National Coastal Condition Report III

DRAFT

United States Environmental Protection Agency
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Office of Water
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Acronyms and Abbreviations

ADEC	Alaska Department of Environmental Conservation
AOCs	Areas of Concern
ASMFC	Atlantic States Marine Fisheries Commission
BEACH	Beaches Environmental Assessment, Closure, and Health Program
BRI	Benthic Response Index
CBP	Chesapeake Bay Program
CFD	cumulative frequency distribution
CISNet	Coastal Intensive Sites Network
CSO	combined sewer overflow
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorus
DOI	U.S. Department of the Interior
EEZ	U.S. Exclusive Economic Zone
EMAP	Environmental Monitoring and Assessment Program
EMAP–VP	Environmental Monitoring and Assessment Program-Virginian Province
EPA	U.S. Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Medium
ESU	evolutionarily significant unit
FDA	U.S. Food and Drug Administration
FMP	fishery management plan
FRI	Fish Response Index
FWS	U.S. Fish and Wildlife Service
GLNPO	Great Lakes National Program Office
GNP	gross national product
HAB	harmful algal bloom
JWPCP	Joint Water Pollution Control Plant
LME	Large Marine Ecosystem
LNG	liquid natural gas
MAFMC	Mid-Atlantic Fishery Management Council
MAIA	Mid-Atlantic Integrated Assessment
MHI	Main Hawaiian Islands
MMPA	Marine Mammal Protection Act
mt	metric tons
NAD	National Assessment Database
NBEP	Narragansett Bay Estuary Program
NCA	National Coastal Assessment
NCCR I	*National Coastal Condition Report I*
NCCR II	*National Coastal Condition Report II*
NCCR III	*National Coastal Condition Report III*
NCCR IV	*National Coastal Condition Report IV*
NEFMC	New England Fishery Management Council
NEP CCR	*National Estuary Program Coastal Condition Report*

NLFA	National Listing of Fish Advisories
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status & Trends Program
NWHI	Northwestern Hawaiian Islands
NWI	National Wetlands Inventory
OCSEAP	Outer Continental Shelf Environmental Assessment Program
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
PFAs	polyfluoroalkyl compounds
ppb	parts per billion
ppm	parts per million
POPs	persistent organic pollutants
POTWs	Publicly Owned Treatment Works
PSAMP	Puget Sound Ambient Monitoring Program
QA	quality assurance
QC	quality control
RIDEM	Rhode Island Department of Environmental Management
RMP	Regional Monitoring Program for Trace Substances
SAV	submerged aquatic vegetation
SCB	Southern California Bight
SOLEC	State of the Lakes Ecosystem Conferences
SSO	sanitary sewer overflows
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
TOC	total organic carbon
UME	unusual mortality event
URI	University of Rhode Island
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOC	volatile organic compound
WSDE	Washington State Department of Ecology
WWTPs	wastewater treatment plants

Executive Summary

Coastal waters in the United States include estuaries, bays, sounds, coastal wetlands, coral reefs, mangrove and kelp forests, seagrass meadows, and upwelling areas (deep water rising to surface). Coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. These coastal resources also provide nesting, resting, feeding, and breeding habitat for 75% of waterfowl and other migratory birds.

Section 305(b) of the Clean Water Act (CWA) requires that the U.S. Environmental Protection Agency (EPA) report periodically on the condition of the nation's coastal 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 has been 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, and the U.S. Department of Agriculture (USDA) agreed to participate in a multi-agency effort to assess the condition of the nation's coastal resources. The agencies chose to assess condition using nationally consistent monitoring surveys 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 coastal resources were in fair to poor condition. The NCCR I used available data collected from 1990 to 1996 to characterize about 70% of the nation's conterminous coastal waters. Agencies contributing these data included EPA, NOAA, the U.S. Fish and Wildlife Service (FWS), and the USDA. The second *National Coastal Condition Report* (NCCR II) was based on available data from 1997 to 2000. The NCCR II data were representative of 100% of the coastal waters of the conterminous 48 states and Puerto Rico and showed that the nation's coastal waters were slightly improved and rated in fair condition. Agencies that contributed data to the NCCR II included EPA, NOAA, FWS, and the U.S. Geological Survey. Several state, regional, and local organizations also provided information on the condition of the nation's coasts.

This third *National Coastal Condition Report* (NCCR III) assesses the condition of the nation's coastal waters, including the coastal waters of Alaska and Hawaii, based primarily on EPA's National Coastal Assessment (NCA) data collected primarily in 2001 and 2002. The NCA, NOAA's National Marine Fisheries Service (NMFS), and FWS's National Wetland Inventory (NWI) contributed most of the information presented in this report. As shown in this report, the overall condition of the nation's coastal waters is again improved, but continues to be rated fair. This report also presents analysis of temporal changes in coastal condition from 1990 to 2002 for the nation and by region.

With each *National Coastal Condition Report*, the collaborating agencies strive to provide a more comprehensive picture of the nation's coastal resources. The NCCR III builds on the foundation provided by the NCCR I and NCCR II, and efforts are underway to assess even more areas using comparable and consistent analysis methods. In addition to the areas previously assessed in the NCCR II, this report provides condition data for Hawaii and portions of Alaska. It should be noted that the Great Lakes data provided in this report are not directly comparable with the data provided for other regions; however, general comparisons of the Great Lakes condition ratings are provided. Ongoing monitoring efforts in Alaska, Hawaii, and the island commonwealths and territories will support comprehensive assessments of coastal condition in future installments of the *National Coastal Condition Report* series.

The NCCR III 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 this 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 EPA's NCA, which provides information on the condition of coastal waters for all regions of the United States. The NCCR III uses NCA and other data to evaluate five indices of coastal 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, Alaska, Hawaii, and Puerto Rico). The resulting ratings for each index are then used to calculate the overall condition ratings for the regions, as well as index and overall condition ratings for the nation. This NCCR assessment applies to 30 coastal states (22 ocean states, 6 Great Lakes states, and 2 ocean/Great Lakes states) and Puerto Rico (Figure ES-1).

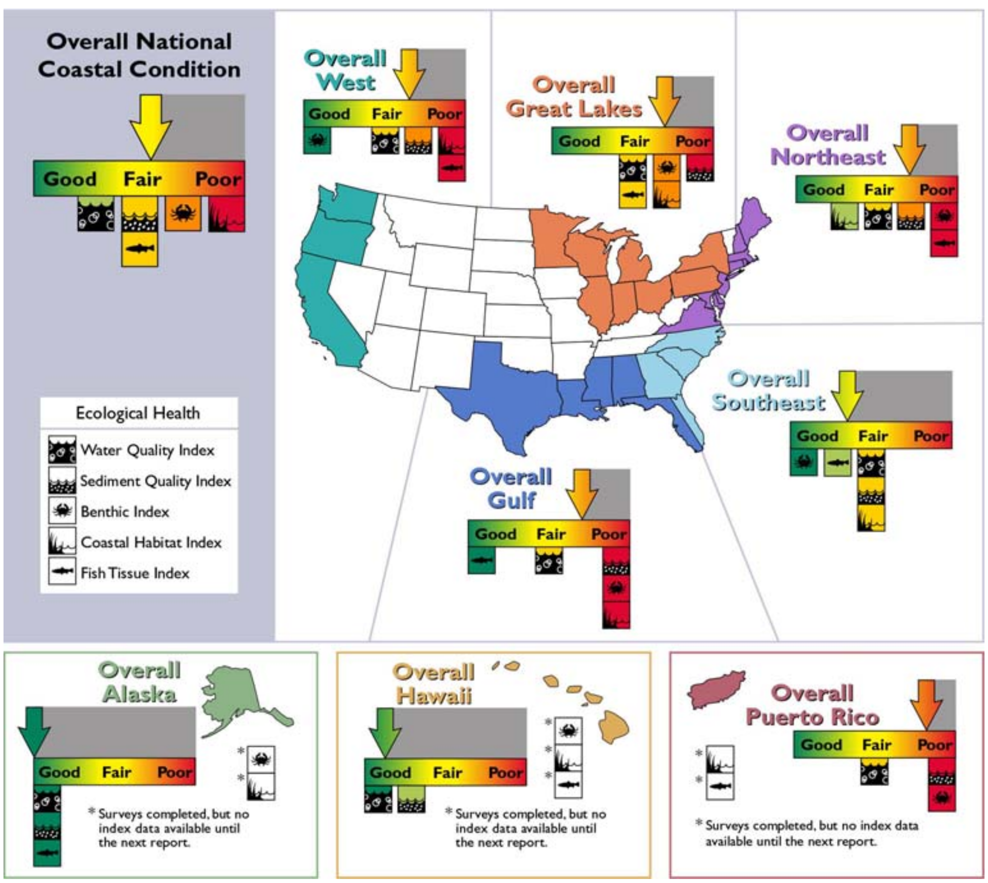

Figure ES-1. Overall national and regional coastal condition, primarily between 2001 and 2002.

In addition to rating coastal condition based on coastal monitoring data, the NCCR III summarizes available information related to offshore fisheries, fish consumption advisories, and beach advisories and closures. This information, together with descriptions of individual monitoring programs, paints a picture of the overall condition of nation's coastal resources.

Summary of the Findings

This report is based on the large amount of monitoring data collected primarily between 2001 and 2002 on the condition of the coastal and Great Lakes resources of the United States. Ecological assessment of these data shows that the nation's coastal waters are rated fair for overall condition. With respect to the coastal waters of the geographic regions assessed in this report, Puerto Rico is rated poor; the Northeast Coast, Gulf Coast, and Great Lakes are rated fair to poor; the Southeast Coast and West Coast are rated fair; and Alaska and Hawaii are rated good. No overall condition assessments were available for Guam, American Samoa, the Northern Mariana Islands, or the U.S. Virgin Islands; however, sampling surveys of Guam, American Samoa, and the U.S. Virgin Islands were conducted in 2004, and data from these surveys will be assessed in the next *National Coastal Condition Report* (NCCR IV). New ecological monitoring programs will permit a comprehensive and consistent assessment of all of the nation's coastal resources by 2008.

The major findings of the 2001–2002 study period are as follows:

- The overall condition of the nation's coastal waters is rated fair, based on the five indices of ecological condition assessed in this report: water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index. This report also assesses component indicators for the water quality index (dissolved inorganic nitrogen [DIN], dissolved inorganic phosphorus [DIP], chlorophyll *a*, water clarity, and dissolved oxygen) and the sediment quality index (sediment toxicity, sediment contaminants, and sediment total organic carbon [TOC]).
- The water quality index for the nation's coastal waters is rated good, with 57% of the nation's coastal area rated good for water quality condition, 35% rated fair, and 6% rated poor.
- Eighteen percent of the U.S. coastal area is potentially impaired for fishing, based on the EPA Advisory Guidance values used to assess the fish tissue contaminants index for this report.
- Coastal habitat loss, sediment quality, and benthic community condition show the poorest conditions throughout the coastal United States, whereas dissolved oxygen and DIN concentrations are most often rated in good condition throughout the nation (Tables ES-1 and ES-2).
- The overall condition of the nation's coastal waters is fair and has improved only slightly since the initial NCCR I in 2001. The water quality index rating for the nation has improved substantially, while smaller improvements in the sediment quality and benthic index ratings were noted. The fish tissue contaminants and coastal habitat index ratings have shown little or no improvement.

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

Indicator	Northeast Coast	Southeast Coast	Gulf Coast	West Coast	Great Lakes	Alaska	Hawaii	Puerto Rico	United States[b]
Water Quality Index	3	3	3[c]	3	3	5	5	3	3.9
Sediment Quality Index	2	3	1	2	1	5	4	1	2.8
Coastal Habitat Index	4	3	1	1	2	—[d]	—[d]	—[d]	1.7
Benthic Index	1	5	1	5	2	—[d]	—[d]	1	2.1
Fish Tissue Contaminants Index	1	4	5	1	3	5	—[d]	—[d]	3.4
Overall Condition	2.2	3.6	2.2	2.4	2.2	5.0	4.5	1.7	2.8

[a] Rating scores are based on a 5-point system, where a score of less than 2.0 is rated poor; 2.0 to less than 2.3 is rated fair to poor; 2.3 to 3.7 is rated fair; greater than 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.
[b] 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] This index was not assessed for this region.

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

Indicator	Northeast Coast	Southeast Coast	Gulf Coast	West Coast	Great Lakes	Alaska	Hawaii	Puerto Rico	United States
Water Quality Index[b]	13	6	14[c]	3	—	0	4	9	6
Sediment Quality Index[d]	13	12	18	14	—	1	5	61	8
Coastal Habitat Index[e]	1.00	1.06	1.30	1.90	—	—	—	—	1.26
Benthic Index	27	7	45	5	—	—	—	35	27
Fish Tissue Contaminants Index[f]	31	10	8	26	—	0	—	—	18

[a] The percent area of poor condition is the percentage of total coastal surface area in the region or the nation (proportional area information not available for Great Lakes).
[b] The water quality index is based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen.
[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 measurements of three component indicators: 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 most recent decadal wetland loss rate (1990–2000).
[f] The fish tissue contaminants index is based on analyses of whole fish samples (not fillets).

Describing Coastal Condition

Three types of data are presented in this report:

- **Coastal Monitoring Data**—Coastal monitoring data obtained from programs such as EPA's Environmental Monitoring and Assessment Program (EMAP) and NCA, NOAA's National Status and Trends (NS&T) Program, and FWS's NWI, as well as Great Lakes information from the State of the Lakes Ecosystem Conference (SOLEC). These data are used to rate indices and component indicators of coastal condition for the geographic regions assessed in this report and the nation. These index scores are then used to calculate overall condition scores and ratings for the regions and the nation.
- **Offshore Fisheries Data**—Data obtained from programs such as NOAA's Marine Monitoring and Assessment Program and Southeast Area Monitoring and Assessment Program. 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 and compiled in nationally maintained databases. These data provide information about designated use support, which affects public perception of coastal condition as it relates to public health. The agencies contributing these data use different methodologies and criteria for assessment; therefore, the data cannot be used to make broad-based comparisons among the different coastal areas.

Coastal Monitoring Data

The overall condition of the nation's coastal waters is rated fair (Figure ES-2), based on the ratings for five indices of coastal condition assessed for this report: water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index. The national indices were assigned a good, fair, or poor rating based on index scores for each coastal region of the United States, and a weighted average of the regional index scores was used to determine an overall condition score and rating for the nation. Supplemental information on the water and sediment quality component indicators (e.g., DIN, DIP, chlorophyll *a*, water clarity, dissolved oxygen, sediment toxicity, sediment contaminants, and sediment TOC), when available, is also presented throughout this report.

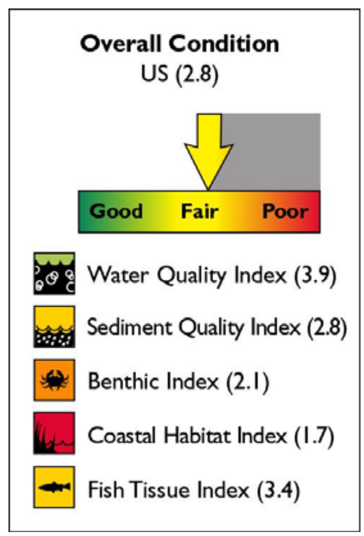

Figure ES-2. The overall condition of U.S. coastal waters is rated fair.

A summary of each index is presented below.

- **Water Quality Index:** The water quality index for the nation's coastal waters is rated good. The percent of coastal area rated poor for water quality ranged from 0 in Alaska to 14% in the Gulf Coast. Most water quality problems in U.S. coastal waters are due to degraded water clarity and increased concentrations of DIP and chlorophyll *a*. Low dissolved oxygen concentrations occur in only 4% of the U.S. coastal area.
- **Sediment Quality Index:** This sediment quality index for the nation's coastal waters is rated fair. The sediment quality index is rated poor for the Gulf Coast, Great Lakes, and Puerto Rico regions; fair to poor for the West Coast and Northeast Coast regions; fair for the Southeast Coast region; good to fair for Hawaii; and good for Alaska. Many areas 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 the coastal waters of the Northeast Coast region and Puerto Rico. Sediment toxicity was observed most frequently in the coastal waters of the Gulf Coast and West Coast regions. High concentrations of sediment TOC (often associated with the deposition of human, animal, and plant wastes) are observed in 44% of Puerto Rico's coastal waters.
- **Benthic Index:** The benthic index for the nation's coastal waters is rated fair to poor. Poor benthic condition is observed in Gulf Coast, Northeast Coast, and Puerto Rico coastal waters, largely due to degraded sediment quality; however, in some cases, poor benthic condition is associated with poor water quality conditions, such as low dissolved oxygen and elevated nutrient concentrations. Both the Southeast Coast and West Coast regions are rated good for benthic condition. Benthic index data were unavailable for Alaska or Hawaii.
- **Coastal Habitat Index:** The coastal habitat index for the nation's coastal waters is rated poor. 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 Gulf of Mexico. It should be noted that the coastal habitat scores and ratings for the NCCR III are identical to those presented in the NCCR II due to a lack of available new data.
- **Fish Tissue Contaminants Index:** The fish tissue contaminants index for the nation's coastal waters is rated fair, with 18% of the stations where fish were caught rated poor for this index. The fish tissue contaminants index is rated good for the Gulf Coast and Alaska regions, good to fair for the Southeast Coast region, fair for the Great Lakes region, and poor for the Northeast Coast and West Coast regions. Fish tissue contaminants data were unavailable for the coastal waters of Hawaii, Puerto Rico, Florida, and Louisiana.

Offshore Fisheries Data

In 2004, NOAA's Office of Sustainable Fisheries reported on the status of 688 marine fish and shellfish stocks. Of the 200 stocks whose status with respect to overfishing is known, 144 were not overfished, and 56 stocks or stock complexes were overfished, compared with 92 in 2000 and 81 in 2001. The overfishing status (when the proportion of a stock taken by a fishery is too high) of 236 stocks is known, of which 44 stocks or stock complexes have a fishing mortality rate that exceeds the overfishing threshold. The NMFS has approved rebuilding plans for the majority of overfished stocks. Five fishery management plan amendments in 2004 were approved to implement final rebuilding plans for 23 stocks of the Northeast Shelf, Southeast Shelf, Gulf of Alaska, and East Bering Sea LMEs. Pacific whiting (groundfish stock of the Gulf of Alaska/California Current LMEs) has been fully rebuilt, and overfishing of this species is no longer occurring. Northeast Shelf LME black sea bass is also no longer overfished, and three more stocks—lingcod, Pacific ocean perch (Gulf of Alaska/California Current LMEs), and king mackerel (Gulf of Mexico LME)—have increased in abundance to the point they are no longer overfished. Rebuilding measures for all these stocks will continue until each stock has fully rebuilt to the level that provides maximum sustainable yield.

Assessment and Advisory Data

States report water quality assessment information and water quality impairments under Section 305(b) of the CWA. States and tribes rate water quality by comparing measured values to their state and tribal water quality standards. The 305(b) assessment data (submitted by the states in 2002) are stored in EPA's National Assessment Database (NAD). These data are useful for evaluating the success of state water quality improvement efforts; however, it should be emphasized that 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. For the 2002 reporting cycle, several states and island territories with estuarine and coastal marine waters did not submit 305(b) assessment information to the EPA. For the states of North Carolina and Washington, as well as the island territories of American Samoa, Guam, and the Northern Marianas Island, no data were available for the 2002 reporting cycle in the NAD. Because the reporting of 2003 305(b) information was not complete for all coastal states and territories, it was decided that this information would not be summarized for inclusion in the NCCR III; therefore, only data from the EPA's NLFA database and the BEACH PRogram tracking, Beach Advisories, Water quality standards, and Nutrients database are presented for calendar year 2003 in this report.

The number of coastal and estuarine waters under fish consumption advisories represent an estimated 77% of the coastal waters of the conterminous United States, including 81% of the shoreline miles and 56% of the estuarine area along the Northeast Coast; 100% of the shoreline miles along the Southeast Coast; 100% of the shoreline miles and 23% of the estuarine area along Gulf Coast; and 10% of the shoreline miles and 21% of the estuarine area along West Coast (Figure ES-3). Every Great Lake is under at least one fish consumption advisory, and advisories covered 100% of the Great Lakes shoreline. 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: PCBs, mercury, DDT and its degradation products DDE and DDD, and dioxins and furans. These four chemical contaminants were responsible, at least in part, for 92% of all fish consumption advisories in effect in estuarine and coastal marine waters in 2003.

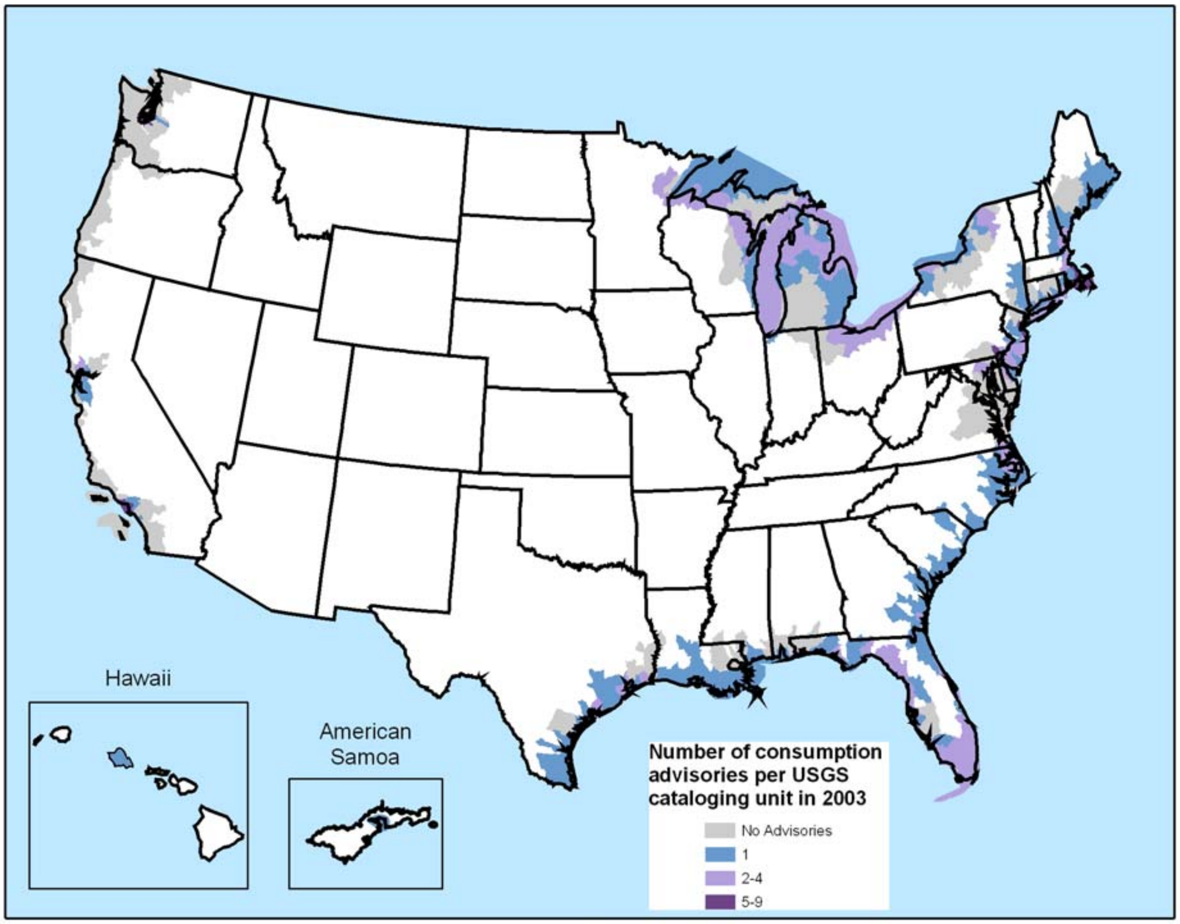

Figure ES-3. The number of fish consumption advisories active for the United States in 2003.

For the 2003 swimming season, EPA gathered information on 4,080 beaches monitored nationwide (both inland and coastal) through the use of a survey. The survey respondents were state and local government agencies from coastal counties, cities, or towns bordering the Atlantic Ocean, Gulf of Mexico, Pacific Ocean, and the Great Lakes, as well as those in Hawaii, Puerto Rico, the U.S. Virgin Islands, Guam, and the Northern Mariana Islands. A few of these respondents were regional (multiple-county) districts. EPA's review of coastal beaches (U.S. coastal areas, estuaries, the Great Lakes, and the coastal areas of Hawaii and the U.S. territories) showed that, of the 4,080 beaches reported in the survey responses, 4,070 were marine or Great Lakes beaches. Of the coastal beaches monitored and reported, 839 (or 20.5%) had an advisory or closing in effect at least once during the 2003 swimming season (Figure ES-4). 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. Some of the major causes of public notifications for beach advisories and closures were stormwater runoff, wildlife, sewer line problems, and in many cases, unknown sources.

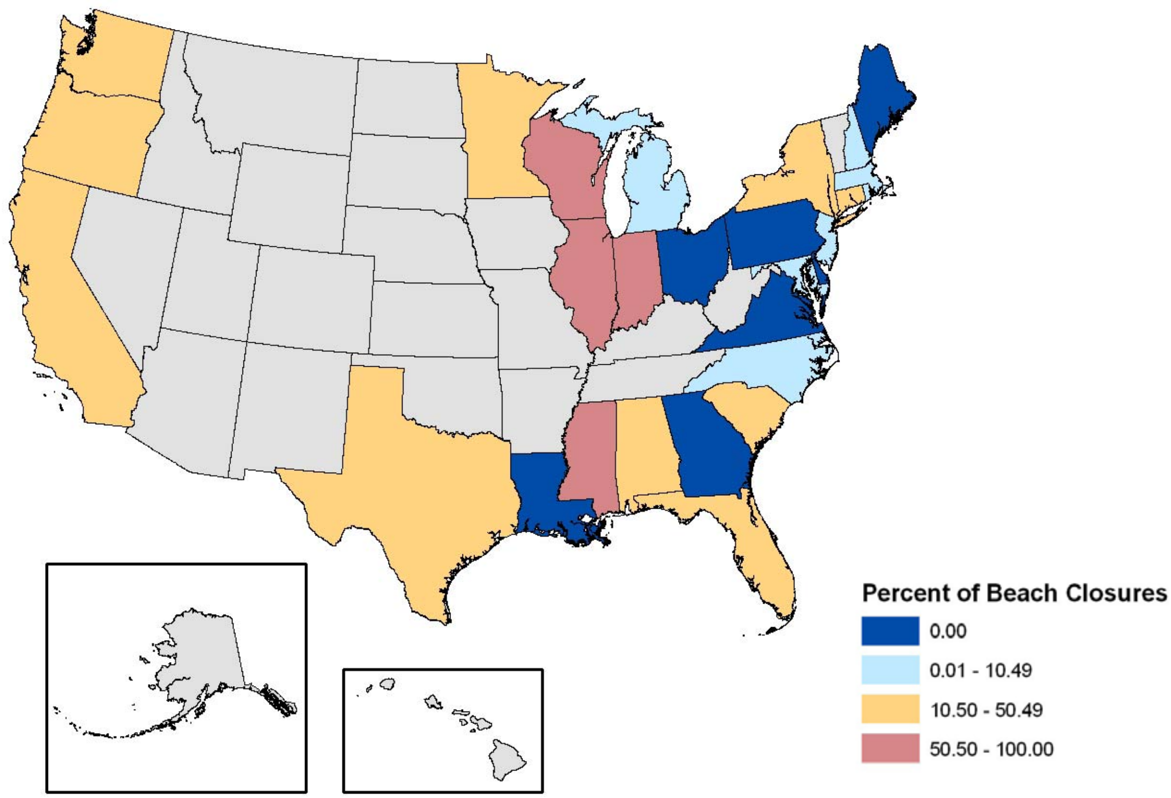

Figure ES-4. Percentages of beaches with advisories/closures by coastal state in 2003. These percentages are based on the number of beaches in each state that were reported, not the total number of beaches.

Shortcomings of Available Data

This report focuses on coastal regions for which nationally consistent and comparable data are available. Such data are currently available for the conterminous 48 states, Alaska, Hawaii, and Puerto Rico. Nearly 75% of the area of all the coastal area, including the bays, sounds, and estuaries in the United States, is located in Alaska, and no national report on coastal condition can be truly complete without information on the condition of living resources and use attainment of these waters. For this report, coastal monitoring data were only available for the south-central region of Alaska. Other Alaskan regions will be assessed in future installments of the *National Coastal Condition Report* series. Coastal monitoring information has not been available for the U.S. Virgin Islands or the Pacific territories to support estimates of condition based on the indices used in this report. Although these latter systems make up only a small portion of the nation's coastal waters 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 were surveyed in 2004 and will be included in future national coastal condition assessments.

This report makes the best use of available data to characterize and assess the condition of the nation's coastal resources; however, the report cannot represent all individual coastal and estuarine systems of the United States or all of the appropriate spatial scales (e.g., national, regional, and local) necessary to assess coastal condition. This assessment is based on a limited number of ecological indices and component indicators for which consistent data sets are available to support estimates of ecological condition on regional and national scales. Through a multi-agency and multi-state 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, Chapter 9 addresses coastal condition in the context of how well coastal waters are meeting expectations for human use. Only one coastal waterbody, the Rhode Island estuary Narragansett Bay, was evaluated for human use expectations in this report. In the case of this estuary, it appears that human uses are being met; however, as with most any other coastal waterbodies, there are shortcomings in some areas, such as public access to beaches, long-term changes in commercial fishing stocks, and fish consumption advisories.

Comparisons to Other National Coastal Condition Reports

A primary goal of the *National Coastal Condition Report* series is to provide a benchmark of coastal condition 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 was insufficient information to examine the potential trends in coastal condition that might be related to changes in environmental programs and policies. In the NCCR III, the information from 1990 through 2002 is evaluated for potential trends.

Comparing data between the NCCR I, NCCR II, and NCCR III is complicated because, in some cases, indices and component indicators were changed 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 index was used in the NCCR II. In addition, reference conditions for some of the indices and component indicators were modified to reflect regional differences. In order to facilitate a comparison between the NCCR I and NCCR II, the values reported in the NCCR I Executive Summary were recalculated, to the extent possible, using the approaches followed in the NCCR II and NCCR III (Table ES-3). Comparison of the overall condition scores presented in each report shows that the overall condition of U.S. coastal waters has improved slightly since the 1990s. Although the overall condition of U.S. coastal waters is rated fair in all three reports, the score increased from 2.1 to 2.3 from the NCCR I to the NCCR II and, with the addition of data for Alaska and Hawaii, increased to 2.8 in the NCCR III. Water quality in U.S. coastal waters has improved substantially since the NCCR I, and smaller improvements in sediment quality and fish tissue contaminants were also noted during this time. Benthic community condition and coastal habitat loss have shown little or no improvement since the NCCR I. A more detailed comparison of the assessment results from the three reports appears in Chapter 2 of this report.

Table ES-3. Rating scores by Index[1] and Region Comparing NCCR I, NCCR II, and NCCR III.

