—dissolved oxygen and dissolved inorganic nitrogen (DIN) (Table ES-1).

Table ES-1. Rating Scores[a] by Indicator and Region

Indicator	Northeast Coast	Southeast Coast	Gulf Coast	West Coast	Great Lakes	Puerto Rico	United States[b]
Water Quality Index	2	4	3[c]	3	3	3	3.0
Sediment Quality Index	1	4	3	2	1	1	2.1
Benthic Index	1	3	2	3	2	1	2.0
Coastal Habitat Index	4	3	1	1	2	—[d]	1.7
Fish Tissue Contaminants Index	1	5	3	1	3	—[d]	2.7
Overall Condition	1.8	3.8	2.4	2.0	2.2	1.7	2.3

[a] Rating scores are based on a 5-point system, where 1 is poor and 5 is good.

[b] The U.S. score is based on an aerially weighted mean of regional scores.

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

[d] No coastal habitat index loss or fish tissue contaminants index results were available for Puerto Rico.

Table ES-2. Percent Area in Poor Condition[a] by Indicator (except Coastal Habitat Index) and Region

Indicator	Northeast Coast	Southeast Coast	Gulf Coast	West Coast	Great Lakes	Puerto Rico	United States
Water Quality Index[b]	19	5	9[c]	3	—	9	11
Sediment Quality Index[d]	16	8	12	14	—	61	13
Benthic Index	22	11	17	13	—	35	17
Coastal Habitat Index[e]	1.00	1.06	1.30	1.90	—	—	1.26
Fish Tissue Contaminants Index[f]	31	5	14	27	—	—	22
Overall Poor Condition[g]	40[h]	23	40	23	—	77	35

a The percent area of poor condition is the percentage of total estuarine surface area in the region or the nation (proportional area information is not available for the Great Lakes).

b The water quality index is based on a combination of water quality measurements (dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity).

c The area of poor condition does not include the hypoxic zone in offshore Gulf Coast waters.

d The sediment quality index is based on a combination of sediment quality measurements (sediment toxicity, sediment contaminants, and sediment TOC).

e The coastal habitat index is based on the average of the mean long-term, decadal wetland loss (1780–1990) and the present decadal wetland loss rate (1990–2000).

f The fish tissue contaminants index is based on analyses of whole fish (not fillets).

g The overall percentage is based on the overlap of the five indicators and includes estuarine area for all of the conterminous 48 states (by region and total) and Puerto Rico.

h In Northeast Coast estuaries, at least one of the five indicators is rated poor at sites representing 40% of total estuarine area.

Describing Coastal Condition

Three types of data are presented in this report:

- **Coastal Monitoring Data**—data from programs such as EPA's Environmental Monitoring and Assessment Program (EMAP) and the NCA Program, NOAA's National Status and Trends (NS&T) Program, and FWS's National Wetlands Inventory (NWI), as well as Great Lakes information from the State of the Lakes Ecosystem Conference (SOLEC). These data are used in this report to develop indicators of condition that are then used to calculate regional and national ratings of coastal condition.
- **Offshore Fisheries Data**—data from programs such as NOAA's Marine Monitoring and Assessment Program (MARMAP) and Southeast Area Monitoring and Assessment Program (SEAMAP). These data are used in this report to assess the condition of coastal fisheries in large marine ecosystems (LMEs).
- **Assessment and Advisory Data**—data provided by states or other regulatory agencies that are compiled in nationally maintained databases. The agencies contributing data use different methodologies and criteria for assessment; therefore, the data cannot be used to make broad-based comparisons among the different coastal areas. These data provide information about designated use support, which affects public perception of coastal condition as it relates to public health.

Coastal Monitoring Data

About 21% of the estuarine area in the contiguous 48 states and Puerto Rico is in good condition for supporting aquatic life and human uses (Figure ES-2). About 28% of the estuarine area shows evidence of impaired aquatic life use, and 22% shows evidence of impaired human use. An additional 44% of estuarine waters show threatened aquatic life and human uses.

For EPA, issues regarding coastal condition can often be reduced to three simple questions: Are the waters swimmable? Are the waters fishable? Do the waters support aquatic life? This report can address all three questions.

- **Swimming.** Suitability for swimming is best analyzed using a measure of microbial contamination of estuarine waters or sediments. However, the NCA has not been able to develop a microbial indicator that is consistently collected throughout U.S. estuarine waters that can meet all quality assurance requirements. The most applicable indicator measured by the NCA that can be used to address swimming is water clarity (an aesthetic indicator). About 25% of estuarine waters assessed have poor water clarity.
- **Fishing.** Twenty-two percent of sites sampled for fish in the United States exceed risk-based noncancer guidelines for consumption of four 8-ounce meals per month. An additional 15% of sites show contaminant concentrations within the range of these noncancer guidelines. The suitability of waters for fishing is measured using the fish tissue contaminants index, which received a national rating of fair.
- **Aquatic Life Use.** Based on the water quality index, sediment quality index, benthic index, and coastal habitat index, 28% of U.S. estuarine surface area is impaired for aquatic life use.

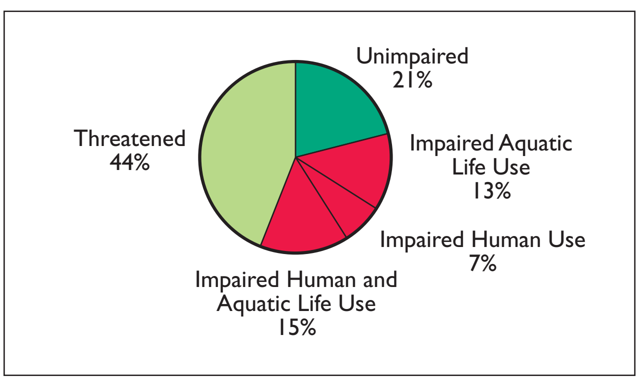
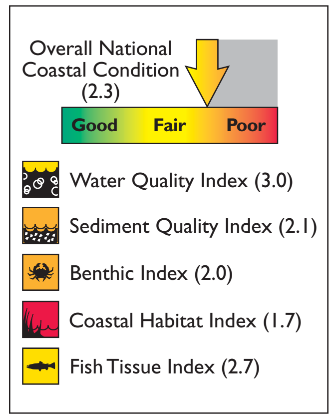


Figure ES-2. National estuarine condition (U.S. EPA/NCA).

The overall condition of the nation's estuarine waters is fair (Figure ES-3). This rating is based on the combination of the five component indicators: water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index. Supplemental information (e.g., information on water clarity, dissolved oxygen, DIN, dissolved inorganic phosphorus [DIP], chlorophyll *a*, sediment contaminants, sediment toxicity, and sediment TOC), when available, is also presented throughout this report according to the rating criteria presented in Table ES-3. These five indicators were assigned a good, fair, or poor rating for each coastal region of the United States. The ratings were then averaged to create an overall score for each coastal area.

Figure ES-3. The overall estuarine condition for the nation is fair.



Of the 2.5 million visitors to the Florida Keys each year, 17% participate in some type of fishing activity during their visit (Photo: Page Guill, Florida Keys NMS).

Table ES-3. Indicators Used to Assess Coastal Condition (NCA)

Icon	Indicator	Ecological Condition by Site	Ranking by Region
Water Quality Index	**Water Quality Index** is an index that is based on five water quality measurements (dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity).	**Good:** No measures are rated poor, and a maximum of one is rated fair. **Fair:** One measure is rated poor, or two or more measures are fair. **Poor:** Two or more measures are rated poor.	**Good:** Less than 10% of coastal waters are in poor condition, *and* less than 50% of coastal waters are in combined poor and fair condition. **Fair:** Between 10% and 20% of coastal waters are in poor condition, *or* more than 50% of coastal waters are in combined fair and poor condition. **Poor:** More than 20% of coastal waters are in poor condition.
Sediment Quality Index	**Sediment Quality Index** is an index that is based on three sediment quality measurements (sediment toxicity, sediment contaminants, and sediment TOC).	**Good:** No measures are rated poor, and the sediment contaminants indicator is rated good. **Fair:** No measures are rated poor, and the sediment contaminants indicator is rated fair. **Poor:** One or more measures are rated poor.	**Good:** Less than 5% of coastal sediments are in poor condition, *and* less than 50% of coastal sediments are in combined poor and fair condition. **Fair:** Between 5 and 15% of coastal sediments are in poor condition, *or* more than 50% of coastal sediments are in combined poor and fair condition. **Poor:** More than 15% of coastal sediments are in poor condition.
Benthic Index	**Benthic Index** (or a surrogate measure) is an indicator of the condition of the benthic community (organisms living in estuarine sediments) and can include measures of benthic community diversity, the presence and abundance of pollution-tolerant species, and the presence and abundance of pollution-sensitive species.	**Good**, **fair**, and **poor** were determined using regionally dependent benthic index scores.	**Good:** Less than 10% of coastal sediments have a poor benthic index score, *and* less than 50% of coastal sediments have a combined poor and fair benthic index score. **Fair:** Between 10% and 20% of coastal sediments have a poor benthic index score, *or* more than 50% of coastal sediments have a combined poor and fair benthic index score. **Poor:** More than 20% of coastal sediments have a poor benthic index score.
Coastal Habitat Index	**Coastal Habitat Index** is evaluated using the data from the NWI (NWI, 2002). The NWI contains data on estuarine-emergent and tidal flat acreage for all coastal states (except Hawaii and Puerto Rico) for 1780 through 2000.	The average of the mean long-term, decadal wetland loss rate (1780–1990) and the present decadal wetland loss rate (1990–2000) was determined for each region of the United States and multiplied by 100 to create a coastal habitat index score.	**Good:** The coastal habitat index score is less than 1.0. **Fair:** The coastal habitat index is between 1.0 and 1.25. **Poor:** The coastal habitat index is greater than 1.25.
Fish Tissue Index	**Fish Tissue Contaminants Index** concentrations are an indicator of the level of chemical contamination in target fish/shellfish species.	**Good:** Composite fish tissue contaminant concentrations are below the EPA Guidance concentration range. **Fair:** Composite fish tissue contaminant concentrations are in the EPA Guidance concentration range. **Poor:** Composite fish tissue contaminant concentrations are above the EPA Guidance concentration range.	**Good:** Less than 10% of estuarine sites are in poor condition, *and* less than 50% are in combined fair and poor condition. **Fair:** From 10 to 20% of estuarine waters are in poor condition, *or* more than 50% are in combined fair and poor condition. **Poor:** More than 20% of sites have poor condition.

A summary of each indicator is presented below.

- **Water Quality Index:** This index is rated fair throughout the United States; however, a slightly larger proportion of waters in Northeast Coast estuaries are in poor condition (19%), resulting in a rating of fair to poor.
- **Sediment Quality Index:** This index is rated fair to poor for the United States. Sediment quality is poor for the Northeast Coast, Great Lakes, and Puerto Rico. Sediment quality in the remainder of the country's estuarine waters is in fair condition. Many regions of the United States have significant sediment degradation, including contaminant concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and metals that are above EPA Guidance levels. Most of these exceedances occur in Northeast Coast and Puerto Rico estuaries. High concentrations of sediment TOC (often associated with the deposition of human, animal, and plant wastes) are observed in 44% of Puerto Rico estuaries.
- **Benthic Index:** Benthic condition is fair to poor in most of the United States. Poor condition is observed in Northeast Coast and Puerto Rico estuaries, largely as a result of degraded sediment quality; however, in some cases, it is associated with poor water quality conditions, low dissolved oxygen, and elevated nutrient concentrations.
- **Coastal Habitat Index:** This index is rated poor for the nation's estuaries. Coastal wetland losses from 1780 to 2000 were greater than or equal to 1% per decade in each region. The index score was greater than 1.25 in coastal wetland areas of the West Coast and the Gulf of Mexico.
- **Fish Tissue Contaminants Index:** The overall rating for fish tissue contaminants for the nation is fair. Fish tissue contaminant concentrations are above EPA Guidance levels in fish captured in Northeast Coast and West Coast estuaries for 4 of the 75 contaminants measured (total PCBs, total PAHs, total dichloro-diphenyltrichlorethane [DDT], and mercury). Projections in fillets based on whole-body concentrations show that mercury concentrations in fillets are likely to exceed EPA Guidance levels for about 42% of sites in the United States. Fish tissue contaminant concentrations were not available for estuaries in Puerto Rico, Florida, and Louisiana.

Offshore Fisheries

Currently, the only comprehensive, nationally consistent data on the condition of offshore coastal waters are fisheries resource data from NOAA surveys. In 2001, NOAA's Office of Sustainable Fisheries reported on the status of 595 marine fish and shellfish stocks out of 951 total stocks (NMFS, 2002). Eighty-one stocks were overfished (compared with 92 in 2000), and 67 of these (83%) were steadily rebuilding. Twenty more stocks had sustainable harvest rates in 2001 than did in 2000. Sixty-five stocks experienced catches exceeding allowable harvest levels. The National Marine Fisheries Service (NMFS) has approved rebuilding plans for the majority of overfished stocks. Of the 81 stocks that are overfished, 67 have an approved rebuilding plan and 9 have plans under development.

Assessment and Advisory

Assessment information from the 2000 305(b) report (data submitted by the states in 2000) is available for 36% of the nation's estuaries and 6% of the nation's shoreline waters. Available information suggests that 51% of assessed estuaries and 14% of assessed shoreline waters in the United States (excluding Alaska) are impaired by some form of pollution or habitat degradation (Figure ES-4). This information is consistent with the national coastal monitoring data presented in this report. States and tribes rate water quality for CWA

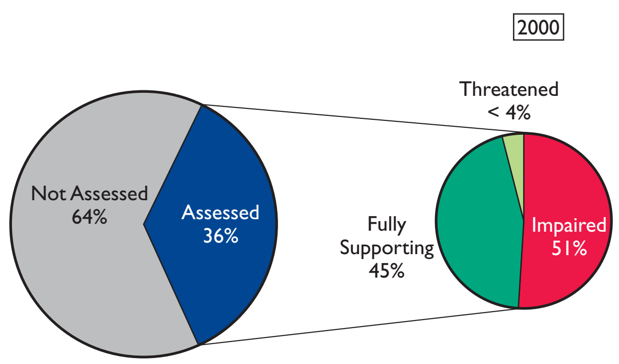


Figure ES-4. Water quality for assessed estuaries of the United States (US EPA).

reporting by comparing available water quality data to their water quality standards (water quality standards include narrative and numeric criteria that support specific designated uses, such as swimming and aquatic life use). Each state has different monitoring resources and uses a different methodology for assessment, so this information is not nationally consistent and is often incomplete. Aquatic life support, primary contact recreation (swimming), and fish consumption are the designated uses that were most frequently impaired. The leading stressors resulting in these impairments are metals, pesticides, oxygen-depleting substances (oxygen is consumed during the degradation of organic matter and the oxidation of some inorganic matter), toxic chemicals, PCBs, and dissolved solids.

The number of coastal and estuarine waters under fish consumption advisories represent an estimated 74% of the shoreline miles of the United States, including 92% of East Coast, 100% of Gulf Coast, and 11% of West Coast shoreline miles. An estimated 50% of the estuarine square miles also are under advisory, including 78% of East Coast estuaries, 23% of Gulf Coast estuaries, and 20% of West Coast estuaries (Figure ES-5). Every Great Lake is under at least one advisory, and advisories covered 100% of the Great Lakes shoreline (U.S. EPA, 2003c).

EPA's review of coastal beaches (U.S. coastal areas, estuaries, and the Great Lakes) showed that of the 1,813 marine or Great Lakes beaches responding to the survey, 529 beaches, or 29%, had an advisory or closing in effect at least once during 2002 (Figure ES-6). Beach closures were issued for various reasons, including sewage contamination, elevated bacterial levels, and preemptive reasons. The major sources of contamination were stormwater runoff, sewerline problems, sewer overflows, and in many cases, unknown sources.

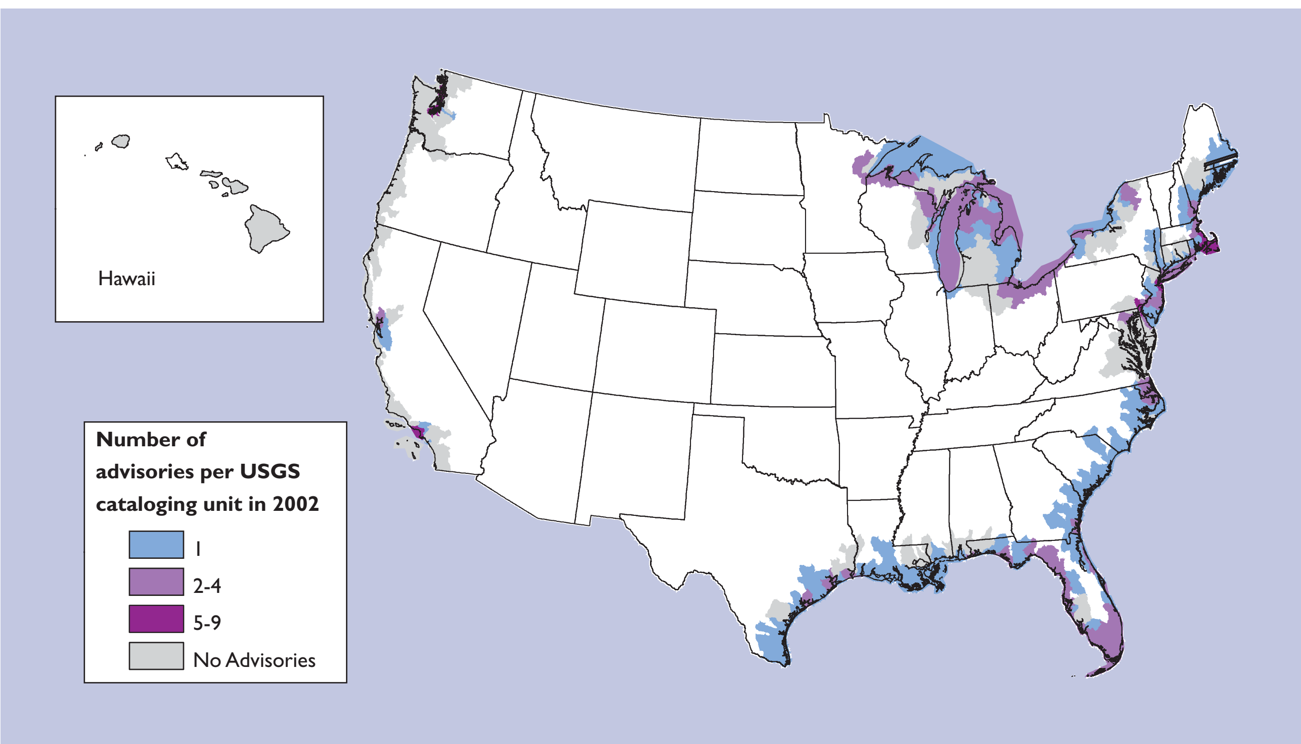


Figure ES-5. The number of coastal and estuarine fish consumption advisories per USGS cataloging unit . This count does not include advisories that may exist for noncoastal or nonestuarine waters. Alaska did not report advisories (U.S. EPA, 2003c).

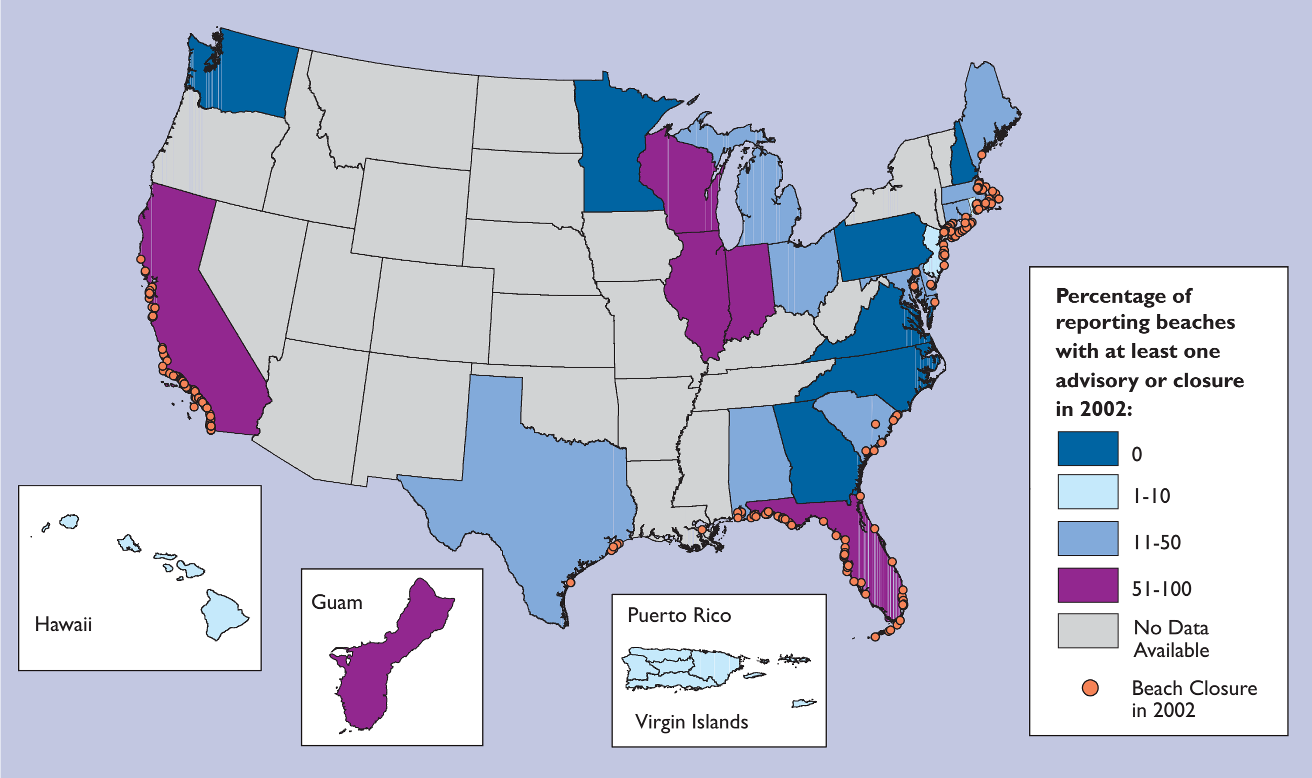


Figure ES-6. Percentage of marine and Great Lakes beaches reporting with at least one advisory or closure in 2002 (U.S. EPA, 2003a).

Shortcomings of Available Data

This report focuses on coastal regions for which nationally consistent and comparable data are available. Such data are currently available only for the conterminous 48 states and Puerto Rico. Alaska has very little information to support the kind of analysis used in this report (i.e., spatial estimates of condition based on indicators measured consistently across broad regions). Nearly 75% of the area of all the bays, sounds, and estuaries in the United States is located in Alaska, and no national report on estuarine condition can be truly complete without information on the condition of living resources and use attainment of these waters. Similarly, little information is available for Hawaii, the Caribbean, or the Pacific territories to support estimates of conditions based on the indicators used in this report. Although these latter systems make up only a small portion of the nation's estuarine area, they do represent a set of estuarine subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States, with the exception of the Florida Keys and the Flower Gardens off the Louisiana/Texas coast. These unique systems should not be excluded from future national assessments, and initial condition surveys have already been completed for monitoring programs in Hawaii and portions of Alaska.

This report tries to make the best use of available data in order to characterize and assess the condition of the nation's estuarine resources; however, the report cannot represent all individual estuarine systems of the United States or all of the appropriate spatial scales (e.g., national, regional, and local) necessary to assess the condition of estuaries. This assessment is based on a limited number of ecological indicators for which consistent data sets are available to support estimates of ecological condition on regional and national scales. Through a multiagency and multistate effort over the continuing decade, a truly consistent, comprehensive, and integrated national coastal monitoring program can be realized. Only through the cooperative interaction of the key federal agencies and coastal states will the next effort to gauge the health of the coastal ecosystems in the United States be successful.

Although most of the chapters in this report use ecological indicators to address the condition of coastal resources in each region, the last chapter addresses coastal condition in the context of how well estuaries are meeting the uses that humans expect of them. Only one estuary, Galveston Bay, was considered for this report. In this case, it appears that human uses for commerce, fishing, and recreation are being met. The exception is that fish consumption advisories are required at the upper end of Galveston Bay near Houston.

Comparisons to the First National Coastal Condition Report

A primary goal of the National Coastal Condition Reports is to provide a benchmark of coastal condition in order to measure the success of coastal programs over time. To achieve this end, the conditions reported in each report need to be comparable. For the first two reports (NCCR I and NCCR II), there is insufficient information to examine the potential trends in estuarine condition that might be related to changes in environmental programs and policies. In the next report (anticipated in 2006), the information from 1990 through 2002 will be evaluated for potential trends.

Comparing data between the NCCR I and NCCR II is complicated because, in some cases, indicators were changed in order to improve the assessment. For example, in the NCCR I, seven indicators were used, including multiple indicators for water quality, whereas a single water quality indicator is used in the NCCR II. In addition, reference conditions for some of the indicators were modified to reflect regional differences. In order to facilitate a comparison between these two reports, the values reported in the NCCR I Executive Summary were recalculated, to the extent possible, using the approaches followed in the NCCR II and are shown in Table ES-4. The table shows that overall condition in U.S. estuaries is essentially the same as in the NCCR I. A more detailed comparison of the results reported in the two reports appears in Appendix C.

Table ES-4. Rating Scores[a] by Indicator and Region Comparing the 2001 and 2004 National Coastal Condition Reports, but Calculated with 2004 Methods.

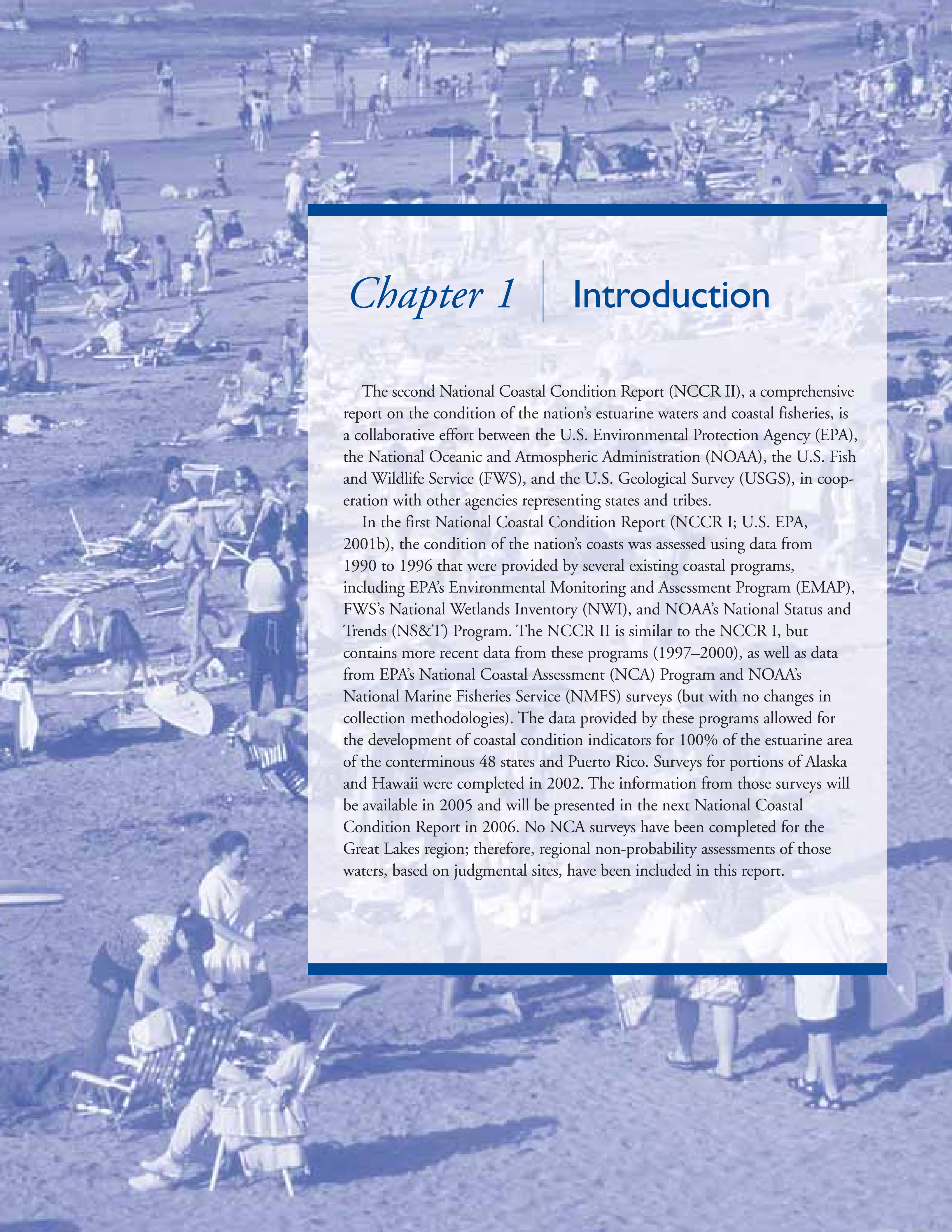
Indicator	Northeast Coast		Southeast Coast		Gulf Coast		West Coast		Great Lakes		Puerto Rico		United States[b]	
	v1[c]	v2[c]	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2
Water Quality Index	1	2	4	4	1	3	1	3	1	3	—	3	1.5	3.0
Sediment Quality Index	2	1	4	4	3	3	2	2	1	1	—	1	2.3	2.1
Benthic Index	1	1	3	3	1	2	3	3	1	2	—	1	1.5	2.0
Coastal Habitat Index	3	4	2	3	1	1	1	1	1	2	—	—[d]	1.6	1.7
Fish Tissue Contaminants Index	2	1	5	5	3	3	3	1	3	3	—	—	3.1	2.7
Overall Condition	1.8	1.8	3.6	3.8	1.8	2.4	2.0	2.0	1.4	2.2	—	1.7	2.0	2.3

[a] Rating scores are based on a 5-point system, where 1 is poor and 5 is good (scores for Puerto Rico are only available for 2004 report).

[b] U.S. score is based on an areally weighted mean of regional scores.

[c] v1 = NCCR I, v2 = NCCR II

[d] No coastal habitat index or fish tissue contaminants index results are available for Puerto Rico.



Chapter 1 | Introduction

The second National Coastal Condition Report (NCCR II), a comprehensive report on the condition of the nation's estuarine waters and coastal fisheries, is a collaborative effort between the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (FWS), and the U.S. Geological Survey (USGS), in cooperation with other agencies representing states and tribes.

In the first National Coastal Condition Report (NCCR I; U.S. EPA, 2001b), the condition of the nation's coasts was assessed using data from 1990 to 1996 that were provided by several existing coastal programs, including EPA's Environmental Monitoring and Assessment Program (EMAP), FWS's National Wetlands Inventory (NWI), and NOAA's National Status and Trends (NS&T) Program. The NCCR II is similar to the NCCR I, but contains more recent data from these programs (1997–2000), as well as data from EPA's National Coastal Assessment (NCA) Program and NOAA's National Marine Fisheries Service (NMFS) surveys (but with no changes in collection methodologies). The data provided by these programs allowed for the development of coastal condition indicators for 100% of the estuarine area of the conterminous 48 states and Puerto Rico. Surveys for portions of Alaska and Hawaii were completed in 2002. The information from those surveys will be available in 2005 and will be presented in the next National Coastal Condition Report in 2006. No NCA surveys have been completed for the Great Lakes region; therefore, regional non-probability assessments of those waters, based on judgmental sites, have been included in this report.

Why Are Coastal Waters Important?

Coastal Waters are Valuable and Productive Natural Ecosystems

Coastal waters include estuaries, coastal wetlands, seagrass meadows, coral reefs, mangrove and kelp forests, and upwelling areas. Critical coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. The coasts also provide essential nesting, resting, feeding, and breeding habitat for 85% of U.S. waterfowl and other migratory birds.

Estuaries are bodies of water that receive freshwater and sediment influx from rivers and tidal influx from the oceans, thus providing transition zones between the fresh water of a river and the saline environment of the sea. This interaction produces a unique environment that supports wildlife and fisheries and contributes substantially to the economy of coastal areas.

Wetlands are the interface between the aquatic and terrestrial components of estuarine systems. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife, and they help improve surface water quality by filtering residential, agricultural, and industrial wastes. Wetlands also buffer coastal areas against storm and wave damage; however, because of their close interface with terrestrial systems, wetlands are vulnerable to land-based sources of pollutant discharges and other human activities.

Coastal Waters Have Many Human Uses

Coastal areas are the most developed areas in the nation. This narrow fringe—only 17% of total contiguous U.S. land area—is home to more than 53% of the nation's population (Figure 1-1). This means that more than one-half of the U.S. population lives in less than one-fifth of the total area of the conterminous 48 states (NRC, 2000). Further, this coastal population is increasing by 3,600 people per day, giving a projected total increase of 27 million people by 2015. This rate of growth is faster than that of the nation as a whole (Figure 1-2).

The Brown Pelican *(Pelecanus occidentalis)*, an endangered species, feeds on schooling fish near the ocean's surface by plunging beak-first from the air. In the 1960s, chemical dichlorodiphenyltrichlorethane (DDT) almost caused the demise of the brown pelican. Pelicans exposed to DDT laid eggs with thin or non-existent shells that broke during nesting, thus reducing the number of surviving offspring. Since DDT was banned in 1972, brown pelicans have made a remarkable recovery, and there are permanent brown pelican nesting colonies on both Anacapa and Santa Barbara Islands. (photo: Shane Anderson)

Figure 1-1. Population distribution in the United States, based on 2000 U.S. Census Bureau data.

In addition to being a popular place to live, the U.S. coasts are of great recreational value. Beaches have become one of the most popular vacation destinations in America, with 180 million people using the coast each year (Cunningham and Walker, 1996). Sport fishing, boating, and diving are enjoyed by millions, as is the simple pleasure of visiting the shore.

Human use of coastal areas also provides commercial services. Almost 31% of the U.S. gross national product (GNP) is produced in coastal counties, and roughly 85% of commercially harvested fish depend on estuaries and nearby coastal waters at some stage in their life cycle (NRC, 1997). Estuaries supply water for industrial uses; lose water to freshwater diversions for drinking and irrigation; are the critical terminals of the nation's marine transportation system and Navy; provide a point of discharge for municipalities and industries; and are the downstream end of nonpoint source runoff.

The average U.S. marine fisheries annual catch of 7 million metric tons (mt) is approximately 4.5% of the world's annual catch. The waters adjacent to the estuaries and wetlands of the United States, from 3 to 200 nautical miles, constitute the federal Exclusive Economic Zone (U.S. EEZ). The waters within and adjoining the U.S. EEZ have been designated as large marine ecosystems (LMEs), based on their distinct bathymetry, hydrography, productivity, and trophic relationships (NOAA, 1988b).

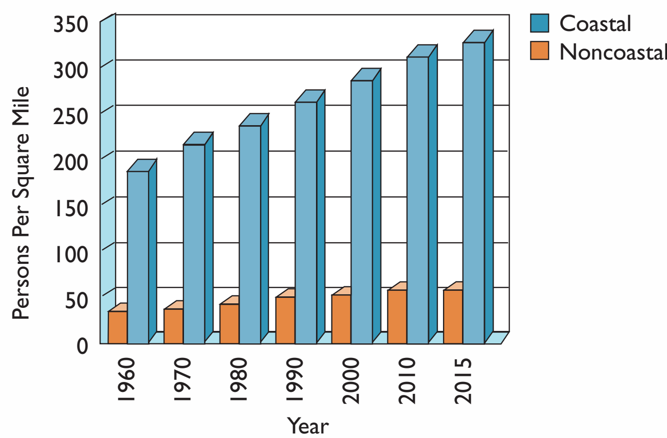


Figure 1-2. Population density from 1960 to 2015 (NOAA, 1998b).

Why Be Concerned about Coastal Condition?

Because a disproportionate percentage of the nation's population lives in coastal areas, the activities of municipalities, commerce, industry, and tourism have created environmental pressures that threaten the very resources that make the coast desirable. Population pressures include increased solid waste production, higher volumes of urban nonpoint 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. Development pressures have resulted in substantial physical changes along many areas of the coastal zone. Coastal wetlands continue to be lost to residential and commercial development, and the quantity and timing of freshwater flow, critical to riverine and estuarine function, continue to be altered. 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 indicators of coastal condition that gauge the extent to which coastal habitats and resources have been altered, but also addresses connections between coastal condition and the ability of coastal areas to meet human expectations for their use.

Indices Used to Measure Coastal Condition

This report examines several available data sets from different agencies and areas of the country and summarizes them to present a broad baseline picture of the condition of coastal waters. Three types of data are presented in this report:

- Coastal monitoring data from programs such as EPA's EMAP and the NCA Program, NOAA's NS&T Program, FWS's NWI, and data from the Great Lakes National Program Office (GLNPO) have been analyzed for this report and used to develop indices of condition
- Fisheries data for LMEs from the NMFS
- Assessment and advisory data provided by states or other regulatory agencies and compiled in national databases.

Available coastal monitoring information is presented on a national scale for the conterminous 48 states and Puerto Rico; these data are then broken down and analyzed at six geographic levels: Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Great Lakes, and Alaska, Hawaii, and Island Territories (Figure 1-3). These geographic regions are comparable to the LME classifications used by NOAA (Table 1-1). The assessment and advisory data are presented at the end of each chapter. Although inconsistencies in the way different state agencies collect and provide assessment and advisory data prevent their use for comparing conditions between coastal areas, the information is valuable because it helps identify and illuminate some of the causes of coastal impairment, as well as the impacts of these impairments on human uses.

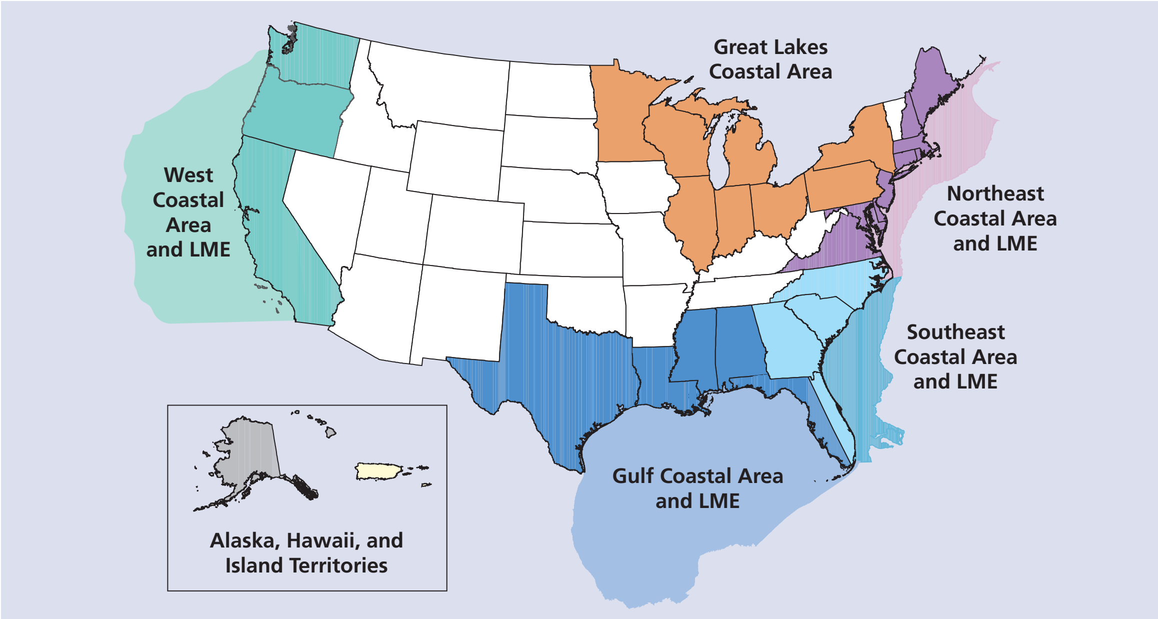


Figure 1-3. Coastal and large marine ecosystem areas presented in the chapters of this report.

Table 1-1. Comparison of NCA's Reporting Regions and NOAA's Large Marine Ecosystems (LMEs)

NCA Reporting Regions	NOAA's LMEs
Northeast Coastal Area	Northeast U.S. Continental Shelf LME
Southeast Coastal Area	Southeast U.S. Continental Shelf LME
Gulf Coastal Area	Gulf of Mexico LME
West Coastal Area	California Current LME
Alaska, Hawaii, and Island Territories	East Bering Sea LME, Gulf of Alaska LME, Chukchi Sea LME, Beaufort Sea LME, Insular Pacific–Hawaii LME, Caribbean Sea LME

Three sources of estuarine information use nationally consistent data-collection designs and methods—NCA, NS&T, and NWI. The NCA Program collects these data from all coastal areas in the United States, except the Great Lakes region, and the data are representative of all estuarine waters. The NS&T Program collects data from all coastal regions in the United States; however, the design of this survey does not permit extrapolation of the data to represent all coastal waters. The NWI provides estimates of wetland acreage (including coastal wetlands) by wetland type based on satellite reconnaissance of all U.S. states and territories.

Purpose of This Report

The purpose of the NCCR II is to present a broad baseline picture of the condition of estuaries across the United States for 1997 to 2000 and, where available, snapshots of the condition of offshore waters. This report uses currently available data sets to discuss the condition of the nation's coasts, and it is not intended to be a comprehensive literature review of coastal information. Instead, the report uses NCA and other monitoring data on a variety of indicators to provide insight into current coastal condition. The NCCR II will serve as a continuing benchmark for analyzing the progress of coastal programs and will be followed in subsequent years by reports on more specialized coastal issues. It will also serve as a reminder of the data gaps and other pitfalls that assessors face and must try to overcome in order to make reliable assessments of how the condition of the nation's coastal resources may change with time. Chapter 9 explores the connections between the condition indicators and human uses of coastal areas. Although the type of assessment described in Chapter 9 cannot be conducted on scales larger than a single estuary, it is important to address coastal condition at several spatial scales (e.g., national, regional, state, and local). Chapter 9 provides an approach that complements the national/regional approach by examining the same national/regional monitoring information with additional site-specific information for a specific estuary, Galveston Bay, in order to evaluate conditions with regard to human uses.

This report also includes special highlight sections that describe several exemplary programs related to coastal condition at the federal, state, and local levels. These highlights are not intended to be comprehensive or exhaustive of all coastal programs, but are presented to show that information about the health of coastal systems is being collected for decision making at the local and regional levels.

Shortcomings of Available Data

Estuarine condition in Alaska is difficult to assess because very little information is available to support the kind of analysis used in this report (i.e., spatial estimates of condition based on indicators measured consistently across broad regions). Nearly 75% of the area of all the bays, sounds, and estuaries in the United States is located in Alaska, and no national report on estuarine condition can be complete without information on the condition of living resources and use attainment of these waters. Similarly, information to support estimates of conditions based on the indicators used in this report is limited for Hawaii, the Pacific territories, and the U.S. Virgin Islands. Although these latter systems make up only a small portion of the nation's estuarine area, they represent a unique set of estuarine subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States, with the exception of the Florida Keys and the Flower Gardens off the Texas/Louisiana coast.

Surveys of Puerto Rico were completed in 2000 and are also included in this report. Collection surveys were completed for Hawaii and portions of Alaska in 2002 and will be included in the next National Coastal Condition Report. In addition, new surveys of ecological coastal condition for Alaska, Hawaii, Puerto Rico, the U.S. Virgin Islands, and the Pacific territories were planned for 2004.

In order to attain consistent reporting in all of the coastal ecosystems in the United States, fiscal and intellectual resources need to be invested in the creation of a national coastal monitoring program. The conceptual framework for such a program is outlined in the National Coastal Research and Monitoring Strategy (http://www.epa.gov/owow/oceans/nccr/H2Ofin.pdf). This strategy calls for a national program that is organized at the state level and carried out by a partnership between federal departments and agencies (EPA, NOAA, DOI, and USDA) and state natural resource agencies, as well as academia and industry.

This monitoring program would provide the capability to measure, understand, analyze, and forecast ecological change at national, regional, and local scales. A first step in the development of this type of program was the initiation of EPA's NCA Program, a national estuarine monitoring program organized and executed at the state level. However, the NCA Program is merely a starting point for developing a comprehensive national coastal monitoring program that can offer a nationwide coastal assessment at all appropriate spatial scales. One approach for examining coastal data at a more local scale—an individual estuarine system—is presented in Chapter 9.

Coastal Monitoring Data

A large percentage of the data used in this assessment of coastal condition comes from programs administered by EPA and NOAA. EPA's NCA Program provides representative data on biota (e.g., plankton, benthos, and fish) and environmental stressors (e.g., water quality, sediment quality, and tissue bioaccumulation) for all coastal states and Puerto Rico (except states in the Great Lakes region). NOAA's NS&T Program provides site-specific data on toxic contaminants and their ecological effects for all coastal regions and Puerto Rico. Coastal condition is also evaluated using information from the FWS's NWI, which provides information on the status of the nation's wetlands acreage.

Five primary indices were created using data available from national coastal programs: water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index. These indices were selected because of the availability of relatively consistent data sets for these indicators for most of the country. These indices do not address all characteristics of estuaries and coastal waters that are valued by society, but they do provide information on both ecological condition and human use of estuaries.

Characterizing coastal areas using each of the five indicators involves two steps. The first step is to assess condition at an individual site for each indicator. For each indicator, site condition rating criteria are determined based on existing criteria, guidelines, or the interpretation of scientific literature. For example, dissolved oxygen conditions are considered poor if dissolved oxygen concentrations are less than 2 mg/L (2 milligrams of oxygen per liter of water). 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 a regional rating for the indicator based on the condition of individual sites within the region. For example, in order for a region to be rated poor with regard to the dissolved oxygen indicator, more than 15% of the coastal area in the region must have dissolved oxygen measured at less than 2 mg/L. The regional criteria boundaries (i.e., percentages used to rate each regional condition indicator) were determined as a median of responses provided through a survey of environmental managers, resource experts, and the knowledgeable public.

Scientists retrieve a Tucker net. A Tucker net is comprised of three nets to collect sample plankton from different water depths (Jamie Hall).

Calculating Aquatic Life Use and Human Use Attainment

The results of the regional and national evaluations of estuarine condition were used to assess aquatic life use and human use attainment. If any of four indicators of condition—water quality condition, sediment quality, benthic condition, or habitat loss—received a poor rating at a given site, then the site was assessed as impaired for aquatic life use. Threatened aquatic life use was assessed as the overlap of fair conditions of these same indicators. For example, if two or more indicators were rated as fair and none as poor, then the site was listed as threatened (all sites had at least one fair rating because the regional ratings for coastal habitat loss were fair in all regions). A site was determined to be unimpaired for aquatic life use if all four indicators were rated good, or only one indicator was rated fair and no indicators were rated poor.

National and regional evaluations for fish tissue contaminants were used to assess human use attainment. If the fish tissue contaminant concentrations exceeded the concentration criteria ranges for risk-based consumption of four 8-ounce meals per month for any contaminant, the site was assessed as impaired for human use. A site was considered to be threatened for human use if the fish tissue contaminant concentrations fell within the criteria ranges for risk-based consumption of four 8-ounce meals per month. Sites were considered unimpaired for human use if fish tissue concentrations fell below the risk-based concentration guidance ranges for consumption for all contaminants.

All spatial areas in a region or the nation were assigned a category of (1) impaired for aquatic life use only, (2) impaired for human use only, (3) impaired for both aquatic life use and human use, (4) threatened (for one or both uses), or (5) unimpaired (for both uses).

Aquatic Use Indices

The following indices examine coastal condition as it relates to use by aquatic organisms.

Water Quality Index

The water quality index is made up of five indicators: nitrogen, phosphorus, chlorophyll *a*, water clarity, and dissolved oxygen. Some nutrient inputs to coastal waters (such as nitrogen and phosphorus) are necessary for a healthy, functioning estuarine ecosystem. When nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, the concentration of available nutrients will increase beyond natural background levels. This increase in the rate of supply of organic matter is called eutrophication, which may result in a host of undesirable water quality conditions (Figure 1-4). Excess nutrients can lead to excess plant

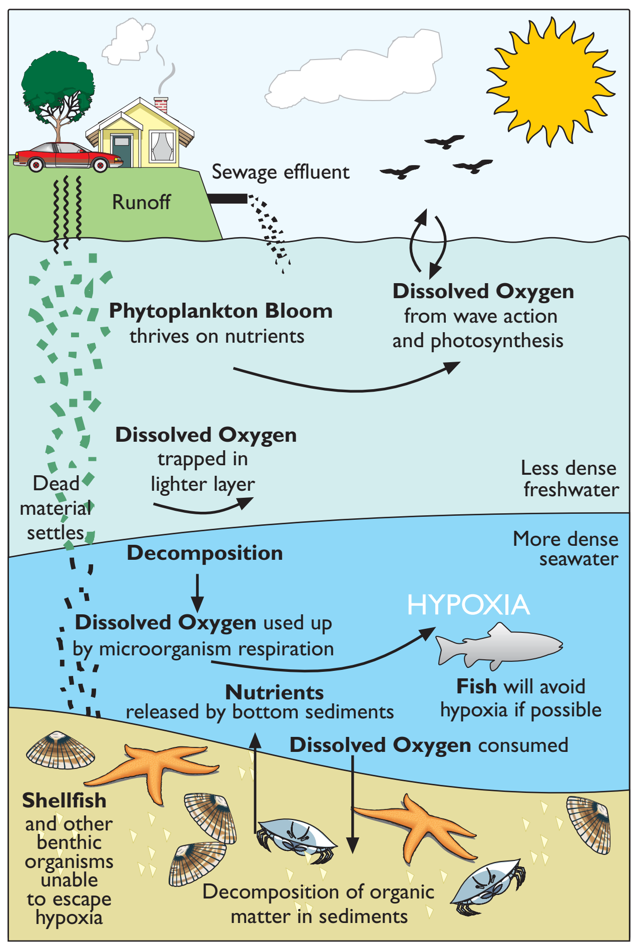


Figure 1-4. Eutrophication can occur when the concentration of available nutrients increases beyond normal levels.

production, and thus, to increased chlorophyll, which can decrease water clarity and lower concentrations of dissolved oxygen.

The water quality index used in this report is intended to characterize acutely degraded water quality conditions. It 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, increased or supplemental sampling is needed.

Nutrients: Nitrogen and Phosphorus

Dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) are necessary and natural nutrients required for the growth of phytoplankton. However, excessive DIN and DIP can result in large, undesirable phytoplankton blooms. For the NCCR I, DIN and DIP information was determined through a survey of estuarine experts conducted by NOAA (Bricker et al., 1999). In the NOAA report, surface maximum DIN values were assessed as high if they were equal to or greater than 1 mg/L; medium if they were less than 1 mg/L, but equal to or greater than 0.1 mg/L; and low if they were less than 0.1 mg/L. Surface maximum DIP values were assessed as high if they were equal to or greater than 0.1 mg/L; medium if they were less than 0.1 mg/L, but equal to or greater than 0.01 mg/L; and low if they were less than 0.01 mg/L. The NOAA report included data from all months of the year.

For the NCCR II, 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, summer is the period of expected peak concentrations for West Coast estuaries). As a result, the DIN and DIP reference surface concentrations used to assess condition in this report are generally lower than those in the NOAA report because of the natural reduction in nutrient concentrations due to uptake by phytoplankton from spring to summer for the production of chlorophyll.

Coastal monitoring sites were rated good, fair, or poor for DIN and DIP using the criteria shown in Tables 1-2 and 1-3. These ratings were then used to calculate an overall rating for each region.

Table 1-2. Criteria for Assessing Dissolved Inorganic Nitrogen

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
Hawaii, Puerto Rico, and Florida Bay sites	<0.05 mg/L	0.05–0.1 mg/L	>0.1 mg/L
Regional Scores	Less than 10% of the coastal area was in poor condition, and more than 50% of the coastal area was in good condition.	10% to 25% of the coastal area was in poor condition, or more than 50% of the coastal area was in combined poor and fair condition.	More than 25% of the coastal area was in poor condition.

Table 1-3. Criteria for Assessing Dissolved Inorganic Phosphorus

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
Hawaii, Puerto Rico, and Florida Bay sites	<0.005 mg/L	0.005–0.01 mg/L	>0.01 mg/L
Regional Scores	Less than 10% of the coastal area was in poor condition, and more than 50% of the coastal area was in good condition.	10% to 25% of the coastal area was in poor condition, or more than 50% of the coastal area was in combined poor and fair condition.	More than 25% of the coastal area was in poor condition.

Chlorophyll *a*

For this report, surface concentrations of chlorophyll *a* were determined from a filtered portion of water collected at each site and were rated good, fair, or poor using the criteria shown in Table 1-4. These ratings were then used to calculate an overall rating for each region.

Table 1-4. Criteria for Assessing Chlorophyll *a*

Area	Good	Fair	Poor
East/Gulf, West Coast sites	<5 µg/L	5–20 µg/L	>20 µg/L
Hawaii, Puerto Rico,	<0.5 µg/L	0.5–1 µg/L	>1 µg/L
Florida Bay sites	<1 µg/L	1–5 µg/L	>5 µg/L
Regional Scores	Less than 10% of the coastal area was in poor condition, and more than 50% of the coastal area was in good condition.	10% to 20% of the coastal area was in poor condition, or more than 50% of the coastal area was in combined poor and fair condition.	More than 20% of the coastal area was in poor condition.

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 submerged aquatic vegetation (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 various parts of the nation; therefore, the water clarity indicator (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 regional reference conditions were determined by examining available data for each of the U.S. regions. Conditions were set at 10% of incident light available at a depth of 1 meter for normally turbid locations (most of the United States), 5% for naturally highly turbid conditions (Louisiana, South Carolina, Georgia, and Delaware Bay), and 20% for regions of the country 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 Chesapeake Bay). Table 1-5 summarizes the rating criteria for water clarity for each monitoring station and for the regions.

Table 1-5. 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.
Regional Scores	Less than 10% of the coastal area was in poor condition, and more than 50% of the coastal area was in good condition.	10% to 25% of the coastal area was in poor condition, or more than 50% of the coastal area was in combined poor and fair condition.	More than 25% of the coastal area was in poor condition.

WCI= (observed clarity at 1 meter)/(regional reference clarity at 1 meter)

Dissolved Oxygen

Dissolved oxygen is necessary for all estuarine life. Many states use a threshold average concentration of 4 to 5 mg/L to set their water quality standards. Concentrations below approximately 2 mg/L are thought to be stressful to many estuarine organisms (Diaz and Rosenberg, 1995; U.S. EPA, 2000a). These low levels most often occur in bottom waters and affect the organisms that live in the sediments. Low levels of oxygen (hypoxia) or lack of oxygen (anoxia) often accompany the onset of severe bacterial degradation, sometimes resulting in the presence of algal scums and noxious odors. In some estuaries, however, low levels of oxygen occur periodically or may be a part of the 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 (e.g., representative of 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 under the NCA Program. Dissolved oxygen was rated good, fair, or poor using the criteria shown in Table 1-6.

Table 1-6. Criteria for Assessing Dissolved Oxygen

Area	Good	Fair	Poor
Individual sampling sites	> 5 mg/L	2–5 mg/L	< 2 mg/L
Regional Scores	Less than 5% of the coastal area was in poor condition, and more than 50% of the coastal area was in good condition.	5% to 15% of the coastal area was in poor condition, or more than 50% of the coastal area was in combined poor and fair condition.	More than 15% of the coastal area was in poor condition.

Calculating the Water Quality Index

Once DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen were assessed for a given site, the water quality index rating was calculated for the site based on these five indicators. The index was rated good, fair, or poor using the criteria shown in Table 1-7.

Table 1-7. Criteria for Determining the Water Quality Index Rating by Site

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

The water quality index was then calculated for each region using the criteria in Table 1-8.

Table 1-8. Criteria for Determining the Water Quality Index Rating by Region

Rating	Criteria
Good	Less than 10% of coastal waters are in poor condition, and less than 50% of coastal waters are in combined poor and fair condition.
Fair	10% to 20% of coastal waters are in poor condition, or more than 50% of coastal waters are in combined fair and poor condition.
Poor	More than 20% of coastal waters are 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 the watershed. The 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 contamination. Fine-grained, organic-rich sediments are likely to become resuspended and transported to distant locations and are also efficient at scavenging pollutants. 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. The NCA Program measured the concentrations of 91 chemical constituents in sediments and evaluated sediment toxicity by measuring the survival of the marine amphipod *Ampelisca abdita* following exposure to the sediments. The results of this research may be used to identify the most polluted areas and give clues regarding the sources of contamination.

The physical and chemical characteristics of surface sediments are the result of interacting forces that control chemical input and particle dynamics at any particular site. In assessing coastal condition, researchers measure the potential for sediments to affect bottom-dwelling organisms. The sediment quality index is based on three indicators of sediment condition: direct measures of sediment toxicity, sediment contaminants, and the sediment TOC concentration.

Some researchers and managers would prefer that the sediment triad (sediment chemistry, 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 based on the joint occurrence of elevated sediment contaminant concentrations and high sediment toxicity (see text box). Benthic community attributes are included in this assessment of estuarine condition as an independent variable 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 uses the combination of sediment toxicity, sediment contaminants, and sediment 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 elements is categorized as poor; condition is assessed as fair if the sediment contaminants indicator is fair; and condition is assessed as good if all three indices are at levels that would be unlikely to result in adverse biological effects due to sediment quality.

Alternative Views for a Sediment Quality Index

Some resource managers object to using effects range median (ERM) and effect reange low (ERL) values to calculate the NCCR II 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 reference sediment. The criteria for rating sediment toxicity based on amphipod survival for each sampling site are shown in Table 1-9. Table 1-10 shows how these site data were used to evaluate the region.

Table 1-9. 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 1-10. Criteria for Assessing Sediment Toxicity by Region

Rating	Criteria
Good	Less than 5% of coastal areas are in poor condition.
Poor	More than 5% of coastal areas are in poor condition.

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 1-11). ERM is the median concentration of a contaminant observed to have adverse biological effects in the literature studies examined. A more protective indicator of contaminant concentration is the ERL criteria, 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 1-12. Table 1-13 shows how these data were used to create a regional rating.

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 values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

Table 1-11. 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
Acenapthylene	44	640
Anthracene	85.3	1,100
Flourene	19	540
2-Methyl napthalene	70	670
Napthalene	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 ug/g dry sediment, equivalent to ppm.
[b] Units are ng/g dry sediment, equivalent to ppb.

Table 1-12. Criteria for Assessing Sediment Contaminants by Site

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

Table 1-13. Criteria for Assessing Sediment Contaminants by Region

Rating	Criteria
Good	Less than 5% of coastal sediments are in poor condition.
Fair	5% to 15% of coastal sediments are in poor condition.
Poor	More than 15% of coastal sediments are in poor condition.

Sediment 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 TOC. The criteria for rating TOC for individual sampling sites are shown in Table 1-14. Table 1-15 shows how these data were used to create a regional ranking.

Table 1-14. Criteria for Assessing Sediment 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 1-15. Criteria for Assessing Sediment TOC by Region

Rating	Criteria
Good	Less than 20% of coastal areas are in poor condition.
Fair	20% to 30% of coastal areas are in poor condition.
Poor	More than 30% of coastal areas are in poor condition.

Calculating the Sediment Quality Index

Once sediment toxicity, sediment contaminants, and sediment TOC were assessed for a given site, the sediment quality index rating was calculated for the site based on these three indicators. The sediment quality index was rated good to poor for each site using the criteria shown in Table 1-16.

Table 1-16. Criteria for Determining the Sediment Quality Index by Site

Rating	Criteria
Good	None of the individual components are poor, and the sediment contaminants indicator is good.
Fair	No measures are poor, and the sediment contaminants indicator is fair.
Poor	One or more of the component indicators is poor.

The sediment quality index was then calculated for each region using the criteria shown in Table 1-17.

Table 1-17. Criteria for Determining the Sediment Quality Index by Region

Rating	Criteria
Good	Less than 5% of coastal sediments are in poor condition, and less than 50% of coastal sediments are in combined poor and fair condition.
Fair	5% to 15% of coastal sediments are in poor condition, or more than 50% of coastal sediments are in combined poor and fair condition.
Poor	More than 15% of coastal sediments are 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 and thus cannot avoid environmental problems. Benthic population and community characteristics are sensitive indicators of contaminant and dissolved-oxygen stress, salinity fluctuations, and sediment disturbance and serve as reliable indicators of estuarine environmental quality. EMAP and NCA have developed regional (Northeast, Southeast, and Gulf coasts) benthic indices of environmental condition for estuaries that reflect changes in diversity and population size of indicator species to distinguish degraded benthic habitats from undegraded benthic habitats (Engle et al., 1994; Weisberg et al., 1997; Engle and Summers, 1999; Van Dolah et al., 1999). These indices reflect changes in benthic community diversity and the abundance of pollution-tolerant and pollution-sensitive species. A high benthic index rating for benthos 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 Program unless otherwise noted. Indices vary with region because species assemblages depend on prevailing temperatures, salinities, and the silt-clay content of sediments. 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.

Not all regions included in this report have developed benthic indices. Indices for the West Coast and Puerto Rico, as well as Alaska and Hawaii, are being developed and are not available for reporting at this time. As a surrogate for a benthic index, benthic community diversity was determined for each site. Values for 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 estuarine benthic diversity). If there was no significant relationship between diversity and these natural gradients in the 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 the region (as in the West Coast), 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). More detailed descriptions of these surrogate analyses are provided in the West Coast chapter (Chapter 6) and the Puerto Rico chapter (Chapter 8). Table 1-18 shows the good, fair, and poor rating criteria for the different regions of the country. These ratings were used to calculate an overall rating for each region.

The relationship between poor benthic condition (poor index values) and environmental stressors (i.e., water quality and sediment quality indices and their component measurements) 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 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 (not measured by NCA).

Coastal Habitat Index

Coastal wetlands are the vegetated interface between aquatic and terrestrial components of estuarine ecosystems. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife. These habitats also filter and process residential, agricultural, and industrial wastes, thereby improving surface water quality, and buffer coastal areas against storm and wave damage. An estimated 95% of commercial fish and 85% of sport fish spend a portion of their life cycles in coastal wetland and estuarine habitats. Adult stocks of commercially harvested shrimp, blue crabs, oysters, and other species throughout the United States are directly related to wetland quality and quantity (Turner and

Table 1-18. Criteria for Assessing Benthic Index

Area	Good	Fair	Poor
Northeast Coast	Benthic index score is greater than 0.0.	N/A	Benthic index score is less than 0.0.
Southeast Coast	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	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 (compared to expected diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of expected mean 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 (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.
Regional Scores	Less than 10% of coastal sediments have a poor benthic index score, and less than 50% of coastal sediments have a combined poor and fair benthic index score.	10% to 20% of coastal sediments have a poor benthic index score, or more than 50% of coastal sediments have a combined poor and fair benthic index score.	More than 20% of coastal sediments have a poor benthic index score.

Boesch, 1988). Wetlands throughout the United States have been and are being rapidly destroyed by human activities (e.g., flood control, agriculture, waste disposal, real estate development, shipping, commercial fishing, oil/gas exploration and production) and natural processes (e.g., sea level rise, sediment compaction, droughts, hurricanes, floods). In the late 1970s and early 1980s, the country was losing wetlands at an estimated rate of 300,000 acres per year. The Clean Water Act, state wetland protection programs, and programs such as Swampbuster (USDA) have helped decrease wetland losses to an estimated 70,000 to 90,000 acres per year. Strong wetland protection must continue to be a national priority; otherwise, fisheries that support more than a million jobs and contribute billions of dollars to the national economy are at risk (Turner and Boesch, 1988; Stedman and Hanson, 2000), as are the ecological functions provided by wetlands (e.g., nursery areas, flood control, and water quality improvement).

The NWI (2002) contains data on estuarine emergent and tidal flat wetland acreage for all coastal states for 1990 and 2000 except Hawaii and Puerto Rico. Data for Hawaii and Puerto Rico are available for 1980 and 1990. The proportional change in regional coastal wetlands over the 10-year time period was determined for each region of the United States (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, and Alaska, Hawaii, and Puerto Rico) and combined with the long-term decadal loss rates for the period 1780 to 1990. The average of these two loss rates (historic and present) multiplied by 100 is the regional value of the coastal habitat index. The national value of the coastal habitat index is a weighted mean that reflects the extent of wetlands existing in each region (different than the distribution of the extent of estuarine area). Table 1-19 shows the rating criteria used for the coastal habitat index.

The NWI estimates represent regional assessments and do not apply to individual sites or individual wetlands. Before individual wetland sites can be assessed, rigorous methodologies for estimating the quantity and, particularly, the quality of wetlands must be developed. Until these methods are available and implemented, only regional assessments of quantity losses can be made. Although a 1% loss rate per decade may seem small (or even acceptable), continued wetland losses at this rate cannot be sustained indefinitely and still leave enough wetlands to maintain their present ecological functions.

Table 1-19. Criteria for Determining the Coastal Habitat Index

Rating	Criteria
Good	The index score is less than 1.0.
Fair	The index score is between 1.0 and 1.25.
Poor	The index score is greater than 1.25.

Human Use Indices

Human use attainment is assessed using the national and regional evaluations for fish tissue contaminants; however, the fish tissue contaminant data used in the assessment are not always from fish species that are widely consumed and that are of market length. If the available fish tissue contaminant values from the NCA surveys exceed the risk-based concentration guidance ranges for consumption of four 8-ounce meals per month for any contaminant (U.S. EPA, 2000c), the site is assessed as impaired for human use. A site is considered threatened for human use if the available fish tissue contaminant information falls within the guidance ranges for consumption of four 8-ounce meals per month. Sites are considered unimpaired for human use if fish tissue concentrations are less than the risk-based guidance concentration range.

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 to remain in the animal 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 fish contaminant guidance values (U.S. EPA, 2000c).

For the NCA surveys, target fish were collected from all sites where fish were available, and whole-body contaminant burdens were determined. No EPA Guidance criteria exist to assess the ecological risk of whole-body contaminants for fish, but the EPA Advisory Guidance can be used as a basis for estimating advisory determinations, even if the data are based on whole-fish or organ-specific body burdens (U.S. EPA, 2000c)(Table 1-20). The whole-fish contaminant information collected by NCA for U.S. estuaries was compared with risk-based thresholds based on the consumption of four 8-ounce meals per month for selected contaminants (approach used by most state advisory programs) and assessed for noncancer and cancer health endpoints (U.S. EPA, 2000c). Table 1-21 shows the rating criteria for the fish tissue contaminants index for each site. Table 1-22 shows how these data were used to create a regional rating.

Table 1-20. Risk Guidelines for Recreational Fishers (U.S. EPA, 2000c)

Contaminant	Screening Value[a] (ppm)	Concentration Range[b] (ppm) (noncancer)	Concentration Range[c] (ppm) (cancer)
Arsenic (inorganic)[d]	1.2/0.026[e]	3.5–7.0	0.008–0.016
Cadmium	4.0	0.35–0.70	
Mercury	0.4	0.12–0.23	
Selenium	20.0	5.9–12.0	
Chlordane	2.0/0.114	0.59–1.2	0.03–0.07
DDT	2.0/0.117	0.059–0.12	0.035–0.069
Dieldrin	0.2/0.0025	0.059–0.12	0.00073–0.0015
Endosulfan	24.0	7.0–14.0	
Endrin	1.2	0.35–0.70	
Heptachlor epoxide	0.052/0.00439	0.015–0.031	0.0013–0.0026
Hexachloro-benzene	3.2/0.025	0.94–1.9	0.0073–0.015
Lindane	1.2/0.0307	0.35–0.70	0.009–0.018
Mirex	0.8	0.23–0.47	
Toxaphene	1.0/0.0363	0.29–0.59	0.011–0.021
PAH (Benzo(a)pyrene)	0.00547		0.0016–0.0032
PCB	0.08/0.02	0.023–0.047	0.0059–0.012

[a] Screening value for recreational fishers.
[b] Range of concentrations associated with noncancer health endpoint risk for consumption of four 8-ounce meals per month.
[c] Range of concentrations associated with cancer health endpoint risk for consumption of four 8-ounce meals per month.
[d] Inorganic arsenic estimated as 2% of total arsenic.
[e] 1.2 and 0.026 are the screening values for inorganic arsenic for noncancer and cancer health endpoints, respectively.

Table 1-21. Criteria for Determining the Fish Tissue Contaminants Index by Site

Rating	Criteria
Good	The index score falls below the range of the Guidance criteria for risk-based consumption associated with four 8-ounce meals per month.
Fair	The index score falls within the range of the Guidance criteria for risk-based consumption associated with four 8-ounce meals per month.
Poor	The index score exceeds the maximum value of the range of the Guidance criteria for risk-based consumption associated with four 8-ounce meals per month.

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

Rating	Criteria
Good	Less than 10% of estuarine sites are in poor condition, and less than 50% are in combined fair and poor condition.
Fair	10% to 20% of estuarine sites are in poor condition, or more than 50% are in combined fair and poor condition.
Poor	More than 20% of estuarine sites are in poor condition.

Summary of Rating Criteria

The rating criteria used in this report are summarized in Tables 1-23 (index indicators) and 1-24 (index components).

Table 1-23. Indicators Used to Assess Coastal Condition (NCA)

Icon	Ecological Condition by Site	Ranking by Region
Water Quality Index	**Water Quality Index** is an index that is based on five water quality measurements (dissolved oxygen, chlorophyll *a*, nitrogen, phosphorus, and water clarity).	
	Ecological Condition by Site	**Ranking by Region**
	Good: No measures are rated poor, and a maximum of one is rated fair.	**Good:** Less than 10% of coastal waters are in poor condition, *and* less than 50% of coastal waters are in combined poor and fair condition.
	Fair: One measure is rated poor, or two or more measures are fair.	**Fair:** Between 10% and 20% of coastal waters are in poor condition, *or* more than 50% of coastal waters are in combined fair and poor condition.
	Poor: Two or more measures are rated poor.	**Poor:** More than 20% of coastal waters are in poor condition.
Sediment Quality Index	**Sediment Quality Index** is an index that is based on three sediment quality measurements (sediment toxicity, sediment contaminants, and sediment TOC).	
	Ecological Condition by Site	**Ranking by Region**
	Good: No measures are rated poor, and the sediment contaminants indicator is rated good.	**Good:** Less than 5% of coastal sediments are in poor condition, *and* less than 50% of coastal sediments are in combined poor and fair condition.
	Fair: No measures are rated poor, and the sediment contaminants indicator is rated fair.	**Fair:** Between 5 and 15% of coastal sediments are in poor condition, *or* more than 50% of coastal sediments are in combined poor and fair condition.
	Poor: One or more measures are rated poor.	**Poor:** More than 15% of coastal sediments are in poor condition.
Benthic Index	**Benthic Index** (or a surrogate measure) is an indicator of 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 Region**
	Good, **fair**, and **poor** were determined using regionally dependant benthic index scores.	**Good:** Less than 10% of coastal sediments have a poor benthic index score, *and* less than 50% of coastal sediments have a combined poor and fair benthic index score. **Fair:** Between 10% and 20% of coastal sediments have a poor benthic index score, *or* more than 50% of coastal sediments have a combined poor and fair benthic index score. **Poor:** More than 20% of coastal sediments have a poor benthic index score.
Coastal Habitat Index	**Coastal Habitat Index** is evaluated using the data from the NWI (NWI, 2002). The NWI contains data on estuarine-emergent and tidal flat acreage for all coastal states (except Hawaii and Puerto Rico) for 1780 through 2000.	
	Ecological Condition by Site	**Ranking by Region**
	The average of the mean long-term, decadal wetland loss rate (1780–1990) and the present decadal wetland loss rate (1990–2000) was determined for each region of the United States and multiplied by 100 to create a coastal habitat index score.	**Good:** The coastal habitat index score is less than 1.0. **Fair:** The coastal habitat index is between 1.0 and 1.25. **Poor:** The coastal habitat index is greater than 1.25.
Fish Tissue Index	**Fish Tissue Contaminants Index** concentrations are an indicator of the level of chemical contamination in target fish/shellfish species.	
	Ecological Condition by Site	**Ranking by Region**
	Good: Composite fish tissue contaminant concentrations are below the EPA Guidance concentration range.	**Good:** Less than 10% of estuarine sites are in poor condition, *and* less than 50% are in combined fair and poor condition.
	Fair: Composite fish tissue contaminant concentrations are in the EPA Guidance concentration range.	**Fair:** From 10 to 20% of estuarine waters are in poor condition, *or* more than 50% are in combined fair and poor condition.
	Poor: Composite fish tissue contaminant concentrations are above the EPA Guidance concentration range.	**Poor:** More than 20% of sites have poor condition.

Table 1-24. Criteria for Measurements Used as Components of Index Indicators Used To Assess Coastal Condition (NCA)

Dissolved Inorganic Nitrogen (DIN) levels are measured as part of the water quality index.

Ecological Condition by Site	Ranking by Region
Good: Surface concentrations are less than 0.1 mg/L (NE, SE, Gulf), 0.5 mg/L (West), or 0.05 mg/L (tropical).	**Good:** Less than 10% of coastal area is in poor condition, *and* less than 50% of coastal waters are in combined poor and fair 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:** From 10% to 25% of coastal area is in poor condition, *or* more than 50% of coastal area is in combined fair and poor 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 coastal area is in poor condition.

Dissolved Inorganic Phosphorus (DIP) levels are measured as part of the water quality index.

Ecological Condition by Site	Ranking by 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 coastal area is in poor condition, *and* less than 50% of coastal area is in combined poor and fair 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:** From 10% to 25% of coastal area is in poor condition, *or* more than 50% of coastal area is in combined fair and poor 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 coastal area is in poor condition.

Chlorophyll *a* is one of the measurements used in the water quality index.

Ecological Condition by Site	Ranking by Region
Good: Surface concentrations are less than 5 µg/L (less than 0.5 µg/L for tropical ecosystems*, except to less than 1.0 µg/L for Florida Bay).	**Good:** Less than 10% of coastal area is in poor condition, *and* less than 50% of coastal area is in combined poor and fair 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, except to between 1.0 to 5.0 µg/L for Florida Bay).	**Fair:** From 10% to 20% of coastal area is in poor condition, *or* more than 50% of coastal area is in combined fair and poor condition.
Poor: Surface concentrations are greater than 20 µg/L (greater than 1 µg/L for tropical ecosystems, except to greater than 5 µg/L for Florida Bay,).	**Poor:** More than 20% of coastal area is in poor condition.

*Tropical ecosystems include Hawaii, Puerto Rico, and Florida Bay sites.

Water Clarity is part of the water quality index. A water clarity indicator (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 turbid conditions, and 20% for areas with significant SAV beds or active SAV restoration programs.

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

(continued)

Table 1-24. Criteria for Measurements Used as Components of Index Indicators Used To Assess Coastal Condition (NCA) (continued)

Dissolved Oxygen is one of the measurements used in the water quality index.

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

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

Ecological Condition by Site	Ranking by Region
Good: Mortality* is less than or equal to 20%.	**Good:** Less than 5% of coastal sediments have greater than 20% mortality in toxicity tests.
Poor: Mortality is greater than 20%.	**Poor:** More than 5% of coastal sediments have greater than 20% mortality in toxicity tests.

*Test mortality is adjusted for control mortality.

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

Ecological Condition by Site	Ranking by Region
Good: No ERMs are exceeded, and fewer than five ERL guidelines are exceeded.	**Good:** Less than 5% of coastal sediments are in poor condition.
Fair: No ERMs are exceeded, and five or more ERL guidelines are exceeded.	**Fair:** From 5% to 15% of coastal sediments are in poor condition.
Poor: One or more ERM guidelines are exceeded.	**Poor:** More than 15% of coastal sediments are in poor condition.

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

Ecological Condition by Site	Ranking by Region
Good: The TOC concentration is less than 2%.	**Good:** Less than 20% of coastal sediments are in poor condition.
Fair: The TOC concentration is between 2% and 5%.	**Fair:** From 20% to 30% of coastal sediments are in poor condition.
Poor: The TOC concentration is greater than 5%.	**Poor:** More than 30% of coastal sediments are in poor condition.

The picturesque wetlands of Tomales Bay, California, stretch inshore and provide important habitat for birds on the Pacific flyway (Dan Howard).

How the Indices Are Summarized

Overall condition for each region was calculated by summing the scores for the available indicators and dividing by the number of available indicators (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:

Indicator	Score
Water Quality Index	4
Sediment Quality Index	4
Benthic Index	3
Coastal Habitat Index	3
Fish Tissue Contaminants Index	5
Total Score Divided by 5 = Overall Score	19/5 = 3.8

To create the national indicator numbers, a weighted average was calculated for each of the five indicators. The indicator scores were weighted by the percentage of total area of estuaries contributed by each geographic area (Figure 1-5). 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 each region. These weighting factors are used for all indicators except the coastal habitat index, which uses the geographic distribution of total area of coastal wetlands (Figure 1-6). The overall national score was then calculated by summing each national indicator score and dividing by five.

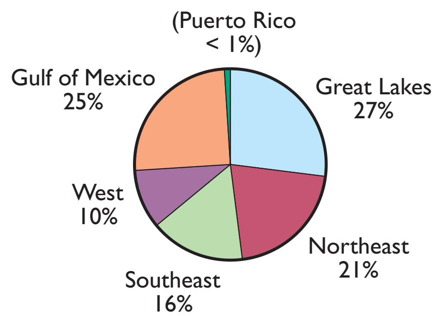


Figure 1-5. Percentage of estuarine area contributed by each geographic region assessed in this report.

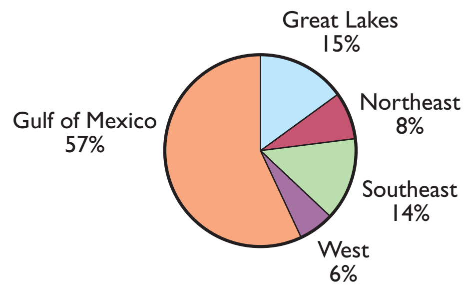


Figure 1-6. Percentage of coastal wetland area contributed by each geographic region assessed in this report.

Large Marine Ecosystem Fisheries Data

In addition to coastal monitoring data, a second type of data used to assess coastal condition in this report is LME fisheries data from the NMFS. The waters adjacent to the estuaries and wetlands of the United States, from 3 to 200 nautical miles offshore, constitute the U.S. EEZ. Waters within and adjoining the U.S. EEZ have been designated as LMEs, based on their distinct bathymetry, hydrography, productivity, and trophic relationships (NOAA, 1988). The NMFS regulates fisheries on the Atlantic, Pacific, and Gulf of Mexico coasts. Information on the status of the fish stocks comes from NMFS assessment data for the Northeast Shelf LME, the Southeast Shelf LME, and the Gulf of Mexico LME. Ultimately, the Secretary of Commerce has management responsibility for most marine life in the U.S. waters. Fishery resources are managed largely by fishery management councils through extensive consultation with state and federal agencies, affected industry sectors, public interest groups, and in some cases, international science and management organizations. Information provided for this report on U.S. living marine resources and the three Atlantic LMEs was compiled from NMFS productivity data and

Our Living Oceans (NMFS, 2003), a report issued periodically by NMFS covering most living marine resources of interest for commercial, recreational, subsistence, and aesthetic or intrinsic reasons to the United States.

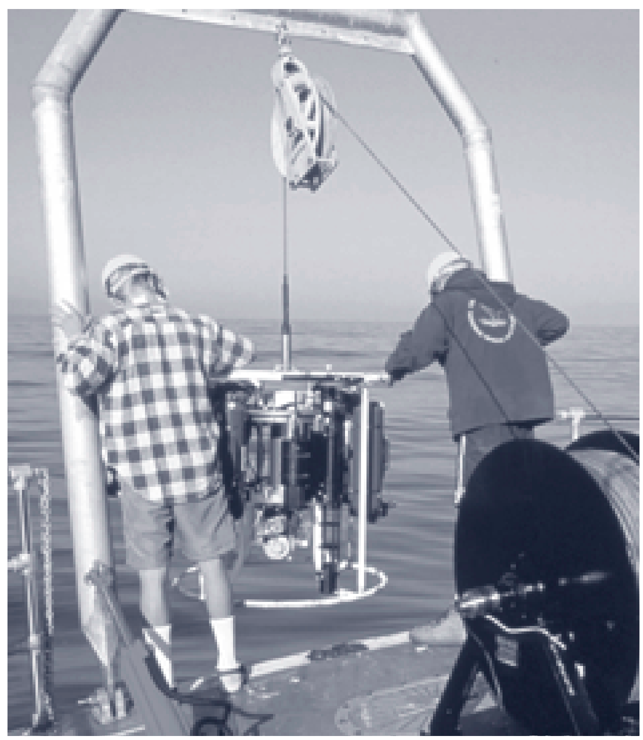
Marine Fisheries Fuel the U.S. Economy

More than one-fifth of the world's most productive marine waters lie within the LMEs of the U.S. EEZ. The value of both commercial and recreational fishing is significant to the U.S. economy, to thousands of private firms, and to individuals, families, and communities.

- More than 170,000 people and 123,300 commercial fishing vessels are employed by the commercial fishing industry in the United States, the world's fifth largest seafood-producing country.
- In 2001, U.S. commercial fishermen landed 9.8 billion pounds of fish and shellfish, valued at $3.3 billion.
- The industry contributed an estimated $28.6 billion (in value added) to the U.S. GNP.
- Recreational fishing added another $25 billion to the U.S. GNP.

Assessment and Advisory Data

Assessment and advisory data provided by states or other regulatory agencies are the third set of data used in this report to assess coastal condition. Several EPA programs, including the Clean Water Act Section 305(b) Assessment Program, the National Listing of Fish and Wildlife Advisories (NLFWA) Program, and the Beaches Environmental Assessment, Closure, and Health (BEACH) Program, maintain databases that are repositories for information about how well coastal waters support their designated or desired uses. These uses are important factors in public perception of the condition of the coast and also address the condition of the coast as it relates to public health. The data for these programs are collected from multiple state agencies, so data collection and reporting methods differ among states. Because of these inconsistencies, data generated by these programs are not included in the estimates of coastal condition.



The Channel Islands National Marine Sanctuary (CINMS) partnered with scientists from the University of California at Santa Barbara to study impacts of the El Niño Storms. The project, named "Plumes and Blooms", investigates the nutrient-rich brown sediment plumes that, in turn, produce green marine algal blooms. (photo: Channel Islands NMS)

Clean Water Act Section 305(b) Assessments

States report water quality assessment information and water quality impairments under Section 305(b) of the Clean Water Act. States and tribes rate water quality by comparing measured values to their state and tribal water quality standards. Water quality standards include narrative and numeric criteria that support specific designated uses and also specify goals to prevent degradation of good-quality waters. States and tribes use their numeric criteria to determine how well the designated uses assigned to waterbodies are supported. The states then consolidate their more detailed uses into general categories so that EPA can summarize state and tribal data. The most common designated uses are

- Aquatic life support
- Drinking water supply
- Recreation, such as swimming, fishing, and boating
- Fish consumption.

After comparing water quality data to the criteria set by water quality standards, states and tribes classify their waters into the following categories:

Fully Supporting	These waters meet applicable water quality standards, both criteria and designated use.
Threatened	These waters currently meet water quality standards, but states are concerned that they may degrade in the near future.
Not Supporting	These waters do not meet water quality standards.

The 305(b) assessment data (submitted by the states in 2000) are stored in EPA's National Assessment Database and are summarized in the *National Water Quality Inventory 2000 Report* (U.S. EPA, 2002). These data are useful for evaluating the success of state water quality improvement efforts. Unfortunately, each state monitors water quality parameters differently, so it is difficult to make generalized statements about the condition of the nation's coasts based on these data alone.

National Listing of Fish and Wildlife Advisories

States, U.S. territories, and tribes have primary responsibility for protecting their residents from the health risks of consuming contaminated, noncommercially caught fish and shellfish. (Sale of commercial fish in interstate commerce is regulated by the U.S. Food and Drug Administration [FDA].) Resource managers protect residents by issuing consumption advisories for the general population, including recreational and subsistence fishers, as well as for sensitive groups (e.g., pregnant women, nursing mothers, children, and individuals with compromised immune systems). These advisories inform the public that high concentrations of chemical contaminants (such as mercury and PCBs) have been found in local fish and shellfish. The advisories include recommendations to limit or avoid consumption of certain fish and shellfish species from specific waterbodies or, in some cases, from specific waterbody types (e.g., all coastal waters within a state).

The 2002 NLFWA is a database— available from EPA and searchable on the Internet at http://www.epa.gov/waterscience/fish— that contains fish advisory information provided to EPA by the states and tribes. The NLFWA database can generate national, regional, and state maps that illustrate any combination of advisory parameters.

Beach Advisories and Closures

There is growing concern in the United States about public health risks posed by polluted bathing beaches. Scientific evidence documenting the rise of infectious diseases caused by microbial organisms in recreational waters continues to grow; however, not enough information is currently available to define the extent of beach pollution throughout the country. EPA's BEACH Program, established in 1997, is working with state and local governments to compile information on beach pollution that will help define the national extent of the problem.

A few states have comprehensive beach monitoring programs to test the safety of water for swimming. Many other states have only limited beach monitoring programs, and some states have no monitoring programs linked directly to water safety at swimmable beaches. The number of beach closings and swimming advisories that continue to be issued annually, however, indicate that beach pollution is a persistent problem. In 2002, there were 529 beach closures and advisories in coastal and Great Lakes waters.

Connections with Human Uses

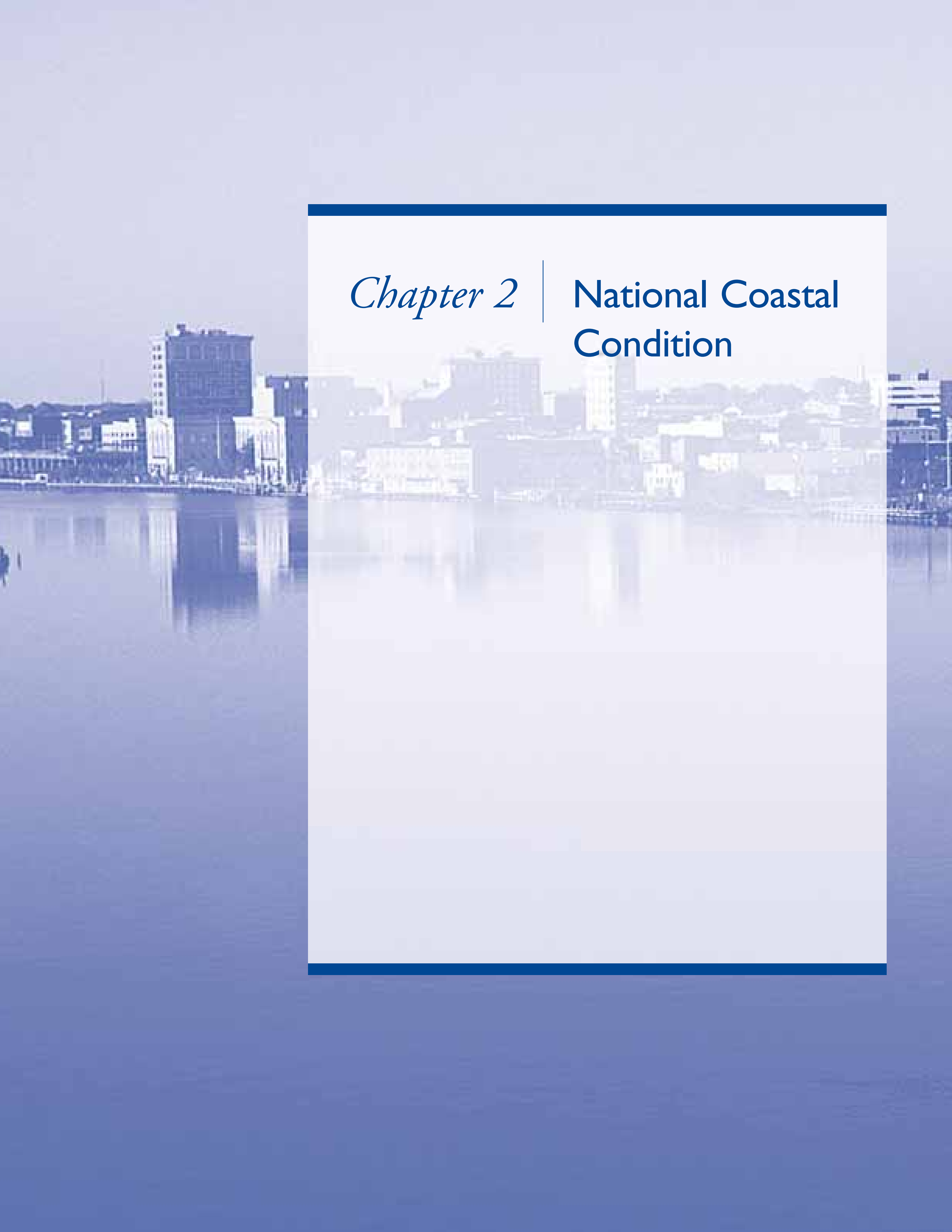
The water quality index, sediment index, benthic index, and coastal habitat index are all measures of ecological condition. The fish tissue contaminants index directly affects human uses of coastal waters and is also a measure of the condition of estuarine fish populations. The final chapter of this report (Chapter 9: Health of Galveston Bay for Human Use) presents a case study that outlines how these indicators of coastal condition connect with human uses. Although this report does not address bacterial contamination as a condition indicator, it does present the areal extent of shellfishing restrictions and swimming advisories based on exceedances of indicator bacteria concentrations in coastal waters. The type of assessment described in Chapter 9 cannot be done on scales larger than a single estuary; however, it is important to address coastal condition at several spatial scales (e.g., national, regional, state, and local). Chapter 9 provides an assessment approach that complements the national/regional approaches by examining the same national/regional monitoring information, as well as additional site-specific information for an individual estuary (Galveston Bay) in order to evaluate conditions with regard to human uses.

Appendices

Three appendices are provided at the end of this report. Appendices A and B assess the quality of data from EPA's NCA Program, the primary source of information for this report. These appendices evaluate the planning, sampling collection, laboratory processing, and auditing aspects of the program, as well as list the uncertainty levels for the estimates provided in Chapters 2 through 8. The appendices also compare these levels with the desired levels of certainty developed through the data quality objective (DQO) process.

Appendix C compares the results of the NCCR I (covering the period 1990 to 1996) with the results of this report (1997–2000). Because of changes in indicators and the availability of different types of data, the comparison cannot be as straightforward as the reader might desire (i.e., direct comparison of the ranking in NCCR I to the ranking in NCCR II). In Appendix C, the estimates and ranking for NCCR I are recalculated using the approaches and methodologies developed in NCCR II. This recalculation allows for a more direct comparison of the two reports.

Giant sea bass *(Stereolepis gigas)* are mainly bottom dwellers, but will come into mid-waters when searching for food. This species was once abundant throughout Southern California, before it was overfished. The giant sea bass eats spiny lobsters, rock crabs, and squid (Mark Conlin).



Chapter 2 National Coastal Condition

National Coastal Condition

The overall condition of estuaries in the United States is fair. Only one of the five indicators of estuarine condition received a poor overall rating, the coastal habitat index. The water quality index and the fish tissue contaminants index received a fair rating, and the benthic index and sediment quality index were rated fair to poor (Figure 2-1 summarizes U.S. estuarine condition). These ratings are based on samples collected at 2,073 estuarine sites in the conterminous 48 states (Figure 2-2) between 1997 and 2000 (about 90% of the samples were collected in 1999 and 2000). Of the five summary indicators (water quality index, sediment index, benthic index, coastal habitat index, and fish tissue contaminants index), only the fish tissue contaminants index was rated good for any region of the United States.

The water quality index is rated fair throughout the estuaries of the United States, although estuarine waters in the Northeast Coast region appear to have poorer water quality conditions than those in other regions of the country. The sediment index is poor in Northeast Coast and Puerto Rico estuaries and in the Great Lakes;

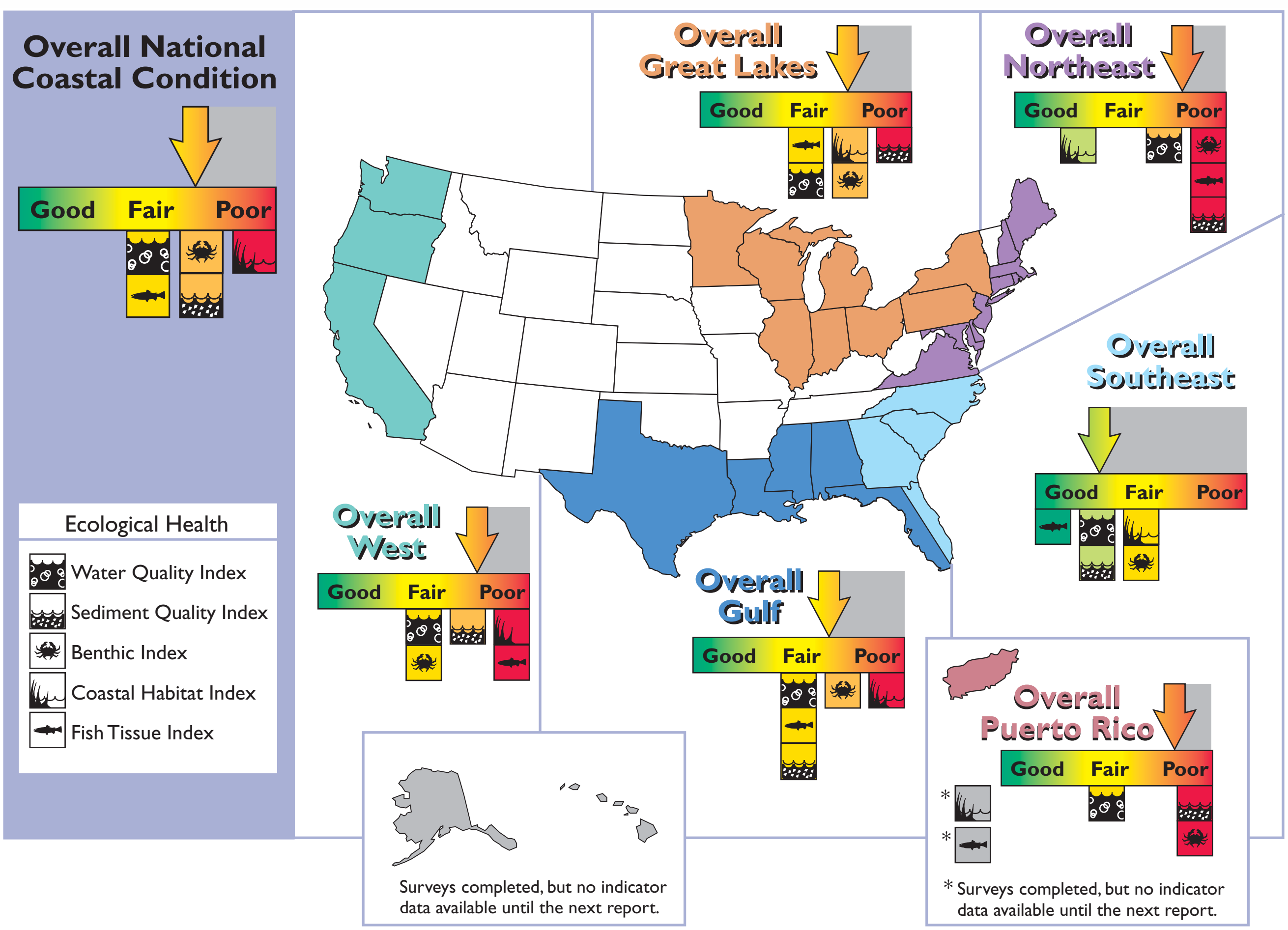


Figure 2-1. Overall national and regional coastal condition between 1997 and 2000.

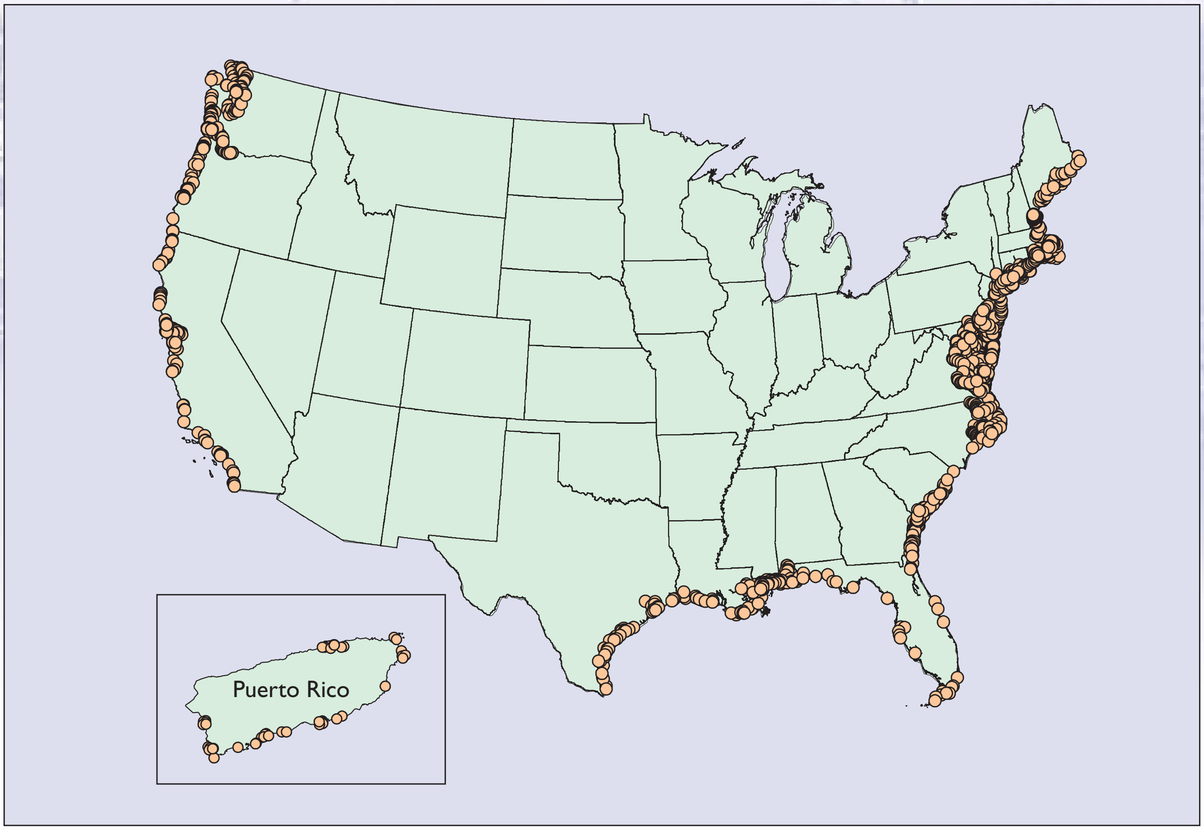


Figure 2-2. Sampling stations for the 1999–2000 NCA Program and for the coastal portion of the 1997–1998 Mid-Atlantic Integrated Assessment (U.S. EPA/EMAP and NCA).

borderline fair in West Coast estuaries; fair in the Gulf Coast estuaries; and borderline good in Southeast Coast estuaries. The benthic index shows that conditions are poor in the Northeast Coast and Puerto Rico, borderline fair in the Gulf Coast and Great Lakes, and fair in the Southeast Coast and West Coast. Condition as measured by fish tissue contaminants is poor in Northeast Coast and West Coast estuaries and fair to good in the remainder of the country.

More specifically, 21% of estuarine area in the United States (excluding the Great Lakes) is unimpaired for human and/or aquatic life uses (Figure 2-3). About 28% of estuarine area is impaired for aquatic life use, 22% is impaired for human use, and an additional 44% is threatened for both uses. Impaired aquatic life use was indicated by lower-than-expected biodiversity, increased abundance of pollution-tolerant species, decreased abundance of pollution-sensitive species, poor water quality condition, poor sediment quality, and coastal wetland losses. Impaired human use was defined as exceedances of fish tissue contaminant risk-based guidelines for consumption (based on four 8-ounce meals per month). Threatened use is equivalent to fair overall condition for any of the indicators.

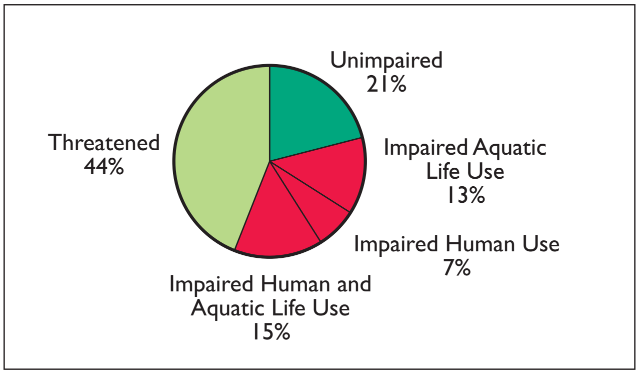


Figure 2-3. National estuarine condition (U.S. EPA/NCA).

Coastal Monitoring Data

This section presents the monitoring data used to rate the five indices of estuarine condition. These calculations do not include proportional area and location data for the Great Lakes. Due to sampling design differences in the data sets, no areal estimates for the Great Lakes can be determined. Although the Great Lakes data are not presented in this section, they are addressed when discussing condition in specific regions of the country. Chapter 7 provides further details of the Great Lakes monitoring data.

Water Quality Index

Data from EPA's NCA Program indicate that the condition of the nation's estuaries, as measured by the water quality index, is fair. This index indicates that 11% of the surface area of the nation's estuaries is in poor water quality condition and an additional 49% is in fair water quality condition (Figure 2-4). Combined, these categories show that 60% of the nation's estuaries are experiencing a moderate-to-high degree of water quality degradation. Poor condition is generally characterized by degradation in water quality response variables (e.g., increased chlorophyll *a* concentration or decreased dissolved oxygen concentration). Fair condition is characterized by some degradation in response variables, but is more likely to be characterized by degradation due to environmental stressors (e.g., increased nutrient concentrations and reduced water clarity). Water quality condition in Northeast Coast estuaries was the poorest in the nation (regionally), with 19% of estuarine waters in poor condition and another 42% in fair condition.

The sampling conducted in the EPA NCA Program has been designed to estimate the percent of estuarine area (nationally or in a region or state) in varying conditions and is 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 indicator 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.

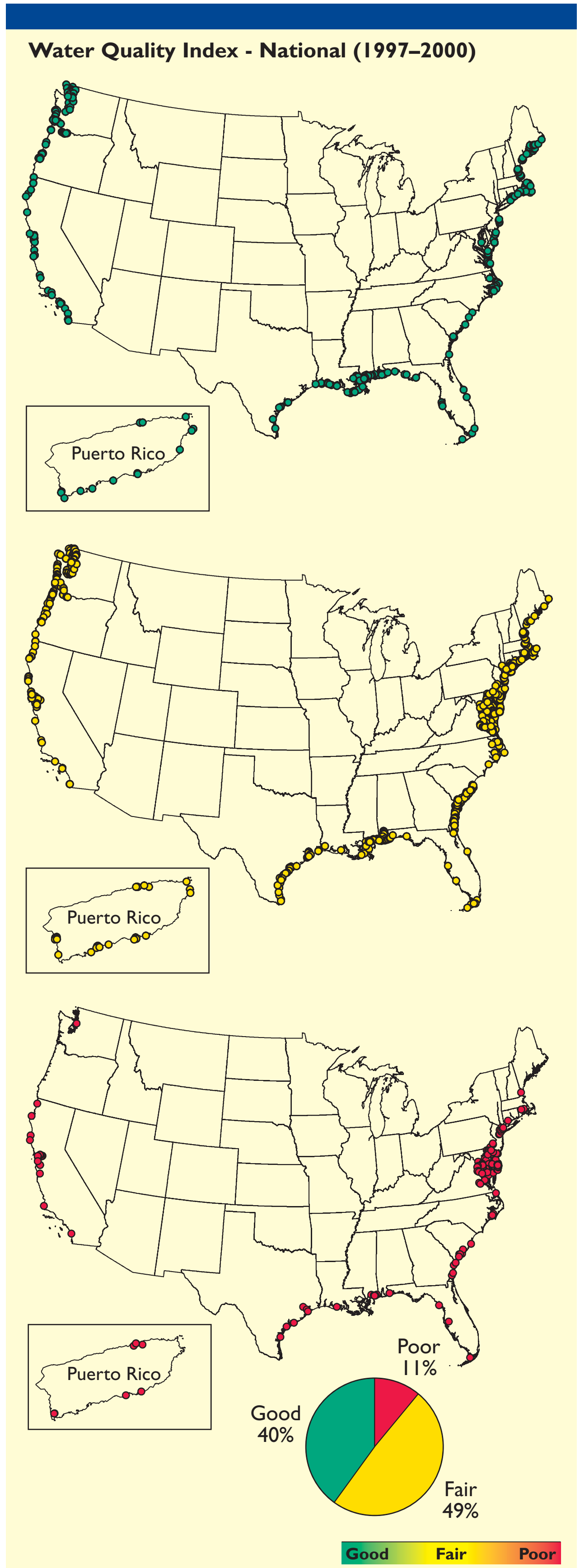


Figure 2-4. National water quality index data (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

Dissolved inorganic nutrient concentrations for summertime conditions in the nation's estuaries were rated good for DIN and DIP. As a result of phytoplankton uptake and growth, nutrient concentrations in summer are expected to be generally lower than at other times of the year, except on the West Coast, where Pacific upwelling events in summer often produce the year's highest nutrient concentrations. Because of the expectation for lower nutrient concentrations, the reference conditions were modified (reduced by 50%) for East Coast and Gulf Coast estuaries. This reduction in reference concentration better represents the "higher, worst-case" conditions generally observed in these regions in the spring.

DIN concentrations were uniformly low throughout U.S. estuaries, with only 5% of waters characterized as having poor condition (Figure 2-5). Most DIN concentrations that exceeded reference conditions were in Northeast Coast estuaries. DIP concentrations exceeded the regional reference conditions in 9% of estuarine waters (Figure 2-6). These elevated summer DIP concentrations were most often observed in Southeast Coast, West Coast, and Gulf Coast estuaries. Elevated DIN and DIP concentrations in Puerto Rico, Northeast Coast, and Gulf Coast estuaries generally correspond to the areas of elevated chlorophyll *a* concentrations.

Figure 2-5. National DIN concentration data (U.S. EPA/NCA).

Figure 2-6. National DIP concentration data (U.S. EPA/NCA).

Chlorophyll *a*

One of the symptoms of degraded water quality condition is the increase of phytoplankton production, as measured by the concentration of chlorophyll *a*. Chlorophyll *a* is a measure used to indicate the amount of microscopic algae (or phytoplankton) growing in a waterbody. High concentrations of chlorophyll *a* indicate the potential for problems related to overproduction of algae. High concentrations of summertime chlorophyll *a* occurred in only 8% of estuarine waters (Figure 2-7), resulting in an overall national rating of good. Moderate concentrations occurred in an additional 41% of estuarine waters. Only one region of the country, Puerto Rico, received a rating of poor, with 29% of its waters exceeding the summertime reference condition. Moderate increases in summertime chlorophyll concentrations occurred most often in Southeast Coast (with 83% of estuarine waters exceeding poor or fair guidelines), Northeast Coast (50%), and Gulf Coast (46%) estuaries. None of the estuaries in these regions experienced large expanses of poor conditions (Southeast = 3%, Northeast = 15%, and Gulf of Mexico = 8%.)

Water Clarity

The overall water clarity of the nation's estuaries is rated fair. Three different regional reference conditions were established for measuring conditions:

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., Louisiana, Delaware, Mobile Bay, Mississippi estuaries) or extensive wetlands (e.g., South Carolina, Georgia).
20%	Areas having extensive SAV beds (e.g., Florida Bay, Indian River Lagoon, and southern Laguna Madre) or desiring to reestablish SAV (e.g., Tampa Bay).
10%	The remainder of the country.

NCA estimates indicate that 25% of the nation's estuaries do not meet these reference conditions (Figure 2-8). Locations with poor water clarity are distributed throughout the country, but the regions with the

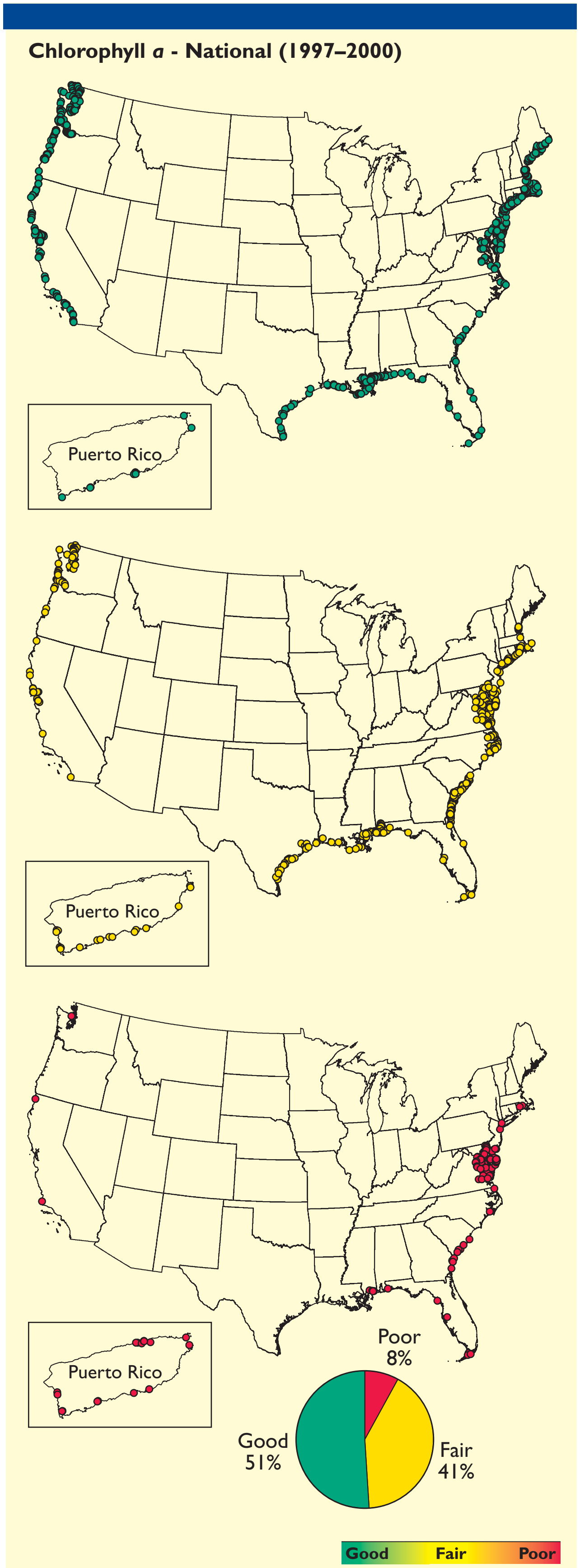


Figure 2-7. National chlorophyll *a* concentration data (U.S. EPA/NCA).

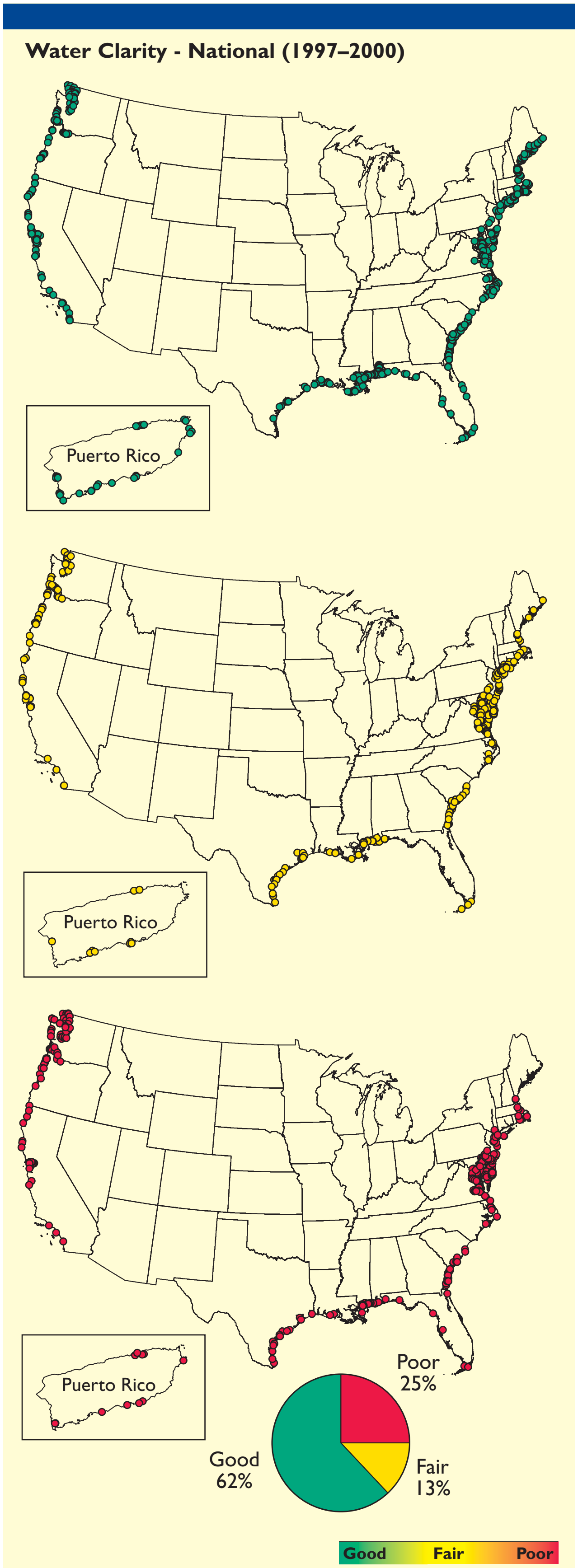


Figure 2-8. National water clarity condition (U.S. EPA/NCA).

greatest proportion of total estuarine area not meeting this condition are in West Coast (36%), Gulf Coast (29%), Northeast Coast (23%), and Puerto Rico (20%) estuaries.

Dissolved Oxygen

Dissolved oxygen conditions in the nation's estuaries are good. Often, low dissolved oxygen occurs as a result of large algal blooms that sink to the bottom and use oxygen during the process of decay. In addition, low dissolved oxygen concentrations can be the result of stratification due to strong freshwater discharge. Dissolved oxygen is a fundamental requirement for all estuarine life. Low levels of oxygen often accompany the onset of severe bacterial degradation, sometimes resulting in algal scums, fish kills, and noxious odors, as well as loss of habitat and aesthetic values. This, in turn, can result in decreased tourism and recreational water use. The NCA estimates that only about 4% of bottom waters in the nation's estuaries have low dissolved oxygen (Figure 2-9). This estimate describes conditions only during daylight hours. All systems have dissolved oxygen cycles in which higher values are observed during daylight (accompanying oxygen production by phytoplankton) and lower values at night (with only respiration occurring). The NCA estimates do not apply to "dystrophic" systems, in which dissolved oxygen levels are acceptable during daylight hours, but decrease to low (even unacceptable) levels during the night. Many of these systems and the biota associated with them are adapted to this cycle—a natural process of oxygen production during the day and respiration at night—which is common in wetland, swamp, and blackwater ecosystems.