	Gulf Coast			Southeast Coast			Northeast Coast			S. Central Alaska[3]	Hawaii[3]	West Coast[2]			Great Lakes[2]			Puerto Rico[2]		United States[4]		
INDEX	v1	v2	v3	v1	v2	v3	v1	v2	v3	v3	v3	v1	v2	v3	v1	v2	v3	v2	v3	v1	v2	v3
Water Quality	1	3	3	4	4	3	1	2	3	5	5	1	3	3	1	3	3	3	3	1.5	3.2	3.9
Sediment Quality	3	3	1	4	4	3	2	1	2	5	4	2	2	2	1	1	1	1	1	2.3	2.1	2.8
Coastal Habitat	1	1	1	2	3	3	3	4	4	--	--	1	1	1	1	2	2	--	--	1.6	1.7	1.7
Benthic	1	2	1	3	3	5	1	1	1	--	--	3	3	5	1	2	2	1	1	1.5	2.0	2.1
Fish Tissue Contaminants	3	3	5	5	5	4	2	1	1	5	--	3	1	1	3	3	3	--	--	3.1	2.7	3.4
Overall	**1.8**	**2.4**	**2.2**	**3.6**	**3.8**	**3.6**	**1.8**	**1.8**	**2.2**	**5.0**	**4.5**	**2.0**	**2.0**	**2.4**	**1.4**	**2.2**	**2.2**	**1.7**	**1.7**	**2.0**	**2.3**	**2.8**

1 - Rating scores are based on a 5-point system where 1 is poor, 3 is fair, and 5 is good.
2 - West Coast, Great Lakes, and Puerto Rico scores for *NCCRIII* are the same as *NCCRII* (no new data for *NCCRIII* except for West Coast benthic index)
3 - AK & HI were not reported in *NCCR* or *NCCRII*
4 - U.S. score is based on an areally weighted mean of regional scores.
v1 = NCCR (adjusted scores from Table C-1 in NCCR2); v2 = NCCRII; v3 = NCCRIII

Chapter 1

Introduction

The *National Coastal Condition Report* series assesses the condition of the estuarine waters and coastal fisheries of the United States The first *National Coastal Condition Report* (NCCR I; U.S. EPA, 2001) assessed the condition of the nation's coasts using data collected from 1990 to 1996 that were provided by several existing coastal programs, including the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (EMAP), the U.S. Fish and Wildlife Service's (FWS's) National Wetlands Inventory (NWI), and the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends (NS&T) Program. The second *National Coastal Condition Report* (NCCR II; U.S. EPA, 2004) provided information similar to the information covered in the NCCR I, but contained more recent (1997–2000) data from these monitoring programs, as well as data from EPA's National Coastal Assessment (NCA) and NOAA's National Marine Fisheries Service (NMFS). The data provided by these programs allowed for the development of coastal condition indicators for 100% of the coastal area of the conterminous 48 states and Puerto Rico.

This third *National Coastal Condition Report* (NCCR III) is a collaborative effort among EPA, NOAA, FWS, and the U.S. Geological Survey (USGS), in cooperation with other agencies representing states and tribes. The NCCR III continues the *National Coastal Condition Report* series by providing updated regional and national assessments of the condition of the nation's coastal waters, including portions of the coastal waters of Alaska and Hawaii, based primarily on NCA data collected in 2001 and 2002. No new information was available for the regions of Puerto Rico or the Great Lakes; therefore, the chapters covering these regions represent summaries of the assessments presented in the NCCR II. The assessment of coastal fisheries provided in this report is based on long-term data collected since monitoring of the individual fisheries began. In addition, this report examines national and regional (Northeast, Southeast, and Gulf coasts) trends in coastal condition from the early 1990s to 2002.

NCA surveys of the nation's estuarine and coastal waters have been conducted annually from 2000 to 2006. The results of surveys conducted after 2002 will be available in 2008 and will be presented in the fourth *National Coastal Condition Report* (NCCR IV) in 2009.

Purpose of This Report

The purpose of the NCCR III is to present a broad baseline picture of coastal condition across the United States for 2001 to 2002 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 coastal waters and is not intended to be a comprehensive literature review of coastal information. Instead, this report uses NCA and other monitoring data on a variety of indicators to provide insight into current coastal condition. The NCCR III also examines national and regional trends in coastal condition from the early 1990s to 2002. The NCCR III 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 natural resource managers face and must try to overcome to make reliable assessments of how the condition of the nation's coastal resources may change with time.

This report also includes special Highlight articles 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, state, regional, and national levels.

The final chapter of this report 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 also complements the national/regional approach by combining the site-specific information for a specific estuary, Narragansett Bay, with the NCA results for this estuary to evaluate estuarine conditions.

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 75% of U.S. waterfowl and other migratory birds (U.S. EPA, 1998).

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. Estuaries also 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 the U.S. Navy; provide a point of discharge for municipalities and industries; and are the downstream recipient of non-point source runoff.

Coastal 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 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 United States. This narrow fringe of land—only 17% of the total contiguous U.S. land area—is home to more than 53% of the nation's population (Figure 1-1). Total coastal population between the years 1980 and 2003 increased by 33 million people (28%), which is roughly consistent with the nation's rate of increase; however, this continued population growth in the limited coastal land area results in increased population density and pressure on coastal resources. The majority of the nation's most densely populated areas are located along the coast. In fact, 23 of the 25 most densely populated U.S. counties are coastal counties. The population density of U.S. coastal counties averages 300 persons/mi^2, much higher than the national average of 98 persons/mi^2 (Crossett et al., 2004).

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

In addition to being a popular place to live, the nation's coasts are of great recreational value. Beaches have become one of the most popular vacation destinations in the United States, with 180 million people visiting the nation's coasts each year (Cunningham and Walker, 1996). From 1999 to 2000, more than 43% of the U.S. population participated in marine recreational activities, including sport fishing, boating, swimming, and diving (Leeworthy and Wiley, 2001).

Human use of coastal areas also provides commercial services for the nation. The 425 U.S. coastal counties generate $1.3 trillion of the gross national product (GNP), and coastal and marine waters support for more than 28 million jobs (Leeworthy, 2000; U.S. Senate, 2003). The annual catch of U.S. commercial fisheries was 5 million metric tons (mt) from 200l through 2003, approximately 4.1% of the world's annual catch (NMFS, 2002; 2003; 2004). Roughly 35% of the nation's commercial catch occurs within 3 miles of shore (NMFS, 2004).

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 coastal living desirable. Population pressures include increased solid waste production; higher volumes of urban non-point source runoff; loss of green space and wildlife habitat; declines in ambient water and sediment quality; and increased demands for wastewater treatment, irrigation and potable water, and energy supplies. 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, which is critical to riverine and estuarine function, continue to be altered. In effect, the same human uses that are desired of coastal habitats 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.

Assessment of Coastal Condition

Three sources of estuarine information use nationally consistent data-collection designs and methods— EPA's NCA, NOAA's NS&T Program, and FWS's NWI. The NCA collects data from all coastal areas in the United States, except the Great Lakes region, and these data are representative of all coastal 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.

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 the nation's coastal waters. Three types of data are presented in this report:

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

This report presents available coastal monitoring information on a national scale for the 50 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 1-2). These geographic regions are comparable to the LME classifications used by the NOAA (Table 1-1). Assessment and advisory data for the regions 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, this 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.

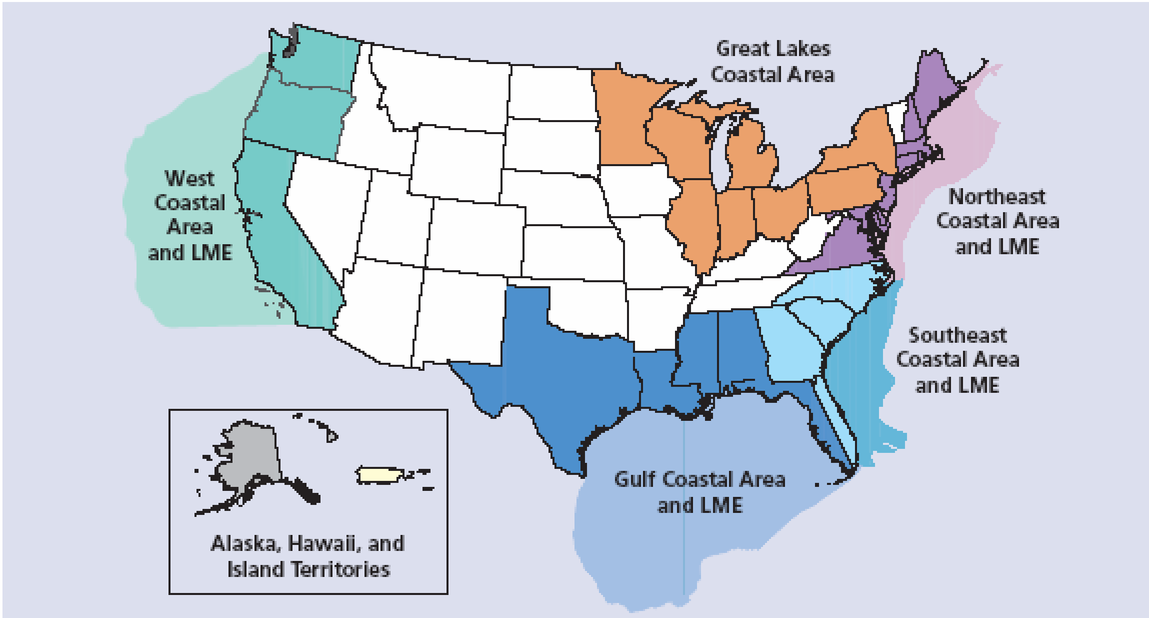

Figure 1-2. Coastal and Large Marine Ecosystem (LME) areas presented in the chapters of this report.

Table 1-1. Comparison of NCA's Reporting Regions and NOAA's LMEs

NCA Reporting Regions	NOAA's LMEs
Northeast Coast	Northeast U.S. Continental Shelf LME
Southeast Coast	Southeast U.S. Continental Shelf LME
Gulf Coast	Gulf of Mexico LME
West Coast	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

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 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 (except states in the Great Lakes region) and Puerto Rico. 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 NWI, which provides information on the status of the nation's wetlands acreage.

Five primary indices of environmental condition were created using data available from these national coastal programs: a water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index. The five indices were selected because of the availability of relatively consistent data sets for these parameters for most of the country. The indices do not address all of the estuarine and coastal-water characteristics that are valued by society, but they do provide information on both ecological condition and human use of estuaries. Component indicators for the water quality index (dissolved inorganic nitrogen [DIN], dissolved inorganic phosphorus [DIP], chlorophyll a, water clarity, and dissolved oxygen) and the sediment quality index (sediment toxicity, sediment contaminants, and sediment total organic carbon [TOC]) are also assessed in the report.

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

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

Shortcomings of Available Data

Coastal surveys of Hawaii and the Alaskan Province of Alaska were completed in 2002, and assessments of these estuaries are included in this report. Estuarine condition in Alaska is difficult to assess because very little information is available for most of the state to support the type of analysis used in this report (i.e., spatial estimates of condition based on the indices and component 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 the living resources and ecological health of these waters. Similarly, information to support estimates of condition based on the indices and component indicators used in this report is limited for Hawaii, the Pacific island territories (American Samoa, Northern Marianas Islands, and Guam), 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, except for the Florida Keys and the Flower Gardens off the Texas/Louisiana coast. A survey of Puerto Rico’s estuarine condition was completed in 2000 and reported in the NCCR II. No new information has been collected for Puerto Rico since the NCCR II; therefore, a summary of that report’s assessment is included in this report.

In order to attain consistent reporting for all the coastal ecosystems of 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), which calls for a national program that is organized at the state level and carried out by a partnership between federal departments and agencies (e.g., EPA, NOAA, the U.S. Department of the Interior [DOI], and the U.S. Department of Agriculture [USDA]), state natural resource agencies, and academia and industry. Such a 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, a national estuarine monitoring program organized and executed at the state level; however, the NCA is merely a starting point for developing a comprehensive national coastal monitoring program that can offer a coastal assessment of the entire nation at all appropriate spatial scales. One approach for examining coastal data at a more local scale (an individual estuarine system) is presented in the assessment of Narragansett Bay provided in Chapter 9.

Indices Used to Measure Coastal Condition

Water Quality Index

The water quality index is based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Some nutrient inputs to coastal waters (such as DIN and DIP) are necessary for a healthy, functioning estuarine ecosystem; however, when nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, their concentration can increase beyond natural background levels. This increase in the rate of supply of organic matter is called eutrophication and may result in a host of undesirable water quality conditions (Figure 1-3), including excess plant production (phytoplankton or algae) and increased chlorophyll *a* concentrations, which can decrease water clarity and lower concentrations of dissolved oxygen.

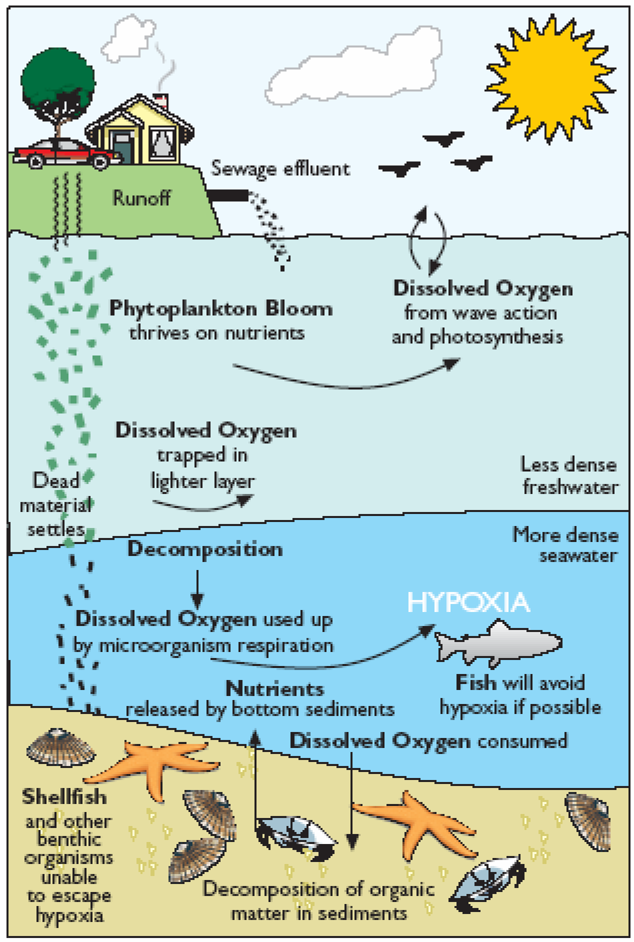

Figure 1-3. Eutrophication can occur when the concentration of available nutrients increases beyond normal levels.

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

Nutrients: Nitrogen and Phosphorus

DIN and DIP are necessary and natural nutrients required for the growth of phytoplankton, the primary producers that form the base of an estuary's food chain; however, excessive levels of DIN and DIP can result in large, undesirable phytoplankton blooms. DIN is the nutrient type most responsible for eutrophication in open estuarine and marine waters, whereas DIP is more likely to promote algal growth in tidal-fresh parts of estuaries. For the NCCR I, DIN and DIP information were determined through a survey of estuarine experts conducted by NOAA (Bricker et al., 1999). In the NOAA report, surface maximum total dissolved nitrogen (TDN) 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 total dissolved phosphorus (TDP) 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 and this report, DIN and DIP, which represent portions of TDN and TDP, were determined chemically through the collection of filtered surface water at each site. The NCA analyses provided for this report differs from results provided in the NOAA report because the nutrient assessment for the NCA surveys is based on summer concentrations, rather than annual average concentrations (NOAA). Due to phytoplankton uptake and growth, nutrient concentrations in summer are generally expected to be lower than at other times of the year for most of the country (however, on the West Coast, Pacific upwelling events in summer often produce the year's highest nutrient concentrations). As a result, the DIN and DIP reference surface concentrations used to assess coastal 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. The site ratings were then used to calculate an overall rating for each region.

Table 1-2. Criteria for Assessing Dissolved Inorganic Nitrogen (DIN).

Area	Good	Fair	Poor
East/Gulf Coast sites	< 0.1 mg/L	0.1–0.5 mg/L	> 0.5 mg/L
West Coast and Alaska 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
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Table 1-3. Criteria for Assessing Dissolved Inorganic Phosphorus (DIP)

Area	Good	Fair	Poor
East/Gulf Coast sites	< 0.01 mg/L	0.01–0.05 mg/L	> 0.05 mg/L
West Coast and Alaska 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
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

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. For this report, surface concentrations of chlorophyll *a* were determined from a filtered portion of water collected at each site. Surface chlorophyll *a* concentrations at a site were rated good, fair, or poor using the criteria shown in Table 1-4. The site ratings were then used to calculate an overall chlorophyll *a* 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, and Florida Bay sites	< 0.5 μg/L	0.5–1 μg/L	> 1 μg/L
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10% to 20% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 20% of the coastal area is in poor condition.

Water Clarity

Clear waters are valued by society and contribute to the maintenance of healthy and productive ecosystems. Light penetration into coastal waters is important for submerged aquatic vegetation (SAV), which serves as food and habitat for the resident biota. Water clarity is affected by suspended sediments, particulate matter, dissolved organics measured as color, and phytoplankton. Estuaries are naturally turbid environments. Turbid waters supply building materials 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. 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 compared to regional reference conditions at 1 meter: 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 locations with naturally high turbidity (Alabama, 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
Coastal waters with naturally high turbidity	> 10% light at 1 m	5–10% light at 1 m	< 5% light at 1 m
Coastal waters with normal turbidity	> 20% light at 1 m	10–20% light at 1 m	< 10% light at 1 m
Coastal waters that support SAV	> 40% light at 1 m	20–40% light at 1 m	< 20% light at 1 m
Regions	Less than 10% of the coastal area is in poor condition, and more than 50% is in good condition.	10% to 25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.

Dissolved Oxygen

Dissolved oxygen is necessary for all aquatic life. Often, low dissolved oxygen occurs as a result of large algal blooms that sink to the bottom, where bacteria use oxygen during the process of decay. In addition, low dissolved oxygen concentrations can be the result of stratification due to strong freshwater river discharge on the surface, which overrides the heavier, saltier bottom water of a coastal waterbody. Many states use a dissolved oxygen threshold average concentration of 4 to 5 mg/L to set their coastal water quality standards, and concentrations below 2 mg/L are thought to be stressful to many organisms (Diaz and Rosenberg, 1995; U.S. EPA, 2000a). These low levels (hypoxia) or a lack of oxygen (anoxia) most often occur in bottom waters and affect the organisms that live in the sediments and frequently accompany the onset of severe bacterial degradation, sometimes resulting in the presence of algal scums and noxious odors. However, in some coastal waters, low dissolved oxygen levels occur periodically or may be a part of the waterbody's natural ecology. Therefore, although it is easy to show a snapshot of the conditions of the nation's coastal waters concerning oxygen concentrations, it is difficult to interpret whether this snapshot is representative of all summertime periods (e.g., representative of variable daily conditions) or the result of natural physical processes. Unless otherwise noted, the dissolved oxygen data presented in this report were collected by NCA at 1 meter above the sediment. Dissolved oxygen concentrations at individual monitoring sites and over regions were rated good, fair, or poor using the criteria shown in Table 1-6.

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 does not measure these events because most samples are taken later in the day. 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. In addition, year-to-year variations in dissolved oxygen levels in estuaries can be substantial as a result of a variety of factors, including variations in freshwater inflow, factors affecting water column stratification, and changes in nutrient delivery.

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
Regions	Less than 5% of the coastal area is in poor condition, and more than 50% is in good condition.	5% to 15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 15% of the coastal area is in poor condition.

Calculating the Water Quality Index

Once DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen were assessed for a given site, the water quality index rating was calculated for the site based on these five component indicators. The index was rated good, fair, poor, or missing using the criteria shown in Table 1-7. A water quality index was then calculated for each region using the criteria shown in Table 1-8.

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

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

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

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

Sediment Quality Index

Another issue of major environmental concern in coastal waters 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 coastal waters from urban, agricultural, and industrial sources in a watershed. These contaminants adsorb onto suspended particles and eventually accumulate in depositional basins, where they can disrupt the benthic community of invertebrates, shellfish, and crustaceans that live in or on the sediments. To the extent that the contaminants become concentrated in the organisms, they pose a risk to organisms throughout the food web—including humans.

Several factors influence the extent and severity of 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 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 measured the concentrations of 91 chemical constituents in sediments and evaluated sediment toxicity by measuring the survival of the marine amphipod *Ampelisca abdita* following a 10-day exposure to the sediments under laboratory conditions. The results of these evaluations may be used to identify the most polluted areas and provide clues regarding the sources of contamination.

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

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.

Alternative Views for a Sediment Quality Index

Some resource managers object to using ERM and ERL values to calculate the sediment quality index because the index is also based on actual measurements of toxicity. Because ERMs are acknowledged to be no greater than 50% predictive of toxicity, these managers believe that the same weight should not be given to a non-toxic 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.

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). However, benthic community attributes are included in this assessment of coastal 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 in this report uses the combination of sediment toxicity, sediment contaminants, and sediment TOC to assess sediment condition. Sediment condition is assessed as poor (high potential for exposure effects on biota) at a site if any one of the component indicators is categorized as poor; assessed as fair if the sediment contaminants indicator is rated fair; and assessed as good if all three component indicators are at levels that would be unlikely to result in adverse biological effects due to sediment quality.

Sediment Toxicity

Researchers applied a standard direct test of toxicity at thousands of sites to measure the survival of amphipods (commonly found, shrimp-like benthic crustaceans) exposed to sediments for 10 days under laboratory conditions. As in all tests of toxicity, survival was measured relative to that of amphipods exposed to uncontaminated reference sediment. The criteria for rating sediment toxicity based on amphipod survival for each sampling site are shown in Table 1-9. Table 1-10 shows how these site data were used to evaluate sediment toxicity by region. It should be noted that for this component indicator, unlike the others outlined in this report, only a good or poor rating is possible—there is no fair rating.

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 the coastal area is in poor condition.
Poor	5% or more of the coastal area is in poor condition.

Sediment Contaminants

There are no absolute chemical concentrations that correspond to sediment toxicity, but ERL and ERM values (Long et al., 1995) are used as guidelines in assessing sediment contamination (Table 1-11). ERM is the median concentration (50th percentile) of a contaminant observed to have adverse biological effects in the literature studies examined. A more protective indicator of contaminant concentration is the ERL criterion, which is the 10th percentile concentration of a contaminant represented by studies demonstrating adverse biological effects in the literature. Ecological effects are not likely to occur at contaminant concentrations below the ERL criterion. The criteria for rating sediment contaminants at individual sampling sites are shown in Table 1-12, and Table 1-13 shows how these data were used to create regional ratings for the sediment contaminants component indicator.

Table 1-11. ERM and ERL Guidance Values in Sediments (Long et al., 1995)

Metal*	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**	**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
Analyte**	**ERL**	**ERM**
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

* units are ug/g dry sediment, equivalent to ppm

** 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	No ERM concentrations are exceeded, and 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 the coastal area is in poor condition.
Fair	5% to 15% of the coastal area is in poor condition.
Poor	More than 15% of the coastal area is in poor condition.

Sediment TOC

Sediment contaminant availability or organic enrichment can be altered in areas where there is considerable deposition of organic matter. Although TOC exists naturally in coastal sediments and is the result of the degradation of autochthonous and allochthonous organic materials (e.g., phytoplankton, leaves, twigs, dead organisms), anthropogenic sources (e.g., organic industrial wastes, untreated or only primary-treated sewage) can significantly elevate the level of TOC in sediments. TOC in coastal sediments is often a source of food for some benthic organisms, and high levels of TOC in coastal 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. Sediment toxicity from organic matter is assessed by measuring TOC. 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. The criteria for rating TOC at individual sampling sites are shown in Table 1-14, and Table 1-15 shows how these data were used to create a regional ranking.

Table 1-14. Criteria for Assessing TOC by Site (concentrations on a dry-weight basis)

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

Table 1-15. Criteria for Assessing TOC by Region

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

Calculating the Sediment Quality Index

Once all three sediment quality component indicators (sediment toxicity, sediment contaminants, and sediment TOC) are assessed for a given site, a sediment quality index rating is calculated for the site. 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 component indicators is rated poor, and the sediment contaminants indicator is rated good.
Fair	None of the component indicators is rated poor, and the sediment contaminants indicator is fair.
Poor	One or more of the component indicators is rated 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 the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.
Fair	5% to 15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.
Poor	More than 15% of the coastal area is in poor condition.

Benthic Index

The worms, clams, crustaceans, and other invertebrates that inhabit the bottom substrates of coastal 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 coastal environments because they are not very mobile and thus cannot avoid environmental problems. Benthic population and community characteristics are sensitive to chemical-contaminant and dissolved-oxygen stress, salinity fluctuations, and sediment disturbance and serve as reliable indicators of coastal environmental quality. To distinguish degraded benthic habitats from undegraded benthic habitats, EMAP and NCA have developed regional (Southeast, Northeast, and Gulf coasts) benthic indices of environmental condition (Engle et al., 1994; Weisberg et al., 1997; Engle and Summers, 1999; Van Dolah et al., 1999; Hale and Heltshe, 2006). 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 a waterbody's sediments contain a wide variety of species, as well as a low proportion of pollution-tolerant species and a high proportion of pollution-sensitive species. A low benthic index rating indicates that the benthic communities are less diverse than expected, are populated by more pollution-tolerant species than expected, and contain fewer pollution-sensitive species than expected. The benthic condition data presented throughout this report were collected by the NCA unless otherwise noted. Indices vary by region because species assemblages depend on prevailing temperatures, salinities, and the silt-clay content of sediments. The benthic index was rated poor at a site 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, Puerto Rico, Alaska, and Hawaii are under development and were unavailable for reporting at this time. In these regions, benthic community diversity was determined for each site as a surrogate for the benthic index. 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 coastal 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, Alaska, and Hawaii), then a surrogate benthic index was used based on the ratio of observed to expected diversity. Expected diversity was determined based on the statistical relationship of site diversity to site salinity (or silt-clay content). Poor condition was defined as less than 75% of the expected benthic diversity at a particular salinity (expected diversity was determined by a regression between diversity and salinity). Table 1-18 shows the good, fair, and poor rating criteria for the different regions of the country, which were used to calculate an overall benthic condition rating for each region.

Table 1-18. Criteria for Assessing Benthic Index

Area	Good	Fair	Poor
Northeast Coast sites			
Acadian Province	Benthic index score is greater than or equal to 5.0.	Benthic index score greater than or equal to 4.0 and less than 5.0.	Benthic index score is less than 4.0.
Virginian Province	Benthic index score is greater than 0.0.	NA*	Benthic index score is less than 0.0.
Southeast Coast sites	Benthic index score is greater than 2.5.	Benthic index score is between 2.0 and 2.5.	Benthic index score is less than 2.0.
Gulf Coast sites	Benthic index score is greater than 5.0.	Benthic index score is between 3.0 and 5.0.	Benthic index score is less than 3.0.

Table 1-18. (Continued)

West Coast, Alaska, and Hawaii sites (compared to expected diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of expected mean diversity for a specific salinity.	Benthic index score is between 75% and 90% of the lower limit of expected mean diversity for a specific salinity.	Less than 75% of observations had expected diversity.
Puerto Rico sites (compared to upper 95% confidence interval for mean regional benthic diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of mean diversity in unstressed habitats in Puerto Rico.	Benthic index score is between 75% and 90% of the lower limit of mean diversity in unstressed habitats in Puerto Rico.	Benthic index score is less than 75% of the lower limit of mean diversity for unstressed habitats in Puerto Rico.
Regions	Less than 10% of the coastal area has a poor benthic index score, and more than 50% of the coastal area has a good benthic index score.	10% to 20% of the coastal area has a poor benthic index score, or more than 50% of the coastal area has a combined poor and fair benthic index score.	More than 20% of the coastal area has a poor benthic index score.

*By design, this index discriminates between good and poor conditions only.

Coastal Habitat Index

Coastal wetlands are the vegetated interface between the aquatic and terrestrial components of coastal ecosystems. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife. These habitats filter and process residential, agricultural, and industrial wastes, thereby improving surface water quality. Wetlands also buffer coastal areas against storm and wave damage. A large portion of commercial and 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 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).

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. For more information about wetlands, refer to EPA's wetlands Web site at http://www.epa.gov/owow/wetlands.

Because no new information on U.S. wetlands was available from the NWI, the assessment of coastal habitat from the NCCR II was used in this report. The NWI (2002) contains data on estuarine emergent and tidal flat wetland acreage from 1990 and 2000 for all coastal states, 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 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 coastal area). Table 1-19 shows the rating criteria used for the coastal habitat index.

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.

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 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.

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

For the NCA surveys, target fish were collected from all sites where fish were available, and whole-body contaminant burdens were determined. No EPA Advisory Guidance values exist to assess the ecological risk of whole-body contaminants for fish, but EPA Advisory Guidance values can be used as a basis for estimating advisory determinations, even if the data are based on whole-fish or organ-specific body burdens (Table 1-20) (U.S. EPA, 2000b). The whole-fish contaminant information collected by NCA for U.S. coastal waters was compared with risk-based thresholds based on a 154-pound adult human's consumption of four 8-ounce meals per month for selected contaminants (approach used by most state advisory programs) and assessed for non-cancer and cancer health endpoints (U.S. EPA, 2000b). Table 1-21 shows the rating criteria for the fish tissue contaminants index for each site, and Table 1-22 shows how these site ratings were used to create a regional rating.

Table 1-20. Risk-based EPA Advisory Guidance Values for Recreational Fishers (U.S. EPA, 2000b)

Contaminant	EPA Advisory Guidelines Concentration Range (ppm)[a]	Health Endpoint
Arsenic (inorganic)[b]	0.35–0.70	non-cancer
Cadmium	0.35–0.70	non-cancer
Mercury	0.12–0.23	non-cancer
Selenium	5.9–12.0	non-cancer
Chlordane	0.59–1.2	non-cancer
DDT	0.059–0.12	non-cancer
Dieldrin	0.059–0.12	non-cancer
Endosulfan	7.0–14.0	non-cancer
Endrin	0.35–0.70	non-cancer
Heptachlor epoxide	0.015–0.031	non-cancer
Hexachlorobenzene	0.94–1.9	non-cancer
Lindane	0.35–0.70	non-cancer
Mirex	0.23–0.47	non-cancer
Toxaphene	0.29–0.59	non-cancer
PAH (Benzo(a)pyrene)	0.0016–0.0032	cancer[c]
PCB	0.023–0.04	non-cancer

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

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

Rating	Criteria
Good	For all chemical contaminants listed in Table 1-20, the index scores fall below the range of the EPA Advisory Guidance* values for risk-based consumption associated with four 8-ounce meals per month.
Fair	For at least one chemical contaminant listed in Table 1-20, the index score falls within the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.
Poor	For at least one chemical contaminant listed in Table 1-20, the index score exceeds the maximum value in the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.

* The EPA Advisory Guidance concentration is based on the non-cancer ranges for all contaminants except PAHs (benzo(a)pyrene), which are based on a cancer range because a non-cancer range for PAHs does not exist (see Table 1-20).

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

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

Summary of Rating Criteria

The rating criteria used in this report are summarized in Table 1-23 (primary indices) and Tables 1-24 and 1-25 (component indicators).

Table 1-23. NCA Indices Used to Assess Coastal Condition

Ecological Condition by Site	Ranking by Region
Water Quality Index – This index is based on measurements of five water quality component indicators (DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen).	
Ecological Condition by Site	**Ranking by Region**
Good: No component indicators are rated poor, and a maximum of 1 is rated fair. **Fair:** One component indicator is rated poor, or 2 or more component indicators are fair. **Poor:** Two or more component indicators are rated poor.	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** Between 10% and 20% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 20% of the coastal area is in poor condition.
Sediment Quality Index – This index is based on measurements of three sediment quality component indicators (sediment toxicity, sediment contaminants, and sediment TOC).	
Ecological Condition by Site	**Ranking by Region**
Good: No component indicators are rated poor, and the sediment contaminants indicator is rated good. **Fair:** No component indicators are rated poor, and the sediment contaminants indicator is rated fair. **Poor:** One or more component indicators are rated poor.	**Good:** Less than 5% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** Between 5% and 15% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined poor and fair condition. **Poor:** More than 15% of the coastal area is in poor condition.
Benthic Index (or a surrogate measure) – This index indicates the condition of the benthic community (organisms living in coastal 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 dependent benthic index scores.	**Good:** Less than 10% of the coastal area has a poor benthic index score, **and** more than 50% of the coastal area has a good benthic index score. **Fair:** Between 10% and 20% of the coastal area has a poor benthic index score, **or** more than 50% of the coastal area has a combined poor and fair benthic index score. **Poor:** More than 20% of the coastal area has a poor benthic index score.
Coastal Habitat Index – This index is evaluated using the data from the NWI (NWI, 2002), which 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.

Table 1-23. (Continued)

Fish Tissue Contaminants Index – This index indicates the level of chemical contamination in target fish/shellfish species.	
Ecological Condition by Site	**Ranking by Region**
Good: For all chemical contaminants listed in Table 1-20, the index scores fall below the range of the EPA Advisory Guidance* values for risk-based consumption associated with four 8-ounce meals per month. **Fair:** For at least one chemical contaminant listed in Table 1-20, the index score falls within the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month. **Poor:** For at least one chemical contaminant listed in Table 1-20, the index score exceeds the maximum value in the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.	**Good:** Less than 10% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition, and more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in good condition. **Fair:** 10% to 20% of the fish samples analyzed (Northeast Coast region) or monitoring stations where fish were caught (all other regions) are in poor condition, or more than 50% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in combined poor and fair condition. **Poor:** More than 20% of the fish samples analyzed (Northeast Coast region) or the monitoring stations where fish were caught (all other regions) are in poor condition.

* The EPA Advisory Guidance concentration is based on the non-cancer ranges for all contaminants except PAHs (benzo(a)pyrene), which are based on a cancer range because a non-cancer range for PAHs does not exist (see Table 1-20).

Table 1-24. NCA Criteria for the Five Component Indicators Used in the Water Quality Index to Assess Coastal Condition

Dissolved Inorganic Nitrogen (DIN)	
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, Alaska), or 0.05 mg/L (tropical*). **Fair:** Surface concentrations are 0.1–0.5 mg/L (NE, SE, Gulf), 0.5–1.0 mg/L (West, Alaska), or 0.05–0.1 mg/L (tropical*). **Poor:** Surface concentrations are greater than 0.5 mg/L (NE, SE, Gulf), 1.0 mg/L (West, Alaska), or 0.1 mg/L (tropical*).	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 25% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 25% of the coastal area is in poor condition.

Table 1-24. (Continued)

Dissolved Inorganic Phosphorus (DIP)	
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, Alaska), or 0.005 mg/L (tropical*). **Fair:** Surface concentrations are 0.01–0.05 mg/L (NE, SE, Gulf), 0.01–0.1 mg/L (West, Alaska), or 0.005–0.01 mg/L (tropical*). **Poor:** Surface concentrations are greater than 0.05 mg/L (NE, SE, Gulf), 0.1 mg/L (West, Alaska), or 0.01 mg/L (tropical*).	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 25% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 25% of the coastal area is in poor condition.
Chlorophyll *a*	
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*). **Fair:** Surface concentrations are between 5 µg/L and 20 µg/L (between 0.5 µg/L and 1 µg/L for tropical ecosystems*). **Poor:** Surface concentrations are greater than 20 µg/L (greater than 1 µg/L for tropical ecosystems*).	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 20% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 20% of the coastal area is in poor condition.
Water Clarity	
Ecological Condition by Site	**Ranking by Region**
Good: Amount of light at 1 meter is greater than 10% (coastal waters with high turbidity), 20% (coastal waters with normal turbidity), or 40% (coastal waters that support SAV) of surface illumination. **Fair:** Amount of light at 1 meter is 5–10% (coastal waters with high turbidity), 10–20% (coastal waters with normal turbidity), or 20–40% (coastal waters that support SAV) of surface illumination. **Poor:** Amount of light at 1 meter is less than 5% (coastal waters with high turbidity), 10% (coastal waters with normal turbidity), or 20% (coastal waters that support SAV) of surface illumination.	**Good:** Less than 10% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 10% to 25% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 25% of the coastal area is in poor condition.
Dissolved Oxygen	
Ecological Condition by Site	**Ranking by Region**
Good: Concentrations are greater than 5 mg/L. **Fair:** Concentrations are between 2 mg/L and 5 mg/L. **Poor:** Concentrations are less than 2 mg/L.	**Good:** Less than 5% of the coastal area is in poor condition, **and** more than 50% of the coastal area is in good condition. **Fair:** 5% to 15% of the coastal area is in poor condition, **or** more than 50% of the coastal area is in combined fair and poor condition. **Poor:** More than 15% of the coastal area is in poor condition.

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

Table 1-25. NCA Criteria for the Three Component Indicators Used in the Sediment Quality Index to Assess Coastal Condition

Sediment Toxicity is evaluated as part of the sediment quality index using a 10-day static toxicity test with the organism *Ampelisca abdita.*	
Ecological Condition by Site	**Ranking by Region**
Good: Mortality* is less than or equal to 20%. **Poor:** Mortality is greater than 20%.	**Good:** Less than 5% of the coastal area is in poor condition. **Poor:** 5% or more of the coastal area is in poor condition.
Sediment Contamination is evaluated as part of the sediment quality index using ERM and ERL guidelines.	
Ecological Condition by Site	**Ranking by Region**
Good: No ERM values are exceeded, and fewer than five ERL values are exceeded. **Fair:** No ERM values are exceeded, and five or more ERL values are exceeded. **Poor:** One or more ERM values are exceeded.	**Good:** Less than 5% of the coastal area is in poor condition. **Fair:** 5% to 15% of the coastal area is in poor condition. **Poor:** More than 15% of the coastal area is in poor condition.
Sediment Total Organic Carbon (TOC)	
Ecological Condition by Site	**Ranking by Region**
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%.	**Good:** Less than 20% of the coastal area is in poor condition. **Fair:** 20% to 30% of the coastal area is in poor condition. **Poor:** More than 30% of the coastal area is in poor condition.

*Test mortality is adjusted for control mortality.

How the Indices Are Summarized

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

Indices	**Score**
Water Quality Index	3
Sediment Quality Index	3
Benthic Index	5
Coastal Habitat Index	3
Fish Tissue Contaminants Index	4
Total Score Divided by 5 = Overall Score	**19/5 = 3.6**

The overall condition and index scores for the nation are calculated based on a weighted average of the regional scores for each index. The national ratings for overall condition and each index are then assigned based on these calculated scores, rather than on the percentage of area in good, fair, or poor condition. The indices were weighted based on the coastal area contributed by each geographic area. 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 (Figure 1-4). These weighting factors were used for all indices except the coastal habitat index, which used the geographic distribution of total area of coastal wetlands (Figure 1-5). The national overall condition score was then calculated by summing each national index score and dividing by five.

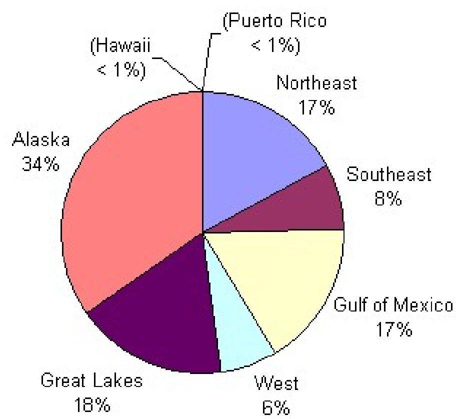

Figure 1-4. Percentage of coastal area contributed by each geographic region assessed in this report.

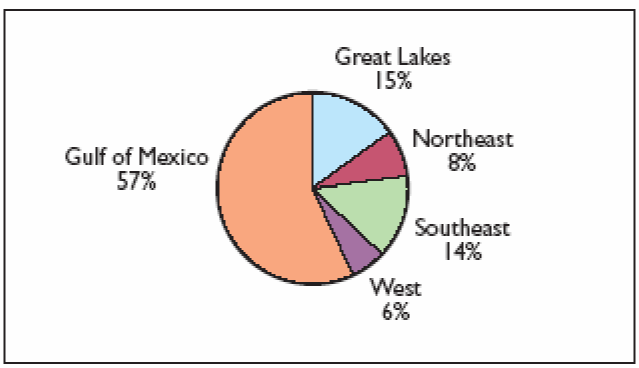

Figure 1-5. Percentage of coastal wetland area contributed by each geographic region assessed in this report.

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 (3 to 200 nautical miles offshore) to the coastal waters and wetlands of the United States constitute the U.S. Exclusive Economic Zone (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 coasts within the boundaries of U.S. LMEs. Information on the status of the fish stocks comes from NMFS assessment data for nine LMEs, including the Northeast Shelf, Southeast Shelf, Gulf of Mexico, California Current, Gulf of Alaska, East Bering Sea, and Insular Pacific LMEs. Ultimately, the Secretary of Commerce has management responsibility for most marine life in 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 living marine resources within U.S. LMEs was compiled from the NMFS productivity data and the report *Our Living Oceans* (NMFS, 2006), which is issued periodically by the NMFS and covers 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, thousands of private firms, and individuals, families, and communities. As shown in Figure 1-6, in 2004

- U.S. commercial fishermen landed 9.6 billion pounds of fish and shellfish, valued at $3.7 billion.
- The commercial marine fishing industry contributed an estimated $31.6 billion (in value added) to the nation's GNP.
- U.S. consumers spent an estimated $61.9 billion for fishery products (NMFS, 2005).

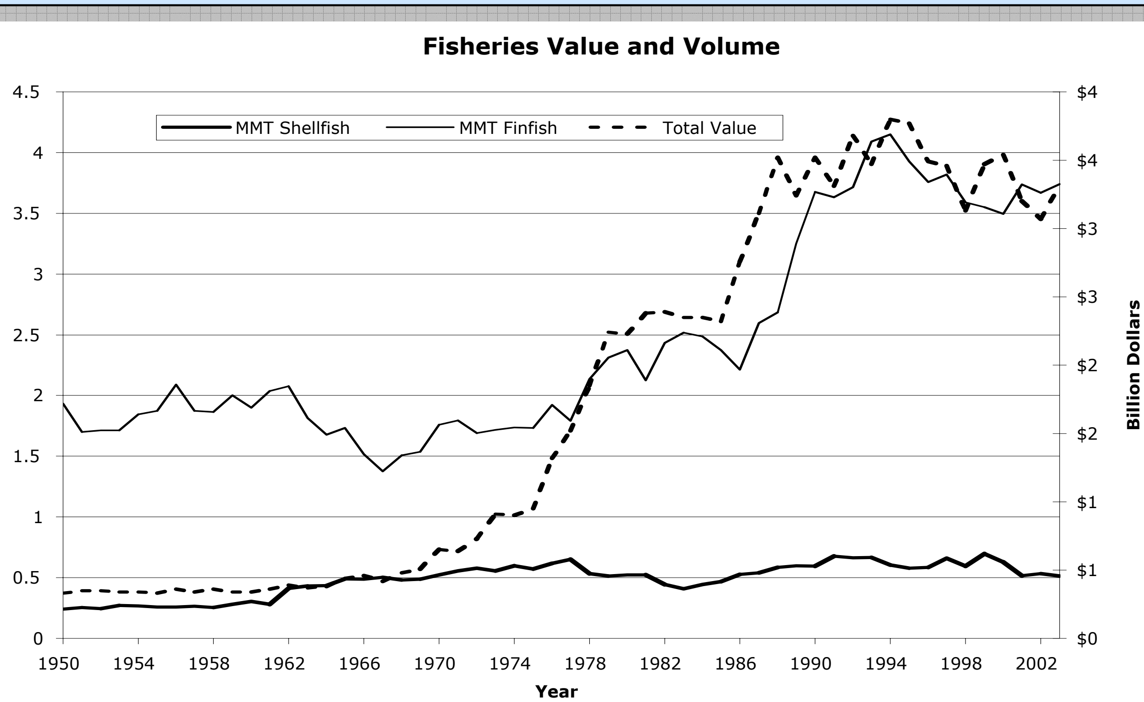

Figure 1-6. Trends in commercial fisheries landings since 1950. Landings reached a peak of 4.8 mmt (10.5 billion pounds) in 1993 and 1994 and a value of $3.8 billion. (FAO, 2005).

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 Advisories (NLFA) 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 the public's perception of coastal condition 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, and 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.

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. The 305(b) assessment data (submitted by the states in 2002) are stored in EPA's National Assessment Database (NAD) and are useful for evaluating the success of state water quality improvement efforts; however, it should be emphasized that 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. For the 2002 reporting cycle, several states and island territories with estuarine and coastal marine waters did not submit 305(b) assessment information to EPA. For the states of North Carolina and Washington, as well as the island territories of American Samoa, Guam, and the Northern Marianas Island, no data were available for the 2002 reporting cycle in the NAD. Because the reporting of 305(b) information was not complete for all coastal states and territories, it was decided that this information would not be summarized for inclusion in the NCCR III. For this report, only data from EPA's NLFA database and BEACH PRogram tracking, beach Advisories, Water quality standards, and Nutrients (PRAWN) database are presented for calendar year 2003.

National Listing of Fish 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 2003 NLFA 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 NLFA 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.

From 1997 through 2002, beach monitoring data was collected and submitted to EPA on a voluntary basis. During this time, sampled areas included coastal, Great Lakes, and some inland waters. Beginning with the 2003 season, the BEACH Act required that states submit data to EPA for beaches that are in coastal and Great Lakes waters and for all other beaches, as available. Due to the new reporting requirements, the 2003 and 2004 data cannot easily be compared to data gathered from 1997 through 2002, and long-term patterns are difficult to establish.

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 2003, there were 839 beach closures and advisories in coastal and Great Lakes waters (U.S. EPA, 2006).

Connections with Human Uses

The first eight chapters of this report address the condition of the nation's coastal waters in terms of how well these waters meet ecological criteria. A related, but separate consideration is how well coasts are meeting human expectations in terms of services they provide for transportation, development, fishing, recreation, and other uses. Human use does not necessarily compromise ecological condition, but there are inherent conflicts between human activities that alter the natural state of the coast (e.g., marine transportation) and activities (e.g., fishing) that rely on the bounty of nature. In Chapter 9 of this report, the emphasis is on human uses for a particular estuary, Rhode Island's Narragansett Bay, and how well these uses are met. Because this approach relies on local information, it can be pursued only at the level of an individual estuary. The corresponding chapter in the NCCR II centered on Galveston Bay, TX.. The choice of Narragansett Bay is to a large extent dictated by the availability of long-term data on the abundances of commercial and recreational fishes for this estuary. Fishing is not the only human use of an estuary, but it is an important use thought to be strongly connected with ecological indicators.

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Chapter 2

National Coastal Condition

As shown in Figure 2-1, the overall condition of the nation's coastal waters is rated fair; the water quality index is rated good to fair; the sediment quality and fish tissue contaminants indices are rated fair; the coastal habitat index is rated poor; and the benthic index is rated fair to poor. Figure 2-2 provides a summary of the percentage of coastal area rated good, fair, poor, or missing for each index and component indicator. This assessment is based on environmental stressor and response data collected between 1998 and 2002 from 2,424 sites in the 24 coastal states of the conterminous United States; the states of Hawaii and Puerto Rico; and the south-central coast of Alaska (Figure 2-3); about 85% of these data were collected in 2001 and 2002. Please refer to Tables 1-23, 1-24, and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

The condition of U.S. coastal waters was determined for this report by combining assessments from the Northeast, Southeast, Gulf, and West Coast regions of the conterminous U.S. with those from Alaska, Hawaii, and Puerto Rico (Figure 2-3). It should be noted that the overall condition and index scores for the nation are determined using a weighted average of the regional scores, rather than the percent area rated good, fair, and poor. Alaska and Hawaii were not included in the national assessment presented in the NCCR II (EPA, 2004b) because data were unavailable for the coastal areas of those states. A

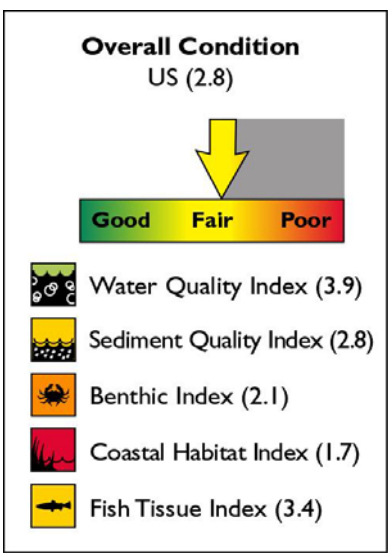

Figure 2-1. The overall condition of U.S. coastal waters is rated fair (U.S. EPA/NCA).

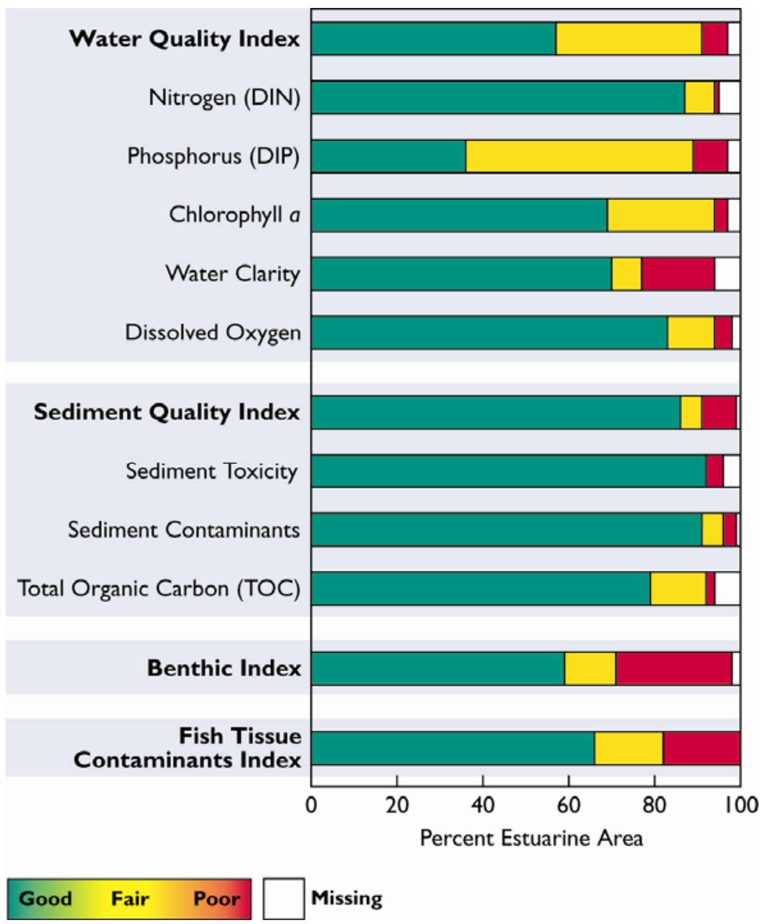

Figure 2-2. Percentage of coastal area achieving each ranking for all indices and component indicators –United States (U.S. EPA/ NCA).

comparison of coastal condition based on data that includes data for Alaska and Hawaii (NCCR III) versus condition with these data excluded (NCCR II) is provided later in this chapter.

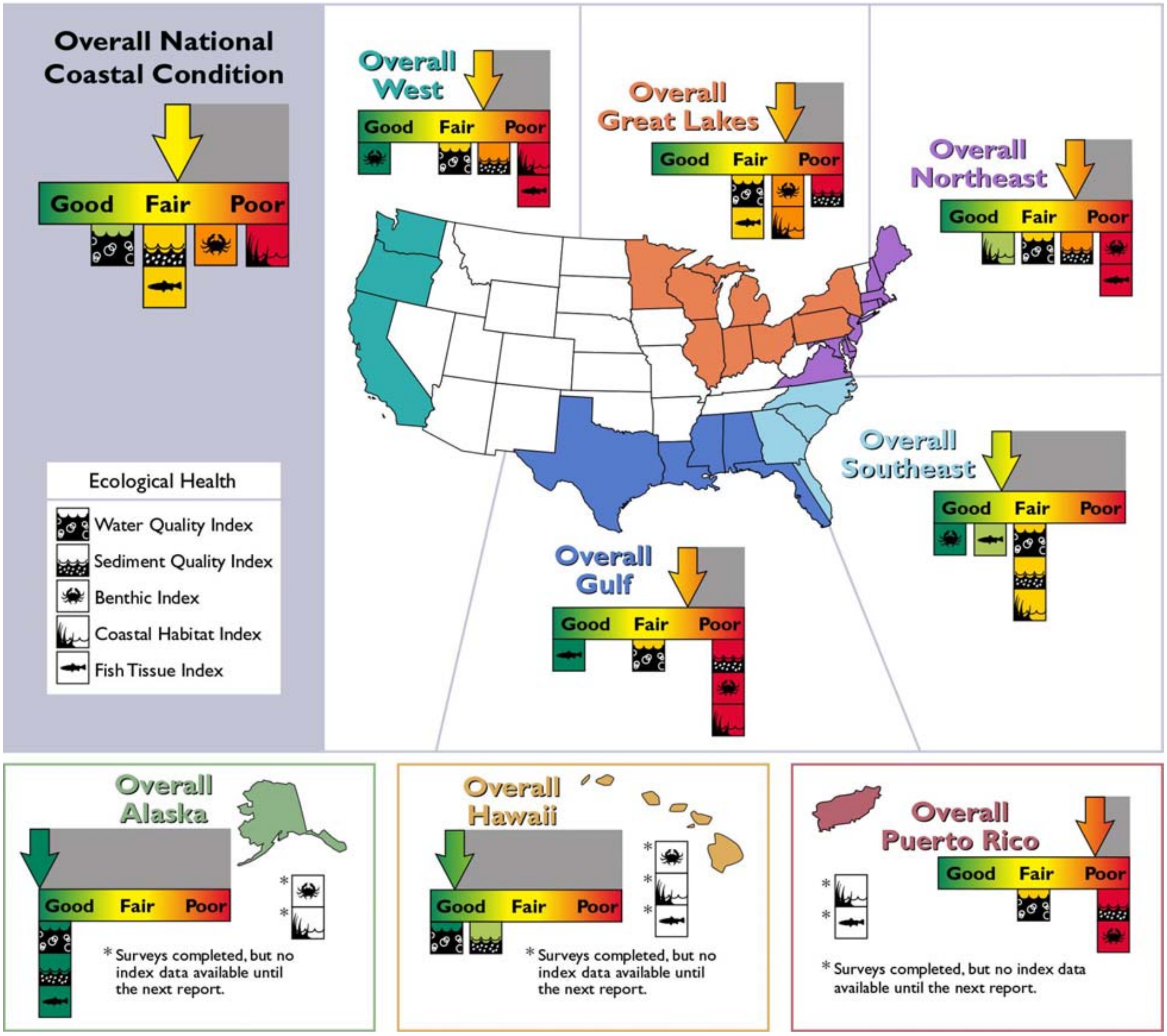

Figure 2-3. Overall national and regional coastal condition between 1998 and 2002 (U.S. EPA/NCA).

Figure 2-4 summarizes the condition of the nation's coastal waters (including portions of the coastal waters of Alaska and Hawaii), as well as provides regional and individual summaries for Hawaii, Puerto Rico, and south-central Alaska. The water quality index is rated fair or good for regions throughout the United States, although the coastal waters of the West Coast region are rated poor for water clarity and the coastal waters of Puerto Rico are rated poor for chlorophyll *a*. The sediment quality index is rated poor for the Gulf Coast, Puerto Rico, and Great Lakes regions; fair to poor for the Northeast Coast and West Coast regions; fair for the Southeast Coast region; good to fair for Hawaii; and good for Alaska. The benthic index shows that biological conditions are rated poor in the coastal waters of the Northeast Coast, Gulf Coast, and Puerto Rico regions; fair to poor in the coastal waters of the Great Lakes region; and good in the coastal waters of the West Coast and Southeast Coast regions. The fish tissue contaminants index is rated poor for the coastal waters of the Northeast Coast and West Coast regions, fair for the Great Lakes region, and rated either good to fair or good for the remainder of the country.

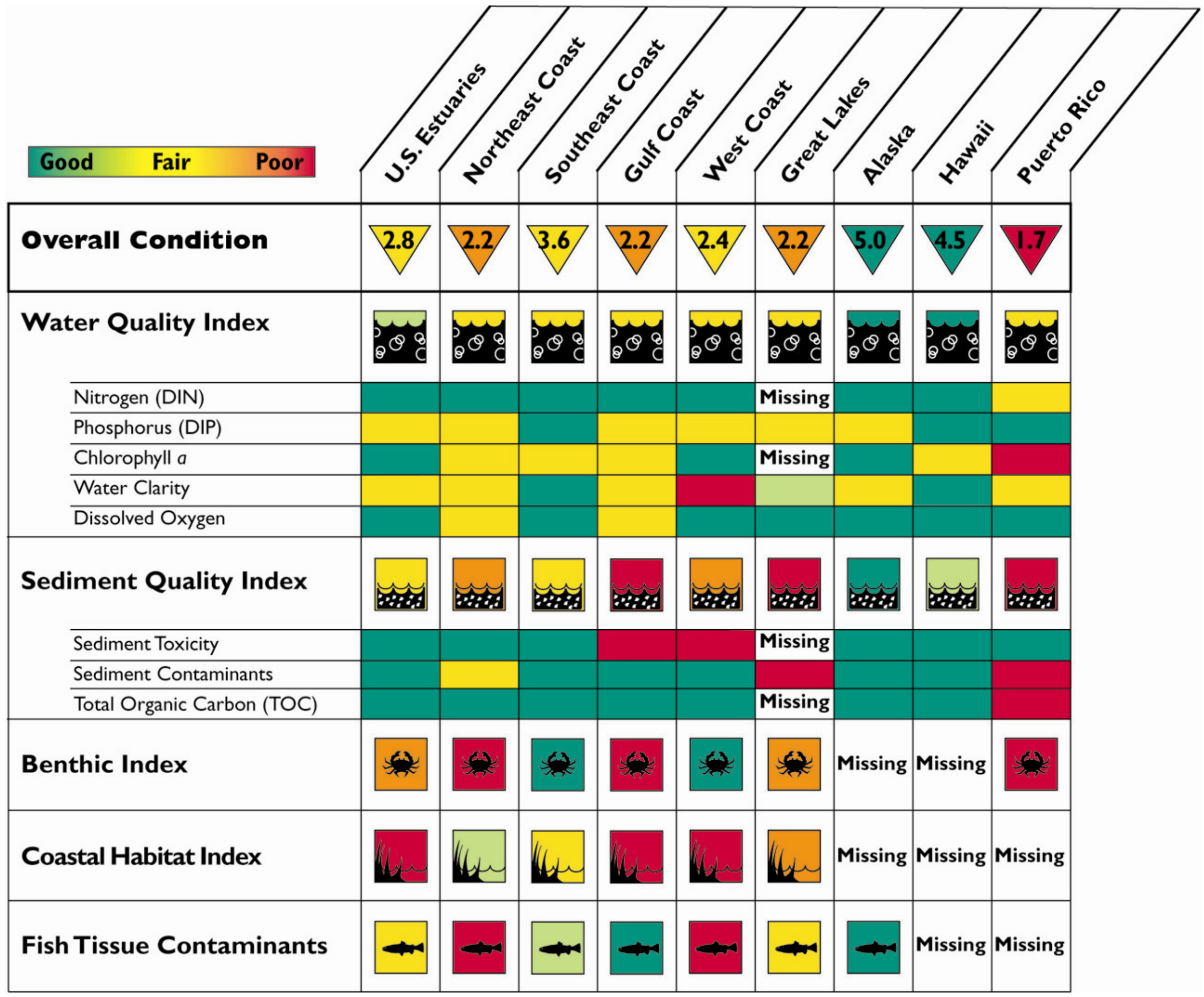

Figure 2-4. Overall national and regional coastal condition between 2001–2002 (U.S. EPA/NCA).

The population of the nation's collective coastal counties increased by 33 million people between 1980 and 2003 (Figure 2-5), constituting a 28% growth rate (NOAA, 2004). This growth rate matched that of the nation's total population, which increased by 63.3 million people during the same time period (U.S. Census Bureau, 2006); however, coastal population increases are frequently accompanied by larger population density increases and greater demands for limited resources because the land area of the nation's coasts comprises roughly 17% of the U.S. total land area (NOAA, 2004). Figure 2-6 shows the distribution of the U.S. coastal population in 2003.

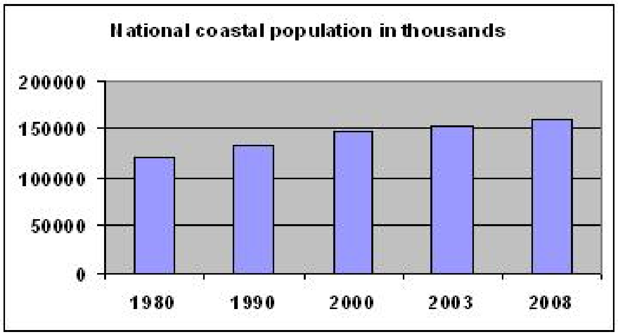

Figure 2-5. Actual and estimated population of U.S. coastal counties from 1980 to 2008 (NOAA, 2004).

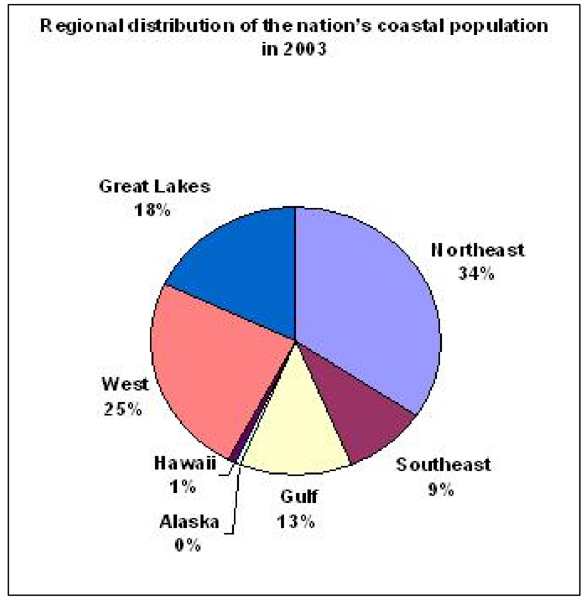

Figure 2-6. Regional distribution of the nation's coastal population in 2003 (NOAA, 2004).

Coastal Monitoring Data – Status of Coastal Condition

This section presents the monitoring data used to rate the five indices of coastal condition assessed in this report. These calculations do not include proportional area and location data for the Great Lakes because, due to sampling design differences in the data sets, areal estimates for the Great Lakes cannot be determined. Although the Great Lakes data are not presented in this section, they are addressed when discussing condition scores in specific regions of the country. Chapter 7 provides further details of the Great Lakes monitoring data.