The guideline used in the NCA analysis for poor dissolved oxygen condition is a value below 2 mg/L in bottom waters. The majority of coastal states either use a different criterion, ranging from an average of 4 to 5 mg/L throughout the water column to a specific concentration (usually 4 or 5 mg/L) at mid-water, or include a frequency or duration of time that the low dissolved oxygen concentration must occur (e.g., 20% of observed values). The NCA chose to use 2 mg/L in bottom waters because this level is clearly indicative of potential harm to estuarine organisms. Because so many state agencies use higher concentrations, the NCA evaluated the proportion of waters that have dissolved

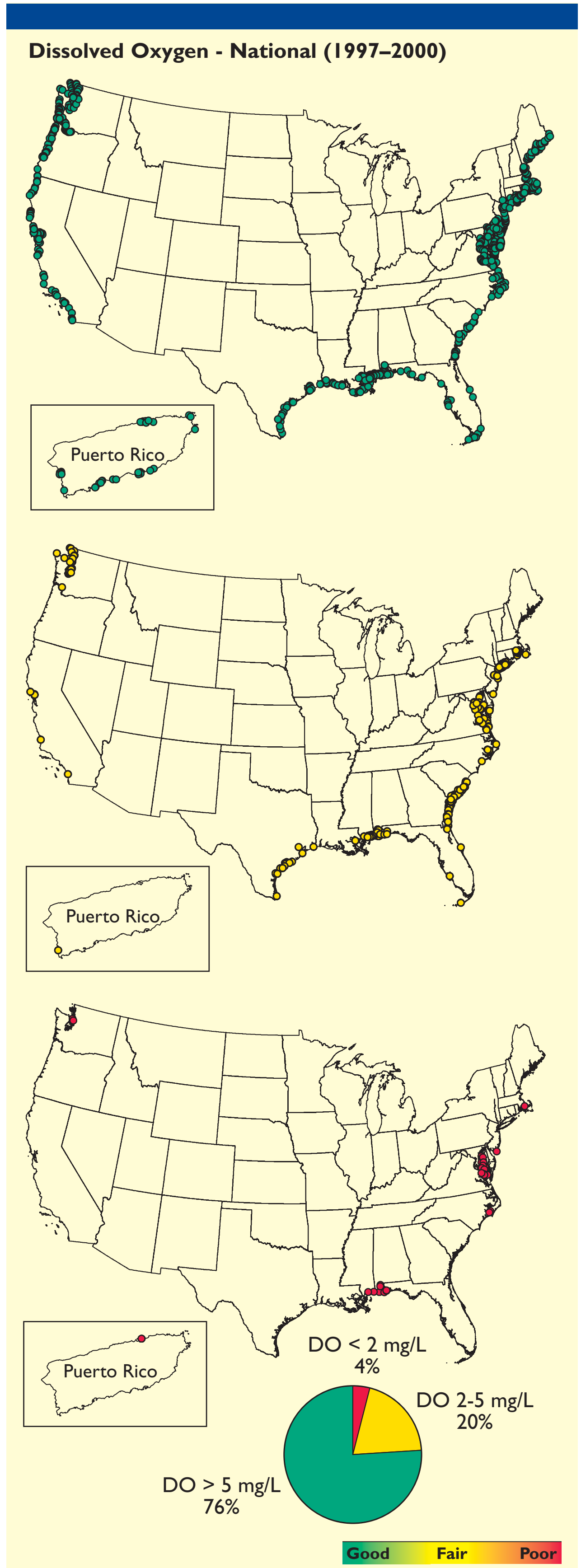


Figure 2-9. National dissolved oxygen concentration data (U.S. EPA/NCA).

oxygen concentrations below 5 mg/L in bottom waters as being in fair condition (i.e., threatened). About 24% of bottom waters have dissolved oxygen concentrations below 5 mg/L (Figure 2-9). Northeast Coast estuaries showed the greatest number of locations experiencing low dissolved oxygen.

The NCA surveys measure dissolved oxygen conditions only in estuarine waters and do not include observations of dissolved oxygen concentrations in offshore coastal shelf waters. The occurrence of hypoxia in Gulf of Mexico shelf waters is a well-known and documented phenomenon. The Gulf of Mexico hypoxic zone is the largest zone of anthropogenic coastal hypoxia in the Western Hemisphere (CAST, 1999). Between 1989 and 1999, midsummer bottom-waters hypoxia increased to include nearly 8,000 square miles. In 2000 (the year of the Gulf of Mexico survey), the hypoxic zone was greatly reduced to less than 1,800 square miles; however, the hypoxic zone returned to about 8,000 square miles in 2001. The reduction in the size of the zone in 2000 corresponds to severe drought conditions in the Mississippi River watershed and, presumably, decreased flow and loading to the Gulf of Mexico from the river mouth. A complete discussion of the hypoxic zone is provided in Chapter 5, Gulf of Mexico Coastal Condition.

Interpretation of Instantaneous Dissolved Oxygen Information

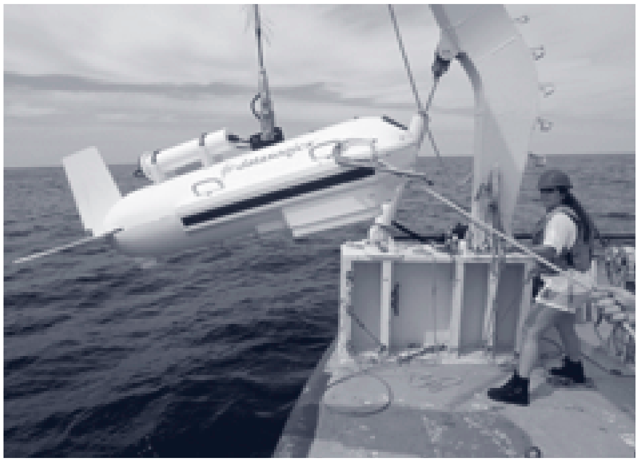
Although NCA survey results do not suggest that dissolved oxygen concentrations are a pervasive problem, the instantaneous measurements on which these results are based may have underestimated the magnitude and duration of low dissolved oxygen events at any given site. Longer-term observations by other investigators have revealed increasing trends in frequency and areal extent of low-oxygen events in some coastal areas. For example, extensive year-round or seasonal monitoring data over multiple years in such places as the Neuse and Pamlico rivers in North Carolina and the Narragansett Bay in Rhode Island (see Highlight in Chapter 3) have shown a much higher incidence of hypoxia than is depicted in the present NCA data. These data show that while hypoxic conditions do not exist continuously, they can occur occasionally to frequently for generally short durations of time (hours).

Sediment Quality Index

National estuarine conditions, as measured by sediment quality, are rated fair to poor. The sediment quality index is based on sediment toxicity, sediment contaminant concentrations, and the proportion of TOC in the sediments. About 13% of sediments in the nation's estuaries received a poor rating for one of these index components (Figure 2-10). The regions showing the largest proportional areas with poor condition were Puerto Rico (61%), Northeast Coast (16%), and West Coast (14%) estuaries. Although there are no areal estimates for poor sediment conditions in the Great Lakes, non-probabilistic surveys of that region conducted locally resulted in sediment quality being given a poor rating.

Sediment Toxicity

Sediment toxicity in the nation's estuaries is rated poor. During the NCA survey, researchers determined sediment toxicity by exposing the organisms to sediments from each location and evaluating the effects of these sediments on the survival of the organisms. Sediment toxicity tests, which were conducted using the benthic amphipod *Ampelisca abdita,* showed significant mortalities associated with 6% of estuarine sediments in the United States (Figure 2-11). Sediment toxicity was observed most often with sediments from West Coast (17%) and Northeast Coast (8%) estuaries. This indicator does not have a fair category; sediments were determined to be either toxic (poor) or non-toxic (good).



A sub-bottom profiler allows geologists to get data about the seafloor and the structure below. (photo: Dan Blackwood, USGS)

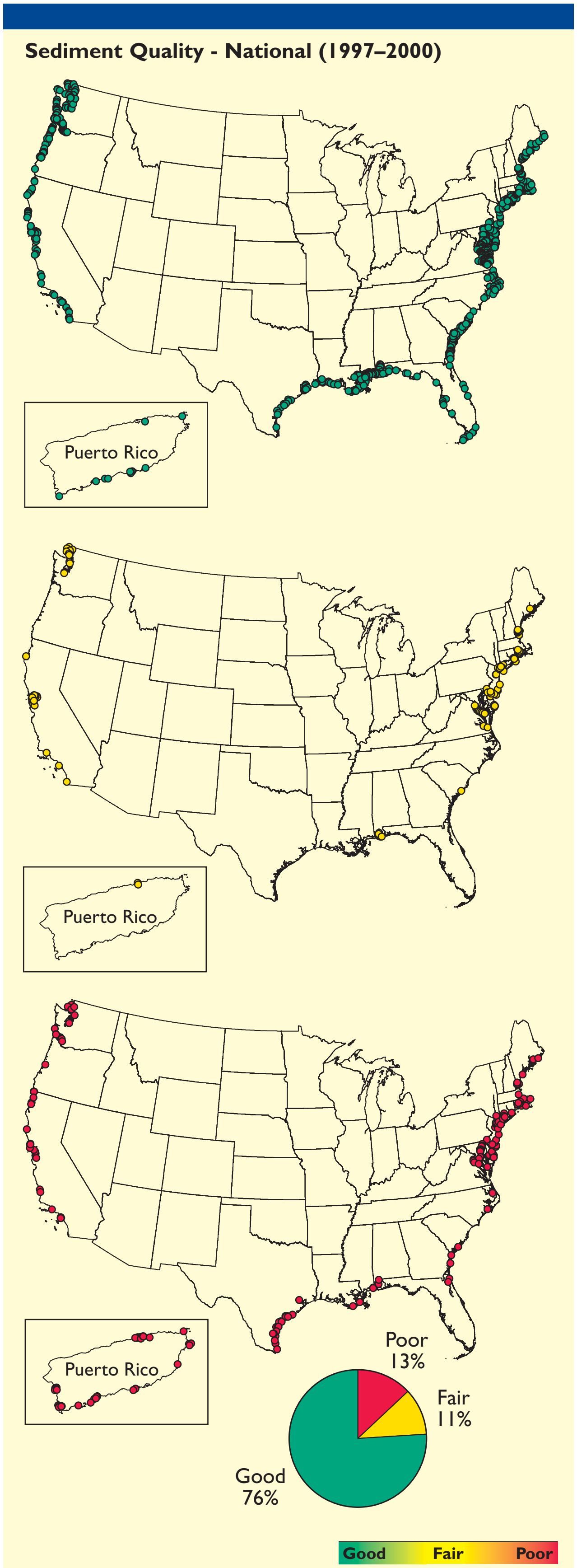


Figure 2-10. National sediment quality index data (U.S. EPA/NCA).

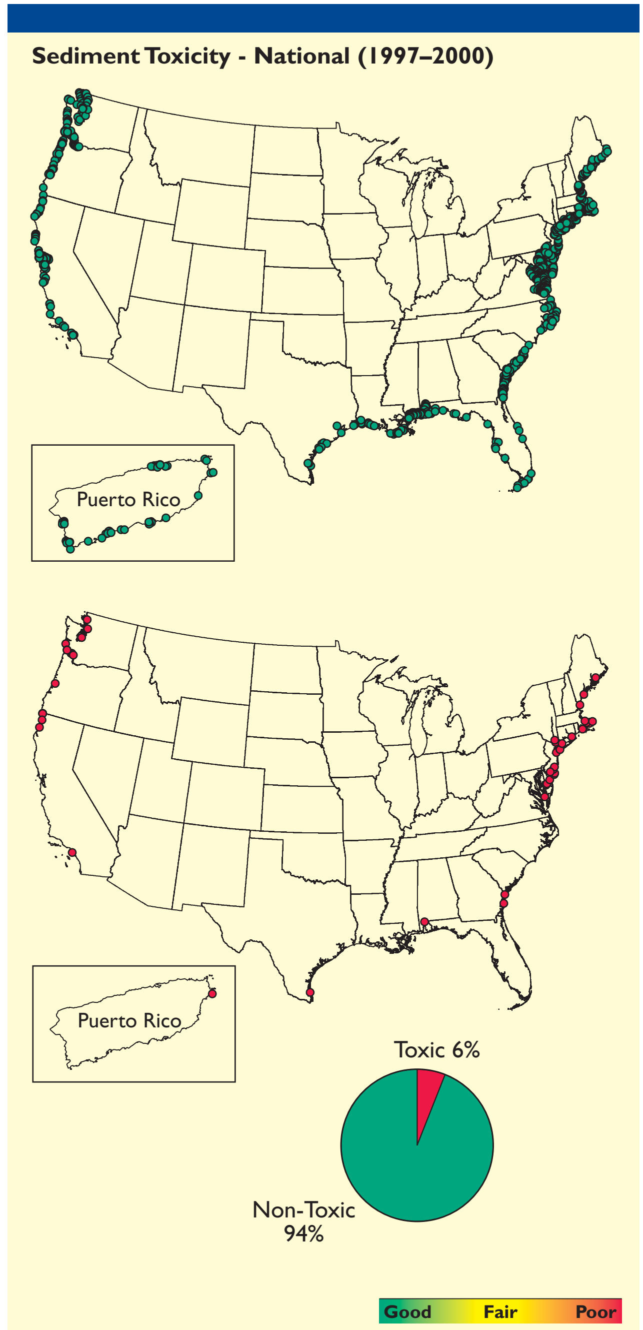


Figure 2-11. National sediment toxicity data (U.S. EPA/NCA).

highlight

A Report to the Nation on the Condition of Coral Reefs

In 1998, growing concerns for the health of coral reefs prompted the issuance of a Presidential Order (E.O. 13089) for the protection of coral reefs, establishing the U.S. Coral Reef Task Force (USCRTF) and requiring a report to the nation every two years on reef condition.

The United States has jurisdiction over tropical coral reefs that cover an estimated 7,607 square miles. In the Atlantic and Caribbean, these reefs include shallow-water coral reefs off Florida, Puerto Rico, the U.S. Virgin Islands, and the Navassa Island National Wildlife Refuge near Haiti. In the Pacific, they include extensive coral reefs off the Hawaiian archipelago, American Samoa, Guam, the Northern Mariana Islands, Wake Atoll, and six remote National Wildlife Refuges. The Pacific Freely Associated States (Republic of Palau, Republic of the Marshall Islands, and the Federated States of Micronesia) have some of the richest coral reefs in the world, covering an estimated 7,250 square miles (Wilkinson, 2002). Once U.S. protectorates, and now associates through formal pacts, these states asked to be included in U.S. coral reef activities.

Scientist conducts coral reef survey (James Maragos, USFWS).

Since the issuance of E.O. 13089, the first required biennial report, *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2002* (Turgeon et al., 2002), has been published. In 2000, the USCRTF issued its *National Plan for Action to Conserve Coral Reefs* (National Action Plan) that called for a mapping and monitoring program to help assess the condition of U.S. coral reefs. Since then, Congress has appropriated substantial funding each year for coral reef conservation. In addition, the Coral Reef Conservation Act of 2000 further integrated international, federal, state, and territorial agency efforts to map, monitor, conduct research on, restore, and manage the U.S. coral reef ecosystems.

To provide reliable assessments of reef health, the National Action Plan called for the mapping of all shallow-water reefs by 2009, the establishment of a nationally coordinated coral reef monitoring network, and the initiation of new monitoring to fill information gaps. Presently, 46% (6,894 square miles) of U.S. shallow-water coral reef habitats have been surveyed. Digital maps are available for Puerto Rico, the U.S. Virgin Islands, Hawaii (http://biogeo.nos.noaa.gov/), and much of the Florida Keys. NOAA has awarded cooperative grants each year since fiscal year 2000 to state and island agencies to build local capacity and fill gaps in monitoring. NOAA also awarded grants to the Pacific Freely Associated States in fiscal year 2002. Data collected under these grants and data from the National Coral Reef Monitoring Network (http://coris.noaa.gov/) will be the basis for the next biennial report on coral reefs in 2004.

Atlantic Coast Environmental Indicators Consortium

The Atlantic Coast Environmental Indicators Consortium (ACE INC) is developing broadly applicable, integrative indicators of ecological condition, integrity, and sustainability across four distinct and representative estuarine systems on the Atlantic coast of the United States. These estuarine systems include the nation's two largest estuarine complexes, the Chesapeake Bay in Maryland and Virginia and the Albemarle-Pamlico Sound in North Carolina; a small estuary, the Parker River, situated in the Plum Island National Science Foundation Long-Term Ecosystem Research (LTER) site in Massachusetts; and a river-dominated system in the southeast Atlantic Bight, the North River Inlet in South Carolina. These sites are representative of three primary producer bases (intertidal marsh—Plum Island and North Inlet; plankton dominated—Chesapeake Bay and Albemarle-Pamlico Sound; and seagrass dominated—portions of Chesapeake Bay and Albemarle-Pamlico Sound). They also have ongoing, long-term water quality and/or habitat monitoring programs in place that provide data for indicator development and testing. These systems each contain both pristine and impaired waters.

Because different types of coastal systems likely differ in their response to man-made or naturally induced stresses, a framework is required to assess status and to predict responses for each of the major system types. ACE INC is working to produce concise and accurate representations of ecosystem function and health, based on key variables, to detect trends in ecosystem health and to use indicators to predict the effects of human actions versus natural variability across a variety of systems, both regionally and nationally. ACE INC defines an indicator as a sign or signal that relays a complex message, potentially from numerous sources, in a simplified and useful manner. An ecological indicator is a measure, an index of measures, or a model that characterizes one or more critical components of ecosystem structure and function. With a foundation of diagnostic research, an ecological indicator may also be used to identify major ecosystem stress (Jackson et al., 2000). The present lack of established regional and national bioindicators, despite extensive monitoring at thousands of sites nationwide and specific community efforts to develop bioindicators, is testimony to the magnitude and complexity of the task. Prior efforts to achieve this goal have suggested that the most promising avenue to success is to link theoretical models with empirical relationships.

Current ACE INC research activities address the following primary objectives:

- Use remotely sensed data and time-series information on key water quality and habitat condition variables to enhance the archive of existing data for these systems
- Apply detailed knowledge of ecosystem structure and function to analyze the existing data archive and develop candidate indicators
- Test the ability of these indicators to gauge ecosystem health and clearly detect trends resulting from both natural variability and man-made stresses in multiple estuaries.

The ACE INC research plan includes the following tasks:

- Development of indicators for microalgal and macrophyte functional groups that control much of estuarine and coastal primary production
- Development of indicators for plankton and fish community structure (organization) and function, specifically indices that relate to trophic transfer and sustainable higher trophic levels
- Coupling of biological indicators with physical-chemical and remote sensing assessments of ecosystem function, trophic state, and change
- Development and application of indicators within a national coastal indicator framework (EPA Estuarine and Great Lakes Ecological Indicators [EaGLe] Program).

ACE INC is examining the indicators that form the backbone of monitoring and modeling efforts for ecosystems, regional and national water quality, habitats, and living resources. These indicators are used to calibrate and ground truth aircraft and satellite remote sensing of estuarine and coastal resources in terms of plant community structure, function, and ecological health. ACE INC is linking phytoplankton, marsh, and seagrass proxies with metrics of trophic structure to provide indicators for the status of living resources.

For more information on ACE INC, visit http://www.aceinc.org.

Status and Trends of Chemical Concentrations in Mussels and Oysters in the United States

NOAA created the NS&T Program to assess the impact of human activities on the quality of coastal and estuarine areas. In 1986, NS&T's Mussel Watch Project began to monitor chemical contamination by analyzing mussel and oyster tissues collected at fixed sites throughout the coastal United States. The term "Mussel Watch" usually refers to a program that uses mollusks as environmental sentinels to monitor chemical contamination. Mollusks are good indicators of contamination because they concentrate chemicals from their surroundings in their tissues. This makes chemical analyses an integrated measurement of contamination over time, rather than a snapshot. Measurements of chemical contaminants concentrated in mollusk tissues are also less prone to error than measurements of lower concentrations of contaminants in water.

The NS&T sites for the Mussel Watch Project were chosen to be representative of their surroundings. Because the sites must support an indigenous community of mollusk, the sites were not selected randomly and were not located in "hot spots" directly influenced by particular sources of contamination. Details on the NS&T sampling strategy, site and species descriptions, quality assurance methods, chemical methods, data analysis information, raw data, and a list of NS&T publications available on the Internet can be found at http://nsandt.noaa.gov.

Table 2-1. Spearman correlation coefficients between molluscan concentration and the number of people living within 12 miles of each site, as per 1990 U.S. Census Bureau data. For silver, copper, and zinc, concentrations in oysters must be analyzed separately from those in mussels because oysters naturally accumulate those elements to a much greater extent than do mussels.

Chemical	Spearman Correlation Coefficient
Total PCBs	0.623
Lead	0.598
Total organotins	0.585
Total chlordane	0.598
Total DDT	0.553
Total HMW PAHs	0.520
Zinc (oyster)	0.486
Silver (mussel)	0.458
Total PAHs	0.473
Copper (mussel)	0.288
Total LMW PAHs	0.252
Copper (oyster)	0.193
Chromium	0.181
Mercury	0.179
Zinc (mussel)	0.174
Total dieldrin	0.153
Silver (oyster)	0.044
Arsenic	-0.024
Nickel	-0.107
Selenium	-0.140
Cadmium	-0.312

Distributions of Concentrations

The Mussel Watch Project samples more than 220 sites regularly. In 1990, it sampled 214 sites, and the sampling results, together with 1990 U.S. Census Bureau data, illustrate a trend in the distribution of chemical concentrations that has persisted throughout the program. Table 2-1 lists correlations between chemical concentrations and the number of people living within 12 miles of a site. There are fairly strong connections between human population density and chemical concentrations in oysters and mussels for total chlordane, total DDT, total PCBs, total butyltin, total high molecular weight (HMW) PAHs, and lead, with Spearman correlation coefficients that are greater than 0.5 (Table 2-1). These findings are not surprising. The first four chemicals are synthetic chemicals whose concentrations would be zero in the absence of human activity. Although total HMW PAHs and lead would normally be found in mollusks, their present concentrations are almost entirely due to human actions. For total dieldrin, total low molecular weight (LMW) PAHs, and the elements silver, mercury, and zinc, the national-scale correlations are low, but more than 40% of the high concentrations (those above the 85th percentile) are found among the 15% of sites with 800,000 or more people living within 12 miles. For other elements, there was no evident tendency for high concentrations to be driven by human actions.

Trends

The national trends in contamination for each chemical measured in the Mussel Watch Project have been described in various publications and on the Web. For each chemical, the national-scale trends have shown either a decrease or no trend at all over the last decade. The only trace element to show a trend (decrease) has been cadmium. All the chlorinated organic compounds whose use has been banned have been showing a decrease. The results for organic chemicals for 1986 through 2002 are shown in Figure 2-12. All the chlorinated compound concentrations continue to show statistically significant decreasing trends, and at this point, there are also evident decreasing trends for LMW and HMW PAHs.

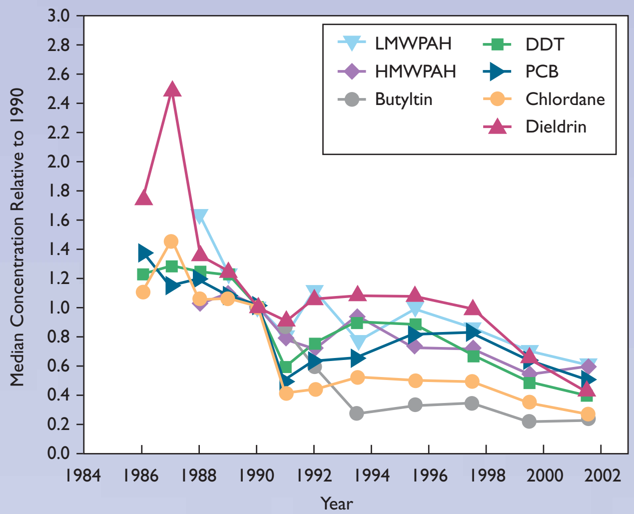


Figure 2-12. Trends in contaminants concentrations measured in NOAA's Mussel Watch Project since 1986 (Developed by NOAA for NCCR II).

Concentrations above Public Health Advisories

The intent of the Mussel Watch Project is to monitor the status and trends of coastal contamination, regardless of whether chemical concentrations present a hazard to marine biota or to human consumers of seafood. One indicator of coastal condition, nonetheless, is the suitability of seafood for human consumption. The FDA prohibits the interstate shipment and sale of seafood containing more-than-specified concentrations of mercury and certain chlorinated hydrocarbons. FDA guidelines also suggest that mollusks not be consumed if concentration limits are exceeded for chromium, nickel, lead, cadmium, and arsenic. Among the 4,000 mussel and oyster samples analyzed in the Mussel Watch Project, no mollusks collected in any year exceeded the FDA limit or guideline for mercury, chromium, nickel, or arsenic. For chlorinated hydrocarbons, only total PCBs at the Angelica Rock site in Buzzards Bay, Massachusetts, exceeded concentration limits. The limit for cadmium (for humans eating shellfish at the 90th percentile consumption rate) was exceeded in 1991 at the site on Lake Ponchartrain in New Orleans, Louisiana. In several years, mollusks at 36 of the sites had lead concentrations that exceeded the 0.8 µg/g wet weight guideline for children consuming mollusks at the 90th percentile rate. Fewer sites had lead in excess of the 1.4 µg/g wet weight limit for children consuming at the mean rate or pregnant women consuming at the 90th percentile rate. No sites had lead concentrations in excess of guidelines for adult consumption.

The guidelines set by EPA for human health are generally more stringent than those set by FDA. For example, although the FDA mercury limit of 1 µg/g wet weight has not been exceeded at any NS&T site, the EPA limit of 0.4 µg/g has been exceeded at least once at 25 sites. Exceedances of the EPA guideline for arsenic depend on how much of the total arsenic in a sample is assumed to be inorganic. With an assumption of 10%, the EPA arsenic guideline has been exceeded in all samples and in all years. With an assumption that only 1% of the total arsenic is in the inorganic form (most toxic form), the guideline has been exceeded in some or all years at 47 sites. Major differences between EPA and FDA limits are evident for dieldrin, total PCBs, and benzo(a)pyrene, the last of which has no FDA limit. For the 222 sites sampled in 2001 and 2002, there were 7 exceedances of EPA guidelines for dieldrin, 47 for total PCBs, and 45 for benzo(a)pyrene.

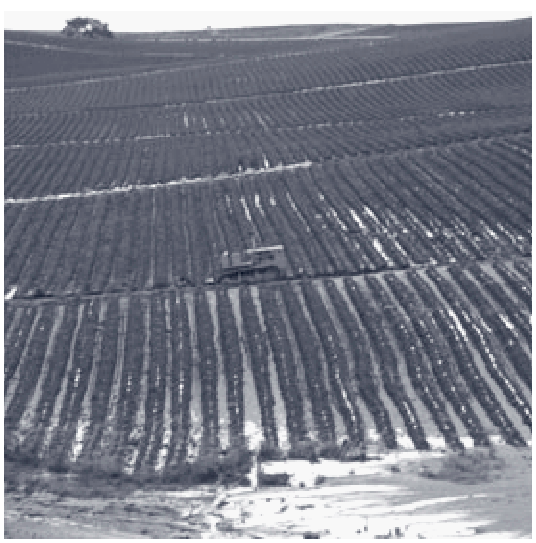
Sediment Contaminants

The sediment contaminant indicator in the nation's estuaries is rated fair. National and regional monitoring programs conducted by EPA and NOAA provide information on the concentrations of contaminants found in estuarine sediments throughout the United States. Measurements of nearly 100 contaminants, including 25 PAHs, 22 PCBs, 25 pesticides, and 15 metals, have been taken at each site. Long et al. (1995) developed ERM and ERL values that were used as guidelines to determine sediment condition. Poor condition was determined to be an exceedance of one or more ERMs, and fair condition was determined to be an exceedance of five or more ERLs. Poor sediment contaminant condition was observed in 7% of the estuarine sediments in the nation, and fair condition was observed in an additional 8% (Figure 2-13). The highest proportion of regional sediments exceeding these ERM guidelines occurred in Puerto Rico (23%), Gulf Coast (11%), and Northeast Coast (8%) estuaries.

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 values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.



Many of the activities that take place on land can also effect the marine life in the Monterey Bay National Marine Sanctuary. Agriculture, an important multi-billion dollar industry, can also deliver pesticides and sediment loads to the sanctuary during periods of heavy rainfall.

Figure 2-13. National sediment contaminants data (U.S. EPA/NCA).

highlight

Endocrine Disruption in Fish: An Assessment of Recent Research and Results

Concern has arisen that certain environmental contaminants, as well as some naturally occurring compounds, have the potential to affect the endocrine system in animals. The endocrine system regulates a number of vital life processes, including reproduction, growth, development, and metabolism, through the production and action of hormones. Compounds that can either mimic or antagonize the action of endogenous hormones are termed endocrine disrupting compounds (EDCs), or endocrine disrupters. Studies on the identification and effects of EDCs have become an important area of human and environmental health research.

NOAA's National Centers for Coastal Ocean Science completed an assessment of recent laboratory and field investigations into endocrine disruption in freshwater and saltwater species of fish. Most of the research to date in fish in the United States and elsewhere has concentrated on reproductive endocrine disruption, although other areas of the endocrine system, such as thyroid hormone balance and function, may also be targets for EDCs. Laboratory studies revealed that a number of chemicals—including certain industrial intermediates (e.g., alkyl phenols and bisphenol-A), PAHs, PCBs, pesticides, dioxins, trace elements, and plant sterols—can interfere with the endocrine system in fish. The potency of these EDCs, however, is typically hundreds to thousands of times lower than that of naturally occurring hormones. Environmental endocrine disruption in fish can result in the presence of female egg proteins in males and reduced levels of natural hormones in males and females, as well as in the presence of both male and female gonadal tissue (intersex fish) in normally separate-sex species. Overt endocrine disruption does not appear to be a widespread environmental phenomenon in fish, particularly in the United States, but rather it is more likely to occur in locations adjacent to sewage treatment plants (STPs), near pulp and paper mills, and in areas of high organic chemical contamination. Some of the most severe impacts, including the presence of intersex fish, have been seen adjacent to STPs, particularly near certain facilities in the United Kingdom. Effects near STPs are thought to be caused primarily by natural and synthetic estrogens and to a lesser extent by degradation products of alkyl phenolic surfactants. Effects in fish near pulp and paper mills include reduced hormone levels and masculinization of females, and they have been linked to the presence of ß-osteral, a plant sterol released during the paper-pulping process. In areas of heavy industrial activity and contamination, reduced levels of estrogens and androgens, as well as reduced gonadal development, have been seen in fish and are thought to be linked to the presence of PAHs, PCBs, and possibly dioxin.

For more information visit http://nsandt.noaa.gov/index_endocrine.htm.

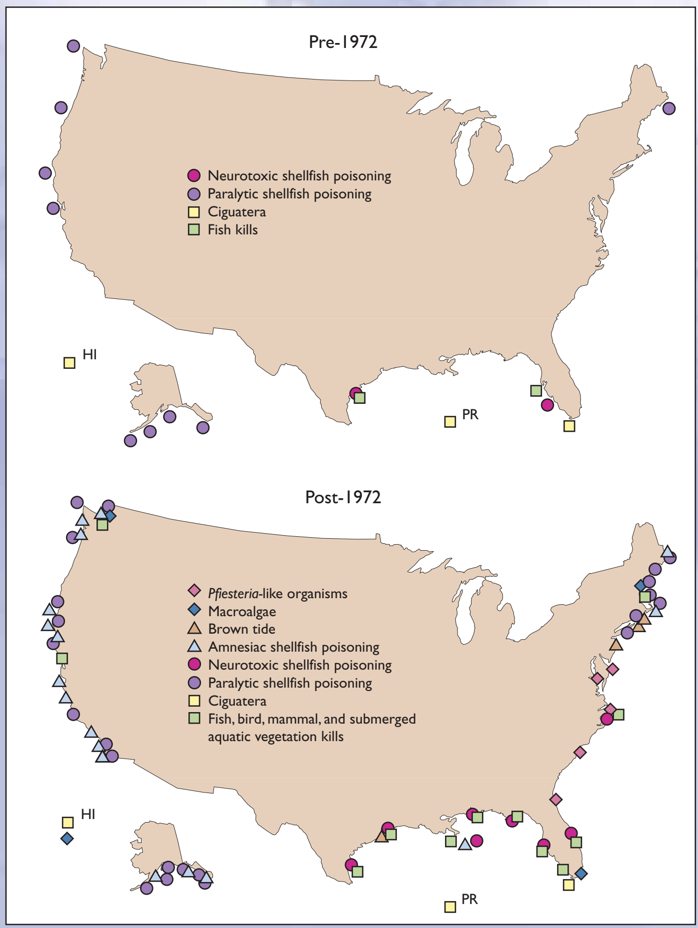
A mixed-species school of rockfish in the ocean above Cordell Bank, CA. (photo: Cordell Bank Expeditions)

Harmful Algal Blooms

The term "harmful algal blooms" (HABs) describes a diverse array of marine algae blooms that cause toxic effects in humans and other organisms; physical impairment of fish and shellfish; nuisance conditions from foul odors to discoloration of waters; overwhelming effects on ecosystems, such as severe oxygen depletion; and overgrowth of bottom populations. For some HAB species, concentrations of only a few algae cells per liter may produce toxic effects that cause illness or death to humans, marine mammals, and other marine life.

HABs have been responsible for an estimated $1 billion in economic losses over the past few decades. These blooms have decimated the scallop fishery in Long Island's estuaries; closed shellfisheries on Georges Bank, from North Carolina to Louisiana, and throughout the Pacific Northwest; killed hundreds of manatees in Florida, sea lions in California, and dolphins in the northern Gulf of Mexico; and caused significant respiratory illness in coastal residents and vacationers.

HABs are found in the waters of almost all coastal and Great Lake states, and they have been increasing in number and extent. Nationwide, there are more HAB species, more HAB events, more algal toxins, more areas affected, more fisheries affected, and higher economic losses today than there were 25 years ago. The reason for the apparent increase in HAB rates is uncertain. Some reports of new HAB events may simply reflect better detection methods and more monitoring rather than new species introductions or dispersal events. Today, more researchers and managers are surveying a greater number of waterways for the presence of HAB species, using more sensitive and more accurate tools than ever before.



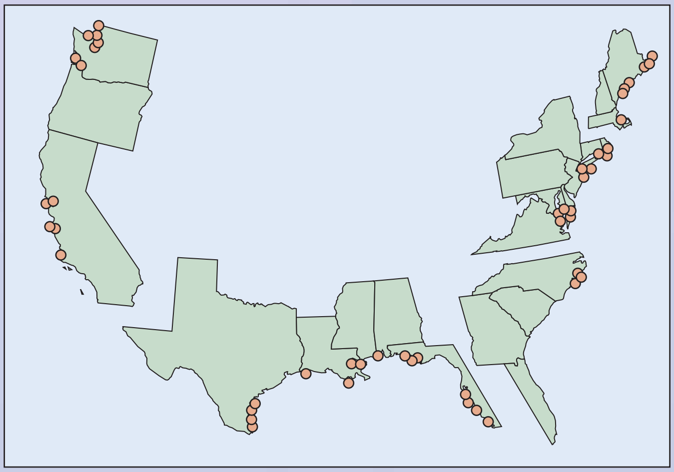
Since 1972, the number and distribution of HAB species and events in U.S. waters have increased (CENR, 2000).

Both natural events and human activities may also be responsible for the apparent increase in HAB rates. In addition, natural events, such as hurricanes, may play a role in the spread of HABs by dispersing the algae population and their nutrient sources via wind and water movement. Humans may also contribute to the expansion of species by transporting toxic species to new port areas in ships' ballast water.

Several causes of HABs have been identified—some natural, others man-made—and research continues to identify and distinguish these causes. Excess nutrients delivered to coastal waters may act as fertilizer and stimulate blooms in populations of naturally occurring algae.

Currently, management options are limited; they include developing methods to reduce the incidence and extent of HABs containing blooms and minimizing the impact of the blooms. Where possible, preventing the growth of HABs is preferable to treating the symptoms. It may be possible to prevent growth of some HABs (1) by controlling the nutrient inputs to HAB species that are stimulated by nutrient, (2) by using clays to precipitate algal cells, or (3) by using viruses to attack the algal cells.

For more information visit http://www.hab.nos.noaa.gov.



U.S. estuaries with reported moderate to high levels of nuisance or toxic blooms, cited as symptoms of high eutrophication conditions that are caused primarily by nutrients (Bricker et al., 1999).

Sediment Total Organic Carbon

Although TOC exists naturally in estuarine sediments and is the result of the degradation of autothonous and allochthonous organic materials (e.g., phytoplankton, leaves, twigs, dead organisms), anthropogenic sources of TOC materials (e.g., organic industrial wastes, untreated or only primary-treated sewage) can significantly elevate the level of TOC in sediments. TOC in estuarine sediments is often a source of food for some benthic organisms, and high levels of TOC in estuarine sediments can result in significant changes in benthic community structure and in the predominance of pollution-tolerant species. Increased levels of sediment TOC can also reduce the general availability of organic contaminants (e.g., PAHs, PCBs, pesticides); however, increases in temperature or decreases in dissolved oxygen can sometimes result in the release of these "TOC-bound" and "unavailable" contaminants. Nationally, the level of TOC in estuarine sediments was rated good, with only 3% of estuarine sediments being rated poor (Figure 2-14). The only exception to this rating was Puerto Rico, where estuarine sediments showed high levels of TOC, with 44% of sediments having TOC levels higher than 5% (poor condition).

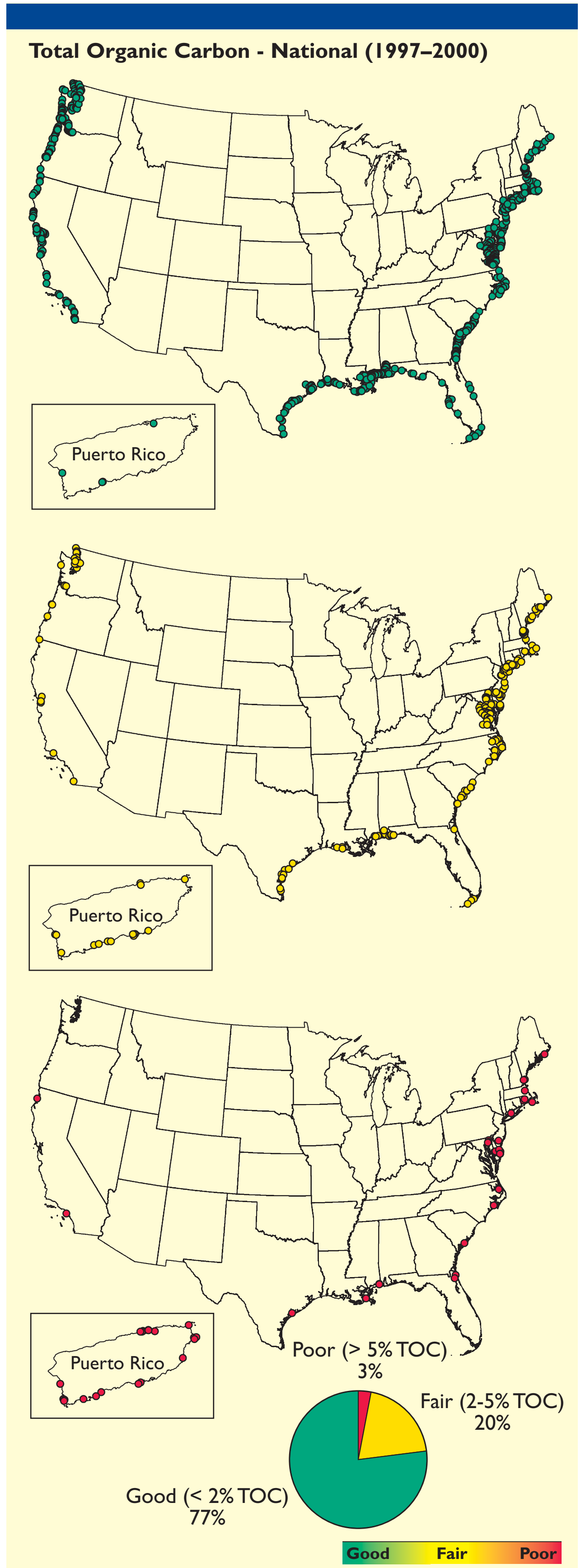


Figure 2-14. National sediment TOC data (U.S. EPA/NCA).

Benthic Index

The condition of benthic communities in the nation's estuaries is fair to poor. Figure 2-15 shows that 17% of estuarine sediments are characterized by benthic communities that are in poor condition (i.e., the communities have lower-than-expected diversity, are populated by greater-than-expected pollution-tolerant species, or contain fewer-than-expected pollution-sensitive species as measured by multimetric benthic indices). Estuaries in the Northeast and Puerto Rico were rated poor, with 22% and 35% of sediments in those regions having poor benthic communities. Estuaries along the Gulf Coast were rated borderline fair, with 17% of sediments rated poor and an additional 26% rated fair for benthic communities.

For the locations that showed poor benthic community quality or reduced benthic diversity, the co-occurrence of poor environmental quality (exposure from degraded water quality or sediment quality variables) is shown in Figure 2-16. Of the 17% of the nation's estuarine area that had poor benthos, 70% also showed indicators of sediment quality and 42% showed indicators of water quality. These figures indicate generally that impaired benthic condition co-occurred in areas with degraded sediment conditions. This co-occurrence does not imply causation. In fact, numerous sites with documented water and sediment quality degradation showed healthy, unimpaired benthic communities, suggesting that the interaction is complex and that increased environmental stress will not always result in degraded aquatic life. However, the converse—the occurrence of poor benthic community conditions—mostly occurred in areas of environmental degradation.

Coastal Habitat Index

Although the loss of wetland habitats in the United States has been significant over the past 200 years, only small losses of coastal wetlands were documented from 1990 to 2000 (Table 2-2). The coastal habitat index score is the average of the mean long-term, decadal loss rate of coastal wetlands (1780–1990) and the present decadal loss rate of coastal wetlands (1990–2000). During the decade from 1990 to 2000, the United States lost approximately 13,210 acres of coastal

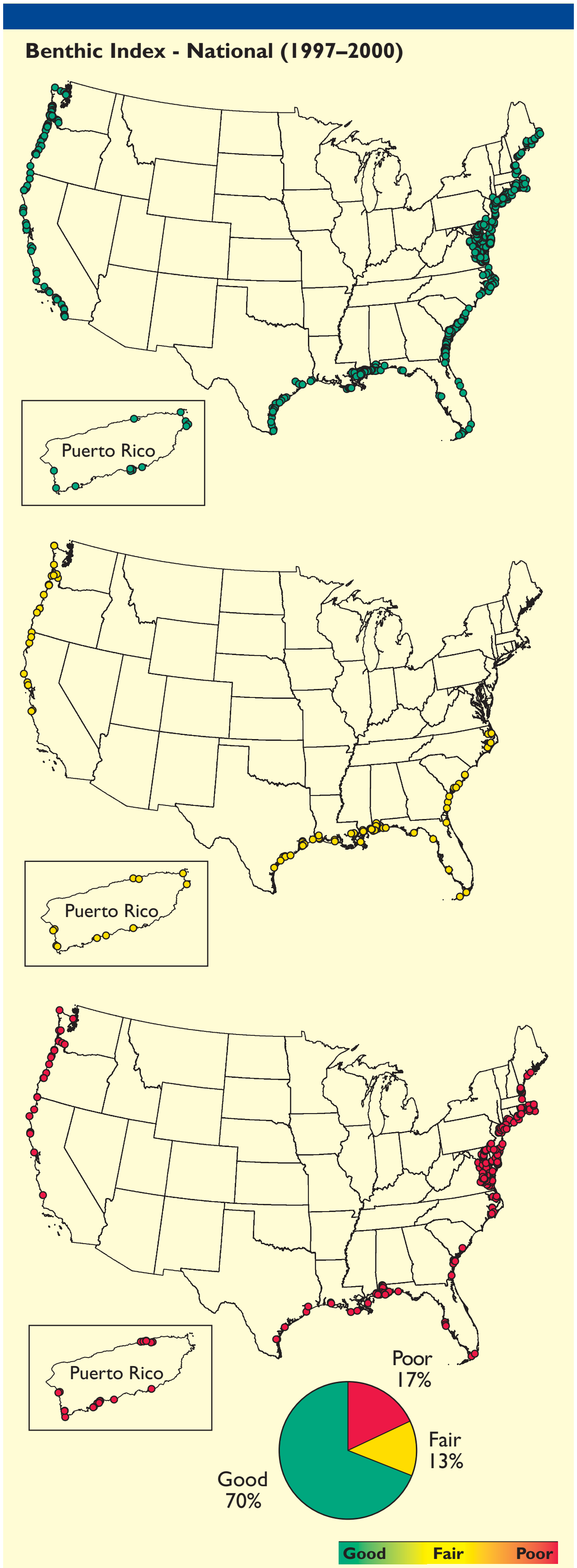


Figure 2-15. National benthic index condition (U.S. EPA/NCA).

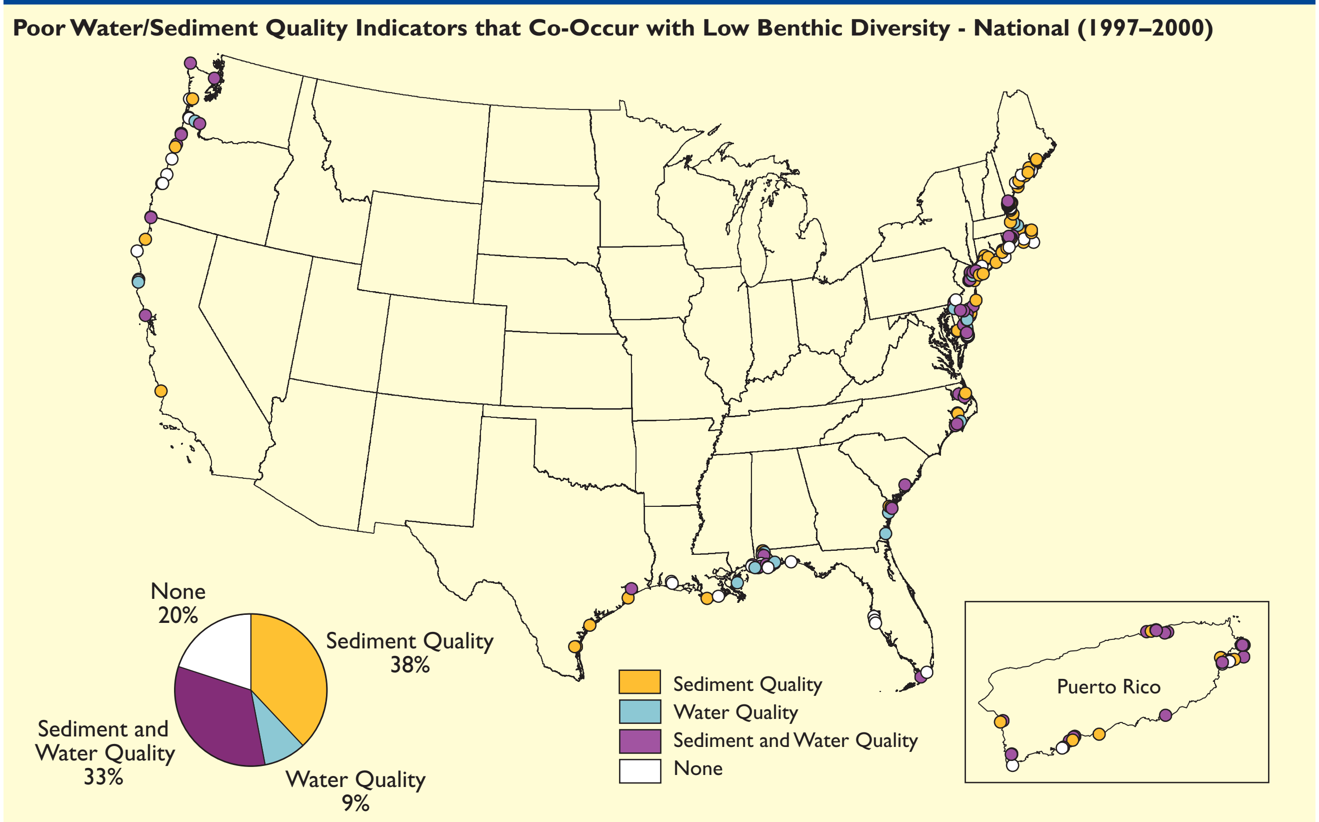


Figure 2-16. Indices and indicators of degraded water/sediment quality that co-occur with poor benthic condition in U.S. estuaries (U.S. EPA/NCA).

wetlands (exclusive of the Great Lakes region). This is a loss rate of about 0.2%. Averaging this recent rate of decadal wetland loss with the mean long-term, decadal loss rate (2.3%) results in a national rating of poor for estuarine condition on the coastal habitat index. The largest index scores were seen in West Coast estuaries (1.90) and in Gulf Coast estuaries (1.30). Because Gulf Coast wetlands constitute two-thirds of the coastal wetlands in the conterminous 48 states and the Gulf Coast index score is high, the overall national rating for the coastal habitat index is poor (1.26). For the Great Lakes region, researchers used other measurement approaches to assess wetland losses and rated them fair to poor.

Table 2-2. Changes in Marine and Estuarine Wetlands, 1780 to 1990 and 1990 to 2000 (Dahl, 1990; Dahl, 2003).

Coastline or Area	Area 1990 (acres)	Area 2000 (acres)	Change1990–2000 (acres) (%)	Mean Decadal Loss Rate1780–1990	Index Value
Alaska	2,132,900	2,132,000	-900 (0.04%)	0.05%	0.05
Hawaii	31,150	No data	—	0.06%	—
Puerto Rico	17,300	No data	—	—	—
Northeast Coast	452,310	451,660	-650 (0.14%)	1.86%	1.00
Southeast Coast	1,107,370	1,105,170	-2,200 (0.20%)	1.91%	1.06
Gulf Coast	3,777,120	3,769,370	-7,750 (0.21%)	2.39%	1.30
West Coast	320,220	318,510	-1,710 (0.53%)	3.26%	1.90
Conterminous 48 States Total	5,657,020	5,644,710	-12,310 (0.22%)	2.30%	1.26
Total (all areas)	7,838,370	7,825,160	-13,210 (0.17%)	1.25%	0.71

Fish Tissue Contaminants Index

National estuarine condition as measured by fish tissue contaminants is poor based on the NCA survey alone; however, incorporating information from the Great Lakes region (Chapter 7) increases the national ranking from poor to fair. Figure 2-17 shows that 22% of all sites sampled through the NCA survey showed contaminant concentrations in fish tissues above EPA guidelines. This percentage may have been increased in part due to the use of juvenile fish rather than fish of commercial size. In most states, NCA surveys collected fish for analysis of whole-body burdens of contaminants (i.e., contaminants from the entire fish—fillets, head, skin, organs). The use of juvenile-sized fish could increase the likelihood of higher, whole-body concentrations of contaminants, especially for those contaminants not found in muscle tissue. In a few states, both edible fillets and whole-body burdens were examined. EPA Guidance describing risk-based concentrations of concern for recreational and subsistence fishers (U.S. EPA, 2000c) applies to fillet, whole-body, and organ-specific concentrations. Whole-body contaminant concentrations for many contaminants (e.g., pesticides, cadmium, PAHs) are higher than the concentration in muscle tissue (fillets); however, mercury concentrations can be severely underestimated using the whole-body concentration data. For example, mercury concentrations can be three to five times more concentrated in muscle tissue than in whole-body samples. About one-third of coastal states often use whole-body concentrations to set advisories for waters where consumer groups eat whole fish. Few contaminant guidelines exist for wildlife protection.

The NCA survey data examined whole-body composite samples (5 to 10 fish of a target species per site) for 90 specific contaminants from 653 sites throughout the estuarine waters of the United States (except from Louisiana, Florida, and Puerto Rico). For most contaminants, whole-body concentrations overestimate the risk of consuming only the fillet portion of the fish unless the contaminant is concentrated in muscle tissue (e.g., mercury), and the findings should be considered accordingly. In addition, most analyses were conducted on juvenile fish (non-market-size fish),

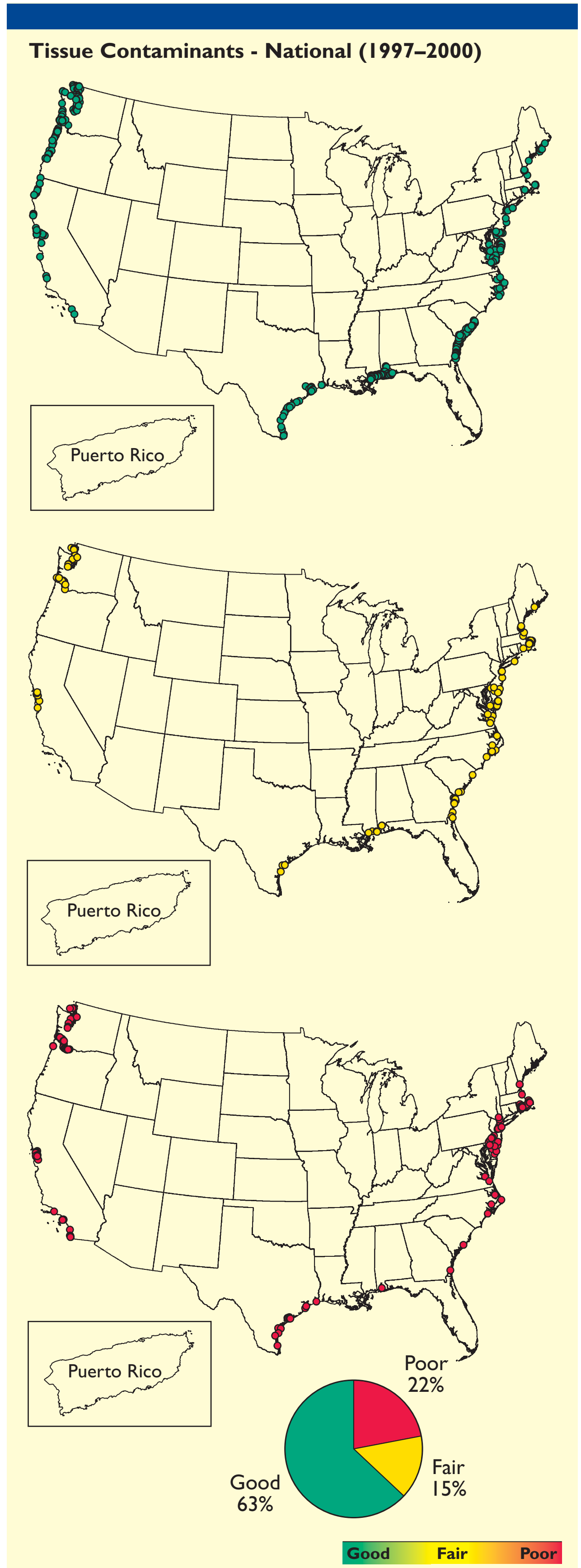


Figure 2-17. National fish tissue contaminants index data (U.S. EPA/NCA).

which are known to have accumulated contaminant levels that are lower than those in larger, market-sized fish.

The whole-body contaminant concentrations in fish and shellfish were compared with the range of concentrations for EPA guidelines. At least one of the analyzed contaminants exceeded the maximum of the range in 22% of estuarine waters sampled in the United States (Figure 2-17). An additional 15% of estuarine waters had fish or shellfish tissue concentrations within the noncancer range for at least one contaminant. Areas of poor and fair condition were dominated by total PCBs (39%), total DDT (16%), total PAHs (6%), and mercury (1%). Fish and shellfish analyzed included Atlantic croaker, white perch, catfish, flounders, scup, blue crab, lobster, shrimp, whiffs, mullet, tomcod, spot, weakfish, halibut, soles, sculpins, sanddabs, basses, and sturgeon. In the Northeast Coast region, 31% of sites where fish were captured were in poor condition, and 29% were in fair condition (the Northeast Coast was the only region that showed poor or fair condition for more than 50% of the sites yielding fish). Exceedances in the Northeast Coast region occurred largely for total PCBs (51%), PAHs (14%), DDT (9%), and mercury (3%). In West Coast estuaries, 27% of sites where fish were captured were in poor condition, and 11% were in fair condition, with exceedances primarily seen in total PCBs (30%) and DDT (17%). Approximately 90% of these sites were in San Francisco Bay, the Columbia River, and the Puget Sound system. Exceedances in Gulf Coast estuaries occurred at 22% of sites, primarily for PCBs (16%) and DDT (10%).

A factor of three was used to correct whole-body concentrations of mercury to approximate fillet concentrations, based on a comparison of the ratio of whole fish to fillet mercury concentrations found in scientific literature, and 42% of estuarine sites that yielded fish in the United States exceeded EPA Guidance values for mercury (Table 2-3). These exceedances included 48% of estuarine sites where fish were captured in the Northeast Coast, 43% in the West Coast, 18% in the Gulf Coast (excluding Florida and Louisiana), and 10% in the Southeast Coast.

Table 2-3. Projected Exceedances of Noncancer Health Endpoints for Associated Four 8-Ounce Fillet Meals per Month for Mercury (Based on Three Times the Observed Whole-Body Concentrations) (U.S. EPA/NCA).

Region	Proportion of Region within the Concentration Range (0.12–0.23 ppm)(Fair)	Proportion of Region above the Upper Limit of the Concentration Range (> 0.23 ppm)(Poor)	Proportion of Region in Poor and Fair Condition
Northeast Coast	34%	14%	48%
Southeast Coast	7%	3%	10%
Gulf Coast	12%	6%	18%
West Coast	19%	24%	43%
Total United States	24%	18%	42%

The snook (*Centropomus undeimalis)* is popular in the recreational fishing industry of the Florida Keys. This species, usually found in the Florida Bay and around the mangroves of the Keys, has also been spotted out on the reef. (photo: Bob Care - Florida Keys NMS)

Large Marine Ecosystem Fisheries

As of 2001, many marine fish stocks in LMEs around the country were healthy, and other stocks were rebuilt. Despite this progress, a number of the nation's most significant fisheries face serious challenges, including West Coast groundfish, the Southeast Coast snapper-grouper complex, and Northeast Coast mixed species.

In 2001, NOAA's Office of Sustainable Fisheries reported on the status of 595 marine fish and shellfish stocks out of 951 total stocks (NMFS, 2002). Eighty-one stocks were overfished (compared with 92 in 2000), and 67 of these (83%) were steadily rebuilding. Twenty more stocks in 2001 had sustainable harvest rates than stocks in 2000. Sixty-five stocks experienced catches exceeding allowable harvest levels. The NMFS has approved rebuilding plans for the majority of overfished stocks. Of the 81 stocks that are overfished, 67 have an approved rebuilding plan, and 9 have plans under development.

Recovery from Biomass Depletion in Large Marine Ecosystems

Mandated management actions of the Northeast Shelf LMEs are reversing declines in biomass yields that have occurred over the last several decades. Since 1994, reductions in fishing effort increased the spawning stock biomass levels of cod, haddock, yellowtail flounder, and other species in the U.S. Northeast Shelf ecosystem.

In the 1990s, herring and mackerel stocks began to recover and establish higher stock sizes. This recovery was due in part to a decrease in the amount of foreign fishing for these species, as well as to more than a decade of low fishing mortality. Bottom trawl survey indices for both species increased dramatically, with more than a tenfold increase in abundance (average of 1977–1981 vs. 1995–1999) by the late 1990s. Stock biomass of herring increased to more than 2.5 million mt by 1997. For mackerel, total stock biomass has continued to increase since the closure of the foreign fishery in the late 1970s. Although absolute estimates of biomass for

Top 10 Commercial Species Landed in 2001

	Top 10 by Quantity		Top 10 by Value	
Rank	**Species**	**Metric Tons**	**Species**	**Dollars (thousands)**
1	Pollock	1,446,260	Shrimp	$568,547
2	Menhaden	789,900	Crabs	$381,667
3	Salmon	327,870	Lobsters	$275,728
4	Cod	229,028	Pollock	$236,923
5	Hakes	225,504	Salmon	$208,926
6	Flounders	159,830	Tunas	$207,300
7	Shrimp	147,182	Scallops	$175,416
8	Tunas	150,185	Clams	$161,992
9	Herring	136,300	Cod	$150,157
10	Crabs	123,490	Halibut	$115,169

Recreational Fishing Statistics for 2001

12.1 million anglers: 52% Atlantic, 25% Gulf of Mexico, 21% Pacific (excluding Alaska), 2% Puerto Rico

86.8 million trips: 61% Atlantic, 26% Gulf of Mexico, 11% Pacific, 2% Puerto Rico

444.2 million fish caught: 55% Atlantic, 36.5% Gulf of Mexico, 8% Pacific, 0.5% Puerto Rico

Source: NMFS, 2002

the late 1990s are not available for mackerel, recent analyses place the stock at or near a historic high in total biomass and spawning stock biomass. In addition, recent evidence indicates that, following mandated substantial reductions in fishing effort, both haddock and yellowtail flounder stocks are responding to the catch reductions favorably, with substantial growth reported in spawning stock biomass size since 1994 for both species. In addition, a very strong year-class of yellowtail flounder was produced in 1998, and a strong year-class of haddock was produced in 1999 (see Figure 2-18).

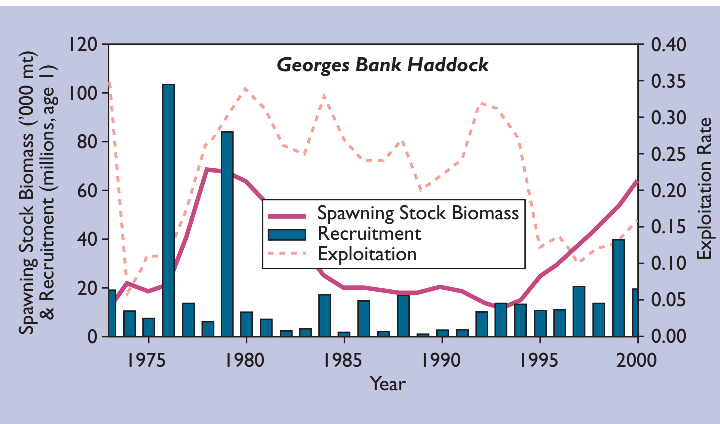


Figure 2-18. Spawning stock biomass, recruitment, and exploitation rate of Georges Bank haddock (Sherman et al., 2002).

During the last two decades, herring and mackerel stocks have undergone unprecedented levels of growth, approaching an historic high in combined biomass. This growth is taking place during the same period that the fishery-management councils for the New England and Mid-Atlantic areas of the Northeast Shelf LME have sharply curtailed fishing effort on haddock and yellowtail flounder stocks. Studies of primary productivity and zooplankton biomass suggest that there are ample food resources for these stocks. The "carrying capacity" of zooplankton that support herring and mackerel stocks and larval zooplanktivorous haddock and yellowtail flounder appears to be sufficient to sustain the strong year-classes reported for 1998 (yellowtail flounder) and 1999 (haddock).

The zooplankton component of the Northeast Shelf LME is in robust condition, with biomass levels at or above the levels of the long-term median values of the past two decades. This zooplankton community provides a suitable prey base for supporting a large biomass of pelagic fish (herring and mackerel), while providing sufficient zooplankton prey to support strong year-classes of recovering haddock and yellowtail flounder stocks. No evidence has been found in the fish, zooplankton, temperature, or chlorophyll component to indicate any large-scale oceanographic regime shifts of the magnitude reported for the North Pacific or Northeast Atlantic Ocean areas.

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

Twenty-three of the 27 coastal states and territories (hereafter, states and territories will be referred to as states), the District of Columbia, the Commonwealth of the Northern Mariana Islands, and the Delaware River Basin Commission rated general water quality conditions in some of their estuarine waters. Altogether, these states assessed 31,072 square miles of estuarine waters, or 36% of the 87,369 square miles of estuarine waters in the nation. Of these 27 coastal states, 14 rated general water quality conditions in some of their coastal waters. They assessed 3,221 miles of ocean shoreline, representing 5.5% of the nation's coastline (including Alaska's 36,000 miles of coastline), or 14% of the 22,618 miles of coastline excluding Alaska.

The states reported that 45% of their assessed estuarine waters have good water quality that fully supports designated uses (Figure 2-19). Of the assessed waters, nearly 4% are threatened for one or more uses.

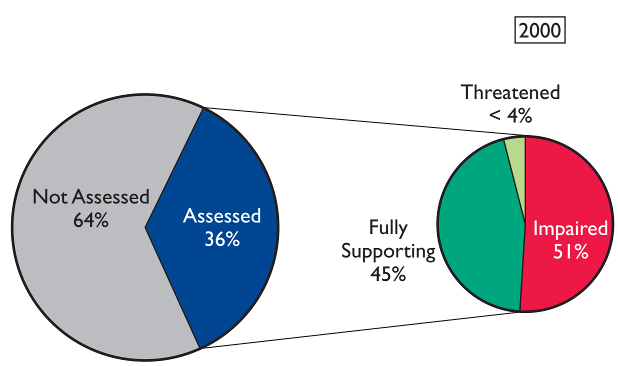


Figure 2-19. Water quality in assessed estuaries of the United States (U.S. EPA, 2002).

Supporting	These waters meet applicable water quality standards, both criteria and designated use.
Threatened	These waters currently meet water quality standards, but states are concerned that they may degrade in the near future.
Partially Supporting	These waters meet water quality standards most of the time, but exhibit occasional exceedances.
Not Supporting	These waters do not meet water quality standards.

Some form of pollution or habitat degradation impairs the remaining 51% of assessed estuarine waters. Most of the assessed ocean shoreline miles (2,755 miles, or 86%) have good quality and support a healthy aquatic community and public activities (Figure 2-20). Of the assessed waters, 79% fully support designated uses and 7% are threatened for one or more uses. Some form of pollution or habitat degradation impairs the remaining 14% of the assessed shoreline.

After comparing water quality data with water quality standards, states and tribes classified the waters into the following categories:

For the purposes of this report, waters classified as partially supporting or not supporting their uses are categorized as impaired. Twenty-two states reported the individual use support of their estuarine waters (Figure 2-21). States also provided limited information on individual use support in coastal waters (Figure 2-22). General conclusions cannot be drawn from such a small fraction of the nation's coastal waters. Significantly, 11 states had adopted statewide coastal fish consumption advisories for mercury, PCBs, and other pollutants as of the 2000 305(b) reporting period. These advisories are not represented in the use support numbers.

The major stressors that impair assessed estuarine waters are metals, pesticides, oxygen-depleting substances, toxic chemicals, PCBs, and dissolved solids. The states reported that pathogens, oxygen-depleting substances, turbidity, suspended solids, oil and grease, metals, and nutrients are the major stressors causing impairment to assessed ocean shoreline miles.

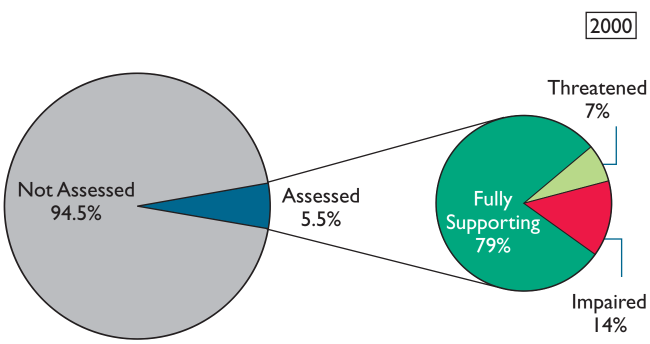


Figure 2-20. Water quality in assessed shoreline waters of the United States (U.S. EPA, 2002).

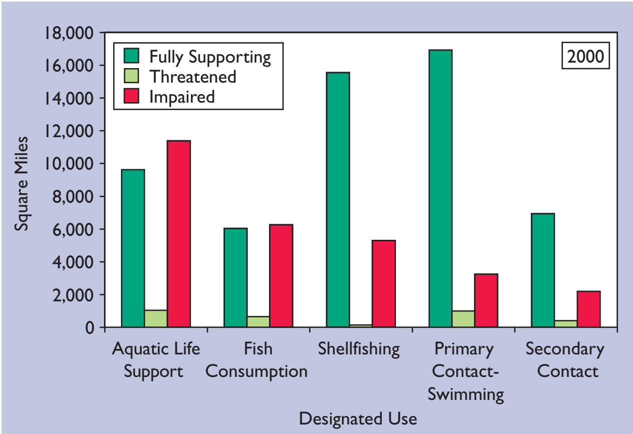


Figure 2-21. Individual use support for assessed estuaries of the United States (U.S. EPA, 2002).

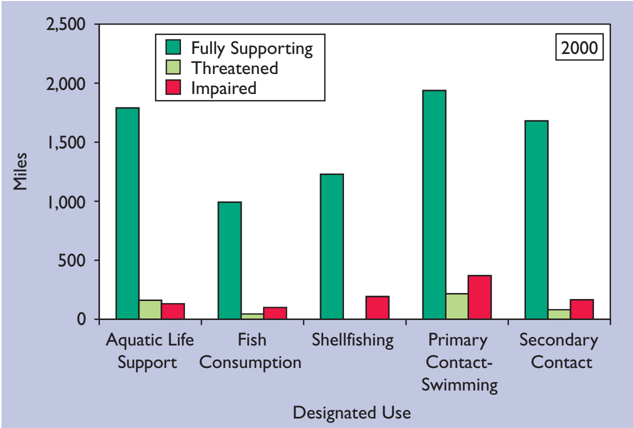
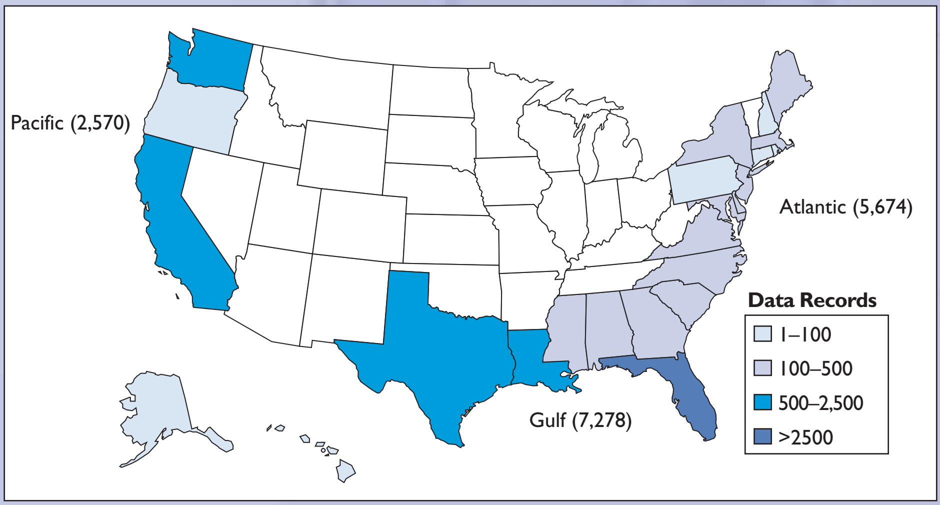


Figure 2-22. Individual use support for assessed shoreline waters of the United States (U.S. EPA, 2002).

Mercury in Marine Life – A Complex Story

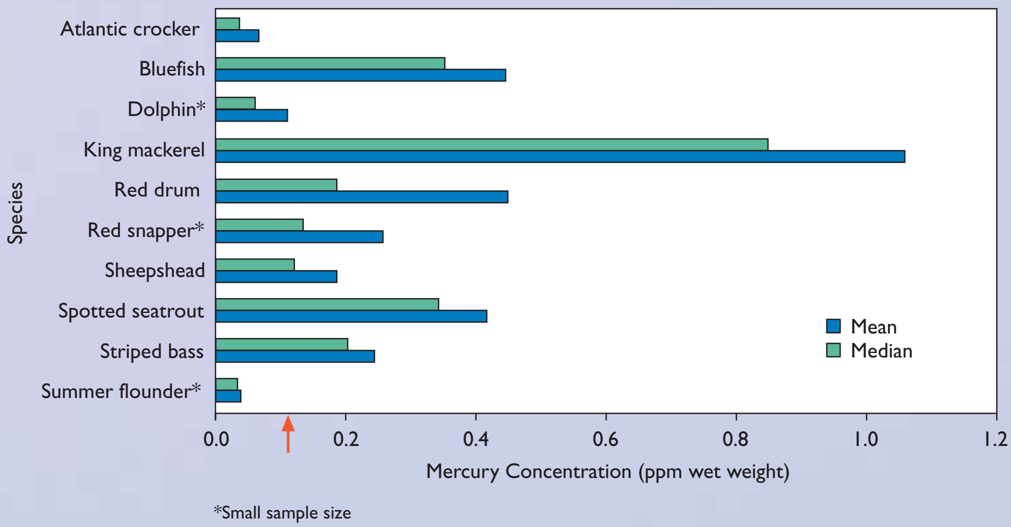
How big a problem is mercury in marine life? Although scientists do not know how much of a problem mercury in marine life poses to humans, they do know that mercury in the human diet comes primarily from fish. Exposure to too much mercury via fish consumption can lead to neurological effects in the developing fetus, children, and adults and can increase the risk of heart disease in adults. Scientists also know that some of the larger predatory fish commonly consumed by humans, such as sharks, swordfish, and king mackerel, have high levels of mercury in their tissues. It is uncertain, however, whether these concentrations are getting higher or lower over time, because there is no national baseline for mercury concentrations in saltwater species.

How do we characterize the transport of mercury in estuarine and marine environments? First, although atmospheric deposition is not the only source of mercury in estuaries and coastal waters, it is a primary source. Mercury that is deposited in estuaries and coastal waters may have originated as air emissions from a nearby source, from a source within the state, from a regional source outside the state, or from a source outside the country, and identifying the correct source can be difficult. Second, conditions in the sediments in coastal areas affect the speed at which inorganic mercury is converted to methylmercury, the most toxic chemical form of mercury that enters the food chain. Scientists are currently unable to determine which coastal areas are more likely to produce methylmercury at high rates and which will have relatively low rates. Unfortunately, even less is known about how mercury is transformed in the deep ocean. Third, although there is some information on the concentrations of mercury in fish and shellfish species, the migratory nature of many marine species requires additional information on where particular species feed and what they eat in order to determine how they are exposed to mercury. Finally, fish move globally in international commerce. Fish consumed in the United States may have been harvested in a foreign country, and fish that people in other countries consume may have been harvested in U.S. waters.



States with data in the Mercury in Marine Life Database (U.S. EPA, 2003b).

What kind of monitoring data do we have? Many of the data collected on mercury from long-term monitoring programs are collected by sampling small fish that serve as prey for larger commercial and recreational species. Although the mercury concentrations are not very high in these small fish, concentrations are higher in the larger predator fish that consume these small fish, and these larger fish are typically the fish preferred by people. Data collected from a variety of sources—5 federal, 4 regional, and 26 state monitoring programs—and assembled by EPA provide a recent snapshot of mercury concentrations in fish and shellfish. The data show that mercury concentrations are relatively high in some species popular among recreational fishers, but data are limited or unavailable for several popular recreational species. In addition, the data show that less information is available for many of the popular commercial species.



Mercury concentrations in the top 10 recreational species in the United States. The arrow at 0.12 ppm represents the lower acceptable concentration limit based on EPA Guidance for consumption of 4 meals/per month (U.S. EPA, 2003b).

What does it mean? For samples of king mackerel collected on the Atlantic and Gulf of Mexico coasts combined, the mean and median mercury concentrations are 1.06 and 0.85 ppm mercury (wet weight), respectively. These are some of the higher concentrations observed in recreational species; however, this is only a starting point. Scientists still need to understand how the mercury is getting into these fish. That is why understanding how mercury is transported among organisms in the marine environment is a complex challenge.

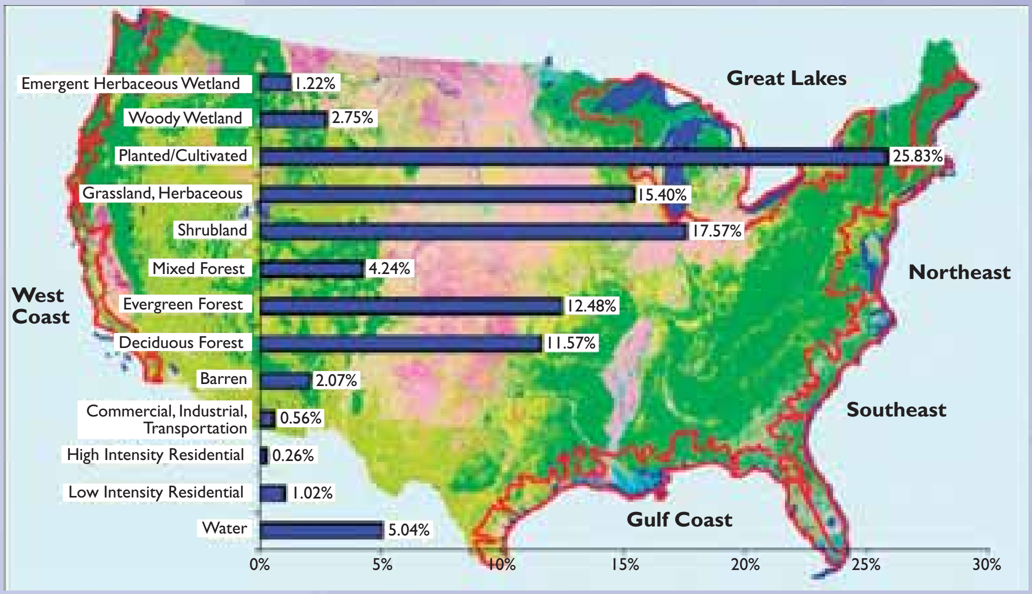
For more information about the data set, contact John Wilson at wilson.john@epa.gov.

highlight

National Land Cover Data

The USGS and EPA created a nationwide land cover data set, National Land Cover Data (NLCD), for the conterminous 48 states based on early to mid-1990s, 30-meter Landsat Thematic Mapper satellite imagery. This NLCD was initially created to meet the needs of six federal environmental monitoring programs that formed a partnership called the Multi-Resolution Land Characterization Consortium. The consortium consists of agencies that produce or use land cover data as part of their missions: USGS, EPA, NOAA, USDA, and the U.S. Forest Service (USFS), the National Aeronautics and Space Administration (NASA), and the Bureau of Land Management (BLM). In addition to these federal agencies, other federal, state, and local government agencies and various environmental groups require recent intermediate-scale land cover data to perform their missions. Before the NLCD was created, USGS had compiled an intermediate land cover data set for the conterminous 48 states based on 1970s aerial photography. Although the 1970s data set can still be used for some applications, many land cover changes have taken place over the past 20 or more years. The NLCD provides a relatively current, consistent, and accurate land cover data set for a variety of applications: calculating land cover statistics, planning land use, deriving landscape pattern metrics, developing land management policies, and assessing ecosystem status and health.

The NLCD consists of 21 classes of land cover categories applied in a consistent manner across the 48 states (http://landcover.usgs.gov/index.asp). The NLCD developers established standard procedures to classify the Landsat Thematic mapper satellite imagery that was used, in conjunction with ancillary data sets, to refine the classification process.



NLCD data for the 48 conterminous states, with a chart depicting percentage of total land cover for selected categories (USGS, 1999).

Total acreage values were calculated for the conterminous 48 states based on the NLCD's 21 classes. The area and percentage of the national total for five land cover categories (low intensity residential; high intensity residential, commercial, industrial, and transportation; woody wetland; and emergent herbaceous wetland) are summarized in the table at right.

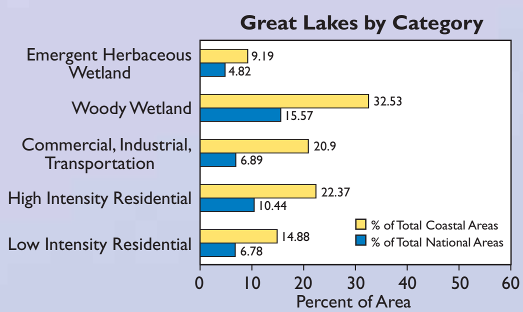
Land Cover Area Totals

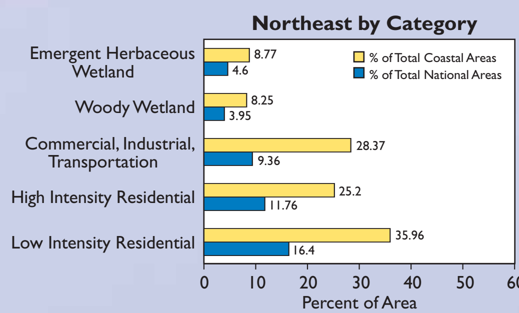
Category Land Cover	Square Miles	Percentage of National Total Area
Low-intensity residential	31,696.13	1.02
High-intensity residential	8,127.12	0.26
Commercial, industrial, transportation	17,550.95	0.56
Woody wetland	85,419.40	2.75
Emergent herbaceous wetland	37,984.70	1.22

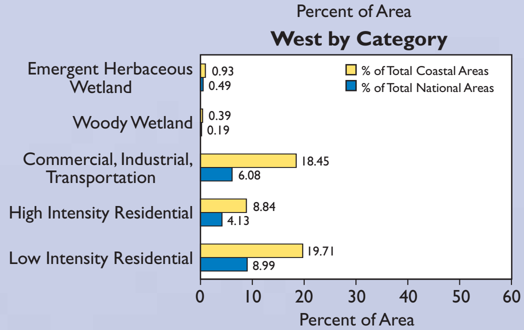
Source: USGS, 1999

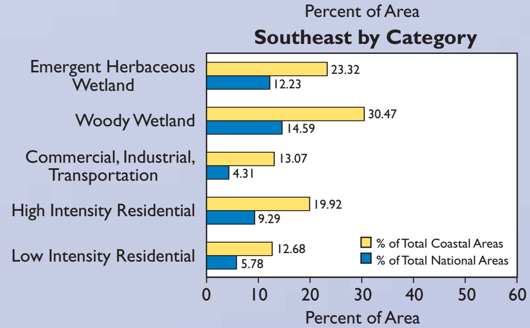
For the NCCR II, areas of interest were extracted and evaluated for the five coastal regions (outlined in red on the map) of the conterminous 48 states. Analyses and comparisons can be made within and among these regions. The five land cover categories highlighted comprise only 5.81% of the total national land cover; however, these highlighted categories are well represented in the nation's coastal regions. The bar graphs show that the combined coastal regions account for the following percentages of the nation's land cover totals, reported by category: 32.97% of commercial, industrial, transportation; 46.67% of high-intensity residential; 45.6% of low-intensity residential; 52.45% of emergent herbaceous wetland; and 47.87% of woody wetland.

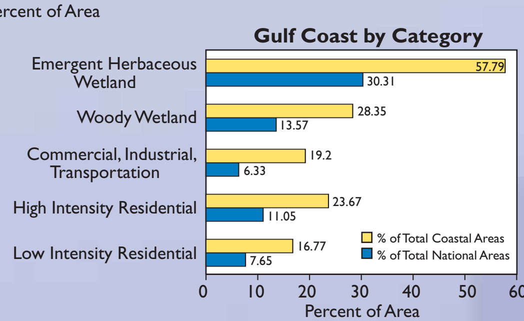
For more information about the NLCD, contact Jimmy Johnston at jimmy_johnston@usgs.gov.











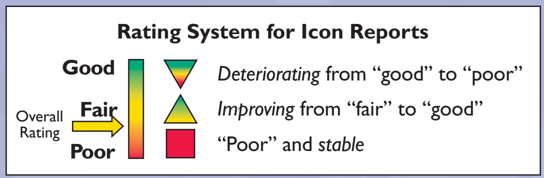
Source: USGS, 1999

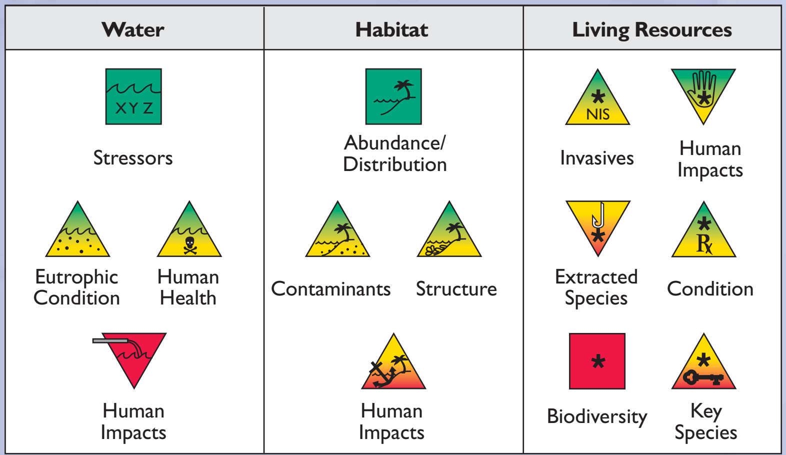
Monitoring in the National Marine Sanctuaries

The National Marine Sanctuary Program is developing a System-Wide Monitoring Program (SWMP) for the nation's 13 marine sanctuaries. The goal of the SWMP is to provide a consistent approach to the integrated design, implementation, and reporting of environmental data from individual sanctuaries, sanctuary networks, and the sanctuary system as a whole. The design process allows for tailored monitoring in all sanctuaries, developing information critical to management while contributing to and benefitting from other local, regional, and national monitoring programs. It also provides a means to design monitoring programs to address networks of sanctuaries, specific issues, or resource types. Driven by scale-specific questions based on existing threats to water quality, habitat and living resources, as well as system questions applicable at all sanctuaries, monitoring programs will be developed and implemented at multiple spatial scales, with priority given to sanctuary-based monitoring.

Key partners operating at relevant spatial scales will support the programs. Local, regional, and national reports will document results at appropriate levels of specificity and incorporate an icon-based scheme to summarize the status and trends for key indicators. The most detailed technical information, and that most applicable to site management, will be reported for individual sanctuaries.

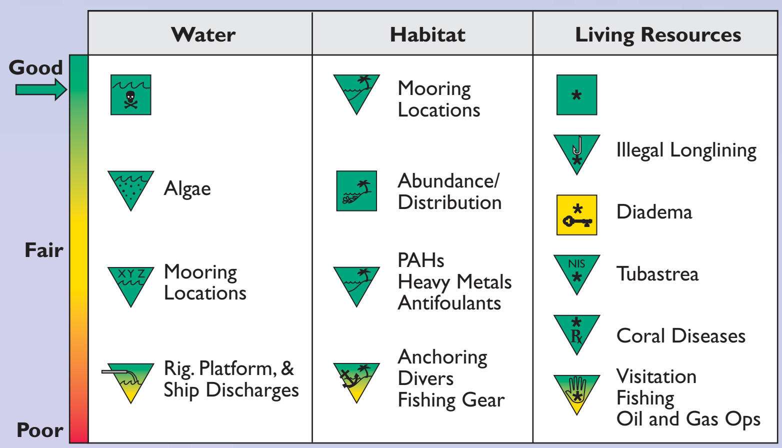
One of the reporting methods that the National Marine Sanctuary Program is considering is a method derived from the format used in the NCCR I. This format consists of customized icons that use color (green, yellow, and red) to show status and shapes (squares and upward- or downward-pointing triangles) to show trends. The use of changing colors in the triangular icons provides a forecast of pending condition based on the judgment of analysts, whereas square icons are used to illustrate static conditions. The icons include pictures or symbols that refer uniquely to elements that affect or compose the sanctuary system. This report card approach summarizes detailed monitoring results for specific sites and provides useful information to audiences with a general interest in marine sanctuaries.





Existing data were used to generate an example of this type of report for the Flower Garden Banks National Marine Sanctuary in the northwest Gulf of Mexico. The diagram below illustrates the good overall condition of the bank's reef resources, as well as several areas of concern to sanctuary management. Text adjacent to the icons indicates specific aspects of the environment that analysts deemed responsible for the resource's condition. For example, the mass mortality of a dominant herbivorous sea urchin, *Diadema antillarum*, in the mid-1980s remains a significant potential disruption to the reef ecosystem (indicated by the yellow box). Recovery of *Diadema* populations has not occurred, yet their mass mortality in the mid-1980s has not resulted in significant long-term changes in the Flower Gardens.

Sanctuary Report: Flower Garden Banks NMS



Another concern in the Flower Gardens is that various discharges may threaten sanctuary water and living resources. Charter dive vessels and oil and gas production facilities in the vicinity are the primary sources of the discharges, which include sewage, bilge water, food, and produced water from wells. High levels of scuba diving activity at certain mooring buoy locations also put stress on some reef areas. In addition, illegal fishing in the sanctuary's deeper areas and mechanical damage caused by anchoring, tow cables, and fishing gear present additional potential threats to the system. Although most of these activities have had minimal consequences on the sanctuary thus far, sanctuary staff are taking steps to characterize and monitor certain contaminants that may act as indicators of problems, and to monitor particular locations because trends indicate that changes may occur in the near future.

Additional information on the National Marine Sanctuary Program is available at http://sanctuaries.noaa.gov/.

Fish Consumption Advisories

A total of 82 fish consumption advisories were in effect for estuarine and coastal marine waters of the United States in 2002, including 74% of the coastal waters of the contiguous 48 states (Figure 2-23). In addition, 30 fish consumption advisories were in effect in the Great Lakes and their connecting waters. An advisory may represent one waterbody or one type of waterbody within a state's jurisdiction, or one or more species of fish. Some of the advisories are issued as single statewide advisories for all coastal estuarine or marine waters within the state (Table 2-5). Although the statewide coastal advisories have placed a large proportion of the nation's coastal waters under advisory, these advisories are often issued for the larger size-classes of predatory species (such as bluefish and king mackerel) because larger, older individuals have had more time to be exposed to and accumulate one or more chemical contaminants in their tissues than have younger individuals.

The yellowtail snapper (*Ocyurus chrysurus*), abundant in the waters of the Florida Keys, is the center of a large commercial and recreational fishing industry. Found in the water column above the reef, this is usually one of the first species a diver or snorkeler will see upon entering the water. (photo: Jim Raymont - Florida Keys NMS)

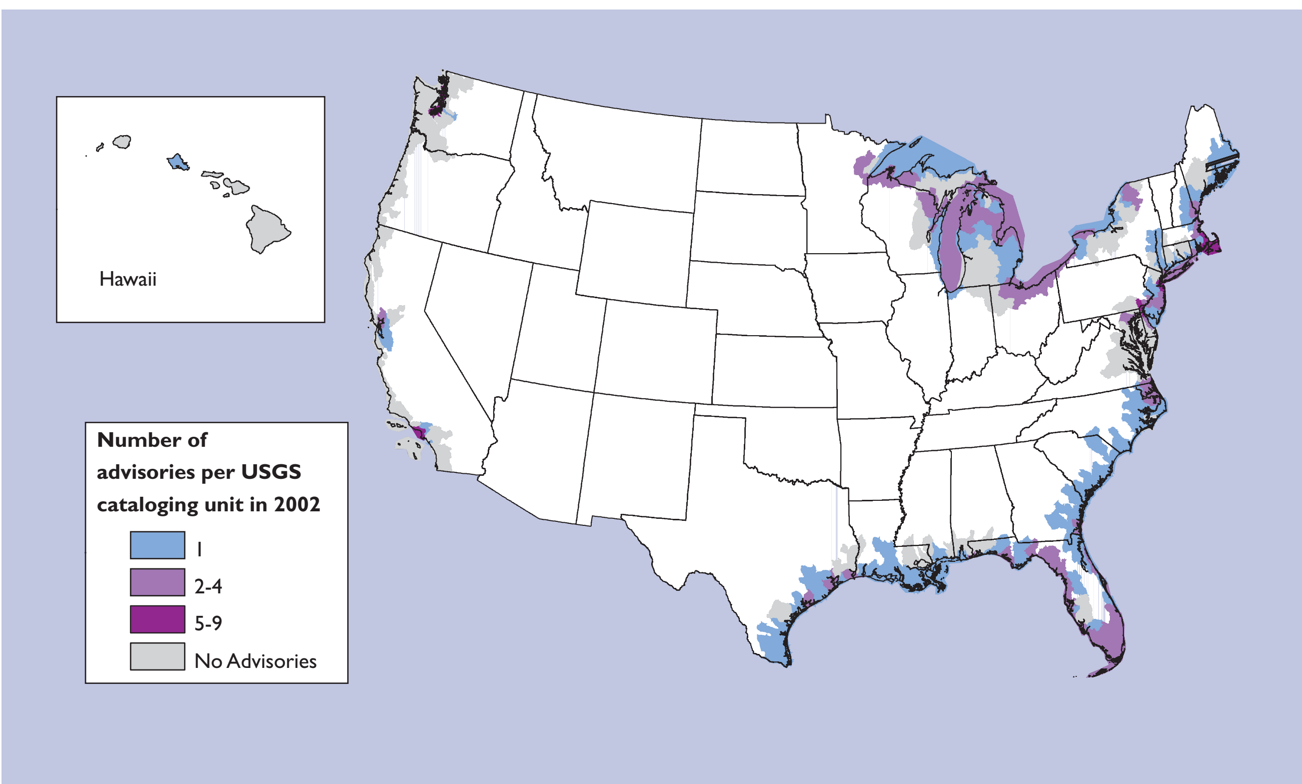


Figure 2-23. The number of coastal and estuarine fish consumption advisories per USGS cataloging unit. This count does not include advisories that may exist for noncoastal or nonestuarine waters. Alaska did not report advisories for 2002 (U.S. EPA, 2003c).

Table 2-4. Summary of States with Statewide Advisories for Coastal and Estuarine Waters (U.S. EPA, 2003c)

State	Pollutants	Species under Advisory
Alabama	Mercury	King mackerel
Connecticut	PCBs	Bluefish Lobster (tomalley) Striped bass
Florida	Mercury	Bluefish Cobia Greater amberjack Jack crevalle King mackerel Little tunny Shark Spotted sea trout
Georgia	Mercury	King mackerel
Louisiana	Mercury	King mackerel
Maine	Dioxins Mercury PCBs	Bluefish Lobster (tomalley) Striped bass
Massachusetts	Mercury PCBs	King mackerel Lobster (tomalley) Shark Swordfish Tilefish Tuna
Mississippi	Mercury	King mackerel
New Hampshire	PCBs	Bluefish Lobster (tomalley) Striped bass
New Jersey	PCBs Cadmium Dioxins	American eel Bluefish Lobster (tomalley) Striped bass
New York	Cadmium Dioxins PCBs	American eel Blue crab (hepatopancreas) Bluefish Lobster (tomalley) Striped bass
North Carolina	Mercury	King mackerel Shark
Rhode Island	PCBs Mercury	Bluefish Shark Striped bass Swordfish
South Carolina	Mercury	King mackerel
Texas	Mercury	King mackerel

The number and geographic extent of advisories can serve as indicators of the level of contamination of estuarine and marine fish and shellfish, but a number of other factors must also be taken into account. For example, the methods and intensity of sampling and the contaminant levels at which advisories are issued often differ among the states. In the states with statewide coastal advisories, one advisory may cover many thousands of square miles of estuarine waters and many hundreds of miles of shoreline waters. Although advisories in U.S. estuarine and shoreline waters have been issued for a total of 23 individual chemical contaminants, most advisories issued have resulted from four primary contaminants. These four chemical contaminants—PCBs, mercury, DDT and its degradation products DDE and DDD, and dioxins/furans—were responsible at least in part for 91% of all fish consumption advisories in effect in estuarine and coastal marine waters in 2002 (Figure 2-24, Tables 2-6 and 2-7). These chemical contaminants are biologically accumulated (bioaccumulated) in the tissues of aquatic organisms to concentrations many times higher than concentrations in seawater (Figure 2-25). Concentrations of these contaminants in the tissues of aquatic organisms may be increased at each successive level of the food web. As a result, top predators in a food web may have concentrations of these chemicals in their tissues that can be a million times higher than the concentrations 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 associated with fish advisories (PCBs, DDT, dieldrin, chlordane, and dioxins) are among the contaminants most often responsible for a Tier 1 National Sediment Inventory classification (associated adverse effects to aquatic life or human health are probable) of waterbodies based on potential human health effects (U.S. EPA, 1997).

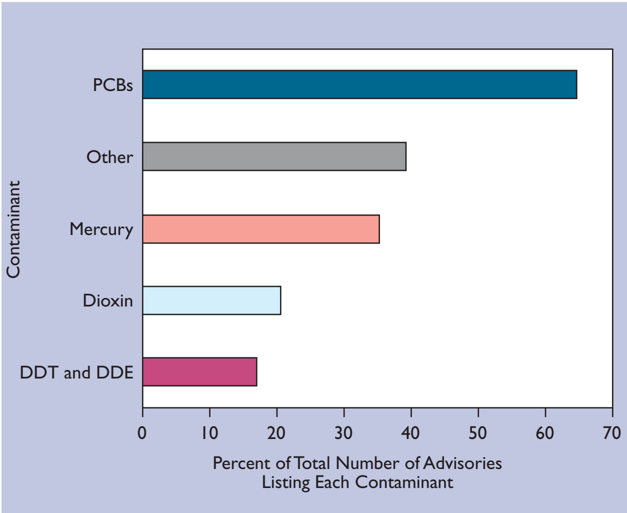


Figure 2-24. Percentage of estuarine and coastal marine advisories issued for each contaminant. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2003c).

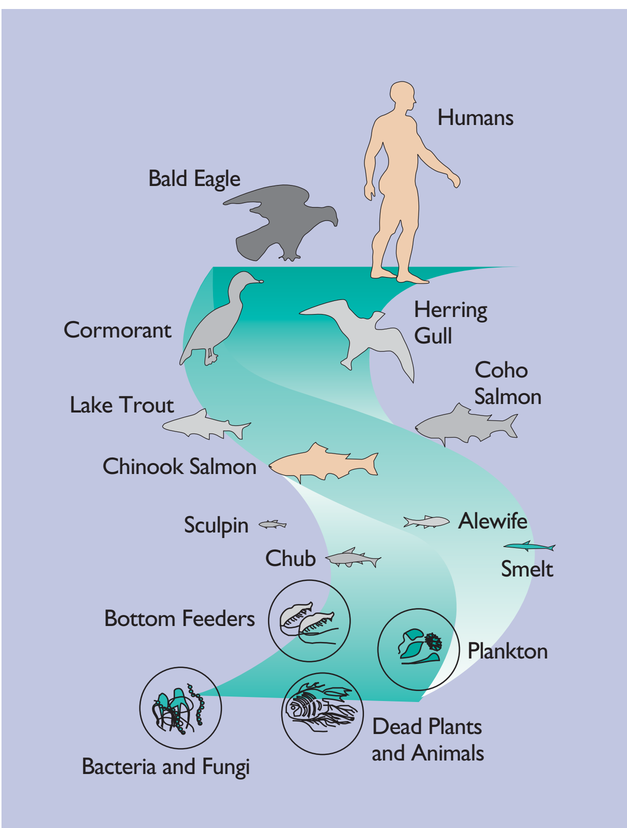


Figure 2-25. Bioaccumulation process (U.S. EPA, 1995).

Table 2-5. The Four Bioaccumulative Contaminants Responsible, at Least in Part, for 91% of Fish Consumption Advisories in Estuarine and Coastal Marine Waters in 2002 (U.S. EPA, 2003c)

Contaminant	Number of Advisories	Comments
PCBs	53	Seven northeast states (CT, MA, ME, NH, NJ, NY, and RI) had statewide PCB advisories, and seven states and the Territory of American Samoa had advisories for specific portions of their coastal waters.
Mercury	29	Eleven states (AL, FL, GA, LA, MA, ME, MS, NC, RI, SC, and TX) had statewide mercury advisories in their coastal waters; six of these states also had statewide mercury advisories for their estuarine waters. Seven states and the Territory of American Samoa had advisories for specific portions of their coastal waters.
DDT, DDE, and DDD	14	All DDT advisories were issued in California (12), Delaware (1), and the Territory of American Samoa (1).
Dioxins	12	Statewide dioxin advisories were in effect in three states (ME, NJ, and NY). Five states had dioxin advisories for specific portions of their coastal waters.

Table 2-6. The Four Bioaccumulative Contaminants Responsible, at Least in Part, for 91% of Fish Consumption Advisories in Estuarine and Coastal Marine Waters in 2002 (Great Lakes) (U.S. EPA, 2003c)

Contaminant	Number of Advisories	Comments
PCBs	30	Eight states (IL, IN, MI, MN, NY, OH, PA, and WI) had PCB advisories for all five Great Lakes and several connecting waters.
Mercury	11	Three states (IN, MI, and PA) had mercury advisories in their Great Lakes waters for Lakes Erie, Huron, Michigan, and Superior, and several connecting waters.
DDT, DDE, and DDD	1	One state (MI) had a DDT advisory in effect for Lake Michigan
Dioxins	14	Dioxin advisories were in effect in three states (MI, NY, and WI) that included all five Great Lakes and several connecting waters.

Beach Advisories and Closures

EPA gathered information on the 2002 swimming season at 2,823 beaches nationwide (both coastal and inland) through the use of a voluntary survey. The survey respondents were state agencies and local government agencies from coastal counties, cities, or towns bordering the Atlantic Ocean, Gulf of Mexico, Pacific Ocean, the Great Lakes, and Hawaii, as well as Puerto Rico, the U.S. Virgin Islands, Guam, and the Northern Mariana Islands. A few of these respondents were regional (multiple-county) districts. Data are available only for those beaches for which officials participated in the survey. EPA conducts the survey each year and displays the results on the BEACH Watch Web site at www.epa.gov/OST/beaches. All data cited in this report were derived from data collected by the EPA's BEACH Watch Program during the 2002 swimming season.

EPA's review of coastal beaches (U.S. coastal areas, estuaries, the Great Lakes, and coastal areas of Hawaii and the U.S. territories) showed that, of the 2,823 beaches responding to the survey, 2,031 were marine or Great Lakes beaches. Of these coastal beaches, 581 (or 29%) had an advisory or closing in effect at least once during the 2002 swimming season (Figure 2-26).

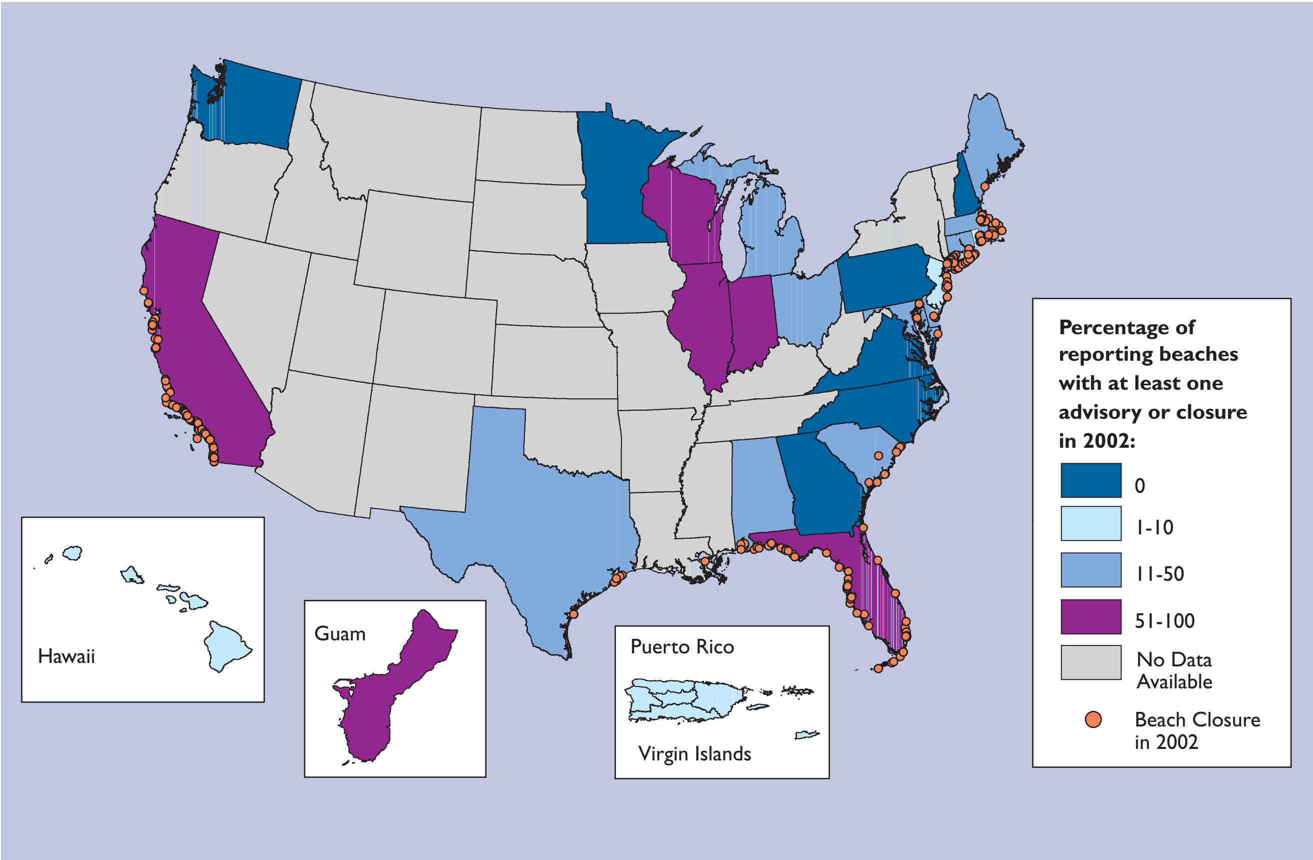


Figure 2-26. Percentage of beaches with advisories/closures by coastal state in 2002. Percentages are based on number of beaches in each state that reported information, not the total number of beaches. There were no BEACH Watch Program survey responses from Alaska, Mississippi, or American Samoa (U.S. EPA, 2003a).

Beach advisories or closings were issued for a number of different reasons, including elevated bacterial levels in the water, preemptive reasons associated with rainfall events or sewage spills, and other reasons (Figure 2-27). Some of the major causes of public notifications for beach advisories and closures were stormwater runoff, wildlife, sewerline problems, boat discharges, publicly owned treatment works (POTWs), and in many cases, unknown sources (Figure 2-28).

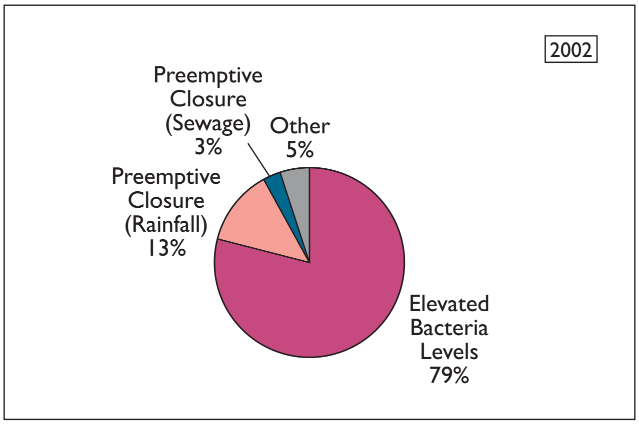


Figure 2-27. Reasons for beach advisories or closures for the nation's coastal waters (U.S. EPA, 2003a).

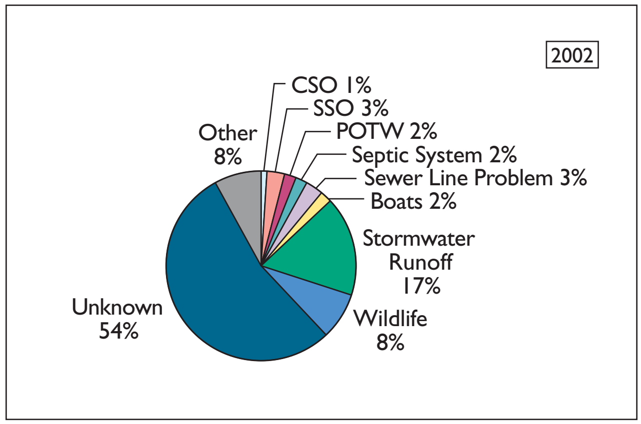


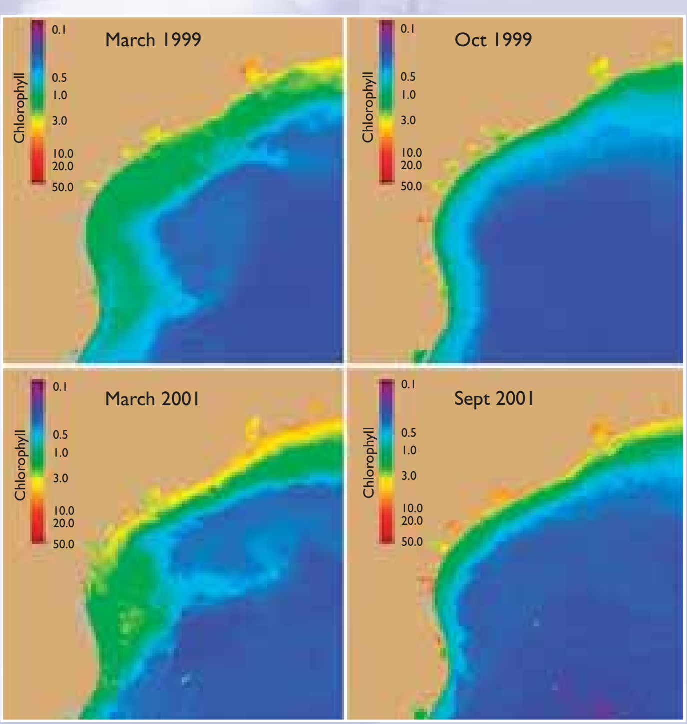
Figure 2-28. Sources of beach contamination for the nation's coastal waters (U.S. EPA, 2003a).

A beach volunteer records the numbers and species of birds present at his designated beach watch. (photo: Gulf of the Farallones NMS)

Sea-Viewing Wide Field-of-View Sensor (SeaWiFS)

The coastal ocean is constantly affected by natural cycles of nutrient and sediment inputs, as well as the impact of increased human population and changing land uses. Rainfall and runoff, usually during the spring, provide nutrients that promote algal blooms. This nutrient flow can affect both estuaries and the coastal ocean. In addition, variations in yearly rainfall can alter the magnitude of algal blooms. Understanding the movement and impact of nutrients and runoff on the coastal zone requires analysis of drainage patterns, pollution transport, concentrations of algae, and sedimentation.

Satellite-borne sensors can provide synoptic data on algae and sediments over large areas, greatly enhancing field programs. A key tool for this application is the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), which has provided imagery during most cloud-free days over the past 5 years. SeaWiFS was developed by Orbimage to support NASA's global climate programs. With a 1-kilometer pixel size, it can monitor large estuaries and the coastal ocean. NOAA's Center for Coastal Monitoring and Assessment (CCMA) has developed new methods for analyzing SeaWiFS data that have allowed it to be used to assess the coastal zone. For instance, the SeaWiFS images above show the seasonal difference in the Texas coast for two different years, 1999 and 2001. A spring algal bloom is evident in March of both years, with higher chlorophyll along the coast. However, conditions vary between years, with chlorophyll concentrations greater in 2001 than in 1999 for both spring and fall. Precipitation in the region was also higher in 2001 than in 1999. The CCMA is examining these patterns in detail for the entire U.S. coastal area for September 1997 to present in order to determine patterns and variability along the coast.



Source: Holderied et al., 2003

For more information, visit http://ccma.nos.noaa.gov/rsd/welcome.html.

Microbial Source Tracking

Urbanization has caused increased point and nonpoint source runoff into estuaries and may increase fecal coliform pollution. Shellfish harvesting areas are opened or closed based on the number of fecal coliforms, mainly *E. coli*, present in seawater and shoreline surveys that identify sources of fecal contamination. These indicators protect the public from disease-causing microorganisms associated with human waste. Unfortunately, fecal coliform standards for shellfish harvesting are sometimes exceeded when no obvious source of contamination can be identified. This often results in shellfish harvesting areas being closed without a specific identified pollution source.

Bacterial pollution sources within coastal areas have three general sources: wildlife, domestic animals, and humans. Fecal coliforms quantified using traditional approaches can be from any of those sources, but human illnesses have generally been only associated with bacterial pollution from human sources. One method that has been developed as a potential technique for bacteria source tracking is the use of antibiotic resistance testing of *E. coli* bacteria. The rational of this method is that fecal coliform bacteria from humans will have acquired multiple antibiotic resistance (to three or more antibiotics) due to the large number of antibiotics used in medical treatment. Wildlife generally will not harbor antibiotic resistant pathogens due to the absence of their use in wildlife species. Domestic animals (e.g., cattle, hogs, and chickens) and pets will generally be more intermediate in their overall antibiotic resistance.

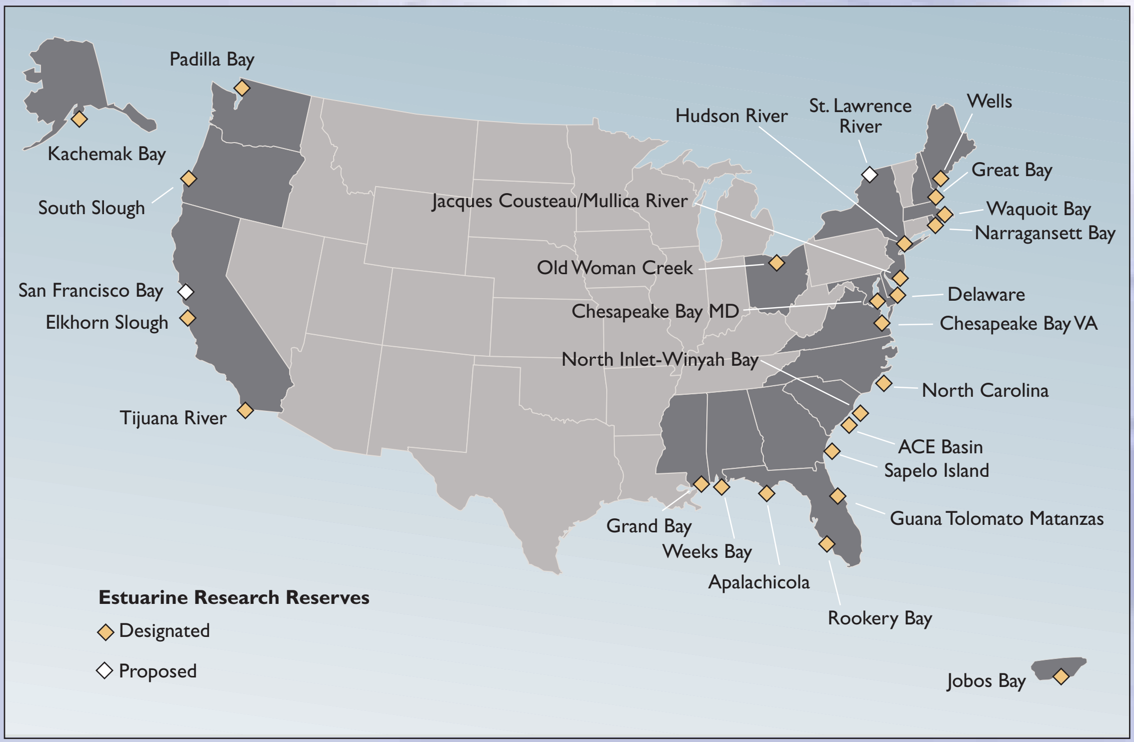
The Urbanization in Southeast Estuarine Systems (USES) study has evaluated the impact of urbanization on estuarine water quality in terms of fecal coliform bacterial effects by comparing water quality in highly urbanized Murrells Inlet and pristine North Inlet in coastal South Carolina. Significant differences were found between these areas in fecal coliform densities and bacterial species comprising the coliform group. Elevated fecal coliform densities were found in the inner and outer regions of the urban estuary, and *E. coli* accounted for 83% of all bacterial species. In pristine North Inlet, the highest coliform densities were found in the inner regions, adjacent to deciduous hardwood forest, and wildlife were the primary pollution source. *E. coli* was the dominant bacterial species detected, but only accounted for 59% of all bacterial species present. Nonetheless, *E.coli* was the dominant species in the coliform group in surface waters of both areas, and it was not possible on that basis alone to identify pollutant sources.

The Multiple Antibiotic Resistance (MAR) method was able to differentiate among pollution sources. MAR results found that 2.5% of *E. coli* bacteria in Murrells Inlet were resistant to multiple antibiotics. The majority of sites had resistance to only a single antibiotic (either ampicillin or penicillin). Only one site had MAR that matched human wastewater treatment plant samples within the region, suggesting a human source. These results compared favorably with other highly urbanized coastal regions of South Carolina including Broad Creek in Hilton Head, where 3% of the *E. coli* were antibiotic resistant. MAR was much lower (<1%) in a rural watershed in Beaufort County, the Okatee River, and in North Inlet. In addition, the MAR index values in urbanized Murrells Inlet (2.47) and Broad Creek (3.40) were higher than in the rural Okatee River (1.04) or North Inlet (<1) watersheds. Similarly, the total number of antibiotics to which *E. coli* exhibited resistance was much higher in urbanized Murrells Inlet (8 antibiotics) and Broad Creek (8 antibiotics), when compared to rural Okatee River (2 antibiotics). Analysis of "Presumptive" Total Maximum Daily Load (TMDL) estimates indicated that the remaining human waste load for Murrells Inlet was less than 1% of the pet waste load estimated for dogs and cats. These findings, when taken in toto for Murrells Inlet, suggest that the vast majority of bacteria in Murrells Inlet is from domestic animals rather than human sources. Thus, to reduce fecal coliform loadings in Murrells Inlet and other coastal areas, it will be important to develop programs to control pet waste loads.

Bacterial closure sign prohibiting shellfish harvesting. This single issue is often a lightning rod at galvanizing public response to changes in environmental conditions within coastal areas.

Condition of the National Estuarine Research Reserve System

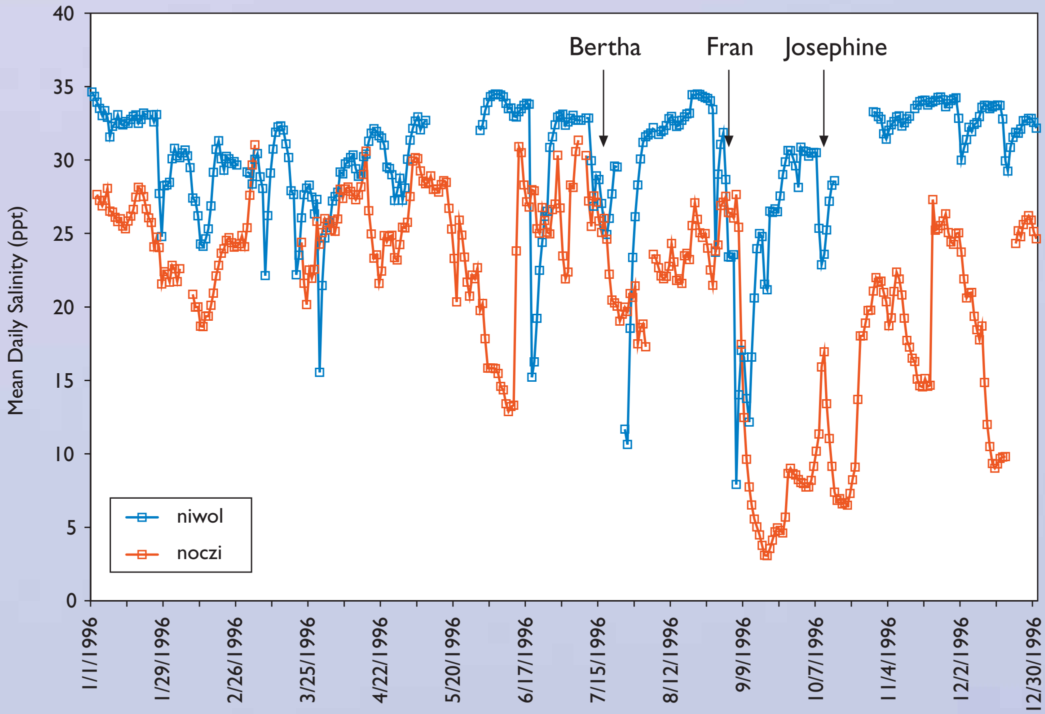
The National Estuarine Research Reserve System (NERRS) is a network of 25 protected areas representing different biogeographic regions of the United States. These protected areas, or reserves, are estuarine areas established to promote long-term research, environmental monitoring, education, and coastal stewardship. NERRS was established by the Coastal Zone Management Act of 1972, as amended, and is a partnership program between NOAA and the coastal states. NOAA provides funding and national guidance, and a lead state agency or university is responsible for managing the reserve with input from local partners.



Prepared by NOAA's Ocean Service, Estuarine Reserves Division, for the National Coastal Condition Report I.

In the mid-1990s, NERRS initiated a monitoring program to improve coastal zone management. The SWMP tracks short-term variability and long-term changes in coastal ecosystems represented in the NERRS. The initial phase of the SWMP began in 1996 and focuses on monitoring of water quality and atmospheric parameters. Future phases of the program will include biodiversity monitoring and land use habitat-change analyses.

The data collected by the program thus far have been used to measure the success of restoration projects and to analyze water quality conditions related to oyster diseases. NERRS has conducted two assessments on water quality data collected through the SWMP. These assessments evaluated water quality data from 22 of the 25 NERRS between 1995 and 2000 and analyzed different aspects of the data collected, including the frequency and duration of hypoxic events, ecosystem metabolism, and the impacts of coastal storms on water quality. Reports documenting the methods and results from these assessments can be downloaded from http://www.ocrm.nos.noaa.gov/nerr/monsys.html. Results from the North Carolina and North Inlet–Winyah Bay, South Carolina, estuaries showed that short-term changes to salinity and depth during the passage of tropical storms were variable and dependent on the fetch (area over which the winds blew) of approaching storms. With a few exceptions for salinity, changes to water quality parameters were abrupt and short-lived.



Effect of storms on mean daily salinity at the North Carolina (noczi) and North Inlet–Winyah Bay (niwol), South Carolina, NERRS sites in 1996 (Sanger et al., 2002).

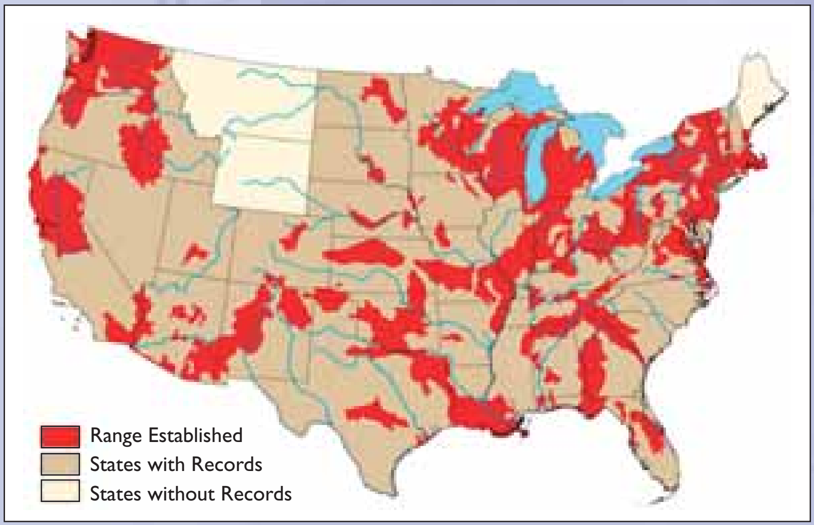
More information about the NERRS program is available at http://www.ocrm.nos.noaa.gov/nerr. Monitoring data for each reserve are available from NERR's Centralized Data Management Office at http://cdmo.baruch.sc.edu.

highlight

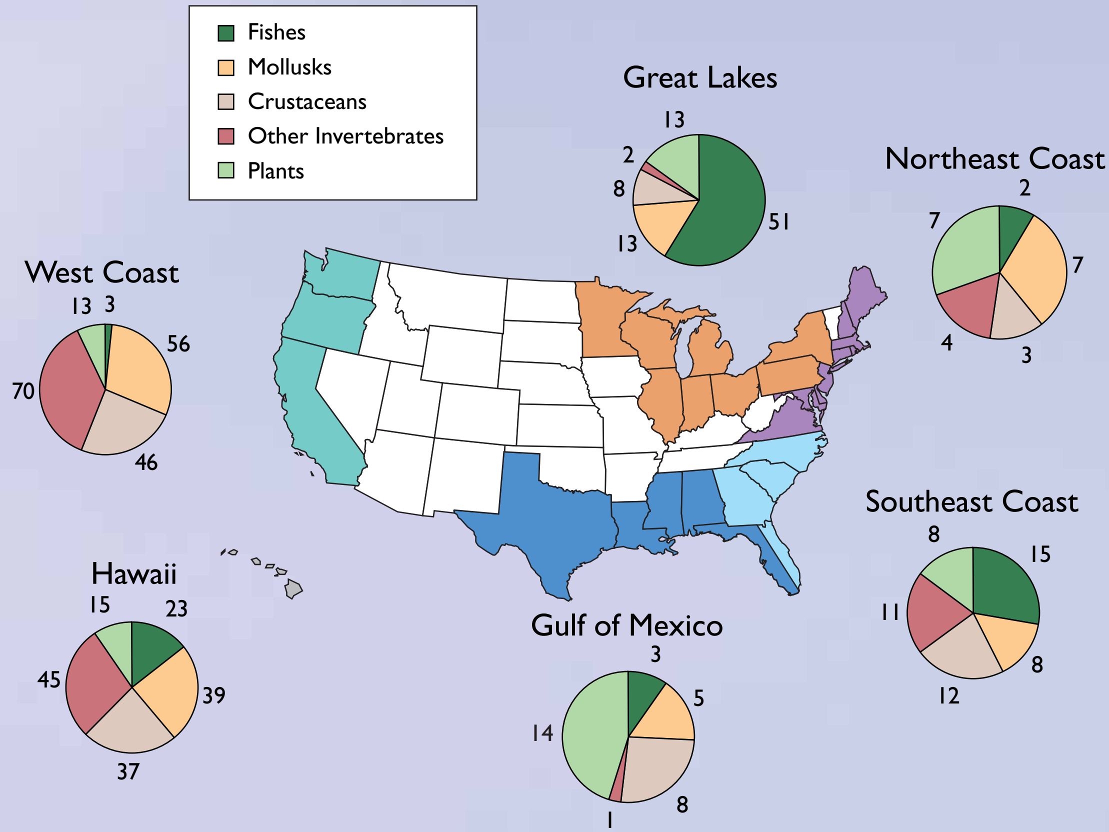
Nonindigenous Species

Nonindigenous species, also known as "exotics" because they are often transported from other countries, are a major threat to biodiversity around the world. The daily inundation of nonindigenous species on the nation's coastlines is a continual concern to environmentalists. Many of the species are transported to the United States by foreign ships, which discharge millions of gallons of ballast water at large commercial shipping ports. Ballast discharges release everything from bacteria and viruses to mussels, crabs, fish, and algae. Although some species do not survive the long voyage, others do, and as ships get faster, the survival rate of these exotic species increases.

The West Coast of the United States, particularly San Francisco Bay, has a very large number of nonindigenous species. One reason for this is that the United States engages in a tremendous amount of trade with Asian countries, and this trade brings many nonindigenous species of Asian origin to the West Coast. Also, San Francisco Bay is a large estuary that is sheltered from the dynamic wave action of the open ocean, and although the West Coast seems to have more nonindigenous species than the East Coast, many more surveys have been conducted along the West Coast to determine what exotic species are present. Recently, however, scientists have been looking at the major ports and estuaries of the East Coast and Gulf of Mexico to obtain similar information. Intracoastal transfer of exotic species is also a concern. Progress is being made in ballast water research and legislation to significantly reduce the number of living organisms being transported from overseas.



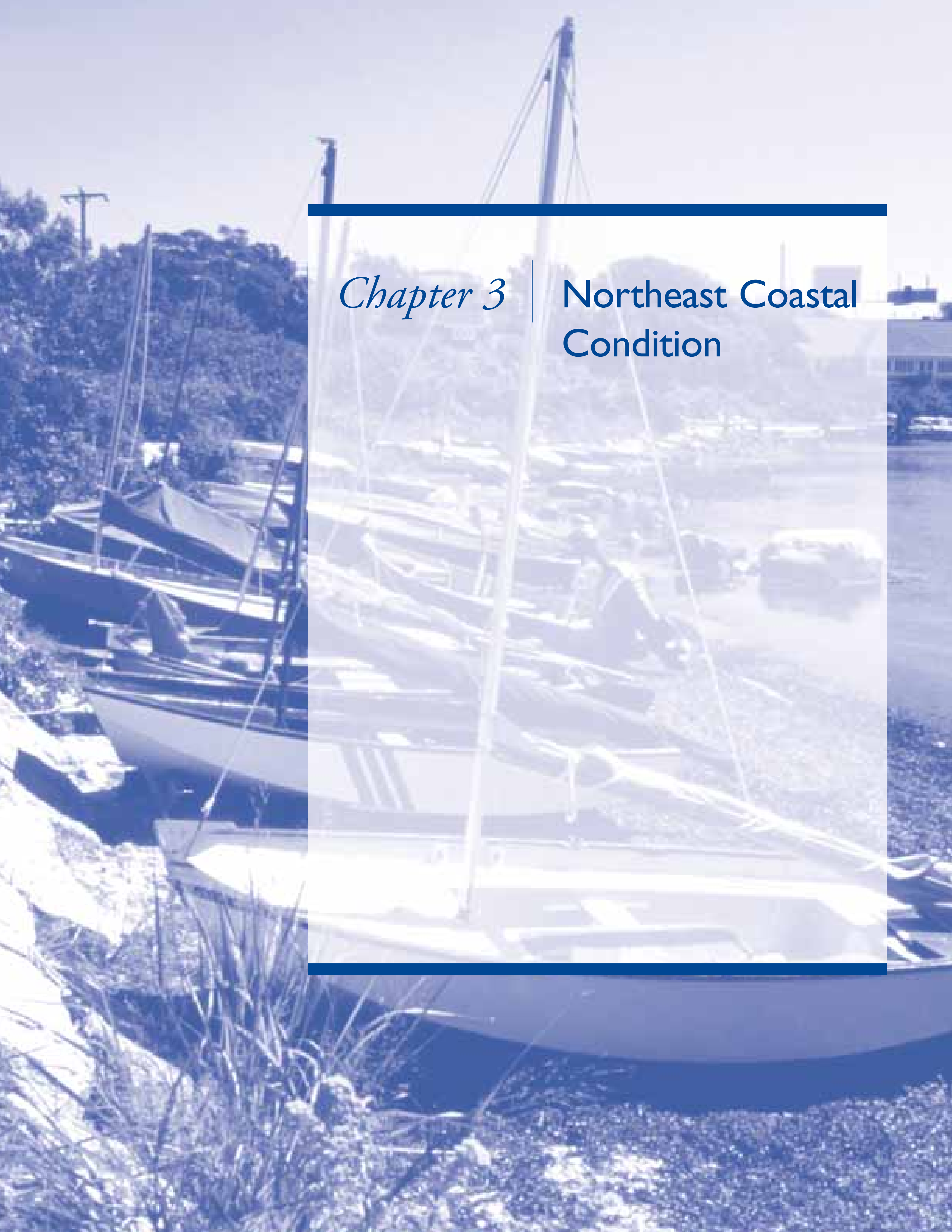
Myriophyllum spicatum distribution in the United States as of April 2003. Map indicates recorded presence in at least one site within the drainage, but does not necessarily imply occurrence throughout that drainage (USGS).



Number of nonindigenous species by taxa in coastal regions of the United States (USGS).

Although many nonindigenous species were transported by ships, most aquatic plants known to be invasive did not arrive in ship ballast water, but were imported intentionally through the aquarium and water garden trade. Submerged aquatic vegetation has a well-founded reputation of vigorous invasiveness and can become permanently established where introduced. Eurasian water-milfoil (*Myriophyllum spicatum*) is a prime example. In the United States, Eurasian water-milfoil grows in every state except Alaska, Hawaii, Maine, Montana, and Wyoming. Although it has long been established in freshwater lakes and rivers of the Northeast and Great Lakes regions, this plant is a newcomer to arid western states, where aquatic systems are often stressed and vulnerable. In many estuarine rivers, fresh to brackish marshes, tidal creeks, and protected bays scattered along the Atlantic, Gulf, and Pacific coasts, the Eurasian water-milfoil has thrived and has often become the dominant submerged aquatic plant.

Information about coordinated agency efforts against nonindigenous species can be found at www.anstaskforce.gov. The USGS maintains a geographic database of nonindigenous aquatic species for the United States at http://nas.er.usgs.gov. For more information, contact Amy Benson at amy_benson@usgs.gov.



Chapter 3 | Northeast Coastal Condition

Northeast Coastal Condition

The overall condition of Northeast Coast estuaries is poor (Figure 3-1). Twenty-seven percent of estuarine area is impaired for aquatic life (poor condition), 31% is impaired for human use, and an additional 49% is threatened for aquatic life use (Figure 3-2). The Northeast Coast region contains diverse landscapes, ranging from mountains and forests and rocky coastal headlands in Maine to coastal plain systems in the Mid-Atlantic. The Northeast Coast is the most densely populated coastal region in the United States and includes the coastal waters of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, and Virginia (Figure 3-3). In the Northeast Coast region, the ratio of watershed drainage area to estuary water area is relatively small when compared to the ratios in the Southeast Coast and Gulf Coast regions. The by-products of past and current human activities in Northeast Coast watersheds are washed to the sea, affecting coastal conditions in the region. The highest levels of sediment contamination are found in depositional environments near urban centers, reflecting current discharges and the legacy of past industrial practices.

Anthropogenic nutrients delivered by rivers to the coast come from a variety of sources. In New England, nutrient inputs from agricultural activity are relatively small. Much of the nutrient delivery to the coast in the nonurban areas of northern Maine results from atmospheric deposition onto watersheds (Boyer et al., 2002).

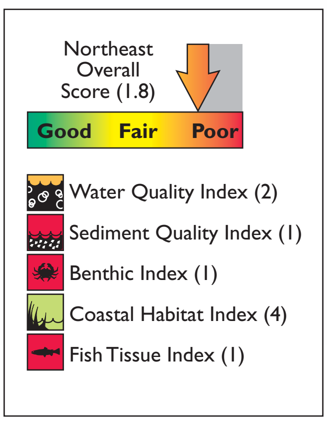


Figure 3-1. The overall condition of Northeast Coast estuaries is poor.

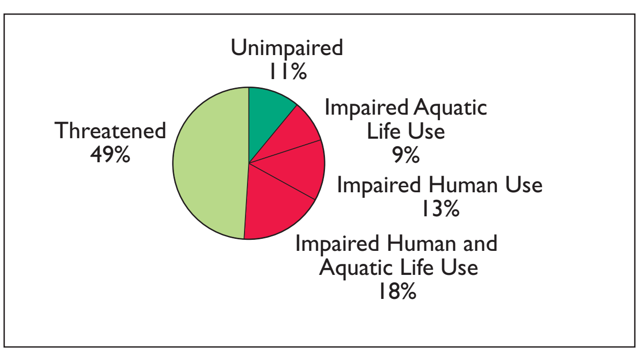


Figure 3-2. Northeast Coast estuarine condition (U.S. EPA/NCA).

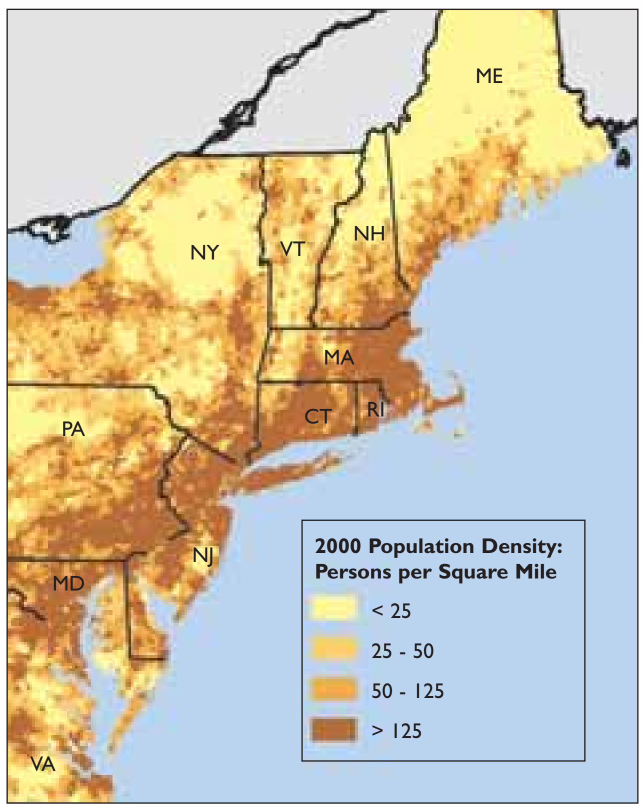


Figure 3-3. Human population density by county for watersheds that drain to the Northeast Coast (U.S. Census Bureau, 2000).

In urbanized coastal settings, from Casco Bay, Maine, through Long Island Sound, wastewater treatment facilities that discharge directly into coastal waters are the major source of anthropogenic nitrogen input. In the Mid-Atlantic, in addition to atmospheric and urban sources, agricultural operations from crops, poultry farms, and manure from other animal operations are important additional sources of nutrients. (Roman et al., 2000) provide a recent and detailed review of the geological history of the Northeast and the effects of human activity along coastal New England. A review of the geologic history and geomorphology of Mid-Atlantic estuaries and subsequent human alterations can be found in Paul (2001).

In New England, successive glacial advances shaped the landscape, soils, and coastline. The major estuaries are former river valleys (Connecticut and Hudson) that were scoured by glaciers and submerged following rapid melting of the most recent large ice sheet between 17,000 and 13,000 years ago. Thicker soils are found in the Mid-Atlantic, due in part to the lack of glacial scouring, and contribute to relatively higher sediment delivery to coastal waters, which reduces the water clarity from New Jersey southward. The resulting reductions in light penetration usually limit seagrass meadows to depths less than 7 feet in Southeast coastal plain estuaries. In contrast, seagrass meadows can exceed 33 feet in depth in the clearer waters of New England (Thayer et al., 1984; Roman et al., 2000). The coastal waters from New York southward are relatively shallow, with samples of marine organisms collected at an average depth of 21 feet, contrasting with an average depth of 57 feet for collection of benthic organisms from the waters from New York northward through Maine.

Woods Hole Yacht Club, Great Harbor at Woods Hole, Massachusetts (Edgar Kleindinst, NMFS Woods Hole Laboratory).

Cape Cod represents a major biogeographic transition area that divides the more boreal waters to the north of Cape Cod (Acadian Province) from the warmer, temperate waters to the south of Cape Cod (Virginian Province) (Figure 3-4). The relatively larger average tidal ranges of 7 to 13 feet in the Acadian Province contribute to greater tidal mixing and flushing, in contrast to the tidal ranges of 7 feet or less in the coastal waters of the Virginian Province. Chesapeake Bay is considered microtidal in character, having average tidal ranges of less than 3 feet (Hammar-Klos and Thieler, 2001).

Chesapeake Bay is the largest estuary in the United States, initially formed as a result of an impact when a bolide (a large extraterrestrial object, such as an asteroid or comet) crashed into shallow seas 35 million years ago (Poag, 1999). Along the western shore of Chesapeake Bay, the Susquehanna, Potomac, and James rivers cut into the side of this crater and currently contribute 80% of the bay's fresh water. As the most recent ice sheet to the north melted, the sea once again entered and flooded former river valleys around the crater's edge (Poag, 1999).

Currently, Chesapeake Bay has a total area of 4,404 square miles, representing 59% of the Northeast Coast water area. The large size and volume of the bay and the relatively small tidal range contribute to a freshwater residence time of 7.6 months, much longer than that of other estuaries in the region (Nixon et al., 1996). In contrast, Delaware Bay, Narragansett Bay, and Boston Harbor have freshwater residence times of 3.3, 0.85, and 0.33 months, respectively (Dettmann, 2001). Because of the size of Chesapeake Bay, conditions heavily influence area-weighted statistical summaries of Northeast Coast conditions.

NCA sampling sites for the Northeast Coast are shown in Figure 3-4. From Delaware northward through Maine, sampling locations are based on probabilistic sampling designs targeting 100% of the coastal waters over a 2-year sampling period. Stations sampled from the 2000 summer field season were included in this analysis and are shown in Figure 3-4. Because these stations are randomly and uniformly distributed throughout the region, they represent the entire area; however, because there were only one-half as many per unit area, their weighting factors were

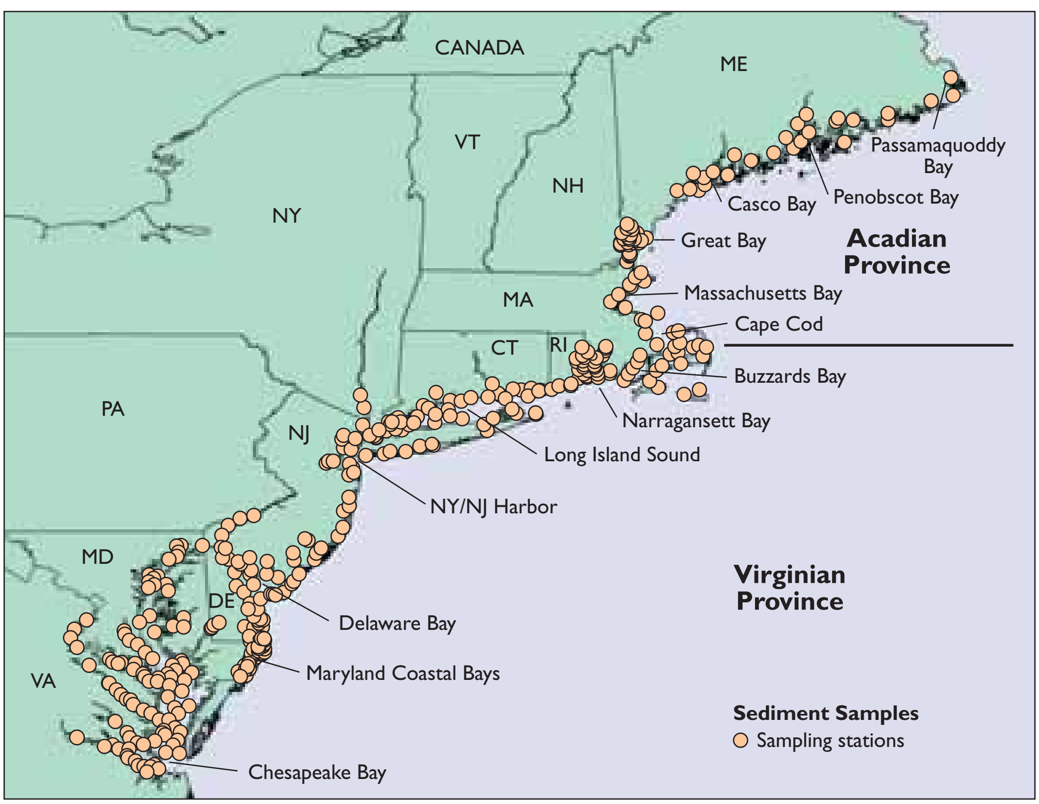


Figure 3-4. Sampling stations on the Northeast Coast used for NCA and Mid-Atlantic Integrated Assessment (MAIA) data (U.S. EPA/NCA).

doubled in calculations. The design of Maryland coastal bays called for 100% sampling of coastal waters in 2000; thus, the weighting factors were not altered. In Chesapeake Bay, the water quality and benthic data measured by the Chesapeake Bay Program in 2000 were used for this analysis. All of the Chesapeake Bay sediment chemistry data and fish tissue contaminant data used in this report are based on the Mid-Atlantic Integrated Assessment (MAIA) 1997 survey (U.S. EPA, 2002).

Several of the coastal states participating in the NCA surveys also have their own separate monitoring networks. For example, New Jersey has shellfish, water quality, and chlorophyll monitoring networks. New Jersey's monitoring networks have a higher density of stations in coastal waters and are monitored at greater frequency than those used in the broad NCA surveys (Baldwin-Brown et al., 2003). These networks are not probabilistically designed, and sites are located largely based on best scientific judgment; however, some sites are essentially placed at random in an area. Some of these random sites have been incorporated in the NCA monitoring design. Such complementary monitoring programs provide essential additional information for the interpretation of time-varying coastal conditions (particularly those that vary over short time scales), as well as provide the additional information needed to document areas of local impairment.

The sampling conducted in the EPA NCA Program has been designed to estimate the percent of estuarine area (nationally or in a region or state) in varying conditions and is 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 indicator 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.

Coastal Monitoring Data

Water Quality Index

The condition of Northeast Coast estuaries as measured by the water quality index is fair to poor. Poor water quality condition was found in 19% of the Northeast Coast estuarine area during the summer of 2000 (Figure 3-5) Most of the stations rated poor were concentrated in a few estuarine systems, in particular New York Harbor, some tributaries of Delaware Bay, the Delaware River, the coastal bays of Maryland and Delaware, and the western and northern tributaries of Chesapeake Bay. Fair condition was observed in 42% of Northeast Coast estuaries. The water quality index indicates that water quality degradation was more prevalent in the coastal waters of the Virginian Province (south of Cape Cod) than in the coastal waters of the Acadian Province (north of Cape Cod), but signs of degraded water quality condition were also noted throughout the Acadian Province. Generally, the relatively open rocky coasts; cold, salty waters; and high tidal ranges of the Acadian Province favor well-mixed conditions that

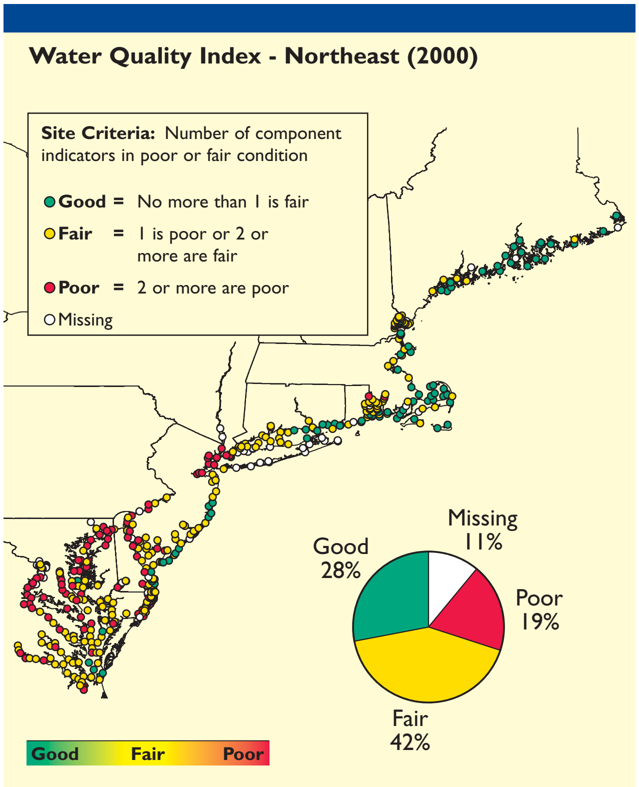


Figure 3-5. Water quality index data for Northeast Coast estuaries (U.S. EPA/NCA).

minimize accumulation of nutrients or organic matter, which lead to the undesirable effects associated with water quality degradation. In contrast, the historically unglaciated parts of the Virginian Province have extensive watersheds to funnel nutrients, sediment, and organic material into secluded, poorly flushed estuaries that are much more susceptible to eutrophication. The pattern of eutrophication also closely reflects the distribution of population density (Figure 3-3).

Further analyses are based on the spatial patterns of the five component indicators used in the NCA water quality index. For local management applications, the results summarized in this report should be interpreted in the context of additional information, such as site-specific criteria and state water quality standards. There are few estuarine water quality standards for nitrogen or chlorophyll *a*. For this regional/national assessment, a single set of guidelines was used throughout the region, except when assessing specific indicators (e.g., water clarity).

Assessing Water Quality Condition in Individual Estuarine Systems

Water quality responses can be complicated and cannot be described by a simple index for all estuarine systems. An index that may work well throughout most of a region may not describe the eutrophic conditions in a specific estuary. For example, Delaware Bay has naturally high concentrations of suspended solids, and DIN concentrations remained high during the sampling period when phytoplankton production was light-limited. Water quality degradation in much of the open portion of Delaware Bay is not considered to be a problem in late summer. In this report, selected tributaries of Delaware Bay and many parts of the Delaware River received poor ratings on the water quality index for specific sites, whereas open water areas in the Delaware Bay received fair or good ratings. For such local situations, less weight could be given to nutrient concentrations measured in late summer and greater weight to phytoplankton production (chlorophyll *a*) or dissolved oxygen concentrations. The water quality index used in this report is intended for regional and national assessments and may not be suitable for every individual estuary. Indicators that account for local ecological conditions may need to be measured, in addition to the standard set of NCA indicators, to provide a better picture of water quality in certain estuarine systems. The NCA data used for the national and regional assessments in this report are of known quality and can be queried using different weighting factors and indicator combinations that may be more representative of specific estuary conditions.

Nutrients: Nitrogen and Phosphorous

Figures 3-6 and 3-7 show the concentration ranges of DIN and DIP in surface waters in the Northeast Coast. From a regional perspective, the overall rating for DIN is fair (11% of the estuarine area is in poor condition), and the overall rating for DIP is good (5% of the estuarine area is in poor condition). DIP is more likely to promote algal growth in tidal-fresh parts of estuaries, whereas DIN is the nutrient type most responsible for eutrophication in open estuarine and marine waters. The highest nutrient concentrations in the Northeast Coast were found in New York Harbor and Maryland coastal bays, Narragansett Bay (Rhode Island), and several tributaries in the Chesapeake and Delaware estuaries. Fair to poor conditions were measured in Delaware Bay, Narragansett Bay, and Great Bay (New Hampshire). Good conditions were notable in the Chesapeake mainstem, Long Island Sound (for DIN), and much of the Acadian Province. Thus, even during the late-summer NCA sampling period, up to 38% of the Northeast Coast had moderate to high levels of nutrients.

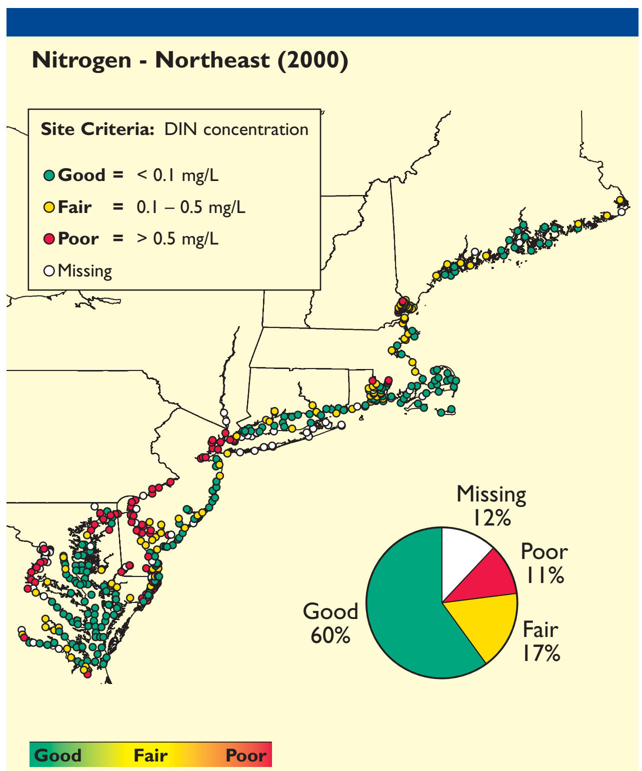
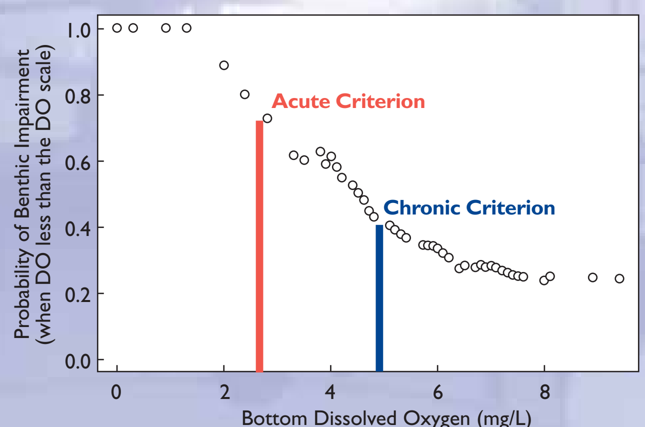


Figure 3-6. DIN concentration data for Northeast Coast estuaries (U.S. EPA/NCA).

Benthic Condition in Chesapeake Bay Declines When Dissolved Oxygen Declines

Changes in the number and types of benthic macroinvertebrate communities (BMC) can help document ecological conditions. Degraded BMCs often have lower species diversity and can include opportunistic species that occur in great abundance. BMC data can be summarized using a BMC index (Paul et al., 2001), which is designed to discriminate between healthy and degraded sites within a region or state. BMC index variations can be analyzed in relation to known stressors (e.g., the probability of degraded benthic conditions in relation to low dissolved oxygen in bottom waters). Using data collected from 1990 to 1993 from the open waters of Chesapeake Bay, there is an increasing probability of BMC impairment (BMC index values <0) at sites with progressively lower dissolved oxygen concentrations. The EPA acute and chronic criteria for dissolved oxygen shown below are based on independent laboratory testing with marine organisms (U.S. EPA, 2000a). This laboratory versus field survey comparison provides some confidence in the validity of the BMC index.



Chesapeake Bay 1990–1993 Virginian Province Data, large systems (Paul et al., 2000).

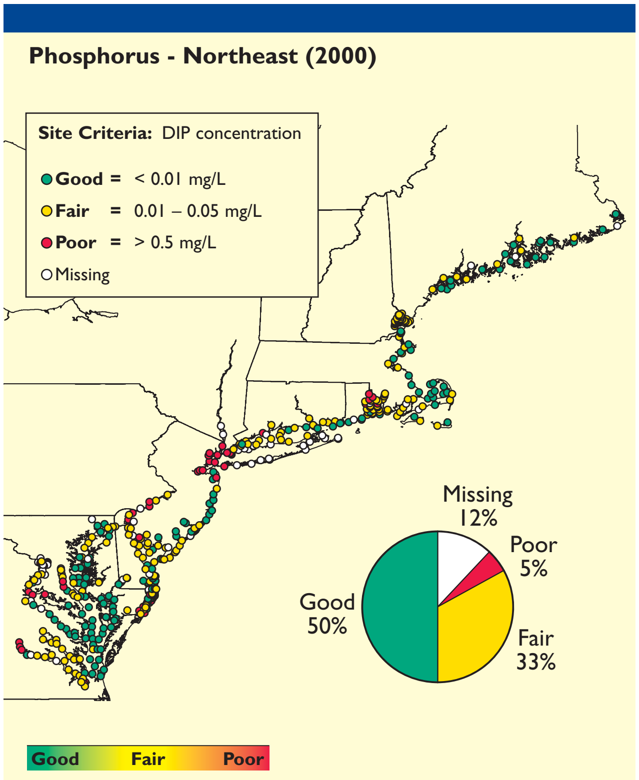


Figure 3-7. DIP concentration data for Northeast Coast estuaries (U.S. EPA/NCA).

Chlorophyll *a*

The concentration of the plant pigment chlorophyll *a* is used to estimate the quantity of algae suspended in the surface water. About 15% of estuarine area in the Northeast Coast is rated poor for this indicator, which results in an overall rating of fair for chlorophyll in the region (Figure 3-8). Generally, the broad pattern of pigment concentration is similar to that of nutrients, with concentration much higher to the south of Cape Cod than to the north. Chlorophyll *a* concentrations mirror nutrient levels in the Maryland coastal bays, Chesapeake tributaries, and much of the Northeast Coast coastal waters; however, there is little apparent spatial correlation between chlorophyll *a* and nutrients in the Chesapeake mainstem, Delaware Estuary, or New York Harbor region. Spatial patterns in nutrient levels and chlorophyll *a* differ for a number of reasons. One reason is that algae may not be able to use nutrients effectively in very turbid water (e.g., in low-light environments, such as the Delaware Bay) or in regions with high flushing rates. As a result of nutrient uptake by phytoplankton blooms, dissolved nutrients may be low. Locations of peak nutrient and biomass concentrations may coincide in space or time.

Fishing boats in the harbor at Smith Island, Chesapeake Bay, Maryland (Mary Hollinger, NODC biologist, NOAA).

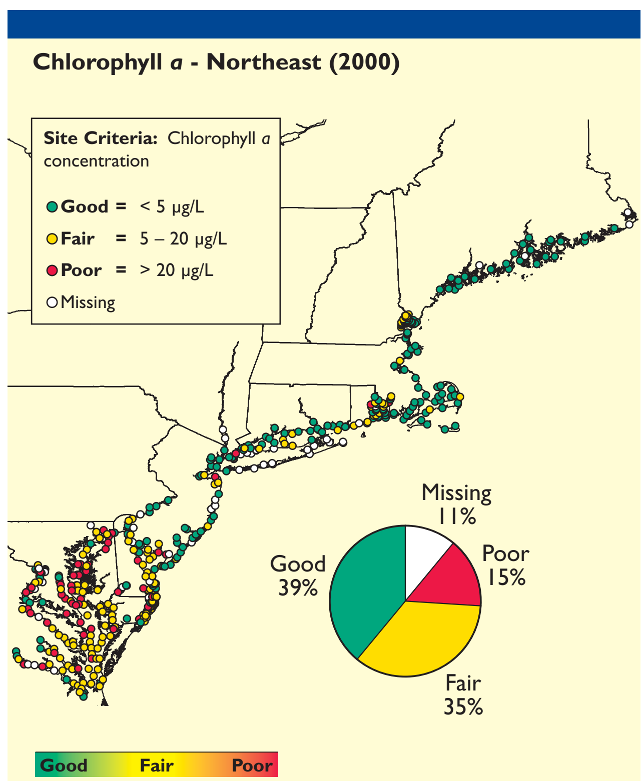


Figure 3-8. Chlorophyll *a* concentration data for Northeast Coast estuaries (U.S. EPA/NCA).

1937 Delaware Statewide Aerial Photography

The ability to assess land use changes over time is a valuable tool for resource managers. Altered shorelines, urban and suburban sprawl, reductions in agricultural acreage, and changes in habitat types are just some land use issues that concern resource managers. In an effort to trace such land use changes, planners in the state of Delaware will soon be able to visually compare current aerial views of the state with historic photos from more than 60 years ago .

Delaware Coastal Programs, in a cooperative effort with the state's Natural Heritage Program, Natural Areas Program, and Forest Service, is undertaking a project that will assist in identifying land use changes by compiling a complete aerial image of the state as it looked in 1937. By comparing these photographs to ones taken in 1997, resource managers will be able to review a 60-year timeframe within which to assess land use changes.

For this project, approximately 700 aerial images of Delaware taken in 1937 were obtained from the National Archives. These photographs were scanned and georeferenced to Delaware State Plane Coordinates, North American Datum 83 meters using ERDAS IMAGINE software. Spatially referenced mosaics were created for each of Delaware's three counties, and any distorted edges, fiducial marks, and photograph borders were cropped. These mosaics enable comparative analysis with existing 1997 statewide Digital Ortho-Quarter Quads. Geographic information systems (GIS) technologies were utilized to identify land use changes.

One analysis currently underway involves evaluating changes in forest cover. In Delaware, older-growth forests are one of the most biologically diverse habitat communities. For the purpose of this effort, older-growth forests are defined as areas that have not been clear cut for 50 years or more. The forest canopy, canopy gaps, and understory of these areas harbor a high number of state-listed rare and endangered species when compared to most upland habitat areas.

To better assess valuable older-growth habitats, forested areas in the 1937 photos were on-screen digitized using ArcGIS software. This coverage will be converted to a grid that can be directly compared with recent photos using spatial analysis techniques to ascertain the location and extent of forest area in 1997 that also existed in 1937. These locations will be used to determine the most likely areas of historic forests. Upon field verification, this information will enable planners and resource managers to prioritize and strengthen conservation efforts of these critical habitats.

Planned future projects include habitat trends and beach extent analysis. Other potential projects using 1937 imagery are also under development.

Coastal Water Quality in New England

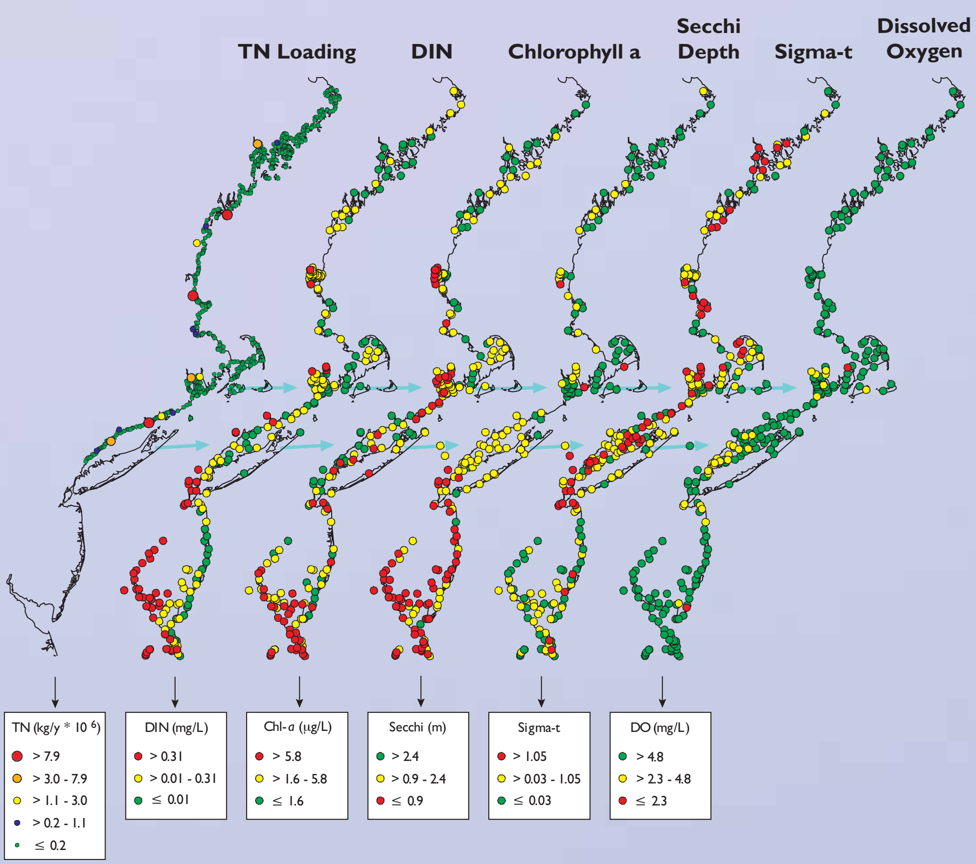
Cooperating state programs have, for the first time, collected and documented regional gradients in New England coastal waters using a consistent set of indicators. Gradients for most of the water quality variables were ranked in the highest 25% (upper quartile), the middle 50%, and the lowest 25% (lower quartile). The figure of coastline traces shown on the following page ranks DIN (sum of nitrate, nitrite, and ammonia), phytoplankton pigment (chlorophyll *a*), light transparency (Secchi depth), water column stratification (delta Sigma-t), and dissolved oxygen with water quality through the use of colored dot markers. These coastal water conditions are based on samples collected in the summer and fall of 2000. Annual Total Nitrogen (TN) loading estimates come from the New England Sparrow model and are based on conditions in the early 1990s. These estimates are shown in the left-most coastline trace on the figure.

Excess nutrient loading can contribute to elevated water column nutrient concentrations, higher levels of phytoplankton pigments, and reduced transparency to light. The red dots indicate data in the upper 25% for DIN and chlorophyll *a*. In contrast, red dots illustrate the lower quartile for light transparency.

When lighter freshwater floats on top of denser saline water, the water column is stratified. In such a water column, the mixing of oxygen to depth is diminished. The red dots indicating surface to bottom water column density difference (delta Sigma-t) illustrate the degree of stratification, with sampling locations falling in the upper 25% (most stratified) colored in red and the lower 25% (least stratified) colored in green. In a well-mixed water column, stratification is absent, and oxygen can be transported from the surface to water at deeper depths.

The far right coastline trace illustrates regional gradients in the dissolved oxygen content of water sampled near the bottom of the water column. Marine water quality criteria for dissolved oxygen are used to define the dot colors. Oxygen concentrations that fall below the EPA acute criterion level of 2.3 mg/L are illustrated with red dots. Yellow dots are used to represent the locations where oxygen concentrations were higher than the acute level, but less than or equal to the EPA chronic criterion level of 4.8 mg/L (U.S. EPA, 2000a).

Regional scale gradients in dissolved oxygen can be noted in these coastline traces. In the Acadian Province north of Cape Cod, dissolved oxygen concentrations measured during the summer 2000 NCA survey were consistently greater than 4.8 mg/L. Water temperatures in the Acadian Province are relatively cold, and consequently, the water holds more oxygen. Tidal ranges are usually greater than 2 meters, promoting increases in tidal currents and an increased mixture of oxygen from the surface to depth. Waters are warmer south of Cape Cod, with tidal ranges less than 2 meters resulting in reduced tidal currents, and consequently, a decreased mixture of oxygen from the surface to depth than locations farther north. Dissolved oxygen concentrations fall below 4.8 mg/L for some of the bottom waters in the area south of Cape Cod, including upper Narragansett Bay, western Long Island Sound, and along the New Jersey shore. Oxygen concentrations persistently below this chronic dissolved oxygen criterion can adversely impact sensitive marine organisms (Coiro et al., 2000).



Source: Moore et al., 2004

Water Clarity

Poor water clarity may be attributed to a number of sources, including suspended sediments, organic material (especially living or dead algae), and dissolved tannins. Estuaries are naturally turbid environments. Turbid waters supply building material for maintaining estuarine structures and provide food and protection to resident organisms; however, the extensive particle loads of turbid waters are harmful if they bury benthic communities, inhibit filter feeders, or block light needed by seagrasses. Because 23% of the Northeast Coast estuarine area has poor water clarity, the overall rating for the region is fair (Figure 3-9).

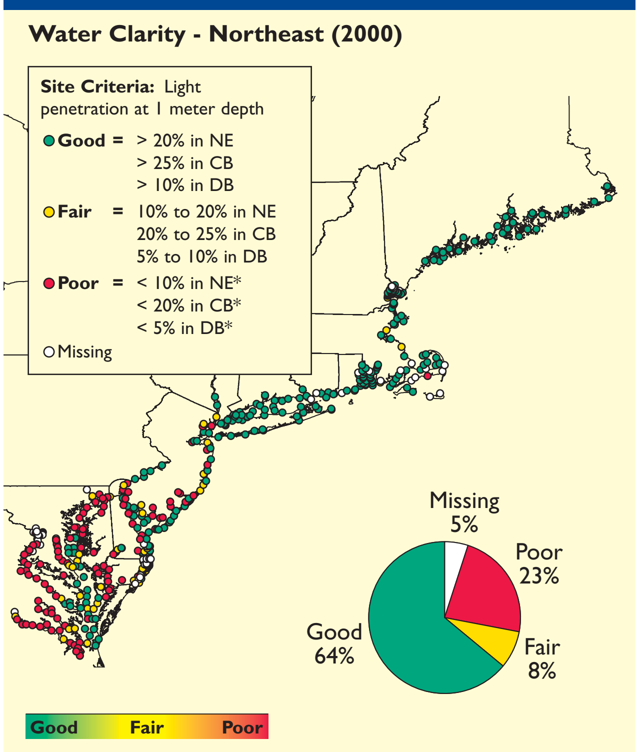


Figure 3-9. Water clarity condition for Northeast Coast estuaries (U.S. EPA/NCA). *NE represents sampling sites in the Northeast Coast region except for those sites located in Chesapeake Bay (CB) or Delaware River/Bay (DB).

Estuarine Systems	Reference Condition for Water Clarity (Percentage of Incident Light Reaching 1 Meter in Depth)
Chesapeake Bay system	20%
Delaware River/Bay system	5%
All remaining Northeast Coast estuarine systems	10%

Large mussels dot the shoreline at Edgar M. Tennis Preserve, Deer Isle, Maine (Captain Albert E. Theberge, NOAA Corps, ret.).

Dissolved Oxygen

The final indicator for the water quality index is the concentration of dissolved oxygen measured 1 meter above the sediment. This indicator is rated fair for Northeast Coast estuaries. Oxygen levels may become depleted in isolated bottom regions when excess organic material sinks and decays, especially if the water column is stratified. Most states use 5 mg/L of dissolved oxygen as the criterion for designating unacceptable water quality. Sensitive organisms can tolerate dissolved oxygen concentrations below 2 mg/L (hypoxia) for only a few days before dying. Hypoxia (and often anoxia) was evident in 10% of the Northeast Coast estuarine area, almost exclusively in the deep, isolated trenches of the Chesapeake mainstem (Figure 3-10). Fair conditions (2–5 mg/L dissolved oxygen) were measured in another 18% of the region, notably in the Chesapeake Bay, Long Island Sound, and Narragansett Bay. Dissolved oxygen levels were acceptable in two-thirds of Northeast Coast estuarine area. The areal extent of low dissolved oxygen in larger estuarine systems in 2000 may have been reduced by drought, which leads to reduced freshwater and nutrient input (e.g., Chesapeake Bay, Long Island Sound).

Temporal variations in dissolved oxygen depletion can have adverse biological effects (Coiro et al., 2000). Stressful hypoxia may occur for a few hours before dawn in productive surface waters, when respiration depletes dissolved oxygen faster than it is replenished. The NCA Program does not measure these events because most samples are taken later in the day. As a result of a variety of factors, year-to-year variations in dissolved oxygen in estuaries can be substantial, including variations in freshwater inflow, factors affecting water column stratification, and changes in nutrient delivery. A recent review of factors affecting the extent of hypoxic bottom water in Chesapeake Bay can be found in Hagy (2002) and Hagy et al. (2004). The Highlight "Use of a Hybrid Monitoring Design in Rhode Island," found at the end of this chapter, focuses on temporal variations in oxygen depletion in upper Narragansett Bay, which are modulated by predictable variations in tidal range. In the summer of 2000, the NCA survey detected dissolved oxygen concentrations below 5 mg/L (yellow dots in Figure 3-10). More intensive and complementary monitoring programs in upper Narragansett Bay documented episodic dissolved oxygen depletion events (dissolved oxygen <2 mg/L) during short time periods. These short-duration events can be accompanied by fish kills.

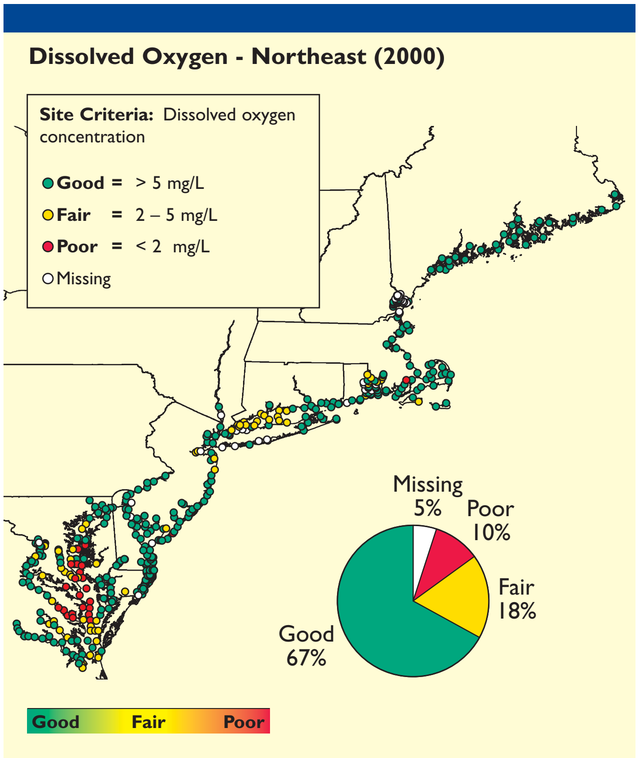


Figure 3-10. Dissolved oxygen concentration data for Northeast Coast estuaries (U.S. EPA/NCA).

Sediment Quality Index

Sediment condition as measured by the sediment quality index in Northeast Coast estuarine areas is rated poor. Sixteen percent of Northeast Coast estuarine sediments received a poor rating (Figure 3-11), meaning that at least one of the component indicators (sediment toxicity, sediment contaminants, or sediment TOC) at each of the sites received a poor rating. Regions that are relatively unimpaired include the Acadian Province (other than Great Bay, New Hampshire), eastern Long Island Sound, and the open regions of the Delaware and Chesapeake bays.

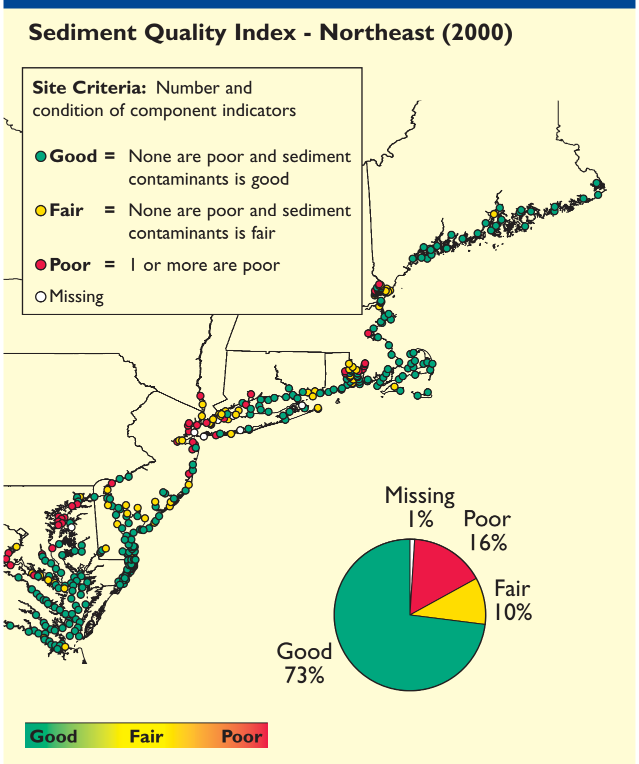
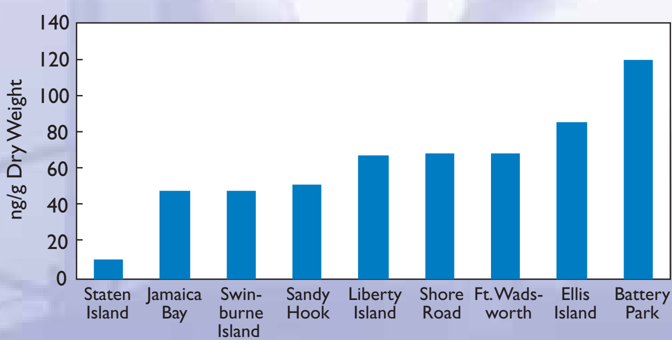


Figure 3-11. Sediment quality index data for Northeast Coast estuaries (U.S. EPA/NCA).

Portsmouth area, New Hampshire (Mr. Sean Linehan, NOAA, NGS, Remote Sensing).

Changes in Organic Contamination in Mussels in New York Harbor after September 11, 2001

The September 11, 2001, attack on the World Trade Center (WTC) resulted in a massive plume of dust and smoke that blanketed lower Manhattan Island and the adjacent harbor area. The NOAA has been monitoring five Mussel Watch Project sites in the Hudson-Raritan Estuary since 1986 for a series of organic chemicals, including PAHs, DDT and other chlorinated pesticides, and PCBs (additional information is available at http://nsandt.noaa.gov). In 1995, those analyses were augmented with measurements of dioxins, furans, and coplanar PCBs, and in 1999, polybrominated biphenyls (PBBs), commonly found in flame retardants, were also quantified. In December 2001, mussels were collected at the five Mussel Watch sites, as well as at four additional sites. Despite the attack on the WTC, the general pattern of improving environmental conditions, continued and was documented by NOAA's Mussel Watch Project. This conclusion holds for PAHs, DDT, chlordane, dieldrin, PCBs, furans, and PBBs. The chemical exceptions are dioxins and polybrominated diphenyl ethers (PBDEs).



Concentrations (ng/g dry weight) of PDBEs following geographic gradient, increasing from Staten Island towards the Battery Park site closest to the WTC (developed by NOAA for the National Coastal Condition Report II).

Dioxin concentrations in December 2001 were generally higher than in 1995. Of the sites sampled, Sandy Hook, Ellis Island, Staten Island, and Shore Road all had higher dioxin mussel tissue concentrations than the highest concentration reported for 1995. The highest concentration of 913 pg/g was found at Shore Road, one of the December 2001 special collection sites and the site located furthest from the WTC.

PBDEs are widely used as flame retardants in items such as furniture and are some of the most likely contaminants to have been mobilized by the WTC disaster. PBDEs have not previously been measured by the Mussel Watch Project; therefore, there are no data to compare across time. PBDE concentrations range from the vicinity from a low of 9.4 ng/g at Staten Island to a high of 119 ng/g at Battery Park. Mussel tissue concentrations of PBDEs generally follow a geographical pattern, with sites with the lowest concentrations typically being located south of the Verrazano Narrows Bridge. With the exception of the Liberty Island site, the general south to north increase in mussel tissue concentrations of PBDEs continues up to the WTC site, with the highest concentrations detected at Battery Park, which lies adjacent to the WTC site.

Sediment Toxicity

Sediment toxicity in Northeast Coast estuaries is rated poor. About 8% of estuarine sediments in the Northeast Coast were toxic and considered in poor condition (Figure 3-12). Regions highlighted as impaired by this indicator include parts of Cape Cod Bay, western Long Island Sound, New York Harbor, and tidal-fresh parts of tributaries in lower New Jersey and Delaware. Figures 3-12 and 3-13 and statistical analysis reveal a generally weak relationship between sediment contamination (ERM exceedances) and amphipod survival. In part, this may reflect the strict criterion of mortality used to characterize toxicity in the amphipod assay. It also highlights the need for a more complete analysis of the bioavailability of the toxicants, e.g., an analysis that considers the effect of equilibrium partitioning and the mitigating effects of sequestering toxicants with sulfides or organic carbon (DiToro et al., 1991; U.S. EPA, 1993; Daskalakis and O'Conner, 1994).

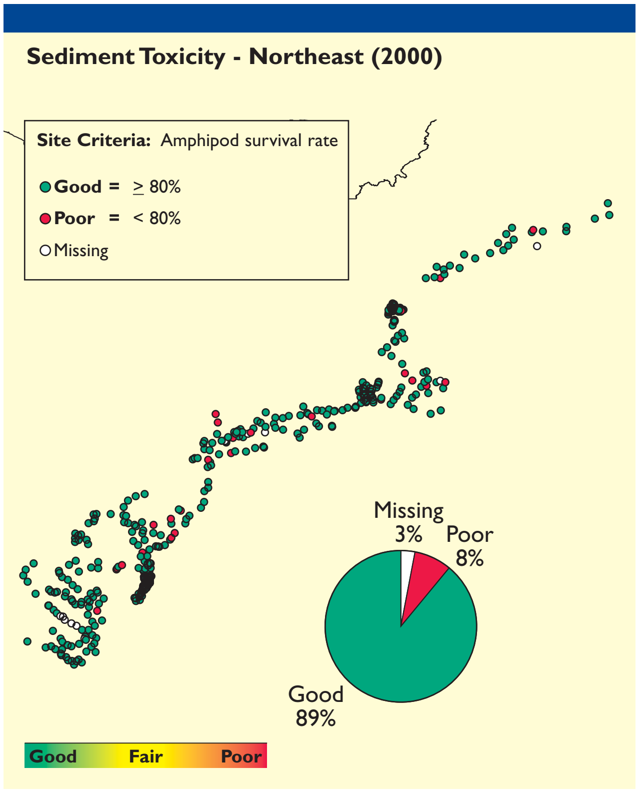


Figure 3-12. Sediment toxicity data for Northeast Coast estuaries (U.S. EPA/NCA).

Sediment Contaminants

The sediment contaminants rating for the Northeast Coast is fair. Eight percent of estuarine area has metal or organic contaminant concentrations that exceed ERM limits, and 12% has concentrations that exceed metal or organic contaminants for five or more ERL limits, but do not exceed ERM limits (Figure 3-13). Poor condition is evident in clusters neighboring major urban areas, including New York Harbor, western Long Island Sound, the upper Chesapeake Bay, and Narragansett Bay. Metals were responsible for most ERM exceedances (primarily nickel and mercury, but also silver and zinc). Most of the remaining ERM exceedances resulted from PCBs and DDT. The 12% of estuarine sediments exceeding ERLs (but not ERMs) for five or more contaminants occurred more frequently for metals (arsenic, chromium, mercury, and nickel) than for organics (primarily DDT).

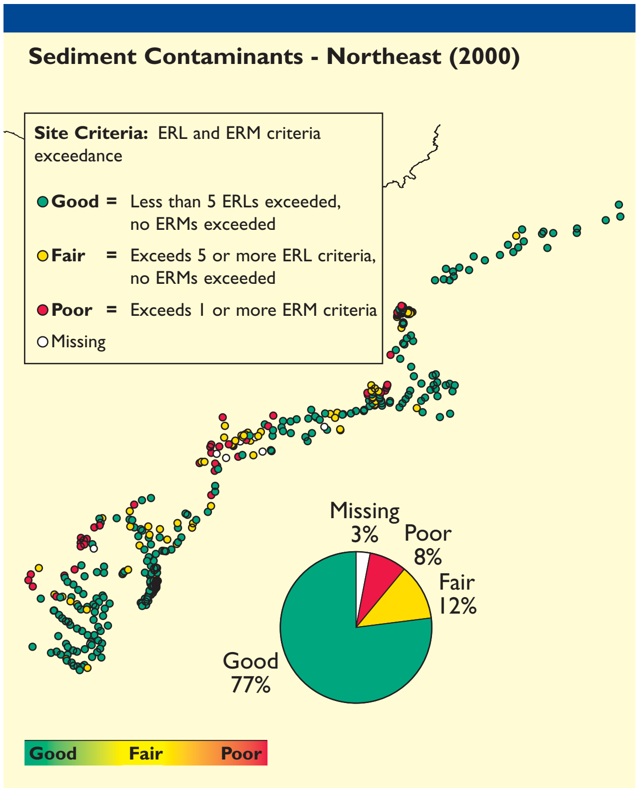


Figure 3-13. Sediment contaminants data for Northeast Coast estuaries (U.S. EPA/NCA).

Sediment Contaminant Criteria (Long et al., 1995)

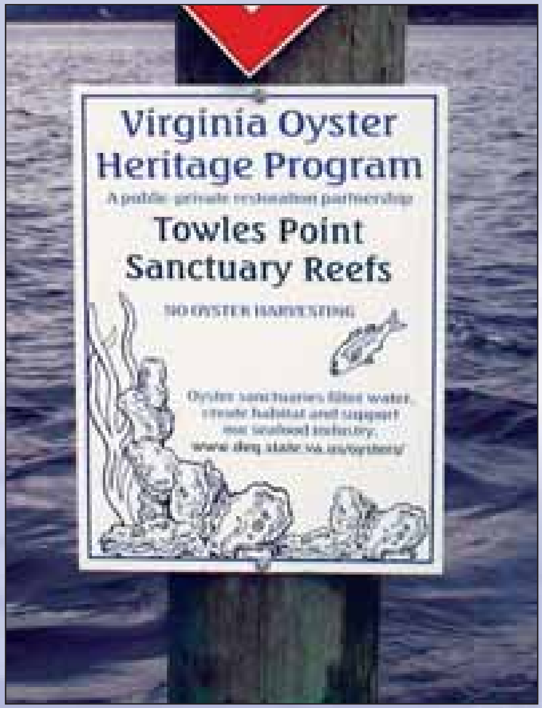
ERM (Effects Range Median)—Determined for each chemical as the 50th percentile (median) in a database of ascending concentrations associated with adverse biological effects.

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

highlight

Virginia Revives its Coastal Heritage and Waters through Oysters

In the early 1900s, oyster landings in Virginia exceeded 9 million bushels annually. Today, the total catch of the state's keystone species is less than 1 percent of that number, and the habitat, water quality, and economic benefits of once-thriving oyster populations have been nearly lost. A collaborative effort spearheaded by the Virginia Coastal Program (VCP) has resulted in a large-scale oyster restoration program, with preliminary monitoring results indicating restoration efforts may be the start of a slow recovery process.

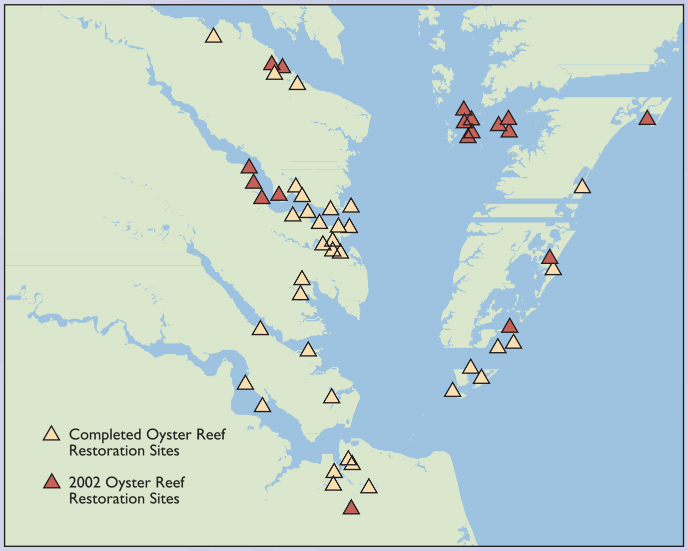


(Photo: Virginia Marine Resources Commission, April 2003)

Since the early 1990s, a number of scientific and environmental agencies have undertaken small-scale oyster restoration projects in Virginia's waters. In 1993, the Virginia Marine Resources Commission (VMRC) began building three-dimensional reefs stocked with disease-tolerant oysters. When that succeeded, the VCP determined it would be worthwhile to increase the project's scale into one large, focused effort.

In March 1999, the VCP established the Virginia Oyster Heritage (VOH) Program, a partnership among state and federal agencies, nonprofit organizations, private companies, and local watermen. The program has managed more than $11 million in funds from federal, state, and private sources. With assistance from watermen, local governments, volunteers, and the U.S. Army Corps of Engineers (USACE), the VMRC is building 1-acre sanctuary reefs throughout Virginia's coastal waters. These designated sanctuaries, consisting of a series of mounds of oyster shell 8 to 10 feet high, provide the substrate necessary for oyster settlement and growth. Planted near them are multi-acre flat beds of shells, where harvest will be allowed. Additionally, volunteer oyster gardeners are planting and growing seed oysters on some of the reefs in conjunction with the Chesapeake Bay Foundation.

During 2000 through 2002, 13 sanctuary reefs were constructed in the lower and upper Rappahannock River, and almost 500 acres of enhanced harvest area were restored with the addition of live oysters and cultch. A large-scale reef restoration effort surrounding Tangier and funded by the USACE began in 2001, with four new reefs and 200 acres of enhanced harvest area. On the seaside of Virginia's Eastern Shore, more than 20 acres of reef also were restored, and by the end of 2002, 8 reefs had been constructed in Tangier and Pocomoke Sounds.



Status of oyster reef restoration in Virginia's coastal zone (Graphic prepared by the Virginia Marine Resources Commission for NCCR II).

In addition to these restoration activities, educating the public about the role oysters play in water quality, biodiversity, and the coastal economy has also been a priority. Thousands of Virginians have learned about the critical role oysters play in keeping coastal waters clean and providing habitat for other marine life. The private, non-profit Virginia Oyster Reef Heritage Foundation has raised hundreds of thousands of dollars and gives businesses and individuals an opportunity to get involved in this initiative. A model for other restoration efforts in the Chesapeake Bay, the VOH Program and its partners served as a catalyst for a bay-wide commitment to increase oyster populations 10-fold over the next 10 years and helped galvanize a bay-wide strategy to meet this commitment. The VOH Program has set the stage with an outdoor laboratory for comprehensive on-the-ground monitoring. Virginia's coastal resource managers have already documented, in numerous places, 10-fold increases in spat abundance where substrate has been provided.

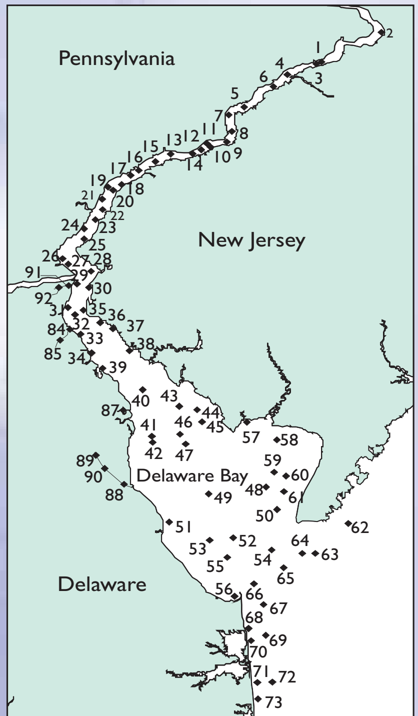
Although scientists are still trying to quantify the reefs' achievements, the partners in the VOH Program are confident about the program's success. Optimism is high that the VOH Program is helping to create an educated citizenry and a sustainable fishery that will benefit both the state's economy and coastal ecosystems.

For more information on the VOH Program, contact Laura McKay at (804) 698-4323 or lbmckay@deq.state.va.us, or Jim Wesson at (757) 247-2121 or jwesson@mrc.state.va.us. Visit the VOH Program at http://www.deq.state.va.us/oysters/ for a map of reef-restoration sites and highlights of monitoring, education, and volunteering activities.

Sediment Toxicity in Delaware Bay

Sediment contamination in coastal waters is an important environmental issue because of its potentially toxic effects on ecological resources, and indirectly, on human health. For this reason, characterizing areas of sediment contamination and toxicity are important goals for coastal resource management.

Delaware Bay, whose watershed drains portions of New York, Pennsylvania, New Jersey, and Delaware, is one of the largest coastal plain estuaries (907 square miles) on the East Coast. The urban centers of Philadelphia, Trenton, Camden, and Wilmington contain numerous sources of contaminants, including municipal and industrial discharges that contribute metals, PCBs, and chlorinated pesticides to the Delaware Bay.



Source: Hartwell et al., 2001

As part of NOAA's NS&T Program, the sediment toxicity of Delaware Bay was measured at 73 stations using a stratified-random sampling design. Samples were concurrently examined for chemical contaminants and BMC structure. Three different toxicity tests were performed: (1) amphipod bioassay survival during 10-day exposures to whole sediment, (2) sea urchin fertilization success in pore waters, and (3) bacterial bioluminescence (Microtox™) in organic extracts of sediment.

Estimates of the area of toxicity in Delaware Bay varied with the bioassay testing procedure used, from 1% toxicity based on the amphipod test to 56% toxicity based on the Microtox™ test, with the sea urchin test resulting in a toxicity estimate of 11%. The latter two tests involve more sediment handling than the amphipod test, and therefore, create less realistic exposures of organisms to sediment. The results of these three tests do not necessarily mean that organisms exposed under natural conditions will be adversely affected. Nonetheless, the 1% of the bay area samples found to be toxic in the amphipod test were also the most heavily contaminated with heavy metals and PAHs.

The condition of BMCs is a response to actual field conditions rather than manipulated laboratory exposures, but is affected by sediment characteristics beyond just chemical contamination. In Delaware Bay, indices of BMC health (e.g., taxa, density, diversity, evenness) were highly variable and poorly correlated with bioassay results. The indices were found to vary much more in response to salinity and to sediment grain size than to any other factors. The upper freshwater portion of the Delaware Bay, however, where chemical contamination was high, was an area where BMCs seem to have been affected most by contamination. For more information, visit http://nsandt.noaa.gov/index_bioeffect.htm.

Sediment Total Organic Carbon

Regions of high TOC content are likely to be depositional sites for fine sediments. If there are pollution sources nearby, these depositional sites are likely to be hot spots for contaminated sediments. Figure 3-14 shows that only 2% of the area of Northeast Coast estuarine sediments have a high TOC content (greater than 5% TOC), and an additional 26% of the area has moderate quantities (2% to 5% TOC). This results in an overall rating of good for TOC in the Northeast Coast. Generally, elevated TOC contents were found in the same locations as contaminated sediments.

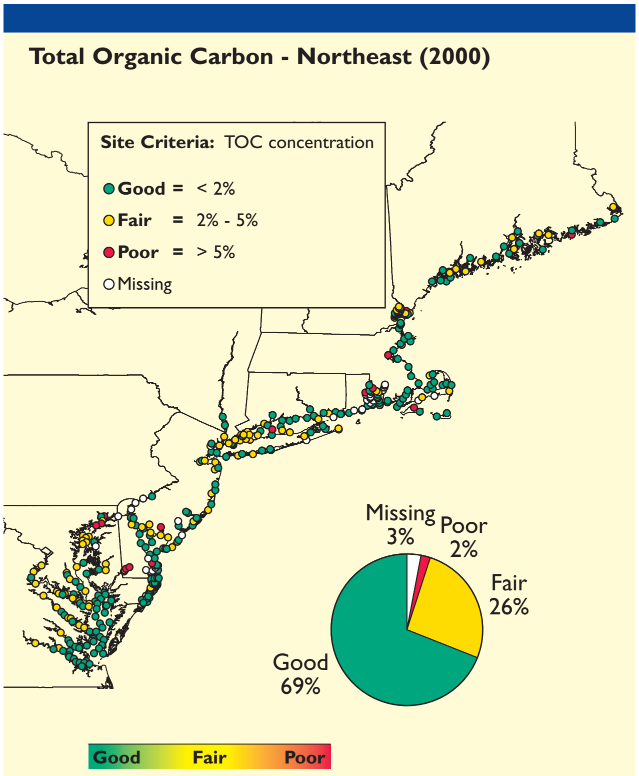


Figure 3-14. Sediment TOC data for Northeast Coast estuaries (U.S. EPA/NCA).

Benthic Index

Coastal condition in the Northeast Coast region as measured by a combination of benthic indices of the Virginian Province (Paul et al., 2001) and the Acadian Province based on biodiversity (developed by NCA for this report) is poor (Figure 3-15). Twenty-two percent of estuarine sediments evaluated using variations in benthic communities in the Northeast Coast received a rating of poor.

Poor conditions are evident at the head of Chesapeake Bay and in most of its major western tributaries. In contrast, most of the eastern shore is in good condition. Poor conditions are also prevalent in many of the Maryland coastal bays, portions of Delaware Bay, New York/New Jersey Harbor, western Long Island Sound, and upper Narragansett Bay. Conditions are good along the northern section of the Maine coast, with localized areas of poor conditions occurring in Maine waters from Penobscot Bay southward.

Coastal conditions in the Acadian Province are more oceanic and have higher bottom-water salinity than in the Virginian Province. In these northern estuaries,

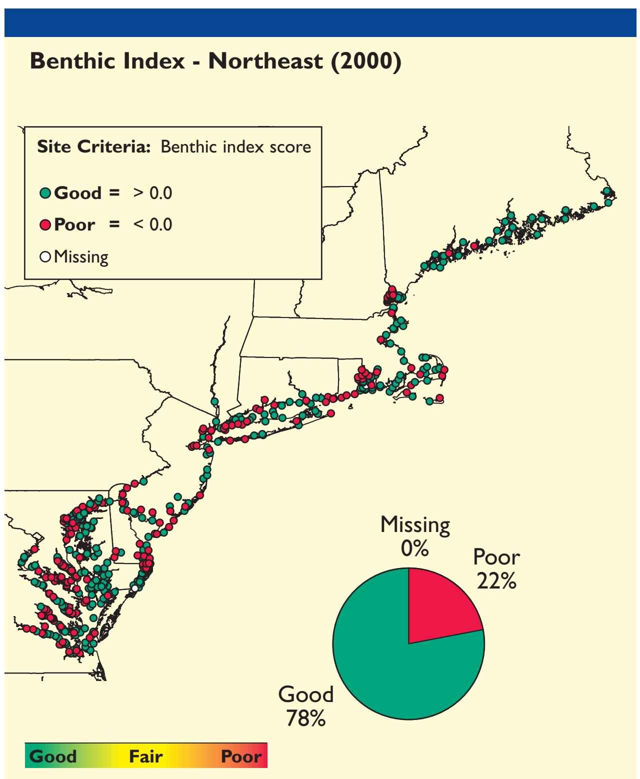


Figure 3-15. Benthic index data for Northeast Coast estuaries (U.S. EPA/NCA).

Northeast Benthic Index

The Northeast Coast region contains two major biogeographic provinces: the Virginian Province, which includes coastal waters along the east coast of Cape Cod and south through Chesapeake Bay, and the EMAP Acadian Province, which includes the U.S coastal waters in the Gulf of Maine. A benthic index (Paul et al., 2001) was used in the Virginian Province based on EMAP Virginian Province data from 1990 to 1993. The EMAP Virginian Province used a level of taxonomic detail for characterizing the benthic community composition comparable to that currently used by the Chesapeake Bay Program and Maryland Coastal Bays Program. However, from Delaware northward through Maine, the analysis of benthic communities used a lower level of taxonomic detail. For the Northeast Coast analysis of benthic conditions summarized in this chapter, the taxonomic detail included in the Chesapeake Bay and Maryland coastal bays summer 2000 surveys was aggregated to the lower level of taxonomic detail so that it would be comparable with the rest of the benthic data for the Northeast Coast.

benthic communities were sampled at stations with an average depth of 57 feet, 36 feet deeper than the average depth of stations sampled in the Mid-Atlantic estuarine waters south of Cape Cod. A calibrated benthic index for the Acadian Province is not currently available. For this report, the Shannon-Weiner H' diversity index was used to characterize benthic communities in the Acadian Province. Areas of low diversity, (Shannon-Weiner H' < 0.63) were classified as poor. This cutoff point was selected to include 75% of the sites in the Acadian Province, where one or more ERMs for either metals or organics were exceeded. Based on this criterion, 9% of the coastal waters of the Acadian Province are considered poor. Some of these areas may have low diversity due to natural causes, including areas with high exposure to wave action and coarse sediment grain size, as well as mesohaline environments (<20 ppt salinity), where lower diversity is associated with salinity stress. A benthic index that is specifically calibrated for use in the coastal waters north of Cape Cod and that makes adjustments for such habitat variables is currently being developed.

The performance of the benthic index was checked against other indicators of coastal condition (except for those stations located in Chesapeake Bay). Water quality and benthic condition were sampled from the same location for all stations. For these sites, the water quality index was good, and the benthic index was good 85% of the time. Also, when the benthic index was good, DIN was good 74% of the time, DIP was good 69% of the time, and good water clarity co-occurred 71% of the time. Dissolved oxygen showed a very strong association with benthic index: when dissolved oxygen in bottom waters fell below 2.0 mg/L, indicating poor condition, the benthic index also indicated poor condition 82% of the time. There was no statistically significant co-occurrence between chlorophyll *a* and benthic index. When the sediment condition index was poor, benthic index was poor 57% of the time. A poor rating for sediment TOC was accompanied by a poor benthic index 65% of the time, and a poor sediment contamination rating was accompanied by a poor benthic index 67% of the time. Sediment toxicity was found to vary independently of benthic index. Figure 3-16 emphasizes the high degree of co-occurrence between poor benthic condition, poor water quality, and poor sediment quality.

Additional refinements to the benthic indices may provide better discrimination between good and poor

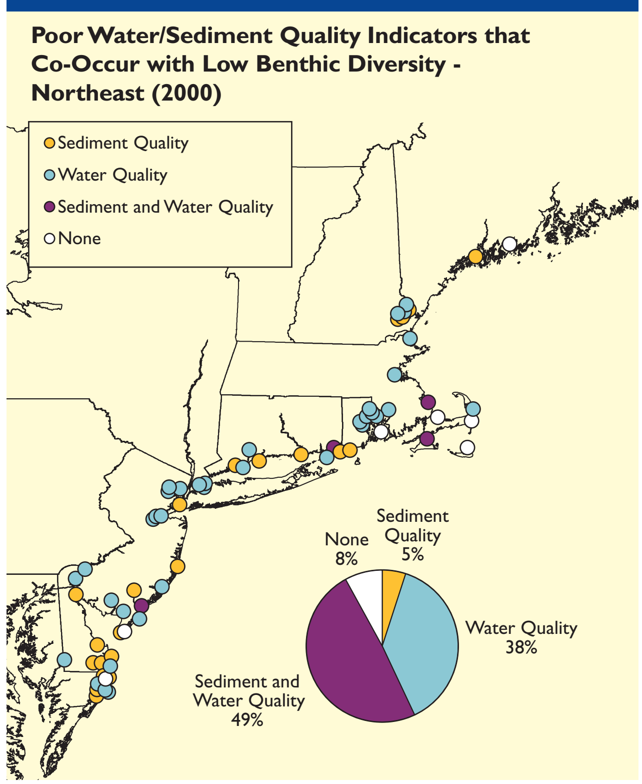


Figure 3-16. Indicators of poor water and sediment quality that co-occur with poor benthic condition in Northeast Coast estuaries (Chesapeake Bay system not included) (U.S. EPA/NCA).

conditions in specific coastal systems. Dauer et al. (2002) provides a summary of recent efforts in using benthic indices to discriminate between different sources of anthropogenic stress in Chesapeake Bay. Although benthic indices can provide important insights about the spatial extent of affected benthos, additional diagnostic work is often needed to attribute observed impacts to underlying causes.

Coastal Habitat Index

Wetlands are threatened by many human activities, including loss and destruction due to land development, eutrophication, the introduction of toxic chemicals, and the spread of non-native species. Ecologists estimate that more than one-half of the Northeast's coastal wetlands have been lost since pre-colonial times. Although modern legislation has greatly slowed the destruction, the Northeast Coast lost 650 acres between 1990 and 2000. This amounts to a loss of 0.14% over 10 years. Combining this average with the mean long-term decadal wetland loss rate from 1780 to 1990 and multiplying by 100 results in a coastal habitat index score of 1.00. This means the coastal habitat index for the Northeast Coast is rated fair to good. For more information about wetlands and threats to the region, refer to EPA's wetlands Web site, http://www.epa.gov/owow/wetlands.

Great Sippewissett Marsh, West Falmouth, Massachusetts (Edgar Kleindinst, NMFS, Woods Hole Laboratory).

Fish Tissue Contaminants Index

Estuarine condition in Northeast Coast estuaries is rated poor for concentrations of contaminants in fish tissues. Figure 3-17 shows that 31% of all sites sampled where fish were caught (48 of 156 sites) exceeded risk-based criteria guidelines used in this assessment. Whole-fish contaminant concentrations may be higher or lower than concentrations associated with fillets only. Only those contaminants that have an affinity for muscle tissue, e.g., mercury, are likely to have significantly higher concentrations in fillets than in whole fish. Concentrations for many other contaminants will be lower in fillets than in whole fish. In Northeast Coast estuaries, elevated contaminant concentrations were observed in various catfish, white perch, weakfish, lobster, flounders, scup, Atlantic tomcod, and blue crab and most often included total PCBs, total PAHs, DDT, and mercury.

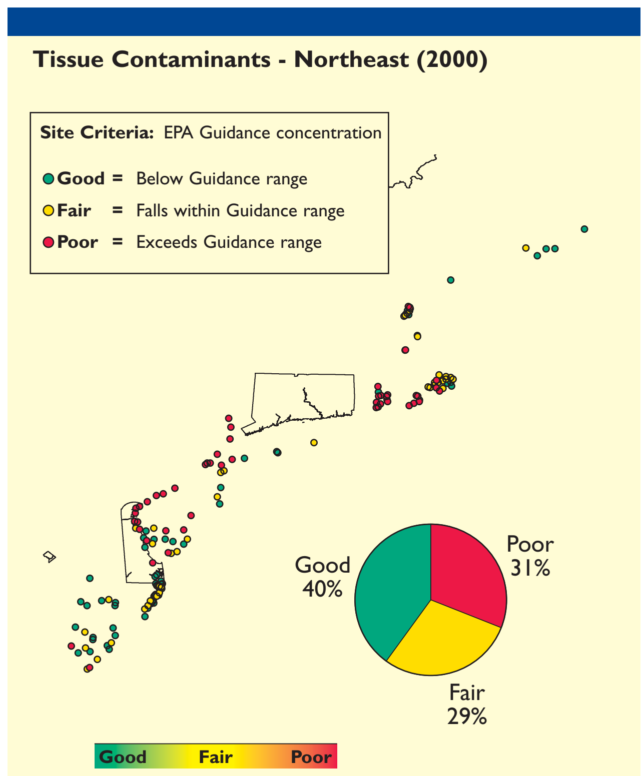
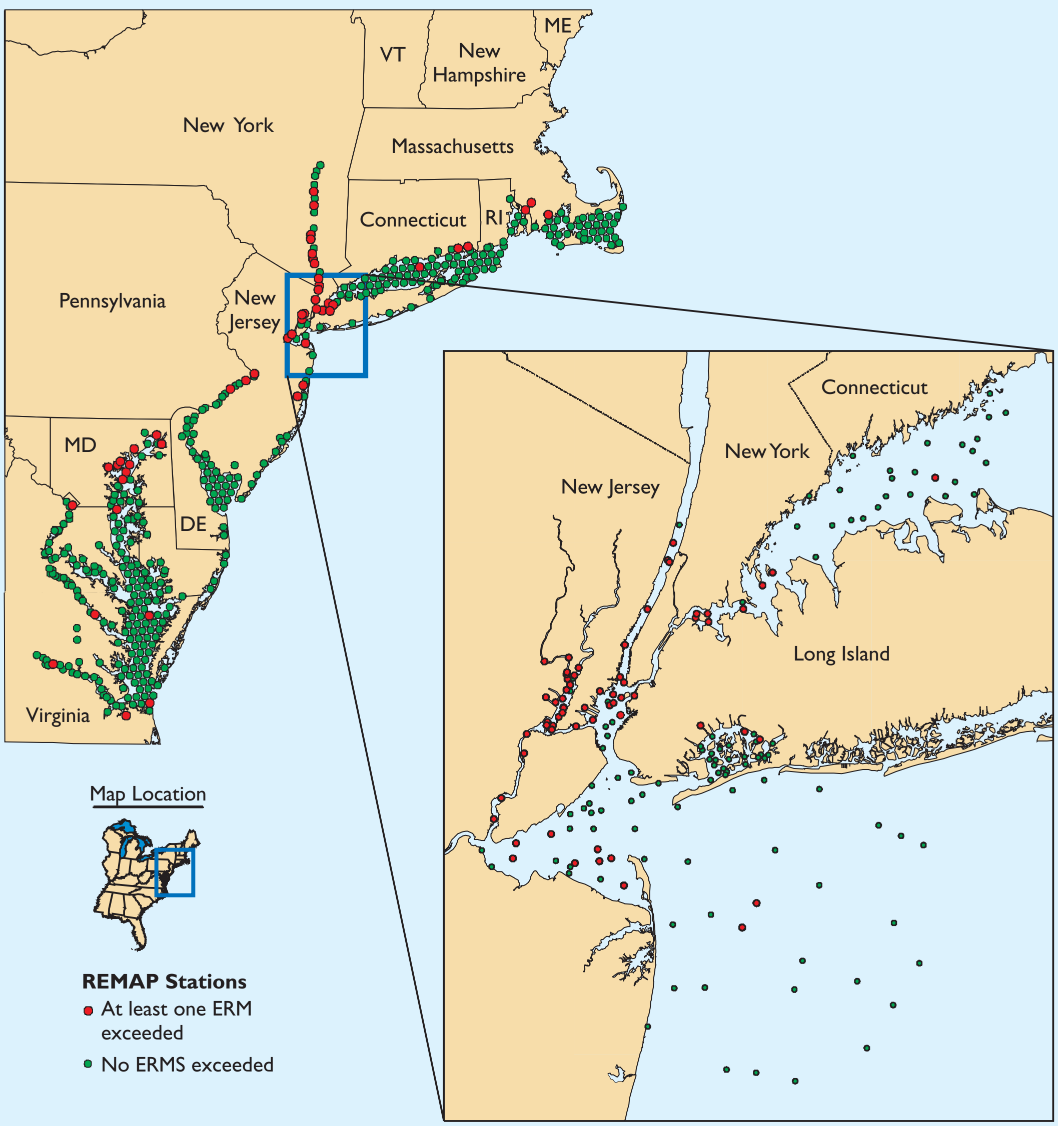


Figure 3-17. Fish tissue contaminants data for Northeast Coast estuaries (U.S. EPA/NCA).

A Case Study of Contamination Assessment in New York Harbor

One of the values of the EMAP Estuaries Program is its ability to provide broad insight about the quality of coastal waters to local managers, potentially spawning smaller, localized studies to investigate coastal conditions. For New York Harbor, results from the EMAP sampling led to a more intense Regional EMAP (REMAP) sampling, with results from these regional studies triggering a more focused sampling using the Contamination Assessment and Reduction Program (CARP). CARP is designed to identify sources of contamination in coastal waters.

EMAP 1990–1993 ERM exceedances in the Virginian Province.



1993–1994 REMAP stations in New York Harbor exceeding ERMs.

Data from EMAP–Virginia Province 1990–1993.

To managers in the New York and New Jersey areas, it was evident that sediment contamination in the New York Harbor area was a substantial problem. When examining EMAP data using ERM exceedances as one indicator of sediment contamination, New York stands out along the East Coast in its concentration of "hits." As a result of this broad-scale monitoring, the New York Harbor Estuary Program (HEP) and EPA Region 2 cooperatively developed a REMAP sampling effort, applying the probabilistic sampling approach more intensively at the local harbor scale. This monitoring plan was designed to assess contamination in the harbor, including sediment degradation and its relationship to contamination or physical properties of the sediment. The plan also examined whether this degradation is localized or widespread in New York Harbor and its sub-basins. The REMAP results showed that half of the Harbor exceeded at least one ERM criterion for contamination (Adams et al., 1998).

Using this REMAP information, the HEP coordinated CARP sampling to identify sources of contaminants and to focus on areas previously identified as contaminated with management implications of dredging activities. The goal of the HEP is to track sources of contaminants from the land, water, and air, utilizing existing state and national programs (Trackdown and Cleanup, Combined Sewer Overflow/Storm Water Abatement, Waste Site Inventory, Superfund, and the Clean Air Act) to identify possible sources, such as sewer and stormwater overflows, industrial discharges, tributary inputs, landfill leachate, accidental spills, and atmospheric deposition. Such data can be used to generate simple and complex models to identify contaminant sources, examine outcomes of clean-up efforts, support a long-term dredging monitoring plan, and make a complete assessment of the dredged material.

Large Marine Ecosystem Fisheries

The U.S. Northeast Shelf is one of the world's most productive LMEs. The most visible natural resource capital of the Northeast Shelf LME is its rich biodiversity of fish, plankton, crustacean, mollusk, bird, and mammal species. The coastal states from Maine to North Carolina currently receive $1 billion of economic benefits annually from the fisheries of the ecosystem. Management efforts are under way to rebuild the depleted condition of cod, haddock, flounder, and other fish stocks to recover the economic potential of these species.

The coastal zone draining into the Northeast Shelf LME has an area of approximately 193,050 square miles. Preliminary estimates suggest that about 7 billion gallons per day of wastewater flow into the system from municipal and industrial treatment facilities. The nitrate and phosphate loadings in several estuaries and embayments have exceeded the present "natural" capacity of the ecosystem to adequately recycle the nutrients, resulting in significant overproduction of phytoplankton and contributing to the increasing frequency and extent of HABs in near-coastal waters. Controlling the amount of nutrient loadings and adequately treating wastewater will reduce the threat of coastal eutrophication.

With appropriate management practices, the ecosystem should provide the necessary capital in natural productivity for full recovery of depleted fish stocks. Previously, severe declines in mackerel and herring populations due to overexploitation were reversed by limiting the fishery for these species through licensing and other restrictions on foreign fishing.

Fishermen maintaining gear on the dock, Gloucester, Massachusetts (Nance S. Trueworthy).

Demersal Fisheries

Northeast Shelf LME demersal (groundfish) fisheries include about 35 species and stocks in waters off New England and the Mid-Atlantic states. In the New England subsystem, the groundfish complex is dominated by members of the cod family (e.g., cod, haddock, hakes, and pollock), flounders, goosefish, dogfish sharks, and skates. In the Mid-Atlantic subsystem, groundfish fisheries include mainly summer flounder, scup, goosefish, and black sea bass.

Groundfish resources of the Northeast Shelf LME occur in mixed-species aggregations, resulting in significant bycatch interactions among fisheries directed to particular target species or species groups. Management is complex because of these interactions. This complexity is reflected, for example, in the use of different mesh, gear, minimum landing sizes, and seasonal closure regulations set by the various management bodies in the region (e.g., New England Fishery Management Council [NEFMC], Mid-Atlantic Fishery Management Council [MAFMC], Atlantic States Marine Fisheries Commission [ASMFC], individual states, and the Canadian government). New England groundfish (14 species) are managed primarily under the *Northeast Multispecies Fishery Management Plan,* as well as peripherally under provisions of the ASMFC's *Northern Shrimp Fishery Management Plan*. Summer flounder, scup, and black sea bass are managed under a joint ASMFC–MAFMC fishery management plan (FMP), and weakfish are managed under an ASMFC FMP. Demersal fisheries in New England were traditionally managed primarily by indirect methods, such as regulating fishing gear mesh sizes, imposing minimum fish lengths, and closing some areas. The principal regulatory measures currently in place for the major New England groundfish stocks are limits on allowable days at sea for fishing, along with closure of certain areas, trip limits (for cod and haddock), and targets for total allowable catch that correspond to target fishing mortality rates. The *Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan* includes provisions for catch quotas aimed at restoring these stocks.

Extensive historical data for the Northeast Shelf LME demersal fisheries have been derived from both fishery-dependent (i.e., catch and effort monitoring) and fishery-independent (e.g., NOAA research vessel) sampling programs since 1963. The boundaries of the Northeast Shelf LME are depicted in Figure 3-18. Since 1989, a sea-sampling program has been conducted aboard commercial fishing vessels to document vessel discard rates and to collect high-quality, high-resolution data on their catch. Despite the past management record, some of the Northeast Shelf LME demersal stocks (e.g., cod, yellowtail flounder, haddock, American plaice, and summer flounder) are among the best understood and assessed fishery resources in the country.

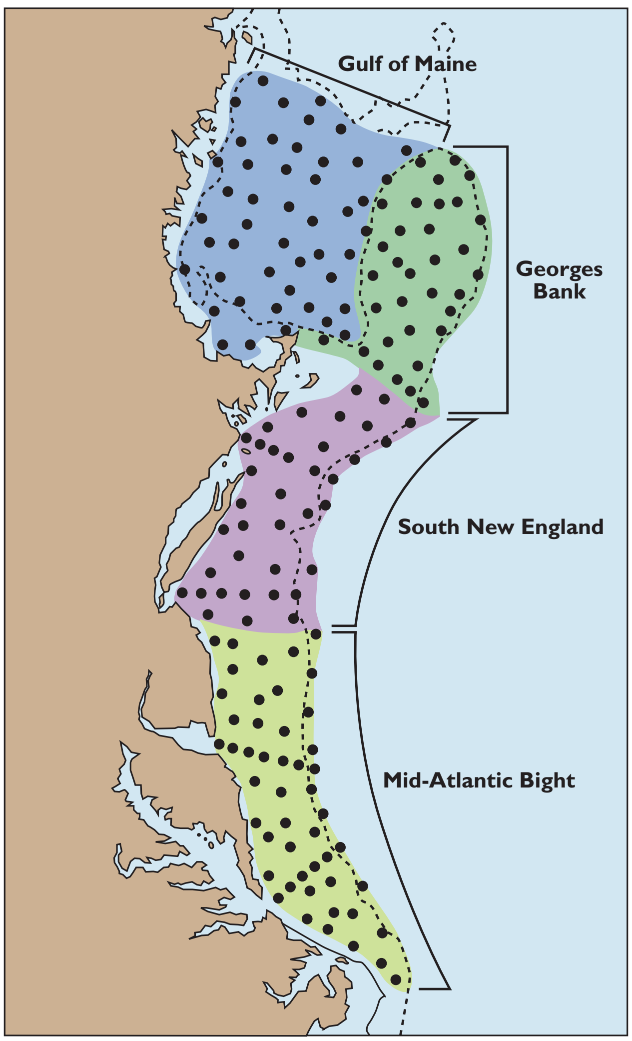


Figure 3-18. Northeast Shelf LME subareas and sampling locations (Sherman et al., 2003).

Principal Groundfish and Flounders

The principal groundfish and flounders group includes important species in the cod family (e.g., Atlantic cod, haddock, silver hake, red hake, and pollock), flounders (e.g., yellowtail, summer, winter, witch, windowpane, and American plaice), and redfish. Recent annual landings of these 12 species (representing 19 stocks) have averaged 81,000 mt (69% U.S. commercial, 21% Canadian, and 10% U.S. recreational landings), compared with a combined long-term potential yield of 247,000 mt (Figure 3-19). Total revenue to fishers from the principal U.S. groundfish and flounder commercial landings in 2000 was $121 million, compared with $109 million in 1997. The Northeast groundfish complex supports important recreational fisheries for species, including summer flounder, Atlantic cod, winter flounder, and pollock.

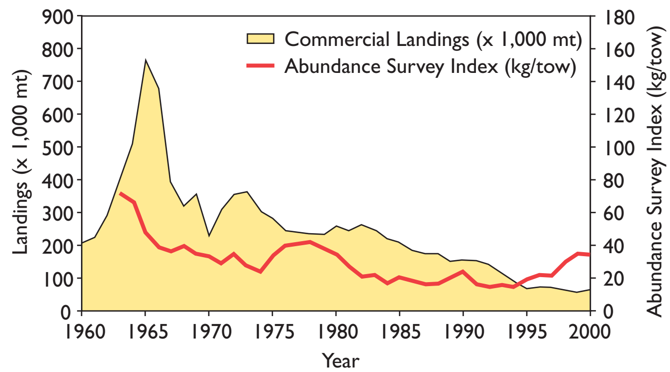


Figure 3-19. Landings in metric tons (mt) and abundance index of principal groundfish and flounders, 1960–2000 (NMFS, 2003).

The abundance index for this group of species declined by almost 70% between 1963 and 1974, reflecting substantial increases in exploitation associated with the advent of distant-water fleets. Many stocks in this group declined sharply, notably Georges Bank haddock, most silver and red hake stocks, and most flatfish stocks. By 1974, indices of abundance for many of these species had dropped to the lowest-ever recorded levels.

Groundfish partially recovered during the mid-to-late 1970s because of reduced fishing efforts associated with increasingly restrictive management. Cod and haddock abundance increased markedly, stock biomass of pollock increased more or less continually, and recruitment and abundance also increased for several flatfish stocks.

The abundance index peaked in 1978, but subsequently declined, and fell to new lows in 1987 and 1988. The abundance index for the principal groundfish and flounders fell to a 30-year low in 1992, but has subsequently more than doubled since that year (Figure 3-19). The most recent changes in the aggregate index are due primarily to substantial increases (since 1996) in the biomass index for redfish in the Gulf of Maine subarea (Northeast Fisheries Science Center, 2001a), but also reflect increased biomasses of haddock and yellowtail flounder in the Georges Bank subarea (Northeast Fisheries Science Center, 2001b).

Landings of most groundfish species declined substantially during the mid-1990s. For many stocks, landings continue to remain relatively low because of generally poor recruitment and despite continued restrictions on days at sea, low trip limits, and additional area closures in the Gulf of Maine. However, for some stocks, including Georges Bank yellowtail flounder and haddock, strong year-classes appearing in 1997 and 1998, respectively, combined with sharp reductions in fishing mortality, led to improved stock conditions (Northeast Fisheries Science Center, 2001b) and resulted in increased landings during 1999 and 2000.

Management Concerns

During most of the 1980s and early 1990s, New England Shelf ecosystem groundfish harvests were regulated by indirect controls on fishing mortality, such as mesh and fish size restrictions, and some area closures. Since 1994, these controls have been more stringent and focused. Amendment 5 to the NEFMC's *Multispecies Fishery Management Plan*, implemented in March 1994, marked the beginning of an effort-reduction program to address the requirement to eliminate the overfished conditions of cod, haddock, and yellowtail flounder. The regulatory package included a moratorium on new vessel entrants, a schedule to reduce the number of days at sea for trawl and gill net vessels, increases in regulated mesh size, and expanded closed areas to protect haddock. Since December 1994, three large areas have also been closed to protect the regulated groundfish stocks; these include Closed Areas I and II on Georges Bank and the Nantucket Lightship Closed Area.

A groundfish vessel buyout program was initiated in 1995, first as a pilot project and later as a comprehensive fishing capacity-reduction project. The program was designed to provide economic assistance to fishermen adversely affected by the collapse of the groundfish fishery and who voluntarily chose to remove their vessels permanently from the fishery. This reduction in vessels helps fish stocks recover to a sustainable level by reducing the excess fishing capacity in the Northeast Shelf LME. The vessel buyout program, which concluded in 1998, removed 79 fishing vessels at a cost of nearly $25 million and resulted in an approximate 20% reduction in fishing effort in the Northeast Shelf LME groundfish fishery.

This flounder is one of several flatfish species found on the Stellwagen Bank and in the basin. Development of juveniles occurs primarily within sheltered bays and estuarine areas (Dann Blackwood and Page Valentine, USGS).

Pelagic Fisheries

The Northeast Shelf LME pelagic fisheries are dominated by four species: Atlantic mackerel, Atlantic herring, bluefish, and butterfish. Mackerel, herring, and butterfish are considered to be underutilized, and bluefish are considered to be overutilized. The abundance of mackerel, herring, and butterfish is presently above average, whereas that of bluefish is below average.

The long-term population trends for mackerel and herring, as measured by research vessel survey data, have fluctuated considerably during the last 25 years (Figure 3-20). The combined abundance index for these two species reached minimal levels in the mid- to late 1970s, reflecting pronounced declines for both species and a collapse of the Georges Bank herring stock, but the index subsequently increased steadily and peaked in 1999.

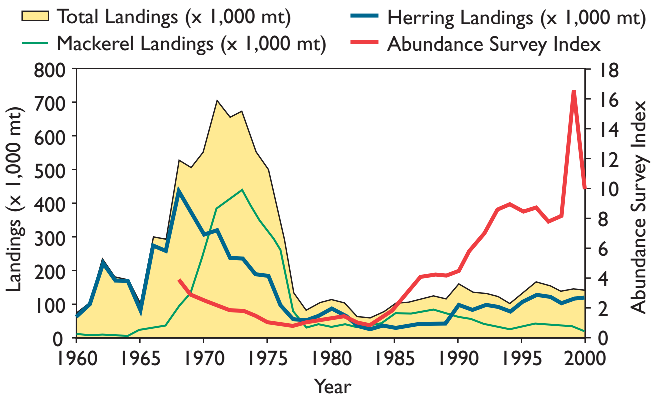
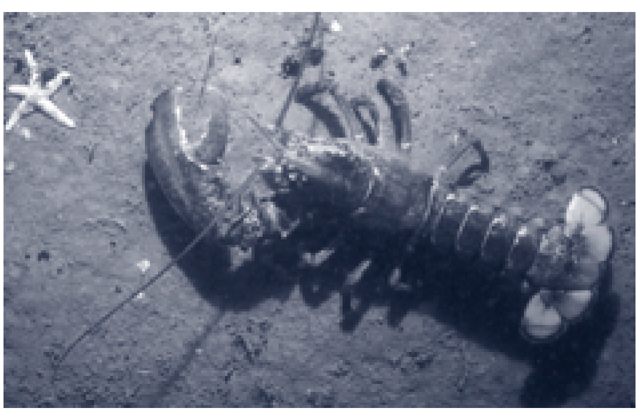


Figure 3-20. Landings in metric tons (mt) and abundance index of principal pelagic fish stocks, 1960–2000 (NMFS, 2003).

Although historical catch data (except perhaps for bluefish) are generally adequate for assessment purposes, stock assessments for the Northeast Shelf LME pelagic resources are relatively imprecise, owing to the highly variable trawl survey indices of abundance used for calibrating cohort analysis models, the short life span of some stocks (butterfish), and the current low exploitation rates of some species (mackerel and herring). The development of more precise assessments will require the use of hydroacoustic and mid-water trawl surveys to estimate herring and mackerel abundance, as well as alternative types of sampling surveys to estimate bluefish abundance. In 1997, autumn hydroacoustic surveys were implemented to improve stock assessments for Atlantic herring by indexing spawning concentrations. Research is under way to estimate the size of herring spawning groups directly from these surveys and to combine these estimates with data from traditional catch-at-age methods.



The American lobster (*Homarus americanus*) finds homes in rock piles or digs holes in muddy places. Its claws, used for catching and crushing prey, can be regenerated if lost, as in the case here. Lobsters come in a variety of colors, including mottled reddish brown, white, and blue (Dann Blackwood and Page Valentine, USGS, Woods Hole, Massachusetts).

Northeast Shelf Ecosystem Invertebrate Fisheries

Offshore fisheries for crustacean and molluscan invertebrates are among the most valuable fisheries of the Northeast Shelf LME. In 2000, U.S. commercial landings of American lobster (38,300 mt) and sea scallops (14,500 mt of shucked meats) ranked first and second in overall ex-vessel value ($304 million and $165 million, respectively). Landings of surf clams, ocean quahogs, squids, and northern shrimp contributed another roughly $100 million in revenue. Revenues from these invertebrate fisheries exceeded those for all Northeast Shelf LME finfish fisheries combined.

American Lobster

A recent assessment of American lobster stocks (ASMFC, 2000) indicated that fishing mortality rates for lobster in the Gulf of Maine were double the overfishing level. For the inshore resource distributed from southern Cape Cod through Long Island Sound and for the offshore stock on Georges Bank, fishing mortality substantially exceeded the overfishing level. Throughout its range, the lobster fishery has become increasingly dependent on newly recruited animals, and commercial catch rates have markedly declined in heavily fished nearshore areas. In some locations, more than 90% of the lobsters landed are new recruits to the fishery, almost all of which are juveniles (i.e., not yet sexually mature). Fishing mortality rates for both inshore and offshore stocks presently far exceed the levels needed to produce maximum yields. Lobster landings during 1998–2000 averaged 38,100 mt, with a record-high catch of 39,700 mt in 1999 (Figure 3-21). Despite overfishing, lobster abundance has remained high due to favorable environmental conditions for lobster reproduction and recruitment.

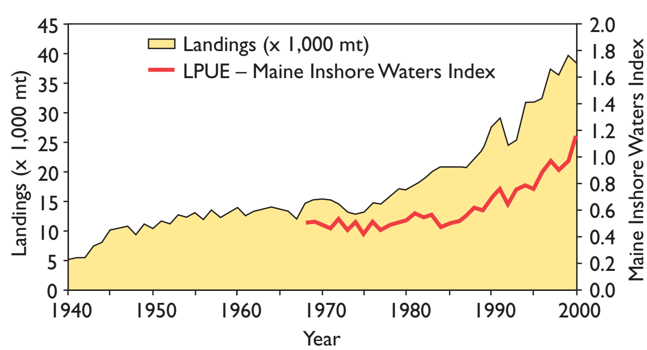


Figure 3-21. Landings of American lobster in the northeastern United States, 1940–2000, in metric tons (mt). The index shows the average number of legal-sized lobsters caught per trap averaged over a 24-hour period in Maine inshore waters (NMFS, 2003). (LPUE = landings per unit effort)

Sea Scallops

Sea scallops are harvested in the United States in the Northeast Shelf LME from Cape Hatteras, North Carolina, to the U.S./Canadian border on Georges Bank and in the Gulf of Maine. Dredges are the principal harvesting gear, although otter trawls take a small proportion of the landings (Serchuk and Murawski, 1997).

Management of the sea scallop fishery changed markedly in 1994, when—to address overfishing—management measures affecting the number of days at sea, vessel crew size, and dredge-ring size were implemented. Since December 1994, the harvesting of sea scallops in two areas on Georges Bank and one area on Nantucket Shoals (closed to protect depressed groundfish stocks) has been prohibited, except under highly controlled, limited area-access provisions. In April 1998, two areas in the Mid-Atlantic subarea were also closed (for 3 years) to scallop fishing to protect large numbers of juvenile scallops.

A recent stock assessment (Northeast Fisheries Science Center, 2001b) indicated that sea scallop biomass in the closed areas increased dramatically between 1994 and 2000. Smaller but substantial increases also occurred in areas open to fishing as a result of reduced fishing effort and good reproductive success. Increases in stock biomass generated large increases in U.S. scallop landings in both 1999 and 2000 (Figure 3-22).