Water Quality Index

The water quality index for the nation's coastal waters is rated good to fair, with 6% of the coastal area rated poor and 34% rated fair for water quality condition (Figure 2-7). The water quality index was determined based on measurements of five component indicators — DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Based on the NCA results, 40% of the nation's coastal waters experience a moderate-to-high degree of water quality degradation. Fair condition is generally characterized by degradation in water quality response variables (e.g., increased chlorophyll *a* concentrations or decreased dissolved oxygen concentrations). Although poor condition is characterized by some degradation in response variables, it is more likely to be characterized by degradation due to environmental stressors (e.g., increased nutrient concentrations and reduced water clarity). The West Coast region has the lowest proportion of coastal area (23%) rated good for water quality. Although none of the regions outlined in this report are rated poor for water quality, the Gulf Coast has the highest proportion of coastal area rated poor for this index (14%), followed by the Northeast Coast (13%) and Puerto Rico (9%) regions.

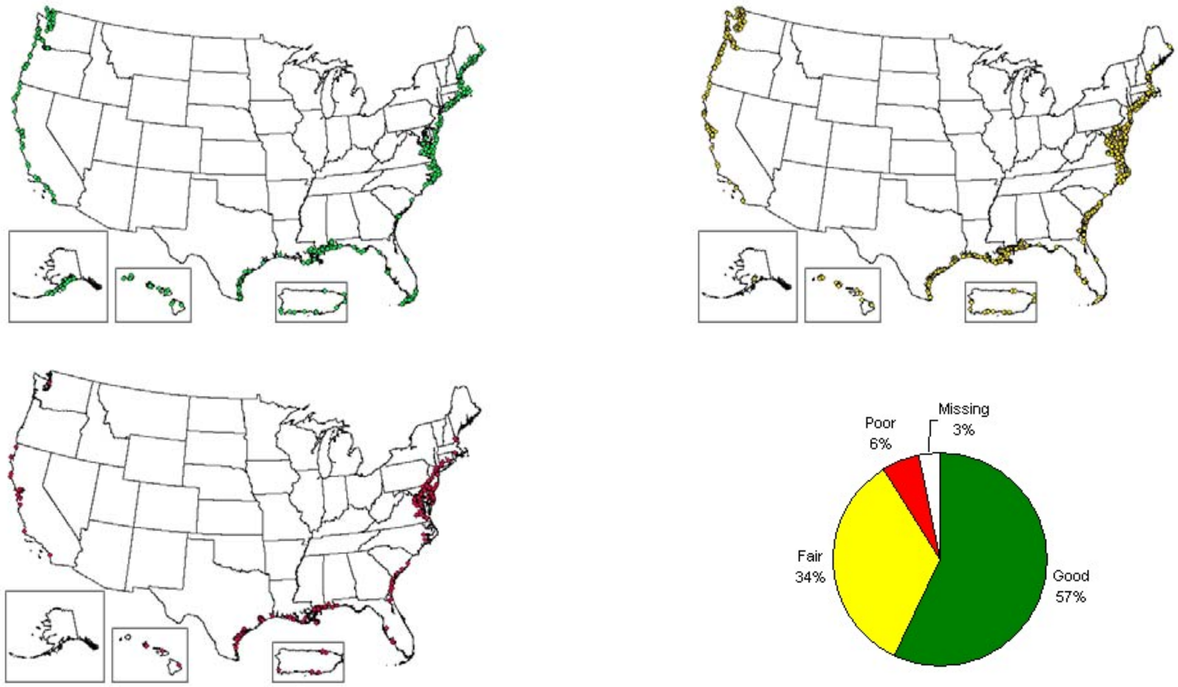

Figure 2-7. Water quality index data for the nation's coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The nation's coastal waters are rated good for DIN concentrations, with only 1% of the coastal area rated poor. The highest percent of coastal area rated poor for DIN concentrations occurred in the Northeast Coast (5%) region and Hawaii (5%). U.S. coastal waters are rated fair for DIP concentrations, with 8% of the coastal area rated poor for this component indicator and 53% of the area rated fair. Elevated summer DIP concentrations were most often observed in the coastal waters of the Gulf Coast region (22%).

Chlorophyll *a*

The nation's coastal waters are rated good for chlorophyll *a* concentrations, with 3% of the coastal area rated poor and 25% of the area rated fair for this component indicator. Puerto Rico was the only region of the country rated poor for chlorophyll *a* concentrations, with 71% of the region's coastal area rated fair and poor (combined) for this component indicator. Moderate summer chlorophyll *a* concentrations also occurred in the coastal waters of the Southeast Coast (59%) and Gulf Coast (52%) regions. With the exception of Puerto Rico, none of the regions experienced large expanses of poor condition for chlorophyll *a* concentrations (Southeast = 9%, Northeast = 9%, Hawaii = 13%, and Gulf Coast = 7%).

Water Clarity

The nation's coastal waters are rated fair for water clarity, with 17% of the U.S. coastal area rated poor for this component indicator. Sites with poor water clarity are distributed throughout the country, but the regions with the greatest proportion of total coastal area rated poor are the West Coast (36%), Gulf Coast (22%), Northeast Coast (20%) and Puerto Rico

(20%) regions. Three different reference conditions were established for measuring water clarity conditions in U.S. waters (see table below).

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 Bay, Mobile Bay, Mississippi) 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.

Dissolved Oxygen

Dissolved oxygen conditions in the nation's coastal waters are rated good, with 4% of the coastal area rated poor and 11% rated fair for this component indicator. The Northeast Coast region showed the greatest proportion of coastal area (9%) experiencing low dissolved oxygen concentrations.

The NCA measures dissolved oxygen conditions only in nearshore coastal waters and does not include observations of dissolved oxygen concentrations in offshore coastal shelf waters. The Gulf of Mexico hypoxic zone is the largest zone of anthropogenic coastal hypoxia in the Western Hemisphere (CAST, 1999), and the occurrence of hypoxia in Gulf of Mexico shelf waters is a well-known and documented phenomenon. Between 1989 and 1999, the mid-summer hypoxic zone in Gulf of Mexico bottom waters steadily increased in area to include nearly 8,000 mi^2. In 2000, the hypoxic zone decreased in area to less than 1,800 mi^2; however, the zone returned to about 8,000 mi^2 in 2001 and 2002 (the years covered by NCA surveys in this report). The reduction in the size of the hypoxic zone in 2000 corresponds to severe drought conditions in the Mississippi River watershed and, presumably, to decreased flow and loading to the Gulf of Mexico from the river mouth. The long-term average area of the Gulf of Mexico hypoxic zone is 4800 mi^2 (1985–2005). A more complete discussion of the Gulf of Mexico hypoxic zone is provided in Chapter 5 of this report, *Gulf Coast Coastal Condition*.

Interpretation of Instantaneous Dissolved Oxygen Information

Although the NCA 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 the 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 North Carolina's Neuse and Pamlico rivers and Rhode Island's Narragansett Bay 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

The sediment quality index for the nation's coastal waters is rated fair, with approximately 8% of the coastal area rated poor for sediment quality condition (Figure 2-8). The sediment quality index is based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. The region showing the largest proportional area with poor sediment quality was Puerto Rico (61%), followed by the Gulf Coast (18%), Northeast Coast (13%), and West Coast (14%) regions. Although there are no areal estimates for poor sediment condition in the Great Lakes region, local, non-probabilistic surveys of that region resulted in a sediment quality index rating of poor. Alaska and Hawaii were the only regions that were rated good or good to fair for sediment quality condition.

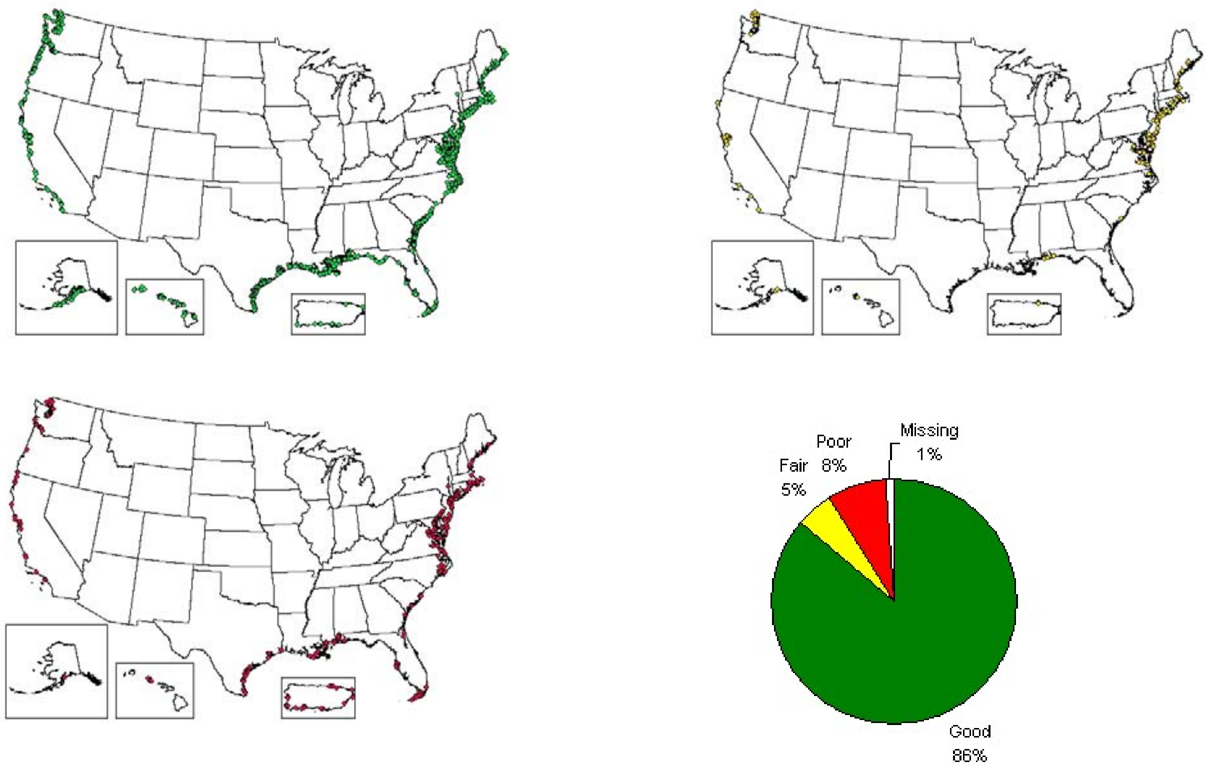

Figure 2-8. Sediment quality index data for the nation's coastal waters (U.S. EPA/NCA).

Sediment Toxicity

Sediment toxicity in the nation's coastal waters is rated good, with 4% of the U.S. coastal area rated poor for this component indicator. Sediment toxicity was observed most often in sediments of the West Coast (17%) and Gulf Coast (13%) regions.

Sediment Contaminants

The sediment contaminants component indicator for the nation's coastal waters is rated good. Poor sediment contaminant condition was observed in 3% of the coastal area, and fair condition was observed in an additional 5% of the coastal area. The highest proportion of area rated poor for sediment contaminants occurred in Puerto Rico (23%), followed by the Northeast Coast (9%) region. Although there are no areal estimates for poor sediment contaminant condition in the Great Lakes region, local, non-probabilistic surveys of that region produced results indicating a poor rating for this component indicator.

Sediment TOC

The nation's coastal waters are rated good for sediment TOC concentrations, with only 2% of the U.S. coastal area rated poor for this component indicator. The only region rated poor for this component indicator was Puerto Rico, where coastal sediments showed high levels of TOC in 44% of the coastal area.

Benthic Index

The benthic index for the nation's coastal waters is rated fair to poor, with 27% of the nation's coastal area rated poor for benthic condition (i.e., the benthic 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 multi-metric benthic indices) (Figure 2-9). The regions with the greatest proportion of coastal area in poor benthic condition were the Gulf Coast (45%), Puerto Rico (35%), and Northeast Coast (27%) regions. The Southeast Coast and West Coast are the only regions where benthic condition was rated good. Data were unavailable to assess the integrity of benthic communities in Hawaii and south-central Alaska.

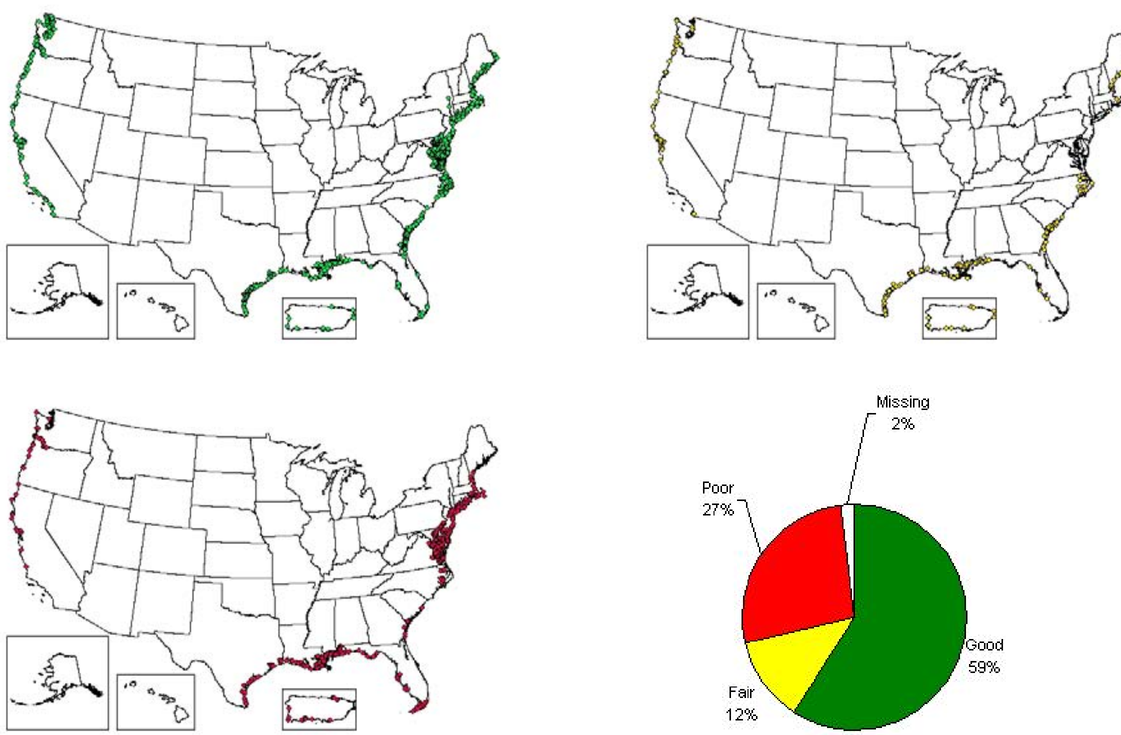

Figure 2-9. National benthic index condition (U.S. EPA/NCA).

Coastal Habitat Index

The coastal habitat index ratings outlined in this report are the same as those reported in the NCCR II because more recent data on coastal habitat conditions were unavailable for incorporation in this document. 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 2-1). 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). From 1990 to 2000, the United States lost approximately 13,210 acres of coastal wetlands (exclusive of the Great Lakes region), resulting in 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 coastal habitat index rating of poor for the nation's coastal waters. The largest index scores were seen in West Coast (1.90) and in Gulf Coast (1.30) regions. Because Gulf Coast wetlands constitute two-thirds of the coastal wetlands in the conterminous 48 states, and the Gulf Coast coastal habitat 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 this region as fair to poor for coastal habitat condition. Figure 2-10 compares the national and regional percentages of wetlands lost.

Table 2-1. Changes in Marine and Estuarine Wetlands, 1780 to 1990 and 1990 to 2000 (Dahl, 1990; 2003).

Coastline or Area	Area 1990 (acres)	Area 2000 (acres)	Change 1990–2000 (acres)(%)	Mean Decadal Loss Rate 1780–1990	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

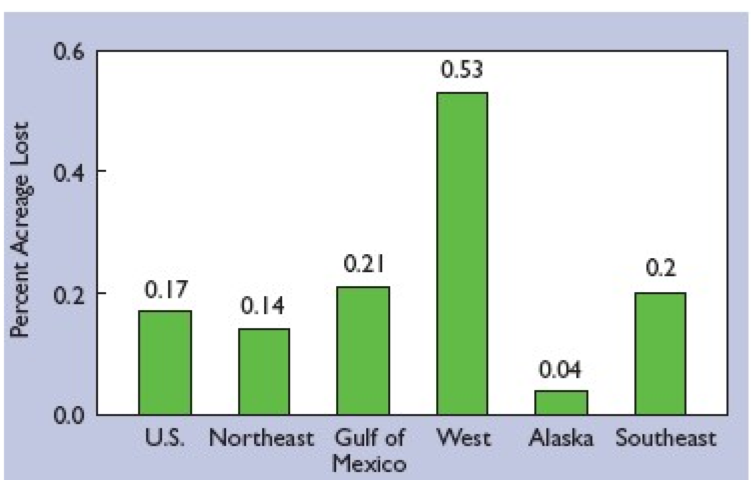

Figure 2-10. Wetlands loss data (Dahl, 2003).

Fish Tissue Contaminants Index

The fish tissues contaminants index for the nation's coastal waters is rated fair. Figure 2-11 shows that 18% of all sites where fish were caught showed contaminant concentrations in fish tissues above EPA Advisory Guidance values. The NCA examined whole-body composite samples (5 to 10 fish of a target species per site) for 90 specific contaminants from 1,277 sites throughout the coastal waters of the United States (excluding Hawaii and Puerto Rico). 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. Areas of poor and fair condition were dominated by elevated concentrations of total PCBs, total DDT, total PAHs, and mercury. In the Northeast Coast region, 31% of sites where fish were caught were rated poor for fish tissue contaminant levels and 28% were rated fair (the Northeast Coast showed poor or fair condition for more than 50% of the sites yielding fish). Alaska and the Gulf Coast region were the only regions that received good ratings for the fish tissue contaminants index.

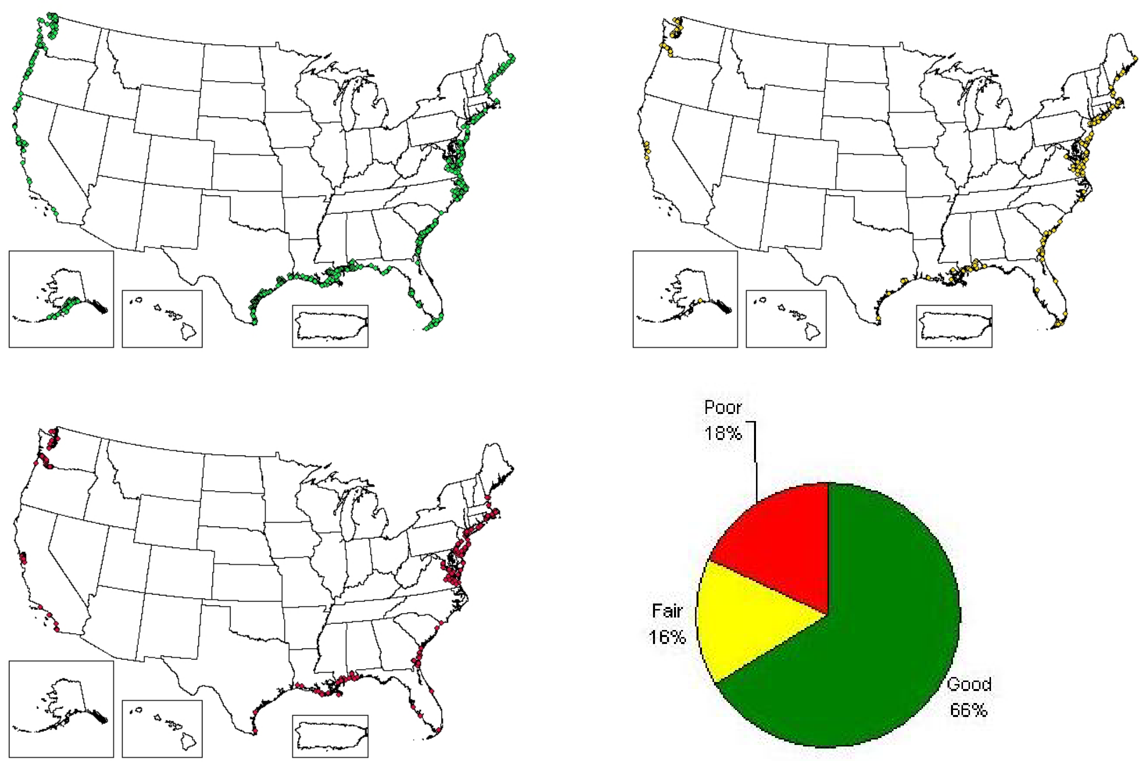

Figure 2-11. National fish tissue contaminants index condition (U.S. EPA/NCA).

National Coastal Condition, Excluding Alaska and Hawaii

A sampling survey of the ecological condition of Alaska's estuarine resources in the south-central region of the state was completed in 2002, the results of which are included in this report. The south-central region of Alaska is referred to as the Alaskan Province and includes Prince William Sound and Cook Inlet. This portion of Alaska encompasses 55,844 km^2 (21,562 mi^2) or 35% of the total U.S. estuarine area surveyed for this report. The national coastal condition scores and ratings represent areally weighted averages of the regional scores; with 35%

of the total estuarine area, the condition of Alaska estuaries has a major influence on the nation's overall condition and index scores. In contrast, the estuarine area of Hawaii is 253 km^2 (98 mi^2), or less than 1% of the total estuarine area of the United States; therefore, estimates of the condition of Hawaii estuaries have little influence on the national scores.

For this report, the condition of U.S. coastal waters was determined by combining regional assessments, including assessments of Alaska, Hawaii, and Puerto Rico. The NCCR II did not include Alaska or Hawaii in its national assessment because data were not available for the coastal waters of those states. The following assessment provides a comparison of the overall condition and index scores for the nation, including data for Alaska and Hawaii, with alternate scores based only on data for the conterminous U.S. regions and Puerto Rico.

The overall condition of U.S. coastal waters is rated fair whether or not data for Alaska and Hawaii are included in the assessment. However, excluding data for Alaska and Hawaii reduces the nation's overall condition score from 2.8 to 2.3, as shown in Figure 2-12. Figure 2-13 provides a summary for the conterminous United States of the percentage of estuarine area in good, fair, poor, or missing categories for each index and component indicator. Removing Alaska and Hawaii from the national score calculations primarily affects the assessments for the water quality and sediment quality indices. The water quality index is rated fair to good (3.9) for U.S. coastal waters when data for Alaska and Hawaii are included, but this score decreases to a

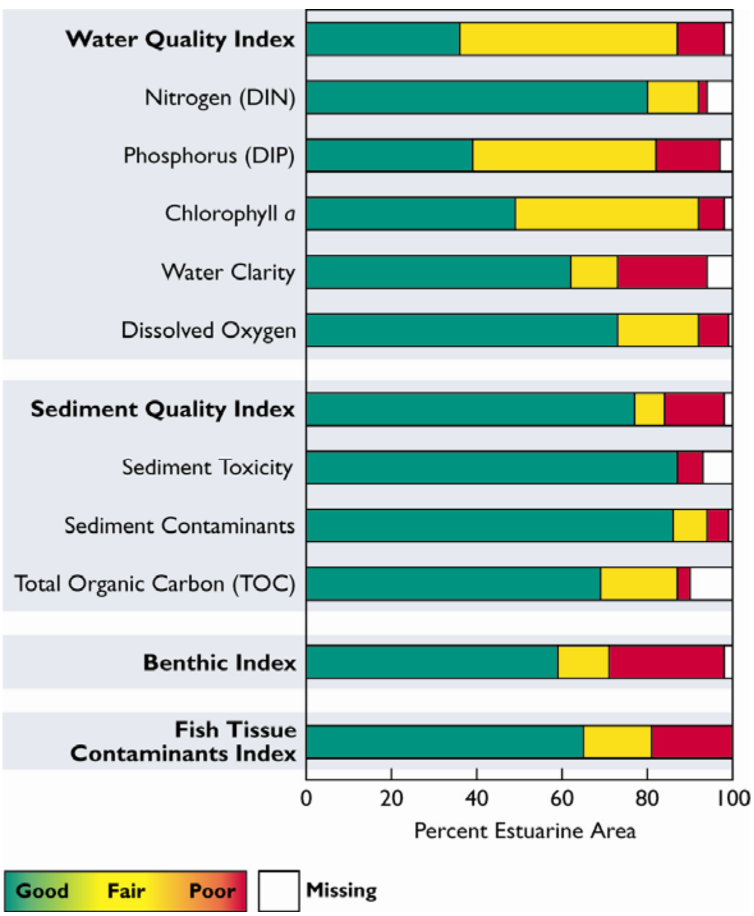

Figure 2-13. Percentage of estuarine area receiving each ranking for all indices and indicators – United States (excluding Alaska and Hawaii) (U.S. EPA/NCA).

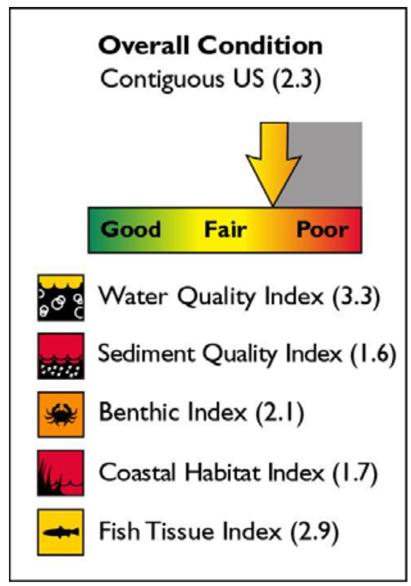

Figure 2-12. The overall condition of U.S. estuaries (excluding Alaska and Hawaii) is fair (U.S. EPA/NCA).

rating of fair (3.3) if data for Alaska and Hawaii are excluded. The sediment quality index is rated fair (2.8) for U.S. coastal waters when data for Alaska and Hawaii are included, but this score decreases to a rating of poor (1.6) when these data are excluded. Benthic and coastal habitat indices were unavailable for Alaska and Hawaii, so these scores do not change. Fish tissue contaminant data were available for south-central Alaska, but not Hawaii. The condition rating for the fish tissue contaminant index is fair whether or not Alaska data were included, but the actual score changed from 3.4 (including Alaska data) to 2.9 (excluding data).

Trends of Coastal Monitoring Data – United States

Coastal condition for the United States has been estimated since 1991, when both the Virginian and Louisianian provinces were first surveyed concurrently. Annual surveys of coastal condition were conducted in the Virginian Province from 1990–1993 and 1997–1998; in the Louisianian Province from 1991–1994; in the Carolinian Province from 1995–1997; and in the West Indian Province in 1995. Beginning in 2000, the coastal waters of all regions of the United States (exclusive of Alaska, Hawaii, and the island territories) have been surveyed and assessed annually. In 2001, the NCCR I for coastal ecosystems was produced for the period 1990–1996 and included information from the Virginian, Carolinian, West Indian, and Louisianian provinces (the Acadian, Californian, and Columbian provinces; island territories; and Alaska were largely excluded from this report). In 2004, the NCCR II included all of the coastal ecosystems in the conterminous United States and Puerto Rico for the period 1997–2000. This NCCR III provides an assessment of the entire continental United States, Hawaii, Puerto Rico, and south-central Alaska for the years 2001 and 2002.

A traditional trend analysis cannot be performed on the data presented in the coastal condition reports because the underlying population (coastal resources included in the survey) has changed for each assessment; however, estimates were made for overall condition of U.S. coastal waters in each assessment. If we assume that the condition of any unsampled waterbodies has a similar distribution to the condition of those sampled, then the report provides estimates for all of the coastal waters of the United States. Table 2-2 shows the primary index and overall condition scores from the three reports for each region and for the nation (including or excluding Alaska and Hawaii).

Table 2-2. Rating scores by Index[1] and Region Comparing NCCR I, NCCRII, and NCCR III.

	Gulf Coast			Southeast Coast			Northeast Coast			S. Central Alaska[3]	Hawaii[3]	West Coast[2]			Great Lakes[2]			Puerto Rico[2]		United States[4]			
INDEX	v1	v2	v3	v1	v2	v3	v1	v2	v3	v3	v3	v1	v2	v3	v1	v2	v3	v2	v3	v1	v2	v3[a]	v3[b]
Water Quality	1	3	3	4	4	3	1	2	3	5	5	1	3	3	1	3	3	3	3	1.5	3.2	3.3	3.9
Sediment Quality	3	3	1	4	4	3	2	1	2	5	4	2	2	2	1	1	1	1	1	2.3	2.1	1.6	2.8
Coastal Habitat	1	1	1	2	3	3	3	4	4	--	--	1	1	1	1	2	2	--	--	1.6	1.7	1.7	1.7
Benthic	1	2	1	3	3	5	1	1	1	--	--	3	3	5	1	2	2	1	1	1.5	2.0	2.1	2.1
Fish Tissue Contaminants	3	3	5	5	5	4	2	1	1	5	--	3	1	1	3	3	3	--	--	3.1	2.7	2.9	3.4
Overall	**1.8**	**2.4**	**2.2**	**3.6**	**3.8**	**3.6**	**1.8**	**1.8**	**2.2**	**5.0**	**4.5**	**2.0**	**2.0**	**2.4**	**1.4**	**2.2**	**2.2**	**1.7**	**1.7**	**2.0**	**2.3**	**2.3**	**2.8**

1 - Rating scores are based on a 5-point system where 1 is poor, 3 is fair, and 5 is good.
2 - West Coast, Great Lakes, and Puerto Rico scores for *NCCRIII* are the same as *NCCRII* (no new data for *NCCRIII* except for West Coast benthic index)
3 - AK & HI were not reported in *NCCR* or *NCCRII*
4 - U.S. score is based on an areally weighted mean of regional scores.
v1 = NCCR (adjusted scores from Table C-1 in NCCR2); v2 = NCCRII; v3 = NCCRIII
a - U.S. score excluding AK & HI
b - Including AK & HI

Table 2-3 shows the percent of the nation's coastal area rated poor for overall condition and the associated overall condition scores from the three national assessments. An increase in a score and/or a decrease in the percent area in poor condition reflects improving condition for a particular index or for overall condition. In principle, a positive change in a score should correspond to a negative change in percent area in poor condition. In general, this is the case shown in Table 2-3; however, some inconsistencies exist due to several reasons, including (1) the scores represent ranges of condition, whereas the percent area in poor condition is an exact number; (2) the interpretation of values has changed as the assessments have become more sophisticated; (3) some index elements were measured only after 2000; and (4) in one case, the elements of an index reversed in importance. Although some of these inconsistencies can be adjusted through a recalculation of the percent of area or the score to "correct" differences to a common baseline for item (2) (see Appendix C in the NCCR II), no adjustment can be made for items (1), (3), or (4). Figure 2-14 depicts the concurrent percent area in poor condition for each index.

Table 2-3. Percentage of U.S. coastal area in poor condition and corresponding score for the NCCR I (1990–1995), NCCR II (1996–2000), and NCCR III* (2001–2002) national ecological condition assessments.

Category	% Area in Poor Condition			Score		
	NCCR I	NCCR II	NCCR III	NCCR I	NCCR II	NCCR III
Water Quality Index	40	11	12	1.5	3.2	3.3
Sediment Quality Index	10	13	14	2.3	2.1	1.6
Benthic Index	22	17	27	1.5	2.0	2.1
Fish Tissue Contaminants Index	26	22	19	3.1	2.7	2.9
Overall United States	44	35	30	2.0	2.3	2.3

* NCCR III assessment is for coastal waters in the conterminous United States (excluding Hawaii and Alaska).