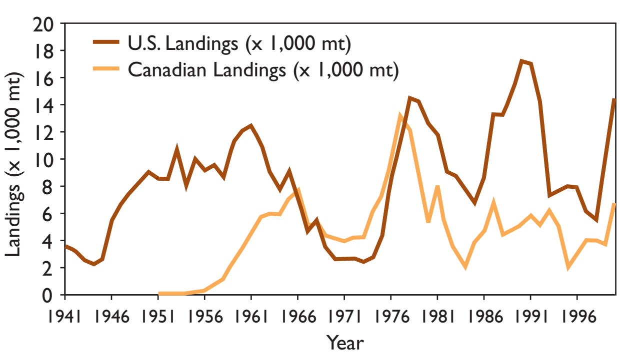


Figure 3-22. Landings of Atlantic sea scallop in the United States and Canada, 1940–2000, by metric tons (mt).

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

The states on the Northeast Coast assessed 10,582 (85%) of their 12,451 estuarine square miles for their 2000 305(b) reports. They used state-specific criteria, which may differ from those used in the NCA analysis, and found that 49% of the assessed estuarine waters fully support their designated uses, 8% are threatened for one or more uses, and the remaining 43% are impaired by some form of pollution or habitat degradation (Figure 3-23). Individual use support for estuaries is shown in Figure 3-24.

In 2000, Northeast Coast states assessed 404 (5%) of their 7,716 shoreline miles. Ninety-two percent of the assessed shoreline waters fully support their designated

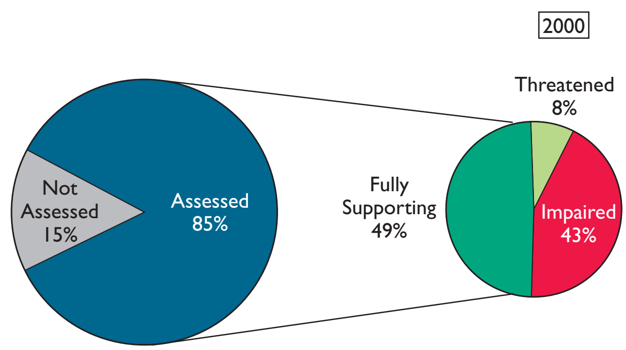


Figure 3-23. Water quality in assessed Northeast Coast estuaries (U.S. EPA, 2002).

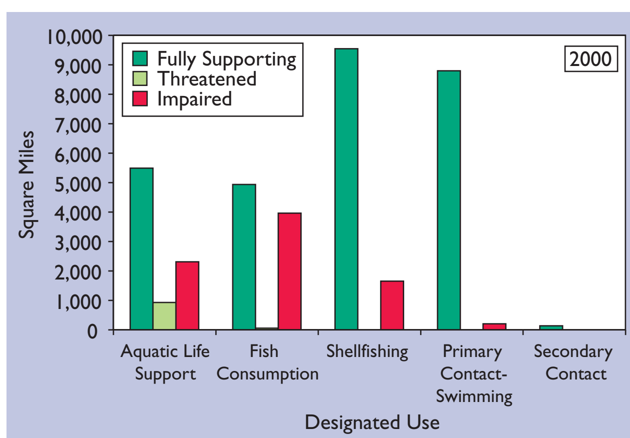


Figure 3-24. Individual use support in assessed Northeast Coast estuaries (U.S. EPA, 2002).

uses, and no uses are reported as threatened; however, 8% are impaired by some form of pollution or habitat degradation (Figure 3-25). Individual use support for Northeast Coast shoreline waters is shown in Figure 3-26 and listed in Table 3-2.

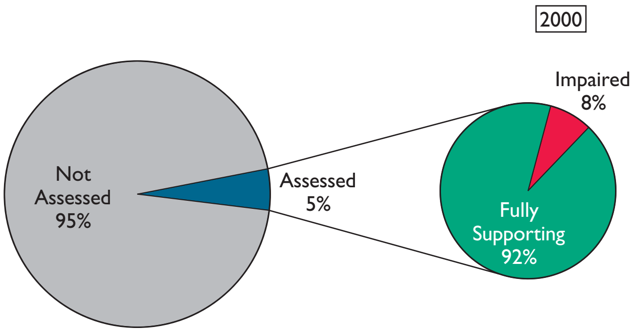


Figure 3-25. Water quality in assessed shoreline waters of the Northeast Coast (U.S. EPA, 2002).

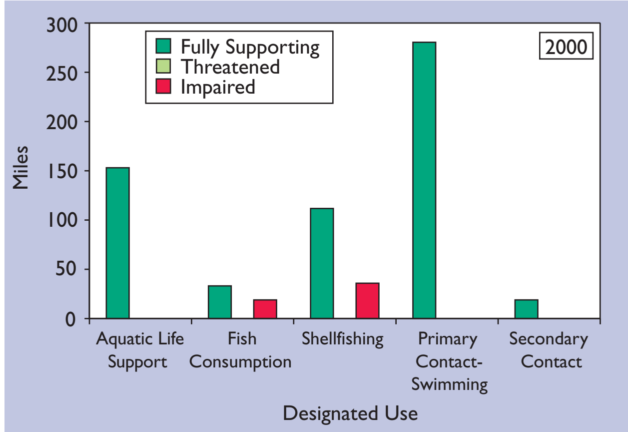


Figure 3-26. Individual use support for assessed shoreline waters of the Northeast Coast (U.S. EPA, 2002).

Table 3-2. Individual Use Support for Assessed Shoreline Waters Reported by the Northeast Coast States under Section 305(b) of the Clean Water Act (U.S. EPA, 2002).

Individual Uses	Assessed Estuaries Impaired (mi^2) and Percentage of Total Area Assessed for the Individual Use	Assessed Shoreline Impaired (mi) and Percentage of Total Area Assessed for the Individual Use
Aquatic life support	2,335 (27%)	0
Fish consumption	3,950 (38%)	18 (36%)
Shellfishing	1,665 (15%)	35 (24%)
Primary contact – swimming	221 (3%)	0
Secondary contact	10 (7%)	0

Replanting marsh grass in an effort to protect and rebuild this beach near Annapolis, Maryland (Mary Hollinger, NODC biologist, NOAA).

Fish Consumption Advisories

In 2002, 7 of the 10 Northeast Coast states (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, and Rhode Island) had statewide consumption advisories for fish in coastal waters, placing nearly all of their coastal and estuarine areas under advisory. Due in large part to these statewide advisories, an estimated 81% of the coastal miles of the Northeast Coast and 56% of the estuarine area were under fish consumption advisories. A total of 33 different advisories were active in 2002 for the estuarine and coastal waters of the Northeast Coast (Figure 3-27).

Advisories in the Northeast Coast were in effect for 10 different pollutants (Figure 3-28). Most of the listings (94%) were, at least in part, caused by PCBs. Boston Harbor was listed for multiple pollutants.

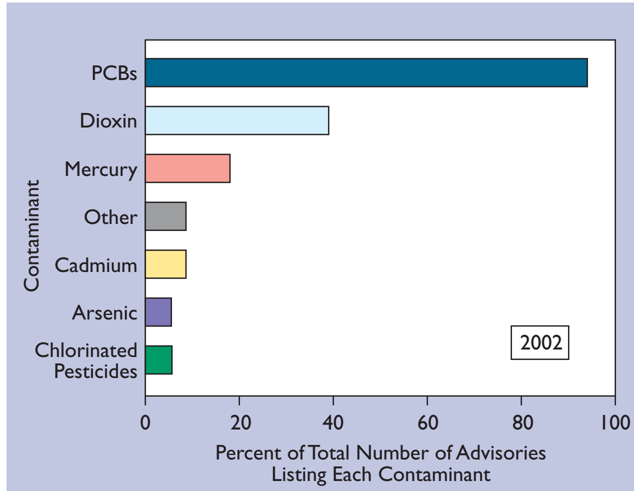


Figure 3-28. Pollutants responsible for fish consumption advisories in northeastern coastal waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2003c).

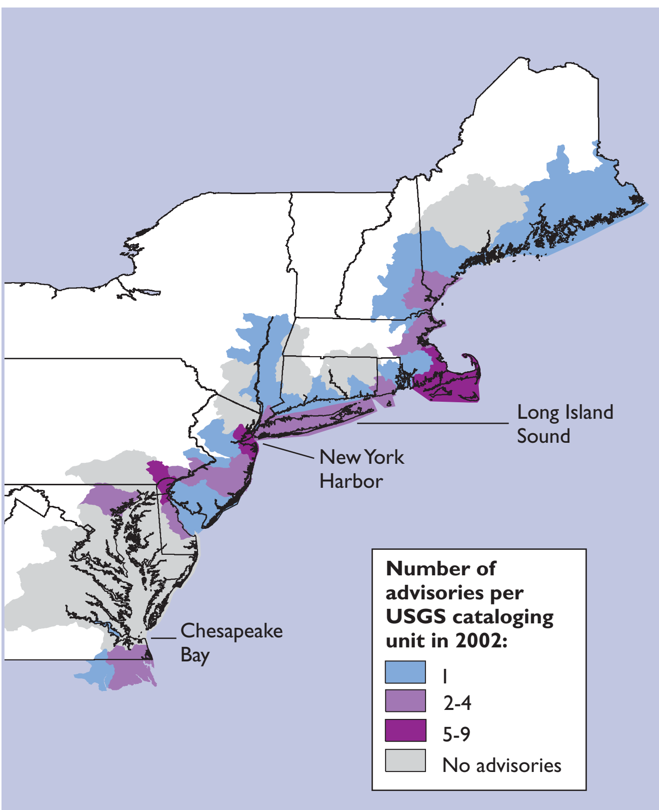


Figure 3-27. The number of fish consumption advisories for the Northeast Coast active in 2002 (U.S. EPA, 2003c).

These species were under advisory in 2002 for at least some part of the Northeast Coast:

American eel	Scup
Bluefish	Striped bass
Brown bullhead	Tilefish
Flounder	White catfish
Lobster	Bivalves
Rainbow smelt	Blue crab (hepatopancreas)
Smallmouth bass	Common carp
Tautog	Largemouth bass
Walleye	Northern hogsucker
Atlantic needlefish	Shark
Blue crab	Swordfish
Channel catfish	Tuna
King mackerel	White perch
Lobster (tomalley)	

Source: U.S. EPA, 2003c

Filleting the day's catch. Patuxent River, Maryland (Mary Hollinger, NESDIS/NODC biologist, NOAA).

Beach Advisories and Closures

Of the 826 coastal beaches in the Northeast Coast that reported information to EPA, only 18% (151 beaches) were closed or under advisory for any period of time in 2002. The states with the highest percentage of beaches with advisories/closures were Maryland and New York, where 33% of 12 beaches and 31% of 199 beaches, respectively, indicated that they were closed at least once in 2002. Table 3-3 presents the number of beaches and advisories/closures for each state. Figure 3-29 shows the percentage of beaches in each county that had at least one advisory or closure in 2002. Only two states in the region (New Hampshire and Virginia) did not have any coastal beach closings in 2002. All of the beaches in the Northeast Coast that reported information have monitoring programs.

The primary reasons why beach advisories and closures were implemented at coastal beaches in the Northeast were elevated bacteria levels or preemptive closures associated with rainfall events or sewage-related problems. Most beaches had multiple sources of water-borne bacteria that resulted in advisories or closures (Figure 3-30). Stormwater runoff and wildlife were most frequently identified as sources, and unknown sources accounted for 28% of the response (Figure 3-31).

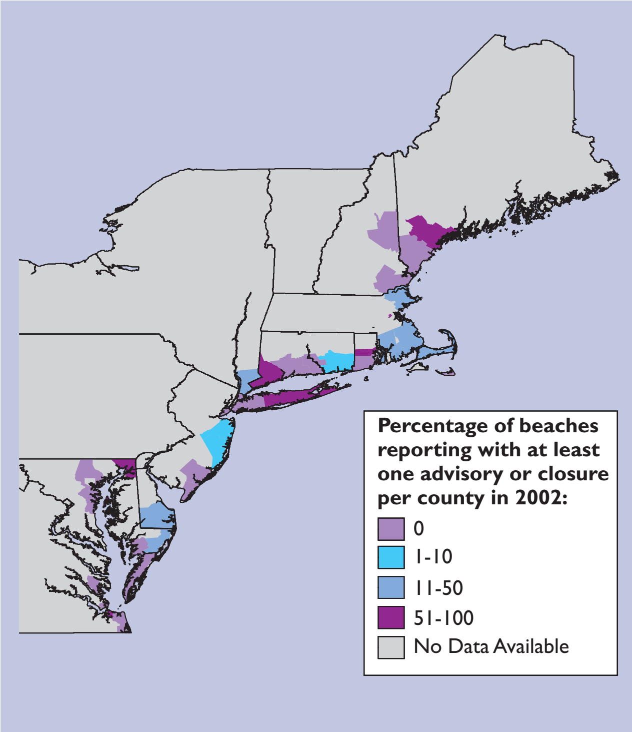


Figure 3-29. Percentage of beaches with advisory or closures by county for the Northeast Coast (U.S. EPA, 2003a).

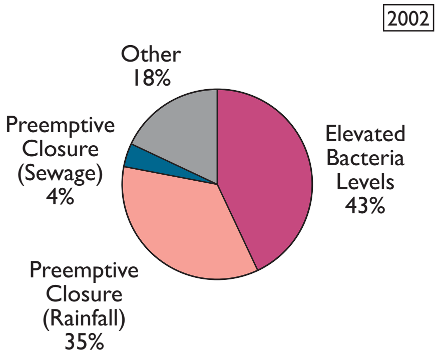


Figure 3-30. Reasons for beach advisories or closures for the Northeast Coast (U.S. EPA, 2003a).

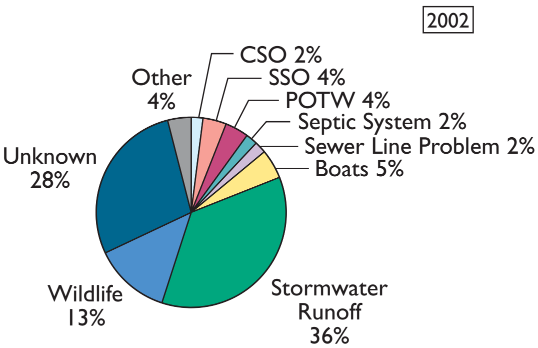


Figure 3-31. Sources of beach contamination for the Northeast Coast (U.S. EPA, 2003a).

Table 3-3. Number of Beaches and Advisories/Closures in 2002 for Northeast Coast States (U.S. EPA, 2003a)

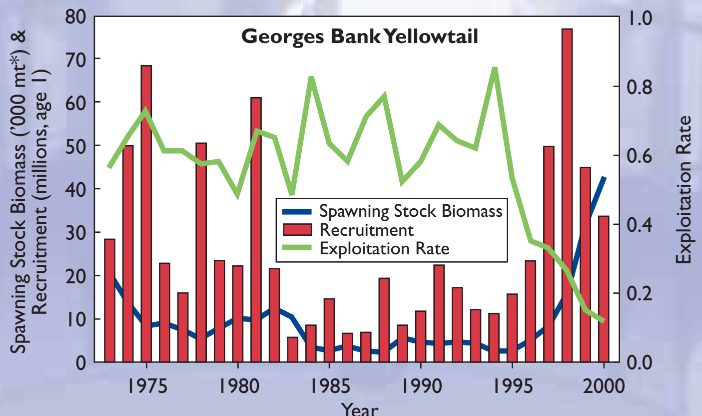
State	No. of Beaches	No. of Advisories/ Closures	Percentage of Beaches Affected by Advisories/ Closures
Maine	7	1	14.3%
New Hampshire	13	0	0.0%
Massachusetts	199	45	22.6%
Rhode Island	74	8	10.8%
Connecticut	70	18	25.7%
New York	199	62	31.2%
New Jersey	228	10	4.4%
Delaware	15	3	20.0%
Maryland	12	4	33.3%
Virginia	9	0	0.0%
TOTALS	826	151	18.3%

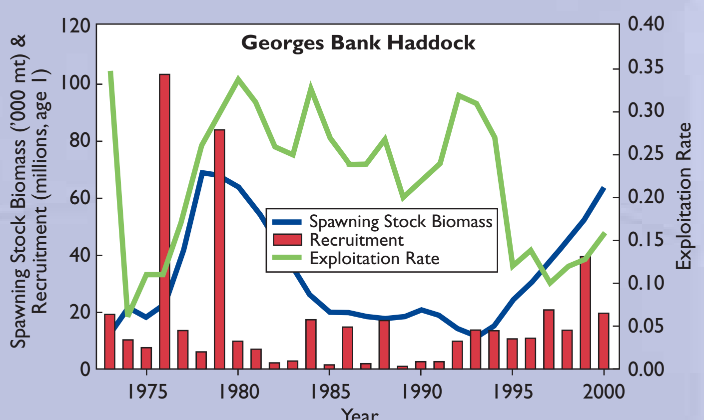
highlight

Recovery from Biomass Depletion in Large Marine Ecosystems

Multi-year time series measurements of the plankton in two LMEs have shown that phytoplankton and zooplankton populations are in good condition, indicative of a stable and highly productive food-web base. The robust condition of plankton enhances conditions for reversing the declines in biomass of demersal fish that have occurred over the last several decades. Since 1994, mandated reductions in fishing effort led to increases in the spawning stock biomass (SSB) levels of haddock, yellowtail flounder, and other species in the Northeast Shelf ecosystem.

Following the cessation of foreign fishing on herring and mackerel stocks in the late 1970s and a decade of very low fishing mortality, both species began to recover to high stock sizes in the 1990s. Bottom trawl survey indices for both species increased dramatically, showing more than a 10-fold increase in abundance (1977–1981 vs. 1995–1999 averages) by the late 1990s. Stock biomass of herring increased to more than 2.5 million mt by 1997. The total stock biomass of mackerel has also continued to increase since the closure of the foreign fishery in the late 1970s. Although absolute estimates of biomass for the late 1990s are not available, recent analyses place the stock at or near a historic high in total biomass and SSB. Additionally, recent evidence indicates that both haddock and yellowtail flounder stocks are responding favorably to catch reductions, with substantial growth reported in SSB size since 1994 for haddock and flounder. In 1998, a very strong year-class of yellowtail flounder was produced, and in 1999, a strong year-class of haddock was produced, as shown in the figures to the right.





*mt - metric tons

Source: Sherman et al., 2003.

At the base of the food web, primary productivity provides an input of carbon that supports important marine commercial fisheries. Zooplankton production and biomass provide the prey-resource for larval stages of fish and the principal food source for herring and mackerel in waters of the Northeast Shelf ecosystem. During the past 20 years, the long-term median value for the zooplankton biomass of the Northeast Shelf ecosystem has been about 29 cubic centimeters of zooplankton per 100 m^3 of water, produced from a stable mean-annual primary productivity of 350 grams of carbon per square meter per year (gCm^2yr). During the last two decades, the zooplanktivorous herring and mackerel stocks underwent unprecedented levels of growth, approaching an historic high combined biomass. This growth took place during the same period that the fishery management councils for the New England and Mid-Atlantic areas sharply curtailed fishing effort on haddock and yellowtail flounder stocks. Given the observed robust levels of primary productivity and zooplankton biomass, it appears that the carrying capacity of zooplankton is sufficient to sustain the strong year-classes reported for yellowtail flounder (1998) and haddock (1999).

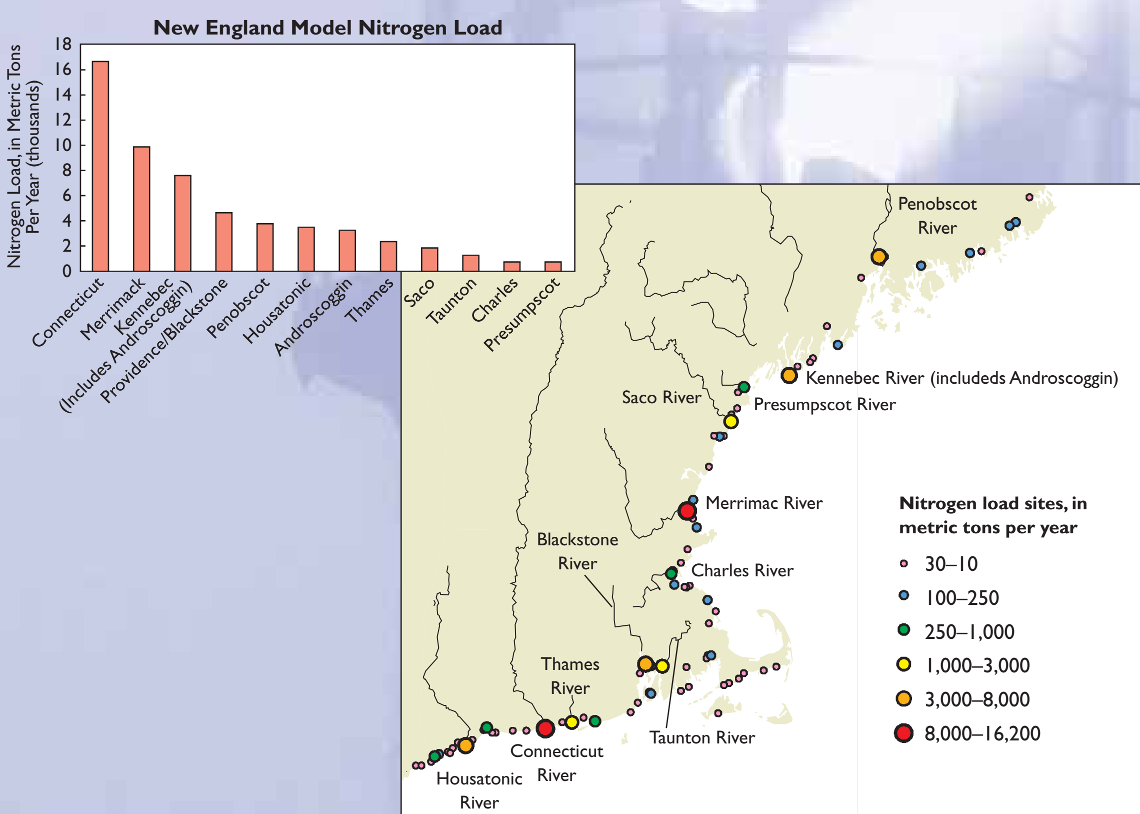
An undulating oceanographic recorder, towed behind a ship, is used to collect ecological parameters needed to assess the state of the marine ecosystem (Jerome Prezioso, NOAA NMFS).

The zooplankton component of the Northeast Shelf ecosystem is in a robust condition, with biomass levels at or above the levels of the long-term median values of the past two decades. This supplies a suitable prey base for supporting a large biomass of pelagic fish (herring and mackerel), and provides sufficient zooplankton prey to support strong year-classes of recovering haddock and yellowtail flounder stocks. The Northeast Shelf ecosystem is in relatively stable oceanographic condition. No evidence has been found in the fish, zooplankton, temperature, or chlorophyll components that indicates any large-scale oceanographic regime shifts of the magnitude reported for the North Pacific or northeast Atlantic Ocean areas.

For more information, contact Ken Sherman at kenneth.sherman@noaa.gov.

Predicted Nitrogen and Phosphorus Loads to the New England Coast using SPARROW Model

In the 1980s and 1990s, the USGS developed SPARROW models to assist in performing national and regional water quality assessments (Smith et al., 1993 and 1997). SPARROW, which refers to Spatially Referenced Regressions on Watershed Attributes, uses regression equations to relate measures of water quality condition to pollution sources and watershed characteristics. These relations are then used to provide estimates of water quality fluxes at unmonitored waters. In 2004, New England SPARROW models were completed by the USGS, in cooperation with EPA and the New England Interstate Water Pollution Control Commission (NEIWPCC). The models provide nutrient (total nitrogen [TN] and total phosphorus [TP] flux estimates for nearly 42,000 stream reaches throughout the region (Moore et. al., 2004). The models were calibrated using nutrient measurements at nearly 70 sites where the USGS and other agencies measure water quality conditions.



Nitrogen loadings from New England watersheds to coastal waters as predicted by the New England SPARROW model (Moore et al., 2004).

The New England SPARROW models have r^2 values of 0.95 for the TN model and 0.94 for the TP model. Significant predictors of TN include atmospheric deposition, developed (urban and suburban) land area, agricultural land area, and discharges from municipal wastewater-treatment facilities. Significant predictors of TP include agricultural land area, developed land area, forested land area, and discharges from municipal wastewater-treatment and pulp and paper facilities.

Development of a New England SPARROW model is being used to enhance the ability of EPA Region 1 to meet requirements under the Clean Water Act, including development of TMDL studies for waters impaired by pollutants and development of nutrient criteria. The New England SPARROW model will provide the following information:

- Estimated mean annual loadings of TN and TP in all 42,000 New England stream segments for the mid-1990s time period
- Estimated TN and TP loadings contributed by pollutant sources in each stream segment
- Estimated TN and TP loadings from individual stream segments to downstream stream TN and TP loadings within watersheds and to coastal waters
- Information on the impact of nutrient-sources (e.g., wastewater treatment facilities; forested, urban, suburban, and agricultural lands), and watershed characteristics (e.g., presence of reservoirs and lakes, and stream-flow velocities) on pollutant loads
- Estimates of TN and TP fluxes to New England coastal waters for use in assessment of coastal conditions as part of the ongoing NCA Program.

Additional information on SPARROW models nationally is available at http://water.usgs.gov/nawqa/sparrow/index.html, and the New England SPARROW Report can be obtained at http://water.usgs.gov/pubs/sir/2004/5012/.

Virginia Seaside Heritage Program

Blue-eyed bay scallop.

Virginia's Eastern Shore—a vast system of barrier islands, bays, and salt marshes—is a global treasure designated by the United Nations (UN) as a Man and the Biosphere Reserve. The intertidal and shallow subtidal areas, undeveloped beaches, and marshes support an incredible array of waterfowl and shorebirds. These habitats also serve as breeding, nursery, and foraging sites for finfish and shellfish, which are of tremendous economic value to commercial and recreational fishermen.

In the 1800s, this barrier island lagoon system was a mecca for hunting, fishing, and recreation for people from Washington, DC, to New York. Finfish and shellfish harvests provided income to thousands of Virginians. Unfortunately, seafood harvests of all types and shorebird populations declined dramatically beginning in the late 1800s due to over-harvesting, disease, the environment, and loss of habitat. Destructive hurricanes and storms also hit Virginia's seaside in the 1880s, 1890s, and early 1900s, and bird populations have declined steadily due to hunting, predation, and habitat loss. Sadly, despite strong conservation efforts over the last few decades, there has not been a great resurgence of seagrasses, oysters, scallops, finfish, and birds.

The Virginia Seaside Heritage Program (VSHP), a new public-private partnership initiated by the VCP and its partners, is an ambitious 3-year program (2002–2004) aimed at restoration, use-conflict resolution, and protection of the aquatic resources of the seaside. The VSHP will build on the momentum of recent restoration success and develop the tools necessary to support long-term restoration and management strategies for the seaside. This area holds tremendous potential to demonstrate appropriate management of economic development and habitat restoration within a rare and fragile ecosystem.

This 3-year program has four elements:

- Development of a comprehensive seaside inventory of natural resources and human use patterns that will form the basis for long-term restoration and management strategies
- Restoration of seagrass acreage, scallop beds, oyster reefs, marshes, and shorebird habitats
- Development of management tools, such as a use-suitability model, improved enforcement capabilities, and public education efforts.
- Development of sustainable ecotourism opportunities through construction or enhancement of public access sites, creation of a canoe/kayak water trail and map, and an ecotour guide certification course.

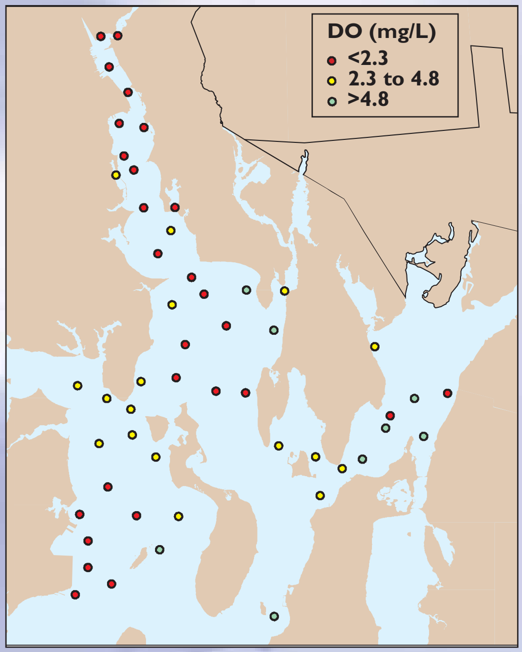
For more information about this project, please contact Laura McKay, VCP Manager, at (804) 698-4323 or lbmckay@deq.state.va.us. Please also visit the VSHP Web site at http://www.deq.state.va.us/coastal/vshpweb/homepage.html.

Use of a Hybrid Monitoring Design in Rhode Island

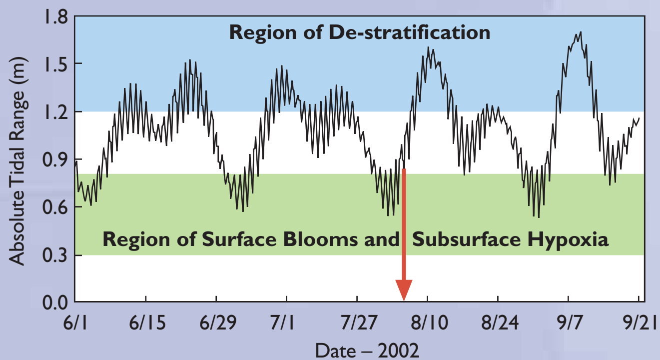
Rhode Island's monitoring program for Narragansett Bay includes random samples during the NCA index period; measurements made from moored instrumentation recording water properties every 15 minutes; towed instrumentation; and targeted sampling designed to document the spatial extent of low dissolved oxygen events that often accompany minimal tidal range in summer and early fall. The upper Narragansett Bay stratifies when the tidal range is less than 0.8 meters.

Phytoplankton often bloom in the surface layer when upper Narragansett Bay stratifies, followed by subsurface declines in dissolved oxygen (Bergando, In press). The August 6 sampling date was selected one year in advance of when a low dissolved oxygen event was considered likely, following a period of minimum tidal range.

Information from two of the moored instruments in upper Narragansett Bay indicated that, preceding the target sampling on August 6, 2002, near–bottom dissolved oxygen concentrations fell below EPA's (U.S. EPA, 2000a) chronic criterion for dissolved oxygen (4.8 mg/L) for 10 days and below the acute criterion for dissolved oxygen (2.3 mg/L) for 5 days. This low dissolved oxygen event was accompanied by fish kills in upper Narragansett Bay.



Dissolved oxygen concentrations in Upper Narragansett Bay, August 6, 2002.



Absolute tidal range – Newport, Rhode Island. (developed by Dana Kester [deceased], formerly of URI GSO)

Summary

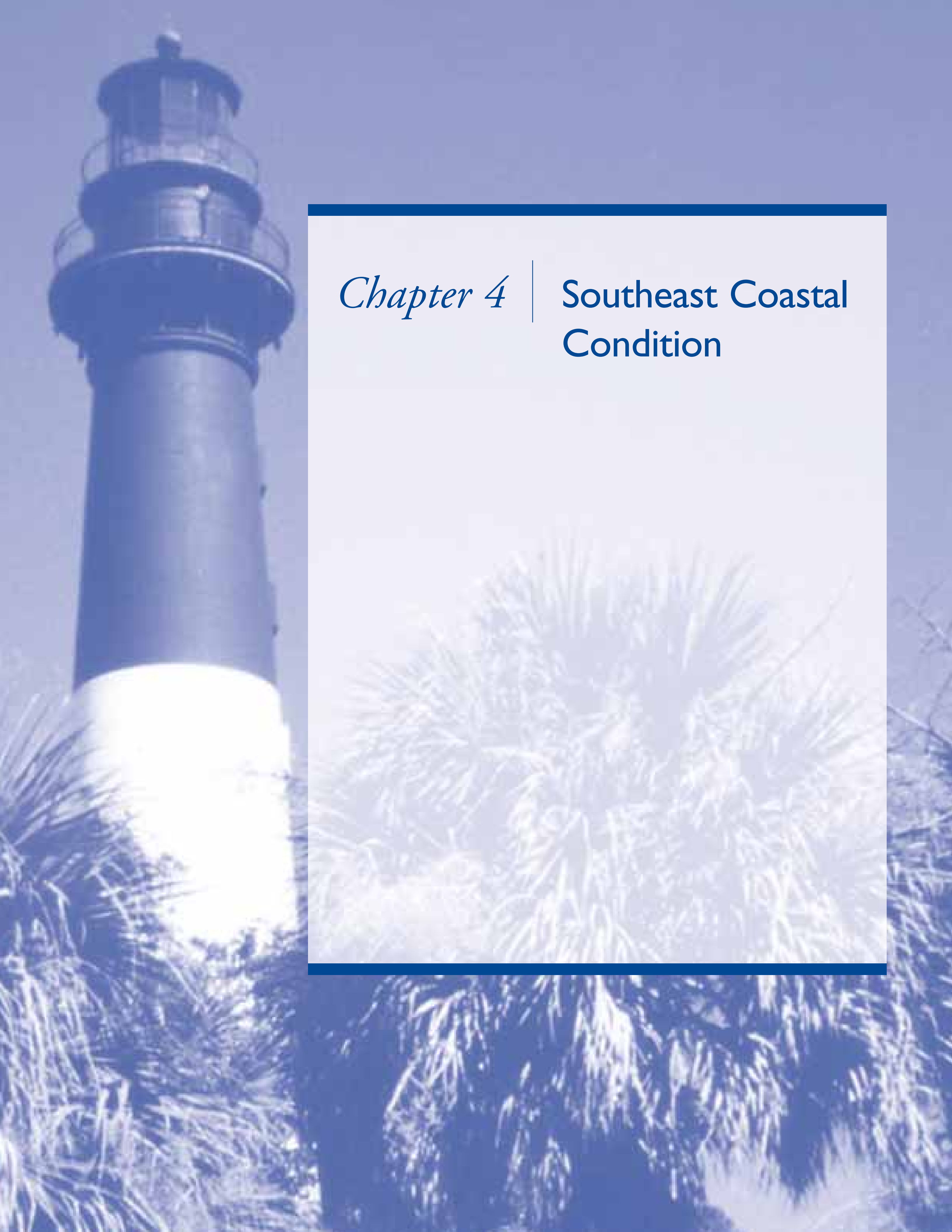
The NCA Program is providing an important baseline of conditions that can serve as the benchmark for determining how conditions change in the 21st century. For the first time, consistently collected data sets from cooperating state programs permit statistically valid comparisons of coastal conditions across the region. The summary of NCA results in this chapter is based on observations from a single survey year of the Northeast Coast during a late-summer index period. Even without temporal replication, dramatic geographic gradients are evident because of the geological history, latitudinal variations in climate and tidal range, and human activities in this region.

Problems associated with excess nutrients from human activities are much less prevalent in the Gulf of Maine than in the waters to the south of Cape Cod. Problems related to low oxygen levels in bottom waters are more severe in the coastal waters of the Virginian Province. The NCA sampling design provides a snapshot of late-summer conditions across the Northeast Coast region. Low oxygen levels between 2 and 5 mg/L are evident in a number of areas. Oxygen concentrations that persist below 4.8 mg/L and periodic fluctuations below 2.3 mg/L (Coiro et al., 2000) can have an impact on benthic communities and lead to fish kills.

Clean sediments with low levels of chemical contamination, an absence of acute toxicity, and moderate to low levels of TOC are found in 73% of the Northeast Coast. High levels of sediment contaminants are found in 8% of the region, with the highest levels of sediment contaminants often found in depositional environments in the vicinity of cities (Figures 3-3 and 3-13). Such sediments require special care when dredging is needed to maintain navigation channels. Lower levels of sediment contamination are found over an additional 12% of the region, associated with areas of high human population density (Figure 3-3). Sediment toxicity is found only in 8% of the Northeast Coast (Figure 3-12). In many situations where low levels of sediment contamination are evident, sediments are found to be nontoxic. In situations where sediment toxicity is evident, additional Toxicity Identification Evaluation (TIE) approaches can be used to help diagnose causes of observed toxicity.

Assessment of communities of benthic organisms can be used to characterize Northeast Coast ecosystem conditions. Based on the benthic index used in this study, conditions are considered to be good along the northern Maine coast, Cape Cod Bay, most of southeastern Massachusetts, near the mouth of Narragansett Bay, eastern Long Island Sound, portions of New Jersey, and the eastern shore of Chesapeake Bay. Benthic conditions are considered to be poor in 22% of the Northeast Coast, often in the vicinity of high human population density.

For the Northeast Shelf LME, mandated management actions have resulted in some recovery of depleted haddock and yellowtail flounder spawning stocks biomass and good recruitment.



Chapter 4 Southeast Coastal Condition

Southeast Coastal Condition

The overall condition of Southeast Coast estuaries is fair to good, although there is evidence of human-induced stress in some areas. In 2000, the NCA collaborated with state resource agencies in the region to facilitate collection of environmental stressor and response data from 151 locations (Figure 4-1) throughout Southeast Coast estuaries using comparable methods and techniques. Results indicate that most of the estuarine area of the southeastern United States is in fair to good ecological condition. This means that in the late summer, when data were collected, environmental stressors (e.g., nutrients, contaminants) and conditions for aquatic life showed few signs of significant impairment (Figure 4-2). Forty percent of the estuarine area fully supports human and aquatic life uses, 37% is threatened for human and aquatic life use, and 23% is impaired for these uses (Figure 4-3).

The estuaries of the southeastern United States (Carolinian Province) extend from Cape Henry, Virginia, through the southern end of the Indian River Lagoon and along the east coast of Florida (Figure 4-1)

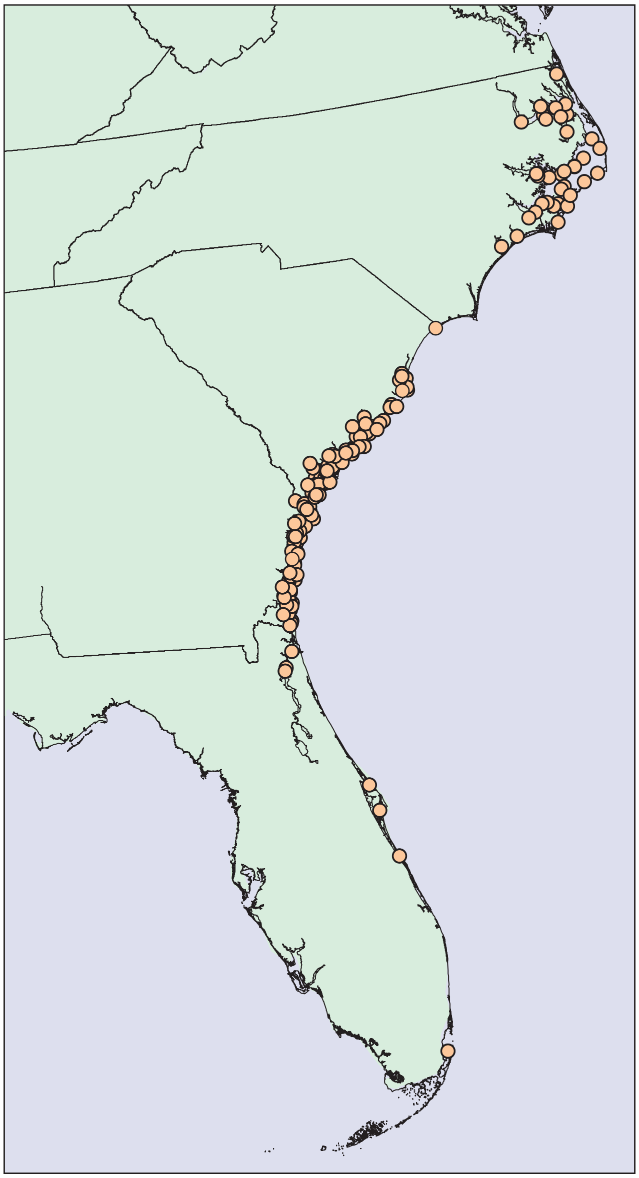


Figure 4-1. Southeast Coast sampling stations (U.S. EPA/NCA).

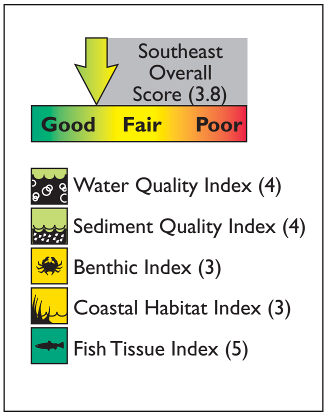


Figure 4-2. The overall condition of Southeast Coast estuaries is fair to good.

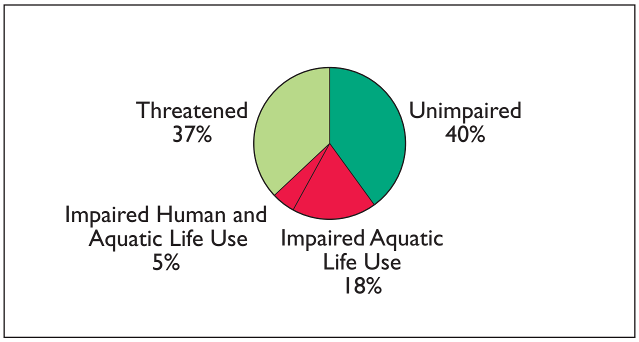


Figure 4-3. Southeast Coast estuarine condition (U.S. EPA/NCA).

to include part of the West Indian Province from Indian River Lagoon through Biscayne Bay. This region of the country is referred to as the Southeast Shelf LME. The Southeast Coast region contains a wealth of resources, including barrier islands such as North Carolina's Outer Banks; busy shipping ports in Miami and Jacksonville, Florida, Savannah, Georgia, and Charleston, South Carolina; quiet coastal wetlands that provide a habitat for migratory birds and other animals; and important commercial and recreational fishery resources. North Carolina contains the Albemarle-Pamlico Sound, one of the largest and most productive aquatic systems in North America. The sound represents North Carolina's key resource base for commercial fishing, recreational fishing, and tourism. Similarly, the coastal resources in other Southeast Coast states provide the resource base for fishing and tourism industries and generate vast amounts of sales tax income for those states.

The population of coastal counties along the Southeast Coast increased 64% between 1970 and 1990 (U.S. Census Bureau, 1996). In 1999, the southern region of the United States was the most populous area of the nation, accounting for 96 million residents. Florida was among the five most populous states in 1999 (U.S. Census Bureau, 2001) and has demonstrated a growth rate of almost 2% per year in its coastal population. Figure 4-4 presents population data for Southeast Coast counties from the U.S. Census Bureau and shows that these coastal county populations have more than doubled since 1960.

The estuarine resources of the Southeast Coast are diverse and extensive, covering an estimated 4,487 square miles. The coastal population in the southeastern United States increased by 160% over the 40-year period from 1960 to 2000, the largest percentage increase in the country. Given the influx of people and businesses to southeastern coastal states and the ensuing pressures on the coastal zones of this region, there is an increased need for effective management of the resources of the Southeast Coast.

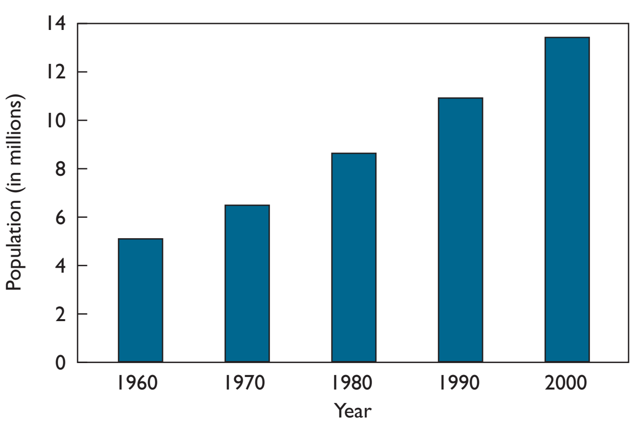
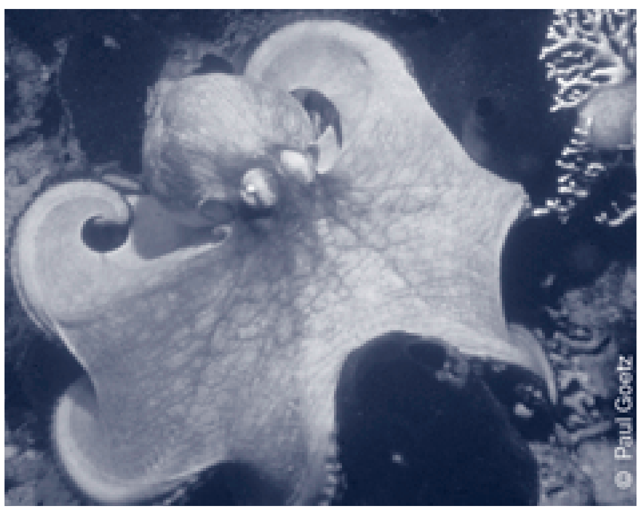


Figure 4-4. Population of coastal counties in the Southeast Coast states from 1960 to 2000 (U.S. Census Bureau, 2003).

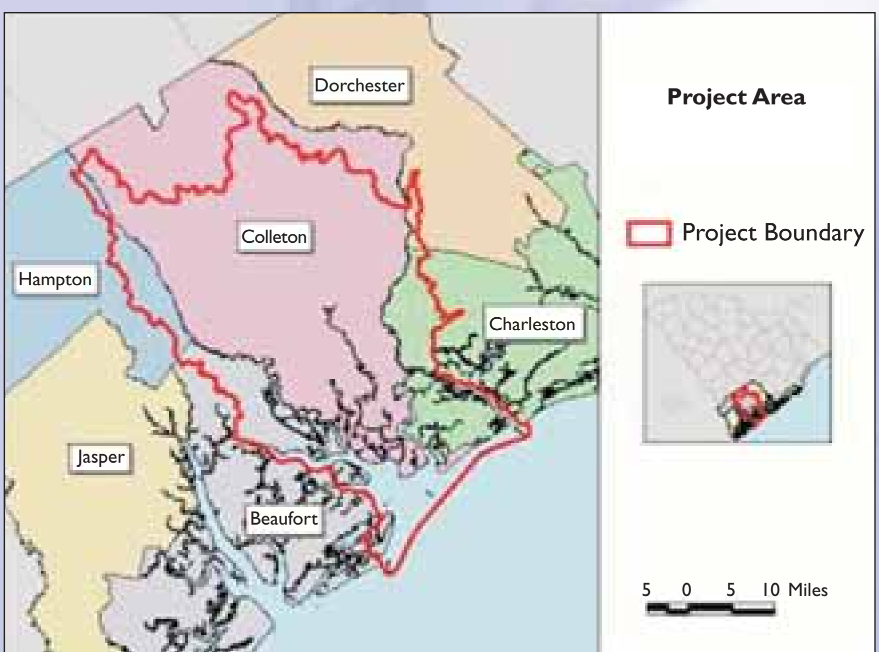


This largest of the Atlantic octopus species, *Octopus vulgaris*, exhibits a threat display to thwart the attention of an inquisitive diver (Paul Goetz).

highlight

South Carolina's Ashepoo-Combahee-Edisto Basin National Estuarine Research Reserve System

The Ashepoo-Combahee-Edisto (ACE) Basin of South Carolina has largely undeveloped tracts of saltwater marshes, maritime forests, upland pines, and bottomland hardwoods. These ecologically important components, coupled with management goals that balance conservation of natural resources with economic development and population growth, have focused national attention on the ACE Basin. Colleton County, South Carolina, in which the ACE Basin study area is located, is expected to increase from its 1990 population of 34,377 to more than 47,500 by the year 2010. People are attracted to the ACE Basin's mild climate, rural character, affordable land prices, recreational opportunities, and natural setting; however, extensive population growth and urbanization may adversely impact the very things that draw people to this area. Stressors associated with such population growth include habitat loss, resource depletion, nonpoint source pollution, and nutrient loadings to estuaries and coastal waters.



Ashepoo-Combahee-Edisto (ACE) Basin

A major challenge for the basin's rural communities will be to strike a balance between supporting the area's socioeconomic needs and protecting its natural resources. This will require strong ecological research and a commitment to responsible growth. Conservation, research, education, and cooperation have provided the basic architecture for the ACE Basin National Estuarine Research Reserve System (NERRS). The reserve is managed by the South Carolina Department of Natural Resources (SCDNR), and a 21-member steering committee representing local business, education, forestry, fisheries, environmental groups, tourism, and private landowners guides the development of research and educational activities. Funding for the ACE Basin characterization has been provided by NOAA and the SCDNR. The SCDNR and its Divisions of Marine Resources; Land, Water, and Conservation; and Wildlife and Freshwater Fisheries implemented the project in partnership with NOAA's Coastal Services Center in Charleston, South Carolina, and the National Geophysical Data Center in Boulder, Colorado.

Because of its relatively pristine nature, the ACE Basin provides ideal sites for monitoring changes in the physical and biological aspects of the region. Interdisciplinary research provides information for conserving biological diversity and for assessing the impacts of pollution on ecosystems and habitats. In addition, the ACE Basin may offer a model for solving similar problems in other coastal regions. Local communities are being introduced to the idea that promoting sustainable development and protecting natural watersheds are advantageous to the region's long-term benefit. Outreach activities that strengthen the community's understanding of these concepts are vital to the region's preservation.

For additional information, please visit the following Web sites: http://www.csc.noaa.gov/acebasin/ and http://www.dnr.state.sc.us/marine/mrri/acechar/.

Coastal Monitoring Data

Water Quality Index

The water quality index for estuaries in the Southeast Coast region is rated fair to good (Figure 4-5). Only 5% of estuarine area was rated poor for water quality, and 45% was rated fair. The water quality index was calculated by combining the indicator values for DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen for Southeast Coast estuaries.

Nutrients: Nitrogen and Phosphorous

High DIN and DIP concentrations in surface waters are often indicators of high eutrophic potential. DIN was rated good because none of the Southeast Coast estuarine area had DIN concentrations that exceeded 0.5 mg/L (Figure 4-6). DIP received a fair rating because 12% of the DIP concentrations exceeded 0.05 mg/L (Figure 4-7). The 12% value for DIP is an approximation because the phosphorus sample was based on filtered, acid-preserved phosphorus for North Carolina samples, which provides a measure of total phosphorus, not of DIP only. Literature suggests that for estuaries in the Southeast Coast region, DIP represents about 97% of the total phosphorus (Van Dolah et al., 2002).

The sampling conducted in the EPA NCA Program has been designed to estimate the percent of estuarine area (nationally or in a region or state) in varying conditions and is 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 indicator 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.

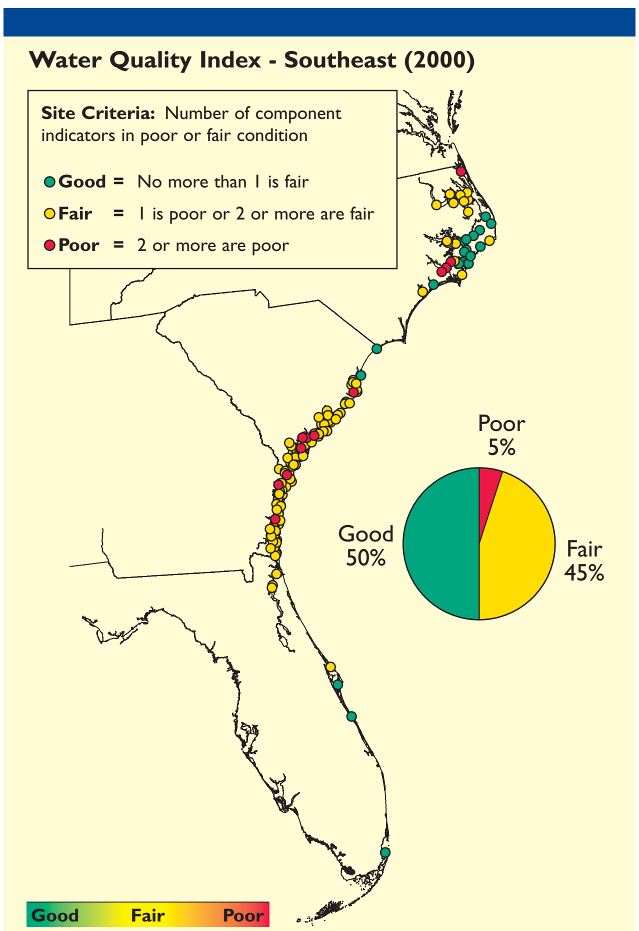


Figure 4-5. Water quality index data for Southeast Coast estuaries (U.S. EPA/NCA).

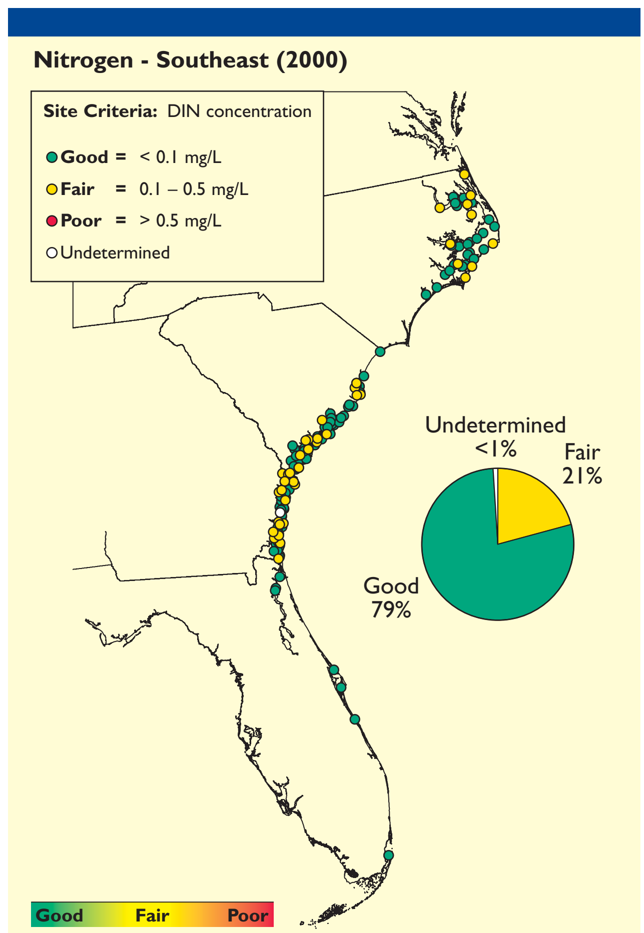


Figure 4-6. DIN concentration data for Southeast Coast estuaries (U.S. EPA/NCA).

Chlorophyll *a*

Chlorophyll *a* received a fair rating because 83% of Southeast Coast estuarine area had concentrations greater than 5 µg/L (Figure 4-8).

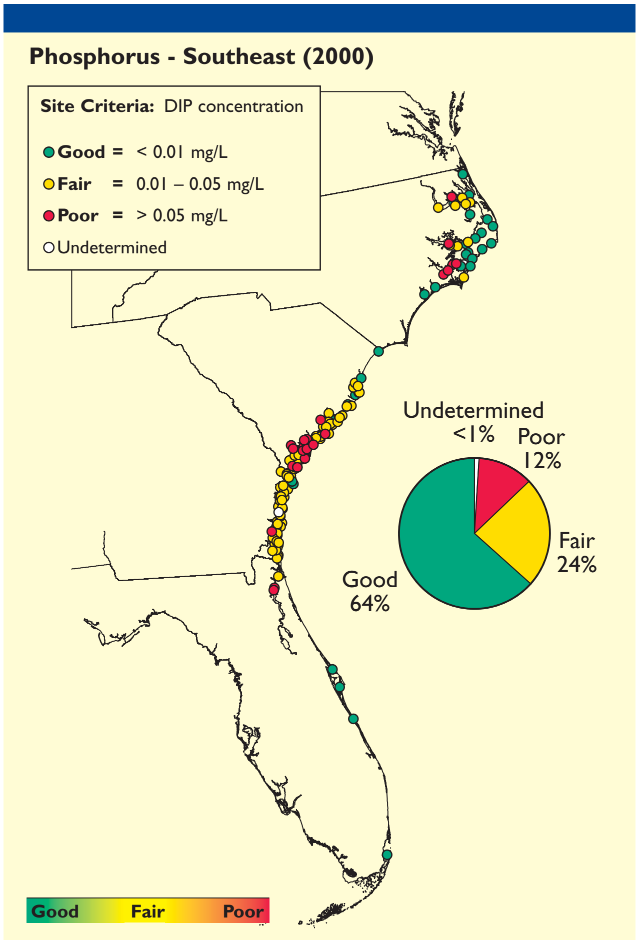


Figure 4-7. DIP concentration data for Southeast Coast estuaries (U.S. EPA/NCA).

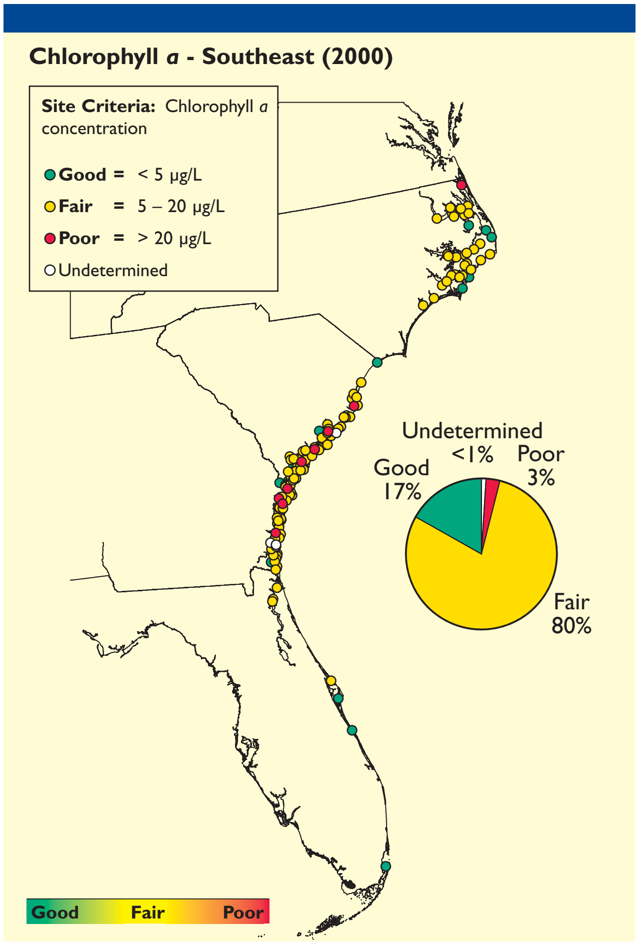
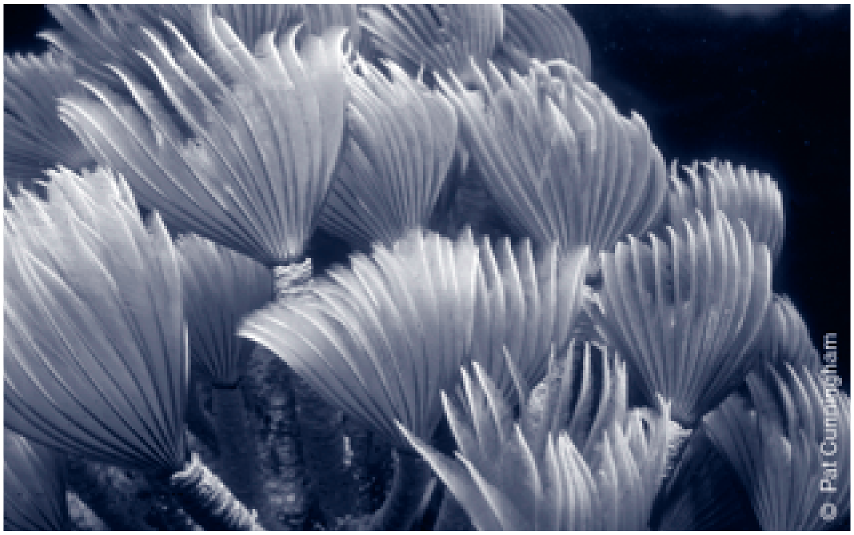


Figure 4-8. Chlorophyll *a* concentration data for Southeast Coast estuaries (U.S. EPA/NCA).



At the slightest disturbance, these social feather duster worms can retract their radioles or food gathering organ back into the safety of their parchment-like tubes (Pat Cunningham).

Water Clarity

Water clarity in Southeast Coast estuaries is fair. Water clarity was estimated by light penetration through the water column using either a transmissivity meter or a Secchi disk. Eighty percent of estuaries have good water clarity, and 12% have poor water clarity (Figure 4-9). Estuaries across the nation were divided into three turbidity classes based on regional expectations for light penetration related to SAV distribution—low, moderate, and high. Highly turbid waters generally have between 5% and 10% transmission of light at 1 meter; moderately turbid waters have between 10% and 25% light transmissivity; and low turbidity waters have between 20% and 40% transmissivity. However, only two turbidity classes were appropriate for most of the Southeast Coast estuaries—high and moderate—because of the high natural organic content of estuaries in the region. By defining reference conditions and ranges for turbidity, measured values can be compared with expected values, taking into account natural causes of turbidity.

Dissolved Oxygen

Dissolved oxygen in Southeast Coast estuaries is good. Twenty-four percent of the bottom waters have dissolved oxygen levels between 2 and 5 mg/L, and 74% of the bottom waters have levels above 5 mg/L (Figure 4-10). Dissolved oxygen is one of the most important water quality measurements because low dissolved oxygen conditions can limit the distribution or survival of most estuarine biota, especially if conditions persist for extended time periods. Results indicate that dissolved oxygen conditions in the Southeast Coast are generally good, even though the NCA Program was designed to sample during the summer index period, when dissolved oxygen levels are at their lowest. The dissolved oxygen measurements collected by states approximate short-term, worst-case conditions that may not necessarily occur for long time periods. State-gathered data under the NCA indicate that only 2% of the bottom waters in Southeast Coast estuaries have dissolved oxygen levels below 2 mg/L.

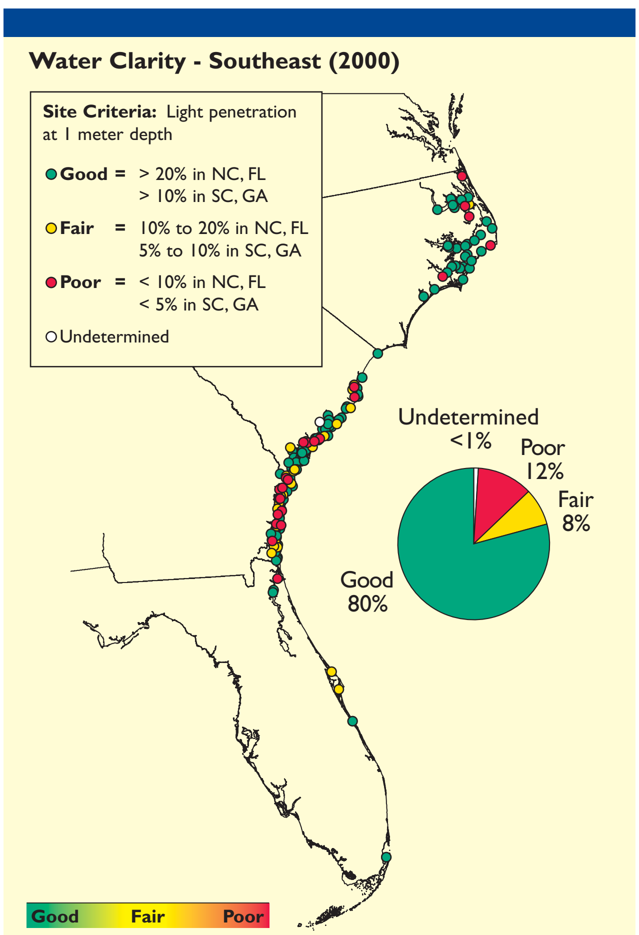


Figure 4-9. Water clarity condition for Southeast Coast estuaries (U.S. EPA/NCA).

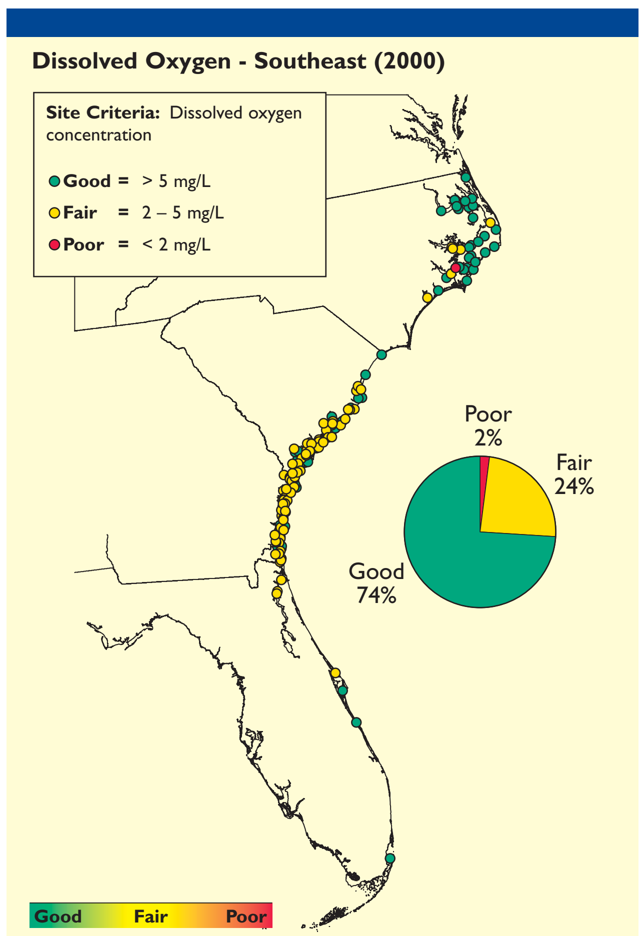


Figure 4-10. Dissolved oxygen concentration data for Southeast Coast estuaries (U.S. EPA/NCA).

Sediment Quality Index

The condition of Southeast Coast estuaries as measured by the sediment quality index is fair to good. Ninety-two percent of estuaries are rated good, and only 8% are rated poor (Figure 4-11). The sediment quality index is calculated using three indicators: sediment toxicity, sediment contaminants, and sediment TOC.

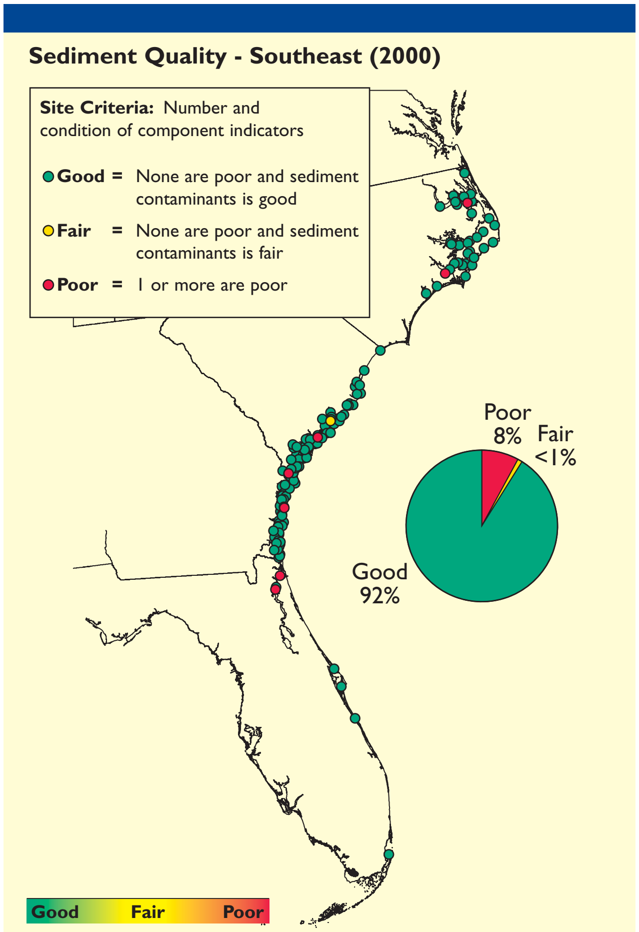


Figure 4-11. Sediment quality index data for Southeast Coast estuaries (U.S. EPA/NCA).

Sediment Toxicity

The sediment toxicity indicator in Southeast Coast estuaries is rated good. Figure 4-12 shows that 86% of the sediment area of these estuaries supported survival of the marine test organism *Ampelisca abdita*. Fourteen percent of the estuaries' toxicity potential was unknown because of missing data or a control failure of the standard toxicity test. Toxicity testing is a valuable tool in assessing the condition of sediments. Sediments received a poor rating if fewer than 80% of the organisms used in the sediment toxicity evaluation survived.

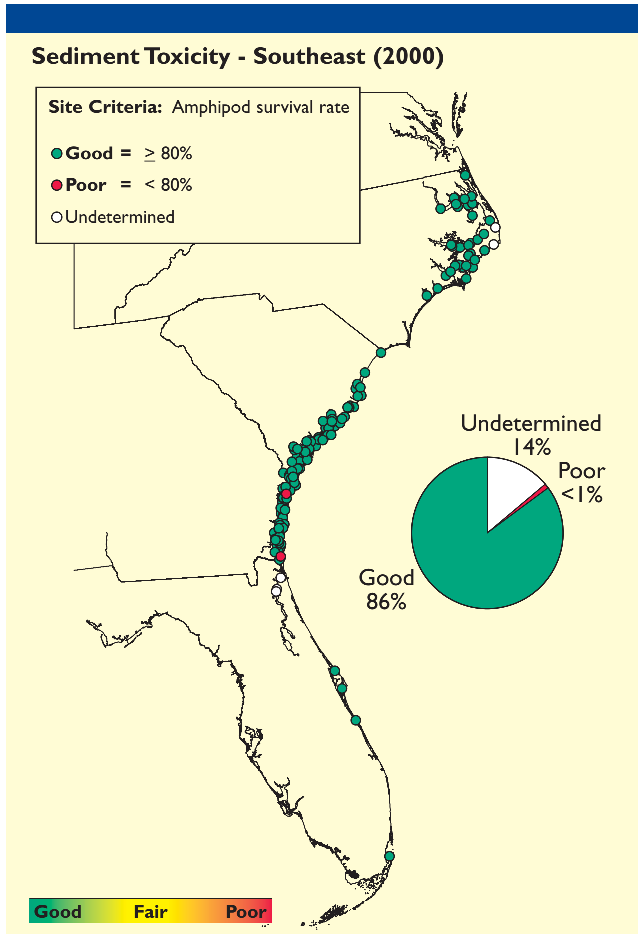


Figure 4-12. Sediment toxicity data for Southeast Coast estuaries (U.S. EPA/NCA).

A banded butterfly fish is a common inhabitant of Atlantic coral reefs (Paul Goetz).

Sediment Contaminants

The condition of Southeast Coast estuaries as measured by sediment contamination is good. For sediment chemical contamination, a poor rating was assigned if concentrations were above ERM values for one or more contaminants, and a fair rating was assigned if concentrations were above ERL values for five or more contaminants. None of the area of Southeast Coast estuarine sediments was rated poor (Figure 4-13). Sediments were analyzed for as many as 28 different chemicals, metals, or chemical classes, and these values were compared with established ERM and ERL values (Long and Morgan, 1990; Long et al., 1995).

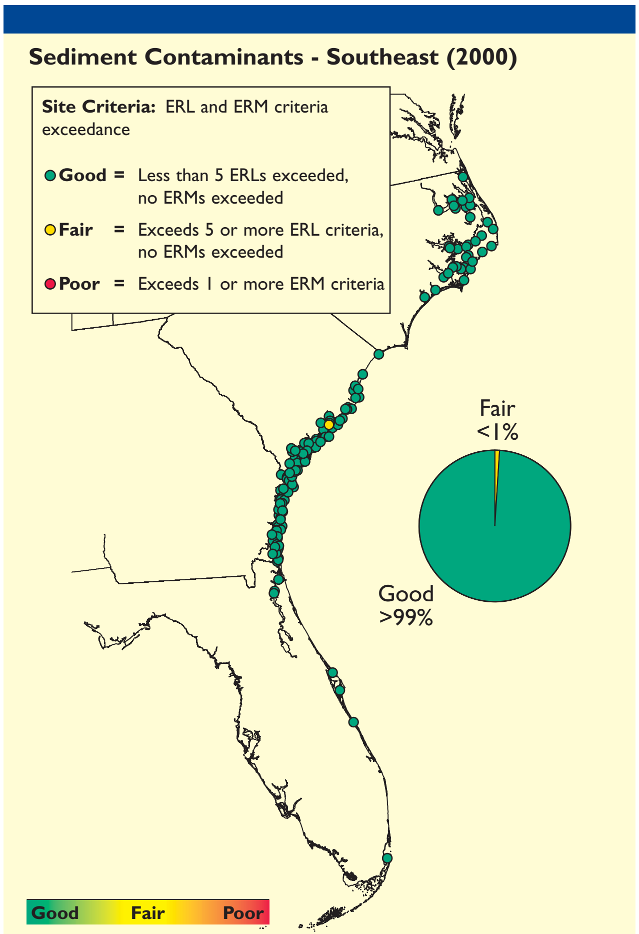


Figure 4-13. Sediment contaminants data for Southeast Coast estuaries (U.S. EPA/NCA).

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 values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

Sediment Total Organic Carbon

The condition of Southeast Coast estuaries as measured by sediment TOC is good. Figure 4-14 shows that 65% of estuaries in the Southeast Coast region are rated good for TOC, and only 7% are rated poor.

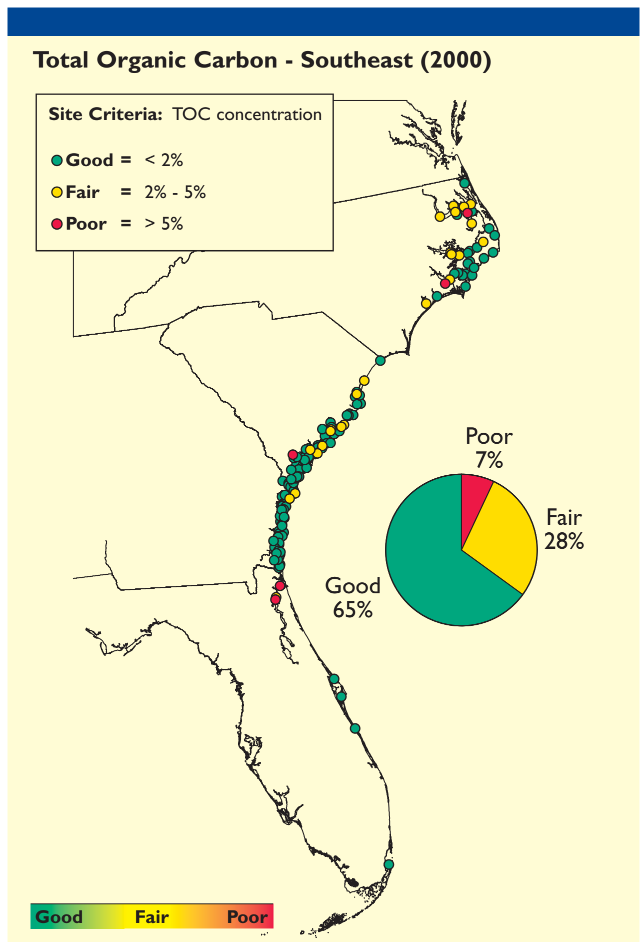
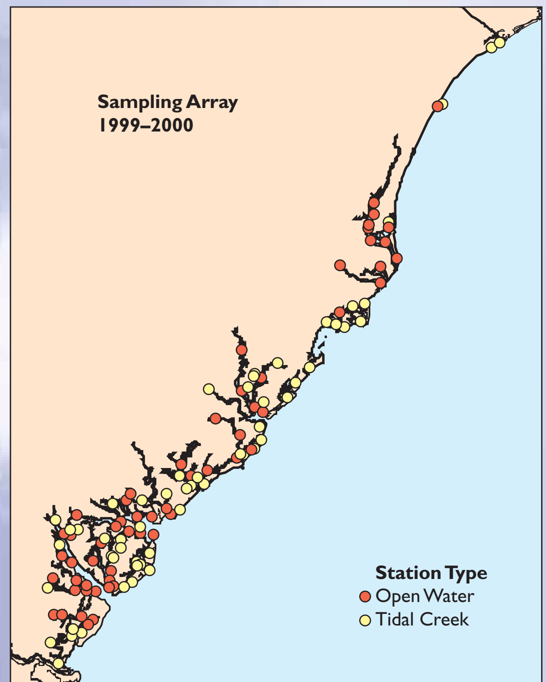


Figure 4-14. Sediment TOC data for Southeast Coast estuaries (U.S. EPA/NCA).

South Carolina Estuarine and Coastal Assessment Program (SCECAP)

In 1999, the SCDNR and the South Carolina Department of Health and Environmental Control (SCDHEC) initiated a collaborative coastal monitoring program, the South Carolina Estuarine and Coastal Assessment Program (SCECAP). This program involved several federal partners, including EPA, NOAA's National Ocean Service, and the FWS. The goal of SCECAP is to monitor the condition of South Carolina's estuarine habitats and associated biological resources and to provide overview reports to both coastal managers and the public. The program collects multiple water and sediment quality measures and annually monitors the biological condition at approximately 60 probabilistically selected sites throughout the state's coastal zone. These measures are integrated into an overall assessment of habitat condition at each estuarine site and collectively for the state's entire coastal zone. The program also expands the focus of historical monitoring activities beyond open water habitats (e.g., bays, sounds, tidal rivers) to include tidal creeks, which serve as important nursery habitat for many valuable species. As many of these tidal creeks are the first point of entry for nonpoint source runoff from upland areas, they can provide early indications of stress related to coastal development, agriculture, and industrial activities.



Distribution of open water and tidal creek stations sampled throughout South Carolina's coastal zone during 1999–2000 (SCDNER, 2002).

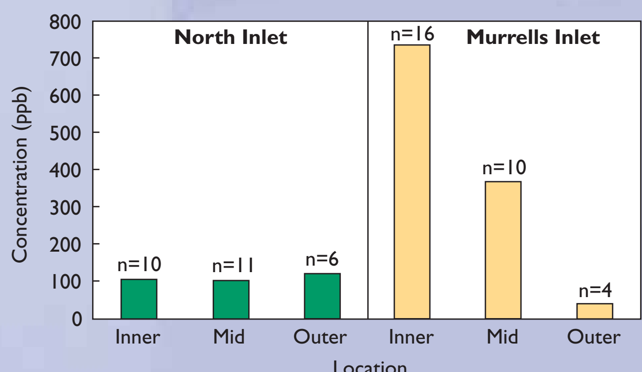
The SCECAP Summary Report provides major findings from the first two years of the program. The more detailed SCECAP Technical Report provides additional data on the monitoring program that may be useful to coastal resource managers and to those scientists conducting research in South Carolina's estuaries. Study results highlight the value of evaluating tidal creek habitats separately from larger open waterbodies. Significant differences were observed for many of the measurements collected in each habitat. Additionally, the study includes newly developed methods for measuring habitat condition that have not been used previously.

Additional information on the SCECAP is available at http://www.dnr.state.sc.us/marine/scecap/.

Comparing and Predicting PAH Concentrations in Urban and non-Urban Sediments

Unmanaged human activity can threaten the environmental health and economic vitality of coastal estuaries. In response to these concerns, as well as to identify the need for spatial models and improved analytical techniques to support sustainable coastal development, a long-term study was initiated to define, measure, and model the impacts of urbanization on high-salinity coastal estuaries of the southeastern United States. The Urbanization and Southeastern Estuarine Systems (USES) Project was begun by the University of South Carolina and the NOAA Center for Coastal Environmental Health and Biomolecular Research. The complexity of estuarine problems currently associated with coastal population growth and commercial development have led many research and management agencies to explore new spatial analytical techniques. These new analytical techniques can provide valid and timely information to assist with productive coastal zone management. This continuing advancement of new technologies enables scientists to design predictive models of how ecosystems and their components respond to natural and man-made pressures. New models and techniques are being developed that incorporate land-use patterns and practices, integrated toxicological and risk assessment modeling, and geographic information processing (GIP) approaches for applied coastal zone management.

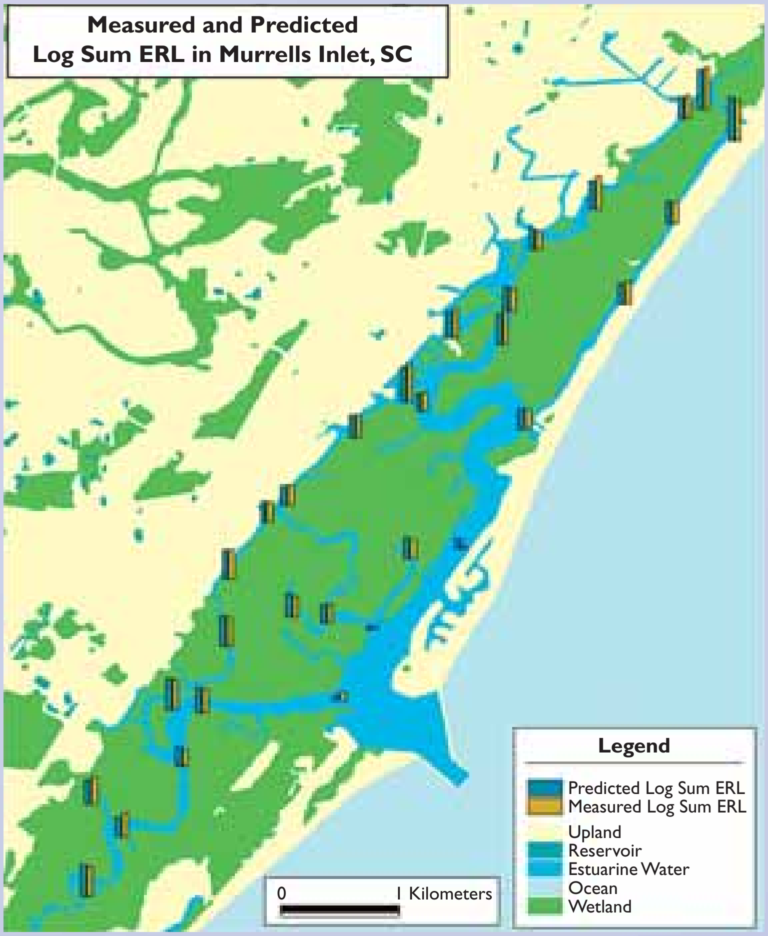
Runoff of PAHs discharged from gas combustion engines in automobiles and boats are a major contaminant source in coastal urban watersheds. PAHs were measured in sediments of Murrells Inlet, South Carolina, and found to have distinct patterns showing that the highest PAH concentrations occurred at estuarine sites adjoining urban residential developments, roadways, and marinas. PAH concentrations at estuarine sites in the middle and outer portions of Murrells Inlet distinctly decreased as distance from land-based PAH sources increased. In contrast, at pristine North Inlet, South Carolina, there were no spatial differences in PAH sediment concentrations related to distance from land sources.



Comparison of PAH sediment concentrations at an urbanized site (Murrells Inlet, South Carolina) and a pristine site (North Inlet-Winyah Bay, South Carolina) (Fortner et al., 1996).

Analysis of land use in Murrells Inlet revealed that there were several metrics, such as distance to roadways, distance to marinas, and distance to urban development, that helped develop multivariate land use models to accurately predict sediment PAH contaminant levels. These findings clearly indicate that high levels of PAHs in sediment are related to land-based pollution sources, and predictions of PAH sediment concentrations within estuarine systems can be accurately based upon simple land use metrics.

For additional information, visit http://www.chbr.noaa.gov/marineecotoxicology.html.



Source: Fortner et al., 1996

Benthic Index

The condition of Southeast Coast estuaries as measured by the benthic index is fair. Van Dolah et al. (1999) developed a benthic index based on several measures of benthic community condition. This index considers the total number of species and integrated measures of species dominance, species abundance, and abundance of pollution-sensitive taxa. The index shows that 11% of the Southeast Coast estuarine area is rated poor (has degraded benthic resources), 10% is in fair condition, and 79% is in good condition (Figure 4-15). Areas rated poor included portions of North Carolina's Neuse and Pamlico rivers and Georgia's Savannah River. Of the 11% of estuaries with degraded benthic condition, most (93%) were associated with some measure of adverse water or sediment quality (Figure 4-16). Poor benthic condition co-occurred most often with degraded sediment quality (73% of sites with poor benthic condition).

Tybee Roads, Savannah River Entrance, Georgia (Marge Beaver, Photography Plus).

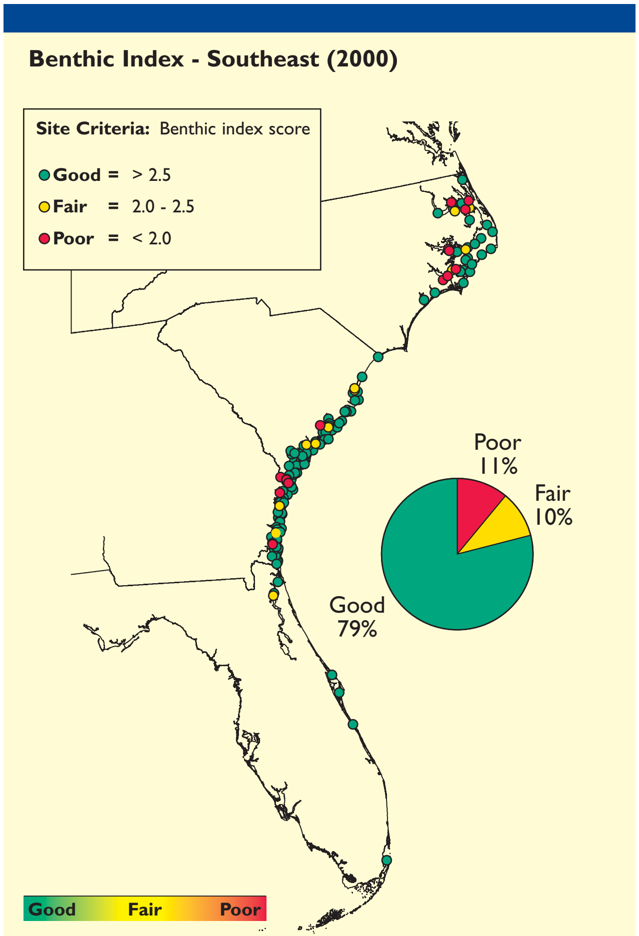


Figure 4-15. Benthic index data for Southeast Coast estuaries (U.S. EPA/NCA).

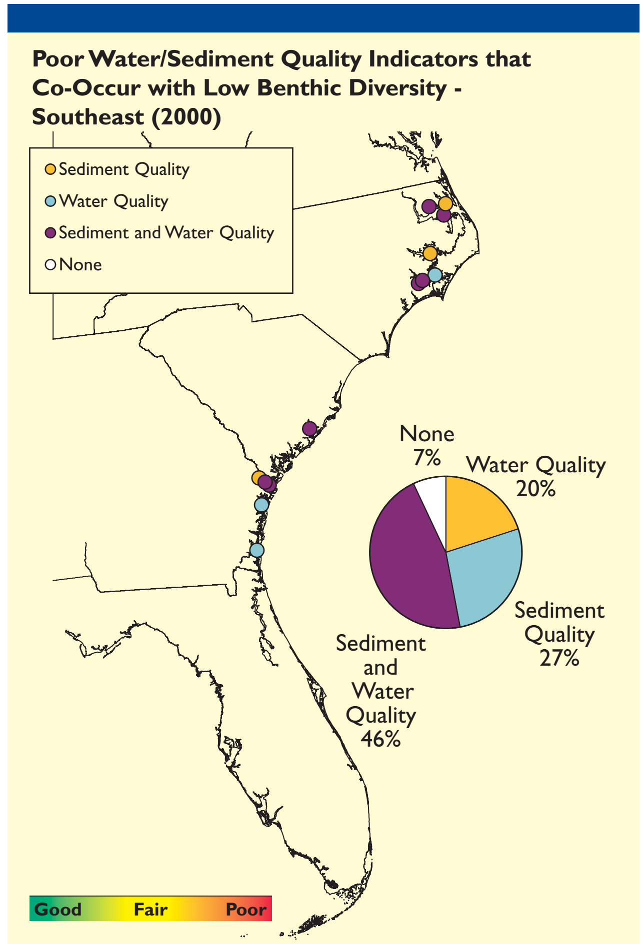


Figure 4-16. Indicators of poor water and sediment quality that co-occur with poor benthic condition in Southeast Coast estuaries (U.S. EPA/NCA).

Coastal Habitat Index

The coastal habitat index for estuaries in the Southeast Coast region is rated fair. Wetlands in the region diminished from 1,107,370 acres in 1990 to 1,105,170 acres in 2000, representing a loss of 2,200 acres or 0.2% (Figure 4-17). The coastal habitat index score was calculated by averaging the mean long-term, decadal wetland loss rate for 1780–1990 with the loss rate for 1990–2000 and multiplying by 100 (for a score of 1.06).

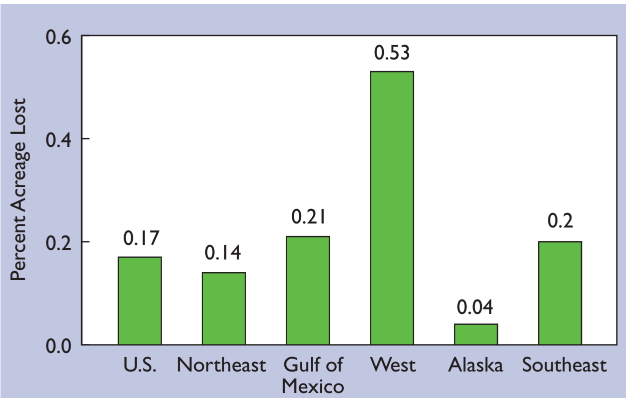


Figure 4-17. Wetland loss data. (Dahl, 2003)

A diver explores a WWII wreck off North Carolina which is now home to schools of juvenile fish and other organisms (Paul Goetz).

Fish Tissue Contaminants Index

The condition of Southeast Coast estuaries based on concentrations of contaminants in fish tissues is rated good. Figure 4-18 shows that 5% of all sites sampled where fish were caught (6 of 119 sites) exceeded risk-based criteria guidelines using whole-fish contaminant concentrations. (Whole-fish contaminant concentrations can be higher or lower than the concentrations associated with fillets. Only those contaminants that have an affinity for muscle tissue, e.g., mercury, are likely to have higher fillet concentrations. Fillet contaminant concentrations for most other contaminants will be lower.) The only contaminants that had elevated concentrations in fish tissues in Southeast Coast estuaries were total PAHs and total PCBs.

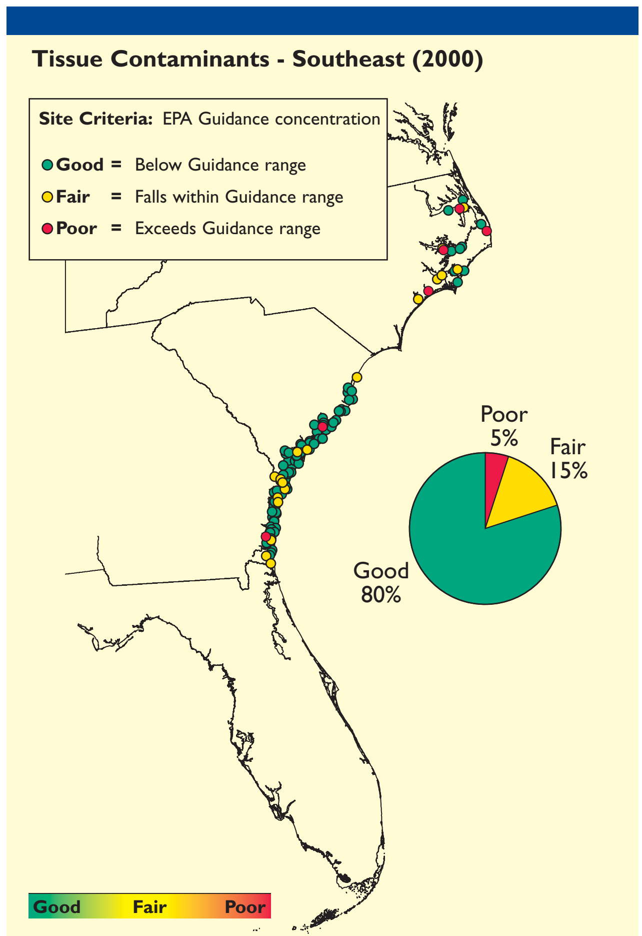
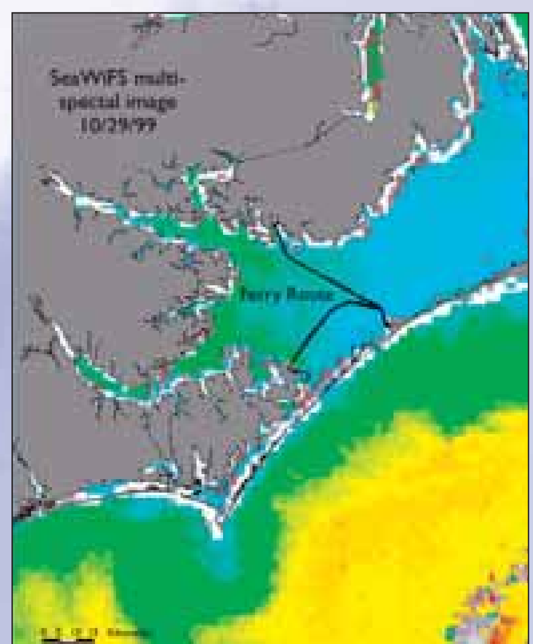


Figure 4-18. Fish tissue contaminants data for Southeast Coast estuaries (U.S. EPA/NCA).

Using Ferries to Monitor Estuarine Water Quality

The Albemarle-Pamlico Estuarine System (APES) is the second largest estuary in the nation. It supports more than 75% of the commercial fisheries in the Southeast and is North Carolina's most important recreational, tourism, and fisheries resource. However, despite its enormous ecological and socioeconomic importance, the majority of the APES is not routinely monitored for water quality.

This estuarine system's resources are threatened by increased pollution from urban and agricultural development in its watersheds. To address the urgent need for rapid, cost-effective, management-oriented water quality assessment, the University of North Carolina at Chapel Hill (UNC) and Duke University have partnered with the North Carolina Department of Environment and Natural Resources and the Department of Transportation to monitor the estuary's ecological health. The partnership, called FerryMon, outfitted three ferries that cross the Albemarle-Pamlico Sound and its tributaries as cost-free "ships of opportunity" with equipment to monitor the estuary's ecological indicators 18 hours a day, 365 days a year. These ferries collect real-time water quality data, including data related to temperature, salinity, dissolved oxygen, turbidity, pH, and chlorophyll. They also collect water samples for nutrient and diagnostic photopigment analyses. Data are transmitted via cell phone to laboratories, water quality management agencies, schools, environmental and outreach groups, and commercial and recreational fishing communities.



Albemarle-Pamlico Estuarine System (APES) (map courtesy of FerryMon, 2003)

FerryMon is administered by the Carolina Environmental Program. Principal investigators are Hans W. Paerl, Kenan Professor of Marine and Environmental Sciences at UNC's Institute of Marine Sciences in Morehead City, North Carolina, and Joseph S. Ramus, professor at the Duke University Nicholas School of the Environment and Earth Sciences Marine Laboratory in Beaufort, North Carolina.

Additional information on this program is available at http://www.ferrymon.org.

Large Marine Ecosystem Fisheries

The Atlantic coast of the United States bordering on the Southeast Shelf LME includes diverse habitats ranging in salinity, flora, and fauna. It includes freshwater and estuarine habitats, nearshore and barrier islands, and oceanic communities. Watersheds that drain the lower Appalachian Mountains, Piedmont, and Coastal Plains empty into the ecosystem along the coastlines of North Carolina, South Carolina, Georgia, and eastern Florida. The flow of fresh water mixes along the coast with prevailing oceanic waters to create diverse wetlands, marsh, and mangrove habitats that transition gradually from freshwater to brackish to saltwater areas. From an ecosystem perspective, this thin fringe of estuaries is dynamic, varying constantly with tidal fluctuations and levels of runoff, and it serves as an important habitat for waterfowl, reptiles, mammals, fish, and invertebrates, as well as a diversity of plants. It also serves as a natural filter to remove pollutants and sediments from upland regions. The estuaries in this area support diverse aquatic organisms and complex food webs in an irreplaceable nursery system. This system promotes the recruitment and development of juvenile fish and invertebrate species that are important to recreational, commercial, and ecological interests.

Reef Fish Resources

In the Southeast Shelf LME, the fishery for reef fishes has historically been conducted within waters that are less than 600 feet deep, or within the area that approximates the outer edge of the continental slope. Reef fishes are generally found on reef or reef-like, hard-bottom habitats. Dominant reef fish species include red, yellowtail, vermilion, and mutton snappers; red and gag groupers; black sea bass; and greater amberjack. Reef fish fisheries are extremely diverse, have many users (commercial and recreational), and vary greatly by location and species.

Combined commercial and recreational landings of the reef fishes from the Southeast Shelf LME area have fluctuated since 1976, showing a slightly decreasing trend over time (Figure 4-19). Meanwhile, fishing pressure has increased significantly. NOAA's FMP prohibits the use of fish traps (except pots for black sea bass) and trawl gear. Other regulations pertaining to the management of reef fishes include minimum size limits, permitting systems for commercial fishermen, bag limits, quotas, seasonal closures, Special Management Zones, and the establishment of Marine Protected Areas prohibiting the harvest of any species.

Of the dominant reef fishes within the ecosystem of the Southeast Shelf, the red, yellowtail, and vermilion snappers, the red and gag groupers, and the black sea bass stocks are currently overfished. The mutton snapper and greater amberjack stocks are not considered to be overfished. The regulatory measures and stock rebuilding plans under way are designed to reduce fishing mortality, to prevent over fishing, and to continue or begin rebuilding of these stocks.

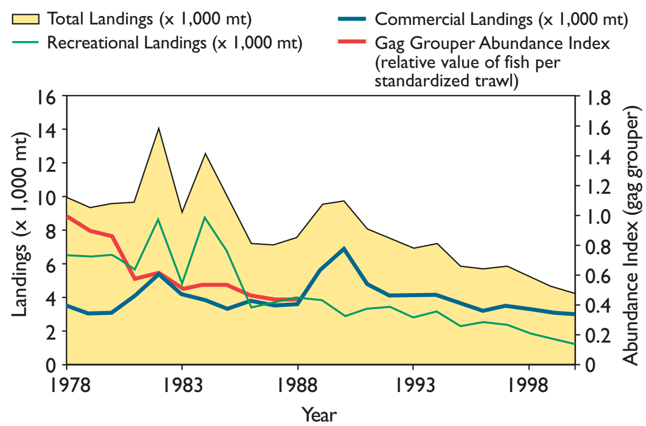


Figure 4-19. U.S. Atlantic coast reef fish landings, 1978–2000, in metric tons (mt). The abundance index is a relative value showing fish per standardize haul (NMFS, 2003).

The black sea bass (*Centropristis striata*), also known as the blackfish, has short, blue-black fins with white areas on the head. The last dorsal spines may have a dark spot at the base. It is the most common predator at Gray's Reef, South Carolina (Karen Roeder).

Sciaenids Fisheries

Fishes of the family *Sciaenidae* include 22 species in the Southeast Shelf LME. Some of the more notable members of this family of fishes include red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), spotted seatrout (*Cynoscion nebulosus*), kingfish (*Menticirrhus spp.*), and spot (*Leiostomus xanthurus*). Sciaenids have constituted an important fishery resource along the Atlantic coast since the late 1800s. Currently, these fish species support substantial harvests for both commercial and recreational fisheries and are captured in almost every type of gear used to fish the coastal waters of the Atlantic.

Of those sciaenid species for which an FMP has been developed, red drum are currently classified as overfished in some states; weakfish have high levels of abundance; and information needed to adequately determine stock status of the remaining species is lacking. Regulations for sciaenid fishes in the Atlantic range from no restrictions in some states to complicated restrictions based on fish size and bag limits in other states. The populations of several species of sciaenids, most notably Atlantic croaker and spotted seatrout, appear to be closely linked to environmental conditions, which result in large annual fluctuations in population levels.

Pond stocking of red drum fingerlings for Florida stock-enhancement programs. Netting covering the ponds prevents bird predation on stock. Port Manatee, Florida (Eileen McVey, NOAA Central Library).

Menhaden Fishery

Landings and participation (23 factories and more than 100 vessels on the Atlantic coast) in the menhaden fishery increased rapidly after World War II (Figure 4-20), reaching peak harvests between 1953 and 1962 (record landings of 712,100 mt in 1956). Sharp declines in landings thereafter resulted in plant closings and vessel reductions. The stock rebuilt during the 1970s and 1980s, and menhaden landings climbed to 418,600 mt in 1983. In 1990, 5 reduction plants operated with about 37 vessels. During the late 1980s and 1990s, the fishery consolidated, primarily because of low product prices. In 2003, only two plants remained on the Atlantic coast (Reedville, Virginia, and Beaufort, North Carolina). with a total of 12 steamers. The Virginia portion of Chesapeake Bay is currently the center of the modern menhaden fishery. Landings since 1998 have ranged between 167,200 and 245,900 mt (landings in 2002 were 174,000 mt).

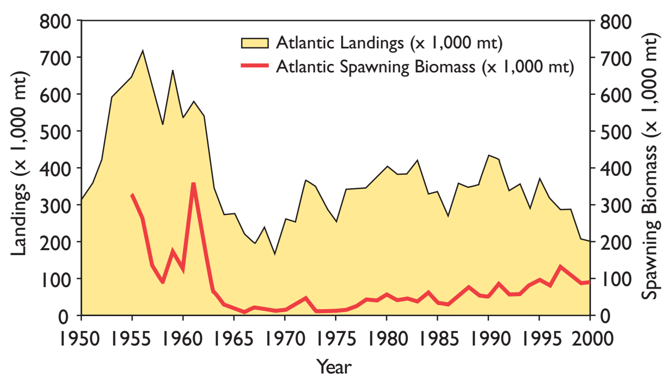


Figure 4-20. Landings and spawning biomass of Atlantic menhaden, 1950–2000, in metric tons (mt) (NMFS, 2003).

Declining fishing effort (hence fishing mortality) in recent years has likely reduced the rate at which older menhaden are removed from the population, allowing time for fortuitous recruitment. Relatively low survival to the age of 1 year has been a major concern for the Atlantic menhaden stock. The last dominant year-class occurred in 1988, and subsequent year-classes have generally been poor to mediocre. Recruitment appears to be hindered largely by environmental conditions (centered in the Chesapeake Bay area) rather than by a lack of spawning stock. If recruitment continues to decline, erosion of the spawning stock may follow.

Mackerel Fisheries

Total catch of Southeast Shelf LME king mackerel averaged 3,345 mt per fishing year from 1981 to 2001, with a maximum of 4,365 mt (1985) and a minimum of 2,570 mt (1999). In 2001, the total catch was 2,748 mt. On average, the landings are larger for the recreational sector (66%) than for the commercial sector (34%). Landings of king mackerel have been below the total allowable catch limitations since 1986. According to the 1998 and 2003 stock assessments, this stock is not overfished, nor is overfishing occurring, although it is near its estimated long-term potential yield. Currently, there are restrictions for the commercial sector, including annual total allocated catch restrictions, minimum size restrictions, gear restrictions, and catch trip limits. For the recreational sector, restrictions include bag limits, minimum size limits, and annual quota allocation. Current issues affecting the Atlantic king mackerel stock concern the bycatch of juveniles in the shrimp trawl fishery and the allocation of landings within the mixing zone between Atlantic and Gulf stocks.

The total catch of Southeast Shelf LME Spanish mackerel averaged 2,307 mt per fishing year from 1984 to 2001, with a maximum of 3,188 mt (1991) and a minimum of 1,406 mt (1995). In 2001, the total catch was 2,305 mt; in contrast to landings for king mackerel, most of the landings for Spanish mackerel are from the commercial sector (69%). For the Southeast Shelf LME Spanish mackerel, landings have also been below the total allowable catch limitations, at least since 1991. The 1998 and 2003 stock assessments concluded that the Atlantic Spanish mackerel stock was not overfished and that overfishing was not occurring, although current estimates indicate that the stock is exploited at its near-optimum long-term yield. At present, management restrictions for the commercial fishery of Southeast Shelf LME Spanish mackerel include minimum size restrictions, gear restrictions, trip limits, and quota allocation. For the recreational fishery, there are minimum size restrictions, bag limits, and charter-vessel permit requirements. Current issues affecting this stock include bycatch from the shrimp trawl fishery and the allocation of landings within the mixing zone between Atlantic and Gulf stocks.

Shrimp Fisheries

The trend in commercial landings of the major shrimp species over the last 40 years has remained stable, while fishing pressure has increased. The shrimp stocks in the Southeast Shelf LME appear to be more affected by environmental conditions than by fishing pressure. Both pink and white shrimp populations are affected by cold weather. The young of these species overwinter in estuaries and can potentially “freeze out” if water temperatures drop to lethal levels. The lower temperatures do not affect brown and rock shrimp because juveniles are not found in the estuaries during cold seasons. Annual variations in white and pink shrimp populations due to fluctuating environmental conditions are a natural phenomenon that will likely continue to occur despite management activities. However, the recovery of the affected stocks can be mediated by management practices.

The current shrimp management plan uses the mean total shrimp landings as a reasonable proxy for maximum sustainable yield. The harvest of shrimp in the Southeast Shelf LME has fluctuated around stable levels for several years. This trend in landings has been maintained even though an increase in vessels has been observed; therefore, it seems these stock are fully exploited.

The latest NMFS catch statistics indicate that commercial shrimp species are being harvested at maximum levels. An increase in effort would most likely not lead to an increase in catch. Although the take of shrimp may affect future stocks in years experiencing harsh environmental conditions, the greatest threat to shrimp populations is the loss or destruction of habitat. Pollution or physical alteration of the salt marsh and inshore seagrass habitats results in changes to habitats that are critical nursery areas for juvenile shrimp.

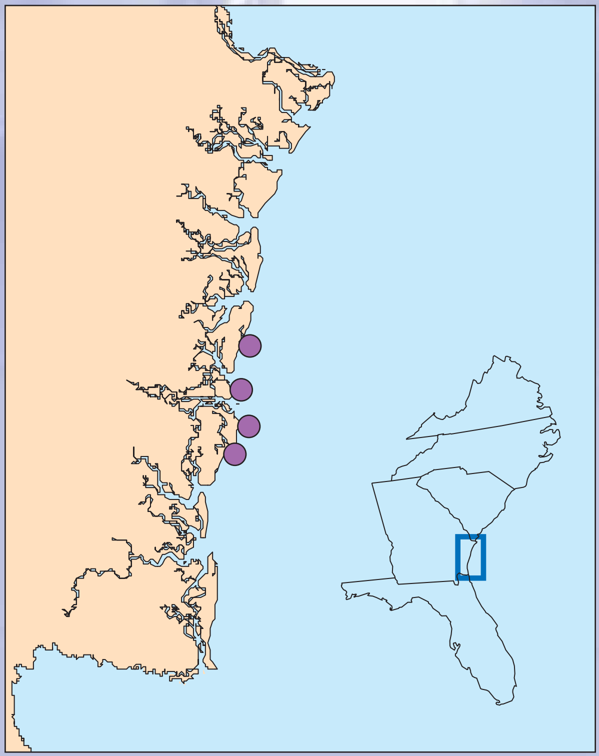
Catch statistics indicate that commercial shrimp species are being harvested at maximum levels. This photo shows three commercial shrimp boats (Ralph F. Kresge).

Georgia Department of Natural Resources' Red Drum Project

Conventional tagging and telemetry studies have demonstrated that the Altamaha River delta provides an important habitat for all life stages of red drum. These studies have shown that adult red drum exhibit spawning site fidelity. After spawning, adult red drum aggregate at shoal and sandbar areas near the mouths of estuaries, where they are targeted by anglers in a growing catch-and-release fishery. Adult red drum remain in these areas until mid-November, when they move out into the open Atlantic Ocean, returning to the estuaries and nearshore waters the following spring.

Through a 2-year age-determination study (1989 to 1991), approximately 300 red drum were captured from the Altamaha River delta with hook-and-line and entanglement gear and then sacrificed for otolith (ear bone) removal and collection of biological data. Evaluation of otoliths revealed that the portion of the adult red drum spawning biomass that frequented the Altamaha River delta was comprised of individuals ranging from age 5 to 40. Young adults (ages 5 to 10) made up a much smaller portion of the sample than expected. As a result, researchers concluded that unregulated harvest of juveniles and sub-adults during the 1970s and 1980s had decreased survival to adulthood.

In the autumn of 2002, the Coastal Resources Division repeated this study, collecting adult red drum from four stations located in the Altamaha River delta using both conventional angling and multi-hook gear with circle hooks as terminal tackle. The goal of this repeat study was to determine and compare the current and historical age structures of the red drum with the previous 2-year study of 1989. If management guidelines implemented over the past decade have been successful, then young adult red drum should represent a larger portion of the spawning population.



Georgia, Red Drum sampling sites (map courtesy of Georgia Department of Natural Resources, Coastal Division, 2002).

In addition, 10 randomly selected individuals (>750 mm fork length) were taken from each of the 4 sampling stations for tissue chemistry analysis. Comparison of the tissue concentrations with sediment chemistry data collected from random sites in 2000 and 2001 in the Altamaha estuarine system will provide unique insight about bioaccumulation of water and sediment-borne substances.

For more information about the Red Drum Project, contact Phillip Flournoy at phillip_flournoy@coastal.dnr.state.ga.us.

Photo courtesy of Georgia's Department of Natural Resources, Coastal Division, 2002.

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

The states on the Southeast Coast assessed 8,234 (93%) of their 8,813 estuarine square miles for their 2000 305(b) reports. Of the assessed estuarine square miles on the Southeast Coast, 81.5% fully support their designated uses, 1.5% are threatened for one or more uses, and the remaining 17% are impaired by some form of pollution or habitat degradation (Figure 4-21). Individual use support for assessed estuaries is shown in Figure 4-22. The states on the Southeast Coast did not assess any of their 9,070 shoreline miles. Although Florida reports water quality information for coastal waters for Section 305(b) compliance, it is not possible from that report to distinguish between Atlantic and Gulf Coast listings; therefore, 305(b) assessment information for Florida is included in its entirety in this section.

Table 4-1 shows individual use support reported by states for their assessed estuaries and shoreline waters.

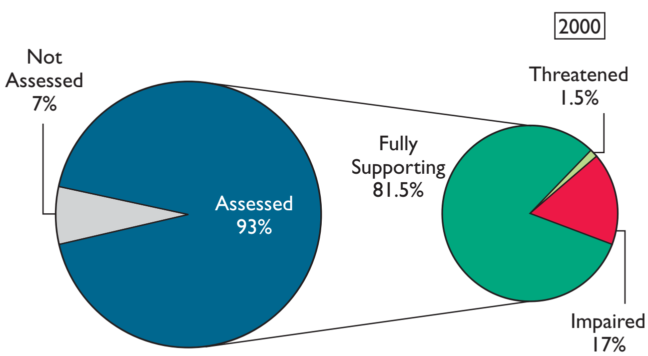
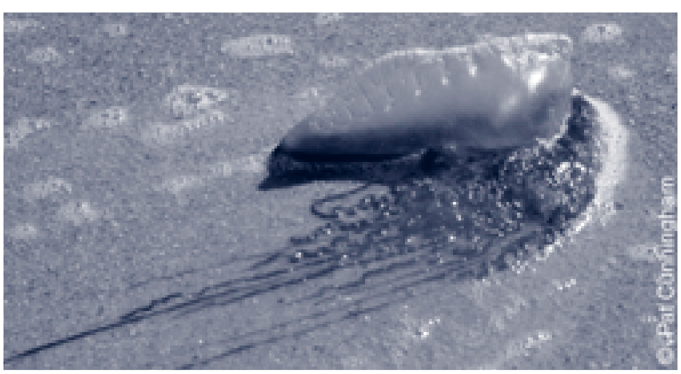


Figure 4-21. Water quality in assessed estuaries of the Southeast Coast (U.S. EPA, 2002).



Portuguese Man-O-War frequently washup Florida's east coast during the spring to threaten beach goers and swimmers alike with their potent and sometimes lethal stinging tentacles (Pat Cunningham).

Wind surfer takes advantage of the coastal wind and waves for an exciting ride (Paul Goetz).

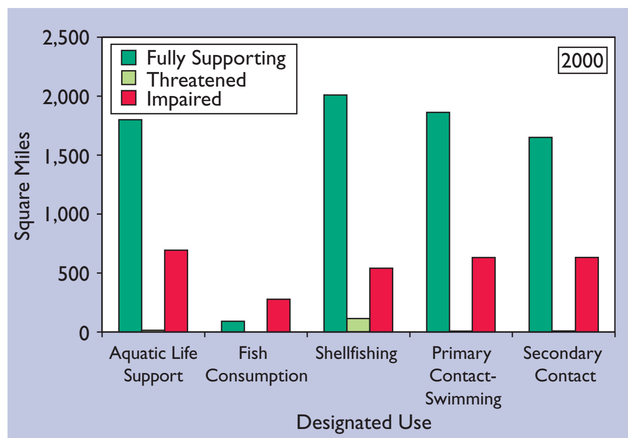


Figure 4-22. Individual use support for assessed estuaries of the Southeast Coast (U.S. EPA, 2002).

Table 4-1. Individual Use Support for Assessed Coastal Waters Reported by the Southeast Coast States under Section 305(b) of the Clean Water Act for 2000 (U.S. EPA, 2002).

Individual Uses	Estuaries Assessed as Impaired (mi^2)	Percentage of Total Area Assessed for Individual Use
Aquatic life support	683	27%
Fish consumption	279	76%
Shellfishing	534	20%
Primary contact – swimming	623	25%
Secondary contact	606	27%

Fish Consumption Advisories

Ten fish consumption advisories were active in the coastal waters of the Southeast Coast region in 2002 (Figure 4-23). All four coastal states—North Carolina, South Carolina, Georgia, and Florida—had statewide advisories covering all coastal waters and estuaries to warn citizens against consuming large quantities of king mackerel because of potential mercury contamination. Florida and South Carolina also have statewide advisories for other species of fish. Because of these statewide advisories, 100% of the total coastline miles of the Southeast Coast region were under advisory. Most (90%) fish consumption advisories for the Southeast Coast were issued at least in part because of mercury contamination (Figure 4-24), with separate advisories issued for only two other pollutants, PCBs and dioxins. All PCB advisories were in Georgia, and the one dioxin advisory was in North Carolina's Albemarle-Pamlico Sound.

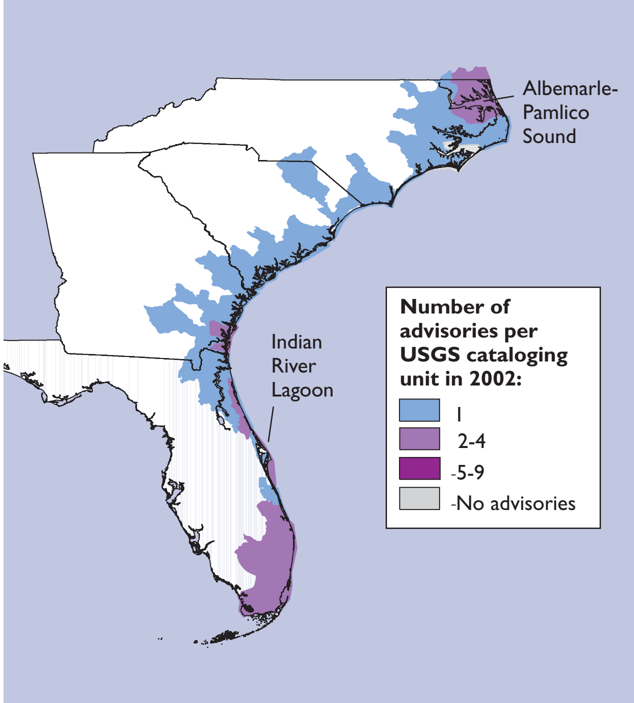


Figure 4-23. The number of fish consumption advisories per USGS cataloging unit in Southeast Coast waters (U.S. EPA, 2003c).

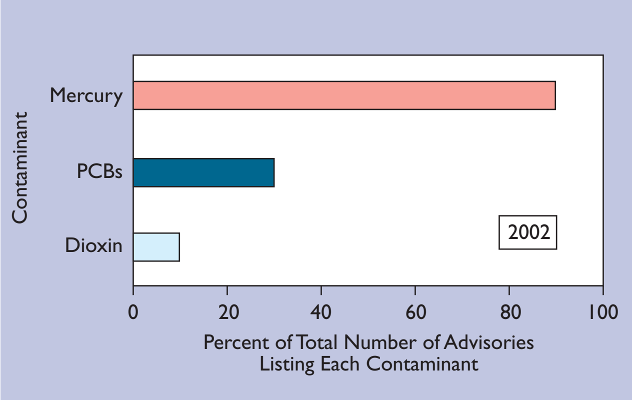


Figure 4-24. Pollutants responsible for fish consumption advisories in Southeast Coast waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2003c).

These species were under advisory in 2002 for at least some part of the Southeast Coast:

Almaco jack	Greater amberjack
Atlantic croaker	King mackerel
Black drum	Ladyfish
Blackfin tuna	Little tunny
Blue crab	Mussels
Bluefish	Oysters
Carp	Red drum
Catfish	Shark
Clams	Silver perch
Cobia	Snowy grouper
Crevalle jack	Spotted seatrout
Flounder	Source: U.S. EPA, 2003c

A blue crab fishing boat loaded with pots and ready to go to work. Mann's Harbor, North Carolina (William B. Folsom, NMFS).

Beach Advisories and Closures

Of the 151 coastal beaches in the Southeast Coast that reported information to EPA, only 15.6% (25 beaches) were closed or under an advisory for any period of time in 2002. Table 4-2 presents the numbers of beaches, advisories, and closures for each state. Only South Carolina and Florida's east coast had beaches with advisories or closures. Figure 4-25 presents advisory and closure percentages for each county within each state.

Most beach advisories and closures were implemented at beaches along the Southeast Coast because of elevated bacteria levels (Figure 4-26). There were multiple sources of water-borne bacteria that resulted in advisories or closures. Stormwater runoff was most frequently identified as a source (71%), and unknown sources accounted for 9% of the responses (Figure 4-27).

Table 4-2. Number of Beaches and Advisories/Closures in 2002 for Southeast Coast States (U.S. EPA, 2003a)

State	No. of Beaches	No. of Advisories/ Closures	Percentage of Beaches Affected by Advisories/ Closures
North Carolina	20	0	0.0%
South Carolina	26	12	46.2%
Georgia	4	0	0.0%
Florida (East Coast)	101	13	12.9%
TOTALS	160	25	15.6%

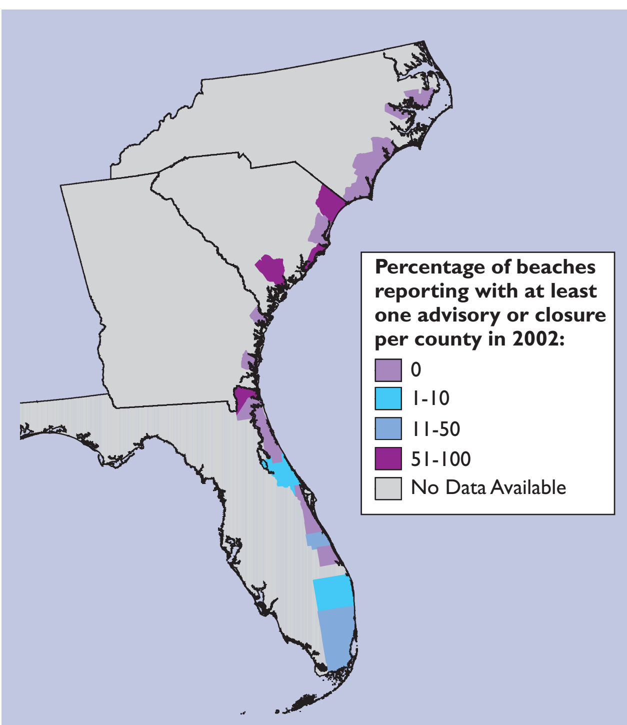


Figure 4-25. Percentage of Southeast Coast beaches with advisories or closures by county in 2002 (U.S. EPA, 2003a).

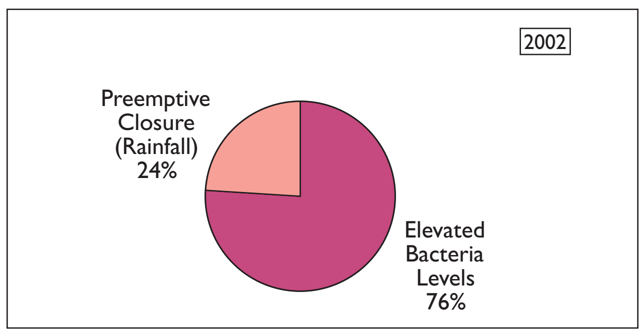


Figure 4-26. Reasons for Southeast Coast beach advisories or closures (U.S. EPA, 2003a).

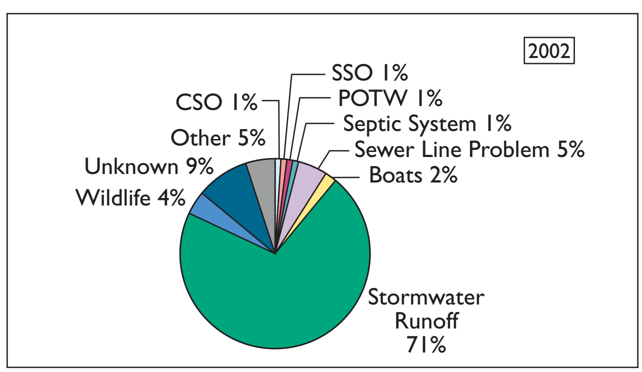
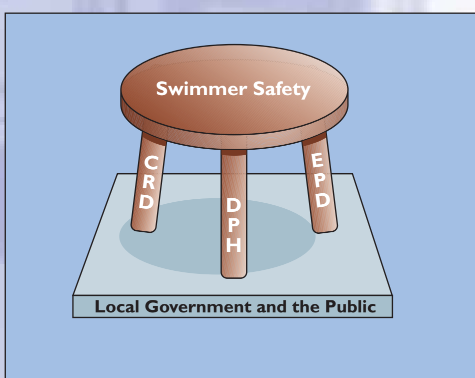


Figure 4-27. Sources of Southeast Coast beach contamination (U.S. EPA, 2003a).

Georgia Beach Monitoring Program

The primary goal of the Georgia Beach Monitoring Program is swimmer safety. The Georgia Department of Natural Resources (DNR), Coastal Resources Division (CRD), is developing an interagency team to address issues that influence swimmer safety. The team consists of the CRD; the State Department of Human Resources, Division of Public Health (DPH); and the DNR Environmental Protection Division (EPD). The team has three primary responsibilities: (1) to monitor regular bacterial water quality; (2) to notify the public of swimmer health risks; and (3) to investigate sources of pollution.

CRD used the analogy of a three-legged stool to explain the team's approach. Swimmer safety is the seat of the stool, and the stool is supported by three legs. All three legs are required to keep the stool upright, but no single agency in Georgia has the jurisdiction to provide the information needed for all three legs. The CRD is the leg that monitors bacterial concentration in water. When bacterial concentrations are high, CRD notifies the DPH. The DPH is the leg that issues a public health advisory. The third leg, the EPD, investigates the source of the bacterial contamination.



The stool requires a stable platform for support and stability. That platform consists of local governments, beach management agencies, news agencies, and the general public. The CRD has worked to educate the groups that form this platform to provide the necessary support for the Georgia Beach Monitoring Program in order to increase the groups' awareness of swimmer safety issues and to explain how their support can help improve swimmer safety.

For more information, contact Elizabeth Cheney at elizabeth_cheney@coastal.dnr.state.ga.us.

Summary

Lighthouse and palmetto trees (Richard B. Mieremet, Senior Advisor, NOAA OSDIA).

The overall condition of Southeast Coast estuaries is fair to good. Monitoring by coastal states in 2000 showed that less than 5% of the area of Southeast Coast estuaries and coastal areas is in poor condition, based on bottom dissolved oxygen concentrations, sediment toxicity, and sediment chemical contamination. Indices of concern include the benthic index (11% rated poor), water quality index (50% rated as fair or poor), and coastal habitat index (1.06 rated as fair). Although only 3% and 12% of Southeast Coast resources were in poor condition for chlorophyll *a* and phosphorus concentrations, respectively, large percentages (80% and 24%) of resources were in fair condition for these two indicators.

Results indicate that most of the estuarine area of the southeastern United States is in fair to good ecological condition. Neither environmental stressors (e.g., dissolved oxygen, contaminants) nor conditions for aquatic life showed signs of serious ecological impairment during the monitoring period. However, increasing population growth in this region of the United States could contribute to increased susceptibility for water quality degradation. Although the overall condition of Southeast Coast estuaries is rated fair to good for 2000, a vigilant attitude should be promoted and environmental education continued to protect and preserve this resource.

Chapter 5 Gulf of Mexico Coastal Condition

Gulf of Mexico Coastal Condition

The overall condition of Gulf Coast estuaries is fair (Figure 5-1). Thirty-five percent of the estuarine area shows indications of impaired aquatic life use, and 14% shows indications of impaired human use (Figure 5-2). Twenty percent of the assessed estuaries are in good ecological condition. In these areas of good condition, data were collected during the most stressful period of the year, and neither environmental stressors (e.g., nutrients, contaminants) nor aquatic life communities showed any evidence of degradation. Thirty-nine percent of estuarine area along the Gulf of Mexico was assessed as threatened (in fair condition). The five Gulf states—Florida, Alabama, Mississippi, Louisiana, and Texas—collected environmental stressor and response data from 191 locations from Florida Bay, Florida, to Laguna Madre, Texas, in 2000 (Figure 5-3).

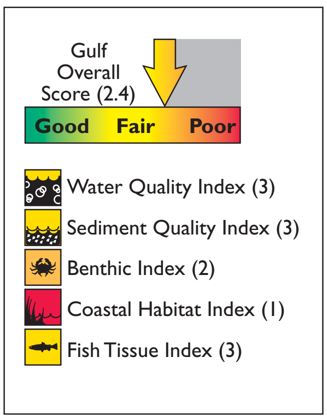


Figure 5-1. The overall condition of Gulf Coast estuaries is fair.

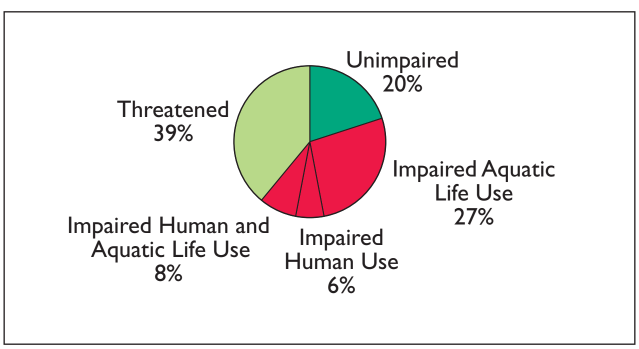


Figure 5-2. Gulf Coast estuarine condition (U.S. EPA/NCA).

Gulf Coast estuaries provide critical feeding, spawning, and nursery habitats for a rich assemblage of fish, wildlife, and plant species. Gulf Coast wetlands provide essential habitat for shorebirds, colonial nesting birds, and migratory waterfowl. The Gulf Coast is also home to an incredible array of indigenous flora and fauna, including endangered species such as sea turtles, the Gulf sturgeon, the Perdido Key beach mouse, the manatee, the white-topped pitcher plant, and the red-cockaded woodpecker. Gulf Coast estuaries support SAV communities that stabilize shorelines from erosion, reduce nonpoint source loadings, improve water clarity, and provide wildlife habitat.

Gulf Coast estuaries are among the most productive natural systems, producing more food per acre than the most productive midwestern farmland. The Gulf Coast region is second only to Alaska for domestic landings of commercial fish and shellfish, with 816,466 mt in 2000, worth more than $900 million (NMFS, personal communication). Shrimp landings in the Gulf of Mexico accounted for 80% of the total U.S. shrimp landings in 2000 (127,006 mt).

Shrimp boats viewed over old, barnacle-encrusted pilings at Conn Brown Harbor, Aransas Pass, Texas (Mr. William B. Folsom, NOAA, NMFS).

The part of Cayo del Oso Creek that empties into Corpus Christi Bay, Corpus Christi Bay, Texas (Mr. William B. Folsom, NOAA, NMFS).

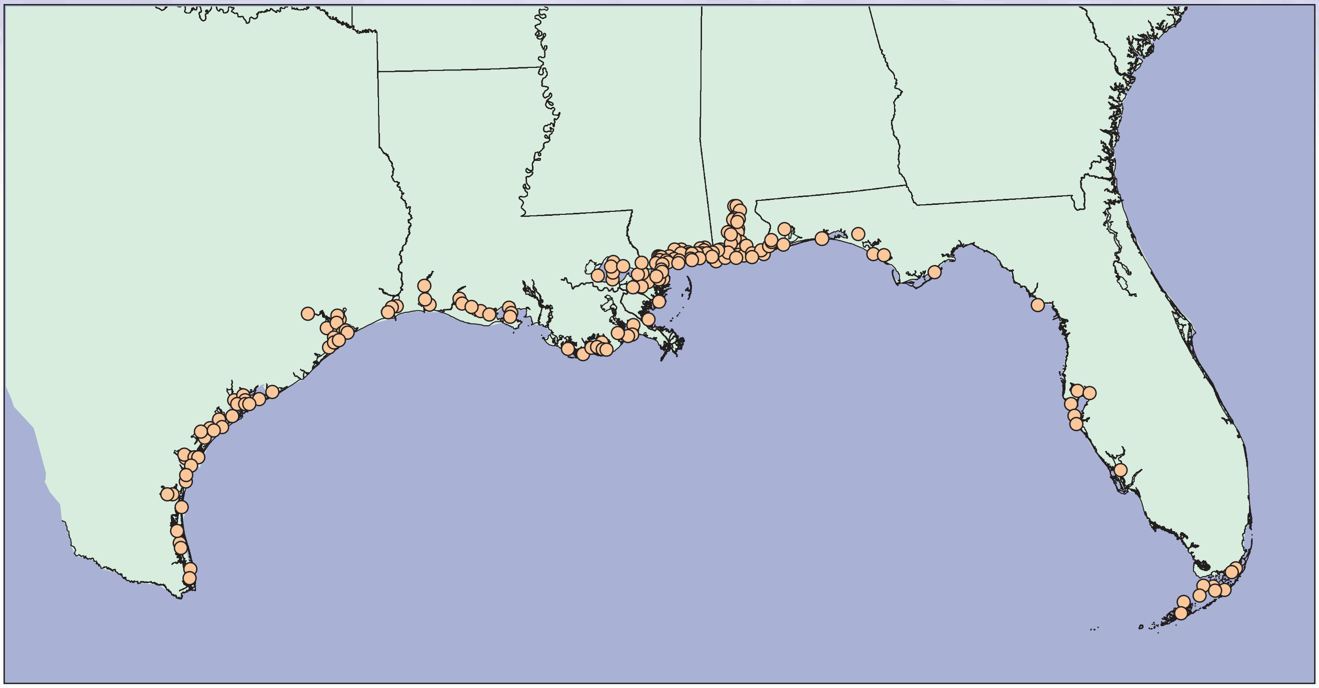


Figure 5-3. Gulf Coast sampling stations for the 2000 NCA Program surveys (U.S. EPA/NCA).

The population of coastal counties in the Gulf Coast region increased more than 100% between 1960 and 2000 (U.S. Census Bureau, 2003; Figure 5-4). EMAP focused its coastal monitoring efforts on Gulf Coast estuaries from 1991 to 1999 (Macauley et al., 1999; U.S. EPA, 1999). The Joint Gulf States Comprehensive Monitoring Program (GMP, 2000) began in 2000, in conjunction with EPA's Coastal 2000 Program. This partnership has continued as part of the NCA Program, with coastal monitoring being conducted by the five Gulf states through 2004. In addition, since the late 1980s, NOAA's NS&T Program has collected contaminant bioavailability and sediment toxicity data from several Gulf Coast locations (Long et al., 1996).

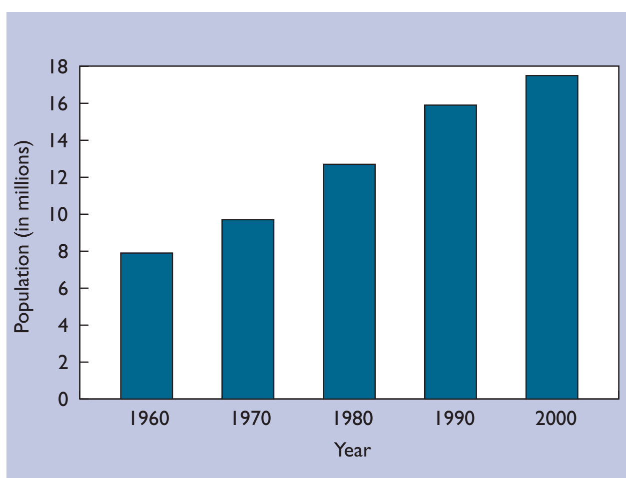
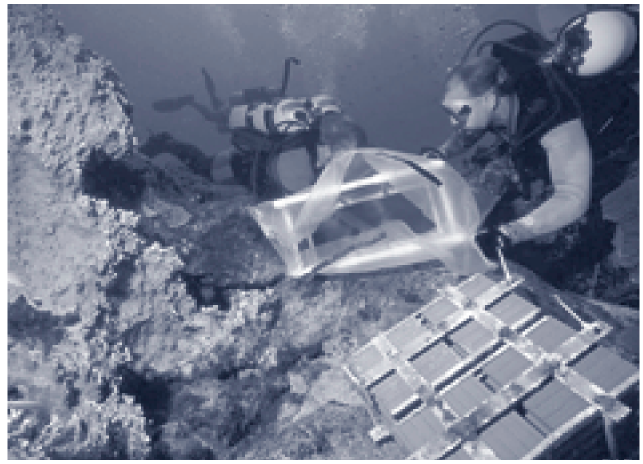


Figure 5-4. Population of coastal counties in Gulf Coast states from 1960 to 2000 (U.S. Census Bureau, 2003).

Coastal Monitoring Data

Water Quality Index

A water quality index was developed for Gulf Coast estuaries, using information from five indicators (DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen). Based on the 2000 NCA survey results, the water quality index is rated fair for Gulf Coast estuaries. In NOAA's Estuarine Eutrophication Survey (NOAA, 1999), the Gulf of Mexico was ranked poor for eutrophic condition, with an estimated 38% of the estuarine area having a high expression of eutrophication. The NCA survey in 2000 showed few estuaries in the Gulf Coast with poor water quality (9%); however, most Gulf Coast estuaries exhibited fair to poor water quality conditions (51%) (Figure 5-5). Estuaries with poor water quality conditions were found in all five states, but the contributing factors differed among states. In Texas and Louisiana, poor water clarity and high concentrations of DIP contributed to poor water quality. In Florida and Mississippi, poor water clarity and high chlorophyll concentrations were the major contributors. Only the Houston Ship Channel in Texas and the Back Bay of Biloxi in Mississippi had high concentrations of both nitrogen and phosphorus. The Perdido River in Alabama showed both hypoxia and high chlorophyll *a* concentrations.



Coral reef researchers Carl Beaver and Hector Guittierez secure a rack of tiles to the exposed reef rock (Ed Enns).

Nutrients: Nitrogen and Phosphorous

DIN concentrations in the surface waters of Gulf Coast estuaries are rated good, but DIP concentrations are rated fair. High concentrations of DIN (> 0.5 mg/L) occurred in 2% of the estuarine area (Figure 5-6). Florida Bay sites were rated poor if DIN exceeded 0.1 mg/L or if DIP exceeded 0.01 mg/L. This modification was made to comply with lower expectations for nutrients in tropical and subtropical waters. Only three sites had DIN concentrations above 0.5 mg/L: Houston Ship Channel, Texas; Calcasieu River, Louisiana; and Back Bay of Biloxi, Mississippi.

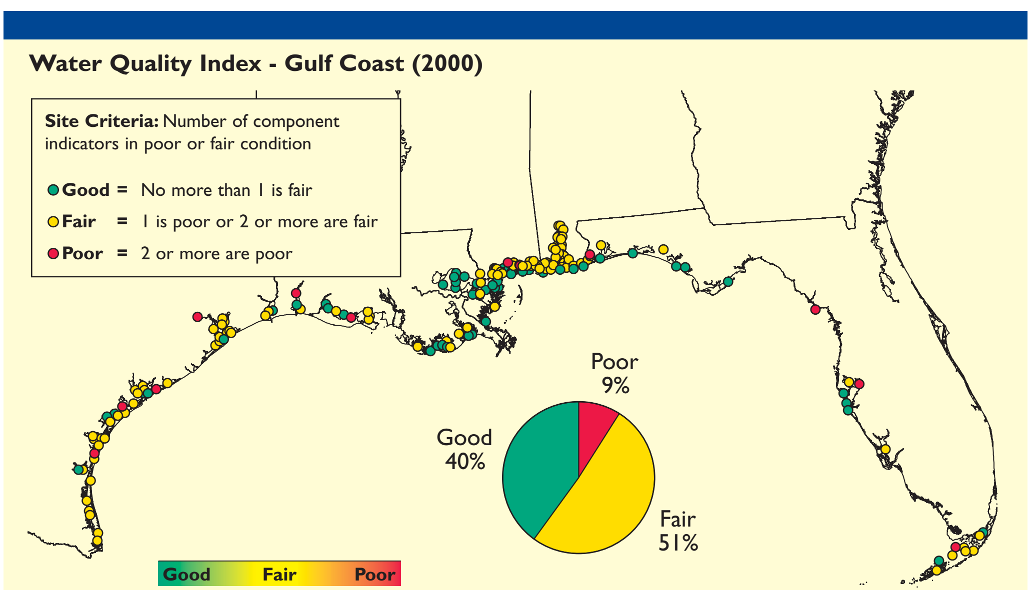


Figure 5-5. Water quality index data for Gulf Coast estuaries (U.S. EPA/NCA).

The sampling conducted in the EPA NCA Program has been designed to estimate the percent of estuarine area (nationally or in a region or state) in varying conditions and is 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 indicator 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.

Elevated DIN concentrations are not expected to occur during the summer in Gulf Coast waters because freshwater input is usually lower and dissolved nutrients are used more rapidly by phytoplankton during the summer. Elevated DIP concentrations (> 0.05 mg/L) occurred in 11% of Gulf Coast estuaries (Figure 5-7). Tampa Bay and Charlotte Harbor, Florida, have naturally high DIP concentrations because of geological formations of phosphate rock in their watersheds, but they also have significant anthropogenic sources of DIP in their watersheds.

Potential for Misinterpretation of Conditions for States with Smaller Coastlines

Alabama and Mississippi resource agencies are concerned that the figures presented in the Coastal Monitoring Data section of this chapter could potentially represent their estuaries unfairly. Both states have at least fifty locations that were sampled in the NCA Program's 2000 survey; however, because of the high density of these sites and the small estuarine resources of these states, even one or two sites rated poor (red circles) give the appearance of poor condition dominating a large portion of the entire coast of these states. Although showing the entire Gulf Coast region in a single graphic is consistent with the goals of this report, these displays do not provide a detailed view of all data, particularly for Alabama, Mississippi, and eastern Louisiana.

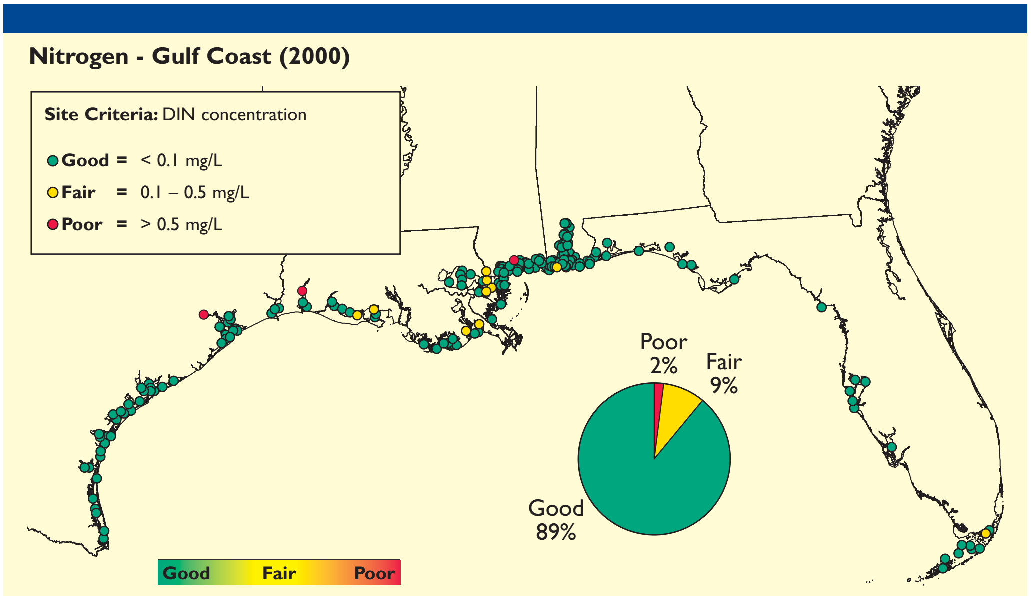


Figure 5-6. DIN concentration data for Gulf Coast estuaries (U.S. EPA/NCA).

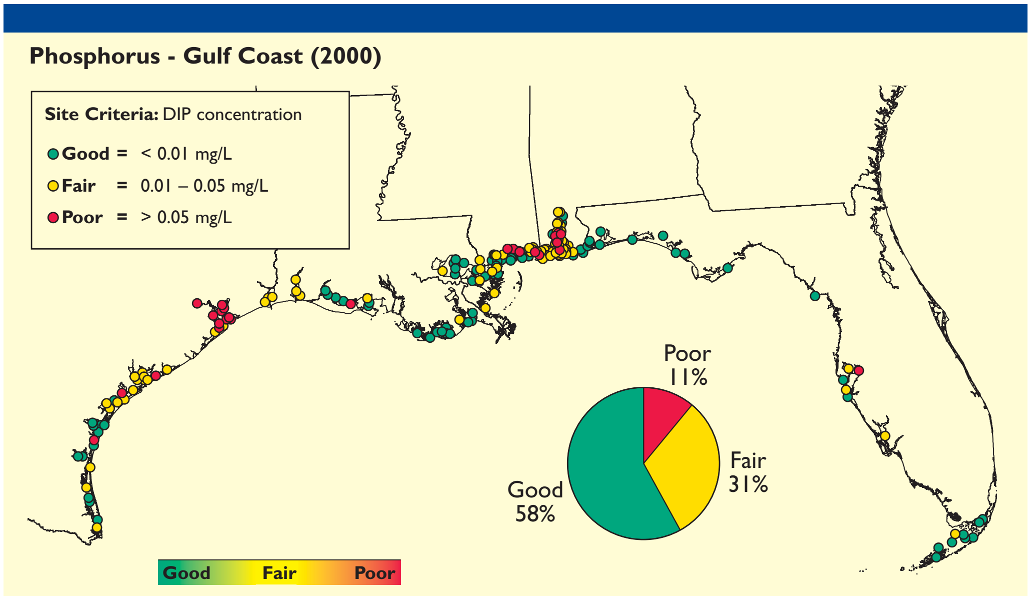


Figure 5-7. DIP concentration data for Gulf Coast estuaries (U.S. EPA/NCA).

The Gulf of Mexico Seagrass Status and Trends Summary Report

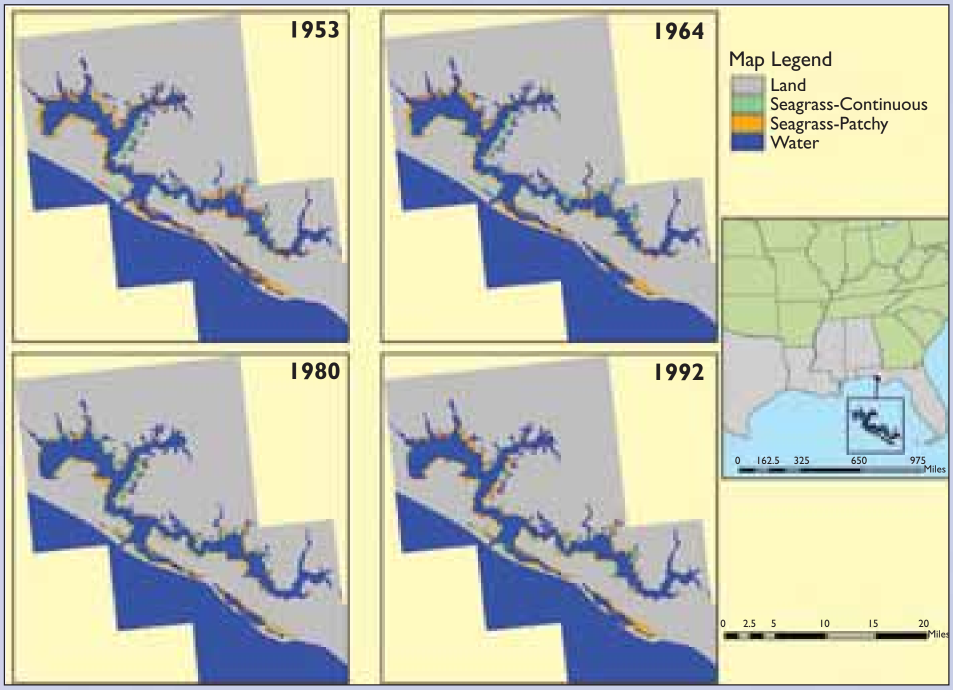
The Gulf of Mexico Program (GMP) is a network of citizens dedicated to promoting the economic health of the region by managing and protecting the resources of the Gulf of Mexico. Although administered by EPA, the GMP engages many organizations across the Gulf Coast region to implement and lead tangible projects that are environmentally and economically sound. The GMP includes representatives from state and federal agencies, nonprofit organizations, the scientific community, business and industry, and an organized citizens group. These members are appointed by the five Gulf state governors. The GMP focuses on three ecological issues: (1) public health, (2) excess nutrient enrichment, and (3) habitat degradation and loss, including the introduction of nonindigenous species.

The GMP has long recognized seagrasses, estuaries, and coastal wetlands as vital in providing food and shelter for plants and animals, improving water quality, sediment filtration, and flood and erosion control. In 1999, the GMP's Habitat Team set a goal to restore, enhance, or protect 20,000 acres of important coastal habitats of the Gulf by 2009. The Habitat Team, recognizing that seagrass beds are some of the most productive habitats in nearshore waters, set a goal to produce a Gulf-wide Seagrass Status and Trends (S&T) Summary Report. The purpose of the Summary Report is to provide current baseline information on the status of seagrasses in the Gulf of Mexico.

To produce this report, the GMP's Habitat Team formed a Seagrass Subcommittee, consisting of over 30 Gulf Coast seagrass scientists and environmental managers. Committee members provided data on seagrass maps, seagrass S&T, causes of change in seagrass acreage, monitoring activities, and restoration efforts important to their area. The USGS National Wetlands Research Center also provided extensive support in the production of data, maps, and editing that will comprise this summary. This map depicts total seagrass change from 1953 until 1992 for St. Andrews Bay, Florida.

In 1992, the total seagrass coverage in waters of the Gulf was estimated at 2.52 million acres (Duke and Kruczynski, 1992). The updated summary will provide a baseline for the status of seagrasses in the Gulf, as well as provide specific area and statewide seagrass information to scientists, managers, and decision makers.

A Seagrass Outreach document, written in layman's terms and developed for the general public, politicians, and Gulf of Mexico stakeholders, will accompany the Seagrass S&T Summary Report. Additional information will be available on the USGS National Wetlands Research Center's Web site at http://www.nwrc.usgs.gov and the GMP Web site at http://www.epa.gov/gmpo/.



Changes in seagrass coverage in St. Andrews Bay Systems, Florida, from 1953–1992 (produced by the USGS National Wetlands Research Center for the NCCRII).

Chlorophyll *a*

Chlorophyll *a* concentrations in Gulf Coast estuaries are rated good. Eight percent of the estuarine area in the Gulf Coast region had high concentrations of chlorophyll *a* (Figure 5-8). Concentrations above 20 µg/L occurred in Mississippi, Alabama, and Florida estuaries. Sites in Florida Bay were rated poor if concentrations of chlorophyll *a* were greater than 5 µg/L. This modification was made to comply with lower expectations for chlorophyll in tropical and subtropical waters.

Water Clarity

Water clarity in Gulf Coast estuaries is fair. The amount of ambient light that reaches certain depths underwater can be measured to provide an estimate of water clarity in coastal waters. Water clarity is affected by suspended sediments, particulate matter, and phytoplankton. A minimum level of water clarity is necessary to sustain SAV beds. Expectations for water clarity to sustain SAV vary across the Gulf of Mexico. In Florida Bay and Laguna Madre, for example, SAV beds flourish, and water clarity is usually high. In contrast, except for some widgeongrass, and duckweed, seagrass, and rooted SAV habitats rarely exist in estuaries in Louisiana because these waters are naturally turbid. Water clarity is expected to be low in Louisiana, Alabama, and Mississippi estuaries, as well as other northern Gulf Coast estuaries.

Water clarity was estimated from an index of expected conditions by comparing Secchi depth with a light-extinction coefficient. Gulf Coast estuaries were classified based on regional expectations for light penetration related to SAV distribution. Water clarity was determined to be good, fair, or poor by comparing a sample light-extinction coefficient calculated from the measured Secchi depth to a range of reference light-extinction coefficients. For approximately 29% of Gulf Coast estuaries, the water clarity measured was less than the reference standard (Figure 5-9). Lower than expected water clarity occurred throughout Gulf Coast estuaries, but was concentrated in the Coastal Bend region of Texas, Mississippi, and south Florida.

Although the current NCA approach used to assess water clarity is an improvement over the previous effort, it still may reach inappropriate conclusions regarding water clarity for parts of the Gulf Coast. Many of the Gulf Coast regions have high natural silt and suspended sediment loads. To modify the water clarity approach for this natural condition, researchers adjusted the approach by the "expected" water clarity levels to lower levels for much of the Gulf Coast. While this adjustment appears to have been successful for much of the Florida, Alabama, Mississippi, and Louisiana coasts, further adjustments may be necessary for Mississippi Sound and the Texas coast.

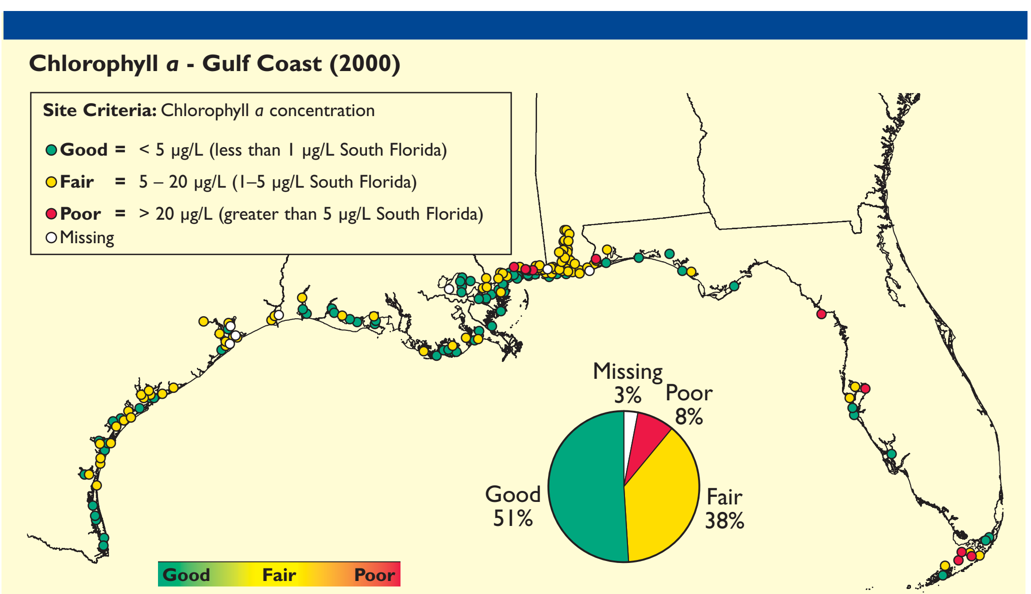


Figure 5-8. Chlorophyll *a* concentration data for Gulf Coast estuaries (U.S. EPA/NCA).

Dissolved Oxygen

Dissolved oxygen conditions in Gulf Coast estuaries are good. NCA estimates for Gulf Coast estuaries show that less than 1% of the bottom waters exhibit hypoxia (< 2 mg/L dissolved oxygen) in late summer (Figure 5-10). These areas are largely associated with Mobile Bay, Alabama, which experiences regular hypoxic events during the summer that often culminate in "jubilees." Occurrences of jubilees, when fish and crabs try to escape hypoxia by migrating to the edges of Mobile Bay, have been recorded since colonial times (May, 1973) and are most likely natural events. Hypoxia in Gulf Coast estuaries results from stratification, eutrophication, or a combination of these two conditions.

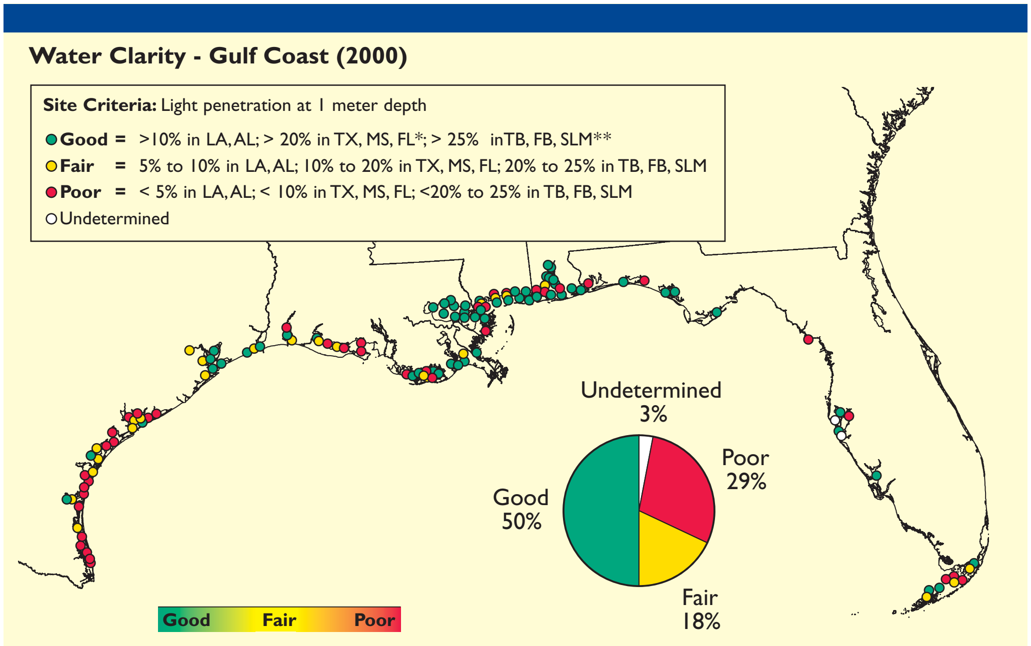


Figure 5-9. Water clarity condition for Gulf Coast estuaries (*FL = Florida Gulf of Mexico estuaries except Tampa Bay [TB] and Florida Bay [FB]; **SLM = southern Laguna Madre) (U.S. EPA/NCA).

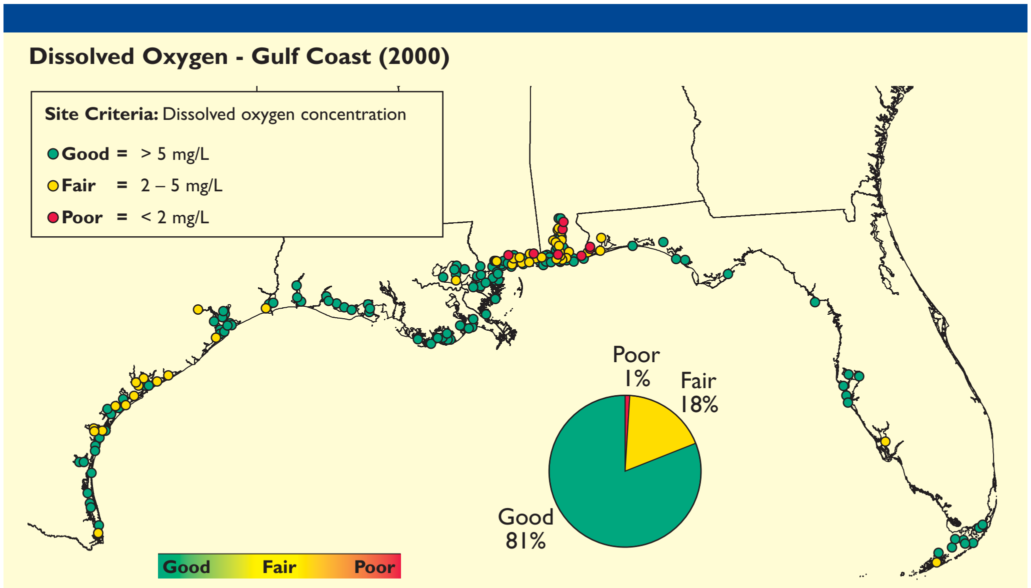
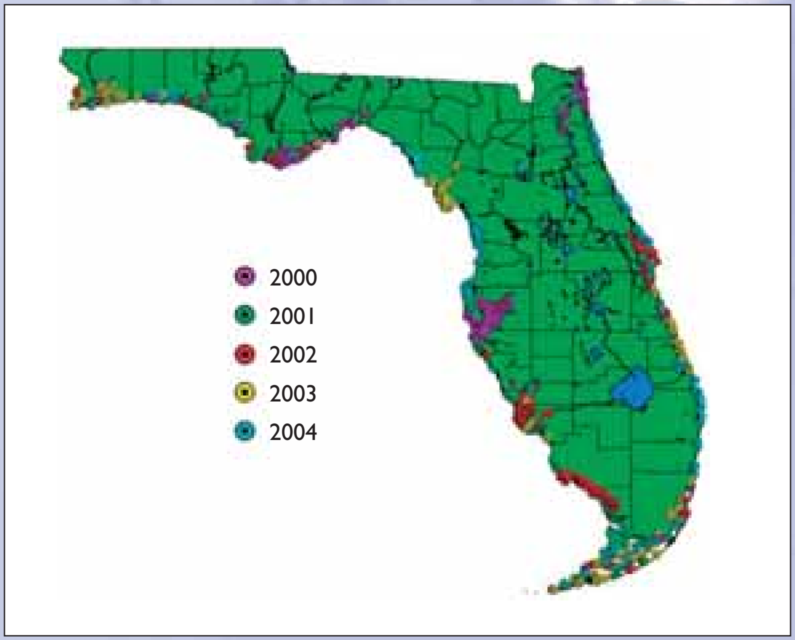


Figure 5-10. Dissolved oxygen concentration data for Gulf Coast estuaries (U.S. EPA/NCA).

Florida's Inshore Marine Monitoring and Assessment Program (IMAP)

Inshore marine resources are one of Florida's most valuable assets. These unique and diverse waters range from major embayments and lagoons to smaller river-mouth estuaries, tidal marshes, and mangrove forests that merge directly with the sea. The Inshore Marine Monitoring and Assessment Program (IMAP) is a collaborative project between EPA and the Florida Marine Research Institute (FMRI) designed to assess the environmental condition of Florida's inshore waters using established environmental indicators. IMAP serves as the inshore marine component of an Integrated Water Resource Monitoring Network (IWRMN). Within this network, Florida's Department of Environmental Protection Ambient Monitoring Program samples freshwater lakes, streams, and groundwater, while IMAP samples estuaries. These sampling schedules are coordinated so that both programs measure the same regions during the same years. This integrated approach allows the state of Florida to comprehensively assess the quality of all water resources within a region.

IMAP's coastal water survey design operates both regionally and statewide. The regions correspond to Florida's five water management districts. A probability-based survey design is used to select sample locations, applying latitude-longitude coordinates to identify randomly selected points within a network of hexagonal grids.



Florida IMAP sampling design, 2000–2004 (FMRI, 2003, unpublished data).

IMAP's environmental data represent the quality of the state's inshore waters and are collected from 180 sites every year (30 sites statewide, and 30 sites per one sampling unit in each water management district). Sampling is conducted during late summer when inshore resources are under significant stress and conditions are relatively stable. Physical-chemical indicators include water quality (e.g., dissolved oxygen, salinity, temperature, nutrients, and chlorophyll), sediment chemistry, and fish tissue chemistry. IMAP's biological indicators integrate environmental conditions over larger spatial and temporal scales. These indicators include fish and benthic invertebrate community composition, individual fish health, seagrass diversity and coverage, and the presence of toxic algae.

In 2000, IMAP sampled Florida's Apalachicola Bay, Lake Worth, Suwannee River, Tampa Bay, and the Nassau, St. Marys, and St. Johns rivers, as well as 30 other sites statewide. Hypoxic conditions, defined by dissolved oxygen levels <2 mg/L, were not observed in Florida during the summer of 2000. Sediment chemistry samples were collected only at the statewide sites, with several metals measured at levels above the threshold effects level (MacDonald, 1994), indicating the potential for adverse biological effects. These metals include mercury, arsenic, chromium, lead, nickel, and copper, although high concentrations were observed at only five sites statewide. Most organic compounds were not detected in Florida sediments. Biological samples included fish, benthic macroinvertebrates, seagrass, and toxic algae. A comprehensive assessment of the ecological condition of Florida's coastal waters will be completed at the end of the 5-year sampling period.

IMAP field crew using a seine to sample fish and invertebrates (photo courtesy of FMRI, 2003).

Although hypoxia is a relatively local occurrence in Gulf Coast estuaries, accounting for less than 1% of the estuarine bottom waters, the occurrence of hypoxia in the Gulf's shelf waters is much more significant. The Gulf of Mexico hypoxic zone, which occurs in waters on the Louisiana shelf to the west of the Mississippi River delta, is the second-largest area of oxygen-depleted waters in the world (Rabalais et al., 2002). From 1985 to 1992, the areal extent of bottom hypoxic waters in midsummer averaged 3,000 square miles; from 1993 to 1997, the average area doubled to 6,500 square miles (Rabalais et al., 1999). In the summer of 2000, the area of the hypoxic zone was reduced to 1,700 square miles, following severe drought conditions in the Mississippi River watershed (Figure 5-11). By 2002, the hypoxic zone had again increased in size to 8,500 square miles. Current hypotheses speculate that the hypoxic zone results from (1) water column stratification driven by weather and river flow and (2) decomposition of organic matter in bottom waters (Rabalais et al., 2002). Organic matter enters the Gulf of Mexico from the Mississippi River as either river-borne organic matter or phytoplankton growth stimulated by riverine-delivered nutrients (CENR, 2000). Annual variability in the area of the hypoxic zone is most likely related to rainfall in the Mississippi River watershed and its effect on river flow. Sediment cores from the hypoxic zone show that shelf algal production was significantly lower in the first half of the twentieth century, suggesting that anthropogenic changes to the basin and its discharges have resulted in the increased hypoxia (CENR, 2000).

Hypoxic Zone - Gulf Coast (2000)

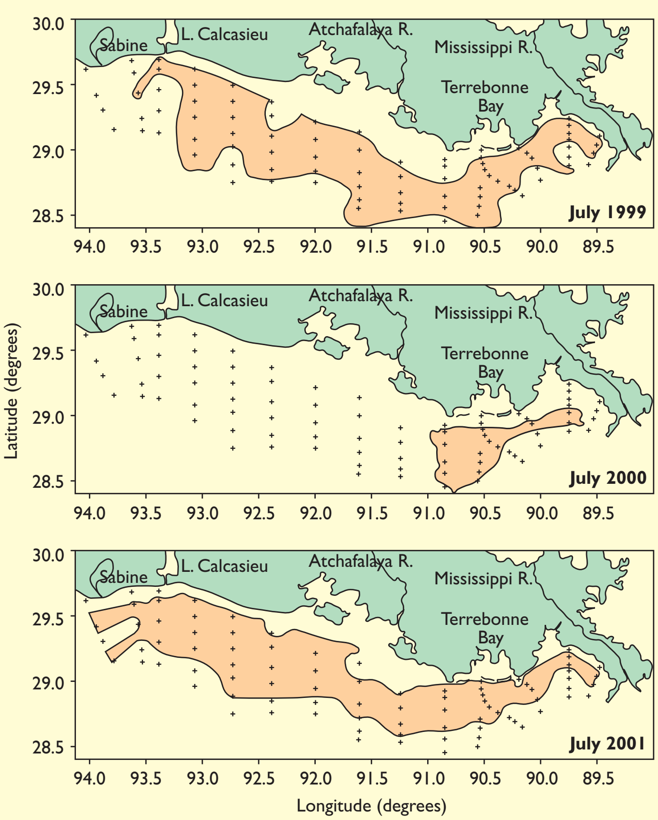


Figure 5-11. Spatial extent of the Gulf Coast hypoxic zone during July 1999, 2000, and 2001 (U.S. EPA/NCA, based on data provided by Nancy Rabalais, 2003, personal communication).

Since 1980, the Mississippi-Atchafalaya River basins, which discharge to this portion of the Louisiana shelf, have averaged 1.6 million mt of total nitrogen load annually (Goolsby et al., 1999). Nitrate load, which constitutes the bulk of total nitrogen load from the Mississippi River basin to the Gulf of Mexico, has increased 300% since 1970. Nonpoint sources contribute most of the nitrogen load to the Gulf of Mexico, particularly agricultural areas north of the confluence of the Ohio and Mississippi rivers (Goolsby et al., 1999). Gulf of Mexico ecosystems and fisheries are affected by the widespread hypoxia. Mobile organisms leave the hypoxic zone for more oxygen-rich waters, and frequently, those organisms that cannot leave die.

Estimates of Gulf of Mexico shelf hypoxia have not been included in the estimates of Gulf Coast estuaries hypoxia; consequently, this good rating for dissolved oxygen in Gulf Coast estuaries should not be considered indicative of offshore conditions.

White ibis feed in the mangrove areas that support a myriad of small crustaceans and fish on which they feed (Paul Goetz).

Sediment Quality Index

The condition of Gulf Coast estuarine sediment is fair, with 12% of the area exceeding thresholds for sediment toxicity, sediment contaminants, or sediment TOC (Figure 5-12).

Sediment Toxicity

Sediment toxicity data from the NCA show that less than 1% of Gulf Coast sediments are toxic (i.e., cause greater than 20% mortality in test organisms) (Figure 5-13). A high proportion (38%) of the toxicity data is missing because of various quality control issues. With this high level of missing data (38%), the proportion of sediments that are toxic could be greater than 1%. Previous bioeffects surveys by NOAA showed less than 1% toxicity in large estuaries in the Gulf (Long et al., 1996).

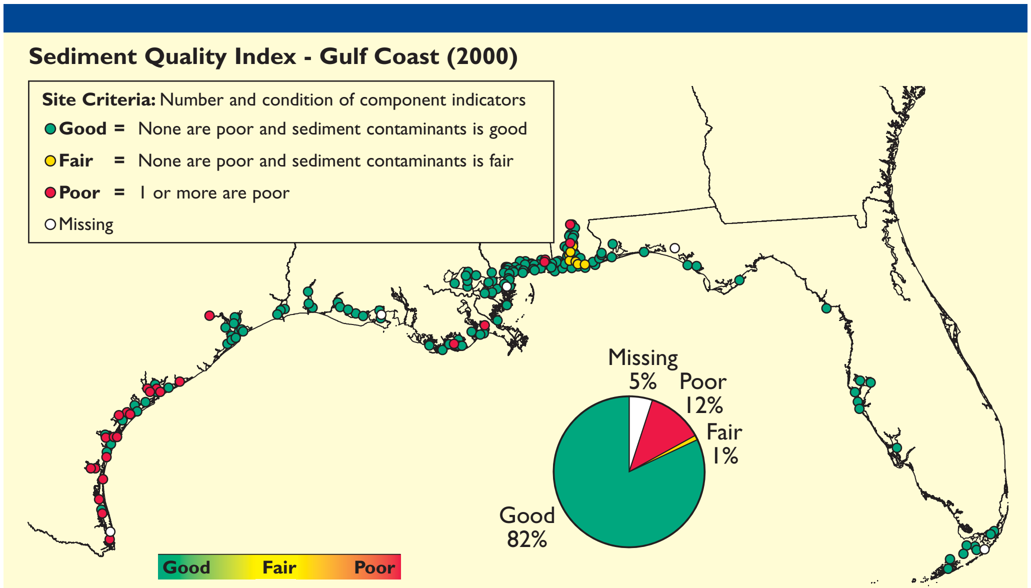


Figure 5-12. Sediment quality index data for Gulf Coast estuaries (U.S. EPA/NCA).

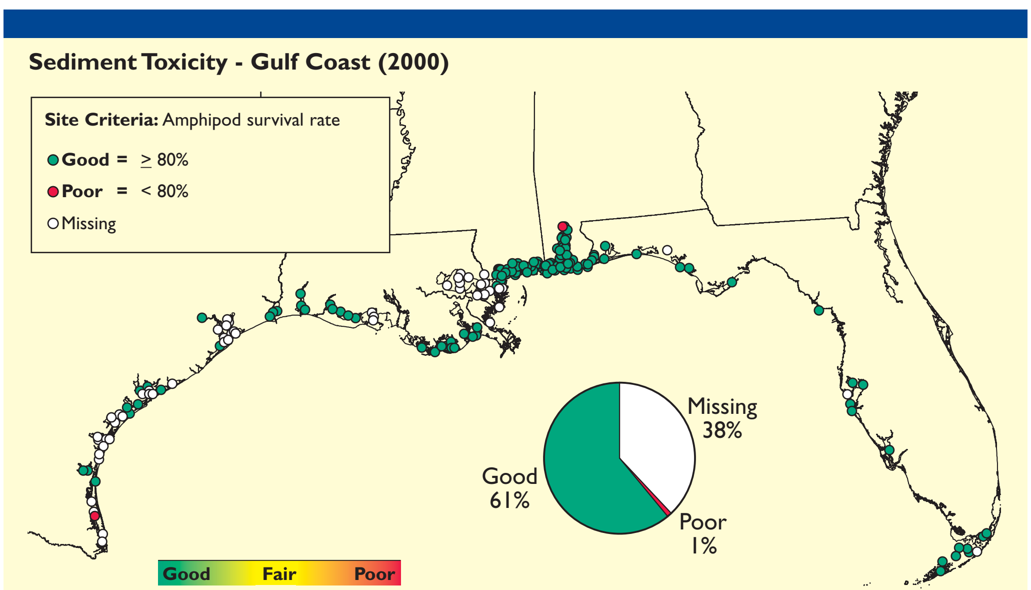


Figure 5-13. Sediment toxicity data for Gulf Coast estuaries (U.S. EPA/NCA).

Sediment Contaminants

Sediment contaminant concentrations greater than ERM guidelines (Long et al., 1995) were observed primarily in Texas estuaries (Figure 5-14). Concentrations of five or more sediment contaminants that were greater than ERL guidelines (Long et al., 1995) occurred only in Mobile Bay, Alabama. At least one metal exceeded ERL guidelines in 28% of the estuarine area, whereas only 12% to 14 % of the area exceeded guidelines for at least one pesticide or PCB. PAHs rarely exceeded ERL guidelines in Gulf Coast estuaries. No contaminant exceedances were observed in Florida's Gulf Coast estuaries.

Sediment Total Organic Carbon

Only 2% of the estuarine area in the Gulf Coast has high levels of sediment TOC (TOC > 5%; Figure 5-15).

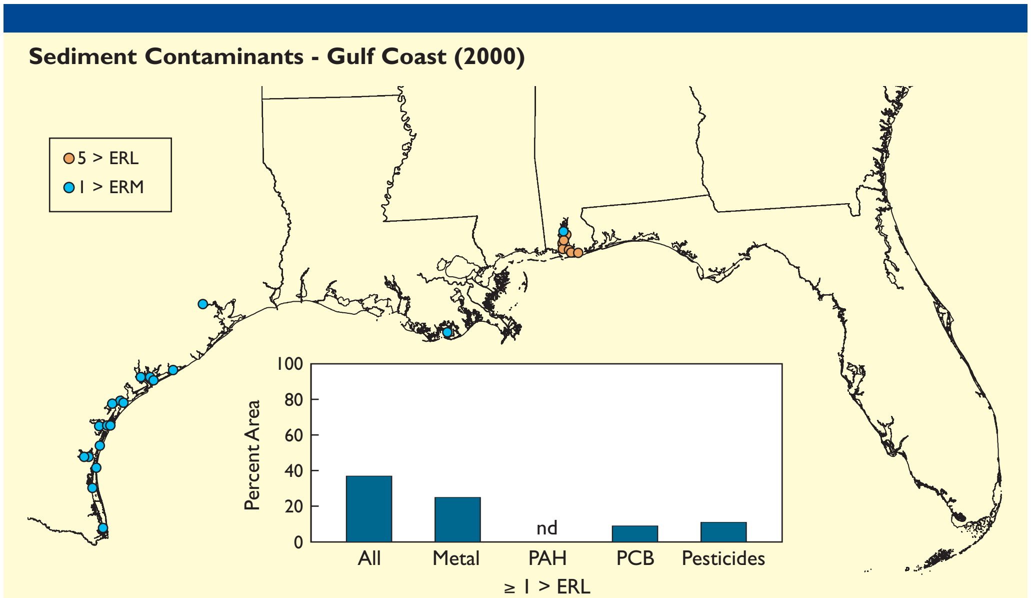


Figure 5-14. Gulf Coast estuary stations with at least one contaminant greater than ERM or at least five contaminants greater than ERL. The bar chart shows the percent area of Gulf Coast estuaries with at least one contaminant greater than ERL for separate categories of contaminants (U.S. EPA/NCA).

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 values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

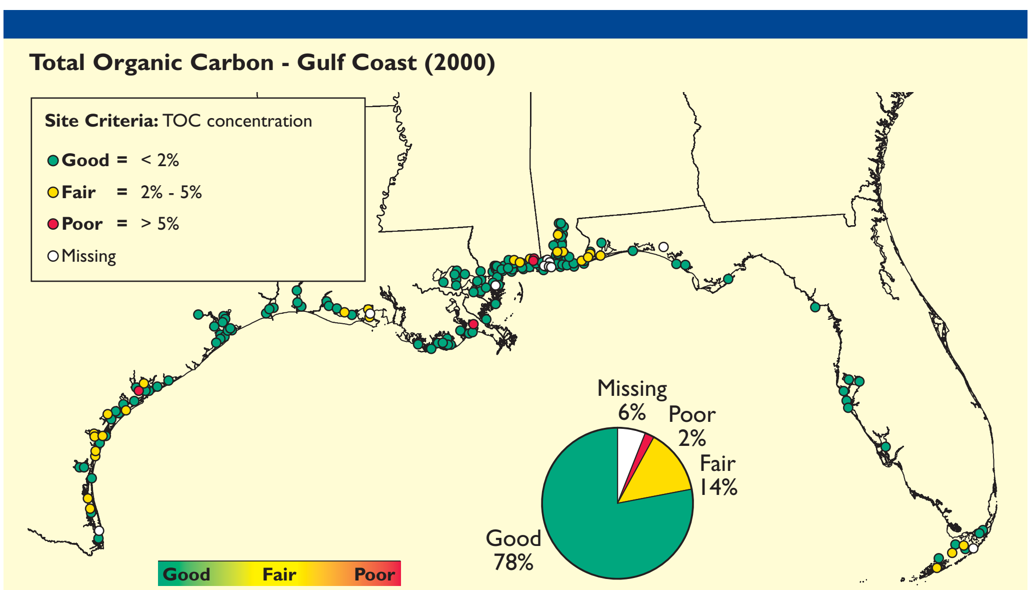
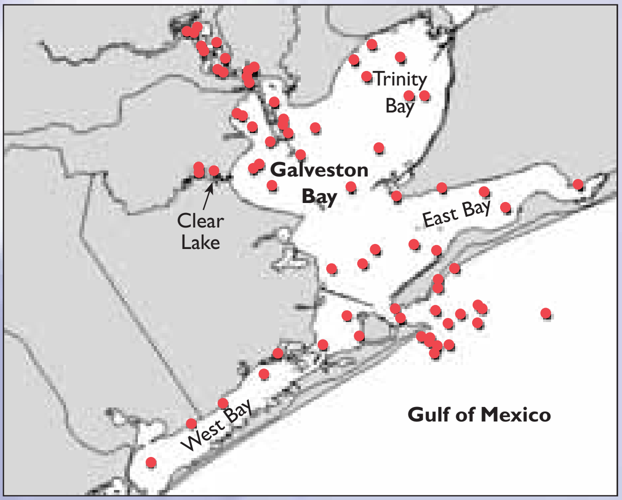


Figure 5-15. Sediment TOC concentration data for Gulf Coast estuaries (U.S. EPA/NCA).

Sediment Toxicity in Galveston Bay

As part of NOAA's NS&T Program, bioeffects surveys have been conducted in several major estuarine systems. Results from 22 surveys were summarized in the first National Coastal Condition Report; however, results from Galveston Bay were not available for publication until now.

Sediment contamination and toxicity were measured over the entire Galveston Bay area, from San Jacinto Park in the north out into the Gulf of Mexico, Trinity Bay, East and West Bay, and Clear Lake. In 1996, 75 stations were sampled using a stratified-randomized design within 21 different sediment layers. Bioassay tests of survival of amphipods exposed to whole sediment for 10 days showed no toxicity at any site. Fertilization tests of sea urchin eggs exposed to pore waters and tests of bioluminescence by bacteria exposed to organic extracts of sediment did show toxic responses. Over the 598.5 square miles of Galveston Bay, no whole sediment samples were toxic to amphipods; pore water extracted from 45% of the sites affected sea urchin fertilization; and organic extracts from 87% affected bacterial bioluminescence. All of these tests require some sediment manipulation prior to testing and do not precisely replicate actual environmental exposures. Required procedures for obtaining samples used in laboratory bioassay tests create conditions unlike those of actual exposures; thus, toxicity measured by these techniques does not necessarily represent the level of actual harm to organisms in the field.



Sediment sampling sites in Galveston Bay study (Harmon et al., 2003).

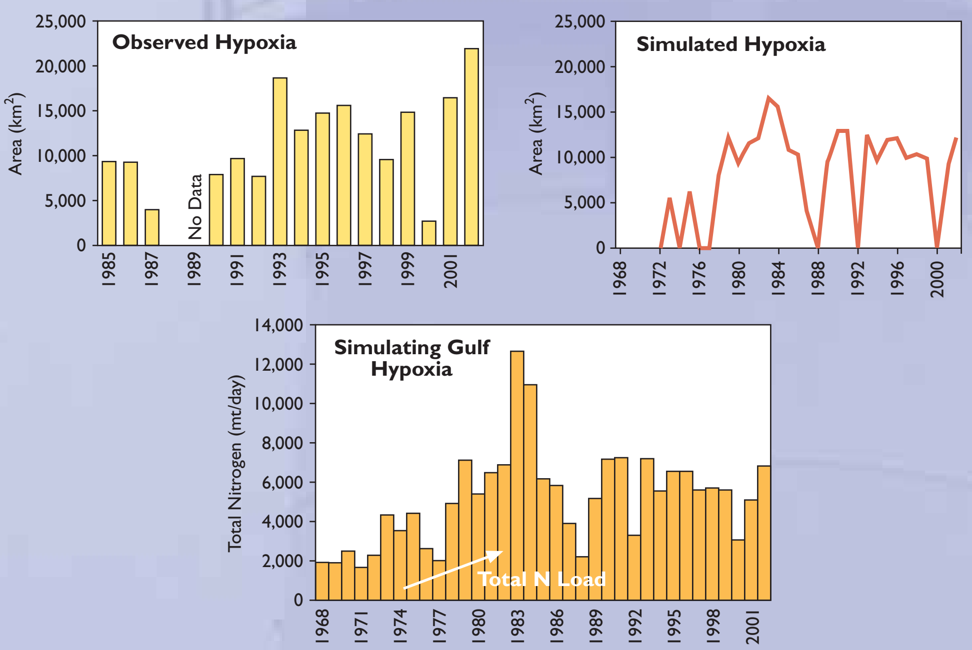
Conversely, the existing indigenous BMC at a site does experience real exposures. Among the 75 stations, a generally increasing gradient existed from north to south in the various ways of summarizing BMC structure, such as numbers of species, density of individuals and species, and species diversity. The lowest values for the BMC measures were found in Clear Lake. Using a criterion of benthic degradation as indicative of five or fewer species per sediment sample, 8% of Galveston Bay sediment samples would be considered degraded.

For more information, visit http://nsandt.noaa.gov/index_bioeffect.htm.

Gulf of Mexico Hypoxia Study

For 17 years, routine measurements of dissolved oxygen and nitrogen concentrations, coupled with computer modeling, have resulted in forecasts of Midwestern nitrogen usage effect on the northern Gulf of Mexico. Each spring and summer, extensive hypoxic regions develop in the Gulf of Mexico with bottom dissolved oxygen levels below 2 mg/L. These regions have recently extended from the mouth of the Mississippi River 372 miles westward past the Texas border. These hypoxic regions averaged 3,205 square miles from 1985 to 1992 and increased to an average of 16,178 square miles from 1993 to 2001.

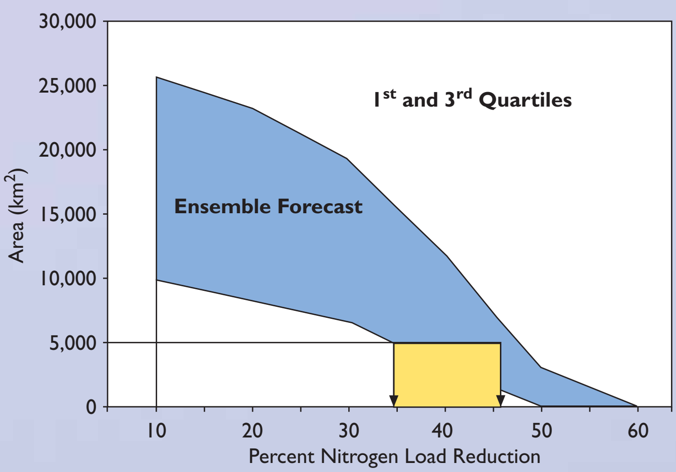
The effects of nutrient loading from the Mississippi River basin on the areal extent of hypoxia were examined using a novel application of a river dissolved oxygen model. The model, driven by river nitrogen load and a simple parameterization of ocean dynamics, reproduced 17 years of observed hypoxia location and extent, sub-pycnocline oxygen consumption, and cross-pycnocline oxygen flux. The model results correlate to those of the observed hypoxic zone areal extents from 1985 to 2002, with a few notable exceptions (see figure below). Hindcasts, using nitrogen loads between 1968 and 1984, suggest that before the mid-1970s, the nitrogen load was not sufficient to produce significant areas of oxygen-depleted bottom waters. Hindcasts show hypoxic areas of 1,930 to 3,860 square miles from 1973 to 1975, minimal hypoxia in 1976 and 1977, and significant and persistent large-scale hypoxia regions between 1978 and 1985.



Simulating Gulf Hypoxia (Scavia et al., 2003).

The Federal-State-Tribal Action Plan for reducing, mitigating, and controlling hypoxia in the northern Gulf of Mexico (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2001) agreed on a goal to reduce the 5-year running average of hypoxic area to less than 1,930 square miles by 2015. The plan suggested that a 30% reduction from the 1980 to 1996 average nitrogen load would be needed to achieve that objective and that most of the reduction would have to come from nonpoint sources as far as 620 miles north of the Gulf. The target reduction was based on current scientific information available and is similar to nutrient-reduction goals in other coastal systems in the United States (Boesch, 2002). This new model, however, suggests that a 30% reduction might not be sufficient to reach this goal in some years, and that it may take a reduction of 40% to 45% to ensure the reduction is attained (see figure below). Data collection and quantitative analyses should be continued if the success of the planned action to reduce nitrogen loading is to be determined, thereby improving future action plans.

For more information, visit http://www.nos.noaa.gov/products/pubs_hypox.html.



Effects of Reduced Nitrogen Load (Scavia et al., 2003).

Benthic Index

The condition of benthic communities in Gulf Coast estuaries is fair to poor. The composition of benthic invertebrate communities reflects long-term exposure to sediment condition in estuaries. Short-term changes in benthic communities occur in response to hypoxic events and disturbances. Indices of biotic integrity have been developed for aquatic systems to describe the condition of biotic communities. Engle and Summers (1999) developed a benthic index of condition for Gulf Coast estuaries. The benthic index integrates measures of diversity and populations of indicator species to distinguish between degraded and reference benthic communities. Benthic index estimates based on NCA 2000 surveys indicate that 17% of the estuarine area has degraded benthic resources (Figure 5-16). Most estuarine regions in the Gulf Coast showed some level of benthic degradation. Poor benthic condition co-occurred most often with poor water quality and poor sediment quality (Figure 5-17).

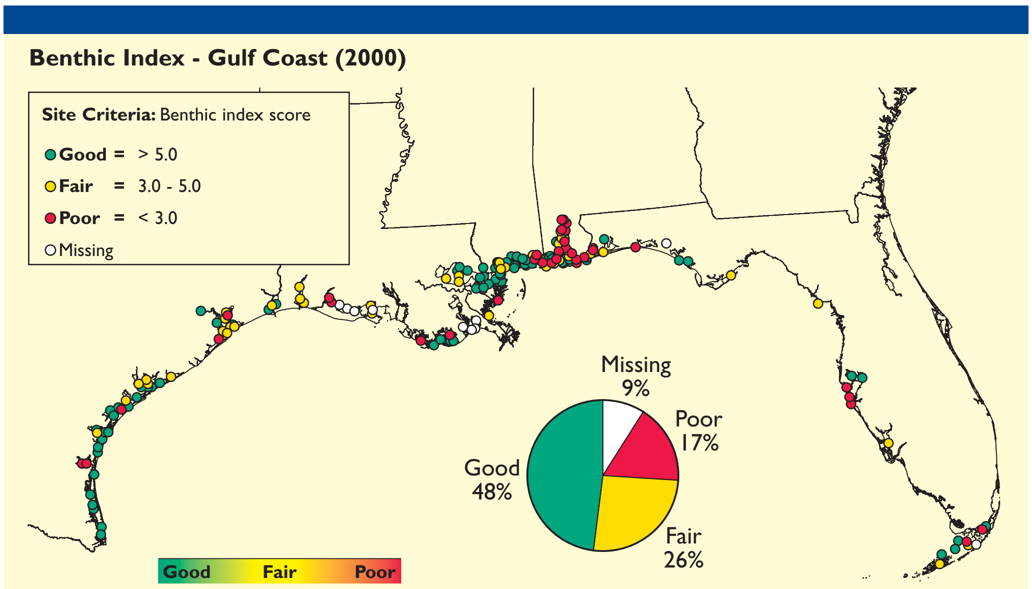


Figure 5-16. Benthic index data for Gulf Coast estuaries (U.S. EPA/NCA).

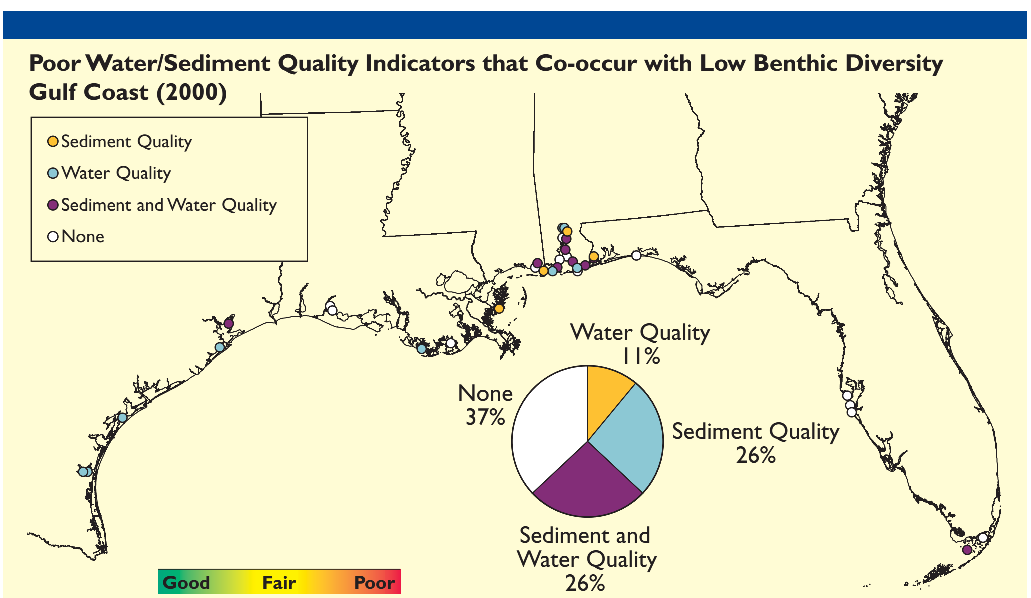
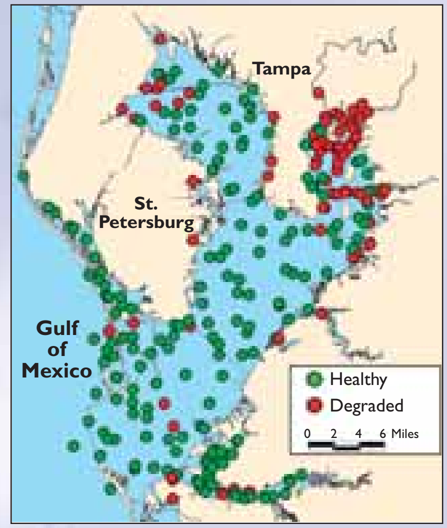


Figure 5-17. Locations in Gulf Coast estuaries where poor benthic condition co-occurred with poor sediment condition, low dissolved oxygen concentrations, or poor water clarity (U.S. EPA/NCA).

highlight

Using a Benthic Condition Index to Set Sediment Quality Targets in Tampa Bay, Florida



Sampling locations in Tampa Bay (TBEP, 2003, unpublished data).

Identification and remedial treatment of contaminated sediments are among the major priorities of the Tampa Bay Estuary Program (TBEP) (Long et al., 1994). Tampa Bay is a large, urbanized estuary in west-central Florida that is subject to the input of chemical contaminants, including metals, organochlorine pesticides, and the organic chemicals PCBs and PAHs (Zarboch et al., 1996). However, the overall benthic condition of the bay is good, with low dissolved oxygen conditions and elevated contaminants typically found in only a few areas.

During the past 7 years, TBEP partners and a national advisory group have worked together to implement a probabilistic benthic monitoring program based on the EMAP design and to develop narrative and numerical sediment quality targets for key indicators of sediment quality. One specific goal was to develop a benthic condition index (BCI) specific to Tampa Bay. This would allow TBEP to establish sediment quality guidelines based on the diversity and abundance of the benthos, as opposed to using costly and time-consuming chemical analysis.

The newly developed BCI will successfully classify sediments as healthy or degraded based on the observed benthos and will serve as a guide from which appropriate management decisions can be made. The BCI will be a refinement of an existing Tampa Bay Benthic Index (Grabe et al., 2002) that incorporates adjustments for salinity based on the work of Engle and Summers (1999). The Tampa Bay BCI was found to have a 90% dissolved oxygen success rate for classifying healthy and degraded samples based on benthos and dissolved oxygen concentration. It also classified 48% of the benthic samples into an intermediate category between healthy and degraded. For each intermediate sample, a numerical BCI value was calculated to quantify whether the sample was closer to a healthy or a degraded condition.

The TBEP is currently working on approaches to incorporate this revised BCI into a sediment quality target-setting process. One promising approach under consideration is to base sediment quality targets on the estimated geographic extent of healthy and degraded habitats and to track the magnitude and trends of these extents annually. The geographic extent, number of samples, and benthic condition of the intermediate samples (i.e., those between a healthy and degraded condition) could similarly be tracked over time. Together, these target-setting metrics can provide the status of degraded habitats and an early warning system to detect healthy habitats moving towards a degraded condition before they become fully degraded.

For more information, visit http://www.tbep.org

Coastal Habitat Index

The coastal wetlands indicator for the Gulf Coast is rated poor. Coastal wetlands, as defined here, include only estuarine and marine intertidal wetlands (e.g., salt and brackish marshes, mangroves and other shrub-scrub habitats, intertidal oyster reefs, and tidal flats, such as macroalgal flats, shoals, spits, and bars). This indicator does not include subtidal SAV, coral reefs, subtidal oyster reefs, worm reefs, artificial reefs, or freshwater/palustrine wetlands. From 1990 to 2000, the Gulf Coast region experienced a loss of 7,750 acres of estuarine wetlands (Figure 5-18). The long-term, average decadal coastal wetlands loss rate is 2.5%. Averaging these two loss rates and multiplying by 100 results in a coastal habitat index value of 1.30. Gulf Coast coastal wetlands constitute 66% of the total estuarine wetland acreage in the conterminous 48 states. Although the Gulf sustained the largest net loss of estuarine wetlands in the last decade compared with other regions of the country, the Gulf Coast region also has the greatest total acreage of estuarine wetlands (3,769,370 acres). Coastal development, sea-level rise, subsidence, and interference with normal erosional/depositional processes contribute to wetland loss along the Gulf of Mexico coast.

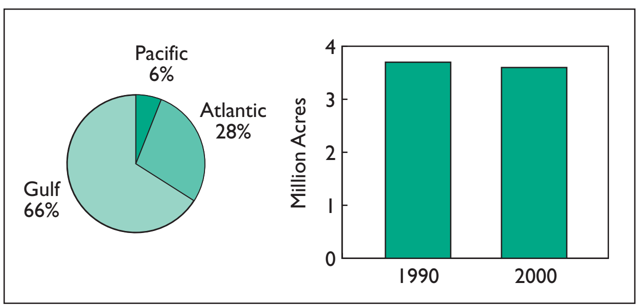


Figure 5-18. Estuarine intertidal wetland estimates for the Gulf Coast as acreage in 2000 and change in acreage from 1990 to 2000 (Dahl, 2003).

Fish Tissue Contaminants Index

Estuarine condition in Gulf Coast estuaries based on concentrations of contaminants in fish tissues is rated fair. Figure 5-19 shows that 14% of all sites sampled where fish were caught exceeded the risk-based guidelines used in this assessment. (Whole-fish contaminant concentrations can be higher or lower than the concentrations associated with fillets only. Only those contaminants that have an affinity for muscle tissue, e.g., mercury, are likely to have higher fillet concentrations. Fillet contaminant concentrations for most other contaminants will likely be lower.) However, for some populations that consume whole fish, these risk calculations are appropriate. Contaminant concentrations exceeding EPA guidance levels were observed in Atlantic croaker, some catfish, scianids, pigfish, pinfish, and shrimp. In Gulf Coast estuaries, the observed contaminants included total PCBs and DDT, and occasionally, cadmium, dieldrin, and mercury.

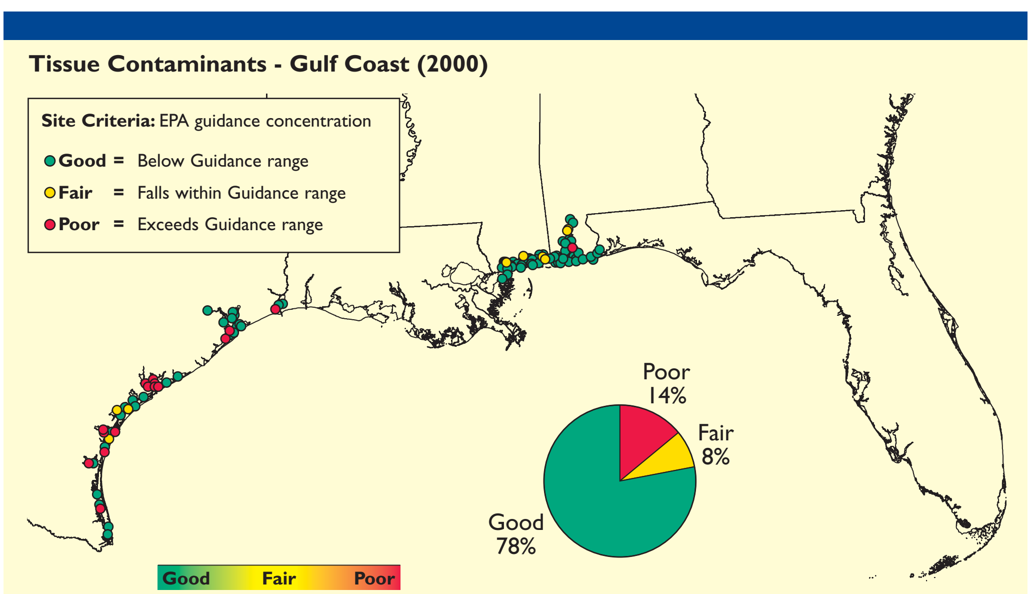


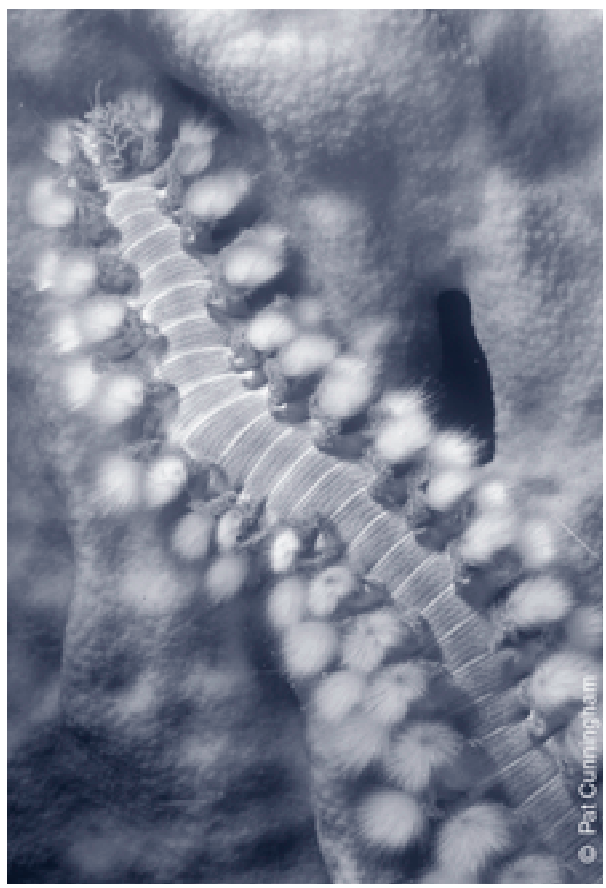
Figure 5-19. Fish tissue contaminants data for Gulf Coast estuaries (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries

The Gulf of Mexico LME bordering the United States includes diverse habitats ranging in salinity, flora, and fauna. It includes freshwater and estuarine habitats, nearshore and barrier islands, and oceanic communities. Watersheds contributing to the Gulf of Mexico LME drain the vast interior of the continent, including the piedmont and coastal plains as far north as the headwaters of the Missouri and Mississippi rivers. Along the coasts of western Florida, Alabama, Mississippi, Louisiana, and Texas, fresh water from upland regions mixes with prevailing oceanic waters in the Gulf of Mexico to create diverse wetland, marsh, and mangrove habitats that transition from freshwater to brackish to saltwater. This thin fringe of estuaries is very dynamic, with constant tidal fluctuations and varying levels of runoff. It serves as an important habitat for waterfowl, reptiles, mammals, fish, invertebrates, and a diversity of plants, and as a natural filter to remove pollutants and sediments from upland regions. It also maintains diverse aquatic communities and complex food webs in an irreplaceable nursery system that supports the recruitment and development of juvenile fish and invertebrate species that are important to recreational, commercial, and ecological interests.

Estuarine and inshore regions are largely buffered from the destructive effects of winds, waves, and occasional hurricanes by a long, thin system of barrier islands extending roughly end-to-end from western Florida to Texas. This natural system is composed primarily of unconsolidated sand, shell, and gravel deposited and redeposited through erosion and accumulation by the dynamics of prevailing oceanic currents, winds, and storms. A well-developed barrier island can produce and support a variety of habitats, ranging from coastal marine beach and maritime marsh on the seaward and inshore sides, to fresh or brackish marsh in the low inland areas, to dunes, shrubs, and forests in the upland areas.

The Gulf of Mexico LME beyond the continental shelf is a semi-enclosed oceanic basin connected to the Caribbean Sea by the Yucatan Channel and to the Atlantic Ocean by the Straits of Florida. Through the narrow but deep Yucatan Channel, a warm current of water flows northward, penetrating the Gulf of Mexico LME and looping around or turning east before leaving the Gulf through the Straits of Florida. This current of tropical Caribbean water is known as the Loop Current, and along its boundary, it produces numerous eddies, meanders, and intrusions that affect much of the hydrography and biology of the Gulf. A diversity of fish eggs and larvae are transported in the Loop Current, and the innumerable eddies, meanders, convergences, and divergences along the current's boundary tend to concentrate and transport early life stages of fish toward estuarine nursery areas, where the young can reside, feed, and develop to maturity.



Bearded fireworms can erect their venomous white bristles at the approach of a diver or other predator (Pat Cunningham).

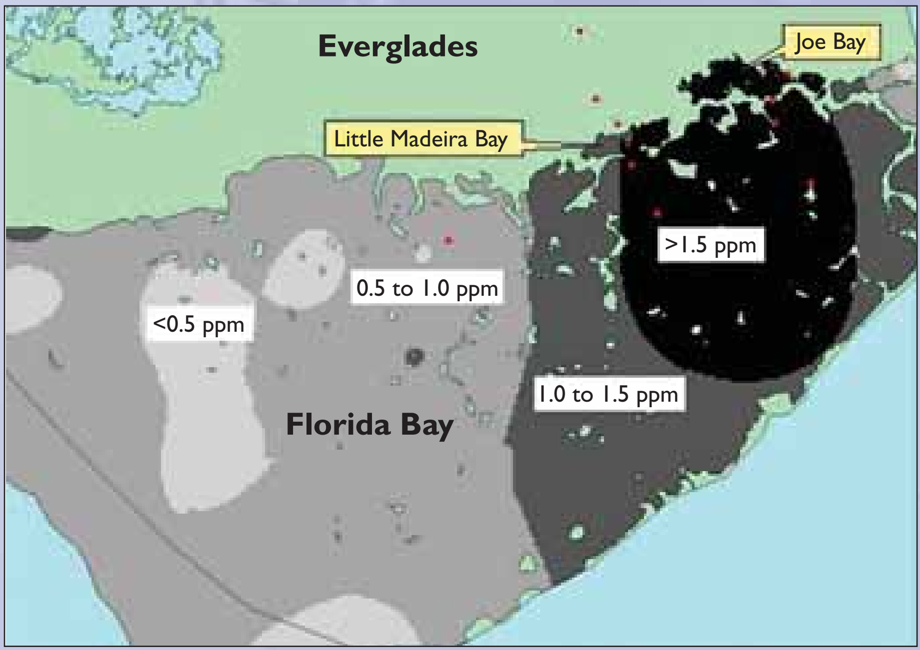
highlight

Florida Bay Mercury Study

The EPA's GMP report, *A Survey of Mercury in the Fishery Resources of the Gulf of Mexico*, identified two regional concentrations for mercury accumulation in fish from the Gulf of Mexico. One of these locations, Lavaca Bay, Texas, was highlighted in the previous National Coastal Condition Report. The extensive mercury contamination in Lavaca Bay is derived from an inactive chlor-alkali production facility.

The second concentration, located in Florida Bay, Florida, lies entirely within Everglades National Park. Surprisingly, there is no significant industrial source of mercury to Florida Bay. High mercury concentrations observed in fish from the Florida Bay are thought to be a result of natural conditions in Florida Bay and its Everglades watershed, which favors the methylation of inorganic mercury entering through nonpoint source runoff and atmospheric deposition. The area is currently under a fish consumption advisory. Gamefish such as spotted sea trout and jack crevalle have shown the highest mercury levels, with red drum, snook, and gray snapper also accumulating mercury to levels of concern.

The NOAA's Center for Coastal Fisheries and Habitat Research, Beaufort, North Carolina, and the South Florida Water Management District initiated a cooperative project to understand the sources of these high mercury concentrations. Studies have shown that the high mercury concentrations center in the region where fresh water from the Everglades enters the eastern



Mercury concentrations observed in spotted sea trout from Florida Bay. Two transects through the mangrove transition zone at Little Madeira Bay and Joe Bay sampled possible inputs of mercury from the Everglades (graphic provided by David W. Evans, NOAA).

portion of Florida Bay. Much of the freshwater habitat of the Everglades is also under a fish consumption advisory because of high mercury concentrations. This finding initially suggested that freshwater runoff was the dominant source of elevated mercury concentrations.

Researchers conducted two surveys of this region to sample for mercury in water, sediments, and fish and found that the watershed was not the only source of methylmercury contamination in fish. The mangrove transition zone that separates the terrestrial Everglades from Florida Bay produced the highest total mercury and methylmercury concentrations in water and sediments. The USGS measured the rate of mercury methylation in sediment samples and found significant methylmercury production occurring in the watershed, mangrove transition zone, and the bay itself. Methylmercury in water mixes among these three source areas, and the exposed fish that move amidst these source areas accumulate methylmercury through feeding. Through this cycle, fish from throughout eastern Florida Bay have bioaccumulated mercury in their tissues at levels of concern.

Such mercury concentrations in fish seem to have changed little over the past decade. This suggests that local reductions in atmospheric mercury emissions have not translated into mercury reductions in fish. Interest remains toward determining the properties of Florida Bay and the environs that contribute to these surprisingly high natural concentrations of mercury in fish. These concentrations may pose health risks for both human and wildlife consumers of fish from Florida Bay.

For more information, contact David Evans at david.w.evans@noaa.gov.

Gray snapper in the mangrove transition zone (Don Demaria).

Reef Fish Resources

Combined commercial and recreational landings of the reef fishes from the U.S. Gulf of Mexico LME have fluctuated since 1976 and show a slightly increasing trend over time. Meanwhile, fishing pressure in this region has increased significantly. The NOAA's Reef Fish FMP prohibits the use of fish traps, roller trawls, and powerheads on spearguns within an inshore stressed area; places a 15-inch total length minimum size limit on red snapper; and imposes data-reporting requirements. The red snapper fishery has been under stringent management measures since the late 1990s. A stock rebuilding plan proposed in 2001 provides (1) a 4,137-mt quota, and (2) bag limits, size limits, and commercial and recreational seasons. This plan, which will remain in effect until 2005, should provide stability and predictability in this important fishery for both industry and consumers. A 20% spawning-potential ratio was established as a basis to measure overfishing. Other regulations pertaining to the management of reef fishes within the U.S. Gulf of Mexico LME include minimum size limits, permitting systems for commercial fishermen, bag limits, quotas, seasonal closures, and the establishment of Marine Protected Areas that prohibit the harvest of any species.

Of the dominant reef fishes within the U.S. waters of the Gulf of Mexico LME, the red snapper and red grouper stocks are currently overfished, and the gag and greater amberjack stocks are approaching an overfished condition. The regulatory measures and stock rebuilding plans currently under way are designed to reduce fishing mortality and to continue or begin rebuilding all these stocks.

Reef species form a complex, diverse, multispecies system. The long-term harvesting effects on reef fishes are not well understood and require cautious management controls of targeted fisheries, as well as bycatch from other fisheries within the U.S. waters of the Gulf of Mexico LME.

Menhaden Fishery

Landings records in the Gulf Coast menhaden fishery date back to the late 1800s, although data to World War II are incomplete. During the 1950s through the 1970s, the fishery grew in terms of numbers of reduction plants and vessels, and landings generally increased with considerable annual fluctuation (Figure 5-20). Record landings of 982,800 mt occurred in 1984. Landings subsequently declined to a 20-year low of 421,400 mt in 1992. The decline in landings was primarily due to low product prices, consolidation within the menhaden industry, and a concurrent decrease in fishing effort, vessels, and fish factories in the northern Gulf of Mexico LME. Landings in recent years (1998–2002) are less variable, ranging between 486,200 and 684,300 mt (574,500 mt in 2002). Historically, Gulf Coast menhaden fishing ranged from the Florida Panhandle to eastern Texas. Currently, the fishery ranges from western Alabama to eastern Texas, with about 90% of the harvest occurring in Louisiana waters.

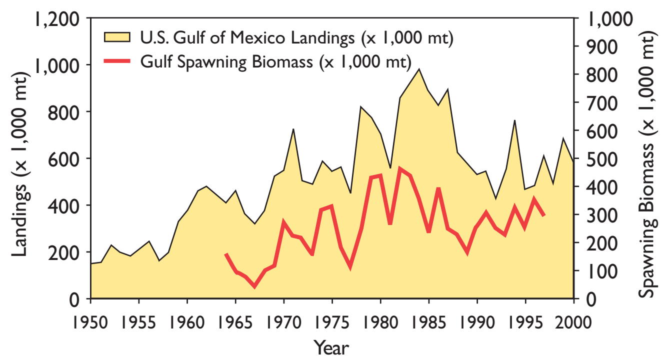


Figure 5-20. Landings and spawning biomass of Gulf Coast menhaden, 1950–2000, in metric tons (mt) (NMFS, 2003).

The 1999 assessment indicates that the menhaden stock is healthy and that catches are generally below long-term maximum sustainable yield estimates of 717,000 mt to 753,000 mt. Comparison of recent estimates of fishing mortality to biological reference points does not suggest overfishing. In 2003, four factories were processing Gulf Coast menhaden in the northern Gulf of Mexico LME (one in Mississippi and three in Louisiana), with a total of about 40 steamers.

Mackerel Fisheries

Total catch of Gulf Coast king mackerel averaged 3,467 mt per fishing year from 1981 to 2000, with a maximum of 5,599 mt (1982) and a minimum of 1,368 mt (1987). In 2001, total catch was 3,649 mt, with the recreational sector accounting on average for 62% of the total catch and the commercial sector for 38%. From 1986 to 1996, the landings were consistently above the total allocated catch, and by 1997, the Gulf of Mexico Fisheries Management Council increased the total allocated catch to 4,812 mt. Landings have oscillated about 3.882 mt in the last 4 years. The 2002 stock assessment indicated that the stock is currently fished at a rate near or at the maximum fishing mortality threshold, and the stock spawning biomass was slightly above the minimum stock-spawning threshold. The Mackerel Stock Assessment Panel concluded that the stock was not overfished or undergoing overfishing, although it recommended that fishing mortality rates be decreased to avoid a high risk of overfishing or overfished status in coming years. At present, the commercial fishery for Gulf of Mexico LME king mackerel has restrictions on minimum size, regional quota allocations, and trip catch limits, as well as gear restrictions. The recreational fishery is regulated with restrictions on minimum size and bag limits for Gulf of Mexico LME king mackerel.

Total catch of Gulf Coast Spanish mackerel averaged 2,081 mt per fishing year from 1984 to 2001, with a maximum of 4,586 mt (1987) and a minimum of 995 mt (1996). Catches dropped substantially (about 50%) in 1995–1996 because of the gill-net ban in Florida waters, where a major portion of the commercial catch took place. In 2001, total catch was 1,737 mt, with on average, a split of 54% from the recreational and 46% from the commercial sectors. Since 1989, the landings of Gulf Coast Spanish mackerel have been consistently below the total allocated catch, and since 1995, total landings have been about 50% of the total allocated catch. The 2003 stock assessment indicated that the stock is currently exploited at the optimum long-term yield level. At present, management restrictions for the commercial fishery of Gulf Coast Spanish mackerel include minimum size restrictions and quota allocation, plus gear restrictions in state waters. For the recreational fishery, minimum size and daily bag restrictions are in place. Current issues affecting this stock involve mainly the bycatch of juveniles in the shrimp trawl fishery.

Shrimp Fisheries

A general fluctuating increase in catch per unit effort (CPUE) was observed for white and brown shrimp from the late 1980s to 2001 (Figure 5-21). Between 1960 and the late 1980s, stocks of brown, white, and pink shrimp had generally shown a decline. A commercial shrimp-harvesting permit system for federal waters was initiated in 2001, with a proposed control date of December 2003. The Gulf of Mexico Fisheries Management Council is considering additional management measures, including measures that would potentially limit entry into the shrimp fishery. Current research is assessing the integrity of the shrimp stocks, as well as the overall economic well-being of the industry.

The most current status of Gulf of Mexico LME shrimp populations in U.S. waters is indicated by the 2000 and 2001 landing statistics. Catch rates of both brown and white shrimp populations were at high levels for the 2001 harvesting season. The 2001 CPUE for brown shrimp was near record levels, equaling 612 lbs/day. White shrimp CPUE for 2001 was also high at 416 lbs/day. Pink shrimp CPUE for 2000 was near the levels seen in the early 1990s. The current CPUE relative to historic levels, as well as the spawning population size indices, reveal no evidence of overfishing occurring within these populations.

All three of the commercial shrimp species are being harvested at maximum levels. Maintenance of shrimp stocks above the overfishing index levels should prevent overfishing of these populations. Because it has been shown that environmental factors determine production, negative effects on habitat have the potential to cause future reductions in shrimp catch. The loss of habitat, such as the destruction of wetland nurseries and the expanding dead zone in Louisiana, may cause declines in the shrimp harvest.

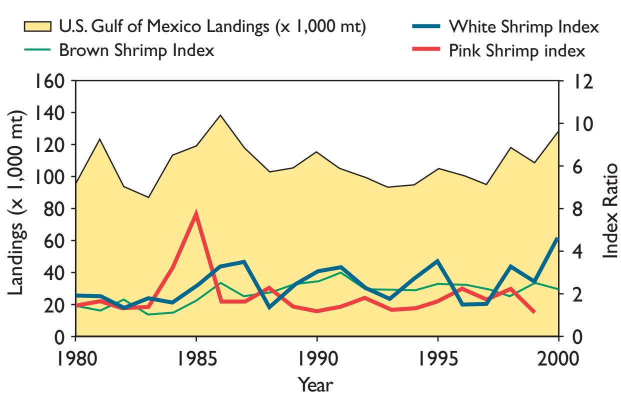


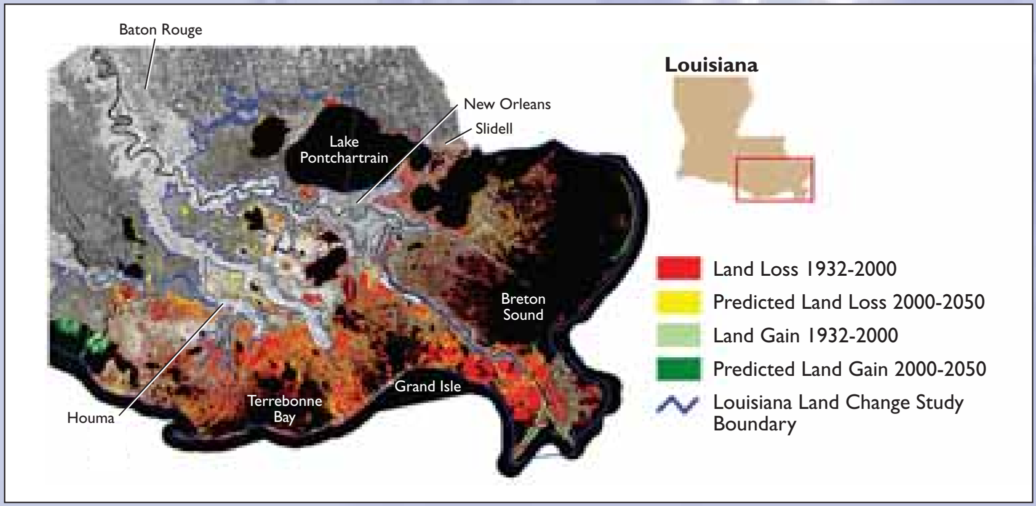
Figure 5-21. Gulf of Mexico shrimp landings, 1980–2000, in metric tons (mt) (NMFS, 2003).

highlight

Coastal Louisiana: America's Vanishing Wetlands

The Louisiana coastline was formed by sediment the Mississippi River carried down from 31 states and 2 Canadian provinces. The Mississippi River Watershed covers 41% of the lower 48 states; however, many factors have led to massive land losses to our nation's most productive coastlines, including actions taken upriver to improve public safety and the welfare of the heartland's economy, our nation's energy needs, global warming impacts, and land subsidence. According to the USACE, dams, levees, and navigation projects built along the Mississippi River's mainstream and major tributaries have resulted in a 67% decrease in sediment delivered to these coastlines. Coincidently, following the flood of 1927, navigation projects upriver, which were started in 1928 and completed in 1963, correspond to the first observations of major coastal land loss.

USGS data, generated in conjunction with the Louisiana Department of Wildlife and Fisheries, indicate that 878,000 acres of fresh marsh, 1.63 million acres of nonfresh marsh, and 1.15 million acres of forested and scrub/shrub wetlands make up a total of 3.7 million acres of coastal wetlands. Within the lower 48 states, Louisiana accounts for 30% of all coastal marshes, 45% of intertidal coastal marshes, and 14% of coastal wetlands (marshes, mangroves, and forests).



100+ years of land change for southeastern coastal Louisiana (Barras et al., 2004)

Within the last 70 years, Louisiana has lost more than 1.22 million acres of coastal wetlands. A new USGS model predicts that another 448,000 acres will vanish into the Gulf of Mexico in the next 50 years. The map of the Mississippi River delta shows the area where more than 70% of this loss has occurred in coastal Louisiana over the last 120 years. This loss exceeds the combined land area of the state of Delaware, the District of Columbia, and the Baltimore, Maryland, metropolitan area. On a national scale, Louisiana experiences about 90% of the total coastal marsh loss in the lower 48 states. These losses foreshadow serious natural resource problems and a societal and economic catastrophe, not only for Louisiana, but also for the entire nation.

Coastal Louisiana wetlands lie at the heart of an intricate ecosystem on the verge of collapse. These wetlands support the largest commercial fishery in the lower 48 states. They provide wintering habitat for millions of waterfowl and migratory birds, as well as a home for several endangered and threatened species. Coastal Louisiana maintains 20 national wildlife refuges and 2 national parks totaling more than 192,000 acres. Some of these areas are experiencing wetland losses that affect their capacity to support fish and wildlife.

A quarter of the nation relies on Louisiana wetlands as natural protection from storms and hurricanes for both people and property. The loss of these wetlands as a buffer could devastate the nation's energy security. Coastal Louisiana is the home of two U.S. Strategic Oil Reserve Sites (a necessity during national emergencies), encompassing thousands of miles of pipelines, numerous refineries, and gas production facilities. These resources provide heat and fuel to public homes and automobiles.

To address this enormous wetland loss issue, the state of Louisiana and the USACE, along with other federal and state partners, are conducting the Louisiana Coastal Area Comprehensive Coastwide Ecosystem Restoration Study. The goal of this effort is to develop a coast-wide comprehensive plan intended to sustain the coastal ecosystem. This ecosystem supports and protects the environment, economy, and culture of southern Louisiana and contributes to the economy and well-being of the nation. Final reports from this effort will be submitted to the U.S. Congress in fiscal year 2004 for authorization of a $14 billion effort.

For additional information and status of the study, please visit http://www.lacoast.gov.

highlight

Restoration of the Florida Everglades

The NMFS is working with the state of Florida, separate federal agencies, and local Native American tribes in an initiative to restore the Florida Everglades and its associated coastal ecosystems, including Florida Bay and the Florida Keys reef tract. The South Florida Ecosystem Restoration Initiative affects many of Florida's natural resource treasures, including Everglades National Park, Biscayne National Park, Dry Tortugas National Park, Big Cypress National Preserve, the Florida Keys National Marine Sanctuary, Rookery Bay National Estuarine Research Reserve, and Corkscrew Swamp Sanctuary.

The Comprehensive Everglades Restoration Project (CERP) is the initiative's congressionally mandated core program led by the USACE and the South Florida Water Management District. CERP's major objective is to restore the vitality and productivity of the remaining natural areas of South Florida. This involves integrated projects to redesign the Central and Southern Florida Flood Control Project. Uncertainty exists about Florida's original (pre-1870) hydrological framework, as well as those characteristics most responsible for maintaining former landscape patterns and the diversity and abundance of native plants and animals. CERP's goal is to reconstitute the natural hydrologic regime to Florida's wetlands and to replenish the quantity, quality, timing, and spatial distribution of freshwater flow to estuaries. Adaptive management, a science-based strategy involving modeling and monitoring of performance measures, is being applied to determine whether system responses are achieving these goals.

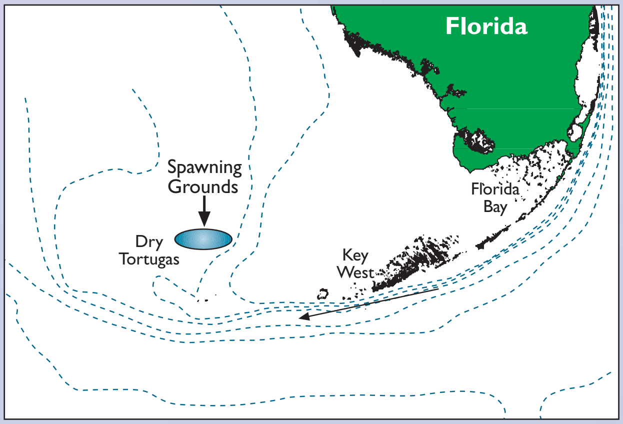

Florida Bay mangrove area.

Performance measures are calculable indicator characteristics that provide a quantitative sign of change. Indicators and performance-measure targets are being used to define goals and to determine whether CERP restoration efforts are being achieved. Water resource management for estuaries such as Florida Bay requires ecological performance measures that are applied, through modeling, to predict the effect of alternative design strategies and, through monitoring, to assess the effects of these projects once implemented. The NMFS is developing these ecological performance measures


Pink shrimp can be substantially affected by the range of the Florida Bay's salinity.

and predictive models to protect and restore essential fish habitats, a major NMFS mandate. The NMFS focus has been on key fishery species, such as pink shrimp, spotted sea trout, and gray snapper, which use estuaries such as Florida Bay as nursery grounds. Performance measures are also being developed for protected species, such as bottlenose dolphin, and a community of prey species, such as dolphin, wading birds, and game fish, which help transfer energy from primary producers to higher trophic-level species.

Developing a performance measure goes beyond the mere formulation of a metric, requiring an analytical understanding of ecological indicators so that any changes may be measured and interpreted correctly. For example, statistical analyses by NMFS researchers have suggested that pink shrimp harvests in the Dry Tortugas are influenced by freshwater inputs to Florida Bay. Adult pink shrimp spawn near the Tortugas, where they support a multi-million dollar fishery, but juvenile pink shrimp develop in Florida Bay and other southwest coastal estuaries. NMFS researchers, using a simulation model and laboratory tests, have determined that growth and survival of juvenile pink shrimp can be substantially affected by the range of the bay's salinity variation, thus identifying one possible link between harvests and freshwater inputs. NMFS and USGS researchers are sampling pink shrimp postlarval stages on both sides of Florida Bay to identify pathways and processes affecting immigration rates. Behavior may also be a factor because shoreward movement of juveniles on tidal currents is facilitated by the juvenile shrimp migrating vertically in the water column (up on the flood tide and down on the ebb tide). The salinity gradient is one possible behavioral cue guiding this vertical movement.



Adult pink shrimp spawning areas.

EPA's focus has been on the development of performance measures relative to water quality indicators. Phosphorus is an indicator of concern in freshwater wetlands, whereas nitrogen is the important indicator in some South Florida estuaries. Contaminants may also be detrimental to the CERP restoration effort. South Florida's hydrologic system has been physically altered to such an extent that correctly managing the water for estuaries may not automatically follow management procedures for upstream wetlands. Special design features may be necessary to provide fresh water in the right quantity and quality, at the right time, and at the right location to protect and restore estuaries. Performance measures will help make this possible.

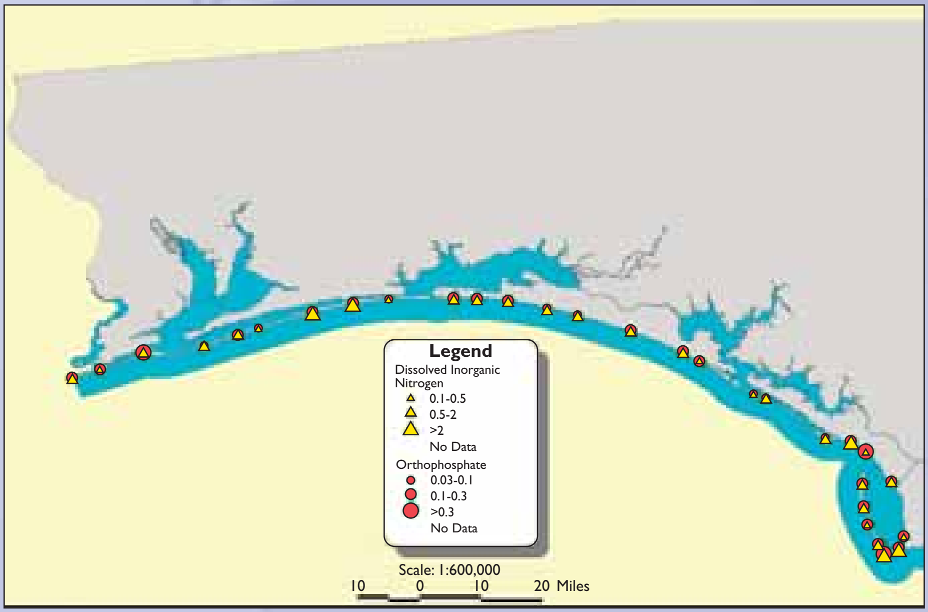
For more information, contact Nancy Thompson at nancy.thompson@noaa.gov.

highlight

A Pilot Study Assessing Beach Conditions in Northwest Florida

Gulf Coast beaches are a valuable local, regional, and national resource. Protection of this resource for recreation and other purposes is an important goal for resource managers. Using an approach similar to EPA's EMAP, EPA's Gulf Ecology Division conducted a pilot shoreline monitoring survey along the Florida Panhandle during August and September, 1999. The study area covered a stretch of coastline from Perdido Key to Port St. Joe, Florida, and included public beach areas. Researchers collected hydrographic data and water chemistry samples at 30 sites selected using a probability-based survey design. Bacterial indicators, enterococci, and fecal coliforms were enumerated in beach water samples according to the EPA Beaches Environmental Assessment, Closure, and Health (BEACH) Program and Florida State guidelines.

EPA developed the BEACH Program to reduce the risk of human illness associated with pathogens found at the nation's beaches and recreational waters through improved recreational water protection programs, risk communication, and scientific approaches. BEACH grants support the development and implementation of programs to inform the public about the risk of exposure to disease-causing microorganisms in the waters of our nation's beaches. The pilot study also measured additional indicators that included the presence or absence of primary and secondary dunes, anthropogenic debris, and vegetation.



Concentrations of DIN and orthophosphate measured at northwest Florida beaches (U.S. EPA/NCA).

Using EMAP evaluation guidelines and Florida state criteria for Class III swimmable waters, the survey indicated that more than 90% of the coastal beach area of northwest Florida met criteria for designated uses. Bacterial indicators are the major criteria for the protection of human health. Additional criteria for the ecological assessment of coastal beaches is lacking due to gaps in data. Such baseline data can help to determine if coastal areas meet designated uses and provide a comparative tool for evaluating future conditional trends from both a human health and an ecological perspective. Even if designated uses are currently met, resource managers must continue to monitor these waters to evaluate the potential for future problems, such as nutrient over-enrichment and fecal contamination. These problems can affect not only recreational beaches, but all shorelines. This pilot study demonstrates that the application of a probabilistic sampling design is a valuable procedure for assessing coastal shoreline condition.

Beach monitoring of bacterial contamination protects public health (U.S. EPA, Gulf Breeze Florida Laboratory).

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

Gulf Coast states assessed 11,219 (71%) of the 15,857 square miles that make up the Gulf Coast estuaries for their 2000 305(b) reports. The 2000 305(b) reports are generally based on data collected in the late 1990s. Although Florida reports water quality information for coastal waters, it is not possible from that report to distinguish between Atlantic and Gulf Coast listings; therefore, 305(b) assessment information for Florida is included in its entirety in this section. Forty-one percent of the assessed estuarine waters on the Gulf Coast fully support their designated uses, and 2% are threatened for one or more uses (Figure 5-22). The remaining 57% of assessed estuarine waters on the Gulf Coast are impaired by some form of pollution or habitat degradation. Individual use support for estuaries is shown in Figure 5-23 and Table 5-1.