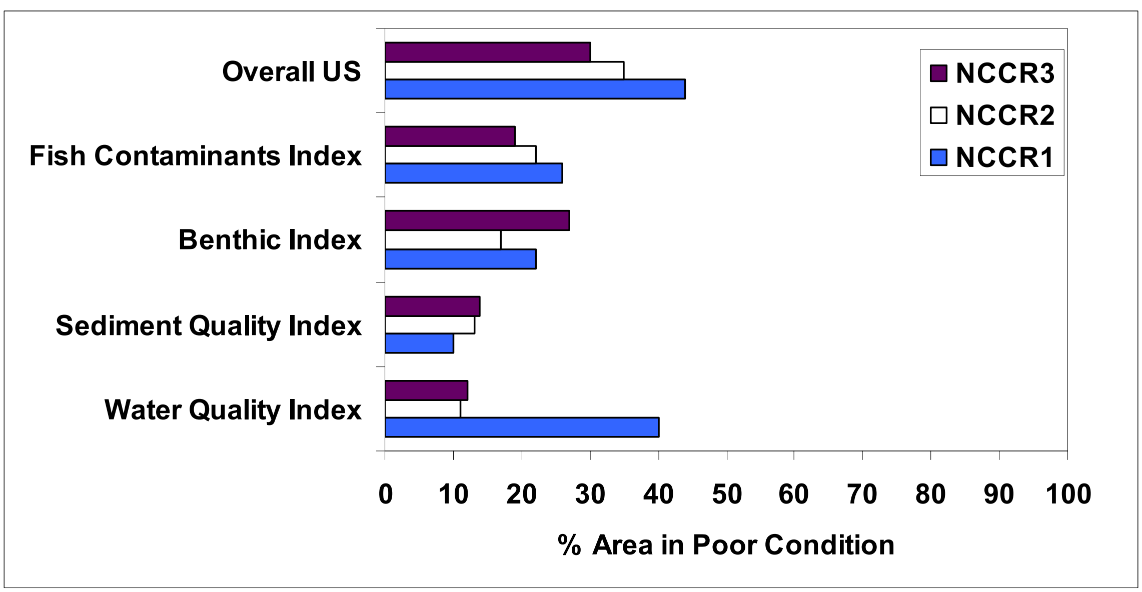

Figure 2-14. Comparison of percentage area in poor condition for the three *National Coastal Condition Report* assessments.

From the NCCR I to NCCR III, the water quality index score increased from 1.5 (rated poor) to 3.3 (rated fair), with a corresponding decrease in percent area rated poor from 40% to 11–12%. Although water quality has likely improved during this time, the dramatic change in the water quality assessment from the NCCR I to the NCCR III is largely due to the reliance on professional judgment for eutrophication information in the NCCR I, rather than on direct measurements from surveys. Nitrogen, phosphorus, and chlorophyll *a* measurements were not used in the NCCR I assessment; instead, a survey of professional judgment conducted by NOAA was used to assess the eutrophication status of estuaries (NOAA, 1999). The NCCR I reported that 40% of the nation's coastal area was rated poor for water quality (rating score of 1.5). In the NCCR II, water quality in the nation's collective coastal waters improved, with a reduction in percent area rated poor (11%) and an increase in the water quality index score to 3.2 (rated fair). The apparent improvement in the water quality index score and the percent area in poor condition is likely not as dramatic as the assessment suggests. In the current assessment (NCCR III), 12% of the coastal area is rated poor, and the water quality index score is 3.3 (rated fair). This assessment demonstrates no significant change in the water quality of U.S. coastal waters since the NCCR II.

Although the percent area in poor condition changed very little (10% to 14%) between the NCCR I and the NCCR III, the sediment quality index score decreased from 2.3 (rated fair) to 1.6 (rated poor), respectively, between the two reports. Initially, this temporal pattern seems inconsistent because a significant decrease in the sediment quality index score should logically correspond to a significant increase in percent area in poor condition. This apparent inconsistency results from the inclusion of a sediment quality index score of 1.0 (rated poor) for the Great Lakes region in determining the sediment quality index score for the nation's coastal waters, whereas the Great Lakes were not included in calculations of percent area. Although the change in the nation's sediment quality index score between the two reports appears to be significant, it actually represents a rating change from fair to poor to poor. According to the regional assessment criteria, a region is rated poor if more than 15% of the coastal area is rated poor and rated fair if between 5% and 15% is rated poor. Based on the regional criteria outlined in Chapter 1 and the percent of national coastal area rated poor (8%), the sediment quality index score for the NCCR III would be 3.0; however, when the national sediment quality index score is calculated based on the weighted average of the regional scores (including the Great Lakes sediment quality score of 1.0), the national score is reduced to 1.6 (rated poor). Similar comparisons can be made for the subsequent assessments.

Please note that some of the percentages discussed in this report differ from those published in the NCCR I or NCCR II. In some cases, data were reassessed to make the results comparable across reports. For example, the NCCR I reported that 35% percent of the national estuarine area was rated poor for sediment quality. This assessment was based on criteria that included both ERM exceedances and five ERL exceedances in its estimate of percent area rated poor. These criteria changed in the NCCR II and NCCR III to reflect only ERM exceedances when calculating percent area poor. When the NCCR I data are reassessed using the updated criteria, the percent area rated poor is reduced to 10%.

The coastal habitat index assessment has not changed from the NCCR I to the NCCR III. No new information was available to assess coastal habitat changes for the NCCR III, and the scores presented in this report are identical to those presented in the NCCR II. Although some regional improvements in coastal habitat occurred in the Northeast Coast region between the NCCR I and the NCCR II, the regions with most of the wetland acreage in the United States (Gulf Coast, Southeast Coast, and Great Lakes) showed little or no change. These areas show a continuing loss of wetlands at about the same rate of 1.25% to 1.5% of available acreage per decade.

The benthic index, although consistent in concept, is calculated differently for each region of the United States; therefore, the assumption that unsampled regions reflect the same distribution pattern of poor conditions as those sampled is not supported. The percent of coastal area with poor benthic condition in the West Coast and Northeast Coast regions is consistently lower than in the Gulf Coast region and the Mid-Atlantic. As a result, the U.S. benthic index score of 1.5 (rated poor) in the NCCR I corresponds to the 22% of coastal area in poor condition in the Gulf Coast, Southeast Coast, and Mid-Atlantic regions. When the Northeast Coast and West Coast regions were included in the NCCR II assessment, the percent of coastal area with poor benthic condition decreased to 17% (within the uncertainty estimates for the NCCR I), and the benthic index score increased to 2.0 (rated fair to poor). However, for the NCCR III, the percent area with poor benthic condition increased to 27% (an increase of 10%), and the benthic index score increased from 2.0 to 2.1 (rated fair to poor). The percent area with poor benthic condition in the Gulf Coast region increased to 45% in NCCR III. Although this increase accounts for the sizeable increase in the percent of U.S. coastal area in poor condition, it has little effect on the national benthic index score because, based on the criteria described in Chapter 1, the regional rating would be poor in both cases. This change in the Gulf Coast region coupled with small improvements in benthic condition in the Southeast Coast and West Coast regions results in the apparent inconsistency with an increase (degradation) in percent coastal area with poor benthic condition in the United States (+10%), but with a minimal increase in overall benthic score (+0.1).

The fish tissue contaminants index shows a consistent improvement from the NCCR I to the NCCR III. The percent area rated poor decreased from 26% of sites where fish were caught (NCCR I) to 19% (NCCR III). This reduction corresponds to an improvement of the fish tissue contaminants index score from the NCCR II (2.7) to the NCCR III (2.9), but is inconsistent with the reduction of the score from the NCCR I (3.1) to the NCCR II (2.7). This inconsistency is the result of differing comparison methodologies. In the NCCR I, fish tissue contaminant concentrations were measured in edible fillets; while in both the NCCR II and NCCR III, whole-fish concentrations were measured. Currently, it is not possible to “adjust” the NCCR assessments (fillets) to whole fish concentrations and scores; however, research completed in 2003–2004, where both fillet and whole-body concentrations were determined, will likely provide the information necessary to make that adjustment. At present, the best interpretation seems to be that there is little change in contaminant levels in fish tissue in U.S. estuaries, with the national fish tissue contaminant index for all three reports receiving a rating of fair.

Large Marine Ecosystem Fisheries

As of 2004, 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 the California Current/Gulf of Alaska LME groundfish, Southeast Shelf LME snapper-grouper complex, and Northeast Shelf LME mixed species.

In 2004, NOAA's Office of Sustainable Fisheries reported on the status of 688 marine fish and shellfish stocks (NMFS, 2005b). Of the 200 stocks whose status with respect to overfishing is known, 144 were not overfished, and 56 stocks or stock complexes were overfished, compared with 92 in 2000 and 81 in 2001 (NMFS, 2002; 2005b). The overfishing status (when the proportion of a stock taken by a fishery is too high) of 236 stocks is known, of which 44 stocks or stock complexes have a fishing mortality rate that exceeds the overfishing threshold. The NMFS has approved rebuilding plans for the majority of overfished stocks. Five fishery management plan amendments in 2004 were approved to implement final rebuilding plans for 23 stocks of the Northeast Shelf, Southeast Shelf, Gulf of Alaska, and East Bering Sea LMEs. Pacific whiting (groundfish stock of the Gulf of Alaska/California Current LMEs) has been fully rebuilt, and overfishing is no longer occurring. Northeast Shelf LME black sea bass is also no longer overfished. Three more stocks—lingcod, Pacific ocean perch (Gulf of Alaska/California Current LMEs), and king mackerel (Gulf of Mexico LME)—have increased in abundance to the point they also are no longer overfished. Rebuilding measures for all these stocks will continue until each stock has fully rebuilt to the level that provides maximum sustainable yield (NMFS, 2005a).

Alaska pollock, described as the largest food fish resource in the world, has been ranked first (in pounds harvested) of the major U.S. domestic commercial species landed from 2001–2004. Menhaden (fatback, bugfish, or munnawhatteaug), an industrial species used as bait and for fish meal and oil, is one of the most important fisheries on the Atlantic coast, with the majority of fish caught from estuaries and nearshore coastal waters. The menhaden fishery has ranked second for the past 5 years, whereas the Pacific salmon fishery ranked third from 2001–2004, and the cod fishery (Atlantic and Pacific combined) has consistently ranked fourth.

Top 10 Commercial Species Landed in 2004
(Numbers in thousands)

	Top 10 by Quantity		Top 10 by Value	
Rank	**Species**	**Pounds**	**Species**	**Dollars (thousands)**
1	Pollock	3,361,989	Crabs	$447,978
2	Menhaden	1,497,610	Shrimp	$452,605
3	Salmon	737,935	Lobsters	$344,070
4	Cod	602,732	Scallops	$322,098
5	Hakes	502,502	Flatfish	$300,896
6	Flounders	440,699	Pollock	$277,029
7	Crabs	314,428	Salmon	$272,730
8	Shrimp	308,275	Cod	$169,647
9	Herring (sea)	255,931	Clams	$158,782
10	Sardines	199,613	Oysters	$111,125

Source: NMFS, 2005b.

In 2004, Alaska led all states in pounds of fish landed (5.4 billion) and in the value of fisheries landings ($1.2 billion) (NMFS, 2005a). With regard to species, the shrimp fishery was ranked first (by value) in 2001 and 2002, then second in 2003 and 2004—the reverse of the crab fishery, which was ranked second for 2 years and then first in monetary value for the past 2 years (2003 and 2004). In monetary values during 2001–2004, the American lobster fishery was consistently ranked third, Alaska Pollack ranked fourth in 2001 and 2002, and flatfish and scallops ranked fourth in 2003 and 2004, respectively (NMFS 2002; 2003; 2004; 2005b).

Recreational Fishing Statistics for 2004

- 14.6 million anglers: 44% Atlantic, 25% Gulf of Mexico (excluding Texas), 27% Pacific (excluding Alaska), 1% Puerto Rico, 3% Hawaii
- 80.8 million trips: 59% Atlantic, 30% Gulf of Mexico, 6% Pacific, 1% Puerto Rico, 4% Hawaii
- 440 million fish caught: 52% Atlantic, 43% Gulf of Mexico, 4% Pacific, 0.3% Puerto Rico, 1% Hawaii

Source: NMFS, 2005b

Recovery from Biomass Depletion in Large Marine Ecosystems

Mandated management actions by the New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Councils (MAFMC), and the Atlantic States Marine Fisheries Commission (ASMFC) for reducing fishing effort within the Northeast Shelf ecosystem are reversing declines in biomass yields that have occurred over the past several decades. Since 1994, reductions in fishing effort resulted in increased spawning stock biomass levels of cod, haddock, yellowtail flounder, and other species in the ecosystem.

During the 1990s, a reduction in fishing effort due to low market demand resulted in increases in herring and mackerel biomass. Stocks began to recover and establish higher stock sizes, 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 ten-fold increase in abundance between the late 1970s and the late 1990s. Stock biomass of herring increased to more than 2.5 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 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, relatively strong year classes produced in 1997 for Georges Bank yellowtail and in 1998, 2000, and 2003 for Georges Bank haddock (Figure 2-15), combined with sharp reductions in fishing mortality, have led to improved conditions for these stocks (NEFSC, 2002) and increased landings since 2000.

Management actions reducing fishing effort and recent reproductive success have led to increased biomass levels and large increases in U.S. scallop landings and revenues (Figure 2-16).

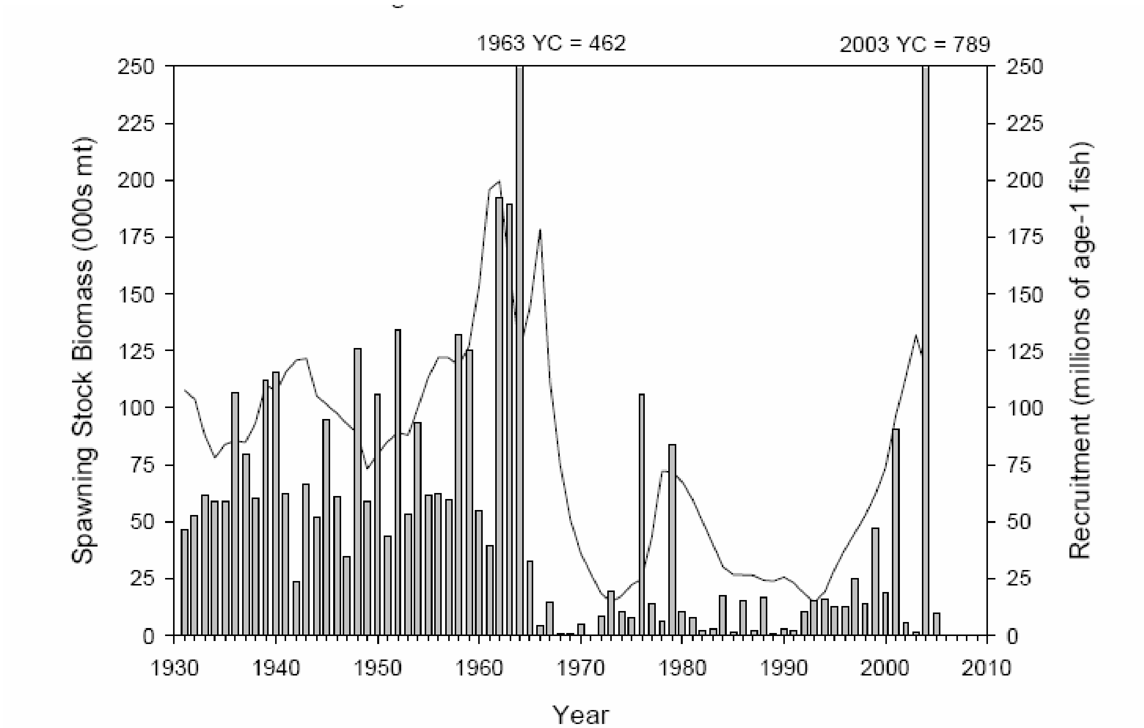

Figure 2-15. Trend in spawning stock biomass (line) and recruitment (bars) for Georges Bank haddock from 1931–2004 (NEFSC, 2005). The low areas represent the effects of excessive fishing, and the peak after 2000 is indication of recovery of the haddock stock.

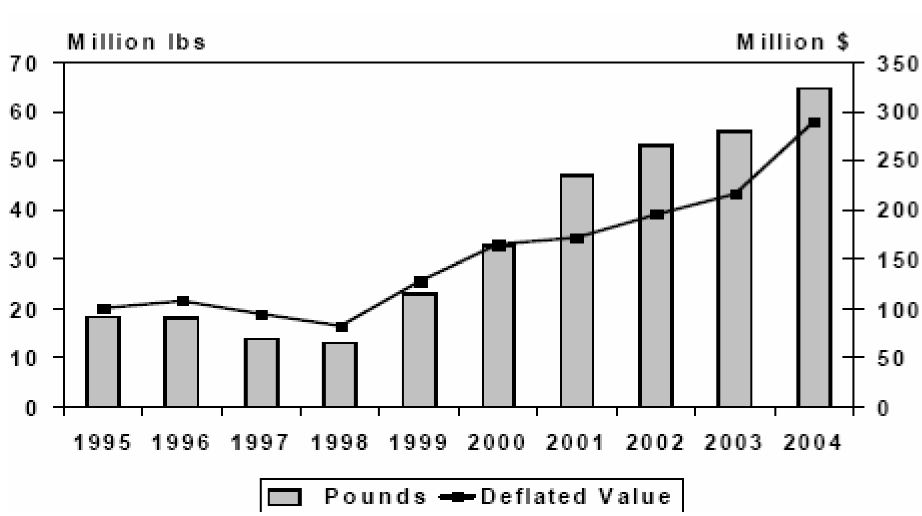

Figure 2-16. Change in commercial landings of Atlantic sea scallops, 1995–2004 (NMFS, 2005b).

Robust Northeast Shelf Ecosystem

During the past 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 as a management measure for increasing spawning stock biomass for depleted demersal fish species. 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 Georges Bank yellowtail flounder in 1997 and Georges Bank haddock in 1998, 2000, and 2003.

The zooplankton component of the Northeast Shelf LME is in robust condition (Figure 2-17), 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.

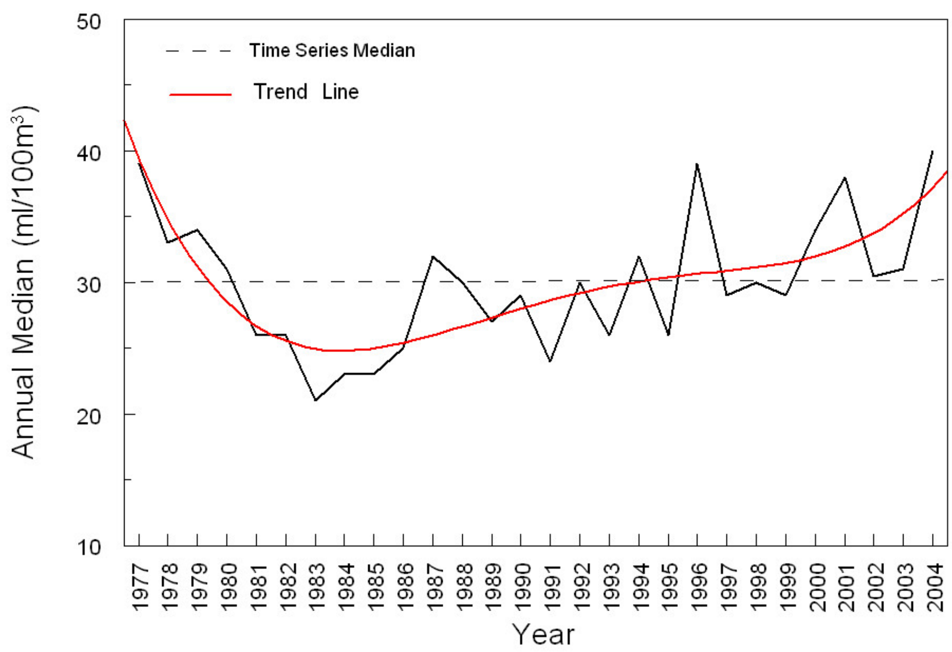

Figure 2-17. Zooplankton biomass in the Northeast Shelf Ecosystem, 1977–2004 (Kane, 2006).

Assessment and Advisory Data

Fish Consumption Advisories

A total of 88 fish consumption advisories were in effect for estuarine and coastal marine waters of the United States in 2003, including about 77% of the coastal waters of the contiguous 48 states (Figure 2-18). 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 estuarine or marine waters within the state (Table 2-4). 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 younger individuals.

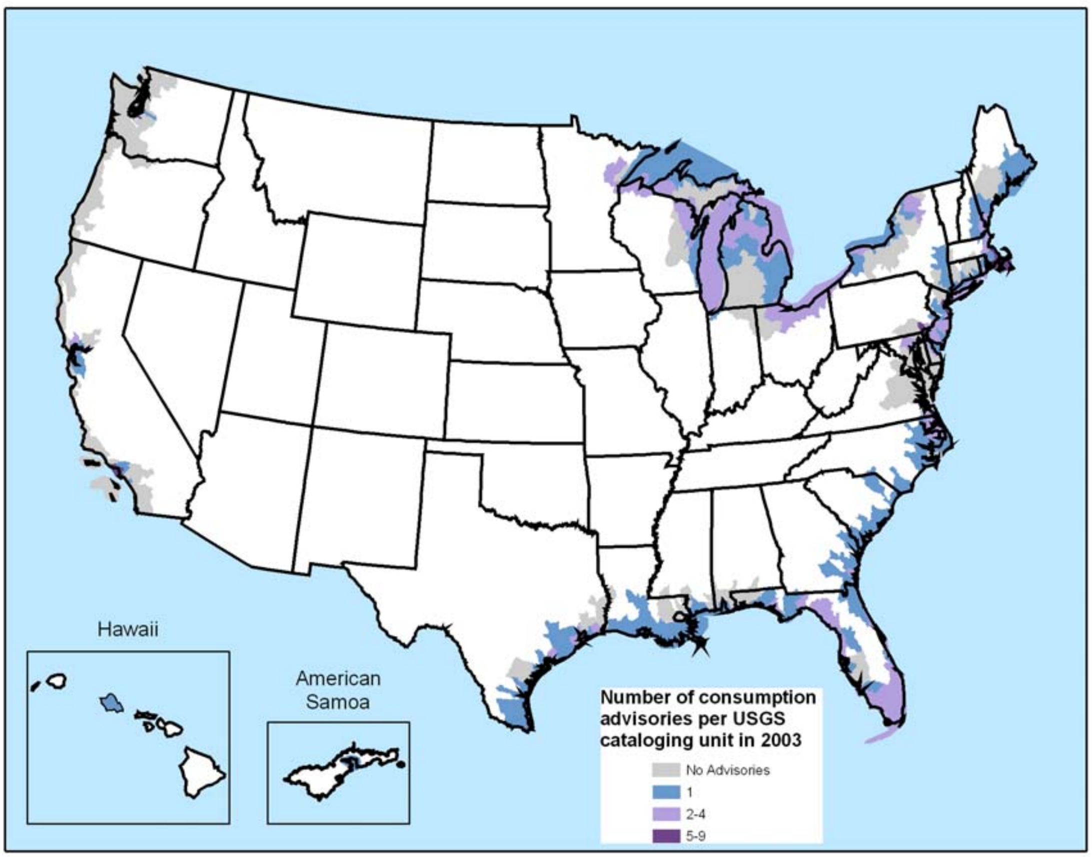

Figure 2-18. The number of fish consumption advisories active for the United States in 2003 (U.S.EPA, 2004c).

Table 2-4. Summary of States with Statewide Advisories for Coastal and Estuarine Waters (U.S. EPA, 2004c)

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 King Mackerel Lobster (tomalley) Shark Shellfish	Striped bass Swordfish Tilefish All other fish
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 Dioxins	American eel Bluefish Striped bass Lobster (tomalley)	
New York	Cadmium Dioxins	American eel Blue crab Bluefish Lobster (tomalley) Striped bass	
North Carolina	Mercury	King mackerel Shark Swordfish Tilefish	
Rhode Island	PCBs Mercury	Bluefish Shark Striped bass Swordfish	
South Carolina	Mercury	King mackerel	
Texas	Mercury	King mackerel	

* Hawaii has a statewide mercury advisory for several species of marine fish.

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 coastal 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: PCBs, mercury, DDT and its degradation products DDE and DDD, and dioxins/furans. These four chemical contaminants were responsible, at least in part, for 92% of all fish consumption advisories in effect in estuarine and coastal marine waters in 2003 (Figure 2-19, Tables 2-5 and 2-6). These chemical contaminants are biologically accumulated (bioaccumulated) in the tissues of aquatic organisms to concentrations many times higher than concentrations in seawater (Figure 2-20). In addition, 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, 4 of the top 10 contaminants associated with fish advisories (PCBs, dioxins, DDT, and dieldrin) are among the contaminants most often responsible for a Tier 1 National Sediment Inventory classification (i.e., associated adverse effects to aquatic life or human health are probable) of waterbodies based on potential human health effects (U.S. EPA, 2004a).

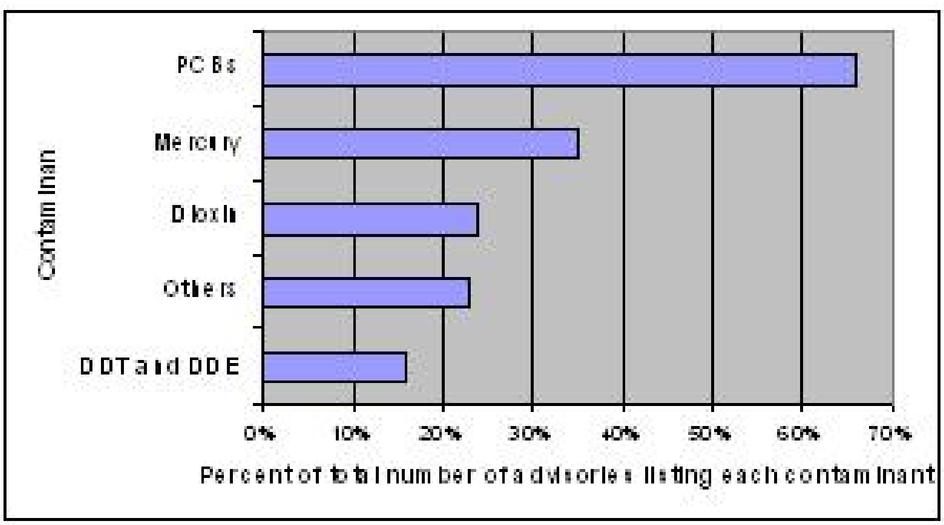

Figure 2-19. Pollutants responsible for fish consumption advisories in U.S. coastal waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S.EPA, 2004c).

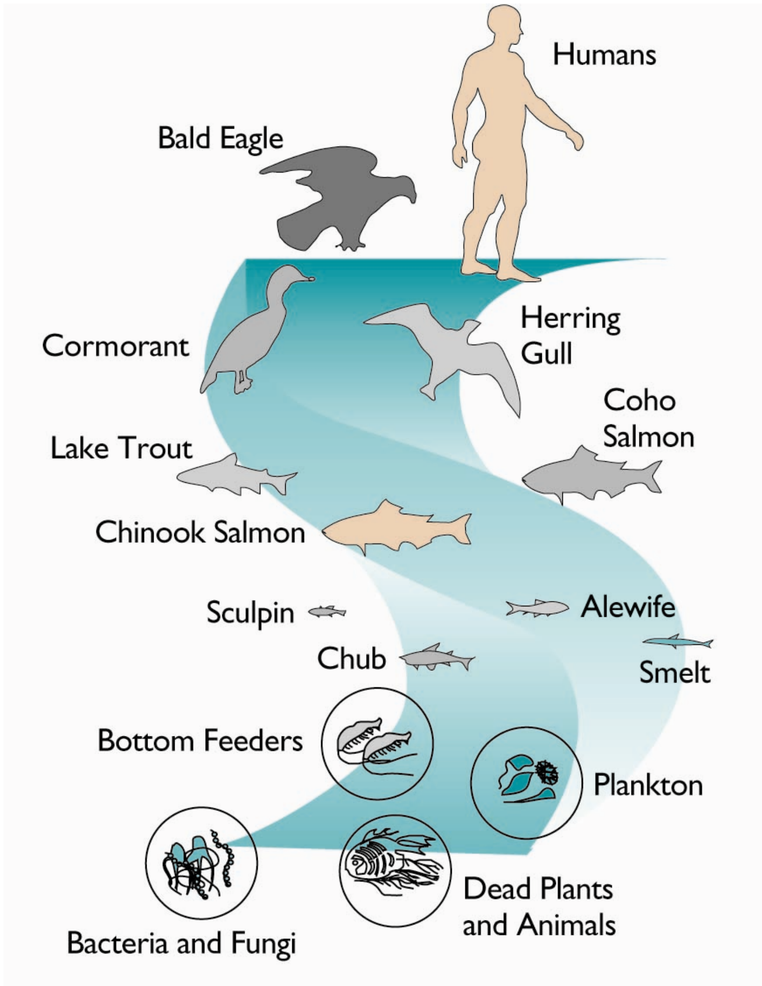

Figure 2-20. Bioaccumulation process (U.S. EPA, 1995).

Table 2-5. The Four Bioaccumulative Contaminants Responsible, at Least in Part, for 92% of Fish Consumption Advisories in Estuarine and Coastal Marine Waters in 2003 (U.S. EPA, 2004c)

Contaminant	Number of Advisories	Comments
PCBs	58	Seven northeastern states (CT, MA, ME, NH, NJ, NY, RI) had statewide advisories.
Mercury	31	Twelve states (AL, FL, GA, LA, MA, ME, MS, MC, NJ, RI, SC, TX) had statewide advisories in their costal marine waters; 11 of these states also had statewide advisories for 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 in effect were in California (12), Delaware (1), or the Territory of American Samoa (1).
Dioxins and furans	21	Statewide dioxin advisories were in effect in three states (ME, NJ, 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 92% of Fish Consumption Advisories in Great Lakes Waters in 2003 (U.S. EPA, 2003b)

Contaminant	Number of Advisories	Comments
PCBs	30	Eight states (IL, IN, MI, MN, NY, OH, PA, WI) had PCB advisories for all five Great Lakes and several connecting waters.
Mercury	11	Three states (IN, MI, PA) had mercury advisories in their Great Lakes waters for Lake Erie, Huron, Michigan, and Superior, as well as for several connecting waters.
DDT, DDD, and DDE	1	One state (MI) had a DDT advisory in affect for Lake Michigan.
Dioxins	15	Dioxin advisories were in effect in three states (MI, NY, WI) for all five Great Lakes and several connecting waters.

Beach Advisories and Closures

For the 2003 swimming season, EPA gathered information on 4,080 beaches monitored nationwide (both inland and coastal) through the use of a survey. The survey respondents were state and local government agencies from coastal counties, cities, or towns bordering the Atlantic Ocean, Gulf of Mexico, Pacific Ocean, and the Great Lakes, as well as those in Hawaii, Puerto Rico, the U.S. Virgin Islands, Guam, and the Northern Mariana Islands. A few of the 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 http://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 2003 swimming season.

EPA's review of coastal beaches (e.g., U.S. coastal areas, estuaries, the Great Lakes, and coastal areas of Hawaii and the U.S. territories) showed that, of the 4,080 beaches reported in the survey responses, 4,070 were marine or Great Lakes beaches. Of these coastal beaches monitored and reported, 839 (or 20.5%) had an advisory or closing in effect at least once during the 2003 swimming season (Figure 2-21). 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 2-22). Some of the major causes of public notifications for beach advisories and closures were stormwater runoff, wildlife, sewer line problems, and in many cases, unknown sources (Figure 2-23).