Mississippi is the only Gulf Coast state that reported on its coastal shoreline. Mississippi assessed 94 miles, which is 1% of the Gulf Coast's 10,063 coastal shoreline miles. The other Gulf Coast states do monitor and assess their coastal waters, but they chose an alternate reporting method to meet their 305(b) requirements. Individual use support for assessed shoreline in Mississippi is shown in Figure 5-24. Individual use support for assessed coastal waters reported by Mississippi is shown in Table 5-1.

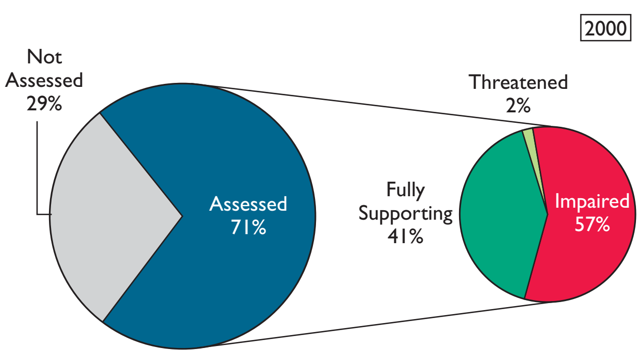


Figure 5-22. Water quality in assessed Gulf Coast estuaries (U.S. EPA, 2002).

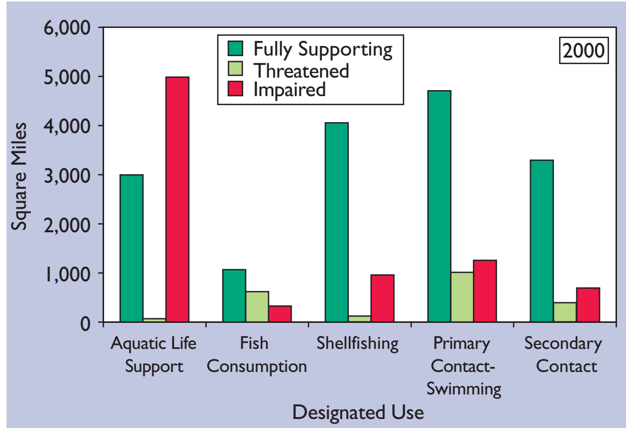


Figure 5-23. Individual use support in assessed Gulf Coast estuaries (U.S. EPA, 2002).

Table 5-1. Individual Use Support for Assessed Coastal Waters Reported by the States on the Gulf Coast under Section 305(b) of the Clean Water Act for 2000 (U.S EPA, 2002).

Individual Uses	Assessed Estuaries Impaired (mi^2)	Assessed Shoreline* Impaired (mi)
Aquatic life support	4,994 (62%)	0
Fish consumption	327 (17%)	0
Shellfishing	945 (18%)	89 (100%)
Primary contact – swimming	1,256 (18%)	26 (18%)
Secondary contact	687 (16%)	26 (81%)

*Data from Mississippi only

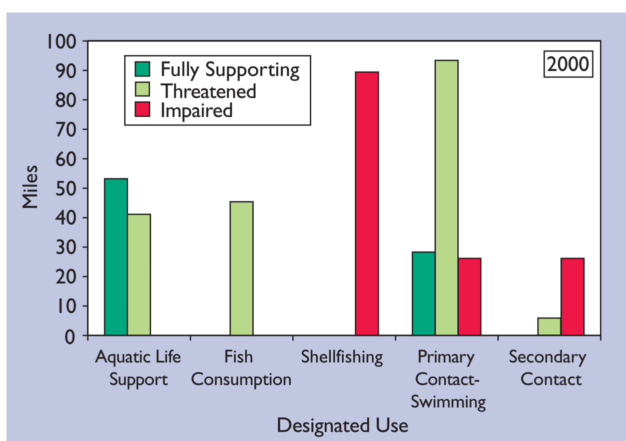


Figure 5-24. Individual use support for assessed shoreline waters in Mississippi (U.S. EPA, 2002).

Fish Consumption Advisories

In 2002, 13 fish consumption advisories were in effect for the estuarine and marine waters of the Gulf Coast. Most of the advisories (12) were issued for mercury, and each of the five Gulf Coast states had one statewide coastal advisory in effect for mercury in king mackerel (for fish longer than 39 inches). The statewide king mackerel advisories covered all coastal and estuarine waters in Florida, Mississippi, and Alabama, but covered only coastal shoreline waters in Texas and Louisiana. As a result of the statewide advisories, 100% of the coastal miles of the Gulf Coast and 23% of the estuarine square miles were under advisory in 2002 (Figure 5-25).

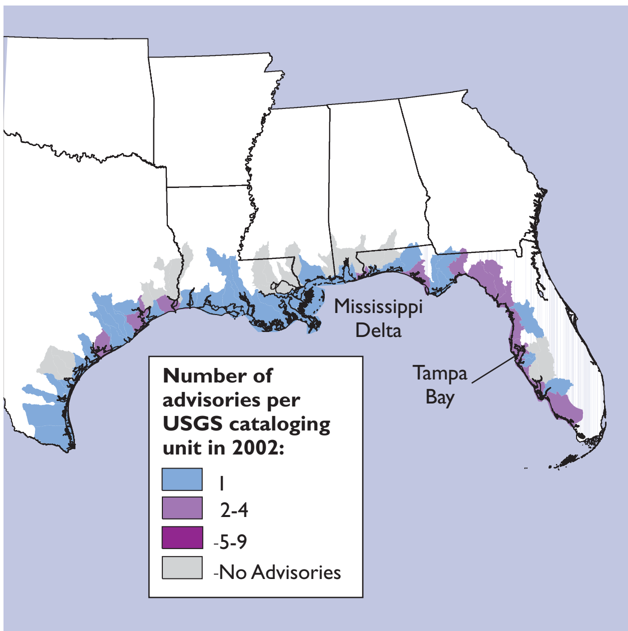


Figure 5-25. The number of Gulf Coast fish consumption advisories active in 2002 (U.S. EPA, 2003c).

Summary of fish and shellfish under human consumption advisories for at least some part of the Gulf Coast:

Barracuda	King mackerel
Blue crab	Ladyfish
Bluefish	Little tunny
Catfish	Permit
Crab	Red drum
Cobia	Shark
Gafftopsail catfish	Snook
Gag grouper	Spanish mackerel
Greater amberjack	Spotted seatrout
Crevalle jack	Wahoo

Source: U.S. EPA, 2003c

Fish consumption advisories placed on specific waterbodies included additional fish species (Figure 5-26). Florida had eight mercury advisories in effect for a variety of fish, in addition to the statewide coastal advisory. In Texas, the Houston Ship Channel was under advisory for catfish and blue crabs because of the risk of contamination by dioxins.

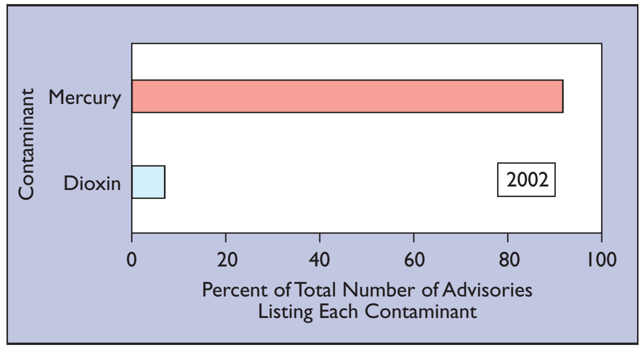


Figure 5-26. Percentage of estuarine and coastal marine advisories issued for each contaminant on the Gulf Coast. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2003c).

Beach Advisories and Closures

Of the 176 coastal beaches in the Gulf of Mexico that reported information to EPA, 36.9% (65 beaches) were closed or under an advisory for some period of time in 2002. Table 5-2 presents the numbers of beaches, advisories, and closures for each state. As shown in the table, Florida's west coast had the most beaches with advisories or closures, and Mississippi did not participate in EPA's 2002 survey. Figure 5-27 presents advisory and closure percentages for each county within each state.

Table 5-2. Number of Beaches and Advisories/Closures in 2002 for Gulf Coast States (U.S. EPA, 2003a)

State	No. of Beaches	No. of Advisories/ Closures	Percentage of Beaches Affected by Advisories/ Closures
Florida (Gulf Coast)	134	52	38.8%
Alabama	11	4	36.4%
Mississippi	N/A	N/A	N/A
Louisiana	1	1	100%
Texas	30	8	26.7%
TOTALS	176	65	36.9%

Most beach advisories and closings were implemented at coastal beaches along the Gulf Coast because of elevated bacteria levels (Figure 5-28). There were multiple sources of water-borne bacteria that resulted in advisories or closings. Stormwater runoff, other sources, and wildlife were frequently identified as sources. Unknown sources accounted for 36 percent of the responses (Figure 5-29).

In Florida, 39% (52 of 134) of beaches responding to the EPA reported that they had issued an advisory or closing at least once during 2002. The primary reasons for public beach notifications were preemptive actions due to rainfall events or the detection of elevated bacteria levels due a variety of sources, including unknown sources, stormwater and other runoff, wildlife, boat discharges, septic systems, and POTW discharges.

In Alabama, 11 coastal beaches responded to EPA's survey, and of these, 4 beaches (36%) reported advisories or closures during 2002 from elevated bacterial levels due to stormwater runoff, unknown sources, wildlife, and sewerline blockage or pipe breakage. In Louisiana, one beach, on the south shore of Lake Pontchartrain, reported being affected by a year-long advisory or closure during 2002 due to elevated bacterial levels from POTWs, sewerline blockage or pipe breakage, and stormwater runoff.

In Texas, 30 beaches reported information to the EPA, and of these, 8 beaches (26%) reported advisories or closures during 2002 due to elevated bacteria levels from unknown sources, stormwater runoff, wildlife, septic systems, boat discharges, sanitary sewer overflows, and sewerline blockage or pipe breakage.

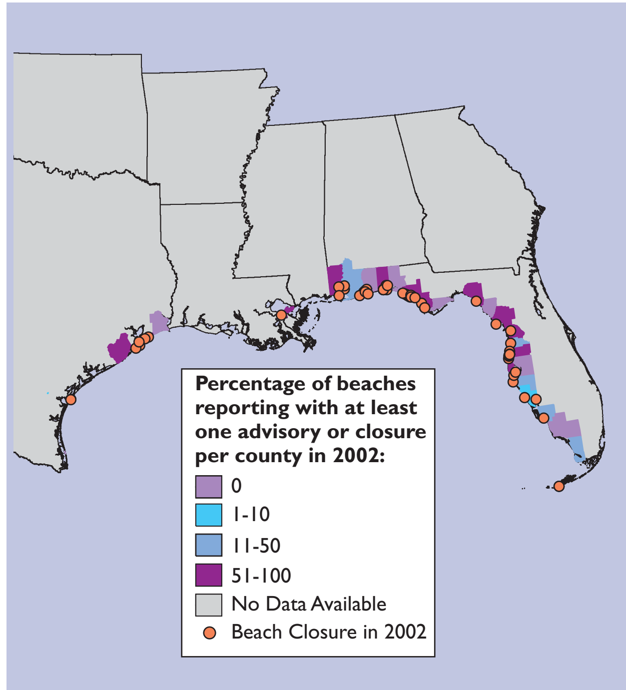


Figure 5-27. Percentage of Gulf Coast beaches with advisories or closures by county in 2002 (U.S. EPA, 2003a).

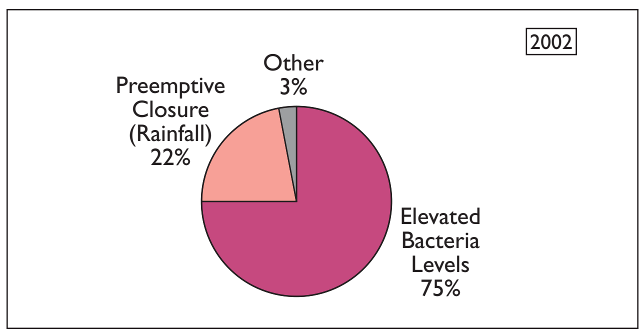


Figure 5-28. Reasons for beach advisories or closures on the Gulf Coast (U.S. EPA, 2003a).

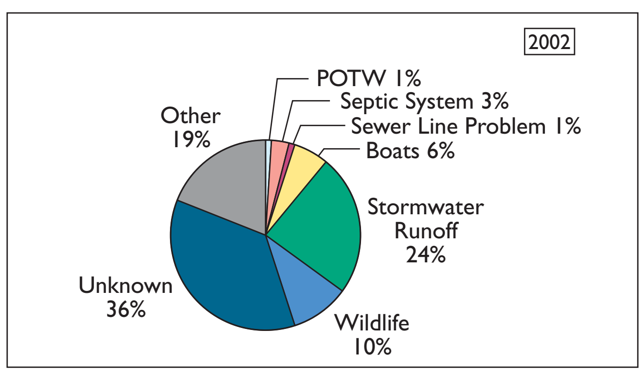
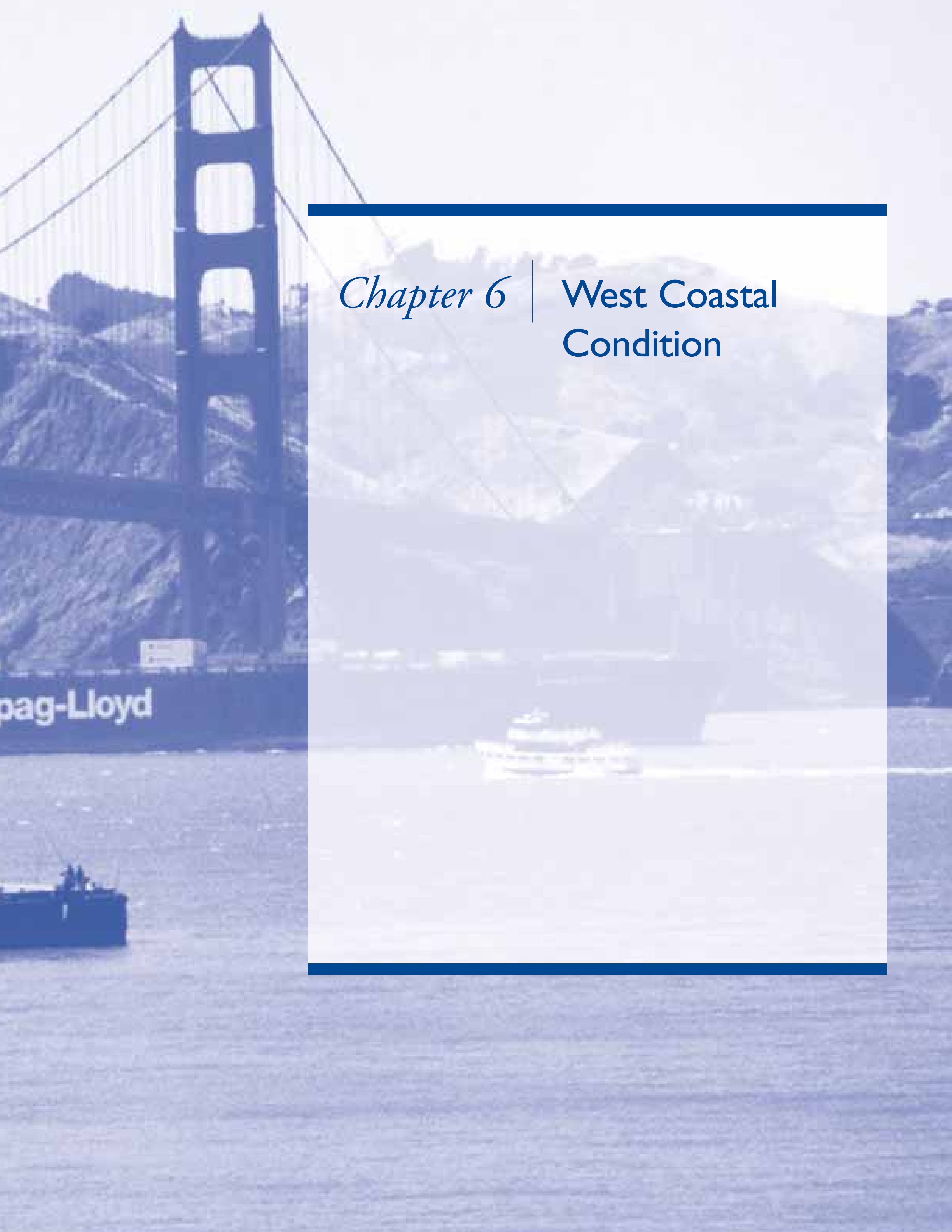


Figure 5-29. Sources of beach contamination on the Gulf Coast (U.S. EPA, 2003a).

A lime-green lettuce sea slug crawls through a meadow of mermaid's wine glass algae (Pat Cunningham).

Summary

Based on the indicators used in this report, ecological conditions in Gulf Coast estuaries are fair. The primary problem in Gulf Coast estuaries in 2000 was coastal wetland loss (rated poor). Fish tissue contaminants, benthic condition, and sediment quality were also of concern (rated fair). Fish tissue contaminant concentrations exceeded risk-based EPA Guidance levels in 14% of sites in Gulf Coast estuaries sampled for fish. These sites were dominated by elevated tissue concentrations of total PCBs and DDT, with some instances of dieldrin, mercury, cadmium, and toxaphene. Benthic index values were lower than expected in 17% of Gulf Coast estuarine sediments, and elevated sediment contaminant concentrations were found in 11% of estuarine sediments. About 2.5% of wetlands were lost per decade from 1780 to 1980, and about 0.25% of wetlands were lost between 1990 and 2000. The water quality index was rated fair (9% of estuarine area in poor condition), with only decreased water clarity and elevated DIP observed in more than 10% of estuarine area (29% and 11%, respectively). Elevated levels of chlorophyll *a* were observed in 8% of estuaries. DIN and dissolved oxygen concentrations rarely exceeded guidelines. Although conditions in Gulf Coast estuaries were among the worst in the country in 1990, the overall rating of 2.4 in this report is an increase from the rating of 1.9 observed in the early 1990s. Some of this improvement may be the result of modification of the water quality index to include nitrogen, phosphorous, and chlorophyll. Increasing population pressures in this region of the country will require additional monitoring programs and increasing environmental awareness in order to correct existing problems and to ensure that indicators that appear to be in fair condition do not worsen.



Chapter 6 | West Coastal Condition

West Coastal Condition

Ecological conditions in West Coast estuaries are fair to poor (Figure 6-1). Based on the 1999–2000 NCA surveys, 14% of the estuarine area in the West Coast region is unimpaired for aquatic life and human uses; 17% is impaired for aquatic life use; and 27% is impaired for human use (Figure 6-2). An additional 59% is considered threatened for these uses (fair condition); however, these survey results do not include benthic community data from San Francisco Bay, Puget Sound, or the Columbia River, and the percentages might be revised after the inclusion of that information. The estuaries that were found to be threatened for aquatic life use had extensive areas with elevated phosphorus concentrations and decreased water clarity.

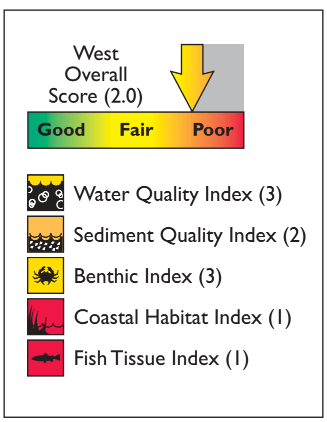


Figure 6-1. The overall condition of West Coast estuaries is fair. (This rating does not include benthic index or fish tissue contaminants information from the San Francisco Estuary, Columbia River, or Puget Sound system.)

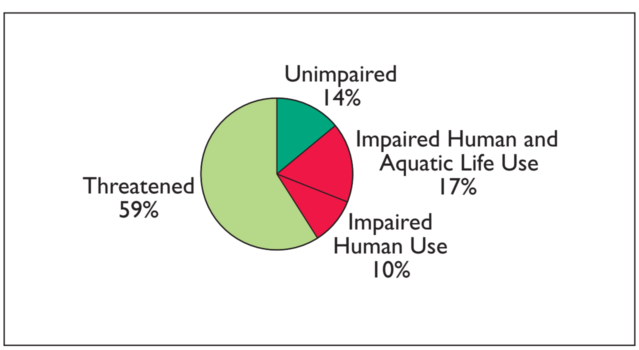


Figure 6-2. West Coast estuarine condition (U.S. EPA, NCA).

The estuaries of the West Coast of the United States represent a valuable resource that contributes to the local economies of the area and enhances the quality of life for those who work, live, and visit there. The population of 47 coastal and estuarine counties on the West Coast increased 13% between 1990 and 2000 to a total of 29.3 million (U.S. Census Bureau, 2001). Some counties adjacent to estuaries in the region (e.g., San Juan County, Washington, on Puget Sound) grew more than 40% over the 10-year period. Population growth rates for the counties bordering the greater Puget Sound region between 2000 and 2020 are projected to range between 16% and 54% (Puget Sound Water Quality Action Team, 2002). These growth rates suggest that human pressures on coastal resources will increase substantially in many areas of the West Coast.

The western coastline comprises more than 410 estuaries, bays, and subestuary systems associated with larger estuaries. Youngs Bay within the Columbia River and South Slough within Coos Bay are examples of subestuaries within larger estuarine systems. Such subestuaries share a number of characteristics with the larger estuarine system, such as climate and biogeographic province; however, they may differ from the larger estuarine system because of local hydrology, geomorphology, or pollutant inputs. The total area of the West Coast estuaries, bays, and subestuaries is 3,940 square miles, 61.5% of which is made up of the three large systems—the San Francisco Estuary, Columbia River, and Puget Sound system (including the Strait of Juan de Fuca). Subestuary systems associated with these large systems make up another 26.8% of the estuarine area. All the other West Coast estuaries combined equal only 11.7% of the total estuarine area. The range of estuary types on the West Coast is illustrated by the five order-of-magnitude range in size of the systems sampled by EMAP in 1999 and 2000—from 0.0237 square miles Yachats River, Oregon) to 2551 square miles (Puget Sound and Strait of Juan de Fuca).

The Golden Gate Bridge as seen from atop NOAA's Gulf of the Farallones National Marine Sanctuary Office at the Presidio, San Francisco, San Francisco Bay, California (Rich Bourgerie, Oceanographer, CO-OPS, NOS, NOAA).

The EMAP West Coast study area consists of two provinces, the Columbian and Californian Provinces. The Columbian Province extends from the Washington-Canada border to Point Conception, California. Within the United States, the Californian Province extends from Point Conception to the Mexican border. Some investigators place the break between the two provinces at Cape Mendocino, California, but EMAP data suggest a stronger faunal transition at Point Conception. There are also major transitions in the distribution of the human population along the West Coast. Major population centers occur in the Seattle-Tacoma area of Puget Sound, around the San Francisco Estuary, and generally around most of the estuaries of southern California. In contrast, the region of coastline north of the San Francisco Estuary through northern Puget Sound has a much lower population density.

Coastal Monitoring Data

In 1999, the Washington Department of Ecology (DOE), Oregon Department Environmental Quality, Moss Landing Marine Laboratories, San Francisco Estuary Institute, and the Southern California Coastal Water Research Project initiated a project to assess the condition of the approximately 400 estuaries, subestuaries, and tidal rivers along the West Coast (Washington, Oregon, and California). The assessment used a probabilistic design and, in 1999, sampled 210 locations in small estuarine systems (Figure 6-3) for dissolved oxygen, light penetration, sediment toxicity, sediment contaminants, tissue residues, fish community parameters, and benthic communities. In 2000, similar data were collected from 171 locations in Puget Sound, the San Francisco Estuary, and the lower Columbia River (Figure 6-3). In both Puget Sound and the San Francisco Estuary, data collection involved extensive collaboration between EPA's NCA and NOAA's NS&T programs.

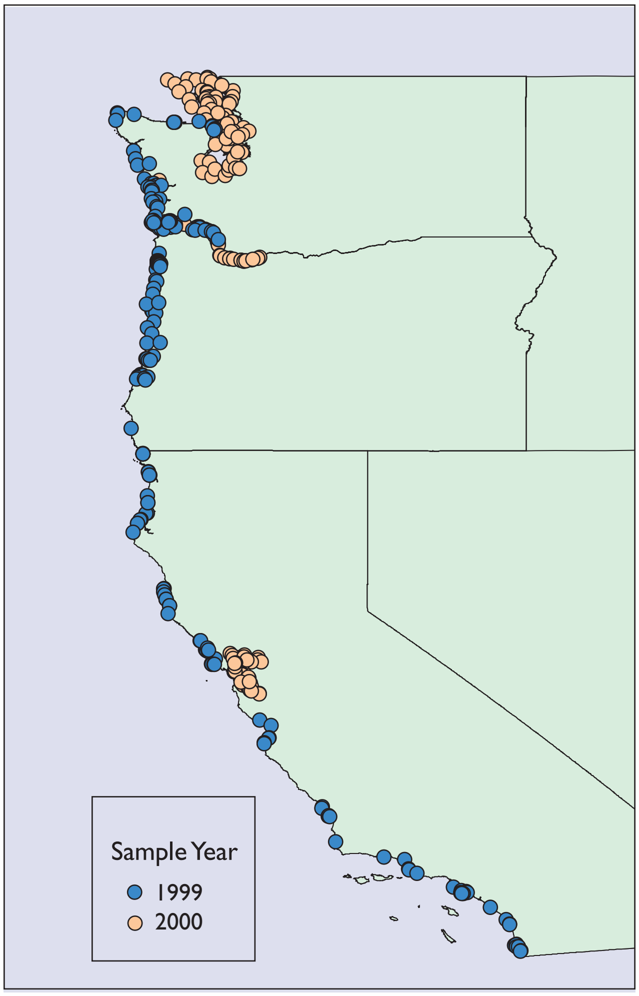


Figure 6-3. West Coast sampling stations for the 1999–2000 NCA survey (U.S. EPA, NCA).

Relatively few national programs have monitoring stations in West Coast estuaries. NOAA's National Estuarine Eutrophication Assessment (NOAA, 1998a) examined a number of eutrophication variables for West Coast estuaries through the use of a survey questionnaire. NOAA's NS&T Program collects data for several western locations (Long et al., 2000), but these sites are not representative of all West Coast estuaries. In addition, EMAP-like surveys have been completed in the Southern California Bight (SCCWRP, 1998). In comparison with these geographically focused studies, the Western EMAP sampled small western estuaries in 1999 and 2001, large estuaries in 2000, the intertidal areas of small and large estuaries in 2002, and the continental shelf in 2003. The data reported in this chapter include surveys of small and large estuaries from 1999 to 2000.

Water Quality Index

Water quality for West Coast estuaries, as measured by five indicators—surface DIN and DIP, chlorophyll *a*, water clarity, and bottom dissolved oxygen—is fair. Most West Coast estuaries (69%) received fair ratings for water quality, largely because of the levels of phosphorus measured. Three percent of estuaries on the West Coast have poor water quality (Figure 6-4). Estuaries with poor water quality were found primarily in California, as well as in both San Francisco Bay and its subestuaries and in other estuaries along the California coast. The only site outside California with poor water quality was south Hood Canal, Washington. Low ratings for the water quality index were driven primarily by poor conditions for phosphorus. The finding that 3% of the West Coast estuarine area has poor water quality should be considered preliminary because only DIP concentrations and water clarity were generally poor. However, most estuarine area in the West Coast has decreased water quality (72% of this area received a poor or fair rating).

The sampling conducted in the EPA NCA Program has been designed to estimate the percent of estuarine area (nationally or in a region or state) in varying conditions and is 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 indicator 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.

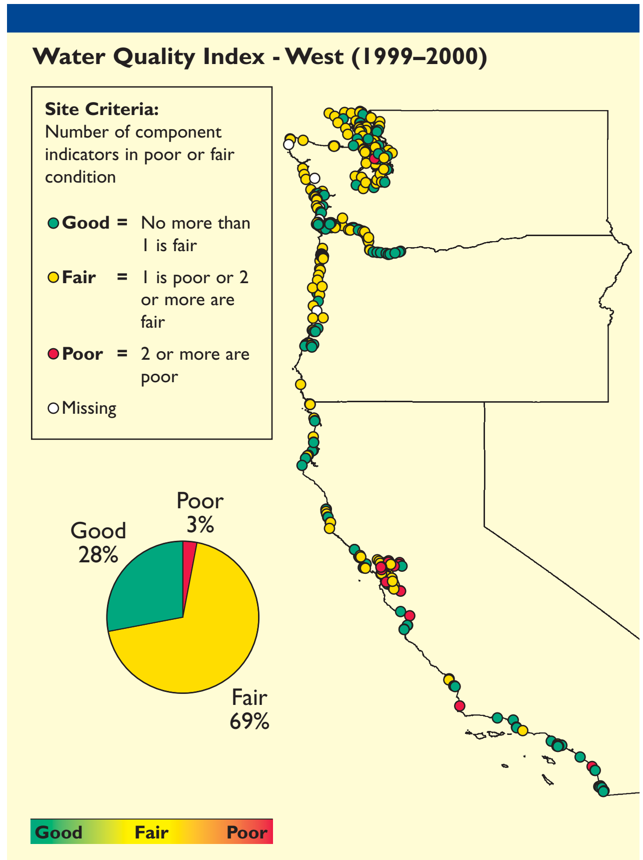


Figure 6-4. Water quality index data for West Coast estuaries (U.S. EPA/NCA).

Looking south at the base of Haystack Rock at Cannon Beach, Oregon (Carol Baldwin, NOAA OMAO).

Nutrients: Nitrogen and Phosphorous

DIN concentrations in West Coast estuaries are rated good. High concentrations of DIN in surface waters occurred in less than 1% of the estuarine area of the West Coast. All sites with high nitrogen were found along the central California coast (Figure 6-5). The threshold for a West Coast site to be rated poor for nitrogen was a concentration in excess of 1 mg/L, as compared with a threshold used by the NCA of 0.5 mg/L for most other regions of the United States. The level of 1 mg/L corresponds to the level used by the NOAA/EPA Team on Near Coastal Waters to indicate high nitrogen levels in its report on susceptibility of West Coast estuaries to nutrient discharges (1991). Along much of the West Coast, summer wind conditions result in an upwelling of nutrient-rich deep water that enters estuaries during flood tides (Landry et al., 1989) and constitutes a potentially important natural nutrient input for many of these West Coast estuaries.

DIP concentrations in West Coast estuaries are rated fair. Whereas high concentrations of DIN were not prevalent in West Coast surface waters, high concentrations of DIP occurred in 10% of surface waters of the estuarine area of the West Coast (Figure 6-6). Only 4% of sites received a rating of good for DIP, in contrast with nearly 93% of sites for DIN. The threshold for a West Coast site to be rated poor for phosphorus was a concentration in excess of 0.1 mg/L, as compared with a threshold used by the NCA of 0.05 mg/L for most other regions of the United States. The level of 0.1 mg/L corresponds to the level used to indicate high phosphorus levels in the report on susceptibility of West Coast estuaries to nutrient discharges conducted by the NOAA/EPA Team on Near Coastal Waters (1991). Sites with high phosphorus tended to be found throughout California, and particularly in the San Francisco Estuary. As with nitrogen, upwelling may be an important contributing factor to the high DIP concentrations on the West Coast during the summer.

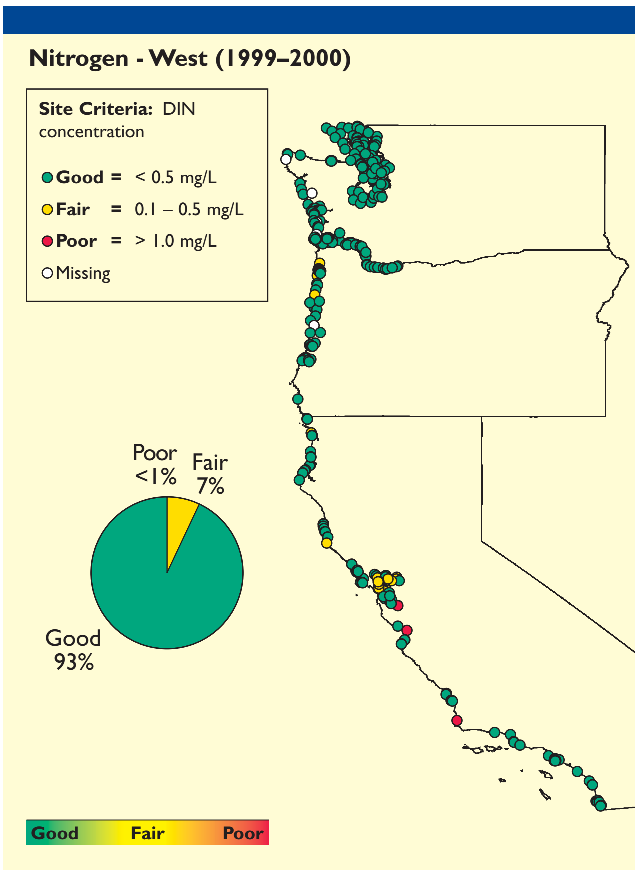


Figure 6-5. DIN concentration data for West Coast estuaries (U.S. EPA/NCA).

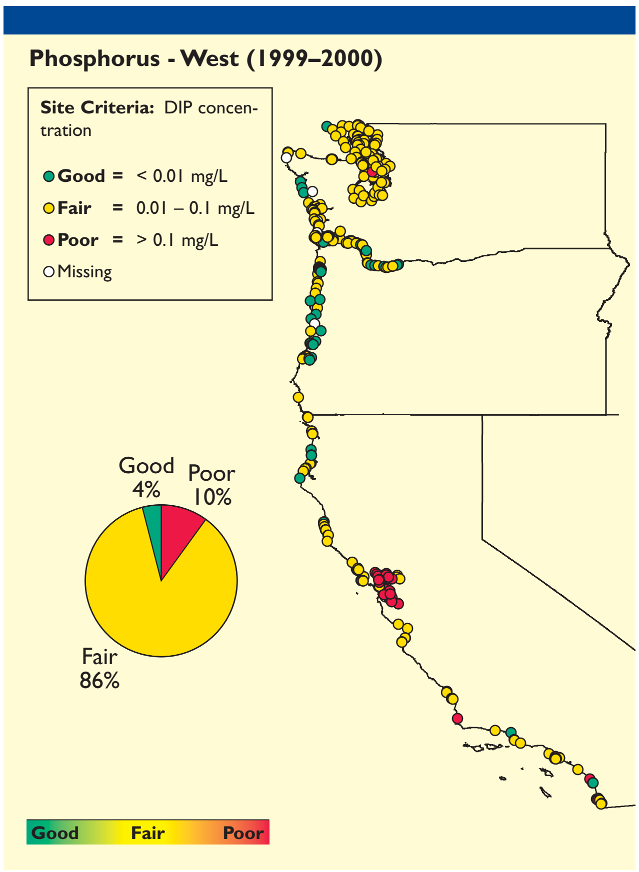
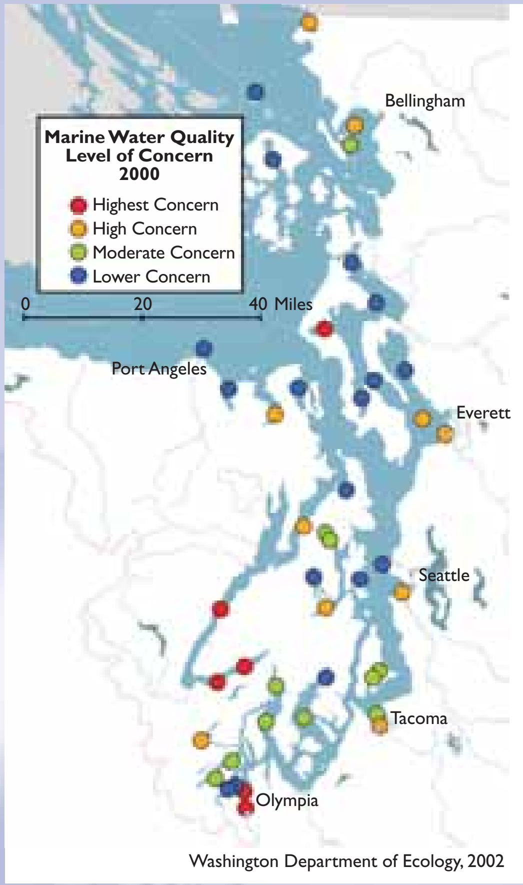


Figure 6-6. DIP concentration data for West Coast estuaries (U.S. EPA/NCA).

Marine Water Quality in Puget Sound

Puget Sound's marine waters provide essential habitat for organisms ranging from plankton to marine fish (including salmon) to marine mammals. Washington's DOE summarizes overall water quality based on the strength and persistence of layers, or stratification, in the water column; lack of nitrogen-containing nutrients for several months; low amounts of dissolved oxygen in the water; high ammonium concentrations; and high fecal coliform bacteria counts. These results are presented in terms of levels of overall water quality concern.



Marine water quality level of concern, 2000.

Components of Marine Water Quality

The following characteristics of marine waters are measured to determine water quality:

Fecal coliform bacteria—not agents of disease themselves, these bacteria indicate the presence of other disease-causing organisms from sewage, wildlife, or agricultural contamination.

Dissolved oxygen—low dissolved oxygen levels can be harmful to some marine life, such as fish.

DIN—some marine waters are susceptible to water quality problems when nutrients are added from wastewater or agricultural sources.

Ammonium—high concentrations can indicate sewage or agricultural contamination.

Stratification—when marine waters develop stable layers, pollutants and nutrients cannot be mixed, and some layers may develop water quality problems.

Status

Based on data from 1994 to 2000, the areas of greatest marine water quality concern in Puget Sound are Budd Inlet, southern Hood Canal, and Penn Cove on Whidbey Island. Concern at Budd Inlet is due to high fecal coliform and ammonium concentrations, strong and persistent stratification, depleted oxygen levels, and low nutrients. Nutrient input to Budd Inlet decreased in the late 1990s as the regional wastewater treatment plant incorporated nitrogen removal. Southern Hood Canal and Penn Cove concerns include very low dissolved oxygen concentrations and sensitivity to additional nutrient loadings. The DOE generally classified sampling stations near urban areas or in areas with reduced levels of tidal flushing as areas of high concern. For more information, visit http://nsandt.noaa.gov/index_bioeffect.htm.

Chlorophyll *a*

Chlorophyll *a* concentrations in West Coast estuaries are rated good. Less than 1% of the estuarine area on the West Coast is rated poor for chlorophyll *a* (Figure 6-7). Concentrations greater than 20 µg/L occurred in only three locations, including two sites in California and one site in Washington (south Hood Canal). Although almost no areas within West Coast estuaries showed high concentrations of water column chlorophyll *a*, this may not indicate low land-based loading of nitrogen and phosphorus. Many West Coast estuaries have large intertidal areas, so nutrient utilization by benthic algae may be of greater importance than nutrient uptake by phytoplankton. Results of 2002 surveys of these intertidal areas, using benthic algal coverage as an indicator of conversion of nutrient loadings to chlorophyll, are not yet available to address this issue.

Water Clarity

Water clarity in West Coast estuaries is rated poor. Water clarity was rated poor at a sample site if light penetration at 1 meter was less than 10% of surface illumination. Approximately 36% of estuarine area in the West Coast received less than 10% of surface illumination at 1 meter (Figure 6-8). This finding is consistent with that made by the NOAA Eutrophication Survey (NOAA, 1998a), which reported high turbidity in 20 of the 38 West Coast estuaries surveyed. This number represents water clarity only in late summer and does not represent high-flow wet season conditions in the winter. The large tidal amplitude found in many estuaries along the West Coast may tend to contribute to higher levels of turbidity in the water column. Stations with limited water clarity were broadly distributed across the West Coast states (Figure 6-8).

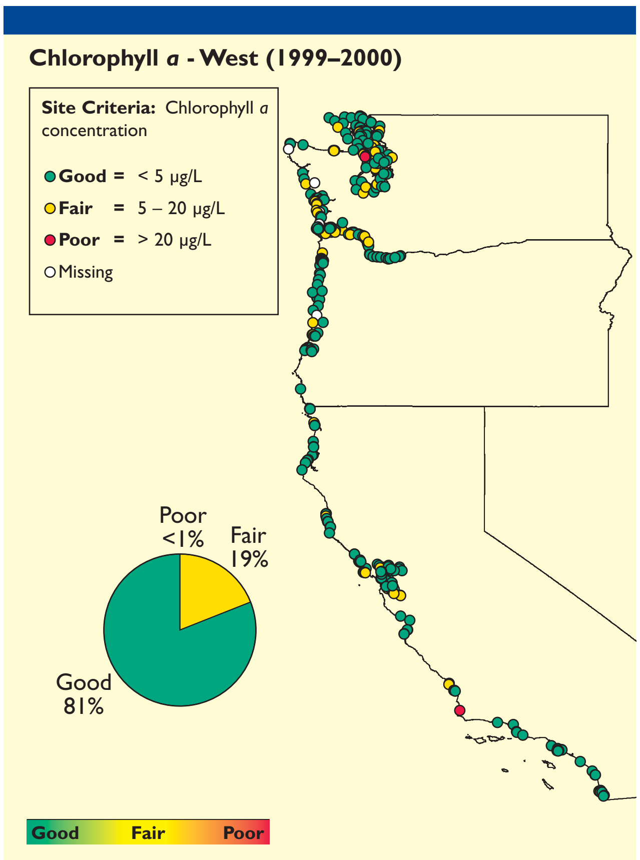


Figure 6-7. Chlorophyll *a* concentration data for West Coast estuaries (U.S. EPA/NCA).

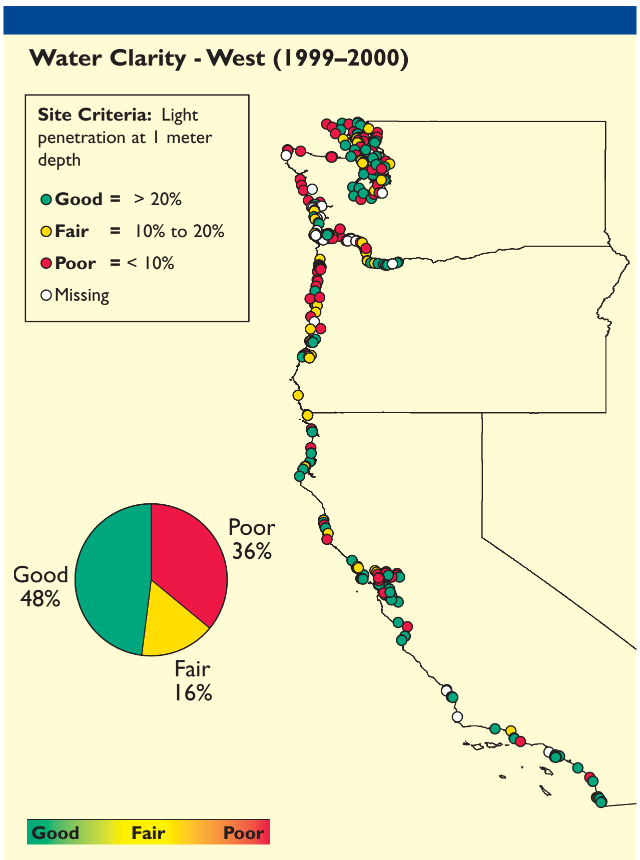


Figure 6-8. Water clarity condition for West Coast estuaries (U.S. EPA/NCA).

highlight

EMAP and NOAA Assess Condition of the Continental Shelf of the U.S. West Coast

EPA's EMAP, in cooperation with NOAA, conducted an assessment of soft sediment habitat conditions on the continental shelf of the West Coast in 2003. The assessment design included a survey of bottom community conditions for the five NOAA National Marine Sanctuaries (Olympic, Cordell Banks, Gulf of Farallones, Monterey Bay, and Channel Islands), as compared to non-sanctuary areas of the West Coast shelf.

NOAA research vessel *McArthur II* (CDR Michele G. Bullock/NOAA).

Principally funded by the EPA, Office of Research and Development, the project involved the cooperation of numerous organizations. NOAA was a major partner in the study, contributing ship time on the research vessel *McArthur II* to the assessment effort. The Northwest Fisheries Science Center of NOAA provided field support and analysis of fish disease conditions and cooperated with EPA to provide fish for contaminant analysis from samples collected under the NOAA West Coast Slope Survey Fisheries Assessment Program. State partners included the Washington DOE, Oregon Department of Environmental Quality, and the Southern California Coastal Water Resources Project (SCCWRP). Moss Landing Marine Laboratories, under contract to SCCWRP, provided field crews for the collection of samples in California coastal waters .

The 2003 West Coast shelf assessment included soft sediment benthic resources of the continental shelf from the Strait of Juan de Fuca in Washington to the Mexican border. A total of 150 stations were sampled at a depth range between 30 and 120 feet. Each state had a minimum of 50 stations. In Washington, the 50 stations were split into two groups consisting of 30 stations randomly selected within the Olympic NMS and 20 stations in the remainder of the shelf waters. Similarly, in California, 50 stations were split into two groups consisting of 30 stations randomly selected within the Cordell Banks, Gulf of Farallones, Monterey Bay, and Channel Islands National Marine Sanctuaries, and 20 stations distributed on the shelf in the remainder of California, north of Point Conception. The shelf region between Point Conception and the Mexican border was sampled for most of the same condition indicators during summer 2003 as part of the Bight 2003 study by a consortium of agencies led by SCCWRP. The Bight 2003 data will be integrated with the EMAP data to provide an overall assessment of the condition of the continental shelf for California and the West Coast.

Environmental condition indicators that were sampled in this study (Table 1) included

(1) general habitat condition indicators
(2) water quality indicators
(3) benthic condition indicators
(4) exposure indicators.

Table 1. Environmental Indicators for the EMAP-West Coast Assessment of Shelf Benthic Condition in 2003 (U.S. EPA/NCA).

Habitat Condition Indicators	Benthic Condition Indicators
Salinity	Infaunal species composition
Water depth	Infaunal abundance
pH	Infaunal species richness and diversity
Water temperature	External diseases in fish
Total suspended solids	Presence of nonindigenous species
Transmittance	
Sediment grain size	
Percent TOC in sediments	
Sediment color/odor	
Presence of trash/marine debris	
Water Quality Indicators	**Exposure Indicators**
Chlorophyll *a* concentration	Dissolved oxygen concentration
Nutrient concentrations (nitrates, nitrites, ammonia, and phosphate)	Sediment contaminants
	Fish tissue contaminants

Dissolved Oxygen

Dissolved oxygen conditions in West Coast estuaries are good. NCA estimates for West Coast estuaries show that less than 1% of the bottom waters exhibit hypoxia (<2 mg/L dissolved oxygen) in late summer (Figure 6-9). Out of the total of 371 stations sampled, dissolved oxygen was measured below 2.0 mg/L at only two station locations. Both of these stations were located in subestuaries of Puget Sound (Dabob Bay and south Hood Canal), which are deeper, fjord-like systems and may often have low dissolved oxygen in bottom waters. In addition, 25% of estuarine bottom waters were found to be in fair condition, with dissolved oxygen concentrations between 2 and 5 mg/L. The Puget Sound Water Quality Action Team (2002) identified south Hood Canal as an AOC for water quality because it may be particularly sensitive to increased nutrient loadings. Although conditions in the West Coast region appear to be generally good for dissolved oxygen, measured values reflect daytime conditions, and some areas may still experience hypoxic conditions at night.

Sediment Quality Index

The overall condition of West Coast estuarine sediment is fair to poor, with 14% of the area exceeding thresholds for sediment toxicity, sediment contaminants, or sediment TOC (Figure 6-10). This estimate of fair sediment condition reflects to a large extent the metal concentrations in the San Francisco Estuary and the metal and organic concentrations in the harbors and bays within the Puget Sound system (e.g., Duwamish River, Commencement Bay). Amphipod toxicity at stations within Puget Sound, the Columbia River, and Willapa Bay was the second most important contributor to the areal estimate of poor condition. Several other areas had either elevated sediment concentrations of contaminants or high sediment toxicity (e.g., Smith River in northern California, Los Angeles Harbor), but these areas constituted a relatively small areal percentage of the West Coast estuaries.

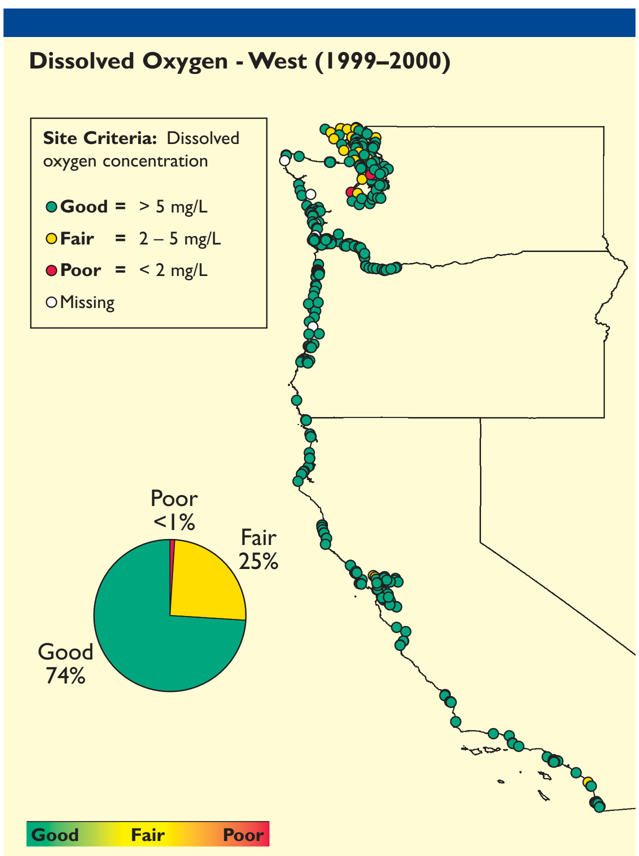


Figure 6-9. Dissolved oxygen concentration data for West Coast estuaries (U.S. EPA/NCA).

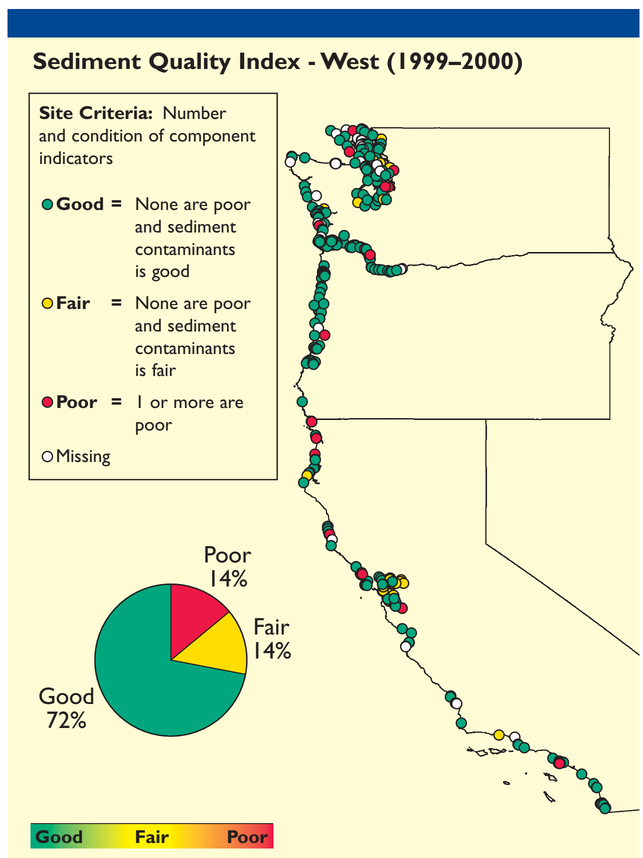


Figure 6-10. Sediment quality index data for West Coast estuaries (U.S. EPA/NCA).

Sediment Toxicity

Sediment toxicity for West Coast estuaries is rated poor. Sediment toxicity was determined using a static 10-day acute toxicity test with the amphipods *Ampelisca abdita* in marine or brackish waters or *Hyalella azteca* in freshwater portions of the Columbia River. Sediment was deemed toxic if the amphipods had less than an 80% control-corrected mean survival rate. Sediments in 17% of the estuarine area of the West Coast were toxic to amphipods (Figure 6-11). These toxic sediments were located largely in northern and central Puget Sound in Washington, in the Columbia River (Washington-Oregon), and in Los Angeles Harbor and several small river systems (e.g., Smith River, Klamath River, Little River) in northern California. Toxic sediments in Puget Sound were contaminated with DDT and metals and, in some cases, also exceeded ERLs for PAHs or PCBs. Sediments found in several northern California small river estuaries exceeded ERM or ERL levels for chromium, and sediments in the lower Columbia River (Grays Bay) exceeded ERLs for arsenic, copper, and chromium. One highly contaminated station in Los Angeles Harbor had 0% *Ampelisca* survival and exceeded 17 ERLs and 7 ERMs for metals, PAHs, and PCBs. Several stations in the Columbia River, Siuslaw River (Oregon), and Willapa Bay (Washington) were uncontaminated with the measured analytes, but had *Ampelisca* or *Hyalella* survival rates below 80%. These stations had very low TOC (0 to 0.1%) and percent fines (0 to 1.0%), which may have inhibited tube formation and survival in *Ampelisca* (U.S. EPA, 1994). For *Hyalella*, however, there is no known effect of grain size or TOC on survival (ASTM, 1995).

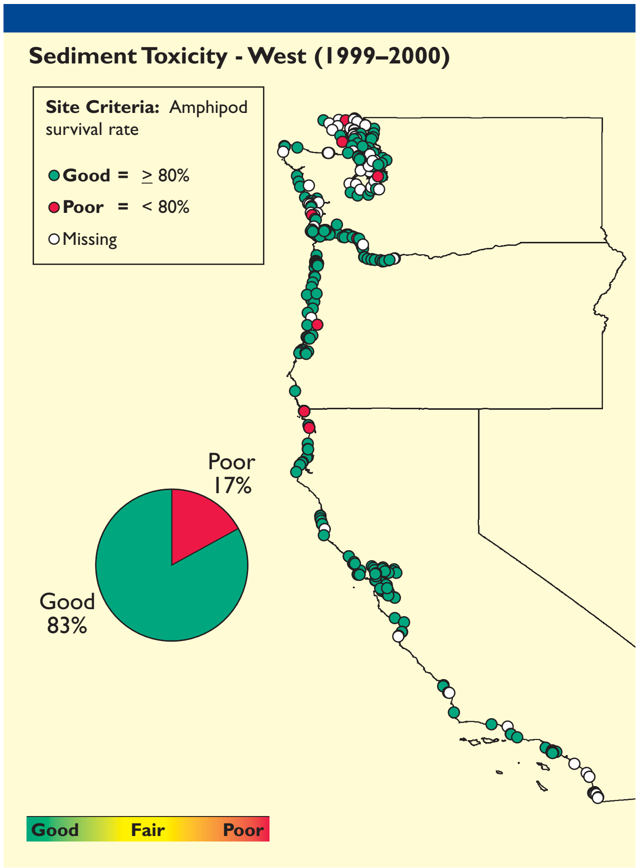
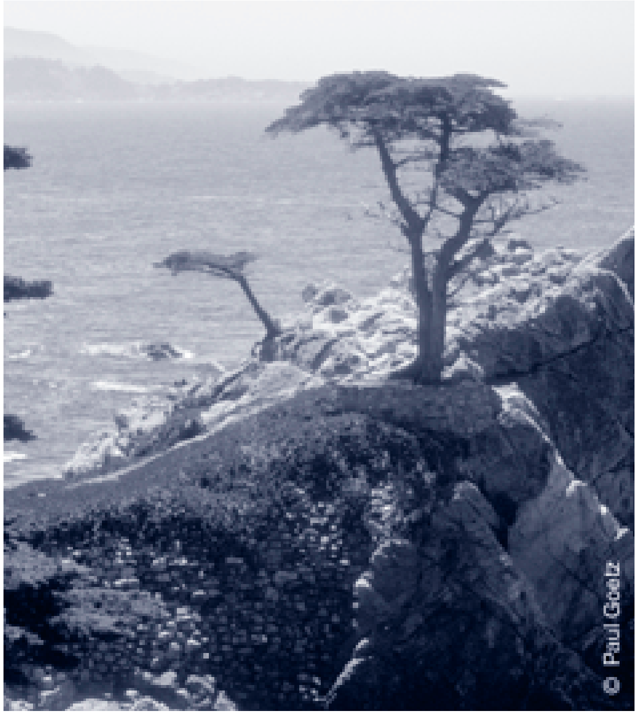


Figure 6-11. Sediment toxicity data for West Coast estuaries (U.S. EPA/NCA).



The rugged California coast is dotted with an abundance of small coves (Paul Goetz).

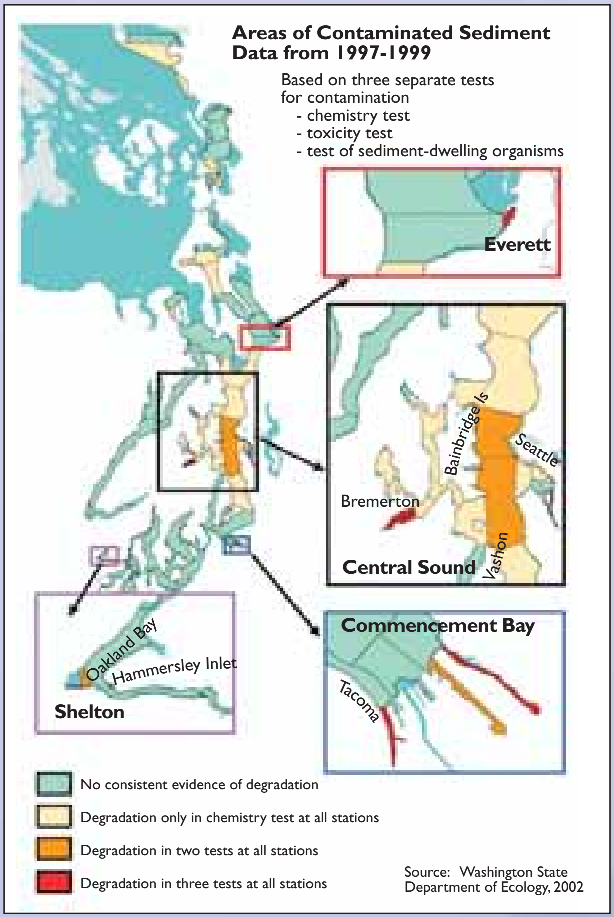
Sediment Quality and Extent of Sediment Contamination in Puget Sound

A cooperative effort to examine the spatial distributions of sediment toxicity in Puget Sound was recently completed by the Washington DOE and NOAA's National Centers for Coastal Ocean Science. Environmental contaminants associated with sediments represent a potential source of toxicity to organisms living in or on the sediments, and through the food chain, to higher trophic level species. These contaminants enter estuarine waters through runoff, freshwater inflow, industrial and municipal discharges, and atmospheric deposition. Once bound to particulate materials in the water column, such contaminants can settle out and become incorporated into surficial sediments.

The overall goal of the 3-year project was to quantify the percentage of significantly degraded sediment quality in Puget Sound. A total of 300 sediment samples were collected using a stratified random sampling design. A triad assessment of chemical contamination, toxicity, and benthic infauna structure was conducted to develop a spatial characterization of the 912-square-mile Puget Sound study area. Sediments were analyzed for 158 contaminants (including trace metals, pesticides, and hydrocarbons) and sediment parameters, most of which are analyzed in NOAA's NS&T Program. Toxicity tests included amphipod survival in bulk sediments, sea urchin fertilization success in pore waters, and microbial bioluminescence activity (Microtox™) in organic extracts of sediment. Organisms inhabiting the sediments were enumerated and identified to the species level.

Chemical concentrations above sediment quality guidelines (SQGs) were found in 1.3% (NOAA guidelines) to 34% (Washington State standards) of the Puget Sound study area. Only 1 in 300 samples resulted in acute toxicity in the amphipod survival test, representing an area of less than 0.1% of the total study area. In the other toxicity tests, significant results were recorded in 1 to 4% of the study area. In general, the spatial extent of toxicity found in Puget Sound was lower than results typically found in other estuarine systems in the United States.

Based on the triad of sediment quality, approximately 39 samples, or 1% of the area surveyed, displayed chemical contamination above an SQG, significant toxicity in any one of the three toxicity tests, and altered benthic infaunal communities. These samples were collected from Everett Harbor, the lower Duwamish River, Sinclair Inlet, Commencement Bay waterways, Olympia Harbor, and along Seattle's waterfront. In contrast, 81 sediment samples, or 42% of the study area, had uncontaminated sediments that were nontoxic and contained diverse and abundant benthos. These areas were typically in deep basins or shallow bays near undeveloped lands. Results of the study did show, however, that 180 samples, or approximately 57% of the study area in Puget Sound, had results that were termed intermediate (i.e., one or two of the three triad parameters were affected), indicating a need for continued monitoring of these areas to assess changes in sediment quality over time.



Sediment Contaminants

To assess the degree of sediment contamination in West Coast estuaries, the sediment concentrations of contaminants were compared with both the ERM and ERL guidelines (Long et al., 1995) (Figure 6-12). Sites with values exceeding an ERM for any pollutant were classified as having poor condition. The analysis of the West Coast estuaries excluded nickel and a PAH, phenanthrene. Phenanthrene was excluded because values were not available from all three states. Nickel was excluded because the ERM value has a low reliability for West Coast conditions where high natural crustal concentrations of nickel exist (Long et al., 1995). Because of its unreliability, nickel was also excluded from a recent evaluation of sediment quality in southern Puget Sound (Long et al., 2000). Additionally, a study of metal concentrations in cores on the West Coast determined an historical background concentration of nickel in the range of 35–70 ppm (Lauenstein et al., 2000), which brackets the value of the ERM (51.6 ppm). Some researchers have also suggested that West Coast crustal concentrations for mercury may be naturally elevated; however, no conclusive evidence is available to support this suggestion. Therefore, mercury data were not excluded from this assessment.

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 values for each chemical as the 10th percentile in a database of ascending concentrations associated with adverse biological effects.

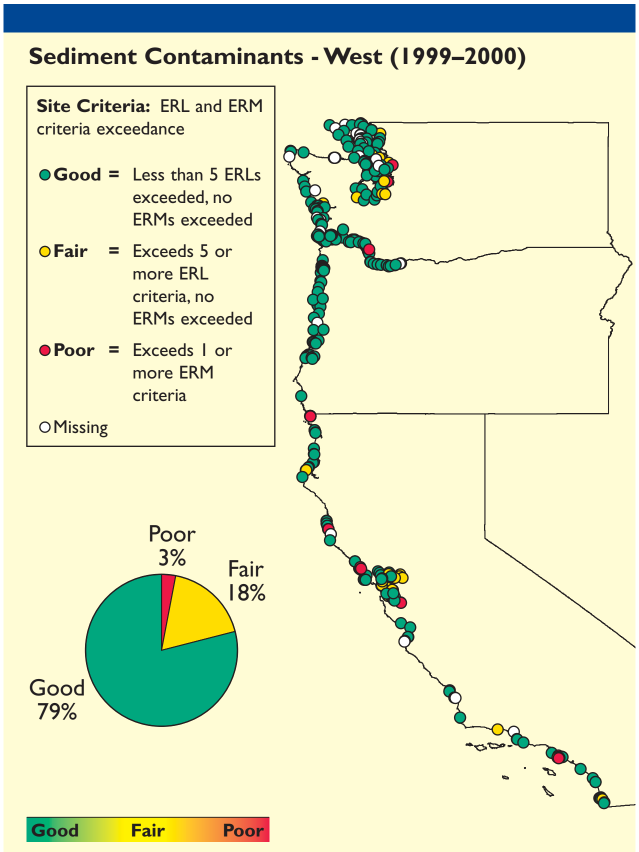


Figure 6-12. Sediment contaminants data for West Coast estuaries (U.S. EPA/NCA).

Excluding nickel, sediment concentrations exceeded their respective ERM values at 24 stations, representing 3% of the estuarine area. Twenty of these sites were located in California, 4 in Washington, and none in Oregon. In California, all the concentrations that exceeded the ERMs north of San Luis Obispo Bay, including the small northern California rivers and the San Francisco Estuary, were due to chromium, mercury, or copper. In Southern California, the exceedances were due to DDT, with the exception of the Los Angeles Harbor, which had high concentrations of several metals and PAHs. In Washington, three of the sediment concentrations that exceeded the ERMs occurred in harbors and bays within the Puget Sound system; one was in the Columbia River. All of these exceedances were due to either PAHs or PCBs.

Any site that had five or more compounds that exceeded their ERL values was classified as having fair condition. As with the ERMs, nickel was excluded from the analysis. To ensure that the analysis was not biased by PAHs, only one exceedance was counted if a site exceeded the ERL for LMW PAHs, HMW PAHs, or total PAHs. A total of 62 stations had five or more pollutants exceeding the ERL value, of which 12 also exceeded one or more ERMs. The 62 sites represent 21% (ERM exceedance = 3% and 5 ERL exceedances = 18%) of the area of the West Coast estuaries. Most of these sites (45) occurred in California, 17 sites occurred in Washington, and none occurred in Oregon. Of the California sites, 37 were located in the San Francisco Estuary. Six of the remaining California sites were in harbors or bays in southern California, and the two remaining sites were in northern California river-mouth estuaries. In Washington, 18 of the 20 sites exceeding these thresholds were located within the subestuaries (e.g., Everett Harbor, Elliott Bay) within the Puget Sound system.

To evaluate the relative contributions of different types of pollutants, the number of individual ERL exceedances was counted by pollutant class. Twenty-four ERLs were evaluated at each site (8 metals, total PCBs, 4,4'-DDE, total DDT, 12 individual PAHs, and total/LMW/HMW PAHs). Metals were the major contributor to sediment contamination in the San Francisco Estuary; about two-thirds of the individual ERL exceedances resulted from arsenic, chromium, copper, mercury, and zinc. Organic contaminants were relatively more important in the Puget Sound system. Total DDT exceeded ERL values at every station in Puget Sound, as well as at every station within the harbors and bays within the Puget Sound system. Combined, PAHs, DDTs, and PCBs contributed about 60% of the total ERL exceedances in the Puget Sound system, versus about 40% for the metals. The metals with the greatest number of exceedances (excluding nickel) in the Puget Sound system were arsenic, chromium, and copper.

Sediment Total Organic Carbon

Another measure of sediment condition is the percent TOC: values exceeding 5% ranked poor, values between 2% and 5% ranked fair, and values less than 2% ranked good. Using these criteria, two sites representing just 0.01% of the area of the West Coast estuaries were ranked poor (Figure 6-13). One of these sites, the Big Lagoon, borders the Redwood National Forest in northern California. This lagoon is periodically closed to the ocean by the natural movement of dune sands, so it is likely that the high organic content results from the natural trapping of terrestrial and wetland plant debris rather than from anthropogenic inputs. The other site that was ranked poor was in the Los Angeles Harbor, and the high organic content at this site may well represent anthropogenic inputs. Another 29 sites (7 sites in California, 6 in Oregon, and 16 in Washington) were ranked fair. In total, these sites represent 11% of the estuarine area of the West Coast. At several of these sites, there are no obvious anthropogenic inputs of organic matter (e.g., Raft River, Washington), and the elevated TOC levels may reflect natural conditions. In other cases (e.g., ports and harbors), the elevated levels may be indicative of anthropogenic inputs.

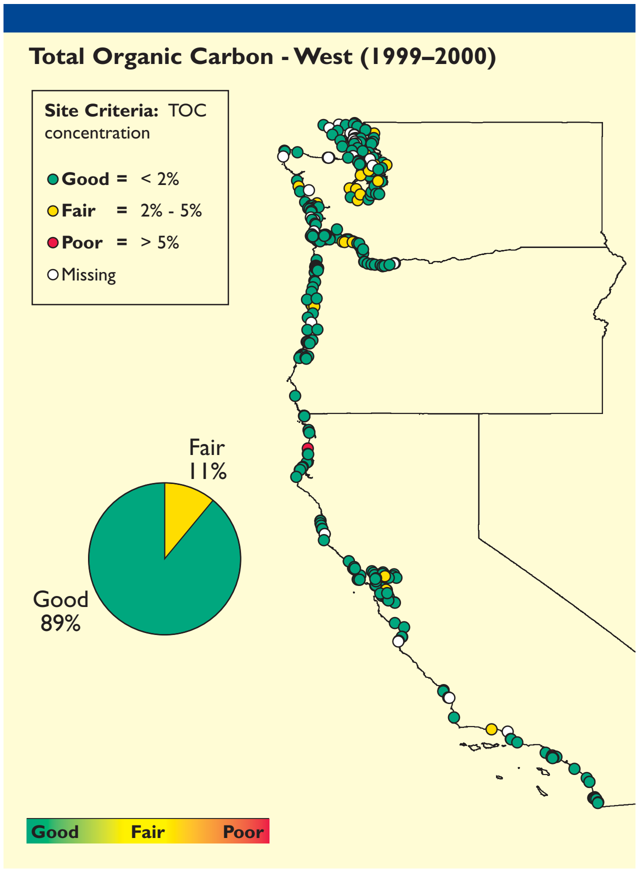
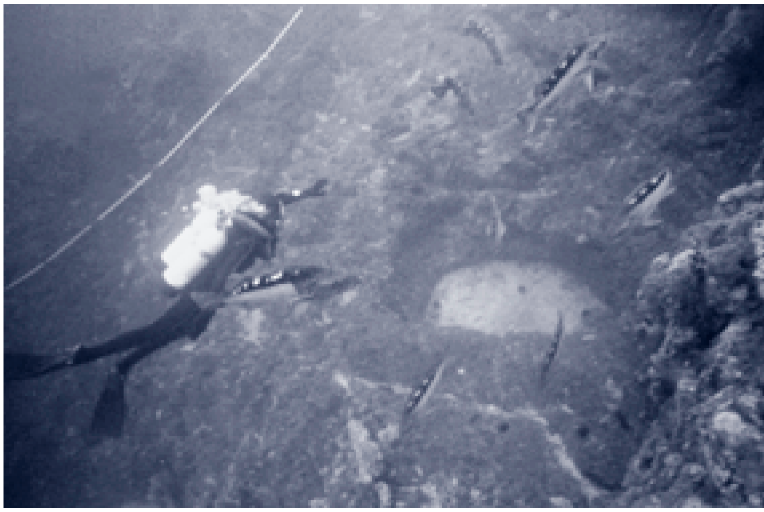


Figure 6-13. Sediment TOC data for West Coast estuaries (U.S. EPA/NCA).



A diver from Cordell Bank Expeditions discovers a small sediment pocket on the bank (Cordell Bank Expeditions).

Benthic Index

Sediment condition in West Coast estuaries as measured by the benthic index is fair. Although several efforts are under way and indices of benthic community condition have been developed for regions of the West Coast (e.g., Smith et al., 1998), there is currently no single benthic community index applicable for the entire West Coast. In lieu of a West Coast benthic index, the deviation of species richness from an estimate of expected species richness was used as an approximate indicator of the condition of the benthic community. The $\log_{10}$ transformed number of species per 0.1 m^2 grab sample was regressed on bottom salinity. The analysis was limited to the 1999 data because the 2000 benthic community data have not received final quality assurance/quality control checks. Therefore, areal estimates of affected benthic communities only apply to the small West Coast estuaries and not to the San Francisco Estuary, Puget Sound, or the main stem of the Columbia River. The benthic condition of any station with fewer species than 75% of the lower 95% confidence limit of the mean from the regression was ranked poor (Figure 6-14).

This approach requires that species richness be predicted from salinity. A significant linear regression between log species richness and salinity was found, although it was not strong ($r^2 = 0.43$, $p < 0.01$). Results of the regression indicated that 26 sites, representing 13% of the area of the West Coast estuaries, had a species richness of less than 75% of the lower 95% confidence limit. Sites with lower diversity were relatively evenly distributed across the three states, with 9 sites in California, 12 in Oregon, and 5 in Washington.

Results should be interpreted cautiously because there was only moderate concordance between lower species richness and indices of water quality or sediment quality, the components that comprise these indices, or individual contaminant ERLs (Figure 6-15). Only 3 of the 26 sites low in species richness occurred at stations

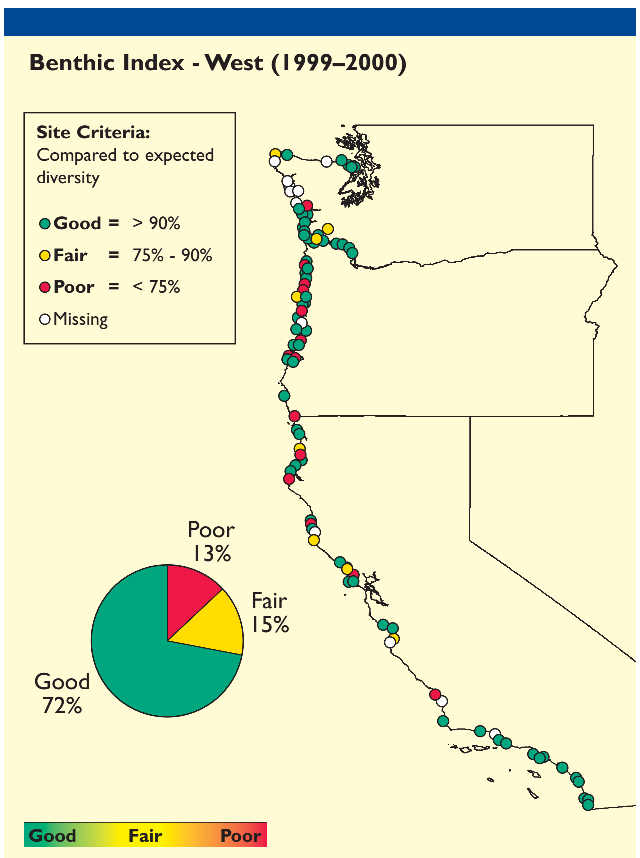


Figure 6-14. Benthic index data for West Coast estuaries (the San Francisco Estuary, Columbia River, and Puget Sound system were not included in the assessment) (U.S. EPA/NCA).

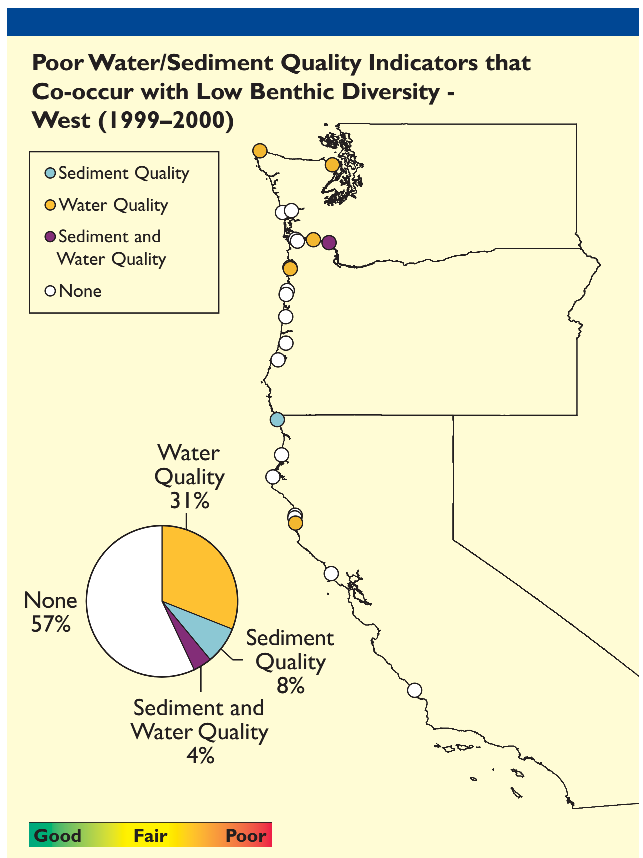


Figure 6-15. Indicators of poor water and sediment quality that co-occur with poor benthic condition in West Coast estuaries (U.S. EPA/NCA).

ranked poor for sediment contamination, high TOC concentrations, or amphipod toxicity. There was higher concordance of reduced diversity with indicators of water quality; only 9 of the 26 sites with reduced species richness occurred at a site ranked poor by the water quality index or its individual components. One site with low species richness also had poor ratings for sediment contamination and water quality. Other anthropogenic stressors, such as dredging, may have contributed to the low diversity at some of the sites comprising the 30% of low diversity sites not related to sediment or water quality variables (e.g., Coos River, Oregon). At some sites, "natural" stressors may be the primary cause for reduced species richness. For example, intense bioturbation by the burrowing ghost shrimp, *Neotrypaea californiensis*, may have limited species richness in the Salmon River, Oregon, an estuary that receives very few anthropogenic inputs. The large salinity fluctuations that the small, Pacific Northwest river-dominated estuaries can experience over a tidal cycle or following heavy rains may also have contributed to the low species richness at some sites.

Coastal Habitat Index

The coastal habitat index for West Coast estuaries is rated poor. From 1990 to 2000, the West Coast experienced a loss of 1,720 acres of estuarine wetlands (0.54%) (NWI, 2002). The long-term, average decadal loss rate of West Coast wetlands is 3.4%. Averaging these two loss rates results in a coastal habitat index value of 1.90. This is equivalent to a rating of poor. Although the absolute magnitude of the acreage lost for the West Coast was less than that in other regions of the country, the relative percentage of existing wetlands lost was the highest nationally. Western coastal wetlands constitute only 6% of the total estuarine wetland acreage in the conterminous 48 states; thus, any loss will have a proportionately greater impact on this regionally limited resource. Another factor affecting coastal resource condition that is not captured in the wetland loss estimates is the proportion of shoreline that has been altered. The Shore Zone Inventory completed in 2000 for the state of Washington found that almost one-third of all salt-water shorelines in the state had some type of shoreline modification structure, such as bulkhead or rip-rap, in place (Puget Sound Water Quality Action Team, 2002).

Fish Tissue Contaminants Index

Estuarine condition in West Coast estuaries as measured by concentrations of contaminants in fish tissues is rated poor. Figure 6-16 shows that 27% of all sites sampled where fish were caught (72 of 266 sites) exceeded risk-based criteria guidelines using whole-fish contaminant concentrations. (Whole-fish contaminant concentrations can be higher or lower than the concentrations associated with fillets only. Only those contaminants that have an affinity for muscle tissue, e.g., mercury, are likely to have higher fillet concentrations. Fillet contaminant concentrations for most other contaminants will be lower.) For populations that consume whole fish, these risk calculations are appropriate. The contaminants found in fish tissues in West Coast estuaries most often included total PCBs, DDT, and occasionally mercury.

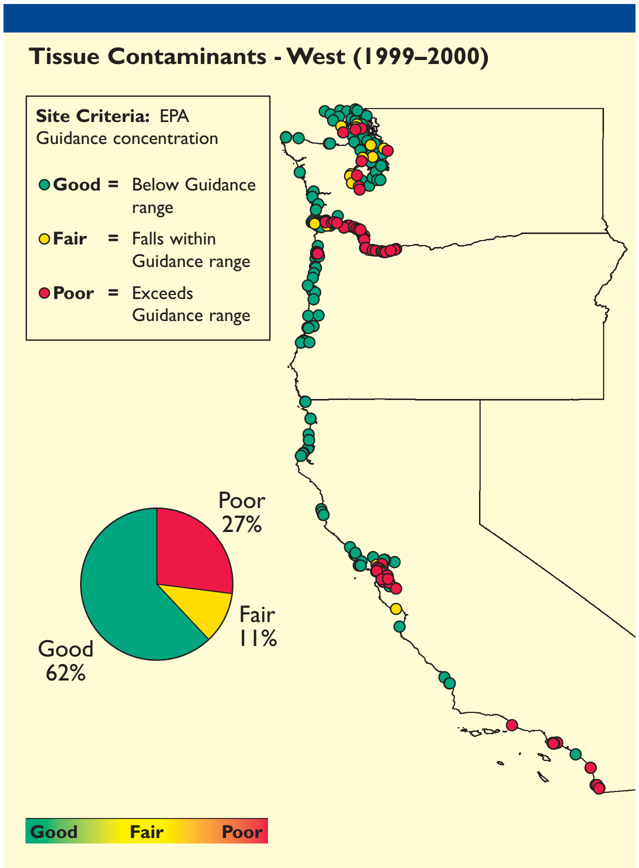


Figure 6-16. Fish tissue contaminants data for West Coast estuaries (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries

Lighthouses are essential along the rocky California coast (Paul Goetz.)

Salmon Fisheries

California Current ecosystem salmon support important commercial and recreational fisheries in Washington, Oregon, and California. Salmon are part of the socio-cultural heritage of the region, having been harvested by Native Americans for millennia. California Current ecosystem salmon are anadromous. These fish spawn in fresh water and migrate to the ocean, where they may undergo extensive migrations. At maturity, they return to their home stream to spawn and complete their life cycle. Pacific salmon in the California Current ecosystem include five species: Chinook, coho, sockeye, pink, and chum salmon. Chinook and coho salmon are harvested recreationally and commercially in the Pacific Ocean, Puget Sound, and in freshwater rivers on their spawning migrations. All species are harvested by Native American tribes for subsistence and ceremonial purposes.

During the years 1995 through 1997, the average annual commercial salmon catch was 13,100 mt, providing revenues averaging almost $22 million at dockside. The abundance of individual stocks of California Current ecosystem salmon and the mixture of stocks contributing to fisheries fluctuate considerably. Consequently, the landings of these species fluctuate. For all species, there is excess fishing power and over-capitalization of the fishing fleets. Although harvest rates in recent years have been held near or below levels that would produce a long-term potential yield, environmental conditions have resulted in poor ocean survival of Chinook and coho salmon in general, as well as some individual stocks of other species. Because of the depressed status of many populations of Chinook and coho salmon, these two species are considered over-exploited, whereas the other species are considered fully exploited. The management of this resource is complex, involving many stocks originating from various rivers and jurisdictions. Ocean fisheries for Chinook and coho salmon are managed under a Pacific Fishery Management Council (PFMC) FMP, with cooperation from states and tribal fishery agencies. Within Puget Sound and the Columbia River, fisheries for these two species are managed by the states and tribes. The other three species (pink, chum, and sockeye salmon) are managed primarily by the Pacific Salmon Commission (PSC), the state of Washington, and tribal fishery agencies.

Fisheries are managed using a variety of regulations. Ocean fisheries are managed primarily by gear restrictions, minimum size limits, and time and area closures, although harvest quotas have been placed on individual fisheries in recent years. The PSC has used harvest quotas, updated on the basis of in-season abundance forecasts. Cumulative impact quotas for weak stocks have been used to regulate some Columbia River commercial fisheries.

Pacific salmon in the California Current ecosystem depend on freshwater habitat for spawning and rearing of juveniles. The quality of freshwater habitat is largely a function of land management practices; therefore, salmon production is heavily influenced by entities not directly involved in the management of fisheries. Salmon management involves the cooperation of the USFS Bureau of Land Management, FWS's Bureau of Reclamation, the USACE, EPA, Bonneville Power Administration, state resource agencies, Native American tribes, municipal utility districts, agricultural water districts, private timber companies, and landowners.

Status reviews have been completed by the NMFS for most species of the California Current ecosystem and have resulted in listings of coho salmon from central California through coastal Oregon; Chinook salmon in California's Central Valley and the upper Columbia and Snake river basins; and sockeye salmon in the Snake River Basin. In March 1999, the NMFS announced the most comprehensive listing decision yet, with final listings of nine evolutionarily significant units (ESUs) of salmon (Chinook, chum, and sockeye) and steelhead trout ranging from the upper Columbia River through Puget Sound. These listings include the metropolitan areas of Portland, Oregon, and Seattle, Washington, that lie within the boundaries of the listed ESUs. Additional information on the status of the five species of Pacific salmon is available in *Our Living Oceans* (NOAA, 1999c).

Pelagic Fisheries

Several stocks of small pelagic fish species support fisheries along the California Current ecosystem. The major species are Pacific sardine, northern anchovy, jack mackerel, chub (Pacific) mackerel, and Pacific herring. Sardine, anchovy, and the two mackerels are primarily concentrated and harvested off California and Baja California. Pacific herring are harvested along the West Coast from California to Washington. Sardine and anchovy are the most prominent of the fisheries from an historical perspective. Population of these small pelagic fish, like Peruvian anchovy and Japanese sardine, tend to fluctuate widely in abundance. California sardines supported the largest fishery in the western hemisphere during the 1930s and early 1940s, when total catches averaged 500,000 mt. Sardine abundance and catches declined after World War II, and the stock finally collapsed in the late 1950s. In the mid 1940s, U.S. processors began canning anchovy as a substitute for sardine; however, consumer demand for canned anchovy was low. In recent years, low prices and market problems continue to prevent a significant U.S. reduction in the fishery for anchovy. The other small pelagic species also have a tendency to fluctuate widely in abundance. All these pelagic fishery resources are currently under management.

Northern anchovy landings in California have fluctuated more in response to market conditions than to stock abundance. Landings in the United States have varied from less than 10,000 mt to nearly 140,000 mt. The well being of ecologically related species in the marine ecosystem is an important factor in management of the anchovy resource. The FMP has specified a threshold for its optimum-yield determination to prevent anchovy depletion and to provide adequate forage for marine fishes, mammals, and birds. More information on the status of pelagic fisheries in the California Current ecosystem is available in *Our Living Oceans* (NOAA, 1999c).

Nearshore Fisheries

Nearshore fishery resources are those coastal and estuarine species found in the 0–3 nautical mile zone of coastal state waters and for which the NMFS has no direct management role. Nearshore resources vary widely in species diversity and abundance. Many are highly-prized gamefish, while others are small fishes used for bait, food, and industrial products. The invertebrate species of greatest interest include crabs, shrimps, abalones, clams, scallops, and oysters. Because the composition of the nearshore fauna is very diverse and management authority is shared among the coastal states and other local bodies, a detailed treatment of the status of these species is difficult. In the California Current ecosystem, California contributes the most commercial landings of nearshore species at an estimated 93,954 mt, followed by Oregon (22,198 mt) and Washington (14,637 mt).

Groundfish Fisheries

Accurate, long-term predictions of potential yield will require a substantial increase in knowledge about competitive and predatory interactions in the biological system of the California Current ecosystem, as well as knowledge about climate effects on this community. The target exploitation rate for most groundfish species is designed to achieve a large fraction of maximum potential yield and reduce the abundance of spawners by about two-thirds (assuming that this will not reduce the mean recruitment level). Only decades of monitoring the stock's performance will ascertain the long-term feasibility of these targets, as well as the degree of natural fluctuation that will occur while maintaining these targets. Unfortunately, there is little historical data on these fluctuations, and the current level of stock assessment data is not adequate to precisely track changes in abundance for more than a few species. In addition, only a low level of effort is directed towards feeding habits studies that may help predict how the interactions among species may change as the abundance of several major species is reduced below unfished levels.

Models of long-term potential yield depend on assumptions of constant average environmental conditions or an ability to predict changing conditions. There is evidence of a decline in zooplankton abundance within the California Cooperative Oceanic Fisheries Investigations' 40-year time series, as well as of an ocean warming during the late 1970s. Dover sole in southern areas, bocaccio rockfish, and lingcod exhibit declines in mean recruitment during this same period. Better understanding of potential linkages between fish recruitment and long-term changes in the ocean climate are integral to improving the 5- to 10-year forecasts of potential fishery yield.

EMAP 2002 – West Coast Intertidal Wetlands Condition Assessment

Much of the West Coast of the United States is subject to large tidal fluctuations, resulting in extensive intertidal flats that are sometimes equal to 50% or more of the total estuarine area. Because such fluctuations are important to many West Coast estuaries, EMAP conducted a pilot assessment of the condition of estuarine tidelands from Puget Sound to the Mexican border in 2002. In addition to this regional assessment, localized studies in San Francisco Bay and Southern California focused on development of a range of condition indicators for low salt marsh habitats. These assessments of intertidal wetlands (vegetated and unvegetated habitat between mean low water and mean high water) complement the previous EMAP subtidal assessments conducted between 1999 and 2000, resulting in a more complete picture of estuarine condition on the West Coast.

The intertidal sample design included 61 sites in Washington, 67 sites in Oregon, and 90 sites in California. In California, 30 sites were randomly allocated along the coastline, with another 30 sites randomly allocated within each of the two pilot-study regions. A series of indicators suitable for intertidal habitats, including a variety of plant community indicators (Table 1), were sampled at all sites in the three states. Additional indicators were measured at the two intensive studies in Southern California (Point Conception to the Mexican border) and San Francisco Bay (Table 2). This monitoring design provides both a statewide assessment of intertidal wetland conditions and independent assessments of Southern California and San Francisco Bay wetlands.

Table 1. Environmental Condition Indicators Used for the 2002 Intertidal Wetlands Assessment Study (U.S. EPA, NCA).

- Tidal water temperature, depth, salinity
- Sediment pore water salinity
- Sediment bulk density
- Sediment percent TOC
- Sediment grain size
- Sediment inorganic contaminants
- Sediment organic contaminants
- Sediment percent nitrogen
- Sediment percent phosphorus
- Infaunal species composition
- Infaunal abundance
- Infaunal species richness and diversity
- Emergent macrophyte species richness
- Emergent macrophyte species diversity
- Emergent macrophyte species maximum stem or shoot length
- Percent of macrophyte species as nonindigenous species
- Submerged aquatic vegetation or macroalgal percent cover
- Submerged aquatic vegetation maximum shoot length

The pilot studies in Southern California and San Francisco Bay provided the opportunity to broaden the focus of the International Wetlands Asssessment Study beyond an emphasis on sediment contamination and water quality to include issues specific to intertidal wetland habitats, such as habitat fragmentation, threatened and endangered native species, the spread of nonindigenous species, the modification of tidal flushing, and the impacts of land use alteration on wetlands (Table 2). Inclusion of these landscape and ecosystem-scale indicators should generate a more complete and accurate assessment of the effects of stressors on West Coast estuaries.

Table 2. Environmental Condition Indicators Used in the San Francisco Bay and Southern California 2002 Intertidal Wetlands Assessment Study (U.S. EPA, NCA).

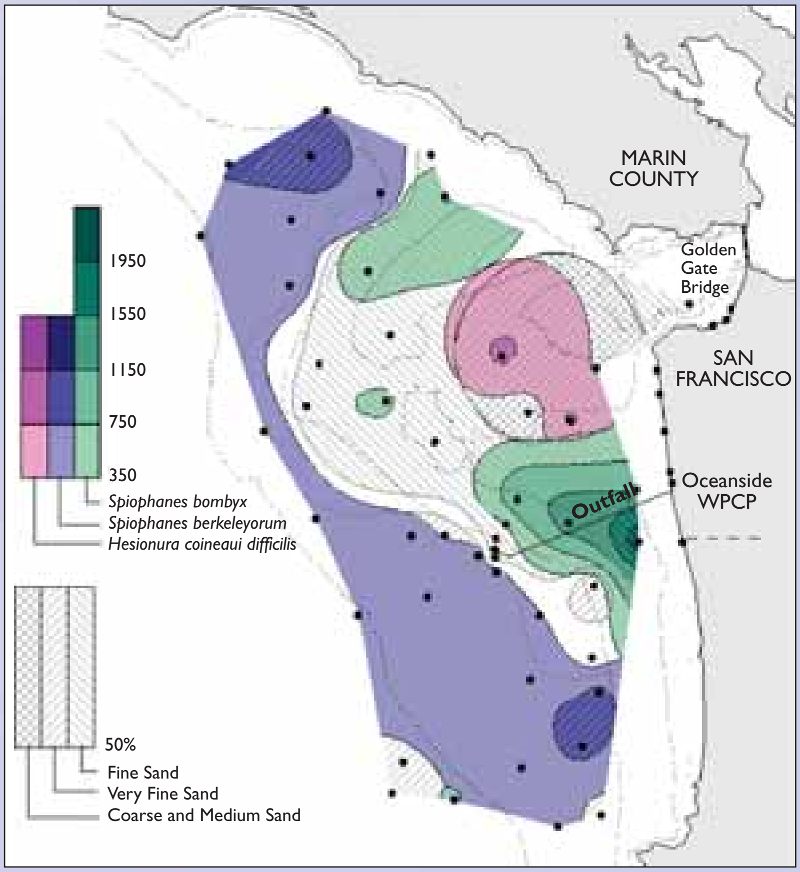
- Plant community composition and percent cover for drainage system
- Wrack line trash composition for drainage system
- Nonindigenous species plants for habitat patch
- Management objectives for habitat patch
- Number of recreational facilities and annual visitors for habitat patch
- Presence of man-made water control structures and levees
- Total annual POTW, industrial, and power plant discharges to wetland watersheds
- Human population density for watershed
- Human population age structure for watershed
- Habitat connectivity of tidal marsh patches
- Percent attenuation of spring tide range
- Intertidal channel density for habitat patch
- Total acreage for habitat patch
- Total perimeter for habitat patch
- Shoreline development index for habitat patch
- Shape index for habitat patch
- Adjacent land cover for habitat patch
- Size class distribution for all habitat patches

City and County of San Francisco Offshore Monitoring Program

The city and county of San Francisco conduct a regional monitoring program offshore of the mouth of San Francisco Bay. San Francisco's combined sewer system collects all sanitary and industrial wastes and stormwater runoff for treatment to primary or secondary standards prior to being discharged to the ocean. Activities from the highly urbanized Bay Area and agricultural Central Valley affect the environmental quality of San Francisco Bay waters, which pass through the study area with each tidal cycle. The program includes bacterial monitoring at beaches to provide public health data and to determine impacts from shoreline discharges. Additionally, offshore monitoring is conducted to evaluate the impacts of treated wastewater discharges on sediments and marine life.

Total coliform bacteria concentrations, an indicator for water-borne pathogens that could cause illness to those involved in beach recreation, are generally low year round, with increases correlating to rainfall and shoreline discharges. Surveys documented beach recreation as low during or following shoreline discharges, which typically occur during severe storm events in midwinter. Beach warnings are posted whenever a shoreline discharge occurs or when bacteria counts are elevated. Beach water quality information and the 5-year summary report (1997–2001) of offshore monitoring data are available on the city's Web site (http://www.sfwater.org). Water quality information is also available on a toll free hotline (1-877-SF BEACH) and at EPA's national Web site (http://www.earth911.org).

Bottom fish and sediment-dwelling benthic invertebrates present in the study area represent species common in central California's nearshore, sand-bottom environments. Sediment grain size is the primary factor influencing the composition of species that live in the sediments. Some outfall stations showed an increase in abundance of these species compared to some reference stations, suggestive of enrichment; however, a comparison of abundance of species living in the sediment at outfalls and reference sites spanning the periods before and after wastewater discharge demonstrated no significant difference. Mean grain sizes at the outfalls have not changed significantly since predischarge and preconstruction periods, suggesting that the wastewater discharge has not affected sediment grain size distribution.



Sediment grain size and species composition of benthic invertebrates near oceanside discharge outfall.

Bioaccumulation of pollutants measured in the tissues of English sole and Dungeness crab are not significantly different between reference and outfall regions. Pollutant levels are higher in fatty tissues (fish liver and crab hepatopancreas) than in muscle tissue. Pollutant levels measured in sediments did not appear to affect pollutant tissue levels in organisms from the study area.

Additional information can be obtained by contacting Michael Kellogg at (415) 242-2218 or mkellogg@sfwater.org.

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

The West Coast states assessed 4,990 (95%) of their 5,249 estuarine square miles for their 2000 305(b) reports (total area of estuaries presented in the states' 305(b) reports differs significantly from that determined from the NCA survey). Of the assessed estuarine square miles on the West Coast, 13% fully support their designated uses, less than 1% are threatened for one or more uses, and almost 87% are impaired by some form of pollution or habitat degradation (Figure 6-17 and Table 6-1). Individual use support for the West Coast estuaries is shown in Figure 6-18.

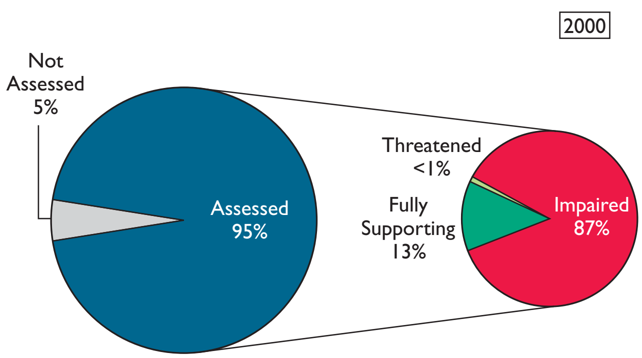


Figure 6-17. Water quality in assessed West Coast estuaries (U.S. EPA, 2002).

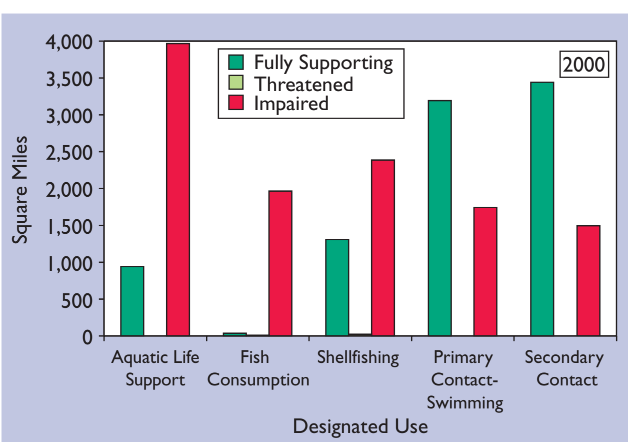


Figure 6-18. Individual use support in assessed West Coast estuaries (U.S. EPA, 2002).

The West Coast states assessed 997 (47%) of their 2,134 shoreline miles. Seventy-eight percent of the assessed shoreline miles fully support their designated uses, no shoreline miles are reported as being threatened, and 22% of the assessed shoreline is impaired by some form of pollution or habitat degradation (Figure 6-19). Individual use support for West Coast shoreline miles is shown in Figure 6-20.

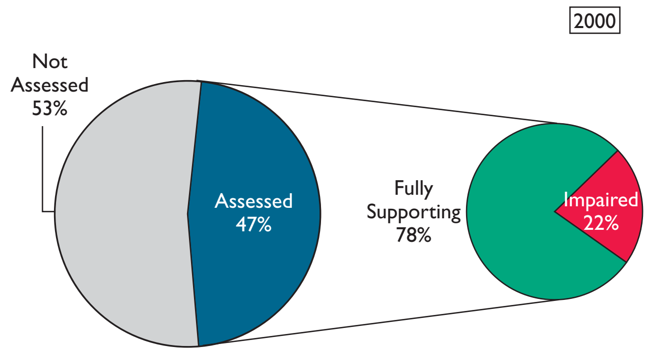


Figure 6-19. Water quality in assessed shoreline waters in the West Coast region (U.S. EPA, 2002).

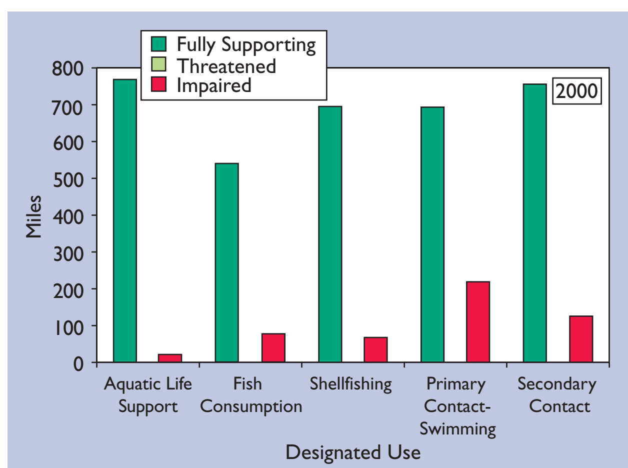


Figure 6-20. Individual use support for assessed shoreline waters in the West Coast region (U.S. EPA, 2002).

Table 6-1. Individual Use Support for Assessed Coastal Waters Reported by the States on the West Coast under Section 305(b) of the Clean Water Act. (Percent impaired is based on the total area assessed for each individual use.) (U.S. EPA, 2002).

Individual Uses	Assessed Estuaries Impaired (mi^2)	Assessed Shoreline Impaired (mi)
Aquatic life support	3,976 (81%)	21 (3%)
Fish consumption	1,974 (97%)	77 (13%)
Shellfishing	2,395 (64%)	66 (9%)
Primary contact – swimming	1,740 (35%)	218 (24%)
Secondary contact	1,501 (30%)	127 (14%)

Fish Consumption Advisories

In 2002, 24 fish consumption advisories were in effect for the estuarine and coastal waters of the West Coast (Figure 6-21). A total of 21% of the estuarine square miles of the West Coast were under advisory in 2002, and all of the estuarine area under advisory was located within the San Francisco Bay/Delta region or within Puget Sound. Only 11% of the coastal miles were under advisory; more than one-half of these miles were located in Southern California, and the rest were located on coastal shoreline in Washington's Puget Sound. None of the West Coast states (California, Oregon, or Washington) had statewide coastal advisories in effect in 2002. Although Oregon did not list any fish consumption advisories for estuarine or coastal waters in 2002, there is a fish consumption advisory for the lower Columbia River (which forms the border between Washington and Oregon) issued by Washington State for all species for PCBs, dioxins/furans, and DDT.

Seventeen different contaminants or groups of contaminants were responsible for West Coast fish advisories in 2002, and 14 of those contaminants were listed only in the waters of Puget Sound and bays emptying into the sound (arsenic, chlorinated pesticides, creosote, dioxin, industrial and municipal discharge, metals, multiple contaminants, PAHs, PCBs, pentachlorophenol, pesticides, tetrachloroethylene, vinyl chloride, and volatile organic compounds [VOCs]). In California and Washington, PCBs were partly responsible for 67% of advisories (Figure 6-22). DDT was partly responsible for 12 advisories issued in California. Although there were only two advisories issued for mercury on the West Coast, the entire San Francisco Estuary was covered by one of these advisories.

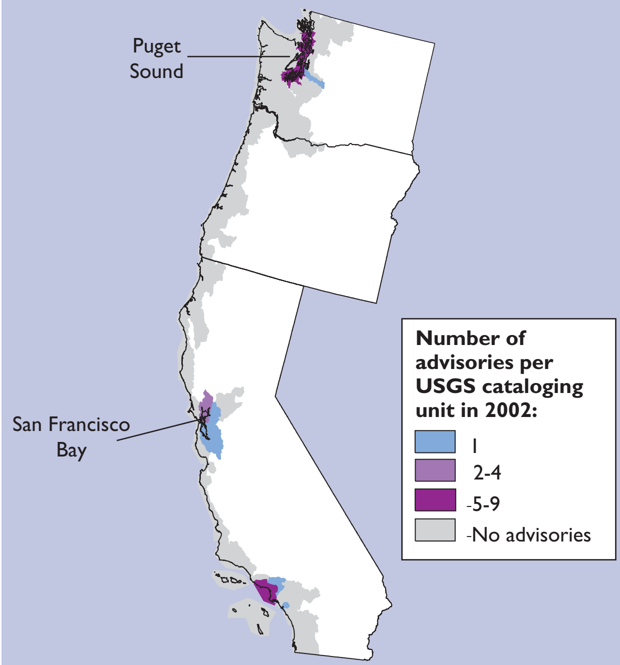


Figure 6-21. The number of fish consumption advisories per USGS cataloging unit for the West Coast (U.S. EPA, 2003c).

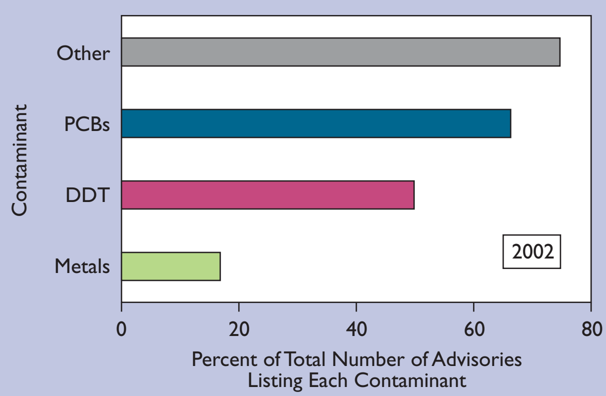


Figure 6-22. Contaminants responsible for fish consumption advisories in the waters of the West Coast in 2002. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2003c).

The following fish and shellfish species were under advisory in at least some part of the coastal waters of the West Coast in 2002:

Black croaker	Queenfish
Bivalves	Rockfish
Bullhead	Sculpin
Clams	Shark
Corbina	Shellfish
Crab	Striped bass
Gobies	Surfperch
Kelp bass	White croaker

Source: U.S. EPA, 2003c

Beach Advisories and Closures

Of the 274 coastal beaches in the West Coast region that reported information to EPA, 65% (178 beaches) were closed or under an advisory for some period of time in 2002. Table 6-2 presents the numbers of beaches, advisories, and closures for each state. California had the most beaches responding to the EPA survey (269), as well as the most advisories and closures. It should be noted, however, that the total number of beach advisories and closures may not be indicative of increased health risks to swimmers, but is generally indicative of more intensive bacterial sampling efforts conducted at the surveyed beaches. In 2002, only five beaches in Washington provided a survey response, and no beaches in Oregon completed the EPA BEACH survey. Figure 6-23 presents advisory and closure percentages for each county within each state.

Most beaches had multiple sources of water-borne bacteria that resulted in advisories or closures. Unknown sources accounted for 74 percent of the responses from West Coast beaches (Figure 6-24).

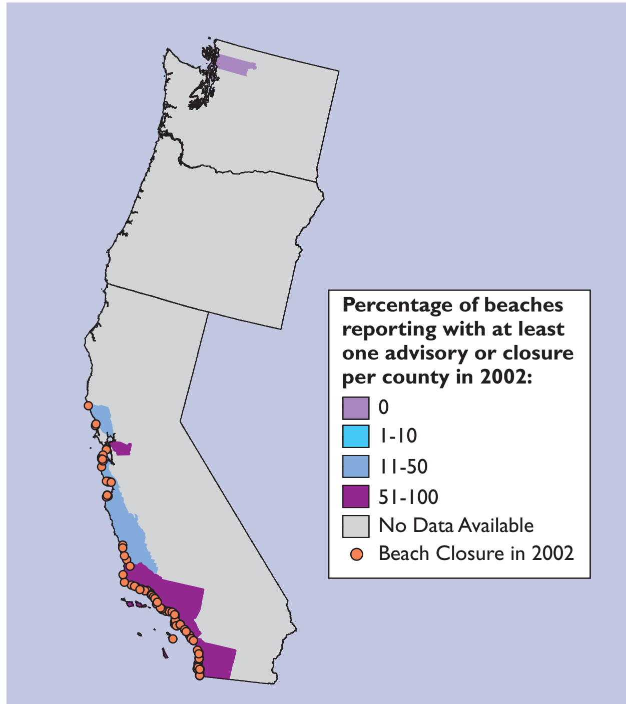


Figure 6-23. Percentage of West Coast beaches with advisories or closures by county in 2002 (U.S. EPA, 2003a).

Table 6-2. Number of Beaches and Coastal Advisories/Closures in 2002 for the West Coast.

State	No. of Beaches	No. of Advisories/ Closures	Percentage of Beaches Affected by Advisories/ Closures
California	269	178	66.2 %
Oregon	-	-	-
Washington	5	0	0.0%
TOTALS	274	178	65.0 %

Source U.S. EPA, 2003a

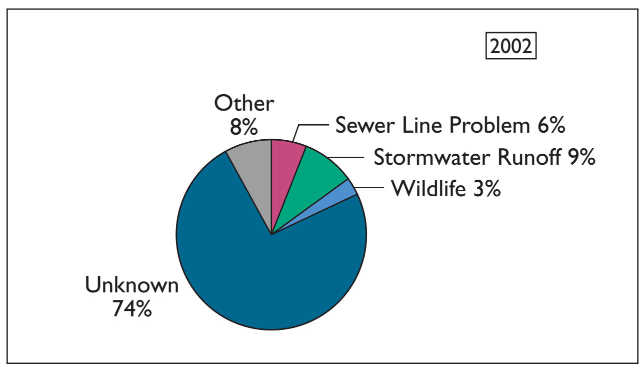


Figure 6-24. Sources of beach contamination in the West Coast region (U.S. EPA, 2003a).

Clamming season opens on the Oregon coast west of Astoria (Commander Grady Tuell, NOAA Corps).

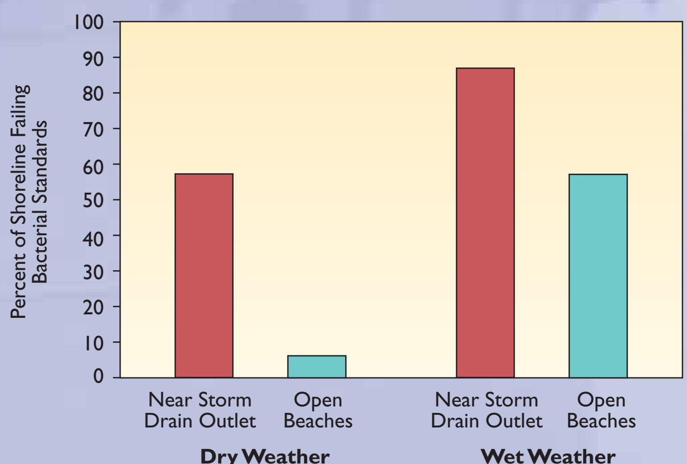
highlight

Southern California's Beach Water Quality

Southern California beaches are a valuable recreational resource, receiving more than 300 million visitors and contributing 9 billion dollars to the local economy annually. Southern California beaches are also the most extensively monitored in the country, with most supervision focused on known problem areas. To better assess overall shoreline water quality, 22 organizations that monitor bacteriological levels along the Southern California shoreline coordinated their efforts to conduct three integrated coastline surveys. Two of the surveys were conducted during dry periods, and one was conducted following a rainfall event.

Multiple bacterial indicators (e.g., total coliforms, fecal coliforms, and enterococci) were collected from nearly 300 beach sites, randomly selected using a stratified sampling design. Water quality along coastal beaches was consistently good during dry weather, with almost 95% of the shoreline sites meeting bacterial standards. The few open coastline samples that exceeded bacterial standards were barely above guidelines and surpassed standards for only one of the three bacterial indicators measured. In contrast, nearly 60% of the beaches near urban runoff outlets (storm drains) failed water quality standards, with most of the samples failing for multiple bacterial indicators. Effects of land-based runoff were more exaggerated during wet weather, when 58% of the open coastline and 87% of the beaches near storm drains failed water quality standards. The levels of these water quality standard failures were also much higher in wet weather.

Results of this study have served to reassure visitors that beach water quality monitoring programs currently being conducted at Southern California's beaches are highly effective. Management efforts are focused on improving urban runoff quality, with warnings not to swim near runoff outlets currently issued for three days following storm events.

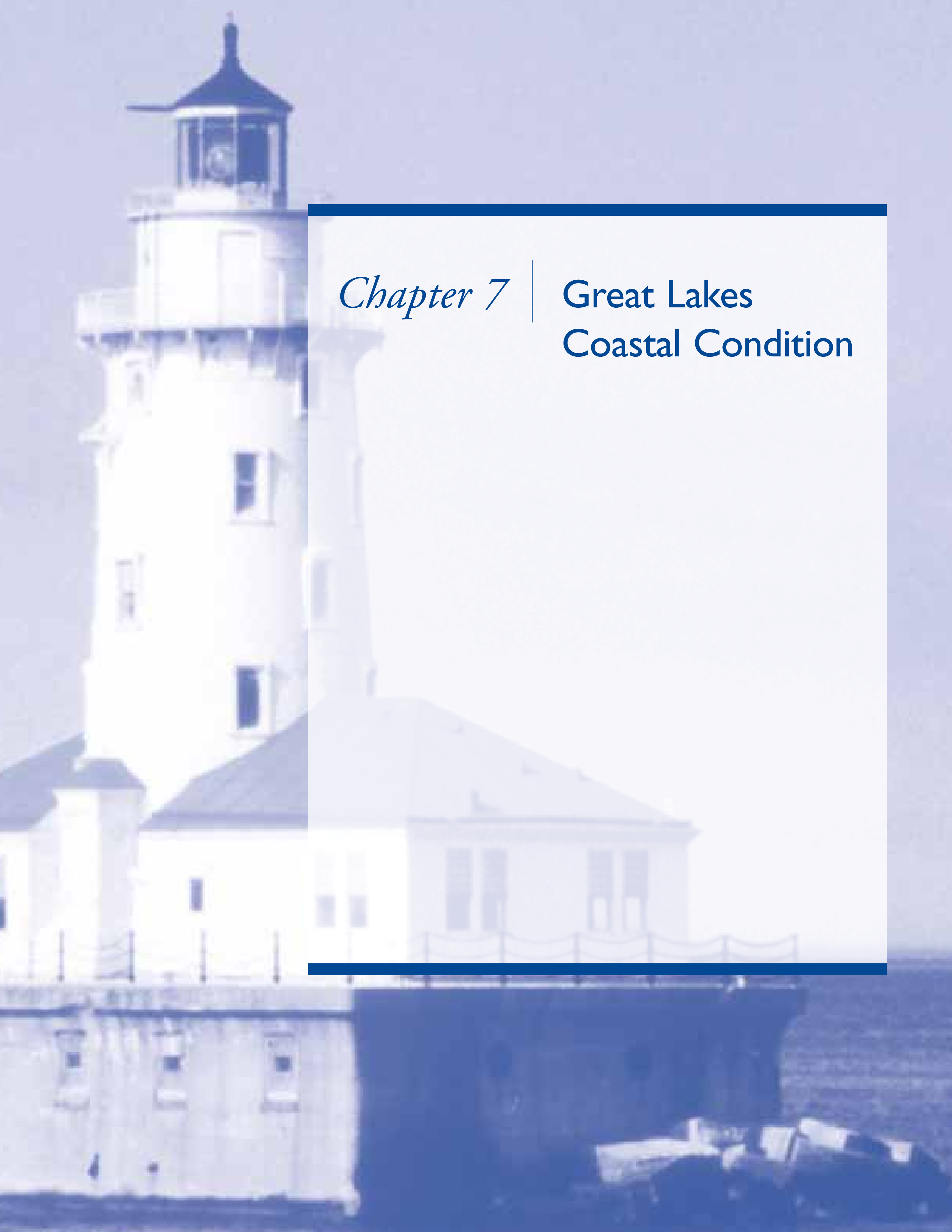


Source: Noble et. al., 2003

Summary

The Golden Gate Bridge as seen from atop NOAA's Gulf of the Farallones National Marine Sanctuary Office at the Presidio, San Francisco, California (Rich Bourgerie, Oceanographer, CO-OPS, NOS, NOAA).