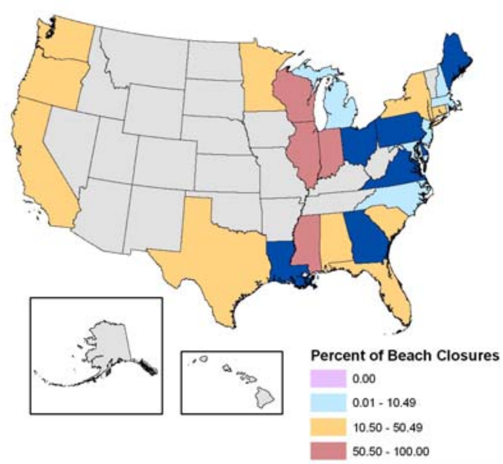

Figure 2-21. Percentages of beaches with advisories/closures by coastal state in 2003. Percentages are based on the number of beaches in each state that were reported, not the total number of beaches (U.S. EPA, 2006).

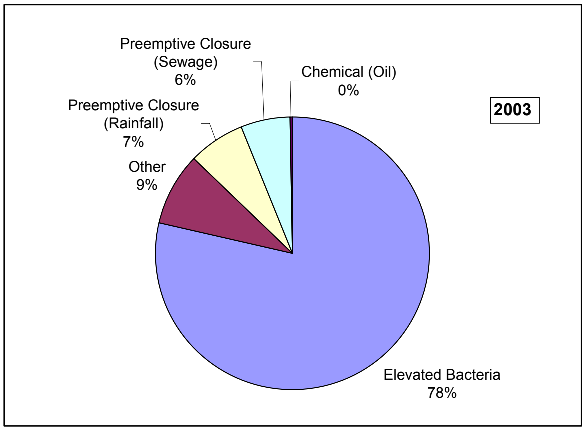

Figure 2-22. Reasons for beach advisories or closures for the nation (U.S. EPA, 2006).

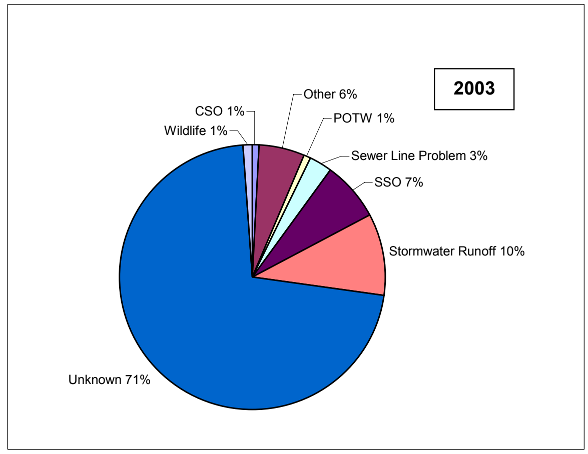

Figure 2-23. Sources of beach contamination for the nation (U.S. EPA, 2006).

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NCCR III

Chapter 2 Highlights

highlight

Integrating Science and Technology to Support Coastal Management Needs: The National Estuarine Research Reserve System-wide Monitoring Program

NOAA's National Estuarine Research Reserve System (NERRS) was established by the Coastal Zone Management Act of 1972. There are 27 reserves covering over 1 million acres of estuarine waters and adjoining lands across the continental United States, Alaska, and Puerto Rico (Figure 1) (NERRS, 2003). The Coastal Zone Management Act created reserves to protect estuarine areas, provide education opportunities, promote and conduct estuarine research and monitoring, and transfer critical information to coastal managers. In 1995, the NERRS established a System-wide Monitoring Program (SWMP) to collect data on water and weather conditions, estuarine biodiversity, and to classify watershed habitats and land use changes. The SWMP was designed to track short-term variability and long-term changes in estuarine ecosystems, as well as to understand and forecast how human activities and natural events can change these ecosystems.

Figure 1. Estuaries of the National Estuarine Research Reserve System. Source: (NERRS, 2003).

In 2005, the NERRS celebrated SWMP's 10th anniversary. The long-term SWMP datasets make it possible to establish baseline conditions, and examine both intra-annual (seasonal) and inter-annual patterns in estuarine systems, as well as the effects of large-scale (e.g., El Niño and La Niña climatic conditions, sea level rise, hurricanes, Nor'easters) and localized episodic events (e.g., floods, drought, contaminant spills).

The NERRS has compiled a subset of examples from across the 27 sites that demonstrate the application of water and weather monitoring data to local, regional, and national coastal management needs. One such example is the Grand Bay Reserve in Mississippi.

Grand Bay NERR, MS—SWMP Data Used to Track Affects of a Phosphate Spill

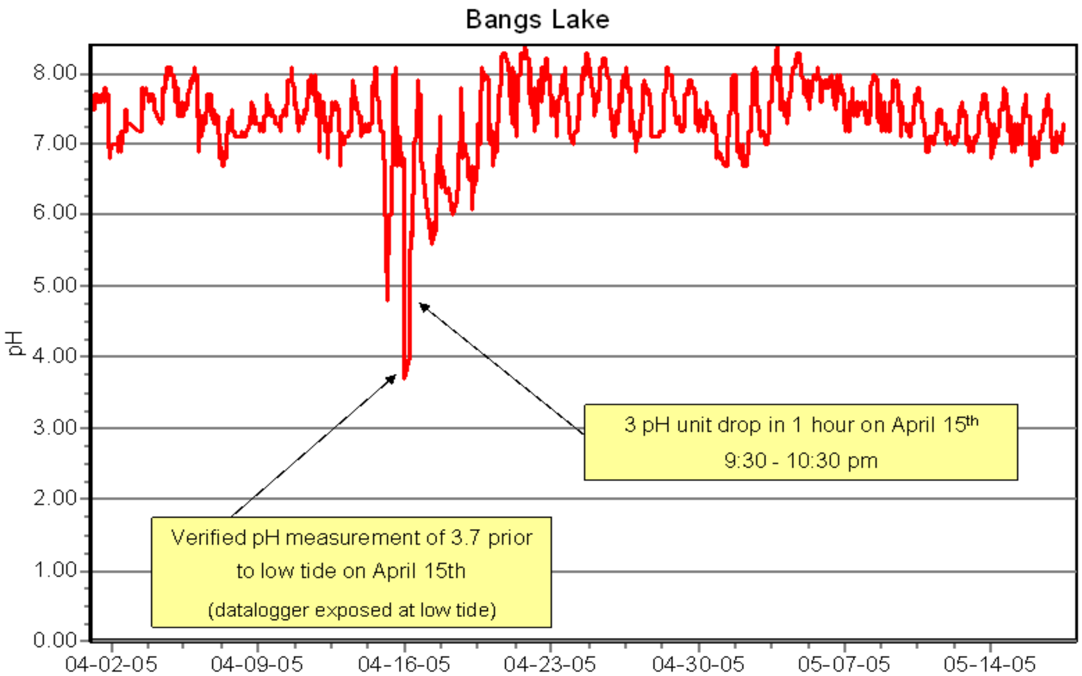

Figure 2. NERRS' SWMP measurements showing affect of an April 14, 2005, phosphate spill on pH in Bangs Lake, MS. (NERRS, 2005)

The western border of the Grand Bay NERR in southeastern Mississippi is lined with industrial plants. Grand Bay NERR staff relies on SWMP data to monitor baseline water quality conditions and to identify anomalies resulting from contaminant spills or other pollution episodes. One such incident occurred on April 14, 2005, when levees surrounding containment ponds at a fertilizer manufacturing plant collapsed after 2 weeks of record-breaking rain. A large volume of effluent water from the plant entered an adjacent tidal lake within the Reserve boundaries, resulting in an abrupt drop in pH. At the SWMP datalogger in the center of the lake, the pH fell from 7.5 to 3.7 within an hour (Figure 2). Eleven days later, phosphorus levels in the lake were ~5,000 times greater than before the spill, and chlorophyll-*a* concentration fell to zero, indicating that primary productivity had ceased. Continual SWMP monitoring at Grand Bay NERR, captured the long-term effects of this spill, and will, in conjunction with additional monitoring, document the full recovery of this vital ecosystem. Following this incident, Grand Bay NERR staff presented the SWMP data to the Mississippi Commission on Marine Resources and worked with the Mississippi Department of Environmental Quality staff to recommend retributions and restoration measures for the spill site (NERRS, 2005).

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

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highlight

Recovery of Endangered and Threatened Species

The primary purpose of the Endangered Species Act (ESA) of 1973, as amended, is the conservation of endangered and threatened species and the ecosystems on which they depend. Conservation efforts aim to recover populations of endangered species to a point where protection under the ESA is no longer necessary. NOAA's National Marine Fisheries Service (NMFS) shares responsibility for implementing the ESA with the U.S. Fish and Wildlife Service.

In 2004, the NOAA Fisheries Service had jurisdiction over a total of 60 species, including 52 domestic species of salmon, sturgeon, sawfish, sea grass, corals, mollusks, sea turtles, and marine mammals; and 8 foreign species found outside U.S. waters. Of the 52 domestic species, 24 were listed as endangered and 28 as threatened (NMFS, 2005). These numbers are encouraging, especially given the large number of highly imperiled species listed in the past decade.

The green turtle (*Chelonia mydas*) is one of 64 endangered and threatened species whose recovery is being addressed by NOAA Fisheries Service. Photograph courtesy of Ursula Kauper-Bennett and Peter Bennett.

Recovery of threatened and endangered species is a long-term challenge. The ESA requires the development of recovery plans for listed endangered and threatened species to organize and guide the recovery process. The ESA also requires a report to Congress every 2 years on the status of efforts to develop and implement recovery plans and on the status of all species for which recovery plans have been developed. In 2005, the NOAA Fisheries Service published the *Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species October 1, 2002–September 30, 2004*, which details recovery efforts for ESA-listed species, including information on species status, current threats and impacts, conservation actions undertaken, and priority actions needed for recovery (NMFS, 2005).

Of the 52 domestic species listed in 2004, 16 had recovery plans, and 6 species' recovery plans (Hawaiian monk seal, eastern and western distinct population segments of Steller sea lions, the North Atlantic right whale, loggerhead, and Kemp's ridley sea turtles) were being updated. In addition, 32 recovery plans were in the draft stage, including those for 26 Evolutionarily Significant Units of Pacific salmon. There are active recovery teams for the white abalone, smalltooth sawfish, Kemp's ridley sea turtle and loggerhead sea turtle, Hawaiian monk seal, and Steller sea lion. Additionally, take reduction teams exist to curb the harassment, harming, pursuit, hunting, shooting, wounding, killing, trapping, capturing, or collection of specific species on the ESA list or the attempt to engage in any such conduct. Two active take reduction teams, formed in accordance with the Marine Mammal Protection Act, assist in the population recovery of ESA-listed species: the Atlantic Large Whale Take Reduction Team (humpback, North Atlantic right, and fin whales), and the Pacific Offshore Cetacean Take Reduction Team (humpback and sperm whales) (NMFS, 2005).

Species recovery strategies are active for all ESA-listed species. Among ongoing conservation and research activities, the following two efforts are especially noteworthy: (1) the Strategy for Sea Turtle Conservation and Recovery and (2) recovery efforts for the North Atlantic right whale, one of the most severely endangered whale species.

(1) One cause of sea turtle population decline is deaths when turtles are caught as bycatch (marine animals caught inadvertently in commercial fishing operations). The Strategy for Sea Turtle Conservation and Recovery is a comprehensive fishing gear-based approach to reducing sea turtle bycatch in state and federal waters of the Atlantic Ocean and Gulf of Mexico. The strategy will result in bycatch reduction measures across jurisdictional boundaries and fisheries for gear types that have the greatest affect on sea turtle populations. These actions will ultimately help reduce sea turtle deaths and encourage population recovery (NMFS, 2005).

(2) There are two facets of North Atlantic right whale population recovery efforts. First, steps to reduce serious injury and death due to entanglement in commercial fishing gear are addressed under the Atlantic Large Whale Take Reduction Plan, primarily through modifications to fishing gear and fishing practices. Second, NMFS developed a draft Right Whale Ship Strike Reduction Strategy to minimize right whale deaths resulting from collisions with ships. This strategy includes mariner education and outreach programs, interagency consultations, and consideration of modifications to ships' operations to reduce ship strikes (NMFS, 2005).

The NMFS is working to meet the challenge of recovery for ESA-listed species and to encourage stakeholder involvement in both recovery planning and implementation. All NOAA Fisheries Service's active recovery teams either have stakeholder representation on their teams, or hold stakeholder meetings to keep the public informed of their progress and to obtain public comment. Stakeholders include federal, state, and local government agencies; affected industries; conservation or other nongovernmental organizations; or affected individuals. In some cases, recovery boards were appointed by the Governor and recovery plans written by local sub-basin recovery teams (e.g., Pacific salmon recovery efforts in Washington State). The NOAA Fisheries Service helps support and actively participates on these teams and is adopting its plans as draft recovery plans to be published for public comment. Experience has shown that true stakeholder involvement in the planning process results in buy-in to the recovery plan both during and after the planning process. Stakeholder involvement is also emphasized in NOAA Fisheries Service's *Interim Endangered and Threatened Species Recovery Planning Guidance for* completed in October 2004 and updated in 2006, which is now being field-tested in regional and field offices (NMFS, 2006b).

For further information on marine species protected by NOAA under the ESA, please visit the NOAA Fisheries Office of Protected Resources Web site at http://www.nmfs.noaa.gov/pr. Recovery plans for domestic ESA-listed species under NOAA

Fisheries Service's jurisdiction are also available at http://www.nmfs.noaa.gov/pr/recovery/plans.htm.

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highlight

Science-based Coastal Habitat Restoration

Restoration is the process of re-establishing a self-sustaining habitat that in time can come to closely resemble a natural condition in terms of structure and function (Turner and Steever, 2002). The five key elements necessary for successful restoration include the (1) reinstatement of ecological processes;
(2) integration with the surrounding environment;
(3) development of a sustainable, resilient system;
(4) re-creation of the historic type of physical habitat that may not always result in the historic biological community structure; and (5) planning process with specific project goals and performance standards for measuring achievement of restoration goals (Society of Wetland Scientists, 2000).

Habitat restoration is a relatively new science. Early restoration efforts frequently took a shotgun approach, with limited planning and limited or no monitoring of project results. Unfortunately, there often was limited success. The philosophy seemed to be that if a project was completed, nature would ensure the new habitat would persist. Somehow, all the component parts would reappear independently and the habitat would be wholly functional again. However, in recent years, there have been many advances in the design of restoration projects, the setting of project goals, and in the scientific approach to research and monitoring of these projects (Thayer and Kentula, 2005). Stakeholder involvement, appropriate goal setting, and science-based monitoring are critical to the success of both small- and large-scale restoration projects. Restoration monitoring contributes to our understanding of complex ecological systems. Monitoring is also essential in documenting restoration performance and adapting project designs based on performance, which should lead to more effective restoration project results (Figure 1) (Thayer et al., 2003, 2005).

Figure 1. Using a fyke net to sample nekton in a restoration research project.

The book, *Science-Based Restoration Monitoring of Coastal Habitats* (Thayer et al., 2003), lays out the steps for a scientifically based restoration monitoring plan that includes the following:

(1) Identification of project goals

(2) Collection of information on similar restoration projects to aide in maximizing efficiency of approaches

(3) Identification and description of the habitats within the area

(4) Identification of the basic structural and functional characteristics for those habitat types

(5) Consultation with experts (e.g., hydrologists, soils experts, botanists, and ecologists)

(6) Development of hypotheses regarding the trajectories of restoration development and recovery

(7) Collection of historical data for the area

(8) Selection of reference sites that can be used to evaluate restoration progress

(9) Agreement on the length of time the project will be monitored

(10) Selection of monitoring techniques to be used

(11) Design of a monitoring review and revision process

(12) Development of a cost estimate for implementation of the monitoring plan.

The incorporation of a scientific approach into the design of the restoration monitoring plan will provide for more successful habitat restoration (Turner and Steever, 2002) and incorporate the five elements considered essential by the Society of Wetland Scientists (2000).

Understanding the value of restoring degraded and damaged habitats has increased in the past decade, and this growing interest was recognized by Congress through the Estuary Restoration Act, Title 1 of the Estuaries and Clean Waters Act of 2000. Better techniques have been developed, results of restoration have been more successful, and statistical rigor has been applied to both restoration and monitoring activity. Additionally, it has become increasingly evident that decisions regarding habitat restoration cannot be made entirely by using ecological parameters alone, but must involve consideration of the affects on and benefits to humans (Thayer *et al*. 2005).

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U.S. Integrated Ocean Observing System (IOOS)

Today, many changes are occurring in the oceans that profoundly affect our society—from sea level rise, hurricanes, and coastal flooding to the occurrence of harmful algal blooms, fish kills, declining fisheries, and environmental pollution. To address these problems, the U.S. Commission on Ocean Policy, the National Ocean Research Leadership Council, and the U.S. Ocean Action Plan (CEQ, 2004) have identified the development of the U.S. Integrated Ocean Observing System (IOOS) as a high priority. The IOOS will significantly improve the nation's ability to achieve the following goals:

- Improve predictions of weather and climate change and their effects on coastal communities and the nation
- Improve the safety and efficiency of maritime operations
- More effectively mitigate the effects of natural hazards
- Improve national and homeland security
- Reduce public health risks
- More effectively protect and restore healthy coastal ecosystems
- Enable the sustained use of ocean and coastal resources.

The IOOS will be a complex system that integrates several subsystems to meet these goals. These subsystems include observation, data management and communications (DMAC), and data modeling and analysis.

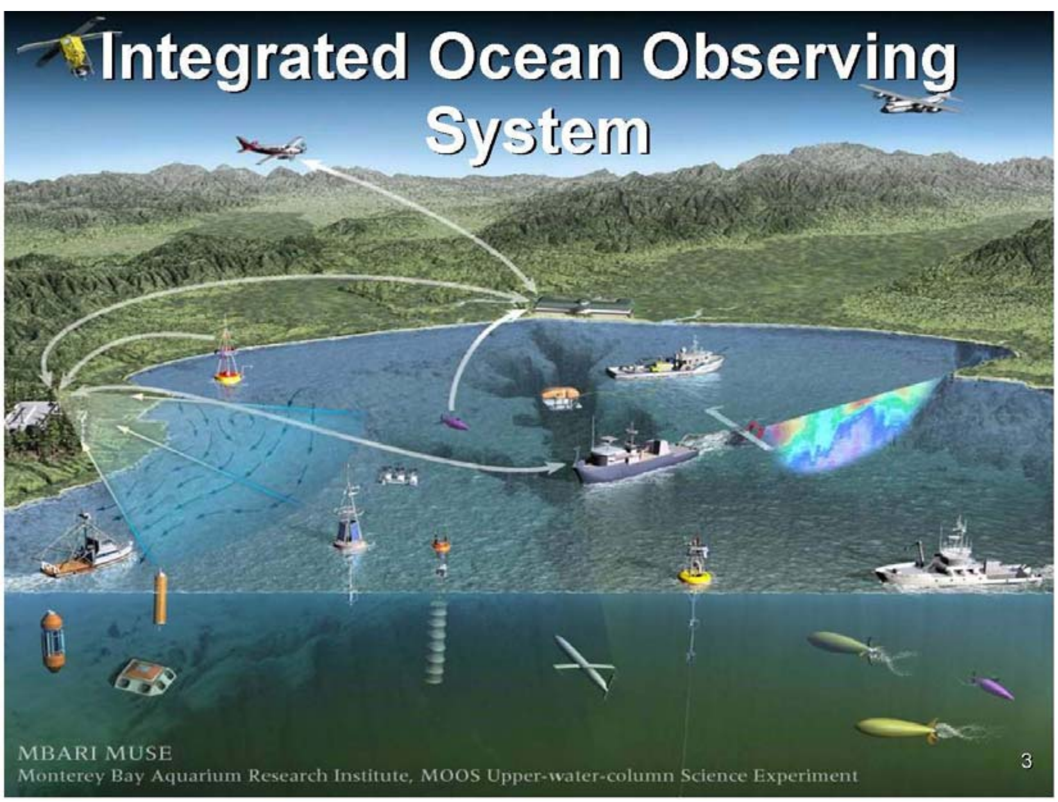

Figure 1. Data is collected at IOOS observation stations and transferred to the data management and communications subsystem.

The IOOS observation subsystem will be a sustained network of buoys, satellites, ships, underwater vehicles, and other observation platforms that will routinely collect data and information needed for rapid and timely detection of changes in our nation's estuaries, coastal waters, open ocean, and Great Lakes. This subsystem will consist of two interdependent components that use both remote and *in situ* sensing to obtain measurements over the broad range of scales needed to detect, assess, and predict the effects of global weather, climate change, and human activities on the oceans and coasts. The coastal component consists of a federation of 11 regional observation systems that collect data from the Great Lakes, territorial waters, and estuarine waters to the edge of the U.S. Exclusive Economic Zone (EEZ). The Global Ocean Component of IOOS will include observation stations in the open oceans (Nowlin, 2001; Ocean.US., 2002).

The DMAC subsystem will be a composed of data systems, regional data centers, and archive centers connected by the Internet, and using shared standards and protocols. The DMAC will integrate the coastal and global ocean components of the observation subsystem and serve as a link between the observation subsystem and the end users (Ocean.US., 2005a; 2005b). The data modeling and analysis subsystem will use real-time and historical data from the DMAC to evaluate and forecast the state of the marine environment (Ocean.US., 2005a).

IOOS will be part of several larger systems that are used to assess the state of the environment worldwide. IOOS is the U.S. contribution to the Global Ocean Observing System (GOOS) and will also serve as the estuarine-marine-Great Lakes component of the U.S. Integrated Earth Observation System (IEOS). IEOS includes ocean, terrestrial, atmospheric, and other observation systems and is the U.S. contribution to the Global Earth Observation System of Systems (GEOSS). IOOS is a key contribution toward attaining the benefits of the GOOS, IEOS, and GEOSS.

IOOS is currently under development, and plans are being prepared by Ocean.US, which is the national office that is coordinating the development of IOOS. Additional assistance is being provided by the Ocean.US Executive Committee (EXCOM) and the National Federation of Regional Associations (NFRA). More information about IOOS, NFRA, and the individual regional observation systems can be found at Ocean.US's Web site at http://www.ocean.us, NFRA's Web site at http://usnfra.org, or contact Brian Melzian (U.S. EPA/EXCOM) at melzian.brian@epa.gov.

Figure 2. Buoys are used as observation stations for IOOS.

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Assessing Coastal Watershed Conditions in the National Parks

The National Park System includes more than 5,000 miles of coastline, including coral reefs, barrier islands, kelp forests, estuaries, and other resources in over 3 million acres of ocean and Great Lakes waters (NPS, 2003, 2005). The National Park Service (NPS) is charged with conserving the natural and cultural resources within parks unimpaired for the enjoyment of current and future generations. To achieve its mission, the NPS Coastal Watershed Condition Assessment (CWCA) Program is providing scientific assessments of resource conditions in each of the coastal parks (Figure 1).

This program reviews and synthesizes existing information to determine the status of coastal park resources, including water quality, habitat condition, invasive and feral species, extractive uses, physical affects from resource use and coastal development, and other issues affecting resource health (NPS, 2005).

Final reports have been published for parks in the Southeast and Gulf Coast regions and include the Padre Island National Seashore, TX; Cape Lookout National Seashore, NC; the Timucuan Ecological and Historic Preserve, FL; Gulf Islands National Seashore, FL and MS; and the Cumberland Island National Seashore, GA. These reports characterize the relative health or status of coastal resources in the National Park System and reveal factors that may cause impairment. The reports also evaluate the need for field studies and identify information gaps that hinder efforts to address resource problems or more fully evaluate conditions. These assessments provide a synthesis of current resource conditions and valuable insights into factors affecting the health of park resources for use by natural resource managers. Stressor Matrix Tables are included in each report (Table 1). The Stressor Matrix Tables are useful summaries of known and potential stressors and are used to develop resource condition scorecards for each park. They will also provide a regional summary of the condition of the NPS coastal units by comparison with the EPA NCA regional scorecards.

Table 1. Potential for impairment of Cumberland Island water resources; Stressor Matrix Table

Indicator	Ocean Beach	Sound Shore	Tidal Creeks	Freshwater Ponds	Ground Water
Water Quality					
Nutrients	LP	PP	ND	LP	LP
Fecal bacteria	LP	PP	ND/PP	ND/PP	ND
Dissolved oxygen	LP	HP	ND	PP	NA
Metal contamination	ND	PP	ND	LP	LP
Toxic compounds	ND	PP	ND	ND	ND
Population Effects					
Fish/shellfish harvest	ND	PP	ND	LP	NA
Invasive species	ND	ND/PP	ND/PP	LP	NA
Habitat disruption	ND	PP	ND/HP	ND/HP	LP

Definitions:
ND – No data to make judgment, NA – Not applicable, LP – Low or no problem,
HP – High problem, PP – Potential problem
Source: Alber, Flory, and Payne (2005)

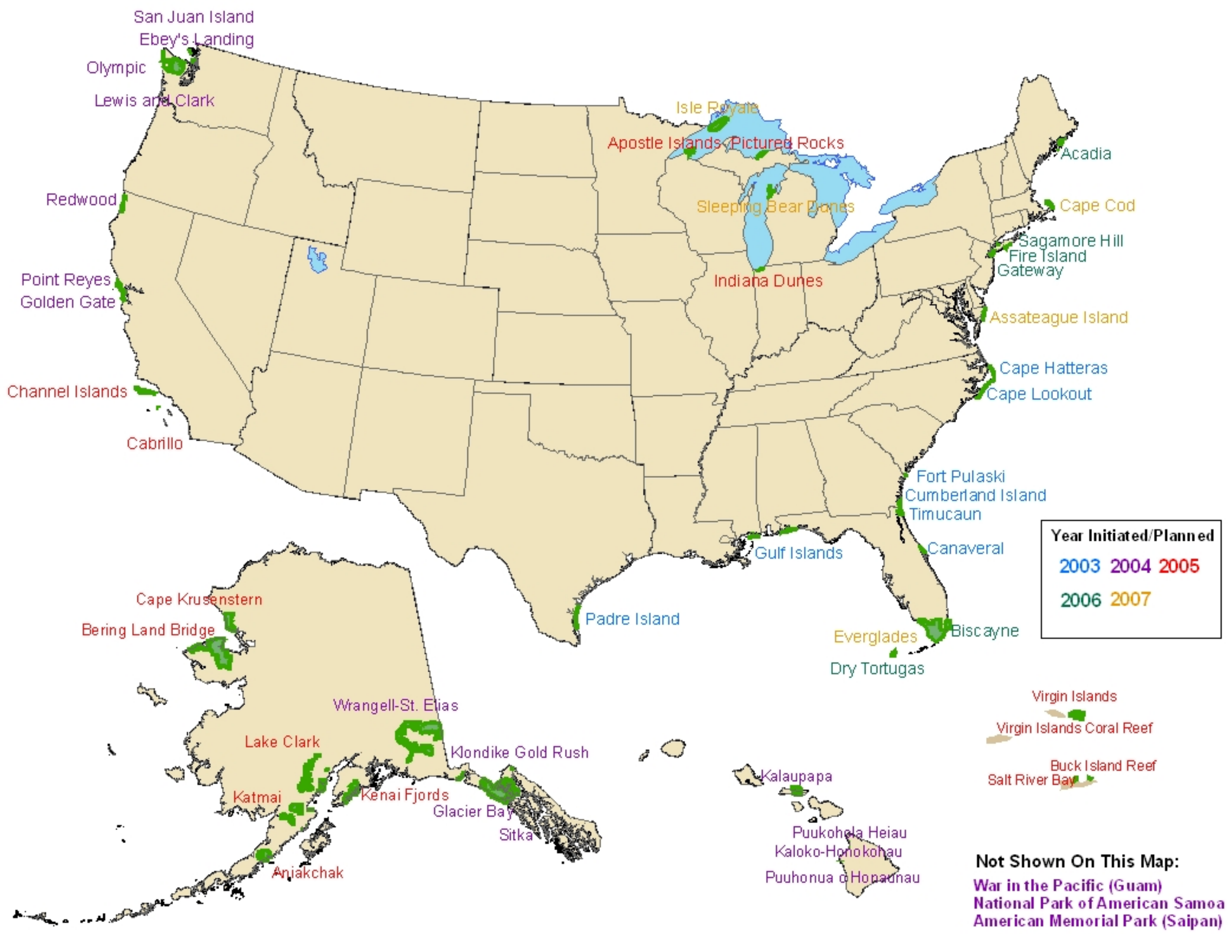

Figure 1. Map of NPS Coastal Parks where assessments have been initiated or are planned. (NPS, 2006)

The NPS Water Resources Division (WRD) is providing the Coastal Watershed Condition Assessment Reports to parks and the NPS Inventory and Monitoring Networks to help guide resource management planning and support the development of Vital Signs Monitoring Plans. The Coastal Condition Assessment Reports could be used to guide more intensive assessments to elucidate known park problems, identify pollution sources or other resource stressors, and develop restoration or cooperative watershed management strategies in individual parks and nationwide. The NPS also plans to work collaboratively with programs, such as EPA NCA, USGS, NOAA, state and local agencies, watershed councils, landowners, and other community stakeholders to address issues cooperatively on a local watershed or regional oceanographic scale. Copies of completed Coastal Watershed Condition Assessment Reports may be found at http://www.nature.nps.gov/water/watershed_reports/WSCondRpts.htm (accessed 2006).

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A National Water Quality Monitoring Network for U.S. Coastal Waters and Their Tributaries

The annual cost of water quality monitoring in U.S. coastal waters and their tributaries is hundreds of millions of dollars. Yet, in recent years, numerous reports have indicated that monitoring has been and remains insufficient and lacks coordination to provide comprehensive information about U.S. water resources. In 2004, the U.S. Commission on Ocean Policy (COP) recommended a national monitoring network to improve management of coastal resources. In response, the Administration produced a U.S. Ocean Action Plan (December 2004), which included creation of a National Water Quality Monitoring Network as a key element for advancing our understanding of the oceans, coasts, and the Great Lakes. The network was designed by the National Water Quality Monitoring Council on behalf of the Advisory Committee on Water Information and in response to a request from the Council on Environmental Quality and two subcommittees of the National Science and Technology Council.

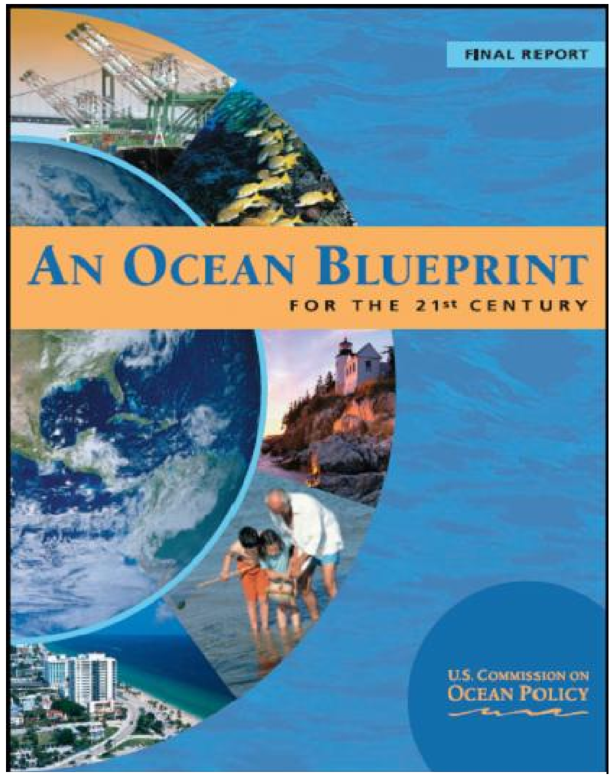

Figure 1. An Ocean Blueprint for the 21st Century: A Final Report from the U.S. Commission on Ocean Policy.

The proposed national water quality monitoring network for U.S. coastal waters and their tributaries (the "Network") shares many attributes with ongoing monitoring efforts, but it is unique in that it uses a multidisciplinary approach to address a broad range of resource components, from upland watersheds to offshore waters. Specifically, the proposed Network has several key design features, including the following:

- Clear objectives linked to important management questions
- Linkage with the Integrated Ocean Observing System (IOOS)
- Integration of water resource components from uplands to the coast, including physical, chemical, and biological characteristics of water resources
- Flexibility in design over time
- Importance of metadata, QA procedures, comparable methodology, and data management that allow readily accessible data storage and retrieval.

This initial design of the Network focuses on U.S. coastal waters and estuaries. A total of 149 estuaries are included in the Network, and 138 of these are in the conterminous United States and represent more than 90 percent of the total surface area of the estuaries and over 90 percent of the total freshwater inflow. The sampling scheme for the estuaries includes the following: (1) probability-based sampling of estuaries in each IOOS region to determine the environmental condition of individual estuaries, (2) targeted and flexible sampling to address estuary-specific resource management issues and to determine temporal trends of selected parameters, and (3) selection of sampling sites to determine short-term variability in parameters of interest, using moored, automated sensors. For nearshore waters and the Great Lakes, the Network design calls for probability-based sampling design, supplemented with additional observations from shipboard surveys, satellite-mounted and aerial sensors, shore-based sensors, and autonomous underwater vehicles. Shipboard sampling and remote sensing will help to monitor the oceanic regime.

River monitoring is focused on sampling rivers that (1) represent 90 percent of the outflow of major inland watersheds, (2) flow directly into Network estuaries, and (3) flow directly into the Great Lakes and drain watersheds greater than 250 mi^2 in area. Network river monitoring will allow calculation of seasonal and annual fluxes of freshwater and loads of constituents from the uplands to coastal marine waters and the Great Lakes.

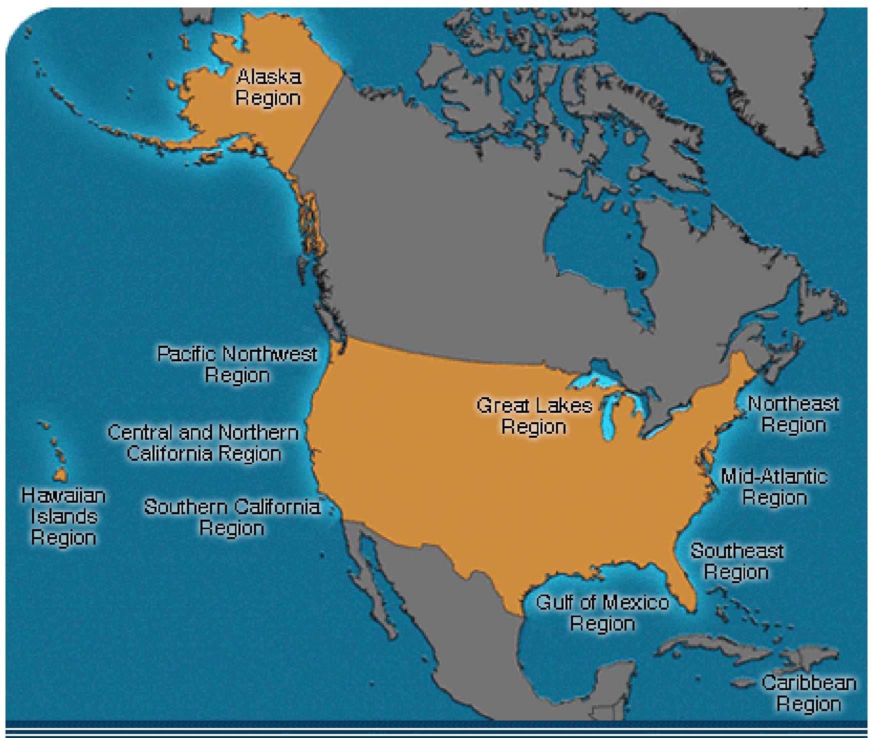

Figure 2. Integrated Ocean Observing System Regions. Source: NWQMC, 2006 (http://acwi.gov/monitoring/network/ppt/index.html).

Physical, chemical, and biological constituents are to be monitored throughout the Network. Specific constituents to be monitored for each resource type and the recommended monitoring frequency are included in the Network. Data management, comparability, storage, and access, as well as metadata standards and QA/QC considerations are fully discussed in the Network report. The Network report and appendices are available at http://water.usgs.gov/wicp/acwi/monitoring/network/design (accessed 2006).

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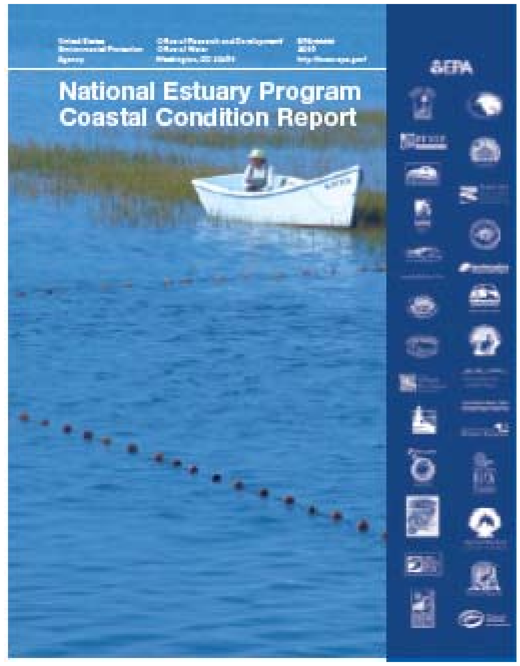
Conditions in Our Nation's National Estuary Program Estuaries



Our nation's estuaries encompass a wide variety of coastal habitats, including wetlands, salt marshes, coral reefs, mangrove and kelp forests, sea grass meadows, tidal mud flats, and upwelling areas. These estuarine habitats include cold temperate waters, as well as subtropical and tropical ecosystems. Estuaries provide spawning grounds, nurseries, shelter, and food for fish, shellfish, and other wildlife species, as well as nesting, resting, feeding, and breeding habitat for 75% of waterfowl and other migratory birds (Boylan and Machean, 1997). Estuaries are also a vital part of our national economy providing areas used for recreation, tourism, commercial fishing and port facilities for domestic and international trade.

The major objective of the *National Estuary Program Coastal Condition Report* (NEP CCR) is to document the condition of the nation's 28 NEP estuaries—a subset of the nation's estuaries that have been designated as nationally significant estuaries. NEP estuaries were nominated for inclusion in the NEP because they were deemed threatened by pollution, human development, or overuse. The Clean Water Act requires that the EPA report periodically on the condition of the nation's estuarine waters. As part of the 1987 amendments to the Clean Water Act, the Section 320 NEP promotes comprehensive planning efforts to help protect these nationally significant estuaries through their individual estuarine-specific programs.

Data collected from 1999 to 2003 by EPA's NCA survey were used to rate the NEP estuaries individually, regionally, and nationally using four primary indexes of estuarine condition (water quality, sediment quality, benthic condition, and fish tissue contaminant concentrations). The NEP CCR presents the following two major types of data for each NEP estuary: (1) estuarine monitoring data collected as part of the NCA surveys, and (2) estuarine monitoring data collected by the individual NEPs or in partnership with interested stakeholders, including state agencies, universities, or volunteer monitoring groups.

The estuarine condition ratings developed in the report are based solely on NCA estuarine monitoring data because these data are the most comprehensive and nationally consistent data available related to estuarine condition. The NEP CCR uses these data in assessing estuarine condition by evaluating the four selected indices of estuarine condition in each region of the United States (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, and Puerto Rico). The resulting ratings for each index are then used to calculate both an overall NEP estuary rating, an overall NEP regional rating, and an overall NEP national rating of estuarine condition. This national assessment applies to 28 individual NEP-designated estuaries in 17 coastal states and the island territory of Puerto Rico (Figure 1). With the NEP CCR, the collaborating agencies and the individual NEPs strive to provide a benchmark of estuarine condition that paints a comprehensive picture of the nation's NEP estuaries.

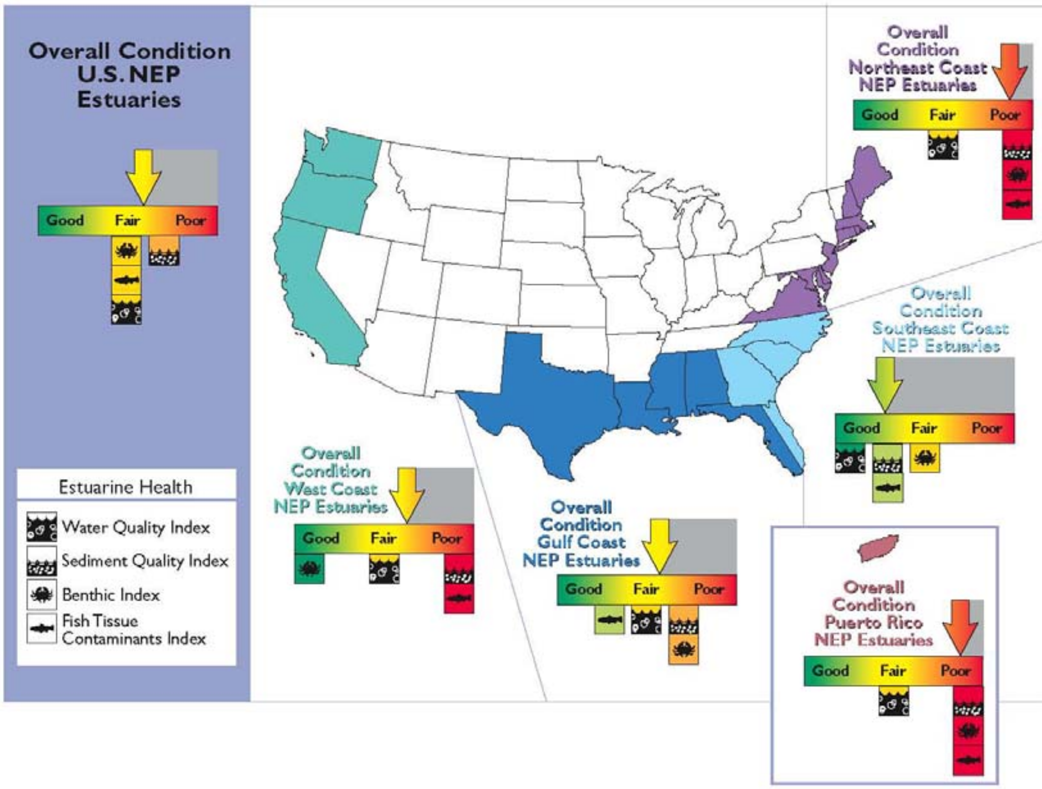


Figure 1. Overall national and regional condition ratings for NEP estuaries based on NCA results (1999–2003) (EPA, 2006).

The major findings of the NEP CCR include the following:

- Ecological assessment of NCA data shows that the nation's estuaries are generally in fair condition nationally, but that regionally, the NEP estuaries are in poor condition in Puerto Rico (San Juan Bay) and in the Northeast, in fair condition in the Gulf Coast and West Coast regions, and in fair to good condition in the Southeast.
- The indices that show the poorest conditions throughout the United States are the sediment quality index, followed by the fish tissue contaminants index, and benthic index. The index that generally shows the best condition is the water quality index.
- Nationally, 37% of NEP estuaries are in poor condition. Regionally, roughly 100% of Puerto Rico's NEP estuary (San Juan Bay) is in poor condition, and 46% of the Northeast Coast, 46% of the Gulf Coast, 36% of the West Coast, and 23% of the Southeast Coast NEP estuaries are in poor condition. (U.S. EPA, 2006)

This report also provides individual NEP profiles of the nation's 28 nationally significant estuaries, including a map, background information on the NEP estuary, environmental concerns of most importance to the NEP and its stakeholders, population pressures affecting the individual NEPs, and environmental indicators used by the NEP to assess estuarine health. This information, together with data from the NCA monitoring program, provides a picture of the overall condition of the coastal resources of the nation's NEP estuaries.

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Monitoring Coastal Land Cover Change

Because the condition of coastal watersheds can range from being highly altered by human activities to being close to pristine, land cover maps are a measure of the pressure imposed by humans on these coastal areas. Land cover data are used to document the current condition of our nation's coasts and the changes that occur, as a result of these anthropogenic pressures, as well as naturally occurring cycles and events over time.

The National Land Cover Database (NLCD) 2001 is a second-generation, moderate resolution land coverage produced from satellite imagery by the Multi-Resolution Land Characteristics (MRLC) Consortium. This consortium, which was originally created to meet the needs of several federal agencies, became a major provider of land cover information by successfully mapping the conterminous United States (NLCD, 1992). The continuing need for current, accurate, satellite-based information resulted in an expanded MRLC effort in 2001 (MRLC 2004). NOAA's Coastal Change Analysis Program (C-CAP) contributes to this nationally standardized database by creating land cover information for the coastal regions of the United States.

C-CAP land cover products use 30 meter Landsat imagery to inventory coastal intertidal areas, wetlands, and adjacent uplands, with the goal of monitoring changes in these habitats on a 1- to 5-year cycle (NOAA, 1995). To date, C-CAP has mapped coastal land cover for all of the conterminous United States and Hawaii (Figure 1). Coastal lands are categorized into 29 land cover classes with detailed information that summarizes the various changes between these classes that are occurring. Additional imagery is now being used to track these changes through time. Such consistent land cover information at a national scale provides data for a wide variety of analyses and applications. Trend information collected as part of this effort provides valuable

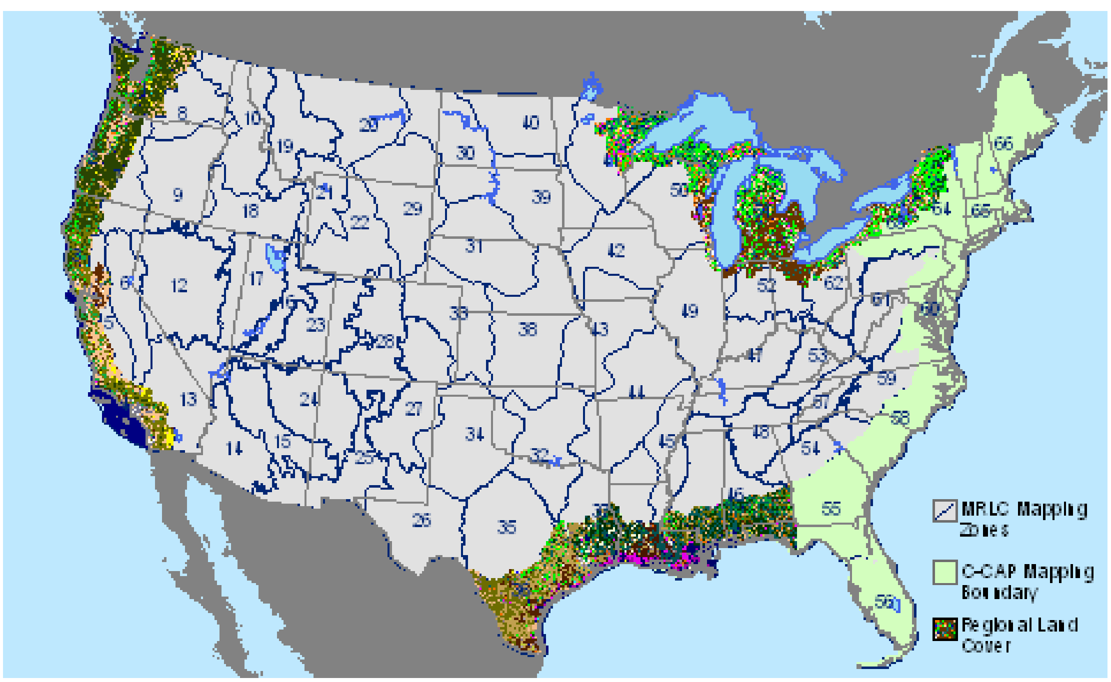

Figure 1. NOAA's C-CAP contributes land cover information for coastal regions of the continental United States. Source: USGS MRLC Program.

feedback to managers on the success of policies and programs, and helps users gain a better understanding of natural and human-induced changes.

Figure 2 shows how West Coast land cover has shifted among 12 land cover categories between 1996 and 2001 (NOAA, 2003). In terms of percentages, the largest changes are associated with increases in barren land and scrub/shrub, as well as decreases in overall forest cover (evergreen, mixed, and deciduous forests) and grasslands. These changes are because of forest management practices common in the Pacific Northwest, and the resulting cycle of harvest and reforestation. Forests are cut for their timber, the barren ground is colonized by grasses, which develops into scrubland and will eventually return to a mature forest. Between 1996 and 2001, the net loss in area of evergreen forest exceeded 1,000 mi^2 (NOAA, 2003). If you combine these practices with the effects due to increasing development, it is clear that human activities within these coastal regions have a considerable impact on the natural environment.

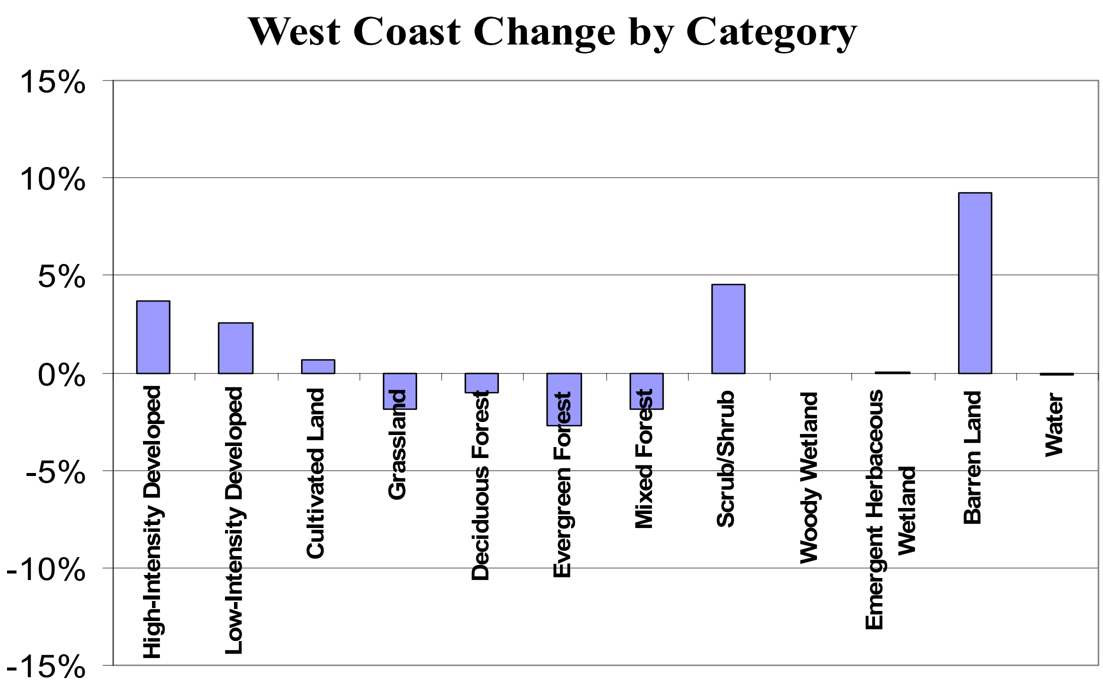

Figure 2. Shifts in West Coast land cover categories from 1996–2001. (Source: NOAA 2003)

More information about NLCD can be found at http://landcover.usgs.gov, or contact Collin Homer at Homer@usgs.gov. Additional information about C-CAP can be found at http://www.csc.noaa.gov/landcover, or contact Nate Herold at Nate.Herold@noaa.gov.

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Chapter 3

Northeast Coastal Condition

As shown in Figure 3-1, the overall condition of the collective estuaries of the Northeast Coast region is rated fair to poor, with an overall condition score of 2.2. The water quality index for the region is rated fair, the sediment quality index is rated fair to poor, the coastal habitat index is rated good to fair, and the benthic and fish tissue contaminants indices are rated poor. Figure 3-2 provides a summary of the percentage of coastal area rated good, fair, poor, or missing for each index and component indicator. Please refer to Tables 1-24 and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each of these parameters.

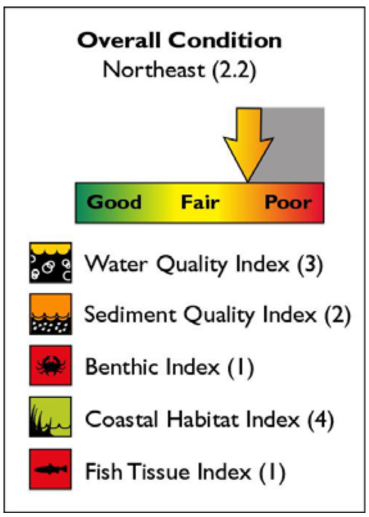

Figure 3-1. The overall condition of Northeast Coast coastal waters is rated fair to poor (U.S. EPA/NCA).

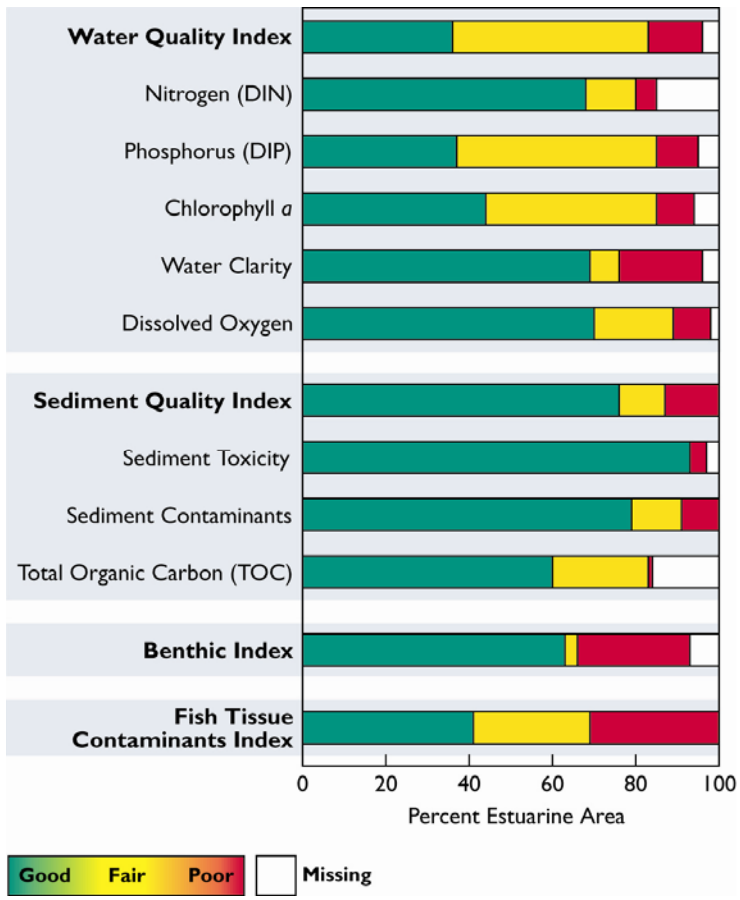

Figure 3-2. Percentage of coastal area achieving each ranking for all indices and component indicators – Northeast Coast (U.S. EPA/ NCA).

The Northeast Coast region contains diverse landscapes, ranging from the mountains, forests, and rocky coastal headlands of Maine, to the coastal plain systems of the Mid-Atlantic states. Cape Cod, ME, represents a major biogeographic transition area for the region's coastal area, dividing the more artic waters to the north of Cape Cod (Acadian Province) from the warmer, temperate waters to the south of Cape Cod (Virginian Province). 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. The region's Chesapeake Bay, the largest estuary in the United States, is considered microtidal in character, having average tidal ranges of less than 3 feet (Hammar-Klose and Thieler, 2001). The current total area of Chesapeake Bay is 4,404 mi^2 and represents 59% of the coastal area of the Northeast Coast region. 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 Northeast Coast 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 in this estuary heavily influence area-weighted statistical summaries of Northeast Coast conditions.

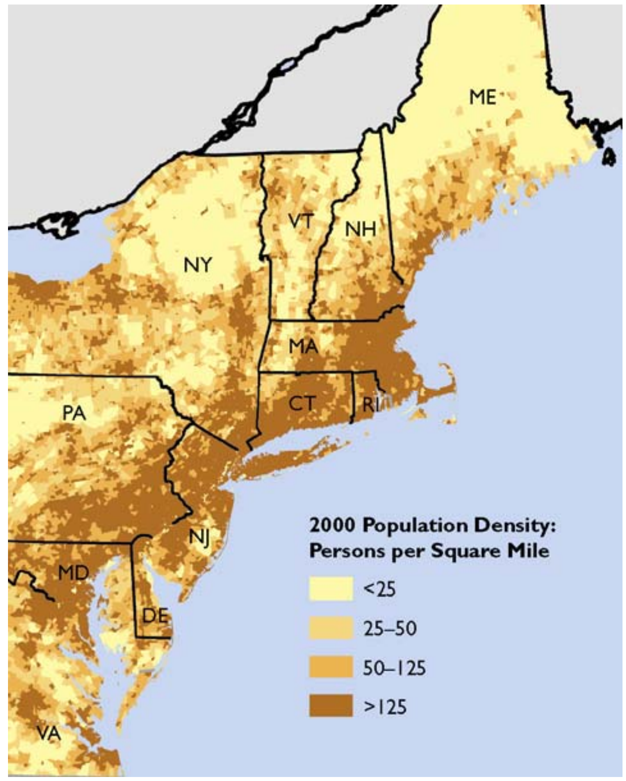

Figure 3-3. Human population density by county for watersheds that drain to the Northeast Coast (U.S. Census Bureau, 2000.)

The Northeast Coast region, which includes the coastal waters and watersheds of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, and Virginia, is the most densely populated coastal region in the United States (Figure 3-3). In 2003, the coastal population of the Northeast Coast region was the largest in the country, with 52.6 million people, representing 34% of the nation's total coastal population. Although coastal counties along the Northeast Coast showed the slowest rate of population increase (58%) between 1980 and 2003, the region gained the second-largest number of people (almost 8 million) of all U.S. regions during this time. Figure 3-4 presents population

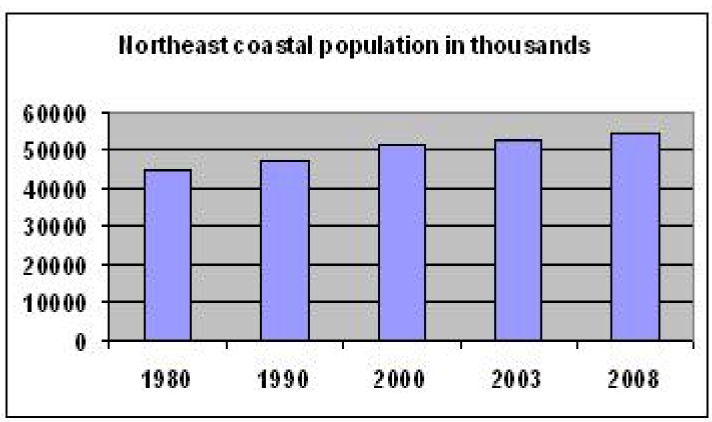

Figure 3-4. Actual and estimated population of coastal counties in the Northeast Coast region from 1980 to 2008 (NOAA, 2004).

data for Northeast coastal counties since 1980 (NOAA, 2004). The ratio of watershed drainage area to estuary water in the Northeast Coast region is relatively small when compared to the ratios in the Southeast Coast and Gulf Coast regions.

Coastal Monitoring Data – Status of Coastal Condition

All sampling sites that contributed data for this report were selected at random according to probabilistic sampling designs and were generally sampled during the summer months of 2001 and 2002 by states participating in the NCA; however, there were some exceptions to this scheme. Several areas, including parts of Maine, Massachusetts, Rhode Island, Connecticut, and New York (in the case of water quality assessment), contributed data only in 2001, either because of planned non-participation in 2002 or because of concerns regarding data quality. Chesapeake Bay was not sampled as part of the NCA survey in 2001 or 2002; therefore, the most recent data available from other programs were used for the assessment of this waterbody. Specifically, water quality conditions and benthic community data were measured by the Chesapeake Bay Program (CBP) during 2001 and 2002, and sediment quality data for the Bay were collected during NOAA's sediment triad cruises from 1998 through 2000.

Conditions for the Northeast Coast region were calculated and expressed in terms of the percentage of coastal area rated good, fair, or poor, or for which data were missing. For areas not participating in the 2002 survey, data were not considered to be missing, and the 2001 data were doubly weighted in order to ensure approximately equivalent representation throughout the Northeast Coast region. An exception to this method of areal weighting was the fish tissue contaminants index, for which survey results were unweighted and reported as the percentage of fish samples analyzed in good, fair, or poor condition.

The sampling conducted in the EPA NCA survey 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 index specifically at the time of sampling. Additional sampling may be required to define variability and to confirm impairment or the lack of impairment at specific locations.

Water Quality Index

The water quality index for the coastal waters of the Northeast Coast region is rated fair, with 13% of the coastal area rated poor and 47% of the area rated fair for water quality condition (Figure 3-5). The water quality index was based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen.

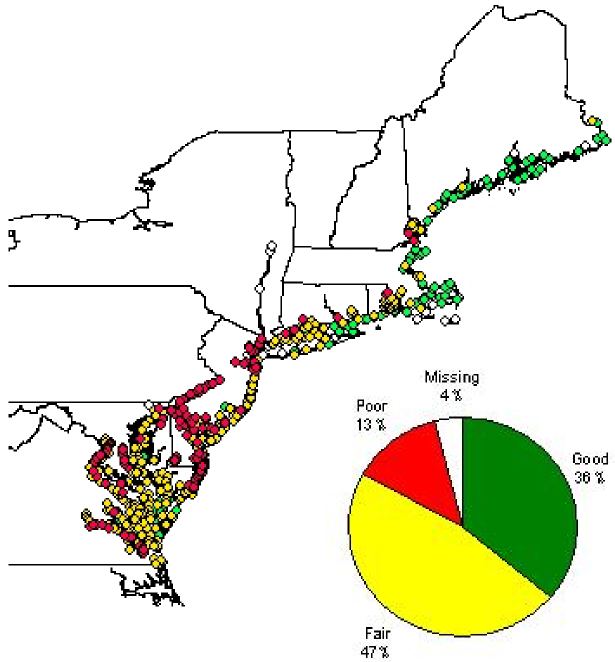

Figure 3-5. Water quality index data for the coastal waters of the Northeast Coast region (U.S. EPA/NCA).