Based on the indices used in this report, ecological conditions in West Coast estuaries are considered fair. These results are largely driven by results from Puget Sound and the San Francisco Estuary; most smaller systems along the coast are estimated to be in better condition. The NCA 1999–2000 data confirm the conclusion of the NCCR I that the primary problems in West Coast estuaries are degraded sediment quality. The NCA data show that 21% of estuarine sediments exceed ERL/ERM guidelines for sediment contaminants. For most of the West Coast estuarine area, sediment contamination was due to exceedance of ERLs for multiple compounds rather than for a single compound exceeding the ERM value. There was little indication of elevated levels of organic matter in the sediments, and although there was evidence of sediment toxicity from amphipod bioassays, in some cases toxicity was not explained by measured contaminants at a site. Dissolved oxygen, chlorophyll *a* concentrations, and levels of nitrogen are considered good for West Coast estuaries, except in some isolated regions of Puget Sound. Based on the water clarity indicator, considerable areas of West Coast estuaries have poor light penetration, but the high tidal amplitude in much of the region may require a reevaluation of the threshold levels used for this indicator in the West. Increasing population pressures (particularly in the Seattle-Tacoma region, the San Francisco Estuary, and Southern California) require continued environmental awareness and programs to correct existing problems and to ensure that environmental indicators currently in fair condition do not worsen and become poor.



Chapter 7 | Great Lakes Coastal Condition

Great Lakes Coastal Condition

The overall condition of the Great Lakes is fair to poor, based on the Great Lakes Index (Figure 7-1). The Great Lakes National Program Office (GLNPO) has been monitoring the open waters of the Great Lakes (approximately 94,250 square miles) annually since 1983. It has collected water and biota biannually from specified water depths from a limited number of locations in each of the five Great Lakes. This monitoring effort was designed to provide data to (1) assess the state of water quality in open lake basins (more than 100 feet in depth or more than 3 miles from shore); (2) detect and evaluate trends and changes in chloride, nitrate nitrogen, silica, phytoplankton, total phosphorus, chlorophyll *a*, and Secchi disk depth; (3) verify or modify water quality models; and (4) estimate the trophic index for each lake. The GLNPO also sampled sediments from select shallow and deepwater locations to characterize benthic communities. Other special-purpose sampling programs focused on known or suspected problem areas, such as the Great Lakes AOCs and rivers and harbors, to determine, for example, whether contamination was increasing or decreasing in sediments and whether remediation efforts were feasible and effective.

State of the Lakes Ecosystems Indicators	**Numerical Rating**				
	1	2	3	4	5
1. Water Clarity				■	
2. Dissolved Oxygen					■
3. Coastal Wetlands		■			
4. Water Quality Index*			■		
5. Eutrophic Condition		■			
6. Sediment Contamination	■				
7. Benthic Health		■			
8. Fish Tissue Contaminants			■		
9. Phosphorus Concentrations			■		
Beach Closures			■		
Drinking Water Quality				■	
Air Toxics Deposition			■		

Figure 7-1. The overall condition of the Great Lakes based on these indicators is fair to poor. (The numbered indicators are similar to those used in the NCA Program, with poor referenced as 1 or red, and good referenced as 5 or dark green. The Water Quality Index [#4] is not part of the SOLEC indicators and was constructed for a more direct comparison to the water quality indices used in this report. It is a combination of SOLEC indications—Water Clarity [#1], Dissolved Oxygen [#2], Eutrophic Condition [#5], and Phosphorus Concentrations [#9].)

Chicago Harbor Light, Chicago Illinois (Richard B. Mieremet, Senior Advisor, NOAA OSDIA).

Lake Michigan waterfront Chicago, Illinois (Richard B. Mieremet, Senior Advisor, NOAA OSDIA).

Houghton County, Lake Superior, Michigan (Richard B. Mieremet, Senior Advisor, NOAA OSDIA).

Coastal Monitoring Data

Although the Great Lakes have an extensive monitoring network, Great Lakes monitoring is not directly comparable with monitoring done under the NCA Program. The Great Lakes Program uses best scientific judgment to select monitoring sites that represent overall condition of the Great Lakes, whereas the NCA Program uses a probabilistic survey design to represent overall ecosystem condition in order to attain a known level of uncertainty. Because the two programs use different methods, spatial estimates of coastal condition cannot be calculated for the Great Lakes that are consistent with those calculated for the Northeast Coast, Southeast Coast, West Coast, and Gulf Coast regions, nor can estimates for the Great Lakes be compared with those for other regions with a known level of confidence. The comparability of these estimates, however, was recently improved by efforts of the GLNPO and Great Lakes scientists to assess the overall status of eight ecosystem components of the Great Lakes, some similar to NCA indicators. The results of these efforts, along with relevant technical information from the SOLEC (http://www.epa.gov/grtlakes/solec/) and GLNPO (http://www.epa.gov/glnpo/), are used to quantify and categorize NCA condition indicators for the Great Lakes. The condition values are based primarily on expert opinion, and they are integrated with other regional condition data to evaluate the overall condition of the nation's coastal environment.

Water Quality Index

In order to more readily compare the SOLEC findings for the ecological condition of the Great Lakes with the NCA findings for U.S. estuaries, several SOLEC indicators (eutrophic condition, water clarity, dissolved oxygen, and phosphorus concentrations) were combined into a water quality index. Of these indicators, one is fair to poor (eutrophic condition), two are fair (water clarity and phosphorus concentrations), and one is good (dissolved oxygen). The same general approach used for NCA data to calculate water quality index ratings was used to calculate the water quality index rating for the Great Lakes, and water quality is rated fair.

Eutrophic Condition

Eutrophic condition in the Great Lakes is rated fair to poor. The GLNPO used a surface water quality index developed by Chapra and Dobson (1981), based on an assumed direct relationship between phosphorus concentrations, chlorophyll *a*, and Secchi depth (clarity), to describe the water quality condition of offshore waters.

Data collected during the 1990s indicate that the trophic condition of Lake Superior, the deepest and coldest of the Great Lakes, is good (oligotrophic—low in nutrients, high in water clarity, and low in productivity), and trends do not suggest future problems. For the remaining Great Lakes, data to calculate trophic-state indices date back to the 1980s and provide a long-term trend. The waters of Lakes Michigan and Huron, the second and third largest of the Great Lakes, respectively, were determined to be good (oligotrophic), with indications that conditions are improving. Lake Ontario, the fourth largest lake, is oligomesotrophic (having both oligotrophic and mesotrophic characteristics over time), with indications that conditions are improving. Lake Erie, the smallest of the Great Lakes, has three distinct basins. The Eastern Basin, the deepest of the three basins, is oligotrophic (good). The Central Basin has characteristics of both oligotrophy and mesotrophy (moderately low in nutrients, moderate in water clarity, and of moderate productivity) and experiences oxygen depletion at deeper depths during the summer months. The Western Basin, the shallowest basin, is classified as mesotrophic, with large annual fluctuations in the index obscuring any trends.

Nutrients: Phosphorus

The condition of the Great Lakes as measured by nutrient concentrations is fair. Average phosphorus concentrations in the open waters of Lakes Superior, Michigan, Huron, and Ontario are at or below guideline levels established by the Great Lakes Water Quality Agreement (Figure 7-2). Offshore waters of Lakes Ontario and Huron meet the guidelines, but some nearshore areas exceed the guidelines, potentially promoting growth of nuisance algae. Phosphorus concentrations in all three basins of Lake Erie exceed the guidelines. Four of six lake basins have total phosphorus concentrations at or below guideline levels; consequently, Great Lakes scientists rank phosphorus concentrations as fair. This indicator, however, is measured in the open waters of the Great Lakes. If phosphorus were measured in nearshore coastal areas (the subject of this report) rather than in open water, the indicator would likely rank lower in condition.

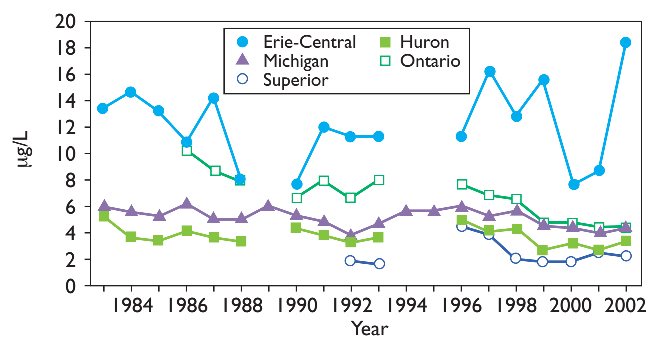


Figure 7-2. Total phosphorus concentrations in the open waters of the Great Lakes (GLNPO, 2003).

Water Clarity

Water clarity, measured by Secchi disk, is good to fair in the Great Lakes. It has increased in all lakes over the last decade, except for Lake Erie. Secchi disk measurements of light penetration in Lake Ontario, for example, increased nearly 100% during the 1990s. Increased water clarity, although visually pleasing, may not be a good indicator of improving conditions in the Great Lakes because increased water clarity is also an indicator of reductions in algal populations, which are the food base for the aquatic food chain.

Turbidity data are often collected in nearshore waters in order to measure water clarity and drinking water quality. Based on data from 98 reporting stations in the Great Lakes Basin collected between 1999 and 2001, the most turbid waters were from the Great Lakes, connecting rivers, and inland rivers; inland lakes and ground waters were less turbid. The trend in turbidity declined during this period, with Lakes Ontario, Superior, and Huron having the least turbid waters during this 3-year period.

Dissolved Oxygen

Dissolved oxygen conditions in the Great Lakes are generally good; however, dissolved oxygen in the central basin of Lake Erie continues to be a persistent problem. Anoxic conditions (< 0.5 mg/L) often occur in late August and continue until turnover occurs in the fall. The frequency and extent of oxygen depletions decreased considerably from the 1970s, leveled off in the late 1990s, and may now be increasing again. This may be due to the invasion of non-native species that have modified Lake Erie's ecosystem function and affected dissolved oxygen concentrations.

Sediment Quality Index

The condition of sediments in Great Lakes harbors and tributaries is poor. Contaminated sediments currently affect beneficial uses at all 31 of the AOCs in the U.S. Great Lakes (Figure 7-3). Sediment contamination contributes to 11 of 14 beneficial use impairments, including a wide range of recreational, habitat, economic, and environmental impairments. Contaminated sediments in the AOCs are the leading cause of fish consumption advisories. Contaminated sediments in the AOCs requiring remediation are roughly estimated to be between 10 and 30 million cubic yards. Sediment contaminants in the AOCs also serve as a source of contaminants to the open waters as a result of sediment resuspension activities, such as storm events. Great Lakes scientists rank sediment contamination by examining the percentage of contaminated sediment volume that has been remediated. Sediment contamination in the AOCs is rated poor because less than 10% of the contaminated sediment volume has been remediated. This poor rating only applies to the most problematic

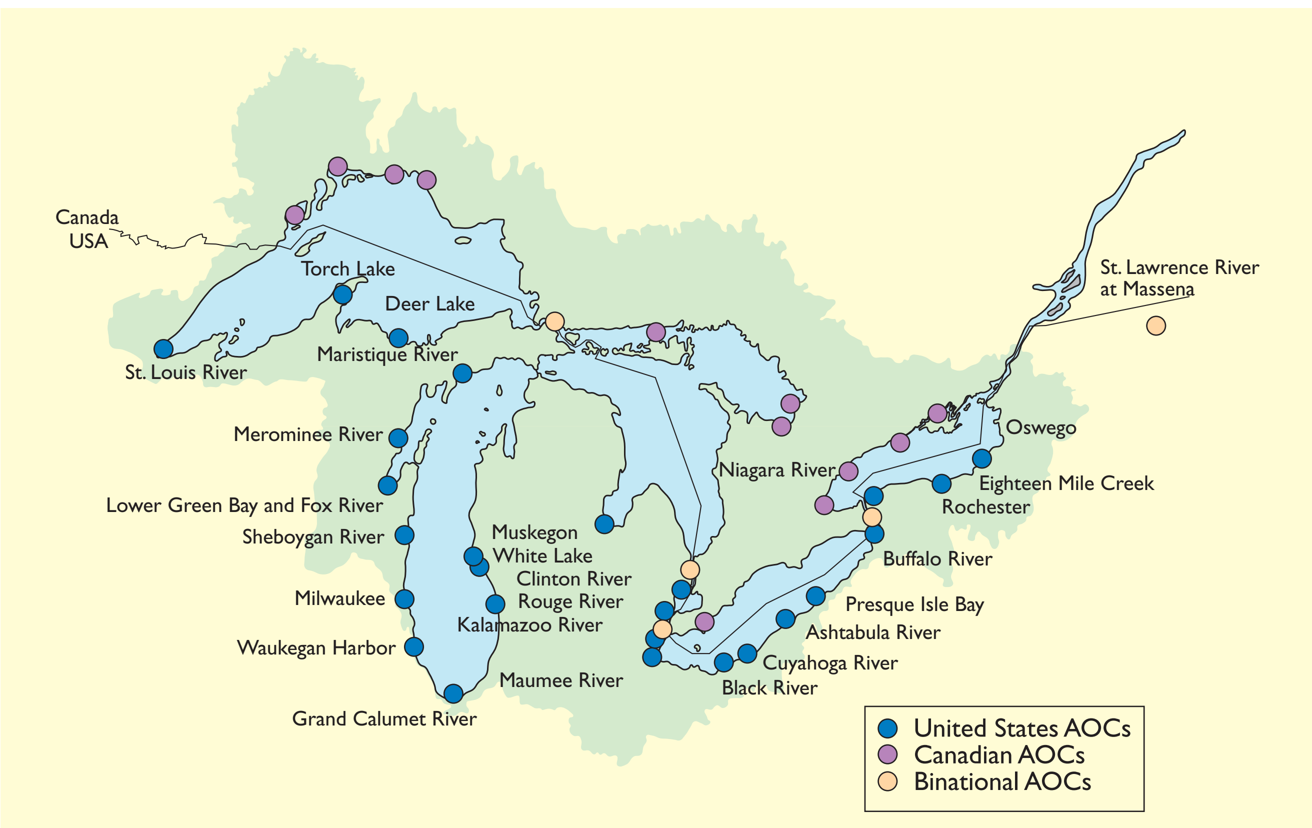


Figure 7-3. Great Lakes Areas of Concern (AOCs) (GLNPO, 2004).

Great Lakes areas and is not intended as an overall assessment of the sediments of the Great Lakes.

The GLNPO assesses the levels of contaminants in rivers and harbors of the Great Lakes to support sediment-based mass balance modeling activities, to promote remediation of sediment contaminants, and to assist in developing sediment policies for the Great Lakes. The results of sediment assessments conducted in 1999 showed that approximately 60% of the sediments sampled in Great Lakes rivers and harbors were considered "probably toxic" because of PCBs, 20% were considered not toxic, and 20% were considered to have uncertain toxicity (Figure 7-3).

Benthic Index

Sediment condition in the Great Lakes as measured by benthic condition is fair to poor. The benthic invertebrates *Diporiea* and *Hexagenia* have historically been sampled because of their importance at the base of the food web. *Diporiea* is an indicator in cold, deepwater habitats, and *Hexagenia* is an indicator of a healthy mesotrophic environment. Nine monitored areas—the deepwater environment of each lake plus four mesotrophic habitats (western Lake Erie, the Bay of Quinte, Saginaw Bay, and Green Bay)—provide the basis for evaluating benthic health. Only two to four of the monitored areas have healthy, sustainable populations of *Diporiea* or *Hexagenia*; consequently, SOLEC scientists rank benthic health for the Great Lakes as poor (Figure 7-4).

The GLNPO initiated a benthic invertebrate biomonitoring program in 1997 to complement its ongoing surveillance sampling (Figure 7-5). All five lakes were sampled for macroinvertebrates and sediment chemistry at a minimum of 45 sampling stations; nearshore (< 165 ft depth) and offshore (> 165 ft depth) stations were sampled to evaluate both large, basin-wide changes (offshore) and more local changes (nearshore). The results demonstrated that, overall, most sites were taxa poor, with a maximum of 7 to 10 taxa per site and a minimum of 1 to 5 taxa per site. Greater numbers of taxa were found in the lower lakes, with the greatest number in Lake Erie, most likely because Lake Erie has a greater number of shallow sampling sites.

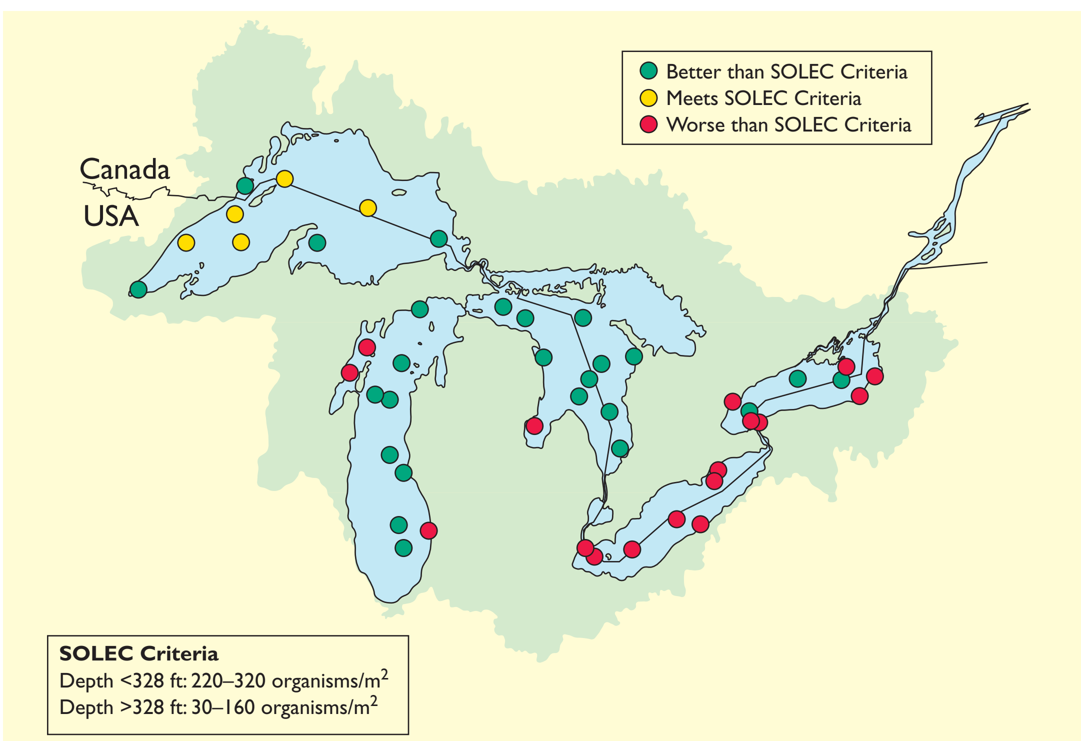


Figure 7-4. *Diporiea* abundance in relation to SOLEC criteria (GLNPO, 1998).

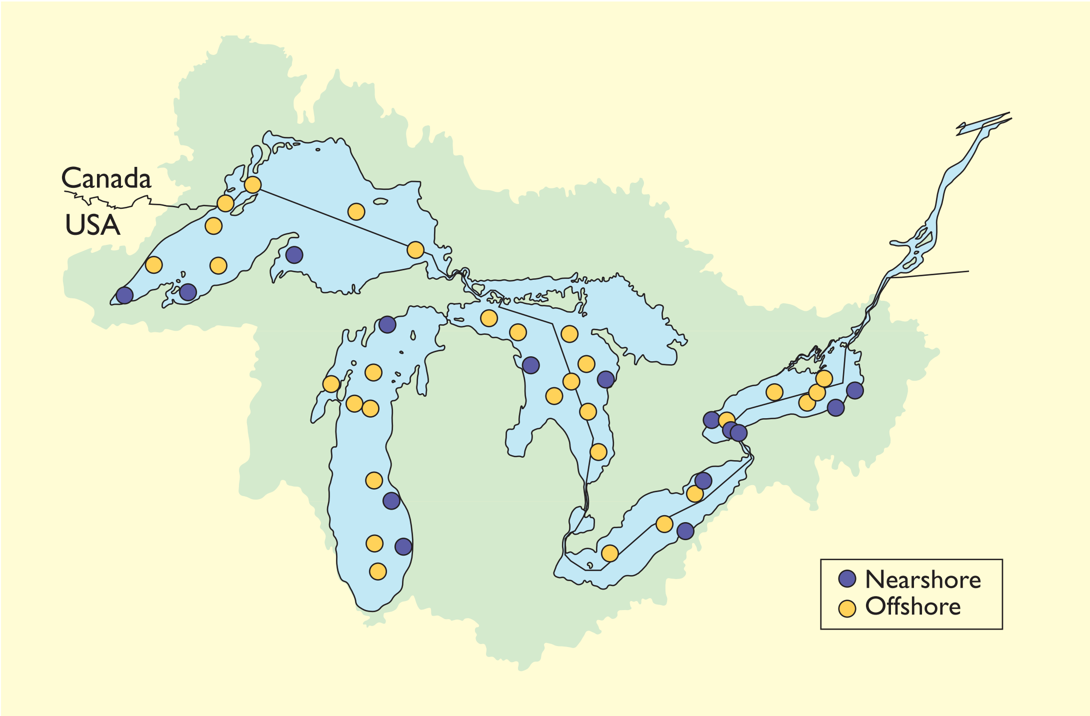


Figure 7-5. Location of benthic sampling sites, summer 1997 (GLNPO, 1998).

Coastal Habitat Index

More than one-half of the Great Lakes coastal wetlands were lost between 1780 to 1980, with the largest losses in Ohio (90%) and the smallest in Minnesota (42%) (Figure 7-6). Today, Great Lakes scientists rate the condition of Great Lakes coastal wetlands by examining amphibian abundance and diversity, wetland-dependent diversity and abundance, coastal wetland area by type, and the effects of water level fluctuations. Based on these measures, the condition of Great Lakes coastal wetlands is rated fair to poor. A binational Great Lakes Coastal Wetlands Consortium of scientists and managers is developing a long-term monitoring program to assess trends in the rate and extent of loss of the Great Lakes coastal wetlands.

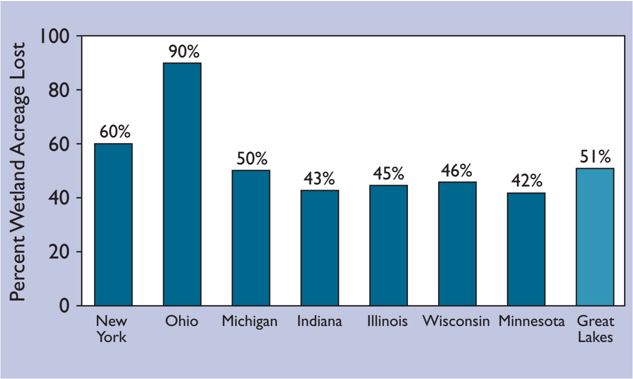


Figure 7-6. Percent coastal wetland habitat loss from 1780 to 1980 by state and for the Great Lakes overall (Turner and Boesch, 1988; Dahl, 1990).

Raspberry Island Lighthouse, Apostle Islands, Wisconsin (Richard B. Mieremet, Senior Advisor, NOAA OSDIA).

Fish Tissue Contaminants Index

The condition of the Great Lakes as measured by fish tissue contaminants is fair. Fish consumption programs are well established in the Great Lakes and offer advice to residents regarding the amount, frequency, and species of fish that are safe to eat. Such advice is based primarily on concentrations of PCBs, mercury, chlordane, dioxin, and toxaphene in fish tissues. These contaminants are generally declining in fish tissues, but are still at levels that trigger fish advisories in all five Great Lakes. Great Lakes scientists rank fish tissue contamination as fair, based on the application of a uniform fish protocol to PCB concentrations in coho salmon from the Great Lakes (contaminants in fish tissue range between 0.2 and 2.0 ppm). Each lake is ranked individually based on PCB concentrations and the corresponding fish advisory category; the final overall ranking is an average of all five individual rankings.

Fish contaminant data can also be used to determine whether fish-dependent wildlife are threatened by toxic chemicals in the environment. Fish-dependent wildlife consume fish as a large part of their diet, and consequently, are susceptible to toxic chemicals in the aquatic environment. The EPA established 0.16 ppm as the wildlife protection value for fish-dependent wildlife, the concentration below which fish-dependent wildlife are reasonably protected. This value is exceeded by a factor of 5 to 10, depending on the specific lake, with highest concentrations in predatory fish from Lake Michigan (Figure 7-7).

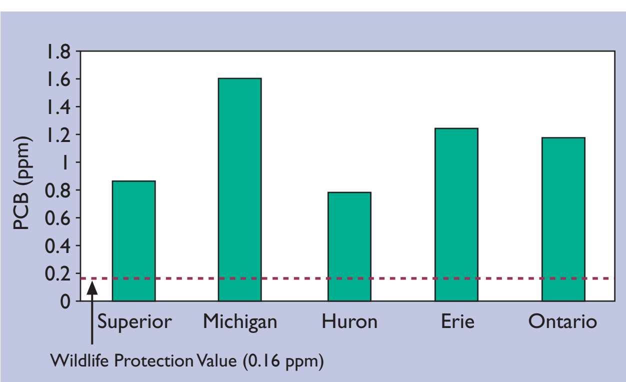


Figure 7-7. PCBs concentrations in Great Lakes top predator whole fish (walleye in Lake Erie, lake trout elsewhere) in 2000 (GLNPO, 2003).

Drinking Water Quality

Drinking water quality in the Great Lakes is fair to good. This indicator is based on the following chemical, biological, physical, and aesthetic parameters: (1) atrazine, nitrate, and nitrite concentrations in raw water; (2) total counts of coliform, *Escherischia coli*, *Giardia*, and *Cryptosporidium* in treated water; (3) turbidity, TOC, and dissolved organic carbon in raw water; and (4) taste and odor of treated water. The desired objective is that all drinking water be safe for human consumption. In other words, densities of disease-causing organisms or concentrations of hazardous or toxic chemicals should not exceed objectives, standards, or guidelines for protecting human health.

The risk to human health from chemical contaminants in Great Lakes drinking water sources is minimal, based on analysis of treated water for atrazine at 104 public water systems and nitrite at 56 public water systems. Data from 98 systems suggested that nearly 36% of public water systems needed to treat water for TOC and dissolved organic carbon (which have the potential to form harmful by-products during water treatment), and treatment was effective in reducing these compounds to safe levels. Three-year data from 48 water treatment plants show higher coliform counts in Great Lakes surface waters and rivers. Water treatment plants reported no to very low occurrences of *Giardia* and *Cryptosporidium* in raw water and no occurrences of these organisms in treated drinking water; consequently, Great Lakes scientists ranked drinking water quality as fairly good.

Air Toxics Deposition

The condition of the Great Lakes as measured by air toxics deposition is fair. Trends in concentrations of PCBs over space and time are used to infer the potential for impacts of chemicals from atmospheric deposition and effectiveness and progress toward eliminating toxics from the Great Lakes. The major pathways for PCBs into the Great Lakes are atmospheric deposition (80% to 95%, based on data from Lake Superior and Lake Michigan), sediment contamination, and tributary loadings. SOLEC scientists rank air toxics deposition as fair based on a rating guideline that measured air toxics concentrations ranging between 55 and 100 pg/m^3.

State of the Lakes Ecosystem Conference (SOLEC)

The SOLEC events are co-hosted biennially by EPA and Environment Canada, as required by the binational Great Lakes Water Quality Agreement (GLWQA) of 1978, as revised in 1987. The purpose of the agreement is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem. These conferences report on the state of the Great Lakes ecosystem and major factors affecting it, as well as provide a forum to inform Great Lakes decision makers of the effectiveness of protection and restoration programs for the ecosystem.

Scientists, environmental managers, and other interested stakeholders from the United States and Canada participate in these conferences, which are often focused on specific, but slightly different issues. SOLEC 1994 focused on aquatic community health, human health, aquatic habitat, toxic contaminants in the water, and the Great Lakes economy. The second conference, SOLEC 1996, focused on the nearshore lands and ecosystem water, where there is high biological productivity and diversity and where human impacts are the greatest. Nearshore waters, coastal wetlands, land adjacent to the Great Lakes, impacts of changing land use, and information availability and management were topics stressed at this conference. Following SOLEC 1996, participants identified the need to develop comprehensive, basin-wide indicators to determine and report on progress in a compatible format; therefore, the objective of SOLEC 1998 was to develop a suite of indicators that fairly represent the condition of the Great Lakes ecosystem components.

SOLEC 1998 initiated a systematic program to assess the state of the Great Lakes using science-based indicators. The challenge of SOLEC 2000 was to determine how many of the 80 recommended indicators from the 1998 conference could be quantified. SOLEC 2002 continued the update and assessment of the state of the Great Lakes using the suite of indicators and emphasized biological integrity. A comprehensive assessment of the state of the Great Lakes basin was reported at the 2002 conference.

The results of SOLEC 2002 conference provide much of the information reported in the Great Lakes Coastal Condition chapter. Summaries of the indicator findings and the ecological condition of each of the Great Lakes and their connecting channels are presented in the document *State of the Great Lakes 2003*. The full indicator report, plus references and data sources, are presented in *Implementing Indicators – A Technical Report*. Both are available online at http://www.binational.net. Additional information about SOLEC is also available at http://www.epa.gov/glnpo/solec/.

Assessments and Advisories

Clean Water Act Section 305(b) Assessments

The Great Lakes states assessed 5,066 miles (92%) of their 5,521 miles of Great Lakes shoreline for the 2000 305(b) reports. None of the assessed shoreline waters fully support their designated uses; 22% are threatened for one or more uses, and the remaining 78% are impaired by some form of pollution or habitat degradation (Figure 7-8). Individual use support for Great Lakes shoreline is shown in Figure 7-9. The states reported that priority toxic organic chemicals, nutrients, pathogens, sedimentation, oxygen-depleting substances, foul taste and odor, and PCBs were the leading causes of impairment to Great Lakes shoreline waters.

Table 7-1 shows how states rated individual use support for their assessed Great Lakes shoreline waters.

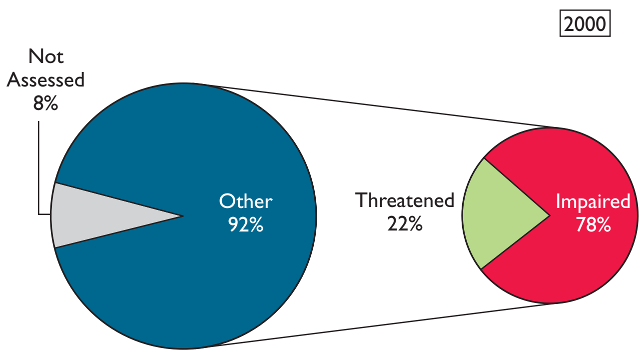


Figure 7-8. Water quality for assessed Great Lakes shoreline waters (U.S. EPA, 2002).

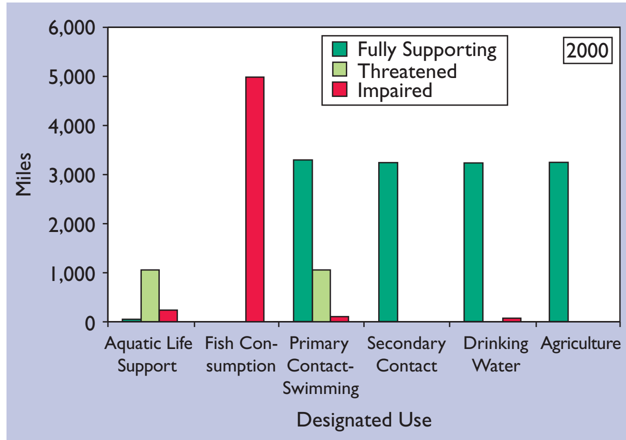


Figure 7-9. Individual use support for assessed Great Lakes shoreline waters (U.S. EPA, 2002).

Table 7-1. Individual Use Support for Assessed Shoreline Waters Reported by States on the Great Lakes under Section 305(b) of the Clean Water Act for 2000 (U.S. EPA, 2002).

Individual Uses	Shoreline Assessed as Impaired (mi)	Percentage of Total Area Assessed
Aquatic life support	245	18%
Fish consumption	4,976	100%
Primary contact – swimming	101	3%
Secondary contact	6	0%
Drinking water	80	2%
Agriculture	0	0%

Park Point area, Lake Superior, Minnesota (Richard B. Mieremet, Senior Advisor, NOAA OSDIA).

Fish Consumption Advisories

Fishing in the Great Lakes region is a way of life and a valued recreational and commercial activity for many people. To protect citizens from the risks of eating contaminated fish, the eight states bordering the Great Lakes had a total of 30 fish consumption advisories in effect in 2002 for the waters and connecting waters of the Great Lakes. During 2002, every Great Lake had at least one advisory, and advisories covered 100% of the Great Lakes shoreline (Figure 7-10). Michigan, which borders four of the five Great Lakes and encompasses four of the six connecting waterbodies, issued the largest number of advisories (13).

Great Lakes fish consumption advisories were issued for six pollutants: mercury, mirex, chlordane, dioxins, PCBs, and DDT. All of the advisories listed PCBs, and almost one-half (47%) also listed dioxins (Figure 7-11). Lake Superior, Lake Michigan, and Lake Huron were under advisory for at least four pollutants each in 2002 (Table 7-2); however, some of the advisories were of limited geographic extent, and advisories in most locations applied primarily to larger, older, individual fish high in the food chain.

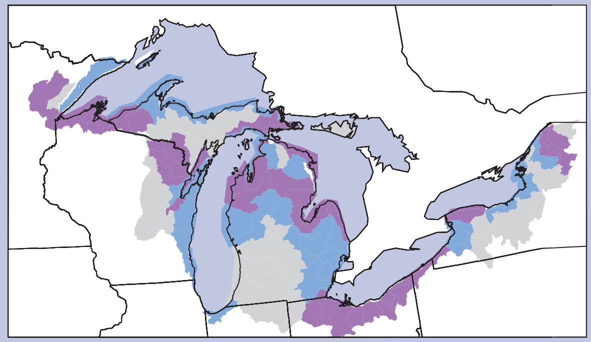


Figure 7-10. Fish consumption advisories were in effect for 100% of U.S. Great Lakes shoreline waters in 2002 (U.S. EPA, 2003c).

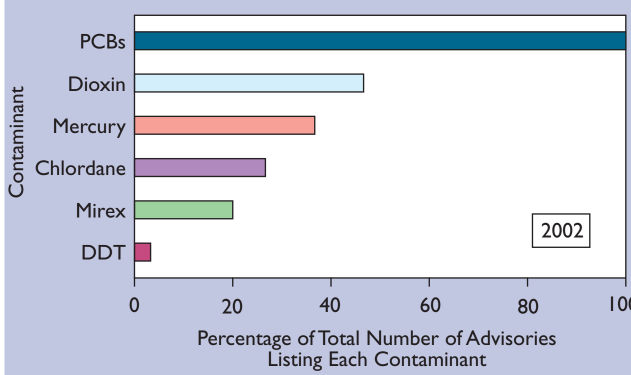


Figure 7-11. Great Lakes advisories were issued for five contaminants. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2003c).

Species under fish consumption advisory in 2002 in at least one of the Great Lakes or connecting waters:

American eel	Largemouth bass
Black crappie	Longnose sucker
Bloater	Northern hogsucker
Blue catfish	Northern pike
Bluegill sunfish	Pink salmon
Bowfin	Quillback carpsucker
Brook trout	Rainbow trout
Brown bullhead	Rock bass
Brown trout	Round goby
Burbot	Silver redhorse
Channel catfish	Siscowet trout
Chinook salmon	Smallmouth bass
Chub	Smelt
Coho salmon	Splake trout
Common carp	Steelhead trout
Freshwater drum	Walleye
Gizzard shad	White bass
Lake herring	White perch
Lake sturgeon	White sucker
Lake trout	Yellow perch
Lake whitefish	

Source: U.S. EPA, 2003c.

Table 7-2. Fish Advisories Issued for Contaminants in Each of the Great Lakes (U.S. EPA, 2003c).

Great Lakes	PCBs	Dioxins	Mercury	Chlordane	DDT	Mirex
Lake Superior	●	●	●	●		
Lake Michigan	●	●	●	●	●	
Lake Huron	●	●	●	●		
Lake Erie	●	●	●			
Lake Ontario	●	●				●

Beach Advisories and Closures

Of the 386 coastal beaches along the Great Lakes that reported information to EPA, only 28.5% (110 beaches) were closed or under an advisory for some period of time in 2002. Table 7-2 presents the numbers of beaches, advisories, and closures for each state. Indiana, Wisconsin, and Illinois had the greatest percentages of advisories or closures. Figure 7-12 presents advisory and closure percentages for each county within each state.

Most beach advisories and closures were implemented at coastal beaches along the Great Lakes because of elevated bacteria levels (Figure 7-13). Most beaches had multiple sources of water-borne bacteria that resulted in advisories or closures. Stormwater runoff (23%) and wildlife (22%) were frequently identified as sources, and unknown sources accounted for 25% of the responses (Figure 7-14).

The highest percentage of beaches closed or under advisory occurred in Indiana, Wisconsin, and Illinois, with almost 71%, 53%, and 51% of beaches, respectively, reporting at least one public beach notification in 2002 (Table 7-3). Pennsylvania and Minnesota both reported that 0% of their beaches were closed or under advisories in 2002.

Table 7-3. Number of Beaches and Advisories/Closures in 2002 for Great Lakes Coastal States (U.S. EPA, 2003a).

State	No. of Beaches	No. of Advisories/ Closures	Percentage of Beaches Affected by Advisories/ Closures
Minnesota	4	0	0.0 %
Wisconsin	53	28	52.8 %
Illinois	43	22	51.2 %
Indiana	17	12	70.6 %
Michigan	174	26	14.9 %
Ohio	52	12	23.1 %
Pennsylvania	13	0	0.0 %
New York	30	10	33.3 %
TOTALS	386	110	28.5 %

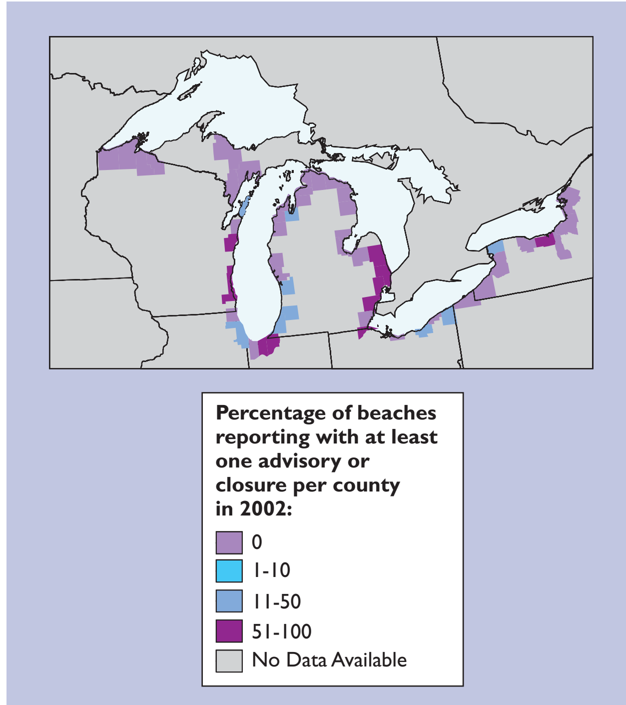


Figure 7-12. Percentage of Great Lakes beaches responding to the survey with at least one advisory or closure (U.S. EPA, 2003a).

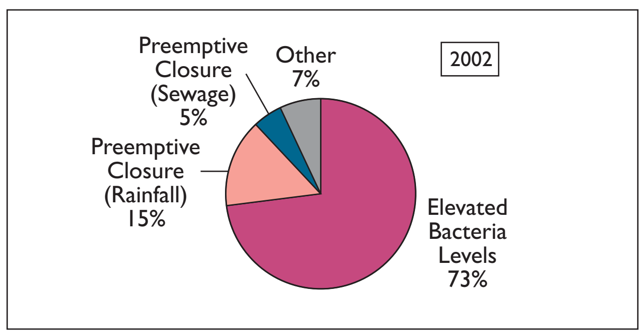


Figure 7-13. Reasons for beach advisories or closures in the Great Lakes (U.S. EPA, 2003a).

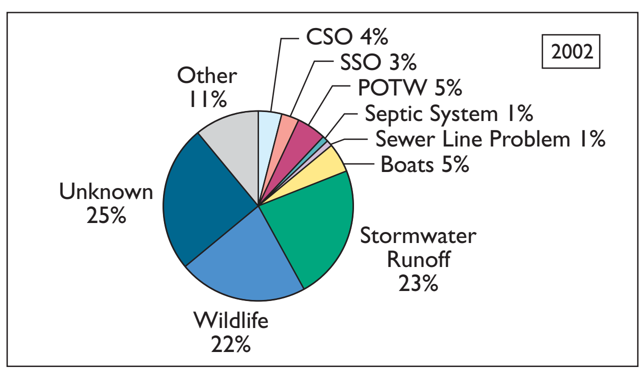


Figure 7-14. Sources of beach contamination in the Great Lakes (U.S. EPA, 2003a).

Great Lakes Strategy 2002: A Plan for the New Millennium

The Great Lakes Strategy 2002 was created by the United States Policy Committee (USPC), a forum of senior representatives from federal, state, and tribal governmental agencies that share the responsibility for environmental protection and management of the natural resources of the Great Lakes Basin. The strategy's purpose is to advance the restoration and protection of the Great Lakes Basin ecosystem, as related to fulfilling the goals of the GLWQA of 1972, as amended in 1987. It is intended to coordinate and focus USPC efforts by establishing a common set of goals for multi-lake and basin-wide environmental issues. The strategy supports multi-stakeholder efforts to restore and protect the Great Lakes, such as Lakewide Management Plans and Remedial Action Plans for AOCs. International issues will be discussed between the USPC and Canadian counterparts at the Binational Executive Committee meetings that typically occur twice a year.

The long-term vision of the Great Lakes Strategy is to eliminate the need to issue health advisories for fish consumption, beaches, or drinking water; to create a balanced, self-sustaining fishery; to restore and protect native species, natural communities, and ecological systems; to make land use and water quality decisions based on a comprehensive understanding of the ecosystem; and to maintain environmental and economic prosperity in a sustainable balance.

The strategic priorities are expressed within four major long-term goals:

1. **Chemical Integrity.** Reduce toxic substances in the Great Lakes ecosystem to maintain a balance of nutrients to ensure a healthy aquatic ecosystem and protection of all organisms.
2. **Physical Integrity.** Restore and protect the physical integrity of the Great Lakes, supporting habitats of healthy and diverse aquatic communities and wildlife in the Great Lakes Basin.
3. **Biological Integrity.** Restore and maintain stable, diverse, and self-sustaining populations of native fish and aquatic life, wildlife, and plants in the Great Lakes Basin.
4. **Cooperative Management.** Work together to restore and protect the Great Lakes Basin by establishing effective programs, coordinating authorities and resources, reporting on progress, and holding forums for information exchange and collective decision making to achieve the objectives of the GLWQA.

For each goal, the strategy identifies major environmental challenges, describes the challenge, lists major governmental programs to address the issue, establishes ambitious objectives, including a scheduled deadline with a measurable environmental result, and identifies key actions to accomplish the objectives. Additional information on the Great Lakes Strategy 2002 is available at http://www.epa.gov/grtlakes/gls.

Volunteer Monitoring Program for Aquatic Nuisance Species

The Lake Erie Aquatic Exotics Squad Volunteer Monitoring Program is a collaborative project between the Pennsylvania Department of Environmental Protection's (DEP's) Coastal Zone Management Program, Lakes Management Program, Citizen Volunteer Monitoring Program, and Pennsylvania Sea Grant. The pilot phase of this program was conducted in 2003 and trained citizens, watershed organizations, and students in the coastal Lake Erie watershed to identify and monitor aquatic nuisance species (ANSs). The monitoring data collected by volunteers were used to enhance the DEP's database on established invaders. The data will also be used to create an early detection network and to assist in future management and education initiatives to minimize the spread and harmful impacts of ANSs.

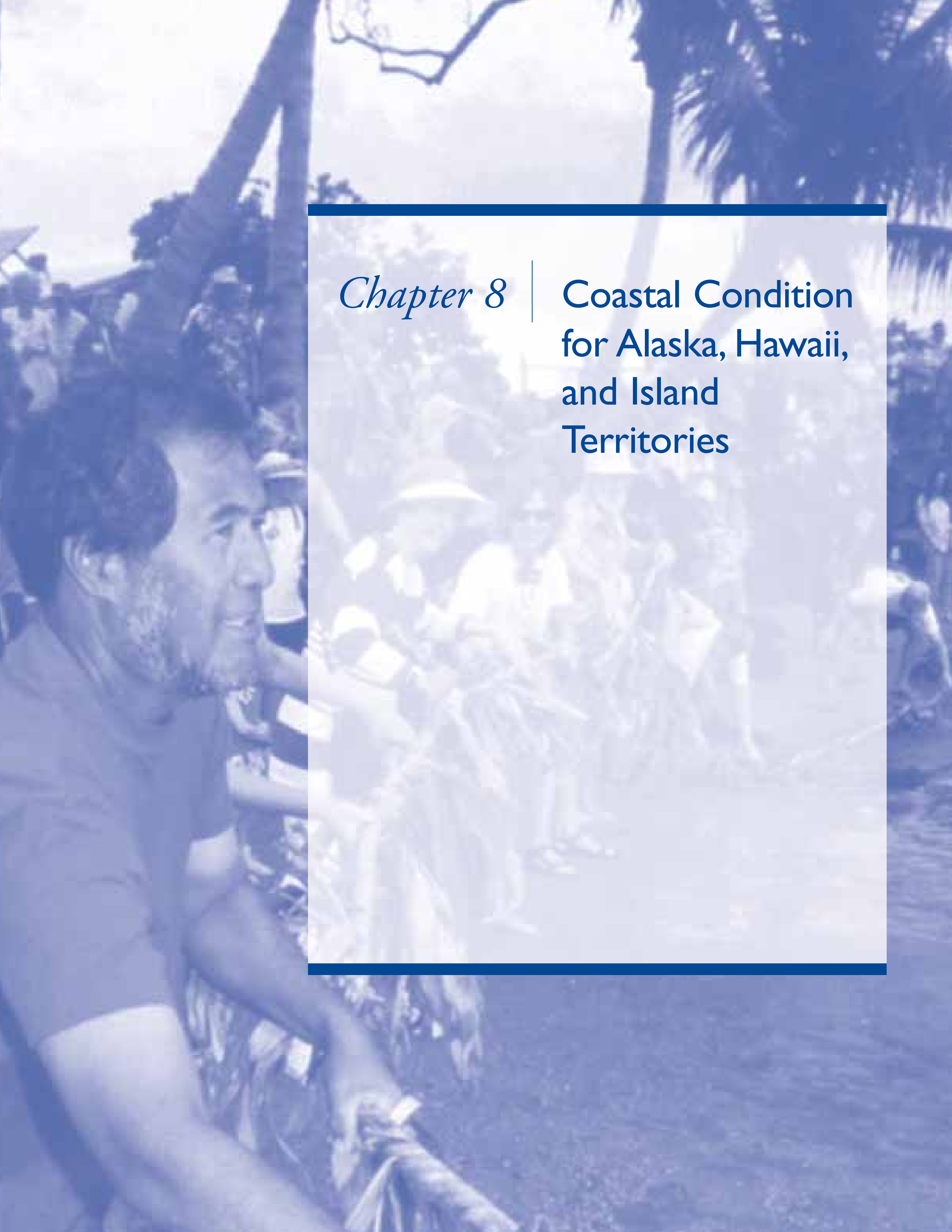
Purple loosestrife stand along the shore of Lake Erie.

The pilot program focused on zebra mussels and six aquatic plants: curly-leaf pondweed, Eurasian watermilfoil, *Hydrilla*, *Phragmites*, purple loosestrife, and water chestnut. Several of these species were already present in the watershed, but others, such as water chestnut, were potential invaders. Twenty-two volunteers participated in a 1-day workshop to gain hands-on training in ANS identification and monitoring protocols. The participants received a training manual containing fact sheets, protocols, and data-reporting forms; a field guide to ANSs in the region; and a set of stream or lake monitoring equipment. Following the workshop, volunteers selected one to two sites to monitor twice a month from June to August 2003. They then submitted their data monthly to DEP for analysis. At the end of the summer, DEP compiled a final report containing data from all the sampling sites.

For more information, contact Kirstin Wakefield at c-kwakefie@state.pa.us.

Summary

Although the Great Lakes has an extensive monitoring network with respect to objectives, design, or approaches, Great Lakes monitoring is not directly comparable with monitoring done by the NCA Program. For example, the GLNPO monitors indicators at locations selected according to best scientific judgment to represent the overall condition of the Great Lakes, whereas the NCA Program monitors indicators at sites selected using a probabilistic sampling design in order to yield direct, representative estimates of overall condition with known levels of uncertainty. Consequently, spatial estimates of coastal condition that are consistent with those calculated for the East Coast, West Coast, and Gulf Coast regions cannot be calculated for the Great Lakes nor can calculations for the Great Lakes be concisely compared with calculations from other regions. Best professional judgment of knowledgeable scientists, however, was recently used to assess the overall status of eight ecosystem components in relation to established endpoints or ecosystem objectives, when available. The Great Lakes were rated fair using available assessment information. The purpose of this exercise was to establish a baseline for the overall health of the Great Lakes to determine if conditions improve in the future as a result of management and control strategies. The results of these assessments will be used as a basis to compare and integrate overall condition of the Great Lakes with other coastal resources in this report.



Chapter 8 | Coastal Condition for Alaska, Hawaii, and Island Territories

Coastal Condition for Alaska, Hawaii, and Island Territories

There is currently very little monitoring of coastal resources in Alaska, Hawaii, and the island territories. EPA Regions 2 (Puerto Rico and U.S. Virgin Islands), 9 (Hawaii, Guam, the Northern Mariana Islands, and American Samoa), and 10 (Alaska) and the attendant state resources agencies conduct some water quality monitoring, but it is often irregular and focused on specific locations. There are no consistent monitoring programs that cover all the coastal resources in these states, territories, and commonwealths. Efforts conducted through EPA's NCA Program are starting to fill this void for Alaska (ongoing), Hawaii, and Puerto Rico, and the NCA plans to conduct coastal ecological condition surveys in the U.S. Virgin Islands, Guam, and American Samoa in coming years. No plans are currently in place, however, to survey conditions associated with the Northern Mariana Islands. In 2002, the NCA conducted surveys of Alaska (south-central region) and Hawaii, and information from these surveys will be available for future reports.

This chapter briefly describes the surveys and presents some preliminary findings. Both Alaska (southeastern region) and Hawaii will be surveyed in 2004. In 2000, the NCA surveyed Puerto Rico, and the results of that survey are also provided in this chapter. Plans to resurvey Puerto Rico were also scheduled for 2004.

During a dedication ceremony at the Hawaiian Islands Humpback Whale National Marine Sanctuary, the entire community was invited to participate in a Native Hawaiian fish-gathering activity known as a "hukilau." The sanctuary office sits in front of one of the last remaining Native Hawaiian fishponds in South Maui. Prior to the sanctuary's official approval, many people from the fishing community feared the imposition of additional sanctuary regulations. On the contrary, fishing is not regulated in the sanctuary, but rather encouraged and welcomed throughout its waters (Jeff Alexander).

Alaska

Coastal Monitoring Data

Alaska has approximately 45,000 miles of coastal marine shoreline, which constitute more than 50% of the total U.S. coastline. The surface area of coastal bays and estuaries in Alaska is 33,211 square miles, almost three times the estuarine area of the contiguous 48 states. Historically, coastal assessments have focused on areas of known or suspected impairment to examine the impacts of natural resource extraction activities, such as mining or oil exploration and production. One large-scale assessment occurring before resource development was the Alaska Outer Continental Shelf Environmental Assessment Program (OCSEAP), conducted by NOAA in the 1970s. A large amount of physical, chemical, and biological data was collected through this program, but much of it remains difficult to locate, though a summary may be found in Hood et al. (1986). Numerous assessments have also been conducted along the coastline affected by the Exxon Valdez oil spill in 1989, and this area continues to be monitored.

A few programs have provided an assessment of contaminants in Alaska as part of larger national assessments. For example, NOAA's NS&T Program analyzed contaminants in sediments and bottom fish at several sites along Alaska's coast as part of its Benthic Surveillance Program, as well as measured contaminants in intertidal mussels and sediments as part of its Mussel Watch Program. However, despite Alaska's long coastline, its extensive bays and estuaries, and the reliance of many coastal Alaskan communities on healthy populations of biological resources, no region-wide monitoring program has been established to document contaminant concentrations and spatial distributions, or to provide a baseline to assess trends in the future survey of data.

Promontory on Sutwik Island in Shelikof Strait, Southwest Alaska (Commander Grady Tuell, NOAA Corps).

Because of Alaska's low population relative to its size and the distance of most of its coastline from major urban or industrial areas, Alaska's coastal resources are generally in pristine condition. Concentrations of contaminants have been measured at levels significantly lower than those in the rest of the coastal United States. For most data collected in coastal Alaska to date, contaminant levels are consistently below EPA's level of concern; however, Alaska does have localized areas where specific contaminants can be quite high. For example, one of the highest concentrations of PAHs ever measured in a mussel tissue sample in the United States was collected from a boat harbor in a small Alaskan community (Mearns et al., 1999).

There has been increasing concern that contaminants from local sources and from long-distance transport have the potential to accumulate in Alaska's coastal resources. Long-range atmospheric and oceanic transport have been identified as major mechanisms for potential delivery of persistent organic contaminants to Alaska, and studies suggest that the Eastern Aleutian Islands may be receiving increased levels of PCBs relative to southeast Alaska (AMAP, 2004). Alaska's 1998 Section 303(d) list included 20 Tier I or Tier II coastal bays, estuaries, or harbors. Some of these waterbodies are affected by a specific industry, and others are affected by nonpoint source pollution. Although these impaired waterbodies amount to less than 1% of the total coastal bays, estuaries, and harbors in Alaska, there is concern that impairment due to pollution is increasing in the state. As a result, Alaska's Department of Environmental Conservation (ADEC) is implementing several strategies to assess and control potential environmental degradation. In a recent report (Chary, 2000), persistent organic pollutants were identified as a particular concern in Alaska, in part because of the subsistence lifestyle of many Native Alaskan communities.

In 2001, the NCA developed a sampling design in conjunction with ADEC and EPA Region 10 to assess all of the estuarine resources in Alaska by monitoring 250 sites spread throughout the state. Because of the huge expanse of Alaska, the reduced sampling window in Arctic regions, and the unique fiscal and logistical challenges of sampling coastal resources in the state, it is not feasible to survey the entire state at a single point in time. The NCA, EPA Region 10, ADEC, and other state resource agencies determined that the sampling design for Alaska would be executed in five parts—southeastern Alaska, south-central Alaska, the Aleutian Islands, the Bering Sea, and the Arctic region. Each part would survey one of these areas, and the target schedule for completion would be 5 to 10 years (Figure 8-1). Before this collaboration between Alaska's resource agencies and EPA, ADEC routinely assessed only about 1% of its coastal resources, focusing its efforts on waterbodies known or suspected to be impaired.

A sampling survey of the ecological condition of Alaska's estuarine resources in the south-central region of the state (Alaskan Province) was completed in 2002. The survey assessed 50 cores sites and 25 alternate sites (Figure 8-2). The south-central region of the state was selected for the first survey because of the importance of the major estuarine resources in the region (Prince William Sound and Cook Inlet) to the local and state economy, as well as to aquatic living resources. The indicators collected during the survey (55 stations successfully sampled) correspond to those collected in the surveys in other regions.

Because of the long distances between sites (even in this reduced area), the surveys were conducted using a large ocean-going research vessel (Figure 8-3). Many of the samples collected during the 2002 survey are still being analyzed. These data will be available in 2004; however, some of the preliminary data are reported in this chapter. Because the data are preliminary, they will not be presented in the same format as previously used in this report (e.g., maps of poor condition locations and pie charts of conditions).

Figure 8-1. Five Alaskan provinces used in the NCA sampling design (U.S. EPA/NCA).

Figure 8-2. Sampling design for the south-central region (Alaskan Province) of Alaska in 2002 (U.S. EPA/NCA).

The survey collected data at a total of 55 sites, with depths ranging from 1 to 108 feet. Many of the shallowest stations occurred in nearshore areas of Cook Inlet, areas known for wide intertidal, depositional zones. The deepest stations occurred in Prince William Sound, which is characterized by deep canyons and fjords that cross the continental shelf. The next survey (in 2004) will cover Alaska's southeastern region (Juneau and the island passage area), which includes 50 sites (Figure 8-4).

Figure 8-3. Research sampling vessel required for coastal surveys in Alaska (Alaska Department of Environmental Conservation).

Figure 8-4. Sampling design for southeastern region (Columbian Province) of Alaska in 2004 (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries

Gulf of Alaska and East Bering Sea Ecosystems

Native Alaskan peoples and their heritage have a long, rich tradition of relying on salmon from the Gulf of Alaska and East Bering Sea ecosystems for economic, cultural, and subsistence purposes. Today, residents and nonresidents depend heavily on this resource for recreation, food, industry, and commercial fisheries, along with a rapidly growing salmon and groundfish sport fishery that provides the state of Alaska with its largest private-sector employment.

Oceanographic and Climate Forcing in the East Bering Sea Ecosystem

Recruitment responses of many Bering Sea fish and crabs are linked to decadal scale patterns of climate variability. Decadal changes in recruitment of some flatfish species in the eastern Bering Sea appear to be related to patterns seen in atmospheric forcing. The Arctic Oscillation, which tracks the variability in atmospheric pressure at the polar region and mid-latitudes, tends to vary between negative and positive phases on a decadal scale. The negative phase brings higher-than-normal pressure over the polar region, and the positive phase does the opposite, steering ocean storms farther north. These patterns in atmospheric forcing in winter may influence surface wind patterns that transport fish larvae on or off the shelf. Some species, such as Bering Sea herring, walleye pollock, and Pacific cod, show interannual variability in recruitment that appears more related to climate variability. Years of strong onshore transport, typical of warm years in the Bering Sea, correspond with strong recruitment of walleye pollock, possibly due to separation of young fish from cannibalistic adults. Alaskan salmon also exhibit decadal scale patterns of production, which are inversely related to salmon production patterns on the west coast. Environmental variables such as sea surface temperature and air temperature significantly improved the results of productivity models of Bristol Bay sockeye salmon compared to models containing only density-dependent effects.

highlight

Alaska's Cook Inlet Advisory Council

In the aftermath of the Exxon Valdez oil spill in Prince William Sound, Congress crafted the Oil Pollution Act of 1990 (OPA90) to insure that the complacent attitude that led to the spill would not be repeated in the future. Under OPA90, two Regional Citizen Advisory Councils (RCACs) were created—one for Prince William Sound and one for Cook Inlet. Congress envisioned these councils as a mechanism to foster long-term partnerships between industry, government, and the coastal communities of Alaska.

The Cook Inlet RCAC has numerous mandates under OPA90, one of which is to conduct environmental-monitoring programs to assess potential impacts of oil industry operations in the Cook Inlet area. Studies have been developed to assess hydrocarbon concentrations in subtidal and intertidal sediments and in the tissues of bivalves that live in the Cook Inlet sediments, including an emphasis on building a database of hydrocarbon "fingerprints" of potential man-made and natural sources.

To better interpret the results of their studies, the Cook Inlet RCAC sought opportunities to obtain data from the larger coastal areas surrounding Cook Inlet. This regionwide data provides a context by which to interpret the smaller, more focused Cook Inlet studies. The coastal EMAP is ideal because scientists use a core set of parameters, resulting in consistent and comparable data at the local, state, regional, and national level.

Granite Point platform in Cook Inlet. (Photo courtesy of Unocal).

In 2001, the Cook Inlet RCAC formed a unique partnership with ADEC and several other organizations to conduct the first portion of Alaska's coastal EMAP. Cook Inlet RCAC provided the scientific lead for planning and implementing the program as an in-kind match to the federal funds provided to ADEC. Through this partnership, the Cook Inlet RCAC and ADEC maximized the expertise and financial resources available for this coastal assessment.

In 2002, scientists from the Cook Inlet RCAC, the NMFS, the International Pacific Halibut Commission, the University of Washington, Washington DOE, and EPA completed a 50-day voyage to collect the necessary water, sediment, and bottom trawl samples for Alaska's coastal EMAP in south-central Alaska.

Additionally, the Cook Inlet RCAC is actively sponsoring research with the University of Alaska on the physical oceanography of Cook Inlet, developing numerical models to understand surface oil spill and dispersed plume trajectories. Cook Inlet is an extremely dynamic environment, possessing the world's second-highest tidal range. Cook Inlet RCAC has piloted a coastal habitat mapping project that provides coastal geomorphology and wetland, intertidal, and shallow subtidal biota data in south-central Alaska. This project provides the additional information needed to understand potential impacts to the different coastal habitats. A recent recommendation by agency partners in the Cook Inlet study suggested that the program should be expanded to coastlines statewide.

Through these partnerships, as well as the one developed for Alaska's coastal EMAP, the Cook Inlet RCAC is able to conduct and sponsor research that is of the highest scientific merit while fulfilling the mandates in OPA90.

Sorting bottom trawl samples (Alaska Department of Environmental Conservation).

In contrast, periods of strong Aleutian Lows are associated with weak recruitment for some Bering Sea crab species and are unrelated to recruitment of others, depending on species-specific life history traits. Winds from the northeast favor retention of crab larvae in offshore mud habitats that serve as suitable nursery areas for young Tanner crabs to burrow in sediment for protection. Winds from the opposite direction promote inshore transport of crab larvae to coarse, shallow water habitats in inner Bristol Bay that serve as nursery areas for red king crabs to find refuge among biogenic structures (Tyler and Kruse 1998). Timing and composition of the plankton blooms may also be important, because red king crab larvae prefer to consume *Thalassiosira* diatoms, whereas Tanner crab larvae prefer copepod nauplii.

Salmon Fisheries

Alaska salmon harvests in the state's two ecosystems have increased over the last three decades and may have peaked in 1995. After dropping to record low catches in the 1970s, most populations have rebounded, and the fisheries are now at or near all-time peak levels in many regions of the state. A number of factors have contributed to the high abundance of Pacific salmon currently in the state of Alaska. These factors include (1) pristine habitats with minimal impacts from extensive development, (2) favorable ocean conditions that promote high survival rates of juveniles, (3) improved management of the fisheries by state and federal agencies, (4) elimination of high-seas drift net fisheries by foreign nations, (5) hatchery production, and (6) reduction of bycatch in fisheries for other finfish species. Quality spawning and nursery habitat, favorable oceanic conditions, and sufficient numbers of spawning fish are most likely the paramount factors affecting current abundance. Alaska salmon management continues to focus on maintaining pristine habitats and ensuring adequate escapements; however, ocean conditions that favored high marine survival rates in recent years can fluctuate due to interdecadal climate oscillations. There is recent evidence that a change in ocean conditions in the north Pacific Ocean and Gulf of Alaska ecosystem may be underway, possibly reflecting the downturn in abundance of Alaska salmon runs observed in 1996 and 1997.

Pelagic Fisheries

Pacific herring is the major pelagic species harvested in the Gulf of Alaska and East Bering Sea ecosystems. These fisheries occur in specific inshore spawning areas. In the Gulf of Alaska ecosystem, spawning fish concentrate mainly off southeast Alaska in Prince William Sound and around the Kodiak Island-Cook Inlet area. In the East Bering Sea ecosystem, the centers of abundance are in northern Bristol Bay and Norton Sound. This fishery occurs within state waters (3-mile limit) and is monitored and managed by the Alaska Department of Fish and Game (ADFG) within 20 separate fishery areas. From catch records, it is evident that herring biomass fluctuates widely due to influences of strong and weak year-classes. Currently, the herring populations in both ecosystems remain at moderate levels and are in relatively stable condition, with the exception of Prince William Sound. Herring abundance levels typically increase abruptly following major recruitment events and then decline slowly over a number of years because of natural and fishing mortality. Prince William Sound herring continue to be depressed from a disease outbreak in 1993, but have recovered to above threshold levels. In more recent years, herring harvests in both ecosystems have averaged about 45,000 mt, with a value averaging around $30 million.

Groundfish Fisheries

The groundfish complex is the most abundant of all fisheries' resources off the Gulf of Alaska and the East Bering Sea ecosystems, totaling more than 21,000,000 mt of exploitable biomass and contributing more than 2,000,000 mt of catch each year. Another 1,000,000 mt of underutilized sustainable potential yield is available. The Magnuson-Stevens Fishery Conservation and Management Act extended federal fisheries management jurisdiction to 200 nautical miles and stimulated the growth of a domestic Alaskan groundfish fishery that rapidly replaced the foreign fisheries. Much of the groundfish catches are exported, particularly to Asia, and such trade contributes prominently as a major source of revenue for U.S. fishermen. The total catch in 1997 of the East Bering Sea and Aleutian Islands groundfish was 1,740,000 mt, valued at $405 million (ex-vessel). The dominant species harvested were walleye pollock, Pacific cod, and yellowfin sole. Groundfish populations have been maintained at high levels since implementation of The Magnuson-Stevens Act. The walleye pollock produce the largest catch of any single species inhabiting the U.S. EEZ. Until 1992, another large fishery targeted the portion of the Aleutian Basin stock residing outside of the U.S. and Russian EEZs in the "Donut Hole" of the central Bering Sea. Historical catches from this stock were apparently too high (well over 1,000,000 mt throughout the late 1980s) and not sustainable. Consequently, the abundance of the Aleutian Basin stock was greatly diminished, and all fishing ceased in 1993. Groundfish abundance in the Gulf of Alaska ecosystem peaked at 5,300,000 mt in 1982. Abundance since then has remained relatively stable, fluctuating between 4,500,000 and 5,300,000 mt.

The groundfish catches are dominated by pollock, followed by Pacific cod, flatfish, and rockfish. The recent average yield of the complex is 211,922 mt. Pollock abundance has been increasing in recent years. The western-central Gulf of Alaska ecosystem's total allowable catch for pollock is further apportioned among three areas and three seasons. This temporal and spatial apportionment of the pollock quota was implemented to accommodate Steller sea lion concerns; pollock are a major prey item of Steller sea lions in the Gulf of Alaska ecosystem. Pollock are considered fully utilized, and Pacific cod are abundant and fully utilized. Flatfish are, in general very abundant, primarily due to large increases in arrowtooth flounder biomass, and are underutilized due to halibut bycatch considerations. Rockfish (slope rockfish, pelagic shelf rockfish, thorny-head rockfish, and demersal shelf rockfish) are conservatively managed due their long life spans and consequent sensitivity to overexploitation. See *Our Living Oceans* (NOAA, 1999) for more information on transboundary issues and multispecies interactions.

Shellfish Fisheries

Major shellfish fisheries developed in the 1960s in the Gulf of Alaska ecosystem, subsequently expanded to the East Bering Sea ecosystem. Shellfish landings in 1997 generated an ex-vessel value of $151 million. The most important of these fisheries are the king and snow crab fisheries. King and Tanner crab fisheries are managed primarily by the state of Alaska, with advice from a federal FMP for the East Bering Sea and Aleutian Islands stocks.

Alaska crab resources are fully utilized. Catches are restricted by quotas, seasons, and size and sex limits, with landings limited to large male crabs. Fishing seasons are set at times of the year that avoid molting, mating, and soft-shell periods. Japanese and Russian

Sea lions often haul themselves onto floating docks to sunbathe (Paul Goetz).

fisheries were phased out of the Bering Sea in 1974; however, catches there have remained low. Gulf of Alaska ecosystem catches peaked in 1965, then varied at a relatively low level for a decade before dropping lower still in 1983. Almost all Gulf of Alaska ecosystem king crab fisheries have been closed since 1983.

Three king crab species (red, blue, and golden or brown) and two Tanner crab species (Tanner crab and snow crab) have traditionally been harvested commercially off the two major ecosystems of Alaska. The recent average yields for king crabs (7,170 mt) and Tanner crabs (2,857 mt) are below their respective, long-term potential of 36,481 and 21,751 mt, respectively. By contrast, the recent average yield of 39,053 mt for snow crab is above its long-term potential yield of 37,202 mt.

Shrimp are also managed by the state of Alaska. The domestic shrimp fishery in the waters of the East Bering Sea ecosystem is currently at a low level. Shrimp abundance is also too low in the Bering Sea to support a commercial fishery. The western Gulf of Alaska ecosystem has been the main area of operation for the shrimp fishery, with shrimp landings indicating that catches in the western Gulf rose steadily to about 58,000 mt in 1976 and then declined precipitously. As with crabs, the potential yields of shrimp stocks in both Alaskan marine ecosystems are not well understood.

Nearshore Fisheries

Nearshore fishery resources are those coastal and estuarine species found in the 0–3 nautical mile zone of coastal state waters and for which the NMFS has no direct management role. Nearshore resources vary widely in species diversity and abundance. Management authority is shared among the coastal states and other local bodies. Nearshore resources provide important subsistence and recreational fishing opportunities for Alaskans of the Gulf of Alaska and East Bering Sea. Most nearshore fisheries take place in the Gulf of Alaska ecosystem near population centers, although subsistence fishing is distributed all along the Alaska coastline into the Bering Sea and Beaufort Sea ecosystems.

The nearshore resources and fisheries are managed by the ADFG. Dungeness crabs are harvested near shore by small-boat commercial fleets and recreational fisheries, primarily in the Yakutat and Kodiak areas of the Gulf of Alaska ecosystem. Management of these crab fisheries suffers in the absence of stock assessment

Viewed at low tide, Pacific tidepool rocks are covered with kelp and other macro algae that support a healthy community of fish and invertebrates (Paul Goetz).

research. The traditional fishery for red king crab in the Gulf of Alaska ecosystem, however, is optimistic. The fishery reopened in 1993 following 8 years of closure and is now managed under a conservative harvest regime supported by an annual stock assessment survey.

The scallop fishery is regulated by the state of Alaska, which limits the number of vessels and sets catch quotas. Sea cucumbers and sea urchins are recent fisheries resources, harvested by divers and exported primarily to Asian markets. These fisheries are managed conservatively according to their recent historical performance. The ADFG surveys the resource periodically at selected sites to monitor major changes in relative abundance of the stocks. The amount of nearshore resources harvested by the subsistence and recreational fisheries off the three Alaska ecosystems (Gulf of Alaska, East Bering Sea, and Beaufort Sea ecosystems) has been difficult to compile because of the state's wide geographical expanse and remoteness of such fishing activities. The most important component of these resources are the invertebrates.

Alaska Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

Before monitoring efforts were conducted in coordination with the NCA Program, Alaska's water quality assessments focused on areas with known or suspected impairments. For its 2000 305(b) report, Alaska assessed 28 (0.1%) of its 33,204 estuarine square miles. Alaska reported on overall use support only, with 25 square miles (89% of assessed waters) of the state's estuaries impaired for overall use support (Figure 8-5).

The state also assessed 25 (0.1%) of its 36,000 miles of coastal shoreline. Sixty-four percent of the assessed shoreline miles fully support overall use, and the remaining 36% of assessed miles are impaired by some form of pollution or habitat degradation (Figure 8-6).

Fish Consumption Advisories

No consumption advisories were in effect for chemical contaminants in fish and shellfish species harvested in Alaskan waters in 2002 (U.S. EPA, 2003c).

Beach Advisories and Closures

Alaska did not report beach monitoring and advisory or closings data to the EPA in 2002 (U.S. EPA, 2003a).

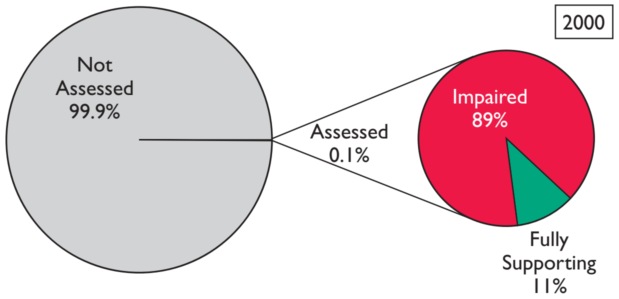


Figure 8-5. Water quality in assessed Alaskan estuaries (U.S. EPA, 2002).

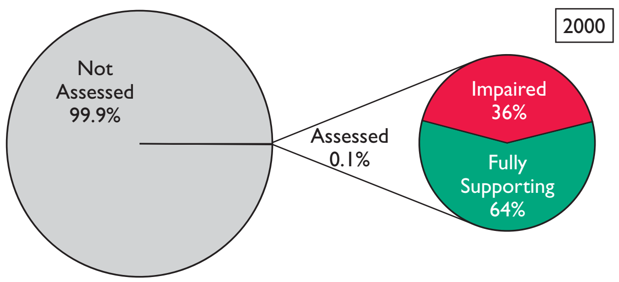


Figure 8-6. Water quality for assessed shoreline waters in Alaska (U.S. EPA, 2002).

Hawaii

Coastal Monitoring Data

Hawaii does not have a comprehensive coastal monitoring program. Some monitoring occurs in Oahu and is planned for adjacent coral reef ecosystems. Most monitoring of coastal resources, however, is targeted to address specific bays and issues such as nonpoint source runoff and offshore discharges. For example, Mamala Bay has been sampled intensively to examine public wastewater outfalls from Oahu into the bay. This sampling showed that the discharge areas were not statistically different from reference areas; however, no comprehensive spatial examination was conducted of Mamala Bay to interpret these findings in a statewide or regional context. In 2002, the NCA, in conjunction with state agencies, Region 9, and the University of Hawaii, conducted the first comprehensive survey of the condition of estuarine resources in Hawaii (Figure 8-7).

The dazzling peaks off the island of Kahoolawe are just one the many types of coastlines seen throughout Hawaii. Shorelines range from white sandy beaches on Oahu to the tallest sea cliffs in the world on Molokai. Each island offers its own unique habitat for marine life (Marc Hodges) .

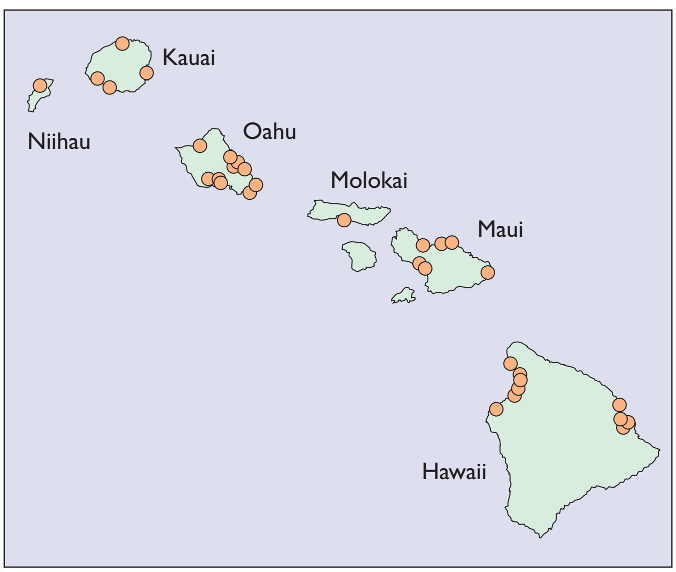


Figure 8-7. Sampling design for Hawaii in 2002 (U.S. EPA/NCA).

The survey sampled 79 stations on islands of the Hawaiian chain and included all of the indicators of the NCA surveys. The Hawaiian survey, however, did not produce estimates of sediment toxicity because of insufficient soft sediments, and rather than assessing contaminant levels in fish, it assessed the body burdens of sea cucumbers (Figure 8-8). Information from this survey will be available in the next edition of this report (2006).

Figure 8-8. An example of sea cucumbers used for assessment of tissue contaminants in Hawaii (Dr. Richard Brock, University of Hawaii at Manoa, 2003).

Large Marine Ecosystem Fisheries

The Insular Pacific-Hawaiian ecosystem supports a variety of fisheries in both the Northwestern Hawaiian Islands (NWHI) and the Main Hawaiian Islands (MHI). In the NWHI, the lobster fishery is the major commercial marine invertebrate fishery in the western Pacific. A very small-scale, primarily recreational fishery for lobster also exists in the MHI within the Insular Pacific-Hawaiian ecosystem, as well as outside the ecosystem in American Samoa, Guam, and the Northern Mariana Islands. A deepwater shrimp resource is found throughout the Pacific islands; however, this stock is relatively unexploited.

A resource of deepwater precious coral (gold, bamboo, and pink corals) also exists in the Insular Pacific-Hawaiian ecosystem and possibly in other western Pacific areas. Precious corals occurring in the U.S. EEZ are managed under an FMP implemented in 1983 by the Western Pacific Regional Fishery Management Council. Very limited quotas are allowed under regular permits, and experimental permits are required for unassessed coral beds. A short-lived (1974–1979) domestic fishery operated off Makapu'u Point on Oahu, but there has been no significant precious coral harvest for 20 years. Interest in the fishery has recently resurfaced, however, and one federal permit was issued in 1997.

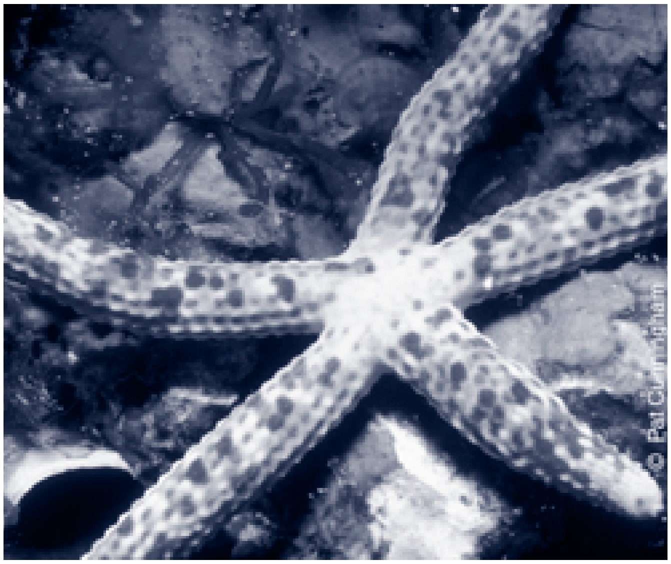
Invertebrate Fisheries

The NWHI lobster fishery, which began in 1977, harvests spiny and slipper lobsters and is governed by the Western Pacific Regional Fishery Management Council under an FMP. The MHI lobster fishery is managed by the state of Hawaii, although a few offshore banks are included in the *Fishery Management Plan for the Crustacean Fishery of the Western Pacific Region*. This FMP was implemented in 1983 and has since been amended nine times. Many of the earlier amendments were in response to requirements to eliminate lobster trap interactions with the endangered Hawaiian monk seal (Amendments 2 and 4), to protect spiny and slipper lobster reproductive potentials (Amendments 3 and 5), and to specify overfishing definitions (Amendment 6). The most significant change to the FMP occurred in 1992, when it was amended in response to continuing declines in commercial lobster CPUE (Amendment 7). This amendment set forth an annual 6-month closed season (January–June) for lobster harvesting, limited entry into the fishery, and established an annual catch quota. The FMP was amended again in 1996 (Amendment 9) to implement a quota system based on a constant harvest rate that allows only a 10% risk of overfishing in any given year, as well as the retention of all lobsters caught.

Populations of spiny and slipper lobster declined dramatically from the mid-1980s through the mid-1990s. Much of this decline has been attributed to the combined effect of a shift in oceanographic conditions affecting recruitment and fishing mortality in the mid-1980s. The spawning potential ratio (SPR), which is used to measure the status of the stocks, has ranged between 74% and 88% over the past three seasons (1995–1997).

Coral Fisheries

Because there has been no fishery on precious corals during the past 20 years, little solid evidence is available on recovery of the population from the low levels that existed when the Magnuson-Stevens Act was first passed in 1976; however, recent video analysis suggests that the previously harvested beds have recovered much of their potential and that new coral beds have been identified. Nonetheless, it also appears that illegal foreign fishing in some remote areas during the 1980s had a significant impact on some coral beds.



A colorful starfish creeps across the ocean bottom looking for food (Pat Cunningham).

In 1997, a company obtained a permit to harvest precious coral at Makapu'u, Oahu, under a 2-year permit quota for 4,409 pounds of pink coral and 1,322 pounds each for bamboo and gold coral. Harvesting of these species began in early 1998.

Bottomfish Fisheries

The western Pacific bottomfish fishery geographically encompasses the Insular Pacific-Hawaiian ecosystem (which includes the MHI and the NWHI), Guam, the Northern Mariana Islands, and American Samoa. In contrast, the pelagic armorhead is harvested from the summits and upper slopes of a series of submerged seamounts along the southern Emperor-Northern Hawaiian Ridge. This chain of seamounts is located just west of the International Dateline and extends to the northernmost portion of the NWHI.

In the MHI, as in Guam, the Mariana Islands, and American Samoa, these fisheries employ relatively small vessels on 1-day trips close to port. As a result, much of the catch is harvested by either part-time commercial or sport fishermen. In contrast, the NWHI species are fished by full-time, commercial fishermen on relatively large vessels that range far from port on trips of up to 10 days in duration. Fishermen use the handlining technique in which a single weighted line with several baited hooks is raised and lowered with a powered reel. The bottomfish fisheries are managed jointly by the Western Pacific Fishery Management Council and territorial, commonwealth, or state authorities.

In the Insular Pacific-Hawaiian ecosystem, the harvested bottomfish species include several snappers (ehu, onaga, opakapaka), jacks (ulua, butaguchi), and a grouper (hapu'upu'u), whereas the more tropical waters of Guam, the Mariana Islands, and American Samoa include a more diverse assortment of species within the same families, as well as several species of emperors. These fish are found on rock and coral bottoms at depths of 170–1300 ft. Catch weight, size, and fishing effort data are collected for each species in the five areas; however, the sampling programs among these areas vary in scope and design. About 90% of the total catch is taken in the Insular Pacific-Hawaiian ecosystem, with the majority of the catch harvested in the MHI as compared to the NWHI.

Stock assessments, though somewhat limited, indicate that the spawning stocks of several important MHI species (e.g., ehu, hapu'upu'u, onaga, opakapaka, and uku) are at only 5–30% of their original levels, with onaga and ehu presently appearing as the most stressed among MHI bottomfish species. Because overutilization is a concern and the fishery and bottomfish habitat are predominantly within Hawaiian waters, the Western Pacific Fishery Management Council has recommended that Hawaii take action to prevent overfishing. During the past two years, the state of Hawaii conducted a series of meetings with fishery managers, scientists, and fishermen to develop an FMP for the Hawaii's bottomfish fishery. In 1998, the state established a new administrative rule that governs bottomfishing in state waters and includes restrictions on fishing gear and fishing areas.

Armorhead Fisheries

The seamount groundfish fishery has targeted just one species: the armorhead. Since 1976, this bottom trawl fishery has been almost exclusively conducted by Japanese trawlers fishing the seamounts in international waters beyond the Hancock Seamounts. The fishing grounds comprising the Hancock Seamounts represent

The Kona Coast of Hawaii has many tidepools filled with a myriad of small fish, mollusks, echinoderms, and crustaceans (Paul Goetz).

less than 5% of the total fishing grounds. The long-term potential yield is 2,123 mt, but recovery to these former levels has not occurred.

Standardized stock assessments were conducted during 1985–1993. Research cruises were focused on Southeast Hancock Seamount, and the armorhead stock was sampled with bottom longlines and calibrated against Japanese trawling effort. Although catch rates vary, they have not shown the increases expected after the fishing moratorium was imposed. Furthermore, the increase in the 1992 seamount-wide CPUE caused by high recruitment was apparently short-lived, as CPUE declined appreciably in 1993 and thereafter. Closure of only the small U.S. EEZ portion of the pelagic armorhead's demersal habitat may not be sufficient to allow population recovery because these seamounts remain the only part of the fishery currently under management.

No progress toward cooperative international management is foreseen for the pelagic armorhead. Cooperative exchanges of fishery data with scientific colleagues in Japan have provided annual commercial catch data by seamount. Recently acquired biological data of importance for future management considerations indicate that armorhead undergo a 2-year pelagic phase prior to recruitment into the fishery, and that the seamount populations comprise a single stock.

Nearshore Fisheries

For the purposes of this report, nearshore fishery resources are defined as those coastal and estuarine species found in the 0–3 nautical mile zone of coastal state waters and for which the NMFS has no direct management role. Nearshore resources vary widely in species diversity and abundance. Many are highly-prized gamefish, whereas others are small fishes used for bait, food, and industrial products. The invertebrate species of greatest interest include crabs, shrimps, abalones, clams, scallops, and oysters.

Because the composition of the nearshore fauna is very diverse and management authority is shared among the many coastal states and other local bodies, a detailed treatment of their status is difficult. This chapter presents information on the more significant species of national interest. For more comprehensive assessments of individual species, readers should refer to reports published by state natural resource agencies.

Fisheries in the nearshore waters of the tropical and subtropical Insular Pacific-Hawaiian ecosystem and the other U.S.-associated Pacific islands are highly diverse, though lower in aggregate volume than commercial or recreational fisheries of the U.S. mainland. Landings are reported to be about 1,400 mt annually. Many fisheries are unique to certain localities, such as that for the palolo worm in American Samoa, seasonal fisheries for rabbitfish in Guam, and limpet (opihi) fisheries in the Insular Pacific-Hawaiian ecosystem. Other fisheries are common to all Western Pacific areas, such as the fisheries for bigeye scad (called akule) in the Insular Pacific-Hawaiian ecosystem, atule in American Samoa, and atulai in Guam and the Northern Mariana Islands.

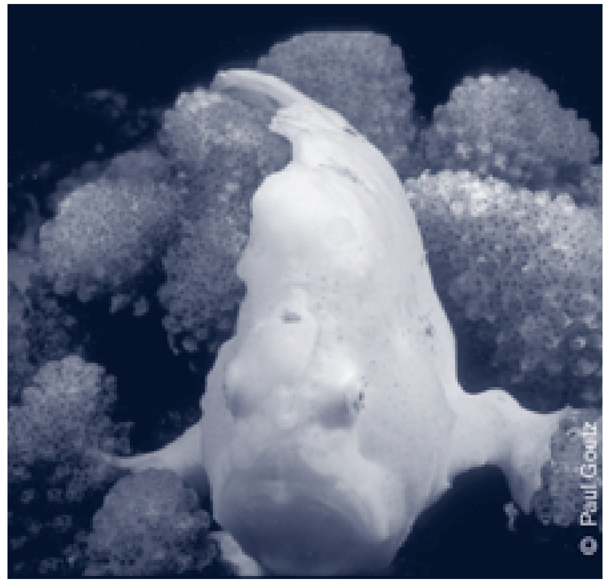
The more highly populated islands of the Insular Pacific-Hawaiian ecosystem receive the heaviest inshore fishing pressure, while less densely populated islands and mostly uninhabited islands of the Insular-Pacific-Hawaiian ecosystem and Commonwealth of the Northern Mariana Islands receive less fishing pressure. In the main islands of the Insular Pacific-Hawaiian ecosystem between 1980 and 1990, commercial fisherman reported an average annual harvest of 1,179 mt for fish and invertebrates taken from waters up to 600 feet in depth. According to the Hawaii Division of Aquatic Resources, two pelagic carrangids, akule and opelu, support the largest inshore fisheries in the state. During the 1993–1995 period, annual commercial landings for akule and opelu averaged 310 and 160 mt, respectively.

Other important commercial fisheries include those for surgeonfish, squirrelfish, parrotfish, goatfish, snappers, octopus, and various jacks or trevallies. There are significant recreational fisheries, but participation, landings, expenditures, and economic values are not well documented. The recreational and subsistence component of the marine fisheries of the Insular Pacific-Hawaiian ecosystem was last assessed in 1986, when it was estimated that 200,000 trips were taken by 6,700 vessels involved in nonmarket fishing (this total includes recreational, subsistence, and submarket sales). Estimated landings by these "recreational" fishermen were 9,525 mt (21 million), of which 4,536 mt (10 million) were sold ($22 million). Total direct expenditures by these fisheries totaled $24 million, and the nonmarket value of the fishing experience was valued at $23 million.

Hawaii Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

The state of Hawaii assessed 99% of its 55 estuarine square miles and 83% of its 1,052 miles of shoreline for its 2000 305(b) report. Of the assessed estuarine square miles, 43% fully support their designated uses, and 57% are impaired by some form of pollution or habitat degradation (Figure 8-9). Individual use support for Hawaii's assessed estuaries is shown in Figure 8-10. Of assessed shoreline, 97% fully supports its designated uses, 1% is threatened for one or more uses, and 2% is impaired by some form of pollution or habitat degradation (Figure 8-11). Individual use support for assessed shoreline in Hawaii is shown in Figure 8-12.



A lemon-yellow frogfish braces itself from the ebb and flow of the current with its leg-like pectoral fins (Paul Goetz).

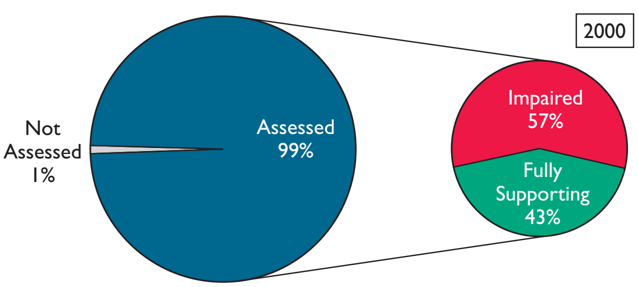


Figure 8-9. Water quality in assessed Hawaiian estuaries (U.S. EPA, 2002).

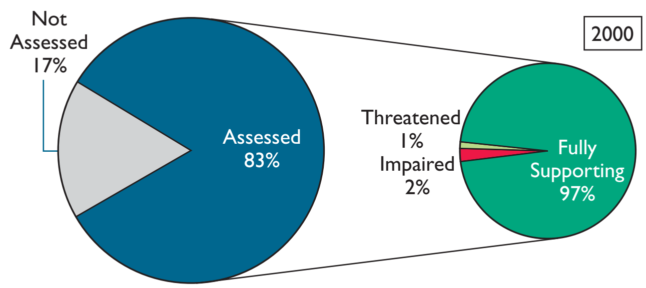


Figure 8-11. Water quality in assessed shoreline waters in Hawaii (U.S. EPA, 2002).

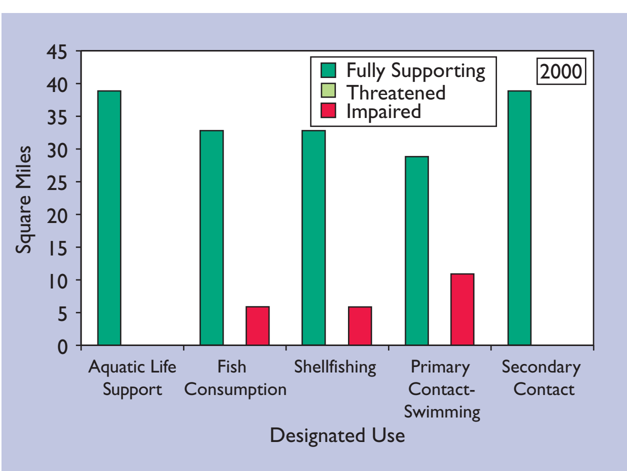


Figure 8-10. Individual use support for assessed estuaries waters in Hawaii (U.S. EPA, 2002).

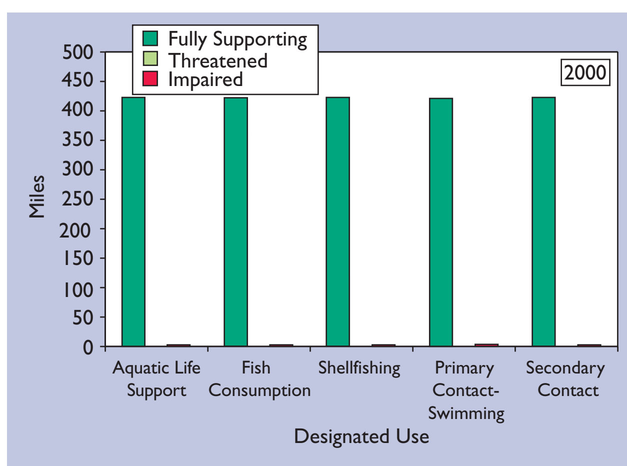


Figure 8-12. Individual use support for assessed shoreline waters in Hawaii (U.S. EPA, 2002).

Fish Consumption Advisories

The state of Hawaii reported that one estuarine advisory resulting from PCB contamination was in effect for the Pearl Harbor area on the island of Oahu. The advisory, which has been in effect since 1998, advises all members of the general population (including sensitive populations of pregnant women, nursing mothers, and children) not to consume any fish or shellfish from the waters of Pearl Harbor (U.S. EPA, 2003c).

Beach Advisories and Closures

Beach advisory and closure data were provided for the islands of Oahu, Hawaii, Kauai, and Maui (Figure 8-13). Of the 87 coastal beaches that reported information to EPA, only 8% (seven beaches) were closed or under an advisory for any period of time in 2002. Beach advisories and closures were implemented primarily for preemptive reasons associated with sewage-related problems (Figure 8-14). Sewer line problems were cited as the source of beach contamination in 75% of the survey responses (Figure 8-15).

Hanauma Bay in Hawaii attracts snorkelers and divers to a beautiful coral reef within minutes of downtown Honolulu (Paul Goetz).

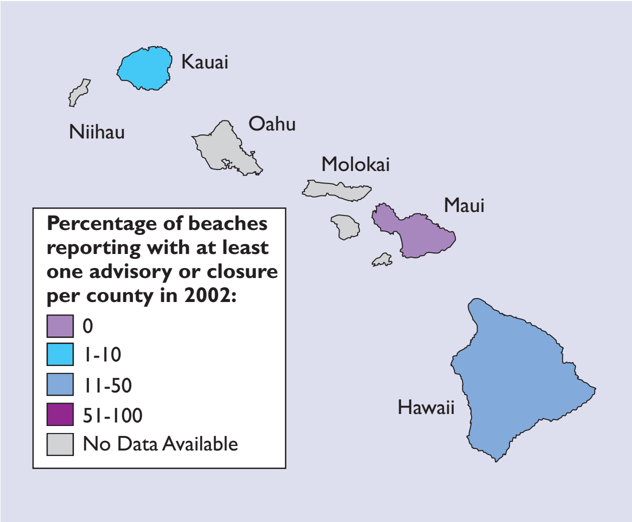


Figure 8-13. The percentage of Hawaiian beaches participating in the survey that had a least one advisory or closure in 2002 (U.S. EPA, 2003a).

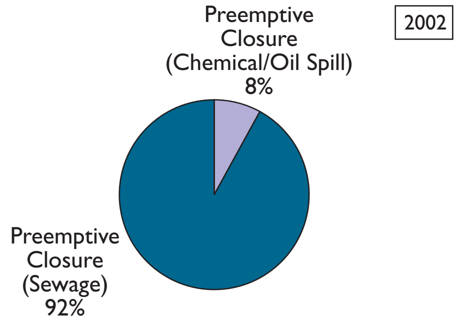


Figure 8-14. Reasons for beach advisories and closings in Hawaii (U.S. EPA, 2003a).

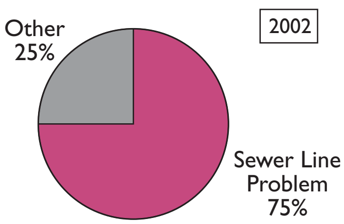


Figure 8-15. Sources of beach contamination in Hawaii (U.S. EPA, 2003a).

Puerto Rico

Coastal Monitoring Data

Although EPA Region 2, the San Juan Harbor National Estuary Program, and the Caribbean Environmental Protection Division have conducted some coastal monitoring in Puerto Rico, these surveys have been completed almost exclusively in the San Juan area. In 2000, the NCA, in cooperation with the above offices and programs, conducted a comprehensive survey of the ecological condition of Puerto Rico estuarine waters (Figure 8-16). The survey included 50 sites and examined the full suite of indicators, with the exception of fish tissue contaminants. The survey was not granted a permit to trawl for fish because of the sensitive nature of the bottom communities (e.g., soft corals) in these waters. Fish tissue contaminants will be examined in subsequent surveys.

Elkhorn coral are a predominant shallow-water species found throughout the warm waters of the Atlantic and Caribbean (Pat Cunningham).

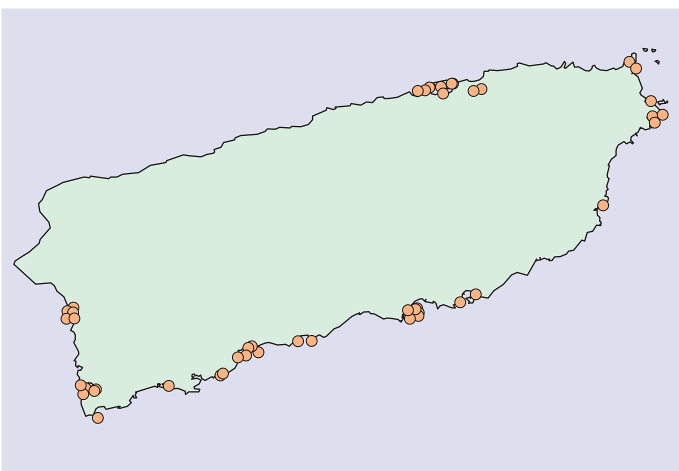


Figure 8-16. Sampling design for Puerto Rico for the NCA Program's 2000 survey (U.S. EPA/NCA).

The overall condition of Puerto Rico's estuarine waters is borderline poor (Figure 8-17). Based on information collected in 2000 from 47 sites throughout Puerto Rico, none of the assessed estuarine area is in good ecological condition (Figure 8-18). Sixteen percent of assessed estuaries are threatened for aquatic life use, and 77% of Puerto Rico's estuarine area showed indications of poor aquatic life conditions (benthic community conditions) or showed degradation in water or sediment quality.

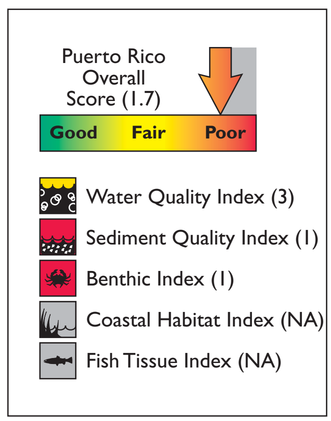


Figure 8-17. The overall condition of Puerto Rico's estuaries is borderline poor.

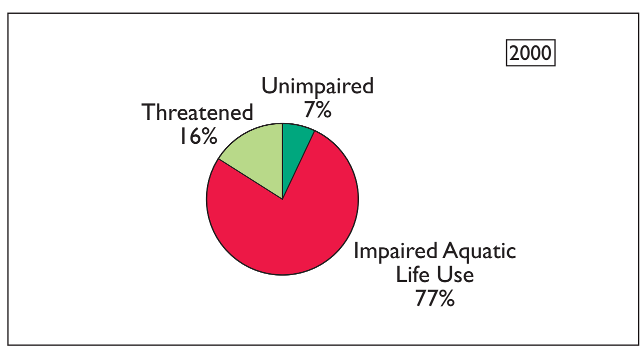


Figure 8-18. Puerto Rico estuarine condition (U.S. EPA/NCA).

Water Quality Index

Based on the cumulative score for the five water quality indicators (nitrogen, phosphorus, and chlorophyll, dissolved oxygen, and water clarity), the water quality index in Puerto Rico's estuaries is fair. Although only 9% of waters were determined to have poor water quality (poor condition for two or more indicators), 63% of estuarine waters in Puerto Rico are rated either poor or fair (Figure 8-19).

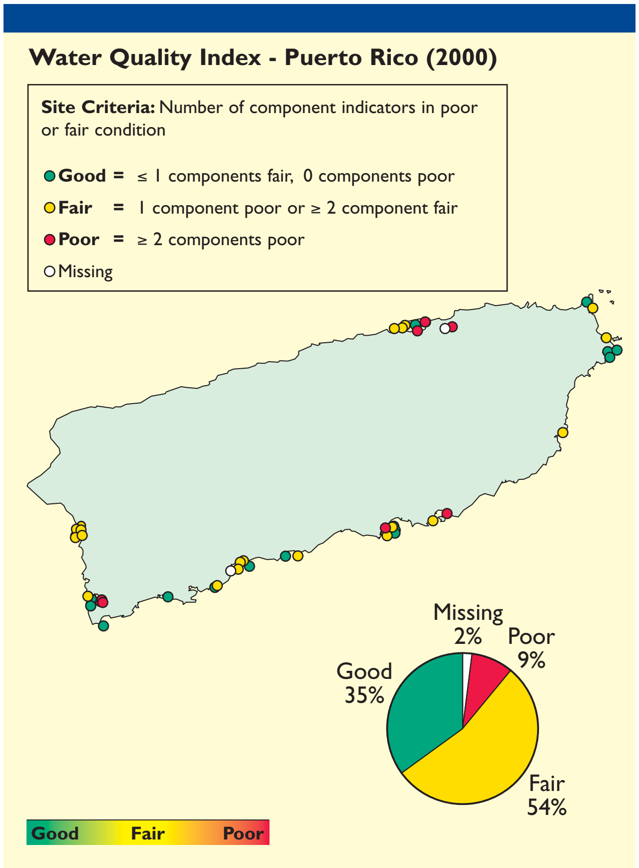


Figure 8-19. Water quality index data for Puerto Rico's estuaries (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

Nutrients in Puerto Rico's estuaries are rated fair for nitrogen and good for phosphorus for the period sampled. High DIN concentrations for tropical estuarine ecosystems (> 0.1 mg/L) were not observed at any of the sampling locations in Puerto Rico (Figure 8-20).

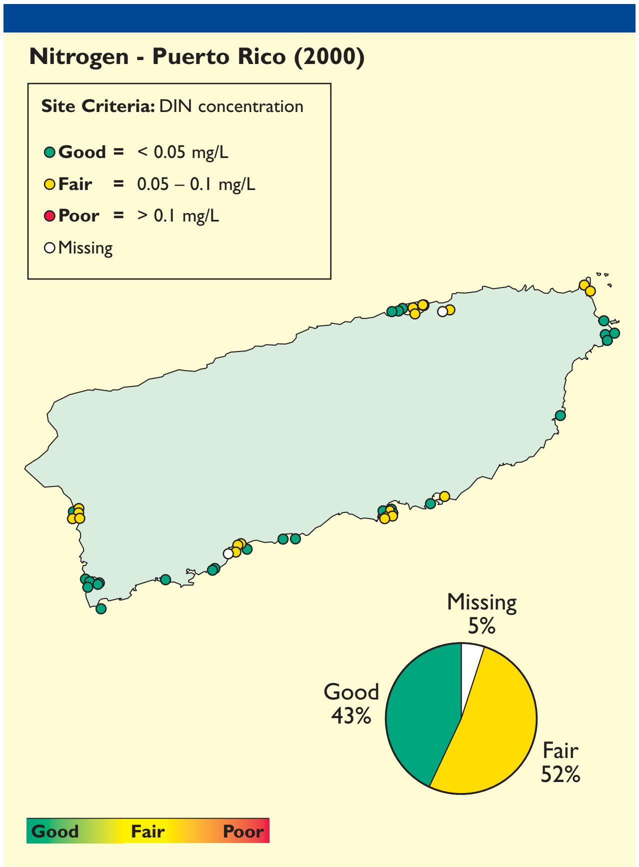


Figure 8-20. DIN concentration data for Puerto Rico's estuaries (U.S. EPA/NCA).

The sampling conducted in the EPA NCA Program has been designed to estimate the percent of estuarine area (nationally or in a region or state) in varying conditions and is 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 indicator 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.

Although DIN concentrations did not exceed 0.1 mg/L (the value indicative of poor conditions), 52% of estuarine waters had concentrations between 0.05 and 0.1 mg/L and were thus rated fair. Elevated phosphorus concentrations (> 0.01 mg/L) occurred in 6% of the estuarine waters of Puerto Rico (Figure 8-21). Elevated concentrations of dissolved nutrients are not expected during late summer months in tropical coastal waters because freshwater inflow is lower and available dissolved nutrients are readily utilized by phytoplankton during summer months.

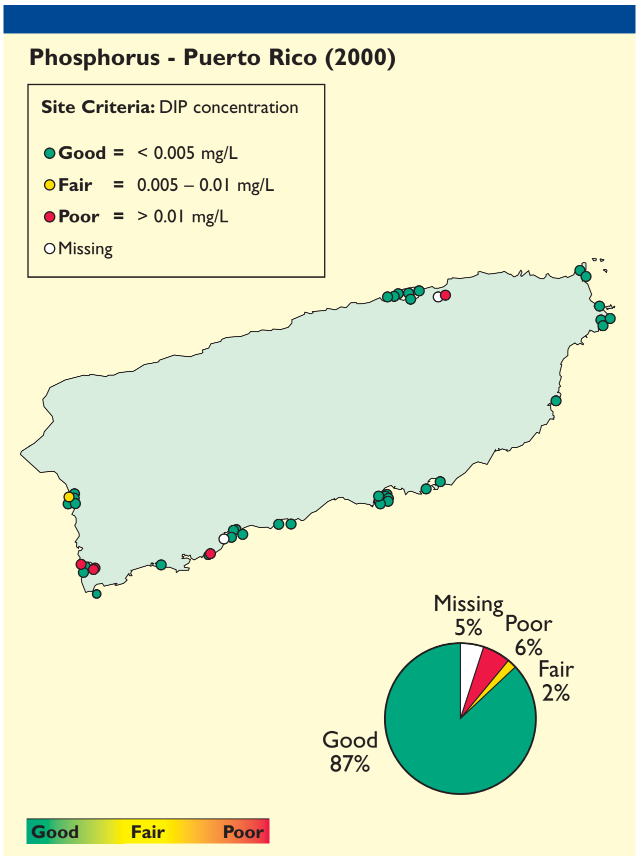


Figure 8-21. DIP concentration data for Puerto Rico's estuaries (U.S. EPA/NCA).

Chlorophyll *a*

Puerto Rico's estuaries are rated poor for chlorophyll *a*. Twenty-nine percent of estuarine waters in Puerto Rico have concentrations of chlorophyll *a* that were greater than 1 g/L (Figure 8-22), indicating that whatever dissolved nutrients are available in the summer months are rapidly incorporated into phytoplankton biomass.

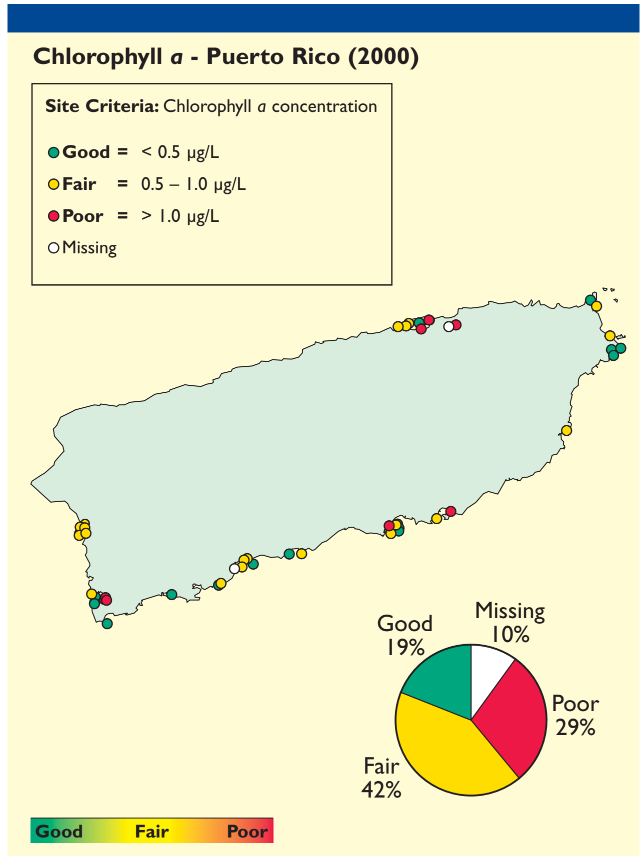


Figure 8-22. Chlorophyll *a* concentration data for Puerto Rico's estuaries (U.S. EPA/NCA).

Jobos Bay National Estuarine Research Reserve. Sea turtles are occasionally seen near seagrass meadows around coral reefs in the Reserve (NOAA National Estuarine Research Reserve Collection, Jobos Bay, Puerto Rico).

Water Clarity

Water clarity in Puerto Rico's estuarine waters is fair. Water clarity was estimated by light penetration through the water column and compared with the reference condition for tropical ecosystems supporting SAV and coral communities. In approximately 20% of the waters in Puerto Rican estuaries, less than 20% of surface light penetrated to a depth of 1 meter (Figure 8-23).

Dissolved Oxygen

Dissolved oxygen conditions in Puerto Rico's estuaries are good, except for in a single location in San Juan Harbor. The NCA estimates for Puerto Rico's estuaries show that about 1% of bottom waters in these estuaries have hypoxic conditions or low dissolved oxygen (<2 mg/L) on a continual basis in late summer (Figure 8-24). This area is associated with the inner reaches of San Juan Harbor.

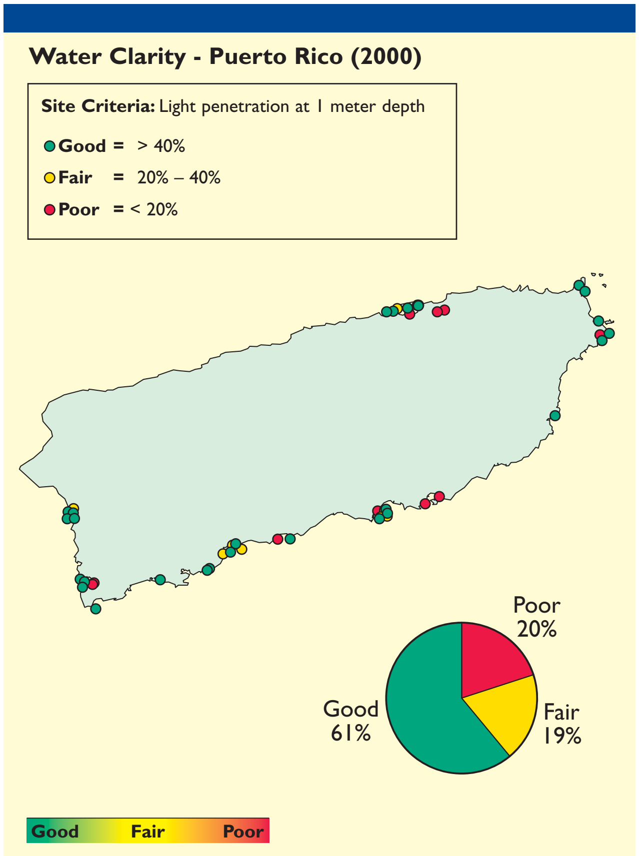


Figure 8-23. Water clarity condition for Puerto Rico's estuaries (U.S. EPA/NCA).

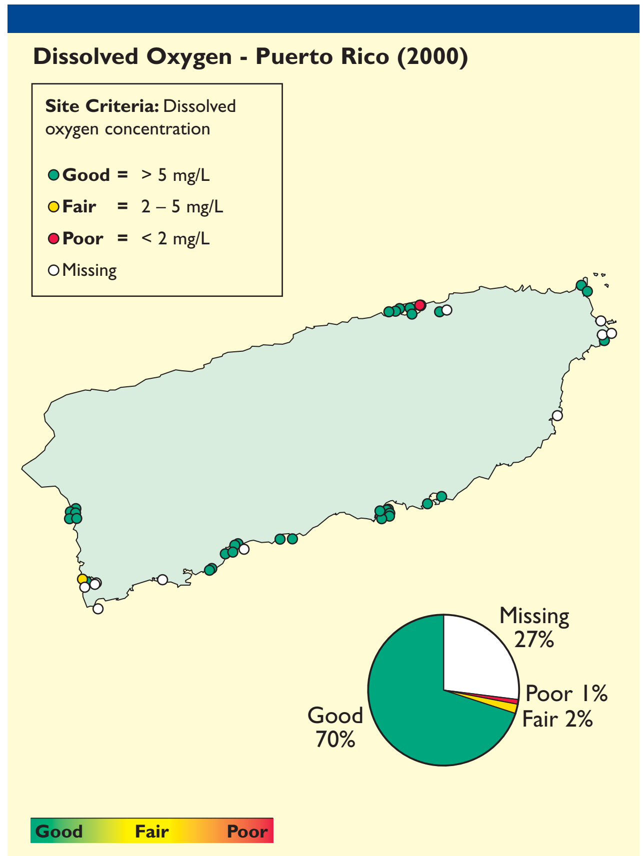


Figure 8-24. Dissolved oxygen concentration data for Puerto Rico's estuaries (U.S. EPA/NCA).

A snorkeler encounters a friendly, slow-moving manatee (Paul Goetz).

Sediment Quality Index

The condition of the estuarine sediments of Puerto Rico was determined to be poor. Sixty-one percent of the estuarine sediments in Puerto Rico displayed poor condition for one or more of the three indicators—sediment contaminants, sediment toxicity, and the proportion of sediments that contains TOC (Figure 8-25).

Sediment Toxicity

Only 3% of sediments sampled were toxic to test organisms (Figure 8-26). As a result, Puerto Rico's estuarine sediments are ranked good with regard to sediment toxicity. Sediments were determined to be toxic when test organisms exposed to the sediments had more than a 20% mortality rate in a 10-day exposure test.

A diver encounters a spiny pufferfish, whose defense strategy is to blow itself up with water to deter would-be predators (Paul Goetz).

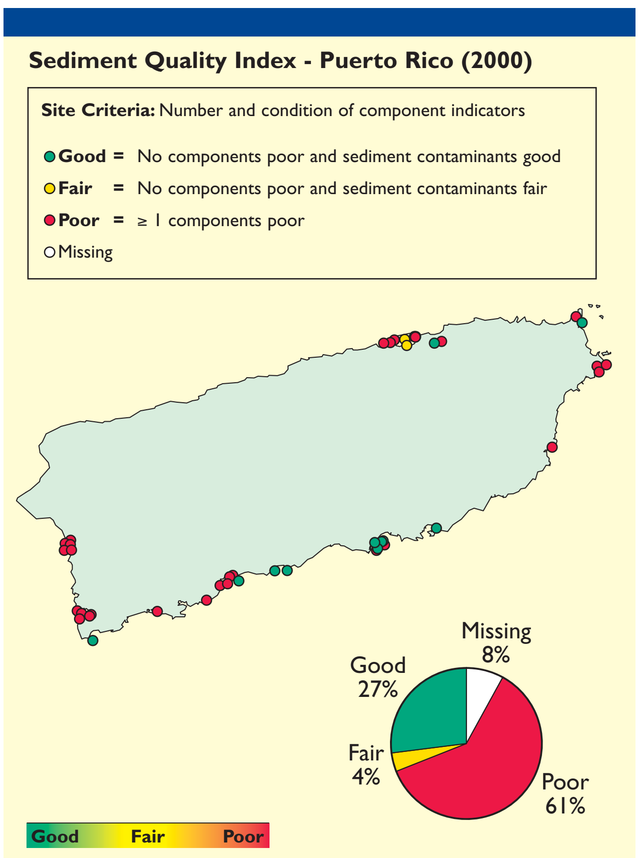


Figure 8-25. Sediment quality index data for Puerto Rico's estuaries (U.S. EPA/NCA).

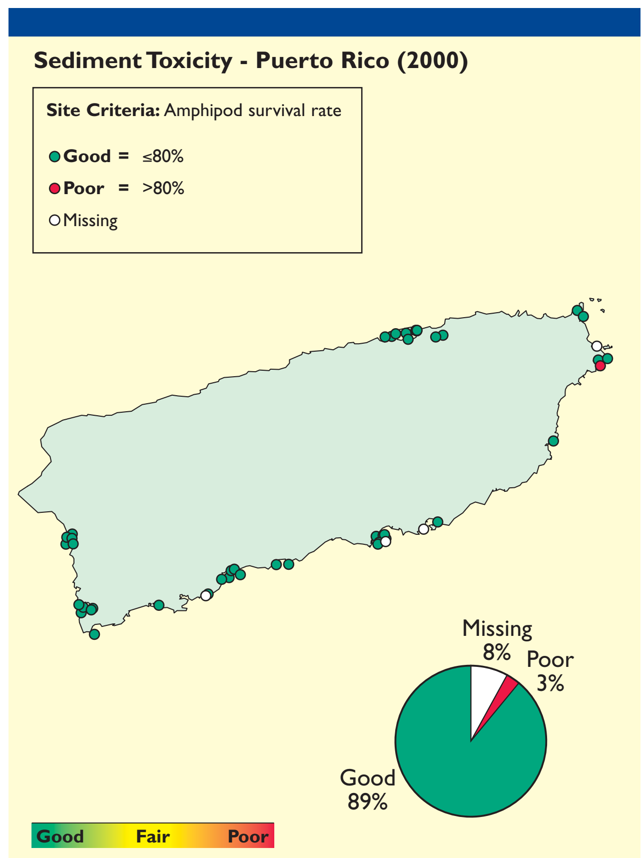


Figure 8-26. Sediment toxicity data for Puerto Rico's estuaries (U.S. EPA/NCA).

Sediment Contaminants

Estuarine sediments in Puerto Rico contained several contaminants that exceeded guidelines representing the likelihood of biological effects. These sediments were ranked poor and included 23% of all estuarine sediments in Puerto Rico (Figure 8-27). In most of these cases, concentrations exceeded the ERM guideline (i.e., the concentration likely to result in biological effects). An additional 44% of sediments exceeded the ERL guideline (i.e., the concentration that potentially could result in a biological effect) for at least one contaminant.

Of the 23% of sediments ranked poor, 100% showed exceedances in heavy metals, 41% showed exceedances in pesticides, and 26% showed exceedances in PCBs. None of these sediments contained PAHs exceeding the guidelines.

Sediment Total Organic Carbon

Puerto Rico sediments are rated poor with regard to sediment TOC. Analyses of estuarine sediments in Puerto Rico showed that 44% contained TOC content greater than 5% (Figure 8-28) and were thus ranked poor. An additional 33% of sediments contained between 2% and 5% TOC. Although higher percentages of TOC would be expected in tropical regions (sometimes 2% to 3%), TOC levels in estuarine sediments above 5% are often associated with organic loading to the estuaries via untreated wastewaters, agricultural runoff from livestock areas, and industrial discharges. However, these elevated TOC levels are occasionally associated with natural processes in mangrove estuaries.

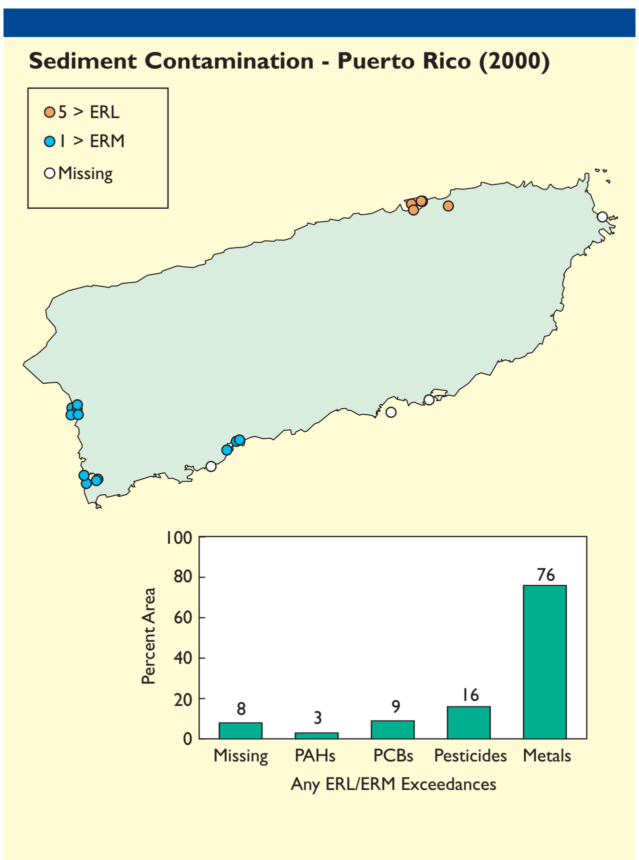


Figure 8-27. Sediment contaminant data and locations for sites with more than five contaminants exceeding ERL guidelines or one contaminant exceeding ERM guidelines in Puerto Rico (U.S. EPA/NCA).

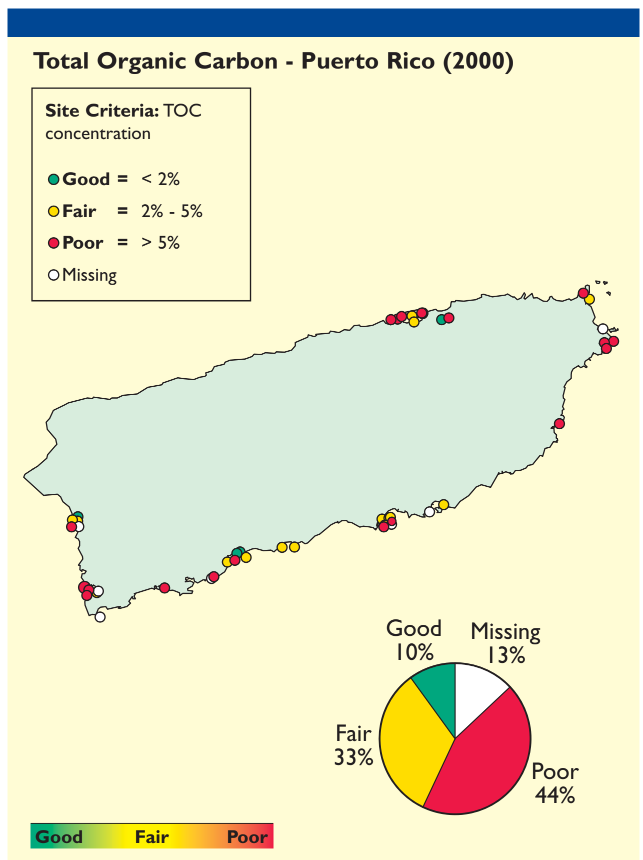


Figure 8-28. Sediment TOC data and sample sites in Puerto Rico (U.S. EPA/NCA).

Benthic Index

A benthic index has not yet been developed for Puerto Rico, but one will be developed as additional data are collected. As a surrogate for benthic condition, the benthic samples from Puerto Rico's estuaries were examined using ecological community indicators: biological diversity, species richness, and abundance. Biological diversity and species richness are measurements that contribute to all of the benthic indices developed by the NCA Program in the Northeast Coast, Southeast Coast, and Gulf Coast regions. Biological diversity is directly affected by natural gradients in salinity and silt-clay content. Analyses using data for Puerto Rico showed no significant relationships between benthic diversity and either salinity or silt-clay content. Thus, benthic diversity was used directly to evaluate benthic condition. If a site's benthic diversity was less than 75% of the observed mean diversity for all locations in Puerto Rico, the site was rated poor (Figure 8-29).

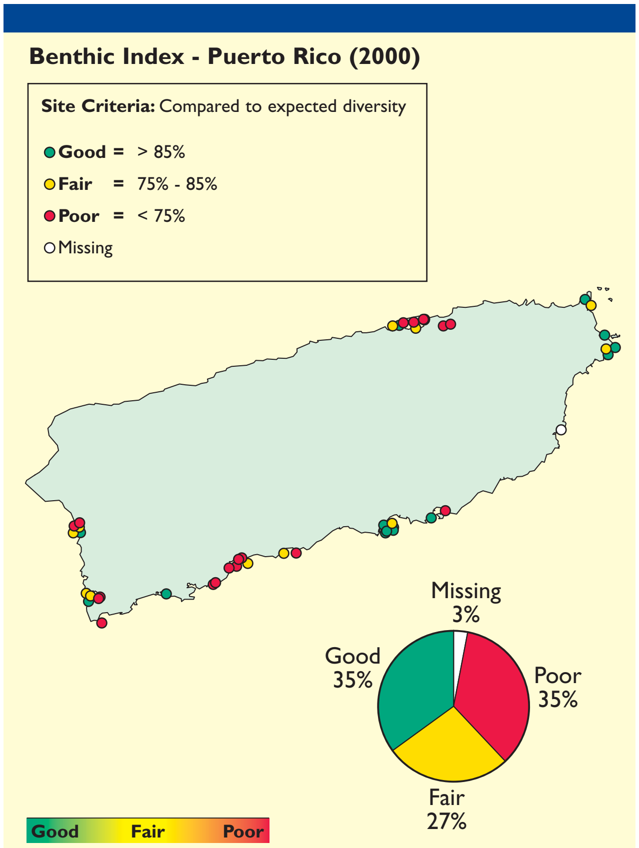


Figure 8-29. Benthic index data for Puerto Rico's estuaries (U.S. EPA/NCA).

Overall benthic condition in Puerto Rico's estuaries is rated poor. Thirty-five percent of the estuarine sediments in Puerto Rico had low benthic diversity (Figure 8-29). Of these areas of low benthic diversity, 90% co-occurred with poor sediment conditions, and 60% co-occurred with poor water quality conditions (Figure 8-30).

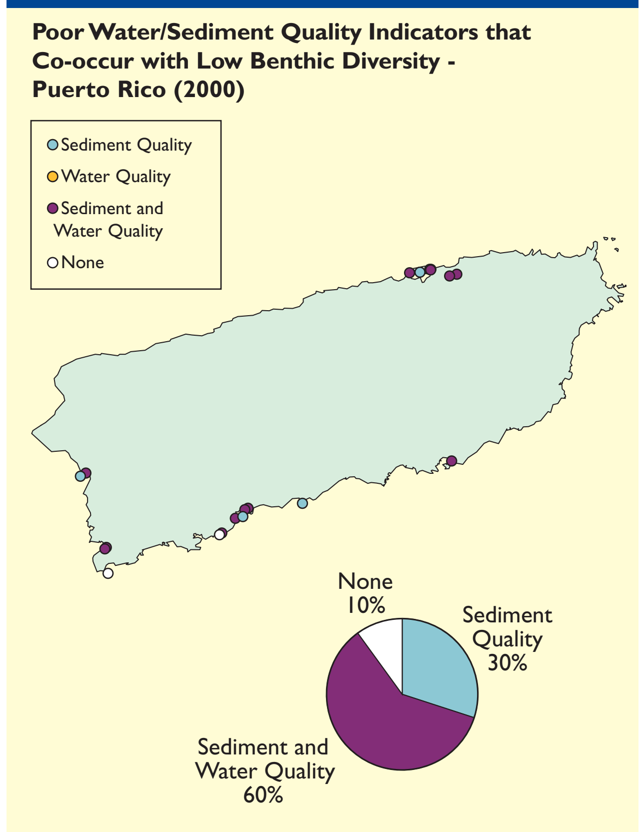


Figure 8-30. Indicators of poor water/sediment quality that co-occur with low benthic diversity in Puerto Rico (U.S. EPA/NCA).

Coastal Habitat Index

The coastal wetland indicator for Puerto Rico cannot be scored because the only information available regarding the acreage of coastal wetlands for Puerto Rico represents a single point in time, and rate of loss cannot be determined from this value. In 1990, the acreage of coastal wetlands in Puerto Rico was determined to be 17,300 acres. Although acreage estimates for 2000 are not available, it is clear that losses to coastal wetland acreage in Puerto Rico can be affected by development, sea-level rise, and interference with normal erosional/depositional processes.

Puerto Rico Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

Puerto Rico assessed 175 linear miles of estuaries (total number of estuarine square miles is unknown) and 550 linear miles of shoreline (100%) for its 2000 305(b) report. Of estuarine miles, 6% fully support their designated uses, 10% are threatened for one or more uses, and the remaining 84% are impaired by some form of pollution or habitat degradation (Figure 8-31). Fifty-five percent of ocean shoreline fully supports its designated uses, 24% is threatened for one or more uses, and the remaining 21% is impaired by some form of pollution or habitat degradation (Figure 8-32). Individual use support for assessed shoreline in Puerto Rico is shown in Figure 8-33.

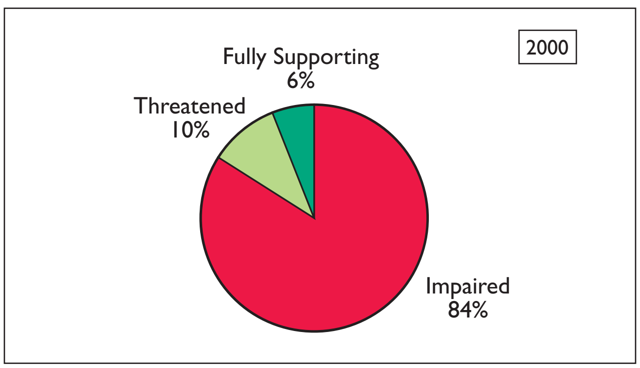


Figure 8-31. Water quality in assessed estuaries in Puerto Rico (U.S. EPA, 2002). Puerto Rico assessed 175 linear miles of estuaries, but the total number of estuarine square miles is

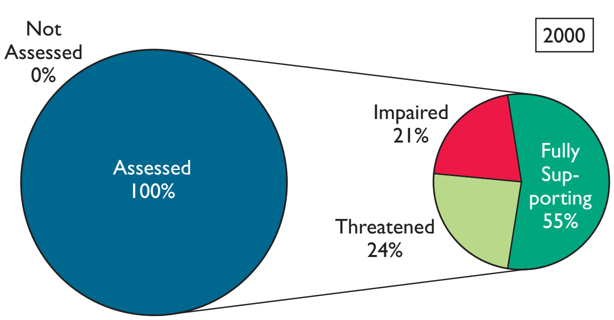


Figure 8-32. Water quality for assessed shoreline waters in Puerto Rico (U.S. EPA, 2002).

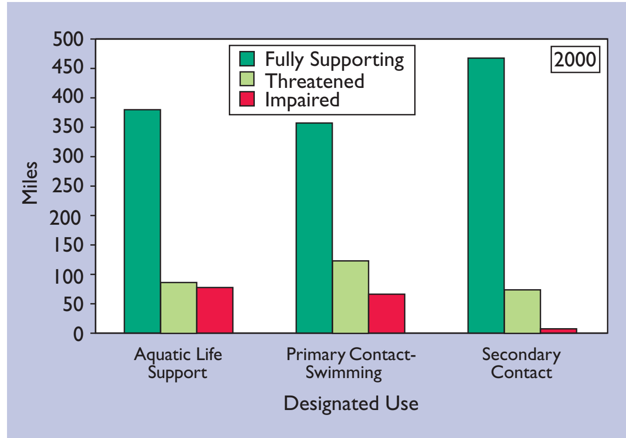


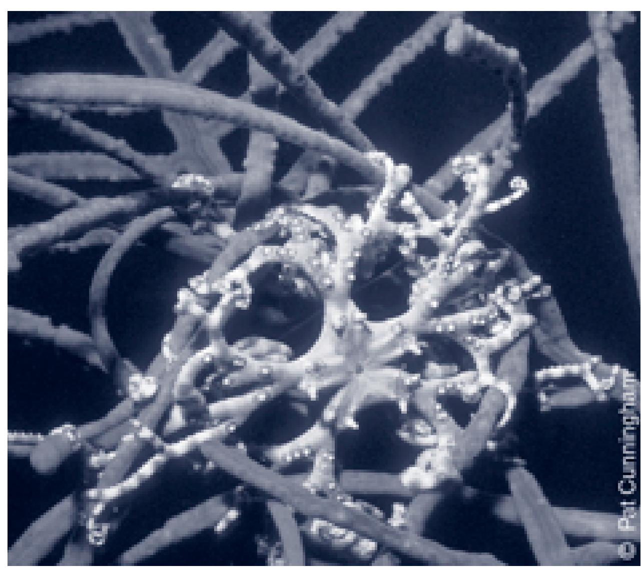
Figure 8-33. Individual use support for assessed shoreline waters in Puerto Rico (U.S. EPA, 2002).

Fish Consumption Advisories

Puerto Rico did not report fish consumption advisory information to EPA in 2002 (U.S. EPA, 2003c).

Beach Advisories and Closures

Puerto Rico reports beach advisories and closure data to EPA, but of the 24 beaches reporting in Puerto Rico, none reported being affected by either an advisory or a closure during 2002 (U.S. EPA, 2003a).



A juvenile basket star entwines itself in the soft coral for protection during the day (Pat Cunningham).

Coastal Biological Invasions

Biological invasion is considered the greatest cause of loss of plant and animal diversity after habitat destruction (Vitousek et al., 1997). The National Invasive Species Council reports that early detection of invasive species and a quick, coordinated response can eradicate or contain these invasions at much lower cost than long-term control programs, which may be unfeasible or prohibitively expensive. Carlton (2001) postulated that eradication of new populations of non-native species may succeed with the implementation of an early warning system. While there are several terrestrial models (e.g., the USDA's Animal and Plant Health Inspection Service), there is no such system for coastal waters, nor is there a national plan to monitor, share information, or advise field response teams on how best to control alien species before they become widespread.

With growing scientific concern for the increasing rate of biological introductions to United States coastal waters and the relative lack of action to reverse this trend, NOAA initiated in fiscal year 2002 a new coastal alien species program with five components:

(1) an inventory of coastal marine species

(2) a warning system to alert managers

(3) a national information dissemination system

(4) risk assessments and predictions of alien species becoming invasive

(5) early detection and monitoring of alien species.

The first implemented prototype component of this program is the Hawaiian Pilot Reporting, Warning, and Information Dissemination System for Coastal Alien Species. One of many partners, Bishop Museum, is preparing an electronic inventory of Hawaiian coastal species. Taxonomic experts will peer review this species inventory, while the state of Hawaii, the University of Hawaii, NOAA's Fisheries Service, and other organizations are making their monitoring data available to NOAA. NOAA's Coastal Data Development Center will integrate the monitoring data and link it to the inventory to create an information-dissemination system that Web site users can query by species name, search by geographic area, and download summary data to their desktops.

An up-do-date inventory of native and alien species known to reside in U.S. coastal waters and a verification process for validating the names of species reported as new to a region is integral to building a reliable reporting and warning system for biological invaders. The American Fisheries Society (AFS) has published peer-reviewed volumes on the names of fishes and invertebrates of Canada and the continental United States, and updates the volumes each decade. A primary partner in the new venture, AFS has granted copyrights to NOAA so that this information can be used to build the initial baseline inventory. Voucher specimens and photographs will be required before reported species can be confirmed, a warning to coastal managers issued, and the baseline inventory revised. Members of the museum community and other taxonomic experts who helped prepare and peer review the AFS volumes have volunteered to assist in the reporting system and to verify species reported as potentially new to a region.

Following successful testing of the prototype system in fiscal year 2003, NOAA and its partners will expand the Hawaiian coastal inventory, reporting, warning, and information-dissemination system to include other regions of the United States. (Other likely candidate regions include the Gulf of Mexico and Caribbean and Pacific Islands.) NOAA and the USGS are planning a joint venture in fiscal year 2004 to initiate the early detection and monitoring components of the alien species program.

Other Island Systems

Coastal Monitoring Data

No consistent coastal monitoring programs exist for American Samoa, Guam, the Northern Mariana Islands, or the U.S. Virgin Islands. The NCA Program may include one or more of these territories in the 2004 survey.

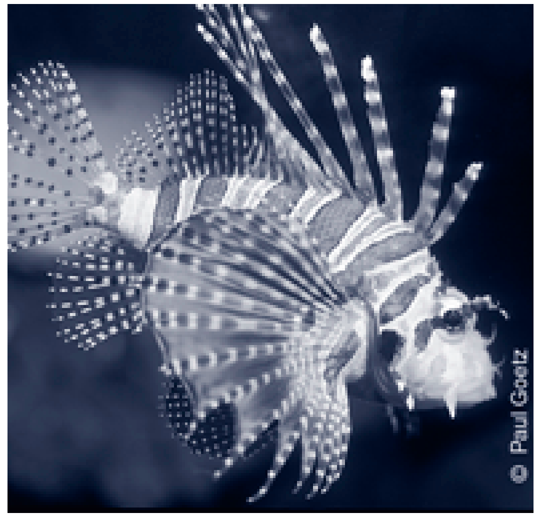
American Samoa

Large Marine Ecosystem Fisheries

The islands of American Samoa are partially surrounded by a narrow, fringing coral reef that is inhabited by a diverse array of fish and invertebrates. These reefs are harvested by local residents on an almost daily basis. Total inshore subsistence catch for 1993–1995 averaged 160 mt, with a value worth $560,000. The catch is dominated in some years by the coastal migratory species atule, but typically, more resident species such as other jacks, surgeonfish, mullet, octopus, groupers, and snappers are most consistently harvested.

Samoans also fish on the predicted nights of emergence of the paolo worm, whose reproductive segments are considered a delicacy. During its annual spawning, the hind end of the paolo worm containing the reproductive segments or epitokes separate from the anterior end of the worm and swarm to the surface, releasing sperm and eggs into the ocean. These epitokes are collected and consumed by many local fishermen. The head end of the worm remains below and regenerates a new epitoke in preparation for spawning the following year.

For Samoan inshore fisheries, downward trends in catch and CPUE have been observed in recent years, especially when the catches of the highly variable atule have been removed from the analysis.



The beauty of the Pacific lionfish belies its venomous spines (Paul Goetz).

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

American Samoa assessed 53 (46%) of its 116 shoreline miles for its 2000 305(b) report. Of the assessed miles, 13% fully support designated uses, 57% are threatened for one or more uses, and the remaining 30% are impaired by some form of pollution or habitat degradation (Figure 8-34). Individual use support for American Samoa's shoreline is shown in Figure 8-35.

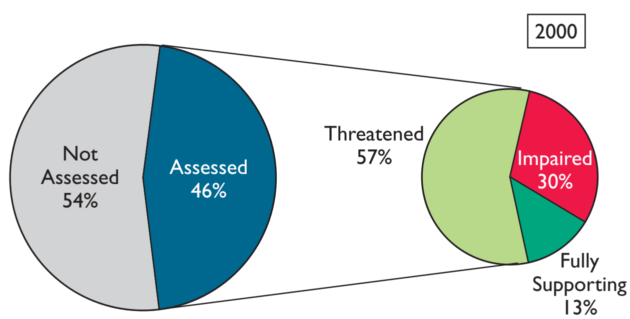


Figure 8-34. Water quality for assessed shoreline waters in American Samoa (U.S. EPA, 2002).

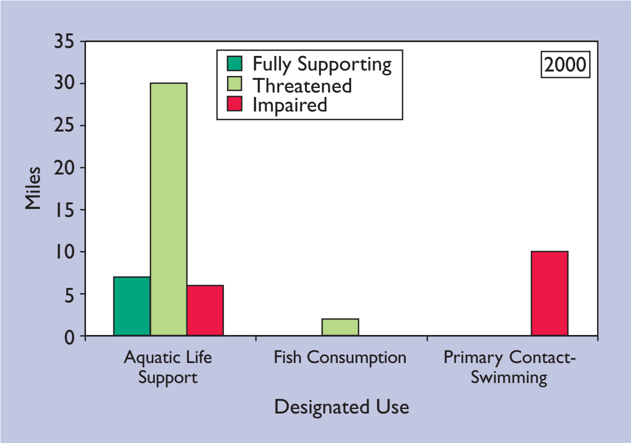


Figure 8-35. Individual use support for assessed shoreline waters in American Samoa (U.S. EPA, 2002).

Fish Consumption Advisories

Since 1993, American Samoa has had a fish consumption advisory in effect for chromium, copper, DDT, lead, mercury, zinc, and PCBs in Inner Pago Pago Harbor (U.S. EPA, 2003c). This estuarine advisory advises all members of the general population (including sensitive populations of pregnant women, nursing mothers, and children) not to consume any fish, fish liver, or shellfish from the waters under advisory. In addition, these same waters are also under a commercial fishing ban that precludes the harvesting of fish or shellfish for sale in commercial markets.

Beach Advisories and Closures

American Samoa did not report monitoring or closing information for any beaches in 2002 (U.S. EPA, 2003a).

Guam

Large Marine Ecosystem Fisheries

Guam is the southernmost and largest island in the Mariana Island Archipelago, and like American Samoa, the principal inshore fisheries are based on a wide assortment of coral reef fishes. Harvested fish include jacks and scads (especially atulai, the bigeye scad), surgeonfish, squirrelfish, fusilier, rudderfish (guili), snappers, mullet (aguas), goatfish (ti'ao), and rabbitfish (mañahak). Invertebrate species include various marine crabs (including land crabs), spiny and slipper lobsters, sea urchins, octopus, squid, cuttlefish, tridacnid clams, topshells, chitons, conchs, strombids, and nerites. Guam's inshore reefs appear to be fully exploited and have shown signs of overfishing. During 1993–1995, the catch of nearshore reef fisheries averaged 90 mt.

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

Guam assessed 17 (15%) of its 117 coastal shoreline miles for its 2000 305(b) report. Six percent of the assessed miles fully support designated uses, 35% are threatened for one or more uses, and 59% are impaired because of some form of pollution or habitat degradation (Figure 8-36).

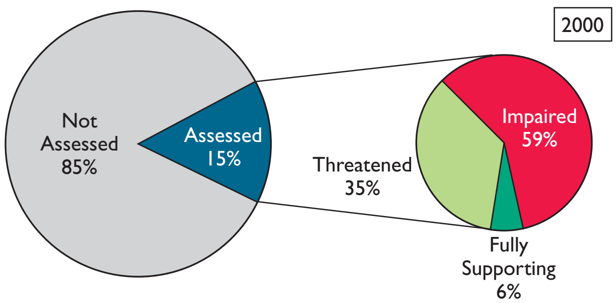


Figure 8-36. Water quality for assessed shoreline waters in Guam (U.S. EPA, 2002).

Fish Consumption Advisories

Guam did not report fish consumption advisory information to EPA in 2002 (U.S. EPA, 2003c).

Beach Advisories and Closures

Of 42 beaches in Guam that reported information to EPA, 39 (93%) were under advisories or closings at least once during 2002. Many of these advisories or closings were issued because monitoring had revealed elevated bacterial levels. Also, some beaches were closed preemptively because of sewage discharges or spills. The major source of elevated bacterial levels was unknown in most cases; however, the source of preemptive closures was sewerline blockage or pipe breakage (U.S. EPA, 2003a).

Northern Mariana Islands

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

The Commonwealth of the Northern Mariana Islands assessed 1 (less than 0.01%) of its 15,989 square miles of bays, estuarine areas, and lagoons for its 2000 305(b) report. The entire assessed estuarine area (100%) is impaired because of some form of pollution or habitat degradation (U.S. EPA, 2002).

Fish Consumption Advisories

The Northern Mariana Islands did not report fish consumption advisory information to EPA in 2002 (U.S. EPA, 2003c).

Beach Advisories and Closures

Three beaches reported advisory or closing information, and all three beaches were affected by public beach notifications. The beach notifications were issued in all three cases because monitoring revealed elevated bacteria levels. The sources of the elevated bacterial counts were SSOs, septic systems, stormwater runoff, and other sources.

U.S. Virgin Islands

Assessment and Advisory Data

Clean Water Act Section 305(b) Assessments

The U.S. Virgin Islands assessed 202 (97%) of its 209 miles of coastal shoreline for its 2000 305(b) report. Eighty-six percent of assessed shoreline fully supports its designated uses, 10% is threatened for one or more uses, and the remaining 4% is impaired by some form of pollution or habitat degradation (Figure 8-37). Individual use support for assessed U.S. Virgin Islands shoreline is shown in Figure 8-38.

Fish Consumption Advisories

The U.S. Virgin Islands did not report fish consumption advisory information to EPA in 2002 (U.S. EPA, 2003c).

Beach Advisories and Closures

All three of the main islands of the U.S. Virgin Islands—St. Croix, St. Thomas, and St. John—reported beach advisory and closing data in 2002 (U.S. EPA, 2003a). Of 62 beaches reporting data, only 3% (three beaches) reported advisories or closings, and these three beaches were all on St. Croix. The reason for all three closures was preemptive—sewage discharges or spills of sewage from POTWs.

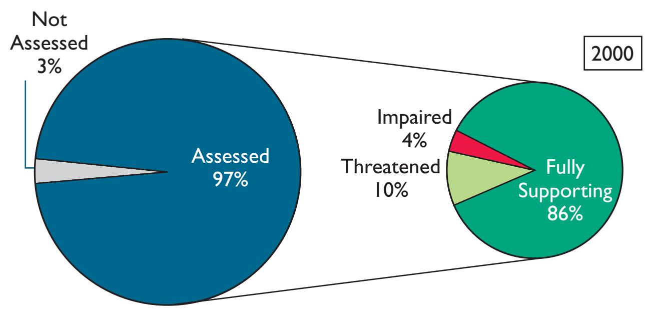


Figure 8-37. Water quality for assessed shoreline waters in the U.S. Virgin Islands (U.S. EPA, 2002).

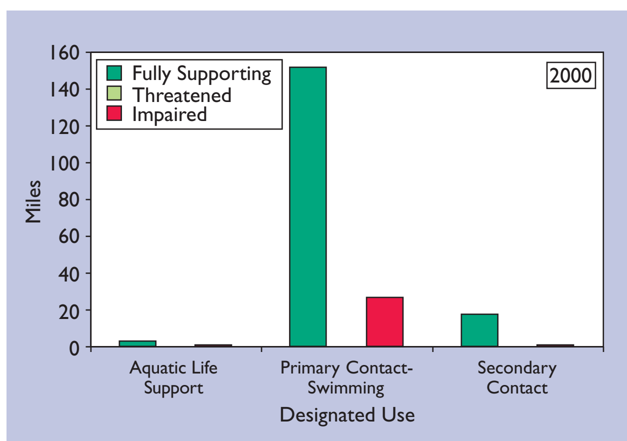
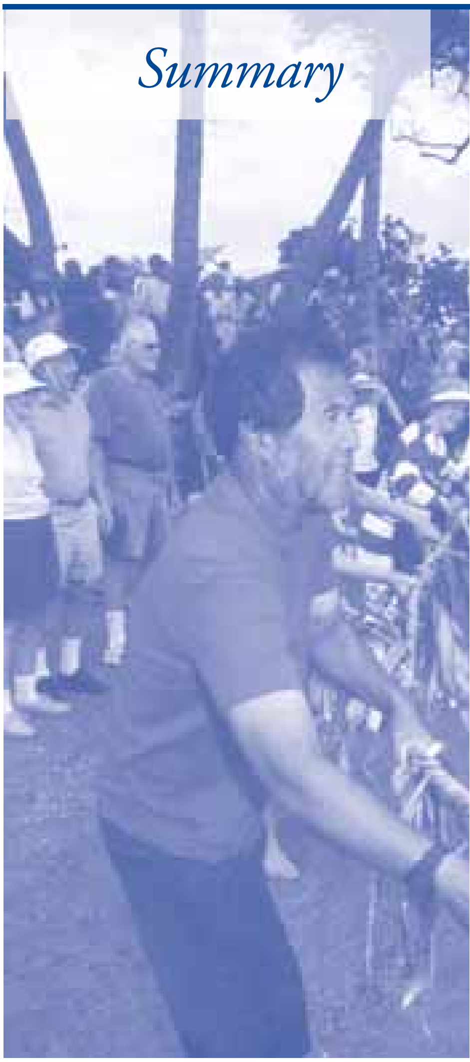


Figure 8-38. Individual use support for assessed shoreline waters in the U.S. Virgin Islands (U.S. EPA, 2002).



Summary

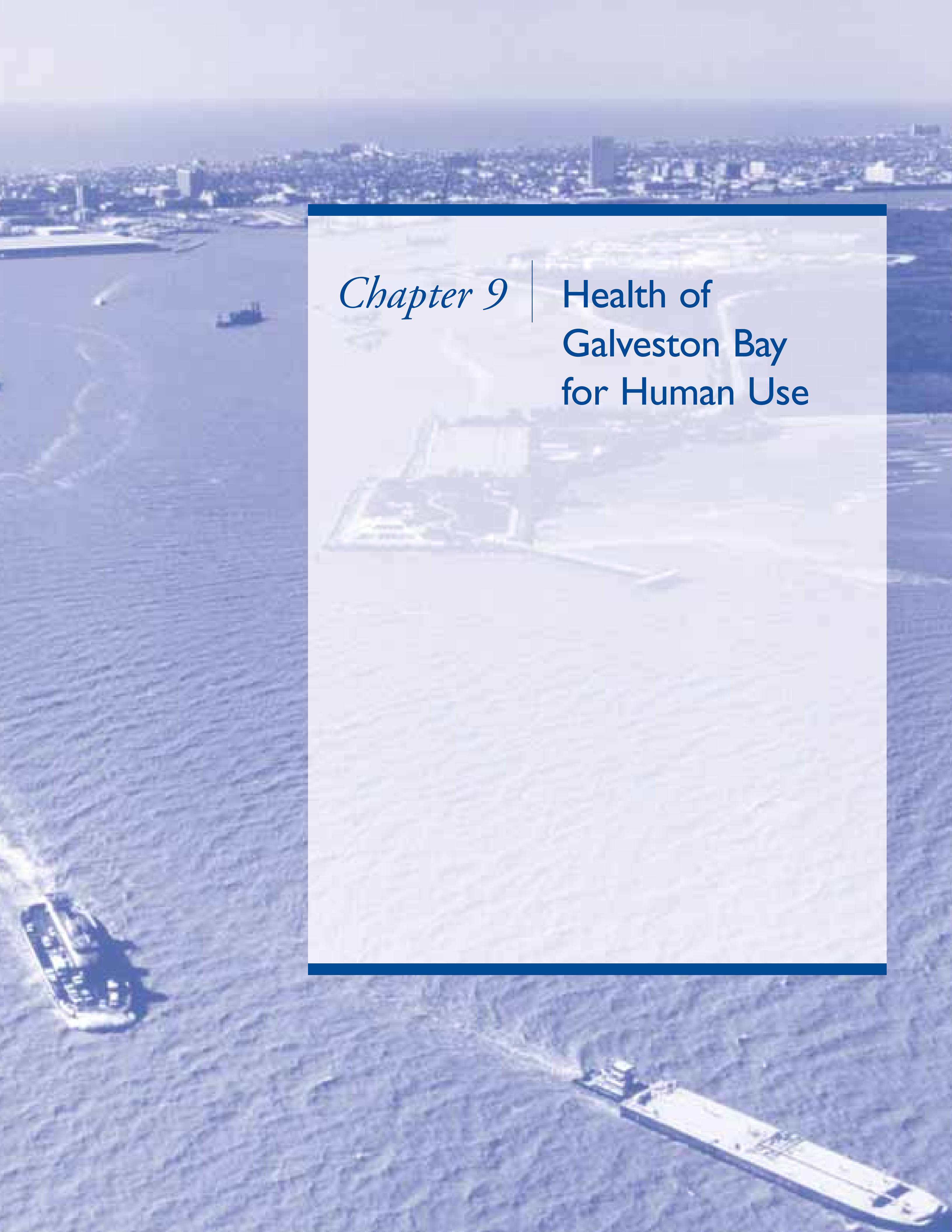
Ecological conditions of the coastal resources in Alaska, Hawaii, Puerto Rico, the U.S. Virgin Islands, and the Pacific island territories of American Samoa, Guam, and the Northern Mariana Islands are largely unknown. Alaska assessed less than 0.1% of its coastal estuaries and less than 0.1% its coastal shoreline in 2000; however, NCA assessments were completed for the Alaskan Province in 2002 and were scheduled in 2004 for Alaska's southeast region (Columbian Province), which includes Juneau and the island passage area. Additional NCA monitoring is planned for the Aleutian, Bering Sea, and Arctic areas in subsequent monitoring years because of the geographic expanse of these areas and the restricted time period in which sampling can be conducted.

Hawaii's 2000 305(b) data suggest that 57% of Hawaii's estuarine area is impaired by some form of pollution or habitat degradation, whereas only 2% of its coastal shoreline is impaired. Most monitoring in Hawaii is focused on known AOCs; therefore, it is difficult to interpret these results. NCA surveys conducted in 2002 and 2004 will provide a less biased view of Hawaii's estuarine condition in future National Coastal Condition Reports.

Although coastal monitoring in Puerto Rico has occurred in some coastal regions, these surveys were almost exclusively conducted in the San Juan area. The NCA Program conducted comprehensive survey of coastal resources in Puerto Rico in 2000. This survey, which included data from 50 sampling stations throughout the island, determined that the overall condition of Puerto Rico's estuarine waters is borderline poor, with 7% of the estuarine condition rated as unimpaired, 16% rated as threatened, and 77% judged to be impaired by some form of pollution. Habitat degradation for Puerto Rico could not be scored because the only information on the island's coastal wetlands represents a single point in time (17,300 acres of wetlands existed on the island in 1990). Puerto Rico's 2000 305(b) data provided similar results on estuarine area conditions, with 6% of assessed estuaries in Puerto Rico fully supporting their designated uses, 10% rated as threatened, and 84% impaired by some form of pollution or habitat degradation.

The 2000 305(b) data for the U.S. Virgin Islands suggests that the islands' coastal resources are in good condition. Approximately 86% of assessed shoreline fully supports its designated uses, 10% is threatened for one or more uses, and only the remaining 4% are impaired by some form of pollution or habitat degradation. Estuarine areas on the U.S. Virgin Islands were not assessed because these islands do not have waterbodies that are true estuaries.

Coastal resources in several of the Pacific island territories are believed to be in good condition; however, available data are relatively scarce for these jurisdictions. The 2000 305(b) data for American Samoa revealed that of the assessed coastline miles, 13% fully support their designated uses, 57% are threatened for one or more uses, and the remaining 30% are impaired by some form of pollution or habitat degradation. The 2000 305(b) data for Guam revealed that of the assessed coastline miles, only 6% fully support their designated uses, 35% are threatened for one or more uses, and the remaining 59% are impaired by some form of pollution or habitat degradation. No water quality assessments of estuarine condition were made for American Samoa or Guam. Finally, the 2000 305(b) data for the Northern Mariana Islands revealed that of the 1 square mile of estuaries and bays assessed (representing less than 0.01% of 15,989 square miles of estuarine area), 100% is impaired by some form of pollution or habitat degradation. The NCA Program may include one or more of these island territories in their 2004 survey to obtain a more comprehensive perspective on estuarine and coastal resources.



Chapter 9 Health of Galveston Bay for Human Use

Health of Galveston Bay for Human Use

Estuaries are expected to support a variety of human uses, ranging from commercial and recreational fisheries to marine transportation to discharge of chemical and thermal wastes. How well estuaries are meeting these human uses is one measure of coastal condition. Traditionally, coastal condition is described in terms of the effects of human activities on one or more environmental metrics. The previous chapters have followed this traditional approach and have used the results of estuarine assessments to describe the current condition of coastal resources in each region of the United States. This final chapter complements that approach by assessing the health of an estuary based on its ability to meet society's desired uses. Using Galveston Bay (the largest estuary of the Texas coast) as an example, this chapter will examine the following questions:

- What are society's stated uses for the system?
- How well are those uses being met?
- In instances in which a particular use is not being achieved to the desired level, are there relationships between the impairment and the National Coastal Condition Report indicators? If so, how might improving one or more of the indicators affect a particular use?

Addressing estuarine health in this manner can help researchers interpret existing data in terms of an estuary's ability to meet society's desired uses, as well as drive the collection of new data directly related to perceived problems. The first steps in enabling managers to enhance and balance those uses are to determine how society currently chooses to use these areas and to estimate the social, economic, and environmental costs and benefits of optimizing one or more uses. The relationship between coastal condition indicators and human use impairments will be addressed in more detail in future National Coastal Condition Reports.

The type of assessment described in this chapter cannot be done on scales larger than a single estuary. Galveston Bay was chosen for this first evaluation for two reasons. First, on a very large scale, Galveston Bay supports a wide array of human uses, from industrial activities, such as oil and gas extraction and petrochemical operations, to fisheries, recreation, tourism, and marine transportation. Second, a great deal of information has been gathered and made readily available by the Galveston Bay Estuary Program (GBEP), formerly the Galveston Bay National Estuary Program (GBNEP); the Texas Parks and Wildlife Department (TPWD); the NMFS; and the USACE.

Overview of Galveston Bay

Galveston Bay (Figure 9-1) is classified as a bar-built estuary in a drowned river delta. The open bay has a surface area of approximately 600 square miles (GBEP, 2002). With an average depth of 6 feet and a maximum nondredged depth of 10 feet, it is a shallow estuary. The watershed has an area of approximately 24,500 square miles (NOAA, 1990), which includes all or portions of 44 counties within the state of Texas. Five counties surround the estuary: Brazoria, Chambers, Galveston, Harris, and Liberty. In addition, the metropolitan areas of Houston, Dallas, and Fort Worth are also contained in the watershed.

Galveston Bay itself is commonly divided into four subbays: Galveston Bay, Trinity Bay, East Bay, and West Bay. Galveston Bay receives inflow from the San Jacinto River and local drainage from the Houston

Figure 9-1. Galveston Bay watershed.

metropolitan area via the Buffalo Bayou and its tributaries. The Trinity River empties into Trinity Bay. East Bay, on the inside of the Bolivar Peninsula, receives inflow from Oyster Bayou and from local runoff. West Bay, landward of Galveston Island, receives freshwater inflow from a series of bayous.

With an estimated input of 10 million acre-feet per year, Galveston Bay has the largest freshwater inflow volume of any estuary wholly or entirely within Texas (Martin et al., 1996), flushing the system between four and five times annually (GBNEP, 1994a). The major source of freshwater to Galveston Bay is the Trinity River, accounting for 54% of the inflow, followed by the San Jacinto River basin (28%) and the local watershed (18%) (GBNEP, 1994a).

In the upper half of Galveston Bay, salinity is typically less than 10 ppt, and it is lower near the point where the Trinity River enters the bay. In the lower half of the estuary, higher salinities are common, including salinities as high as 30 ppt at the Gulf inlet located between Galveston Island and Bolivar Peninsula (GBEP, 2002). Vertical salinity stratification is slight, averaging less than 0.6 ppt/meter. The Houston Ship Channel, which extends approximately 50 miles from Houston to the Gulf of Mexico, has also produced changes in bay circulation and salinity.

Within Galveston Bay, six major estuarine habitat types have been identified: oyster reefs, seagrass meadows, marshes, intertidal mud and sand flats, open-bay waters, and open-bay bottoms (GBEP, 2002). Species living in Galveston Bay move in and out of these areas, typically associating with one or more habitats during their life cycle.

What Does Society Want Galveston Bay to Look Like?

According to *The Galveston Bay Plan: The Comprehensive Conservation and Management Plan for the Galveston Bay Ecosystem* (GBNEP, 1994a) developed by the GBNEP, there are a number of land uses identified as important to society. These land uses include marine transportation; commercial and recreational fishing; receiving waters for industrial, municipal, and thermal wastes; recreational activities, such as sailing and motorboat cruising and sightseeing; habitat for fish, birds, shellfish, dolphins, reptiles, and other species; sites for oil and gas production; human residential housing; and also use as a general indicator of the health of the environment.

Society's desired uses of Galveston Bay are also reflected in land use patterns (Table 9-1). In general, urban and industrial development is concentrated on the western side of the bay, with the eastern side being more rural, dominated by agriculture and the extraction of natural resources (GBEP, 2002). There are more than 800 point source dischargers in the watershed, and many of these are wastewater treatment plants (Figure 9-2). Significant industrial activity exists around Galveston Bay, much of it centered along the Houston Ship Channel and in Texas City. As much as 50% of the nation's petrochemical production and as much as

30% of its petroleum industry can be found within the five-county area surrounding Galveston Bay (Gersten, 1995). There are approximately 50 petrochemical facilities and 40 inorganic chemical producers in the area. Manufacturing in the five counties surrounding Galveston Bay accounts for an estimated annual value of more than $95 billion (Table 9-2).

The Port of Houston is the third largest port in the Unites States and the sixth largest in the world (Port of Houston Authority, 2003). It is used primarily by ships in support of the petroleum and petrochemical industries (Martin et al., 1996). The combined annual revenue of the Port of Houston, Texas City, and Galveston Bay has been estimated at more than $15 billion per year.

Agriculture is a significant human use, particularly on the eastern side of the bay. The major crops in the five counties surrounding Galveston Bay include rice, sorghum, soybeans, and corn. The raising of livestock, primarily beef cattle, is also an important activity. In the five counties surrounding Galveston Bay, agriculture generates an estimated market value of more than $130 million per year (Table 9-2).

Tourism is an important and growing use of Galveston Bay and its surrounding areas, generating an estimated $7.5 billion in travel and payroll dollars (Martin et al., 1996). Sport fishing and associated expenditures in and around Galveston Bay have been estimated to generate as much as $2.8 billion per year.

Galveston Bay ranks as the second most productive estuary in the United States in terms of seafood (Martin et al., 1996). The commercial fishing industry produces a total economic impact of up to $358 million each year (Martin et al., 1996), approximately one-third of the commercial fishing income in Texas (GBEP, 2002). The most commercially valuable species from Galveston Bay are brown and white shrimp, oysters, and blue crabs.

Although Galveston Bay has been modified substantially to support human uses, large tracts of natural areas in and around the bay still remain intact, in part because of the value society has placed on these areas. For example, there are an estimated 345 square miles of wetlands in and around Galveston Bay and approximately 585 square miles of forest land. Wetlands and seagrasses are important habitats for many species and life stages of aquatic organisms that inhabit Galveston Bay.

Table 9-1. Land Use in the Galveston Bay Watershed (NOAA, 1999).

Land Use	Lower Watershed ($mi.^2$)*	Upper Watershed ($mi.^2$)
Urban	1,141	1,757
Residential	31	238
Commercial and services	4	47
Industrial	46	12
Transportation, communication, and utilities	7	57
Strip mines and quarries	1	19
Agricultural lands	1,627	9,817
Rangeland	<1	1,714
Forest	585	5,679
Wetlands	345	74
Estuaries, lakes, and reservoirs	608	444
Streams and canals	21	6

* Lower watershed or estuarine drainage is defined as that portion of the watershed downstream of the head of tide.

As might be expected, society wants and expects Galveston Bay to provide all of these goods and services at optimal levels. This chapter examines how well these uses are being met. In addition, it examines relationships between fisheries and improving the National Coastal Condition Report indicators in Galveston Bay.

How Well Are These Uses Being Met?

In general, the desired human uses in Galveston Bay are being met. There are indications that some of the uses could be improved, and in several cases, efforts are under way to realize these improvements.

Marine Transportation

Marine transportation is of critical importance to the Galveston Bay economy, accounting for approximately $16 billion and over 230 million tons of cargo moved annually (Port of Houston, 2003). Work is under way to maintain this use by dredging both the Houston and Galveston Bay ship channels to accommodate today's larger ships and to enhance navigational safety (USACE, 2003). The Houston-Galveston Navigation

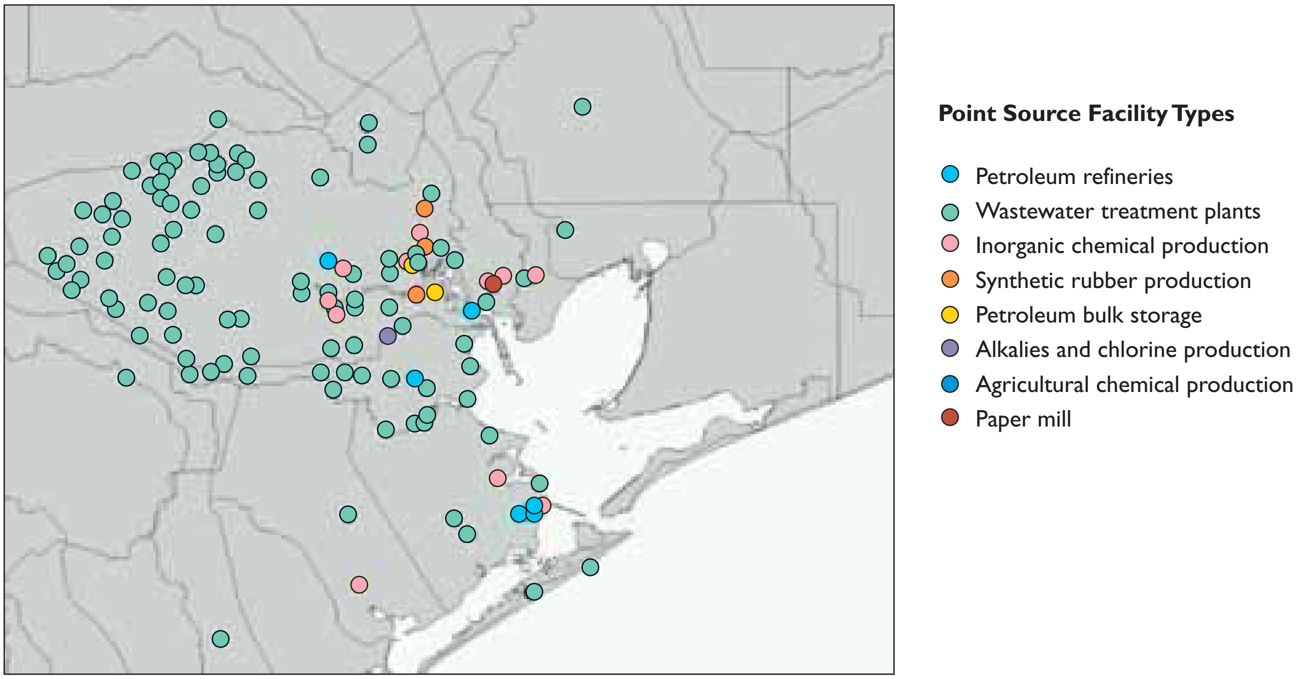


Figure 9-2. Major point sources adjacent to Galveston Bay (U.S. EPA, 2004).

Table 9-2. Production and Value ($) Estimates of Human Uses in Galveston Bay

Use	Economic Impact	Production/Employment
Commercial fishing	$358 million (Martin et al., 1996)	11 million lbs/year (Martin et al., 1996)
Recreational fishing	$2.8 billion (Martin et al., 1996)	40,000 jobs; 100,000 pleasure boats (GBEP, 2002)
Tourism	$7.5 billion (Martin et al., 1996)	80,000 jobs (Martin et al., 1996)
Marine Transportation		
Port of Houston	$11 billion (Port of Houston Authority, 2003)	175 million tons; 6,800 vessels (GBEP, 2002)
Port of Galveston	$440 million [1]	7 million tons; 927 vessels (GBEP, 2002)
Port of Texas City	$4.2 billion [1]	67 million tons; 9,600 vessels (GBEP, 2002)
Manufacturing	$95.3 billion	
Employment	183,000 jobs (U.S. Census Bureau, 1997)	
Agriculture	$132 million (USDA, 1999)[2]	5,558 farms; 1.5 million acres (USDA, 1999)

[1] Estimated value of cargo for Galveston Bay and Texas City calculated using per ton value from Port of Houston.

[2] Market value of agricultural product sold.

Project is a project to increase the depth of the channels from 40 to 45 feet and to widen their bottom widths from 400 to 530 feet. In addition to improving marine transportation in and out of Galveston Bay, dredge material will be used in the construction or rehabilitation of several islands and marshes. A total of nearly 4,500 acres of habitat is being created over the 50-year life of this project, as well as approximately 120 acres of oyster reefs (GBEP, 2002).

The marine commerce industry in Galveston Bay is already large, and despite ongoing efforts to accommodate growth in the industry, it is anticipated that marine commerce in the bay will overwhelm the available port facilities sometime after 2010. Planning for that growth is well under way, and environmental impact statements have been filed with the USACE to build new ports at Baytown and Texas City.

A Place to Live

The area around Galveston Bay is home to approximately 4 million people (GBEP, 2002), and population growth is expected to continue. The majority of the population lives in Harris County (Figure 9-3), home to significant manufacturing activities. Much of the population growth around Galveston Bay can be attributed to the growth of industry, ranging from petrochemicals to electronics manufacture (GBEP, 2002).

Although population growth in the cities of Houston and Galveston has slowed, growth in the suburban communities is expanding to meet the needs of the population. Many people also want to live near the bay itself. In Chambers County, approximately 45% of the population lives within 2 miles of the bay; in Galveston County, that figure climbs to more than 70% (GBEP, 2002).

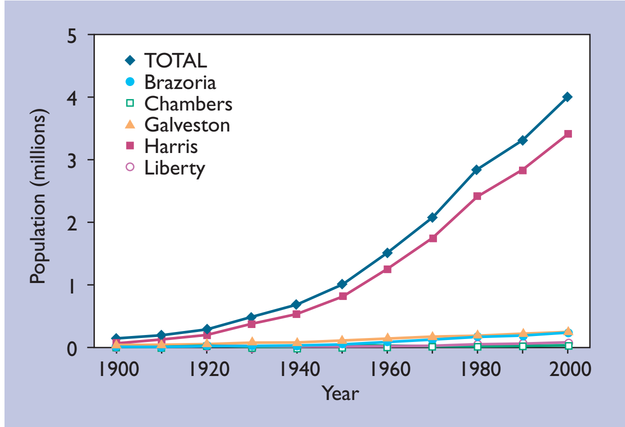


Figure 9-3. Population change in the counties surrounding Galveston Bay (U.S. Census Bureau, 2001).

Oil and Gas Production

The discovery of oil and gas in the early part of the twentieth century drove much of the region's growth. There are currently more than 5,300 oil wells and 1,500 gas wells in the Galveston Bay area (GBEP, 2002). Although oil and gas production is still an important industry in the region, production has decreased considerably since the 1970s (GBNEP, 1994b). In 1979, oil production in Brazoria, Chambers, Harris, and Galveston counties totaled 52 million barrels. By 2001, that figure had declined to approximately 5.4 million barrels. The decline appears to be related to external factors, such as falling oil and gas prices worldwide, which have led to less extraction of reserves in the Galveston Bay area. The crash of the oil industry in the 1980s also led to diversification of the bay area's economy.

Manufacturing

As shown in Table 9-2, manufacturing is the major economic engine in the Galveston Bay area. An estimated one-half of the total chemical production in the United States takes place in the five counties that surround Galveston Bay (GBEP, 2002). Most of this manufacturing is concentrated in Harris County. Major production categories include petrochemicals, inorganic chemicals, plastics and rubber products, fabricated metal manufacturing, machinery, and computer and electronic products. The region's economy has expanded fairly continuously over the past 50 years, indicating the continued desire for increased production of goods and services, and this trend will likely continue. In 1997, the value of shipments in the five counties surrounding Galveston Bay was approximately $95 billion, (U.S. Census Bureau, 1997).

Recreational Activities

Recreation is important in Galveston Bay. For the most part, it appears that this use is also being met. Major activities include duck hunting, swimming, nature viewing, pleasure boating, fishing, camping, picnicking, and sightseeing (GBNEP, 1994b). With approximately 100,000 registered pleasure boats in the five counties that surround it, Galveston Bay has been called the "boating capital of Texas" (GBEP, 2002). An estimated 40% or more of the residents around Galveston Bay participate in walking, swimming, or picnicking around the bay at least annually (GBEP, 2002), and approximately 20% of the residents in the five-county area use the bay at least once a year for recreational fishing and boating (Whittington et al., 1993).

One concern related to this use, however, is that of access to the bay. Currently, public shoreline access is limited to parks and boat ramps and a few parks (GBNEP, 1994b). As the population of the region increases, the need for greater access to the bay will likely become a greater priority.

Wildlife Habitat

A habitat for wildlife is also listed as an important use in the Galveston Bay management plan. Over the years, the bay has changed significantly. One of the most obvious changes is the loss of wetlands and seagrasses. Wetlands and seagrasses have many functions within estuarine ecosystems, one of the most important being habitat for plants, fish, birds, and wildlife. In Galveston Bay, many of the fishery species of shrimp, crabs, and fish rely on wetlands and seagrasses for at least part of their life cycle (GBNEP, 1994b).

More than 33,000 acres of vegetated wetlands, or approximately 19% of the total, have been lost from Galveston Bay since the 1950s (GBNEP, 1994b). The rate of wetland loss in Galveston Bay is also higher than the national average. Four main causes have been cited: human-induced subsidence and associated relative sea-level rise; conversion of wetlands to agricultural land; dredge and fill activities; and isolation projects. Much of the subsidence was caused by the pumping of groundwater, resulting in compaction of the underlying clay layers. Some wetlands were expanded as upland areas were inundated with water, but overall, losses exceed gains. Subsidence and inundation were most common in brackish or salt marshes. The draining of wetlands for upland uses, such as rangeland, is another significant cause of wetland loss in Galveston Bay.

The loss of seagrasses has been even more significant than loss of wetlands. Seagrasses have decreased from approximately 2,500 acres in the 1950s to 700 acres in 1987, roughly a 70% loss of this habitat (GBNEP, 1994b). The reasons for the loss of seagrasses are not fully understood, but may be related to human activities, including land development, wastewater discharges, chemical spills, and dredging activities, a number of which can result in light attenuation and limit seagrass growth (Pulich and White, 1991). Another cause of the disappearance of seagrasses may be related to subsidence. The removal of natural berms resulting from subsidence may increase the wave energy impinging on seagrass beds and thus increase erosional forces (GBNEP, 1994b).

The loss of wetland and seagrass habitat could also be affecting both ecologically and economically important species; however, no studies have been able to document a causal relationship between species abundance and habitat loss in Galveston Bay (GBNEP, 1994b). Although the loss of wetlands and seagrass habitat could affect the abundance of fish and shellfish that use these areas as a nursery, many of these species can survive and grow over open bay bottom (GBEP, 2002).

Galveston Bay is also home to a variety of birds, from colonial waterbirds to waterfowl and shorebirds. A recent study (McFarlane, 2001) investigated population trends in colonial waterbirds in Galveston Bay. Overall, the results were good: 10 species of birds had stable populations during the period 1973 to 1998, 8 species increased in population, and only 4 species—great blue heron, roseate spoonbill, least tern, and black skimmer—had decreasing populations. The reasons for the decrease in these four species are not clear. In the case of great blue herons and roseate spoonbill, a decrease in the quality or quantity of nesting and feeding habitat, such as wetlands, could be a factor (Walton and Green, 1993).

Status of Fisheries in Galveston Bay

Galveston Bay is an important source for both commercial and recreational species of fish and shellfish. Historically, the bay has been the leading producer of seafood in Texas and one of the leading producers in the Gulf of Mexico. In general, the fisheries appear to be meeting the needs of commercial and recreational fishers.

The status of fisheries in Galveston Bay was assessed primarily using commercial and recreational landings data provided by the TPWD. Seafood dealers provide information on commercial harvest of shrimp, oysters, crabs, and marine fish through a mandatory self-reporting system known as the *Monthly Marine Products Report* (Green et al., 1992). Where appropriate, fishery-independent trawl and seine data, also collected by TPWD, were used to supplement landings data.

Public pressure led to a ban on the use of gill nets in all saltwater habitats in the late 1980s because valued non-target fish and mammals were being caught in the nets (Robinson, 2003). Twenty-year records of commercial landings of some commercial finfish species show overall decreases that are likely a result of that ban;

therefore, only data since 1990 have been used to examine a possible connection between landings and coastal condition.

Commercial Fisheries

The shrimp fishery is the largest commercial fishery in Galveston Bay, averaging approximately 7 million pounds, followed by the fisheries for oysters, blue crabs, and a variety of fish species (Table 9-3). Approximately 95% of the total annual commercial harvest in Galveston Bay is made up of shrimp, oysters, and blue crabs (GBNEP, 1994b).

Table 9-3. Average Harvest of Selected Commercial Species of Fish and Shellfish from Galveston Bay (GBEP, 2002)

	Weight (lbs)	Ex-vessel Value
Shrimp	6,948,629	$9,969,989
Eastern oysters	3,919,514	$8,412,810
Blue crab	1,992,007	$1,240,167
Finfish	211,399	$151,515

Values represent mean for years 1994–1998.

Shrimp

The commercial harvesting of shrimp in Galveston Bay rose to prominence in the 1920s. White and brown shrimp are the major species harvested in Galveston Bay, and pink shrimp are a minor component of the overall harvest and are usually counted as "browns." Slightly more white shrimp are caught in Galveston Bay than brown and pink shrimp (Green et al., 1992). Figure 9-4 shows the commercial harvest between 1990 and 2001 in Galveston Bay, during which time there was an overall increase. In terms of human use, this would appear to indicate the resource is meeting human use needs.

Eastern Oysters

Oysters are the second most important commercial species harvested in Galveston Bay. Most of the bay's large oysters reefs are located in mid-Galveston Bay (e.g., Redfish Reef and Redfish Bar) and also in East Bay (e.g., Hanna Reef), where fresh water from the tributaries mixes with saltwater from the Gulf of Mexico. Commercial landings of oysters increased between 1990 and 2001 (Figure 9-5), and the fishery does not appear to have had an adverse impact on the size of existing oyster reefs (GBEP, 2004). Some of the most heavily fished reefs have not varied much in size since the 1850s, and there is even evidence of accretion on some reefs (GBNEP, 1994b). This resiliency of oysters is interesting not only because of the fishery pressure on the resource, but also because of other stressors, such as disease and predation. For example, the protozoan parasite known as "Dermo" (*Perkinsus marinus*) can cause annual mortalities in market oysters ranging from 10% to 50% (GBEP, 2002).

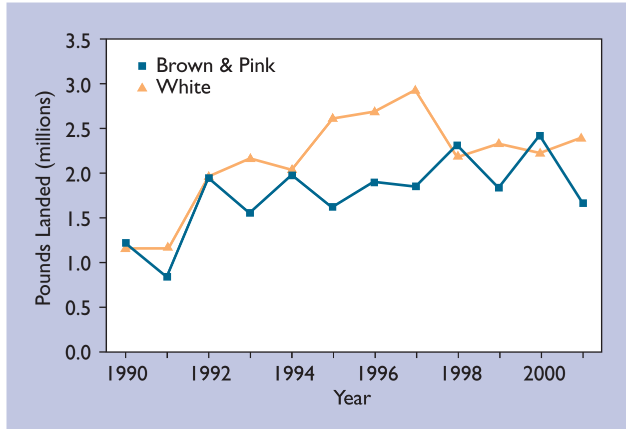


Figure 9-4. Commercial landings of shrimp in Galveston Bay, 1990–2001. Developed by NOAA for NCCR II. Data provided by Texas Parks and Wildlife Department (TPWD, 2003).

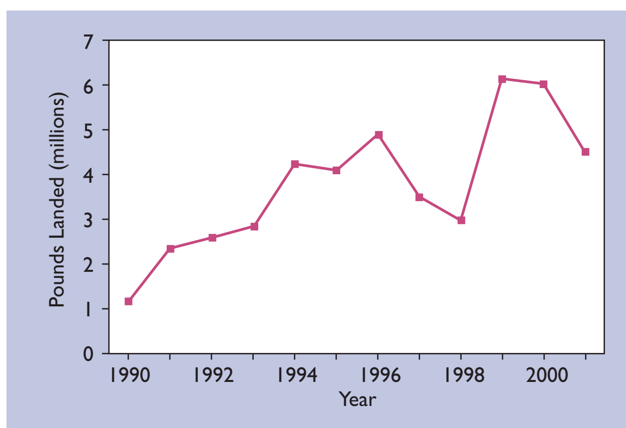


Figure 9-5. Commercial landings of oysters in Galveston Bay, 1990–2001. Developed by NOAA for NCCR II. Data provided by Texas Parks and Wildlife Department (TPWD, 2003).

Although the oyster population appears to be stable (even increasing in some areas), oyster harvesting is restricted in significant portions (43%) of Galveston Bay and is prohibited in small areas (1.5%) (GBEP, 2002). Growing water condition is determined based on observed concentrations of fecal coliform bacteria in the water. The presence of such bacteria is an indicator of the possible presence of pathogens from human or other mammalian fecal material entering the bay, usually from nonpoint terrestrial sources.

Oysters can be commercially harvested from restricted areas, but such harvesting is limited to those who hold privately leased, approved areas and can transport the oysters to these depurate areas prior to sale. The size of restricted areas decreased through the 1990s, opening more beds to all oystermen. This may account for part of the increase in landings over the same period. Another contributing factor is that the TPWD has limited the number of commercial licenses for shrimp and crabs since the mid-1990s, but not for oysters. Also, the recent low prices of shrimp have caused some fishers to target oysters rather than shrimp.

The presence of fecal coliform indicates that fecal waste has entered the estuary from human and other terrestrial sources. Fecal coliform can contaminate oysters and cause disease in humans who consume them. A naturally occurring marine bacterium, *Vibrio parahaemolyticus*, can also be transmitted in raw oysters and cause very serious human disease and sometimes death. Periodic outbreaks of *Vibrio parahaemolyticus* require temporary total closures of oyster harvesting in the bay.

Blue Crabs

Blue crabs became an important fishery in Galveston Bay after 1960, partly because of the increasing commercial value of this species. Currently, more blue crabs are harvested out of Galveston Bay than out of any other Texas estuary (GBEP, 2002). The commercial harvest between 1990 and 2001 averaged 771 mt per year (Figure 9-6). An analysis of the landings data did not indicate any trends in landings data.

An analysis of fishery-independent blue crab trawl data (Figure 9-7) by TPWD, however, did reveal a negative trend in the number of adult crabs captured using a shrimp trawl between 1982 and 2000 (GBEP, 2002). Because the blue crab uses a variety of habitats in the bay during its fairly complex life cycle, a number of natural processes and human alterations could affect the population. Recruitment, however, does not appear to be a problem, because fishery-independent nearshore bag seine capture rates of juveniles appear fairly constant during the last 20 years. Although there is some evidence of contaminant stress in blue crabs inhabiting portions of the Houston Ship Channel (Engle and Thayer, 1998), fishing pressure may be a more likely explanation for the decline in the larger crabs sampled using the shrimp trawl. In 1997, to stem what appears to be overfishing, the TPWD imposed trap limits on the commercial crab industry, set size limits for blue crab males, prohibited the harvesting of egg-bearing females, and began a voluntary program to buy back licenses (Robinson, 2003).

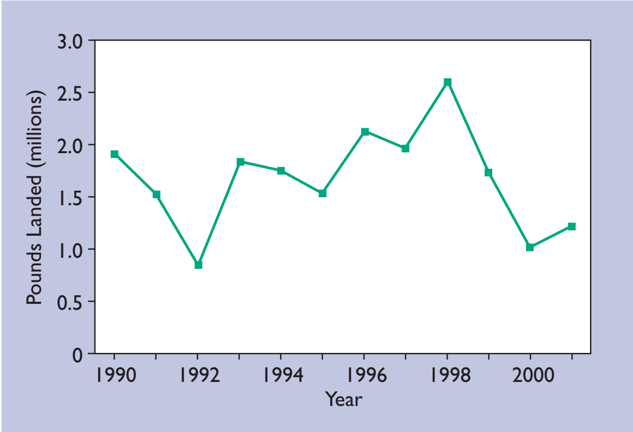


Figure 9-6. Commercial landings of blue crabs in Galveston Bay, 1990–2001. Developed by NOAA for NCCR II. Data provided by Texas Parks and Wildlife Department (TPWD, 2003).

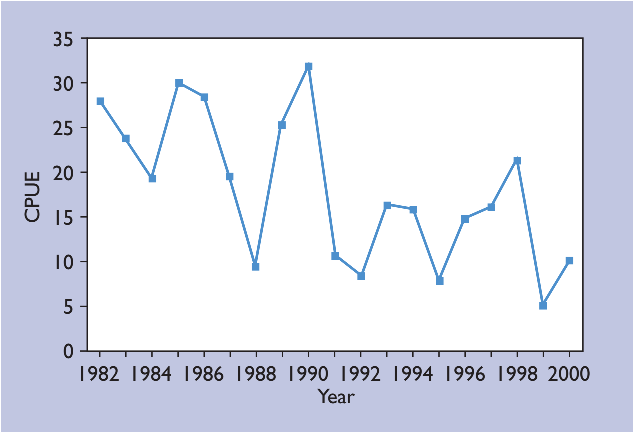


Figure 9-7. Blue crab trawl data, 1982–2000 (GBEP, 2002).

Finfish Landings

In the late nineteenth century, the commercial harvest of seafood from Galveston Bay was evenly divided between finfish and oysters (GBNEP, 1994b). Currently, the finfish commercial harvest accounts for less than 5% of the total commercial seafood harvest from Galveston Bay. The average annual commercial harvest of finfish between 1990 and 2001 was 87 mt. The ex-vessel value of finfish in Galveston Bay averaged approximately $150,000 annually (GBEP, 2002).

A variety of finfish are harvested commercially in Galveston Bay, including black drum, southern flounder, sheepshead, and mullet (Figure 9-8). These four species make up more than 60% of the commercial finfish harvest. Some of these same species are also caught by recreational fishers. Although there is variability in the harvest from year to year, there was no decline in any of the species harvested between 1990 and 2001. There are decreases, however, when data are viewed for the longer period of 1980 to 2001, but these decreases are largely the result of high harvests made in the early 1980s before gill netting was banned.

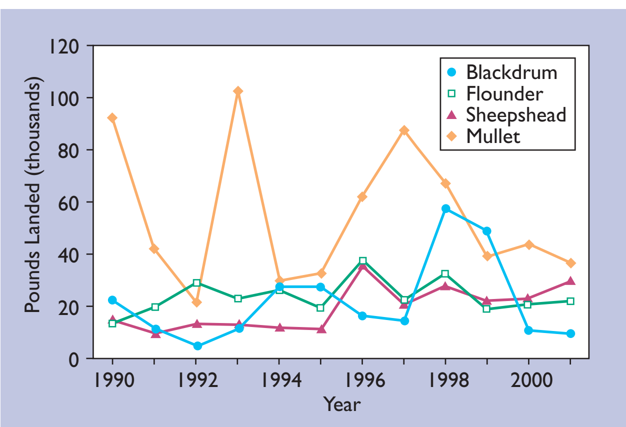


Figure 9-8. Commercial landings of selected fish species in Galveston Bay, 1990–2001. Developed by NOAA for NCCR II. Data provided by Texas Parks and Wildlife Department (TPWD, 2003).

Recreational Fisheries

The recreational harvest of fish is an important part of the economy in Galveston Bay. Approximately 50% of all recreational fishing expenditures in Texas occur in Galveston Bay (GBEP, 2002). In the five counties that surround the bay, more than 260,000 recreational fishing licenses were sold in 1998 and 1999 (GBEP, 2002). In addition to compiling information on the commercial fisheries, the TPWD also collects data on the recreational harvest of finfish. The top five recreational species in terms of the number of fish caught is provided in Figure 9-9. Between 1990 and 2001, sand seatrout, spotted seatrout, and Atlantic croaker had the highest landings, based on the TPWD survey. Of the five species shown in Figure 9-9, only one—the southern flounder—had a negative trend in recreational landings. It is not clear why this occurred. Fishery-independent bag seines of southern flounder by TPWD have shown a nearly stable, slightly increasing trend in CPUE. Overall, the recreational harvest of these species seems to be meeting the needs of recreational fishers in Galveston Bay.

In summary, both the commercial and recreational fisheries in Galveston Bay appear to be meeting human use needs. In the fishery-independent data, there is some evidence of a decreasing blue crab population, but the decrease may be related more to overfishing than to environmental quality.

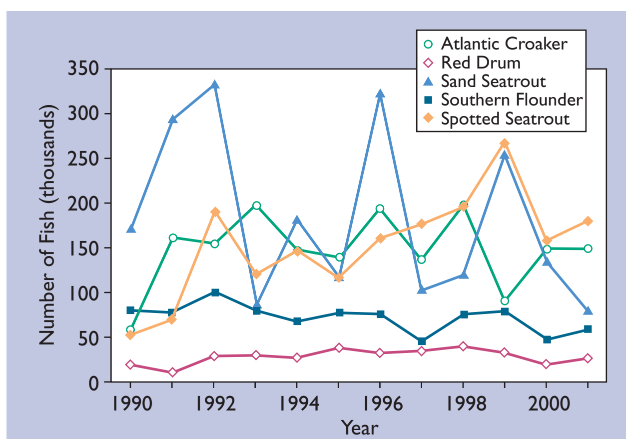


Figure 9-9. Recreational (private boat) landings of selected fish species in Galveston Bay, 1990–2001. Developed by NOAA for NCCR II. Data provided by Texas Parks and Wildlife Department (TPWD, 2003).

Can the Fish Be Eaten?

There would be little point to commercial fishing if the product could not be safely consumed. Recreational fishing, however, has all sorts of benefits in addition to eating the catch. Nonetheless, it is important to determine whether the fish can be eaten safely. The Texas Department of Health (TDH) has declared that "all species of fish and crabs from areas of Galveston Bay south of a line from Red Bluff Point to Five Mile Cut Marker to Houston Point can be eaten without restrictions" (TDH, 2001). However, the TDH declared an advisory area for 50 square miles north of this line (at the point where the channel opens to the wide portion of the bay and back toward the city of Houston), for parts of Buffalo Bayou, for the Houston Ship Channel, and for the lower San Jacinto River. These areas represent about 8% of Galveston Bay.

Since 1990, the TDH has advised that crabs and catfish taken within this advisory area not be eaten by children, women who are pregnant, nursing mothers, or women who may become pregnant, and only be eaten in one 8-ounce portion per month by all others, because of elevated levels of dioxin. Elevated levels of chlorinated pesticides, PCBs, and dioxins caused the TDH to recommend the same consumptive restrictions for all fish species, in addition to crabs and catfish, taken in a small subsection of this area in 2001. The area included the 15 square miles within the upper Houston Ship Channel that extend from the San Jacinto River to Houston.

Human Uses and National Coastal Condition Report Environmental Indicators

With the exception of fish contamination in a small area, reduced benthic conditions at 8 of 10 NCA locations, and restrictions on oyster harvesting over wider areas, Galveston Bay is meeting the demands imposed on it by human uses. Moreover, in terms of the coastal condition indicators used in this report, it is meeting human use needs and maintaining a fair ecological condition. The chlorophyll *a* and total nitrogen indices at the 10 NCA sites were all rated as good or fair. Dissolved oxygen in bottom water is good at eight sites and fair in the other two sites. Phosphorus concentrations, however, were poor at seven sites and only fair at three. None of the sediment samples at any site, except the Houston Ship Channel site, showed sufficient chemical contamination to classify sediment as anything other than good. The NOAA Bioeffect Surveys (summarized in Chapter 2, National Coastal Condition) showed the same results at its 75 sites. There was no toxicity, as measured by 10-day amphipod survival (although 80% of the sites are listed as missing sediment toxicity data), and no cases where sediment guidelines were exceeded, except one site in the Houston Ship Channel. Benthic community conditions, however, were poor at two sites and fair at six sites.

The Galveston Bay estuary system is maintaining a fair ecological condition, despite the many demands from human uses. However, continued surveillance to detect any early warning signs of ecological degradation from the current conditions would be prudent.

Appendix A | Quality Assurance

Background

The National Coastal Assessment (NCA) Program monitors and assesses the quality of the data that is collected through the activities of the NCA Quality Assurance Program. The NCA QA Program is conducted under the guidance of the National Health and Environmental Effects Research Laboratory (NHEERL) Director of Quality Assurance. The NCA QA team consists of:

- National Quality Assurance Coordinator – Assures a QA program is in place and being followed, as well as documentation of the known quality of the data sets developed by the national contract laboratories;
- Four regional QA coordinators – Assure that the QA program is being followed and develop the documentation supporting the known quality of the data collected in NCA; and,
- Twenty-four state QA coordinators – Responsible for reviewing and qualifying all data sets sent to the program from their respective states.

A detailed Quality Assurance Project Plan (QAPP) was developed by NCA (U.S. EPA, 2001b) and provided to all participants in the program. Compliance with the QAPP is assessed through extensive field training exercises, site visits, reviews, and audits. The QAPP addresses multiple levels of the program. These range from the collection of field samples and laboratory processing of these samples, to the review of data sets compiled from the field and laboratory activities. The NCA QA team is responsible for performing assessments of the adequacy of these activities.

1999/2000 Survey

The NCA convened a diverse panel of environmental scientists to help formulate a list of core indicators to help ensure that the NCA collected the appropriate types of data to support its mission. In order to ensure that the data collected were of appropriate quality to generate sound estimates on environmental condition, the NCA utilized the U.S. Environmental Protection Agency's (EPA's) concept of data quality objectives (DQOs) to set the overall level of data quality required by management to make informed decisions. In other words, how much error can be tolerated within the measurement process before the data are deemed unacceptable?

The NCA Program developed an *a priori*, program-level DQO for status estimates: "For each indicator of condition, estimate the portion of the resource in degraded condition within ±10% for the overall system and ±10% for subregions, with 90% confidence based on a completed sampling regime." This requirement was met by all of the indicators used for the 1999 to 2000 estimates, with the exception of Puerto Rico. The NCA design never intended to treat Puerto Rico's samples as a sole measure of the condition of the Caribbean and Pacific island commonwealths. Once other commonwealth islands are included in the NCA surveys, the uncertainty associated with condition estimates will be reduced significantly. The level of uncertainty (error) associated with the individual indicators for each region and the national estimates (Table A-1) ranges from 1% to 16% (including Puerto Rico) and 1-9% (excluding Puerto Rico). The uncertainty associated with areal estimates of ecological condition in the Great Lakes cannot be determined.

Table A-1. Levels of Uncertainty Associated with the Estimate of Proportional Area Exceeding the Indicator Criteria (U.S. EPA/NCA)

Indicator	NE	SE	Gulf	West	Great Lakes	Puerto Rico	United States
Water Quality Index	5%	4%	8%	4%	NA	15%	5%
Water Clarity	5%	5%	9%	3%	NA	15%	4%
Nitrogen	5%	<1%	5%	3%	NA	14%	3%
Phosphorus	6%	5%	8%	3%	NA	8%	4%
Chlorophyll *a*	5%	4%	9%	4%	NA	14%	5%
Dissolved Oxygen	3%	4%	4%	4%	NA	8%	3%
Sediment Quality Index	5%	3%	4%	4%	NA	15%	4%
Sediment Contaminants	4%	1%	8%	5%	NA	10%	3%
Sediment Toxicity	4%	6%	7%	4%	NA	10%	2%
Sediment TOC	2%	6%	8%	4%	NA	16%	5%
Wetland Loss	<.1%	<.1%	<.1%	<.1%	NA	NA	<.1%
Benthic Index/Equivalent	5%	5%	9%	4%	NA	15%	5%
Fish Contaminant Index	6%	5%	5%	5%	NA	NA	4%
Aquatic Life Use Impairment	2%	3%	3%	3%	NA	8%	2%
Human Use Impairment	4%	5%	5%	5%	NA	NA	4%
Unimpaired	2%	3%	3%	4%	NA	9%	2%

Data from the NCA 1999/2000 survey were evaluated and appropriately qualified based on the projects Measurement Quality Objectives (MQOs). MQOs establish the quality goals for the individual measurements taken by the program that are used in the generation of condition indicators utilized by NCA. Approximately 90% of the data collected, processed, and generated for this report fully met the MQO requirements stated in the NCA QAPP. Nine percent of the data partially met the requirements; therefore, it was qualified and only conditionally used. Only 1% of the data failed to meet the requirements and were not used. The conditional use of the data was only allowed after it was determined that the data would not significantly bias the results.

Field Collections

NCA conducted a 4- to 5-day training workshop for all states participating in the program (Table A-2). The workshop included training on the application of the probability-based design to state monitoring activities and standardized methods required for sample collection. State field crews were evaluated on their ability to apply the protocols and received certification after the training based on a field trial. A sample matrix of the state training activities is shown in Table A-3.

Upon initiation of field activities, the field crews from Mississippi, Maine, Delaware, New York, New Jersey, and Rhode Island were audited and found to be compliant with the QAPP. The field crews from Washington and Oregon were observed by a representative from EPA Region 10, and the observations were documented. These observations were evaluated by the NCA QA Coordinator with no findings.

Table A-2. Number of Individuals Trained by NCA in 1999/2000 for Each of the Participating States

Region	State or Agency	Number Trained
West Coast	CA	4
	OR	5
	WA	5
	NOAA/NMFS	6
Gulf of Mexico	TX	13
	LA	10
	MS	2
	AL	5
	FL	7
Southeast	GA	2
Northeast	MA	10
	ME	10
	DE	10
	NH	10
	NY	10
	NJ	10
	CT	10
	RI	10

Table A-3. Matrix of Training Activities for the Northeast Region of NCA in 2000.

Subject	ME	NH	MA	RI	CT	NY	NJ	DE
Intro to C2000	yes	yes	yes	yes	yes	yes	yes	yes
List of Indicators	yes	yes	yes	yes	yes	yes	yes	yes
Station and Sample IDs, Bar Codes	yes	yes	yes	yes	yes	yes	yes	yes
Locating Stations	yes	yes	yes	yes	yes	yes	yes	yes
Station Datasheet	yes	yes	yes	yes	yes, but may not use it	yes	yes	yes
CTD Profile	Include instrumentation	yes	General only	yes	General only	yes	General only	General only
PAR Profile	Include instrumentation	yes	yes	yes	yes	yes	yes	yes
Secchi Depth	yes	yes	yes	yes	yes	yes	yes	yes
Nutrients	Full detail	Full detail	General only	Full detail	General only	Mixed	Full detail	Full detail
Benthic Infauna	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail
Sediment Chemistry	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail
Sediment Toxicity	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail
Trawl Operations	Full detail	Full detail	Full detail	Full detail	General only	Full detail	General only	Full detail
Fish Community	Full detail	Full detail	Full detail	Full detail	General only	Full detail	General only	Full detail
Fish Pathology	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail
Fish Chemistry	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail
Shipping	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail
Computer System	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail	Full detail

Laboratory Analyses

Prior to the analyses of any samples in 1999, the analytical laboratories from Washington, Oregon, and California had to perform a demonstration of capability. Each laboratory was sent a set of Standard Reference Materials (SRMs) as unknown samples for analysis. These samples represented both organic and inorganic compounds in sediment and tissue matrices (Table A-4), which were representative of the type of samples NCA would be providing them. The results from these analyses were evaluated in order to determine whether the lab was capable of correctly identifying and quantifying the analytes of interest within the QA requirements outlined in the NCA QAPP. In lieu of analyzing the SRMs, each lab could submit its results from the National Institute of Standards and Technology (NIST) annual inter-laboratory comparison (ILC), a program examining performance-based quality assurance among multiple laboratories using NIST-generated sediment and tissue contaminant samples of known concentrations. These samples are analyzed by participating laboratories using a variety of methods, and the results are compared to the known concentrations.

Table A-4. Standard Reference Materials sent to Washington, Oregon, and California State Laboratories for a Demonstration of Capability.

SRM	Matrix	Class of Compounds
CRM 2976	Mussel Tissue	Inorganics
CARP-1	Fish Tissue	Organics
MESS-2	Marine Sediment	Inorganics
SRM 1944	NY/NJ Waterway Sediment	Organics

California

Two separate laboratories performed the chemical analyses of samples for the state of California. The laboratory performing the organic analyses submitted the required SRMs for evaluation, while the laboratory performing the inorganic analyses submitted their NIST ILC results. The inorganics laboratory satisfactorily demonstrated technical capability for metals analyses by submitting their results for the current NOAA/NIST interlaboratory calibration exercise. In fact, the NOAA/NIST exercise included samples identical to those distributed by NCA. For both matrices, the laboratory generally exceeded NCA's quality criteria for accuracy, ± 20% agreement to the accepted true concentration (only applies to those analytes with accepted true values greater than 10 times laboratory's method detection limit [MDL]). The laboratory also demonstrated a high degree of precision for the three replicate analyses conducted with each sample. The organics laboratory satisfactorily demonstrated technical capability for pesticide, PAH, and PCB analyses with the successful analysis of the CARP-1 and SRM-1944. The percent recoveries and reported MDLs for the required analytes met or exceeded the NCA quality criteria.

Washington

The laboratory performing the analyses for the state of Washington submitted results from the analysis of the SRMs for inorganics and results from the NIST ILC for organics. The laboratory's results for analyzing SRM Marine Sediment VIII (QA98SED8) were indicative of the laboratory's capability to produce high-quality analytical data for organic contaminants in sediments and met with NCA's general expectation for technical competency.

The laboratory's results for the inorganic SRMs, CRM-2976 and MESS-2, demonstrated that the laboratory had the capability to successfully analyze sediment and tissue samples for metals. Results and MDLs provided were within the general criteria for technical competence required by NCA.

Oregon

The laboratory performing the sample analyses for the state of Oregon submitted their results from analysis of the SRMs for evaluation of capability for both organic and inorganic analyses. The results submitted by the laboratory for the sediments appear marginal when gauged against NCA's established acceptability criteria. For analytes with true/accepted (e.g., SRM) concentrations greater than 10 times the laboratory's reported MDL, the laboratory's submitted values should be within ± 35% of the accepted value (including the confidence limits) for at least 70% of the analytes within a class of compound (e.g., PCBs). It is not uncommon for a laboratory to encounter difficulty in meeting these strict standards. Because continued improvement was anticipated, the laboratory was conditionally approved to initiate the analyses of sediment samples, with the understanding that all results for field samples will be critically reviewed regarding NCA quality standards. If these standards were not met, the data were flagged or even dropped altogether from the regional and national databases.

The results from the analyses of the SRMs, CRM-2976, and MESS-2 generally met with the NCA quality standard for relative accuracy, agreement within + 20 percent of the accepted true value for each analyte.

Other Coastal States

In 2000, 19 additional coastal states became partners in the NCA. Many of the states did not wish to or were not capable of analyzing the samples that were being collected. In order to meet the need for a centralized laboratory processing facility, NCA established national contracts in which commercial laboratories were contracted to perform the required analyses. The management of the contracts, coordination of the shipment of samples, and distribution of resulting data were performed by EPA. The states of New York, South Carolina, Florida, and Texas chose to perform their own analyses and did not utilize the national contract. South Carolina and Florida provided their own QAPPs for review by the NCA QA staff, and New York and Texas agreed to follow the requirements of the NCA QAPP. After review, the QAPPs submitted by South Carolina and Florida were accepted, and each laboratory was conditionally approved to begin analyses. As a condition of each of these four states' cooperative agreements, each state laboratory was audited during the time period 2003–2004.

National Contract Laboratories – NCA

As part of the contract awards evaluation process, each of the respondents were required to submit a QAPP for review with their proposal package. In their QAPP, respondents had to either agree to adhere to the requirements of the NCA QAPP or to provide a plan with requirements that were equal to or greater than those described in the NCA QAPP.

Chemistry

The laboratory selected to perform the chemical analyses for the national contract agreed to adhere to the NCA QAPP. The NCA national laboratory for 2000/2001 underwent a technical systems review in January of 2001. The laboratory was commended for the efforts it was expending to ensure the overall data quality. There were exemplary findings for sample tracking, quality control (QC) checklists, Standard Operative Procedures (SOPs), electronic data assembly, and laboratory personnel. Some concern was noted by the reviewers for validation of storage temperatures, documentation for comparisons of surrogate recoveries, and lack of access to raw inorganics data. Overall, the data received from this laboratory met or exceeded the requirements of the NCA QAPP.

Toxicity

The laboratory selected for the NCA national contract to perform the acute toxicity testing of sediments collected by NCA using *Ampelisca abdita* agreed to adhere to the requirements of the NCA QAPP. A site visit of the national contract toxicity laboratory was conducted during December 2000. The facility and personnel were determined to be technically competent. The contractor had significant previous experience with the performance of the required toxicity tests through its contracting with EPA's Environmental Monitoring and Assessment Program (EMAP) in 1991–1994. The contractor also underwent a data quality audit during November 2001. The audit team was highly satisfied with the laboratory's overall technical capability to conduct the sediment toxicity tests on a high-volume basis. The files were complete, orderly, and with minor exception, in compliance with the NCA QAPP. The exceptions noted were: (1) some data entries were made in pencil, and (2) the laboratory personnel were not initialing receipt of the samples on the log-in form.

Benthic Fauna

The laboratory selected to perform the identification and enumeration of the benthic organisms collected by NCA agreed to adhere to the requirements of the NCA QAPP. The laboratory's basic protocols met or exceeded those required by NCA, including resorting of benthic samples, documentation on 10% of each technicians' samples (95% efficiency required), and taxonomic identifications being verified by a second taxonomist, with an outside expert consulted for difficult identifications. The staff assigned to the project were determined to be technically competent and capable of performing the work.

Nutrients

All water samples collected for determination of dissolved nutrients were analyzed at EPA/ORD/NHEERL's Gulf Ecology Division. The analyses were performed with strict adherence to the NCA QAPP. All analytical batches reported for inclusion in the NCA database met or exceeded the requirements in the NCA QAPP. A six-point calibration curve with an $r^2 > 0.95$, internal check calibrant and external quality control samples were within the acceptable range of certification, and sample matrices were matched.

Five states in the Northeast have chosen to perform their own nutrient analyses. In 2001, the NCA Northeast Quality Assurance Coordinator established an inter-laboratory comparison study for nutrient analysis utilizing samples provided by the National Research Council (NRC)-Canada. Each laboratory was provided an unknown sample for analysis of inorganic nutrients. Laboratories were assessed by how close their results were to the NRC-Canada consensus values. For orthophosphate, one of the five laboratories agreed with the consensus values, three laboratories provided values close to the consensus value, while one laboratory's results were not acceptable. For nitrite, one laboratory did not submit a result, three laboratories provided values close to the consensus value, while one laboratory's results were not acceptable. For nitrate/nitrite, one laboratory did not submit a result, three laboratories provided values in line with the consensus values, and one laboratory provided values that were outside the acceptable range. All laboratories were encouraged to continue participation in the NRC-Canada intercomparison for nutrients as part of their NCA QA programs.

Data Review

All data received from the laboratories and field crews participating in the NCA Program for 1999/2000 were reviewed prior to and during the data analysis phase. The NCA QA team in the Northeast developed a three-level QA review of data collected in their region (Appendix B). All of the data collected in the Northeast for 2000 were reviewed according to this procedure.

NCA West Coast data collected in 1999 underwent an initial review for range checking, completeness, and consistency prior to placement into the database. Final review of the data was performed by the states and then discussed at a 2-day meeting between each state's NCA participants and the NCA-West QA staff. The final version of the data set was then made available to the data analysts.

Southeastern and Gulf of Mexico data for 2000 was reviewed for range checking, completeness, and consistency by the NCA QA staffs for these regions of the country. The data sets were checked for outliers and known relationships were tested. When these evaluations were completed, the data was supplied to the data analysts.

Analytical results from the national contract laboratories were reviewed as they were received. Each report was checked to ensure that the appropriate QC had been performed and that it met the requirements of the QAPP. When the data report was too voluminous to review by hand, the NCA data manager summarized the QA data and checked it in accordance with the NCA QAPP.

Appendix B | Three-Level QA Review of Coastal 2000 Northeast Database

This appendix describes the QA review process performed on Coastal 2000 data in the Northeast Region, coordinated by the Atlantic Ecology Division (AED) (U.S. EPA, 2000d). Each state or Cooperative Agreement recipient measures a suite of field data and collects water, sediment, and fish samples for laboratory analysis. The states may elect to forward the samples to a national contract laboratory or conduct the analytical analyses themselves. The results of the field and laboratory analyses are sent to AED for incorporation into a regional database. These data are subjected by AED to the three levels of QA review described below.

The states or contract laboratories provide the data in electronic form to the project officer at EPA AED. A regional database manager at the AED combines all of the states' data into a "d1-database," organized into separate data files by similarity and by states. For example, all nutrient-related data are entered into the NUTRNTS file. In turn, each data file contains several parameters; for example, the NUTRNTS file includes the nutrient parameters (e.g., nitrate. ammonium, phosphate).

The d1-database contains many parameters that are administrative in nature or descriptive of the sampling event, for example, the identity of the sampling vessel and crew and the weather conditions at the time of sampling. The AED database manager constructs a summary database, or "d2-database," consisting of parameters that have been identified to be the most useful to data users.

Level I QA Review

A Level 1 review examines the d1-database for completeness, format compatibility, and internal consistency. The checks listed below are simple and can be performed without detailed knowledge of the nature of the parameters. A Level I review is complete when all data gaps are filled or explained and obvious errors have been corrected. Records are kept of any changes made to the database. The steps for the Level I review are as follows:

(1) A completeness check is performed on all data submitted by states and laboratories. This check involves comparing the number of data entries in each file to the number of stations sampled. The database manager notes and investigates any missing data.

(2) A range check of each parameter is performed to highlight records falling outside an expected range. The database manager notes outliers and corrects any obvious errors, such as data submitted with incorrect units. Persistent outliers are highlighted for a Level 2 review.

(3) Simple consistency checks are performed by comparing independent records of closely related parameters. For instance, records of latitudes and longitudes are compared with planned locations, and water depths measured by independent methods are compared.

The AED database manager submits any questions/corrections that have been identified with suggested database changes to the Project Officer. The Project Officer transmits these questions/corrections to the Cooperative Agreement Program Manager, who resolves the concerns, concurs/non-concurs with the suggested changes, and submits a revised data file(s) if necessary. Once the Cooperative Agreement recipient concurs with the changes to the database, the Level 1 review is complete. The data files passing Level 1 QA review are made available on the password-protected Coastal 2000 Northeast Web site.

Level 2 QA Review

A Level 2 review is performed on the summary database (d2-database) parameters. The review highlights values that are unusual enough to raise the suspicions of a data user. Anomalous data include values that are especially large or small, or are noteworthy in other ways. Focus is on rare, extreme values because outliers usually merit most attention by users and may affect statistical quantities, such as averages and standard deviations.

(1) Extreme values are flagged by highlighting any record deviating from the average by more than three standard deviations.

(2) Extreme values are also highlighted visually by plotting parameter values vs station ID. The benefit of such a plot is that the outliers can be compared with nearby stations or with associated parameters. For example, if several stations in an estuary are exceptionally high or low, we would suspect that the data may be reliable. Similarly, if several closely associated parameters are extreme at a station (e.g., consistently high nutrients, or consistently high organic compounds), we would suspect that the records may be valid.

(3) Correlations among the parameters are examined. An array of miniature x-y plots is generated, one plot for each combination of associated parameters (e.g., a standard application of SAS Insight). For instance, a matrix of five water quality parameters would generate a 5x5 array of plots systematically varying in variables for the x- and y-axes. Typical plots show a regular relationship between the plotted parameters. Anomalous data are readily evident on these plots. Examination of closely related parameters may resolve questions regarding the accuracy of anomalous data.

Documentation of suspicious data identified is prepared, with invalid data flagged. This documentation becomes part of the metadata. Level 2 data are made available on the same Web site as the Level 1 data.

Level 3 QA Review

A Level 3 review is conducted to evaluate whether data submitted by the states or laboratories are comparable across areas, recognizing that the magnitudes of the values may indeed be different in the various geographic areas.

(1) A regional map is prepared for each measured parameter. Discrete map symbols denote station location and the magnitude of the parameter (e.g., low, moderate, or high). The maps are examined for noteworthy patterns that may be attributed to database errors.

(2) A bar chart is prepared for each measured parameter. The chart shows the percent area of each state's waters designated by a condition category (e.g., low, moderate, or high). The charts are also examined for anomalous patterns that may indicate database irregularities.

(3) A distribution graph is prepared for each parameter, grouping data by estuarine system to compare the range and distribution of measured values across the states.

(4) A table is prepared for each parameter summarizing the descriptive statistics of parameters by state. Although the magnitude of a parameter may vary by state, it is expected that the coefficient of variation should be roughly equivalent across the states.

A summary report is prepared, utilizing the maps, charts, and tables developed in the Level 3 review. This report is made available on the same Web site that the Level 1 and Level 2 data are available on.

Records are maintained of all data files examined and entries considered anomalous. The Project Officer reports the anomalies to the Cooperative Agreement recipient or contract laboratory data managers, who correct and resubmit the data. All changes to the original database are documented.

Appendix C | Normalizing National Coastal Condition Reports I and II

The National Coastal Condition Report (NCCR I) was completed in 2000 (U.S. EPA, 2001) and covered the period from 1990 to 1996. The NCCR I included seven indicators calculated using probabilistic sampling survey data (e.g., EMAP) and non-probabilistic information. Probabilistic sampling data were available for half of the estuarine resources of the Northeast Coast and all of the estuarine resources of the Southeast Coast and Gulf Coast regions. Non-probabilistic information was used from selected West Coast estuaries and the Great Lakes. The indicators (eutrophication potential, water clarity, dissolved oxygen, wetland loss, sediment contaminants, benthic index, and fish contaminants) covered the major stressors (water quality, sediment quality) and biological responses (benthos and fish) for coastal ecosystems. However, only five of these indicators (water clarity, dissolved oxygen, sediment contaminants, benthic index, and fish contaminants) were based on consistent and comprehensive data covering most U.S. estuarine area. Eutrophication potential was based on a combination of expert opinion and long-term data (Bricker et al., 1999). The wetland loss information came from the National Wetlands Inventory (NWI, 1995) and reflected loss rates for twenty decades (1780 to 1980). Although this report included information for all U.S. estuarine systems, the combination of qualitative and quantitative information made the overall indicator scores for the region and nation more uncertain than the survey data.

The NCCR I was relatively well received, but a number of criticisms were made regarding (1) its use of simple nationwide reference conditions (e.g., water clarity); (2) its use of the 200-year loss period for wetlands, when much of the loss occurred prior to 1990; (3) its use of expert opinion for some of its eutrophication information; (4) its use of three indicators representing water quality out of the total of seven indicators used to assess condition; (5) the lack of information for the upper Northeast Coast (Massachusetts through Maine) and the West Coast; and (6) the use of a simple mean of the seven indicators to characterize overall estuarine condition.

This National Coastal Condition Report (NCCR II) uses probabilistic survey data from 1996 to 2000. It attempts to address many of the criticisms about the first NCCR I, but also creates problems for comparisons between the two reports. NCCR II uses indicators representing the same stressors and responses; however, these indicators are constructed differently. NCCR II only uses five indicators (water quality index, sediment quality index, coastal habitat index, benthic index, and fish tissue contaminants index). The additional indicators, water clarity and dissolved oxygen, were still reported, but rather than contributing directly to the overall rating score reported in NCCR II, they contribute to the water quality index. The primary changes made in the NCCR II to address the earlier criticisms are as follows:

- Probabilistic surveys have been conducted in all estuarine waters of the conterminous 48 states. This means that comprehensive, consistent, probabilistic survey data were available for the waters of Massachusetts through Maine and for West Coast estuaries. These data were not available for the first report. Available non-probabilistic data continue to be used to characterize Great Lakes condition.
- Reference conditions for water clarity are regionalized to reflect expected (natural background) conditions rather than using a standard nationwide reference condition of 10% surface light penetration to a depth of 1 meter. This means that in NCCR II, areas of naturally low water clarity are not automatically characterized as poor.

- Wetland losses are characterized by a combination of long-term losses (1780–1990) and losses for the most recent decade (1990–2000). This means the criteria for poor condition for NCCR II decreased by a factor of 40.
- The water quality indicator is based on an index constructed from survey data on nutrients (nitrogen and phosphorus), water clarity, chlorophyll *a*, and dissolved oxygen. These five subindicators are combined into a single measure of water quality. Nitrogen, phosphorus, water clarity, and chlorophyll *a* use regionalized reference conditions that are adjusted to reflect the summertime sampling period. Dissolved oxygen continues to use a nationwide reference condition. This means that the water quality indicator in NCCR II is based on consistent and comprehensive information collected from 1996 to 2000, instead of more long-term data and expert opinion used in the NCCR I.
- Only one measure of water quality (water quality index) is used to characterize overall condition. This means that water quality only contributes 20% to overall condition in NCCR II. In the previous report, water quality indicators contributed more than 40% to the overall rating.
- Sediment quality is based on a combination of sediment contaminants, sediment toxicity, and sediment TOC. In the NCCR I, only sediment contaminants were used. Poor condition in sediment contaminants in NCCR II is based on exceedance of ERM guidelines, whereas in NCCR I, it is based on exceedance of ERM or more than 5 ERL guidelines.
- Fish tissue contaminants are characterized by whole-body concentrations and are compared to EPA risk-based consumption guidelines in the NCCR II. In the NCCR I, fish contaminants were based on fillet concentrations and compared to FDA criteria.

As a result of these changes, the NCCR I and the NCCR II are not directly comparable. In order to facilitate comparisons between the two reports, the results of NCCR I have been re-evaluated using the analysis approaches used in NCCR II. The results (as reported) in the two reports are listed in Tables C-1 and C-2.

In order to compare the two sets of results, the scores from the NCCR I were altered in the following ways:

- Water clarity, dissolved oxygen, and eutrophication were combined into a single water quality index. If any of the three components is poor, the water quality index is rated as poor. Using this method, water quality was poor in all regions for NCCR I except the Southeast Coast, and no measure is available for the Great Lakes. Recalculating this index did not change the regional or national rating for water quality condition.
- Sediment contaminants were recalculated using only ERM values to determine poor condition and combined with sediment toxicity to create a sediment quality index. This method improved the sediment quality index for all regions except the Northeast Coast and Great Lakes in the NCCR I.
- Fish contaminants were recalculated based on the EPA risk-based guidelines for consumption rather than the FDA limits.
- Overall condition was calculated based on five indicators rather than seven.

Table C-1. Comparison of Percent Area of Poor Condition[a] by Indicator and Region for 2001 vs. 2004 National Coastal Condition Reports (v1 = NCCR I and v2 = NCCR II).

Indicator	Northeast Coast		Southeast Coast		Gulf Coast		West Coast		Great Lakes		Puerto Rico		United States	
	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2
Water Quality Index[b]	60	19	13	5	38	9	20	3	–	–	–	9	40	11
Water Clarity[c]	6	23	12	10	22	23	1	36	–	–	–	20	4	23
Dissolved Oxygen[d]	5	10	2	2	4	1	0	1	–	–	–	1	4	4
Sediment Quality Index[e]	41	16	13	8	43	12	–	14	–	–	–	61	35	13
Coastal Habitat Index[f]	39	1.00	40	1.06	50	1.30	68	1.90	51	–	–	–	48	1.26
Benthic Index	23	22	17	11	23	17	–	13	–	–	–	35	21	17
Fish Tissue Contaminants Index[g]	30	31	9	5	20	14	–	27	–	–	–	–	26	22
Overall Condition[h]	43	40[i]	46	23	49	40	–	23	–	–	–	77	44	35

[a] Percent area of poor condition is the percentage of total estuarine surface area in the region or the nation (proportional area information is not available for Great Lakes in 2001 or 2004; it is available for selected estuaries in the West Coast in 2001; and in Puerto Rico, it is available only for the 2004 report).

[b] Water quality index is a combination of dissolved oxygen, chlorophyll, nitrogen, phosphorus, and water clarity in 2004 and the NOAA estimate of high potential for eutrophication in 2001.

[c] Water clarity is used as primary indicator with a national reference value in 2001 and is used as a component of eutrophication with regional reference values in 2004.

[d] Dissolved oxygen is used as a primary indicator with a national reference value in 2001 and is used as a component of eutrophication with a national reference value in 2004.

[e] Sediment quality index is a combination of sediment quality measurements (sediment contaminant concentrations, sediment toxicity, and sediment TOC).

[f] Wetland loss in the NCCR I was based on the percentage lost from 1780 to 1980. In the NCCR II, the coastal habitat index is based on the average mean long-term, decadal wetland loss rate (1780–1990) and the present decade's (1990–2000) wetland loss rate.

[g] Fish tissue contaminants are based on analyses of whole fish (not fillets).

[h] Overall percentage is based on the overlap of the five indicators and includes estuarine area for all 48 conterminous states (by region and total) and Puerto Rico.

[i] In Northeast Coast estuaries, at least one of the five indicators is rated poor at sites representing 40% of total estuarine area.

Table C-2. Rating Scores[a] by Indicator and Region Comparing 2001 (as published) vs. 2004 National Coastal Condition Reports (v1 = NCCR I and v2 = NCCR II).

Indicator	Northeast Coast		Southeast Coast		Gulf Coast		West Coast		Great Lakes		Puerto Rico		United States[b]	
	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2	v1	v2
Water Quality Index	1	2	4	4	1	3	1	5	–[c]	3	–	3	1.7	3.2
Water Clarity	5	NI[d]	4	NI	3	NI	5	NI	5	NI	–	NI	4.3	NI
Dissolved Oxygen	4	NI	5	NI	5	NI	5	NI	4	NI	–	NI	4.5	NI
Sediment Quality Index	41	16	13	8	43	12	–	14	–	–	–	61	35	13
Coastal Habitat Index[f]	2	4	2	3	1	1	1	1	1	2	–	–[e]	1.4	1.7
Benthic Index	1	1	2	3	1	2	3	3	1	2	–	1	1.4	2.0
Fish Tissue Contaminants Index	1	1	5	5	1	3	3	1	1	3	–	–	1.9	2.7
Overall Condition	2.1	1.8	3.6	3.8	1.9	2.4	2.7	2.4	2.2	2.2	–	1.7	2.4	2.3

[a] Rating scores are based on a 5-point system, where 1 is poor and 5 is good (information for Puerto Rico is available only for the NCCR II.)

[b] U.S. score is based on an areally weighted mean of regional scores.

[c] No water quality data were available for the Great Lakes for the NCCR I.

[d] NI = Not included in the rating scores for NCCR II.

[e] No coastal habitat or fish tissue contaminant results are available for Puerto Rico.

The overall effect of the recalculation of the NCCR I scores is to reduce (worsen) all of the regional scores, except the Southeast Coast's, as well as the national score. Rather than a finding of fair condition as was reported in NCCR I, the overall U.S. condition, would have been reported as fair to poor (i.e., score reduction from 2.4 to 2.0) (Table C-3). Other overall changes would have changed ratings in the Northeast Coast (from fair to poor) and the West Coast (from fair to fair to poor). After normalizing the scores in this fashion, a comparison of NCCR I and NCCR II is possible. The information represents too short a time period to assess significant trends, but the comparison of conditions in the early 1990s to 2000 shows higher scores in 2000 for the Gulf Coast and shows the Great Lakes advancing from a poor to fair category. The overall condition scores for Northeast Coast and West Coast estuaries in the 1990s were reduced to poor and fair to poor, respectively, to show no categorical change through 2000.

Table C-3. Rating Scores[a] by Indicator and Region Comparing the 2001 and 2004 National Coastal Condition Reports but Calculated with 2004 Methods.

Indicator	Northeast Coast		Southeast Coast		Gulf Coast		West Coast		Great Lakes		Puerto Rico		United States[b]	
	v1[c]	v2[c]	v1	v2	v1	v2	v1	v2	v1	v2	v1[d]	v2	v1	v2
Water Quality Index	1	2	4	4	1	3	1	5	1	3	–	3	1.5	3.2
Sediment Quality Index	2	1	4	4	3	3	2	2	1	1	–	1	2.3	2.1
Coastal Habitat Index[f]	3	4	2	3	1	1	1	1	1	2	–	–[e]	1.6	1.7
Benthic Index	1	1	3	3	1	2	3	3	1	2	–	1	1.5	2.0
Fish Tissue Contaminants Index	2	1	5	5	3	3	3	1	3	3	–	–	3.1	2.7
Overall Condition	1.8	1.8	3.6	3.8	1.8	2.4	2.0	2.4	1.4	2.2	–	1.7	2.0	2.3

[a] Rating scores are based on a 5-point system, where 1 is poor and 5 is good (scores for Puerto Rico are only available for 2004 report).

[b] U.S. score is based on an areally-weighted mean of regional scores.

[c] v1 = NCCR I, v2 = NCCR II

[d] No rating information is available for Puerto Rico in NCCR I.

[e] No coastal habitat index or fish tissue contaminants index results are available for Puerto Rico for NCCR II.

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Acronyms

ADFG	Alaska Department of Fish and Game
ADEM	Alabama Department of Environmental Management
µg/L	microgram per liter
ACE	Ashepoo-Combahee-Edisto (South Carolina)
ACE INC	Atlantic Coast Environmental Indicators Consortium
ADEC	Alaska Department of Environmental Conservation
AED	Atlantic Ecology Division
AFS	American Fisheries Society
ANS	aquatic nuisance species
AOCs	Areas of Concern
APES	Albemarle-Pamlico Estuarine System
ASMFC	Atlantic States Marine Fisheries Commission
BCI	benthic condition index
BEACH	Beaches Environmental Assessment, Closure, and Health Program (EPA)
BMC	benthic macroinvertebrate communities
CARP	Contamination Assessment and Reduction Program
CCMA	Coastal Monitoring and Assessment
CENR	Committee on Environment and Natural Resources Research
CERP	Comprehensive Everglades Restoration Project
CPUE	catch per unit effort
CRD	Coastal Resources Division (Georgia)
CSO	combined sewer overflows
DDT	dichlorodiphenyltrichloroethane
DEP	Department of Environmental Protection
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorous
DNR	Department of Natural Resources
DO	dissolved oxygen
DOE	Department of Ecology
DOI	U.S. Department of the Interior
DPH	Division of Public Health
DQO	data quality objective
EaGLe	Estuarine and Great Lakes Ecological Indicators
EDCs	endocrine disrupting compounds
EMAP	Environmental Monitoring and Assessment Program (EPA)
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Division

ERL	effects range low
ERM	effects range medium
FDA	U.S. Food and Drug Administration
FMCs	fishery management councils
FMP	Fishery Management Plan
FMRI	Florida Marine Research Institute
FWS	U.S. Fish and Wildife Service
GBEP	Galveston Bay Estuary Program
GBNEP	Galveston Bay National Estuary Program
gCm^2yr	rams of carbon per square meter per year
GIP	geographic information processing
GIS	geographic information systems
GLNPO	Great Lakes National Program Office
GLWQA	Great Lakes Water Quality Agreement
GMP	Gulf of Mexico Program
GNP	gross national product
HABs	harmful algal blooms
HEP	Harbor Estuary Program (New York)
HMW	high molecular weight
IMAP	Inshore Marine Monitoring and Assessment Program
IWRMN	Integrated Water Resource Monitoring Network
km^2	square kilometer
lbs	pounds
LME	large marine ecosystem
LMRs	living marine resources
LMW	low molecular weight
LTER	Long-Term Ecosystem Research
m^2	square meter
MAFMC	Mid-Atlantic Fishery Management Council
MAIA	Mid Atlantic Integrated Assessment
MAR	Multiple Antibiotic Resistance
MARMAP	Marine Monitoring and Assessment Program (NOAA)
mg/L	milligram per liter
mi	mile
mt	metric tons
MQOs	Measurement Quality Objectives
MRLC	Multi-Resolution Land Characterization

NCA	National Coastal Assessment (EPA)
NCCR I	National Coastal Condition Report
NCCR II	National Coastal Condition Report II
NEFMC	New England Fishery Management Council
NEI WPCC	New England Water Pollution Control Commission
NERRS	National Estuarine Research Reserve System
ng/g	nanograms per gram
NHEERL	National Health and Environmental Effects Research Laboratory
NIST	National Institute of Standards and Technology
NIST ILC	NIST annual inter-laboratory comparison
NLCD	National Land Cover Data
NLFWA	National Listing of Fish and Wildlife Advisories
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NS&T	National Status and Trends Program (NOAA)
NWI	National Wetland Inventory (FWS)
OSCEAP	Outer Continental Shelf Environmental Assessment Program (Alaska)
OPA90	Oil Pollution Act of 1990
PAHs	polycyclic aromatic hydrocarbons
PBB	polybrominated biphenyls
PBDEs	polybrominated diphenyl ethers
PCBs	polychlorinated biphenyl congeners
POTW	publicly owned treatment works
ppm	parts per million
PSC	Pacific Salmon Commission
PWSs	public water systems
QA	quality assurance
r^2	coefficient of determination
RCACs	Regional Citizen Advisory Councils
REMAP	Regional Environmental Monitoring and Assessment Program (NOAA)
SAV	submerged aquatic vegetation
SCCWRP	Southern California Coastal Water Research Project
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCECAP	South Carolina Estuarine and Coastal Assessment Program
SEAMAP	Southeast Area Monitoring and Assessment Program (NOAA)

SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
SOLEC	State of the Lakes Ecosystem Conference
SPARROW	Spatially Referenced Regressions on Watershed Attributes
SQGs	sediment quality guidelines
SRMs	Standard Reference Materials
SSB	spawning stock biomass
SSO	sanitary sewer overflow
STAR	Science to Achieve Results Program (EPA)
STPs	sewage treatment plants
SWMP	System-Wide Monitoring Program
TBEP	Tampa Bay Estuary Program
TIE	Toxicity Identification Evaluation
TM	Thematic Mapper
TMDL	Total Maximum Daily Load
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPWD	Texas Parks and Wildlife Department
TDH	Texas Health Department
USACE	U.S. Army Corps of Engineers
UNC	University of North Carolina
USCRTF	U.S. Coral Reef Task Force
USDA	U.S. Department of Agriculture
USES	Urbanization in Southeast Estuarine Systems
USGS	U.S. Geological Survey
USMCMS	University of Southern Mississippi College of Marine Sciences
USPC	United States Policy Committee
U.S. EEZ	U.S. Exclusive Economic Zone
VCP	Virginia Coastal Program
VMRC	Virginia Marine Resources Commission
VOCs	volatile organic compounds
VOH	Virginia Oyster Heritage Program
VP	Virginian Province
VSHP	Virginia Seaside Heritage Program
WCI	water clarity indicator
WTC	World Trade Center
WTPs	water treatment plants

National Coastal Condition Report II

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