Most of the Northeast Coast sites rated poor for water quality were concentrated in a few estuarine systems, in particular New York/New Jersey Harbor, some tributaries of Delaware Bay, the Delaware River, and the western and northern tributaries of Chesapeake Bay. Although signs of degraded water quality are evident throughout the Northeast Coast region, the water quality index indicates that the degradation was more evident in the coastal waters of the Virginian Province than in the coastal waters of the Acadian Province. Generally, the relatively open rocky coasts; cold, salty waters; and high tidal ranges of the Acadian Province favor well-mixed conditions. In contrast, the historically unglaciated parts of the Virginian Province have extensive watersheds that funnel nutrients, sediment, and organic material into secluded, poorly flushed estuaries that are much more susceptible to eutrophication. The pattern of water quality degradation in the Northeast Coast region also closely reflects the distribution of population density (Figure 3-3).

Nutrients: Nitrogen and Phosphorus

The Northeast Coast region is rated good for DIN concentrations, with only 5% of the coastal area rated poor for this component indicator. Poor DIN concentrations (DIN concentrations ranging from 1 to 5 mg/L) were largely confined to the New York/New Jersey Harbor, the western tributaries of Chesapeake Bay, the Delaware River, and the Delaware Inland Bays.

The Northeast Coast region is rated fair for DIP concentrations, with 58% of the coastal area rated fair or poor for this component indicator. The highest DIP concentrations were most evident in parts of the New York/New Jersey Harbor and Delaware River and were found to a lesser extent in Narragansett Bay, Long Island Sound, and the western tributaries of Chesapeake Bay. Good conditions (low DIP concentrations) were notable in Cape Cod Bay, coastal Rhode Island waters, and the mainstem of Chesapeake Bay.

Chlorophyll *a*

The Northeast Coast region is rated fair for chlorophyll *a* concentrations, with roughly 9% of the coastal area rated poor and another 41% of the area rated fair for this component indicator. Generally, the broad pattern of chlorophyll *a* concentrations is similar to that of nutrients, with chlorophyll *a* levels much higher to the south of Cape Cod (Virginian Province) than to the north (Acadian Province). Chlorophyll *a* concentrations mirror nutrient levels in the Maryland Coastal Bays, Chesapeake Bay tributaries, and much of the Northeast Coast coastal waters; however, there is little apparent spatial correlation between chlorophyll *a* and nutrients in the Chesapeake Bay mainstem, Delaware Bay, or New York/New Jersey Harbor areas. Spatial patterns in nutrient levels and chlorophyll *a* differ for a number of reasons. Algae may not be able to use nutrients effectively in very turbid water or in regions with high flushing rates; dissolved nutrient concentrations may be low due to nutrient uptake by phytoplankton blooms; or locations of peak nutrient and biomass concentrations may not coincide in space or time.

Water Clarity

The Northeast Coast region is rated fair for water clarity, with 20% of the coastal area rated poor for this component indicator. Due to differing management levels, water clarity reference levels varied across the Northeast Coast region (see box).

Coastal Areas	Reference Condition for Water Clarity (Percentage of Incident Light Reaching 1 Meter in Depth)
Chesapeake Bay Estuarine System	20%
Delaware River/Bay Estuarine System	5%
All remaining Northeast Coast coastal waters	10%

Dissolved Oxygen

Dissolved oxygen is rated fair for the Northeast Coast region, with 9% of the coastal area rated poor for this component indicator. The areas rated poor were located almost exclusively in the deep, isolated trenches of the Chesapeake Bay mainstem. Fair dissolved oxygen conditions were measured in another 19% of the coastal area, notably in the Chesapeake Bay, Long Island Sound, and Narragansett Bay. Dissolved oxygen levels were rated good in more than two-thirds of the Northeast Coast coastal area. A recent review of factors affecting the extent of hypoxic bottom water in Chesapeake Bay can be found in Hagy (2002), Hagy et al. (2004), and Kemp et al. (2005). In addition, 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.

Sediment Quality Index

The sediment quality index for the coastal waters of the Northeast Coast region is rated fair to poor, with 13% of the coastal area rated poor for sediment quality condition (Figure 3-6). This index in based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Hot spots of poor sediment quality were evident in

Narragansett Bay, western Long Island Sound, New York/New Jersey Harbor, and the upper portions of the Chesapeake Bay and Potomac River. To a large extent, the pattern of the sediment quality index for the Northeast Coast region mirrors the pattern of sediment contamination, a component indicator of this index.

Sediment Toxicity

The Northeast Coast region is rated good for sediment toxicity, with about 4% of the coastal area rated poor for this component indicator. Regions highlighted as impaired for sediment toxicity include parts of Cape Cod Bay, western Long Island Sound, New York/New Jersey Harbor, and the tidal-fresh parts of Delaware Bay. A generally weak statistical relationship between sediment contamination and amphipod survival was present and may reflect, in part, the strict criterion of mortality used to characterize toxicity in the amphipod assay. This weak relationship 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).

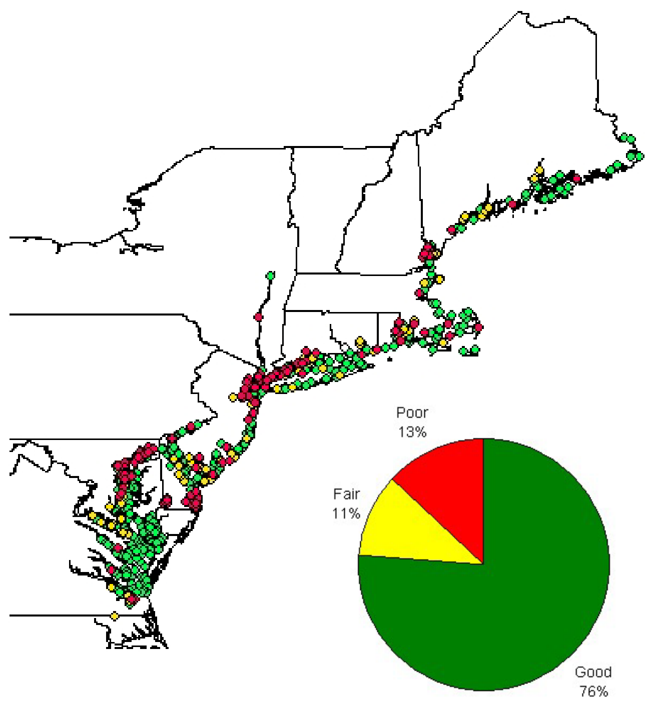

Figure 3-6. Sediment quality index data for the coastal waters of the Northeast Coast region (U.S. EPA/NCA).

Sediment Contaminants

The Northeast Coast region is rated fair for sediment contaminant concentrations, with 9% of coastal area rated poor and 12% of the area rated fair for this component indicator. Stations rated poor for sediment contaminants were clustered in areas neighboring major urban centers, including Narragansett Bay, New York/New Jersey Harbor, western Long Island Sound, upper Chesapeake Bay, and the upper Potomac River. Elevated levels of metals (e.g., nickel, mercury, silver, zinc, arsenic, and chromium), PCBs, and DDT were primarily responsible for the poor sediment contaminant ratings.

Sediment TOC

The Northeast Coast is rated good for sediment TOC because only 1% of the coastal area was rated poor. In addition, 23% of the coastal area was rated fair, and 60% was rated good for this component indicator. Generally, elevated TOC levels were found in the same locations as contaminated sediments. The high percentage of missing data (16%) reflects concerns about the quality of the TOC data analyzed for Connecticut.

Benthic Index

The benthic index for the coastal waters of the Northeast Coast region is rated poor, with 27% of the coastal area rated poor for benthic condition (Figure 3-7). The Northeast Coast region features two distinct biogeographic provinces, and separate benthic indices were developed to evaluate the unique benthic communities: the Virginian Province Benthic Index (Paul et al., 2001) and the Acadian Province Benthic Index (Hale and Heltshe, 2006). Because of the way these indices were developed, the Virginian Province Benthic Index has only two rating categories (good and poor), whereas the Acadian Province index has three rating categories (good, fair, and poor).

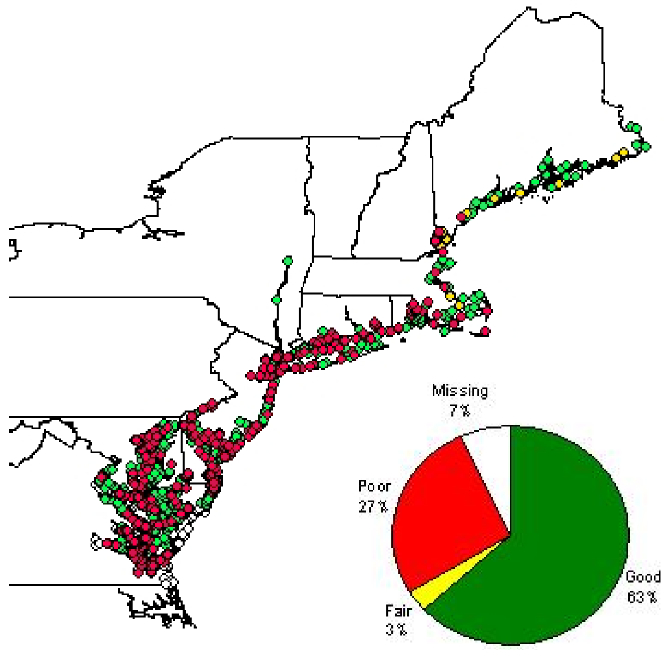

Figure 3-7. Benthic index data for Northeast Coast estuaries (U.S. EPA/NCA).

The benthic condition of the Acadian Province (north of Cape Cod) is very different from condition of the Virginian Province (south of Cape Cod). Poor benthic condition is evident in the upper Chesapeake Bay and in most of the Bay's major western tributaries, as well as in portions of Delaware Bay, New York/New Jersey Harbor, western Long Island Sound, and upper Narragansett Bay. In contrast, most of the eastern shore of Chesapeake Bay shows good benthic condition, as do most sections of the Acadian Province, with the exception of fair condition in New Hampshire Bay. The differences by province reflect exposure to different stress levels by the benthic communities, as well as the distinct differences in physical environment. Coastal conditions in the Acadian Province are more oceanic and have higher bottom-water salinity than those in the Virginian Province. In the northern estuaries (Acadian Province), benthic communities were sampled at sites 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 the Virginian Province.

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 rate of habitat loss, the Northeast Coast region lost 650 acres between 1990 and 2000, which amounts to a loss of 0.14% over 10 years. This rate of wetland loss for this time period was the lowest percent loss for all regions of the conterminous United States. 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 for the Northeast Coast region; therefore, the coastal habitat index for the Northeast Coast is rated good to fair.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the Northeast Coast region is rated poor based on concentrations of chemical contaminants found in composites of whole-body fish and lobster specimens. Thirty-one percent of the fish samples analyzed were rated poor, and 28% were rated fair (Figure 3-8). Although this figure gives an accurate indication of where fish or lobster specimens with appreciable contaminant levels were collected, several associated factors should be carefully considered before relating these findings to human risk or to the evaluation of estuarine condition. For example, one factor that should be considered is the species of fish analyzed because different tissue types have different affinities for specific contaminants, and these differences are likely to be species dependent. Currently, detailed information regarding these affinities is sparse. To improve understanding, NCA sampling and analysis protocols were altered in subsequent years to analyze “split samples” (i.e., samples of edible portions of fish and lobster are analyzed separately from inedible portions). It is helpful to consider the habits of the fish species collected when interpreting results. For instance, knowing the migration patterns of a fish species can help researchers determine the source of the contaminants measured in fish tissue.

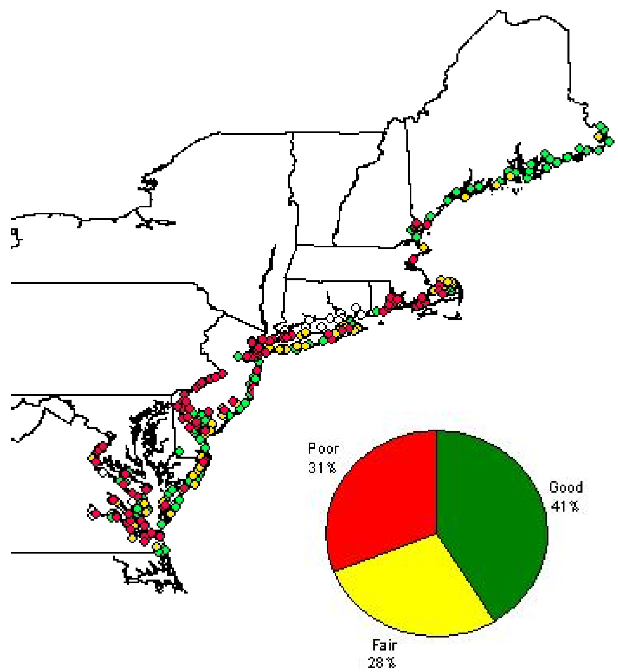

Figure 3-8. Fish tissue contaminants index data for Northeast Coast estuaries (U.S. EPA/NCA).

Elevated concentrations of PCBs were responsible for the fair or poor rating for a large majority of specimens, although other contaminants such as DDT or mercury were also implicated. Based on preliminary information from the split-sample study mentioned above, only those contaminants (e.g., mercury) that have an affinity for muscle tissue 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. NCA data suggest that there may be a pronounced gradient increasing from north to south in the incidence of contamination; however, distinct differences also existed in the types of organisms caught and analyzed across the region (e.g., primarily lobster in Maine and fish such as white perch and summer flounder farther south). It may be the case that cadmium was preferentially accumulated in lobster, whereas the highest levels of PCBs and DDT were measured in the white perch and summer flounder. Further research is needed to understand the relative importance of the species and tissue affinity for contaminants versus availability of the contaminants.

Trends of Coastal Monitoring Data – Northeast Coast Region

Temporal Change in Ecological Condition

Beginning in the early 1990s, EPA and its partners conducted a series of monitoring programs to assess the ecological condition of the nation's coastal waters. A hallmark of the various programs was consistency, both in the probabilistic nature of the sampling designs (sites were selected at random to represent all coastal waters) and in the fact that all programs used a core set of parameters that were measured with equivalent protocols and quality assurance/quality control (QA/QC) procedures. This consistency eases the task of tracking changes over time. The following sections analyze these data to answer two trend-related questions for the Northeast Coast region: what is the year-to-year variability evident in the proportions of the region's coastal area rated in good, fair, and poor condition, and are there significant changes in the area classified as poor during the period from 1990 to 2001?

Several monitoring programs have assessed portions of the Northeast Coast region since the early 1990s, including the EMAP-Virginian Province (EMAP-VP), Mid-Atlantic Integrated Assessment (MAIA), Maryland Coastal Bays Program, and NCA. Details regarding these assessments are described in the following text box. Only common regions, indices, and component indicators measured by these programs over two time periods were considered. The trend analysis for the estuaries north of Chesapeake Bay, through and including southern Cape Cod, compares conditions measured in 1990–1993 with those assessed a decade later in 2000–2001. Core parameters measured consistently in these studies include dissolved oxygen, water clarity, sediment contaminants, sediment toxicity, sediment TOC, and benthic condition. Results for both periods were expressed as the percentage of coastal area rated good, fair, or poor based on the parameters assessed. Standard errors for these estimates were calculated according to methods listed on the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). The reference values and guidelines outlined in Chapter 1 were used to determine good, fair, or poor condition for each indicator from both time periods.

Programs, Parameters, and Time Periods Considered in the Northeast Trend Analysis

Since the early 1990s, four monitoring programs have assessed portions of Northeast coastal waters using similar sampling designs and measurement protocols. For reasons outlined below, data from only two of these programs were used in analyzing trends in the Northeast over time. The contributing programs are the EMAP–VP (1990–1993) and the NCA (2000–2001). Interannual variability in a variety of parameters common to both EMAP-VP and NCA are summarized and used to help identify changes between these two time periods.

In the Northeast, the EMAP–VP project measured conditions in the Virginian Province (Cape Cod through Chesapeake Bay) each summer from 1990 through 1993. Core parameters measured included dissolved oxygen, water clarity, sediment contaminants, sediment toxicity, sediment TOC, and benthic condition. No other water quality indicators, such as chlorophyll *a* or nutrient concentrations, were measured. Results of the EMAP-VP survey were reported by Paul et al. (1999) and in the NCCR I (U.S. EPA, 2001).

The Delaware and Maryland Coastal Bays were assessed in the summer of 1993 using EMAP methods, and results were reported in the report *Assessment of the Ecological Condition of the Delaware and Maryland Coastal Bays* (Chaillou et al., 1996). These data were not included in this trend analysis because they represent a small fraction of the Northeast region, and these Bays were assessed independently in the EMAP-VP study.

The MAIA evaluated the coastal waters from Delaware Bay south through Albemarle-Pamlico Estuarine System during the summers of 1997–1998. All core parameters listed above were measured along with several additional water quality measures. Results were reported in the report *Condition of Mid-Atlantic Estuaries* (U.S. EPA, 1998) and were also included in the NCCR I. Because of the limited overlap of the MAIA study area and Northeast Coast region considered here, MAIA data were not included in the trend analysis.

The NCA sampled all waters in the Northeast Coast region (Maine through the Delmarva Peninsula, with the exception of Block Island and Nantucket sounds) during the summers of 2000 and 2001, and portions of the region in 2002 and later. Conditions were evaluated using the EMAP core indicators listed above and additional water quality parameters, such as chlorophyll *a* and nutrient concentrations. Assessment of 2000 data was reported in the NCCR II (U.S. EPA, 2004a), and data from 2001 and 2002 are assessed in this current report (NCCR III). It should be noted that NCA data from 2002 were excluded from the trends analysis because they were only collected from portions of the Northeast Coast.

Only portions of Chesapeake Bay were monitored by the NCA survey in 2000 and 2001. The assessment of 2000 data, reported in NCCR II, utilized data from the CBP (http://www.chesapeakebay.net) to evaluate water quality and benthic quality, and MAIA 1997–1998 data were used to assess sediment quality for the Bay. A similar approach is used in the current report (NCCR III), using water quality and benthic community data sampled in 2001 and 2002 from the CBP along with 1998–2000 sediment quality data from NOAA. Because of the different sampling designs and time periods for documenting Chesapeake Bay conditions, Chesapeake Bay was excluded from the trends analysis.

In summary, the data considered in the trend analysis for the Northeast were limited to estuaries from southern Cape Cod through the Delmarva Peninsula sampled using data from consistent sampling designs for two time periods: 1990–1993 and 2000–2001. Indicators measured consistently in these studies include dissolved oxygen, water clarity, sediment contaminants, sediment toxicity, sediment TOC, and benthic condition.

In this analysis, water quality is represented by two parameters: dissolved oxygen concentrations in bottom waters and water clarity. Figure 3-9 shows the percentage of the Northeast Coast coastal area rated good, fair, or poor for the periods 1990–1993 and 2000–2001. On average, 83% of the Northeast Coast coastal area had adequate dissolved oxygen levels in the early 1990s, and less than 1% of the area was rated poor. In the 2000–2001 time period, dissolved oxygen levels were rated good in 73% of the coastal area and poor in 4% of the area. The year-to-year variation in dissolved oxygen concentrations is large, and the differences between the two time periods are not significant.

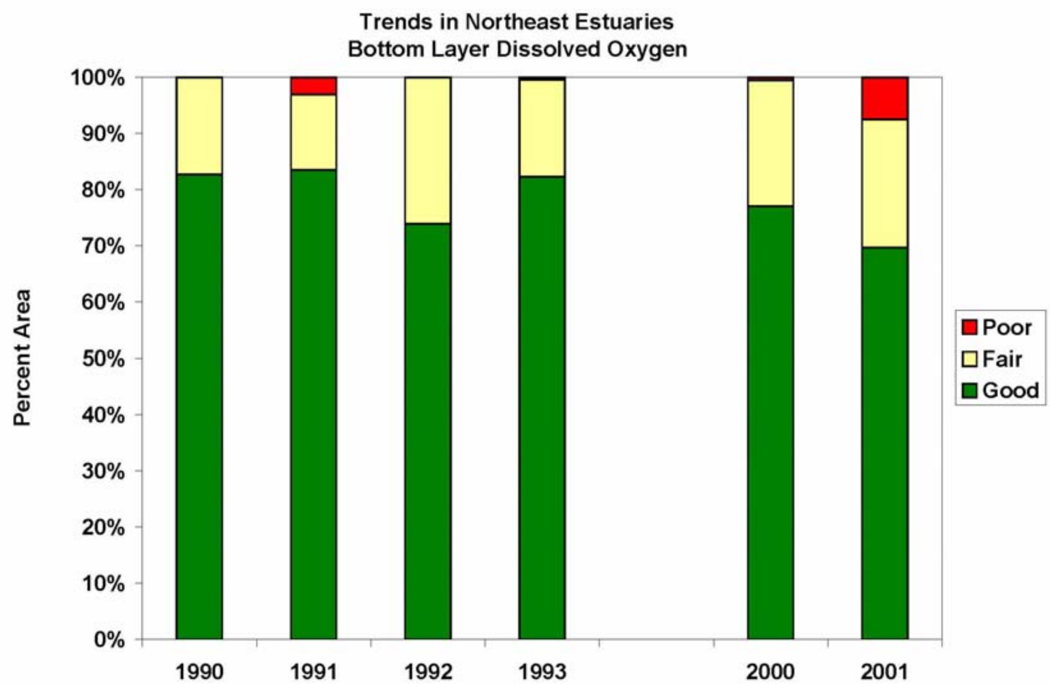

Figure 3-9. Percent area of Northeast Coast coastal waters rated good, fair, or poor for bottom layer dissolved oxygen concentrations measured over two time periods, 1990–1993 and 2000–2001.

Figure 3-10 indicates that poor water clarity was evident in 3% of the Northeast Coast coastal area in the early 1990s and was evident in 4% of the coastal area in 2000 and 2001. As with dissolved oxygen, there were no persistent year-to-year trends of improvement or degradation, and there was no significant difference between the 1990–1993 and 2000–2001 averages.

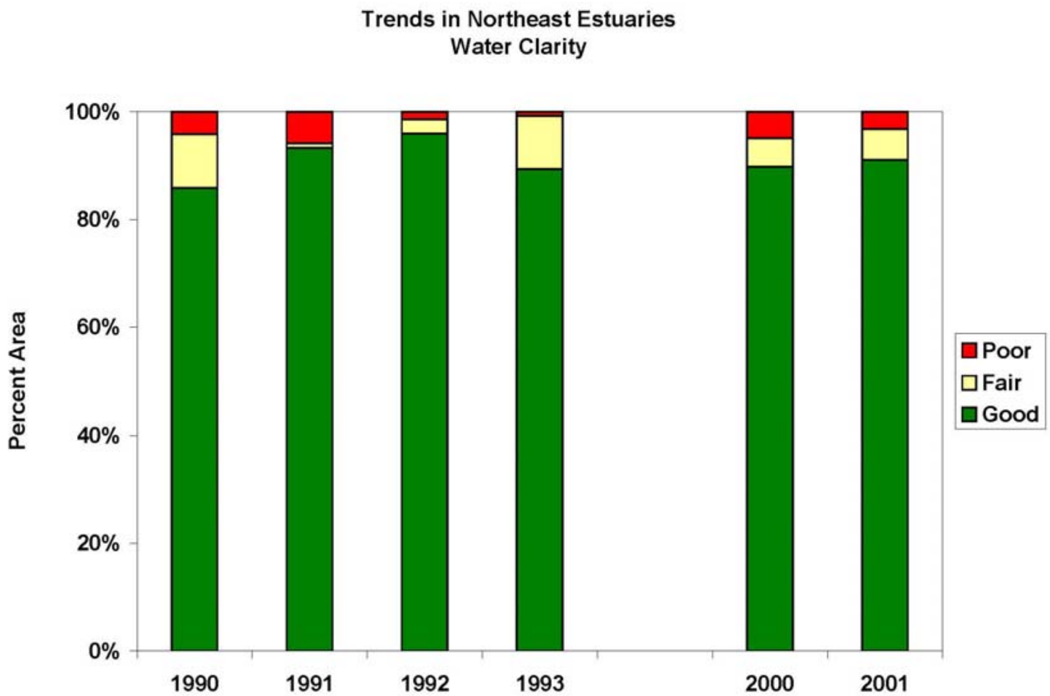

Figure 3-10. Percent area of Northeast Coast coastal waters rated good, fair, or poor for water clarity measured over two time periods, 1990–1993 and 2000–2001.

The condition of coastal sediments was evaluated using three component indicators: sediment toxicity, sediment contaminants, and sediment TOC; however, the overall sediment quality index was not compared. Figure 3-11 indicates that the proportion of coastal area rated fair or poor for sediment contamination is variable. For example, 7% of the coastal area was rated poor and 18% was rated fair in 1990–1993 as compared to 12% poor and 17% fair in 2000–2001. Figure 3-12 shows that less than 2% of Northeast Coast region's coastal area had excessive concentrations of TOC in sediments, and comparable areas were classified as fair for this indicator. Approximately 9% of the Northeast Coast coastal area was rated poor for sediment toxicity during each time period (Figure 3-13).

The benthic index for the Northeast Coast coastal area is a multimetric indicator of the biological condition of benthic macroinvertebrate communities. This index measures the habitability of sediments for stable benthic communities and serves as an overall indicator of water and sediment conditions. Figure 3-14 shows a lack of detectable trend in the percent of Northeast Coast coastal area that was rated poor. On average, 26% of the coastal area was rated poor in 1990–1993 and 34% of the area was rated poor in 2000–2001, although the difference is not significant.

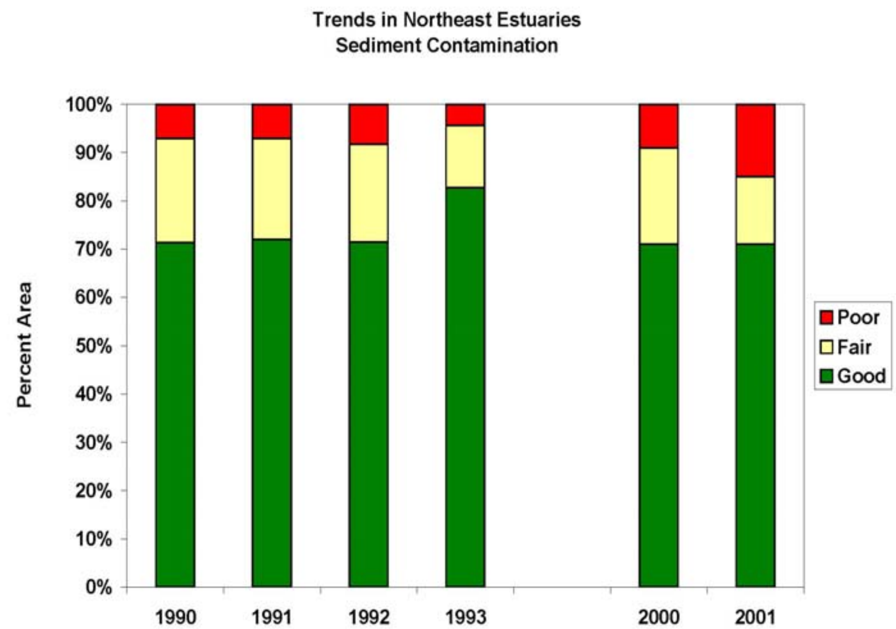

Figure 3-11. Percent area of Northeast Coast coastal waters rated good, fair, or poor for sediment contamination measured over two time periods, 1990–1993 and 2000–2001.

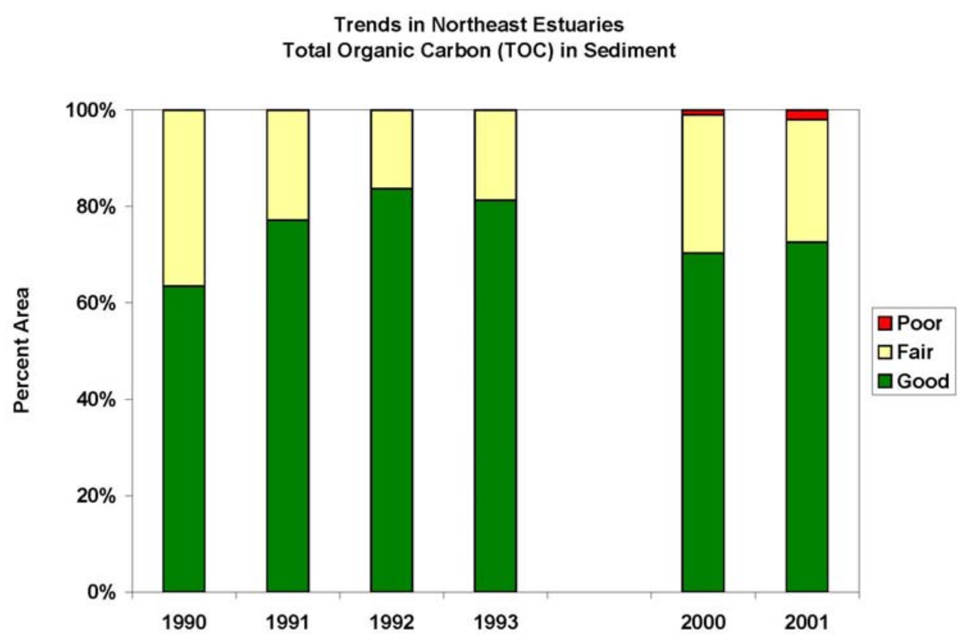

Figure 3-12. Percent area of Northeast Coast coastal waters rated good, fair, or poor for sediment TOC measured over two time periods, 1990–1993 and 2000–2001.

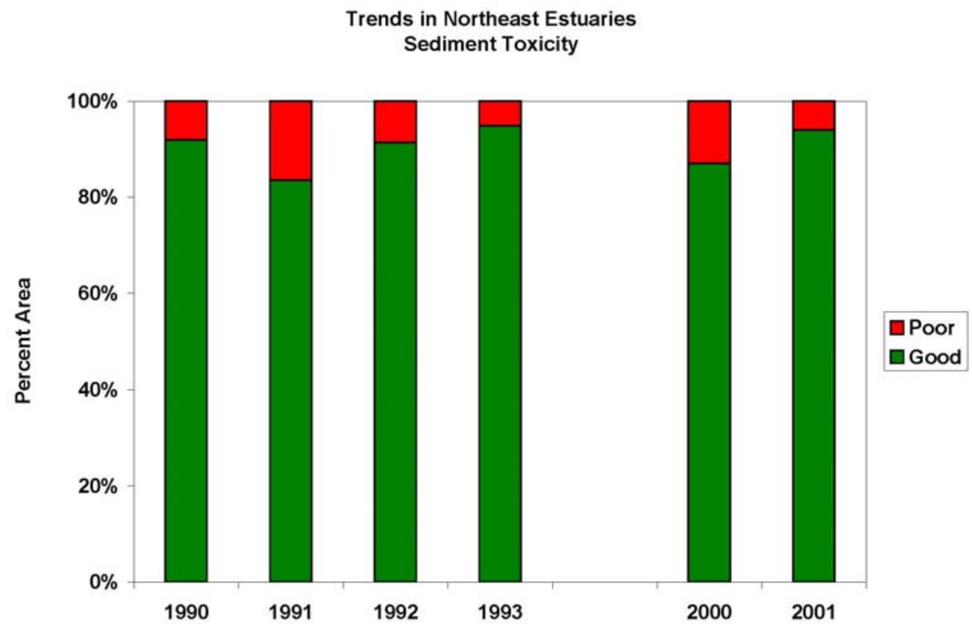

Figure 3-13. Percent area of Northeast Coast coastal waters rated good, fair, or poor for sediment toxicity measured over two time periods, 1990–1993 and 2000–2001.

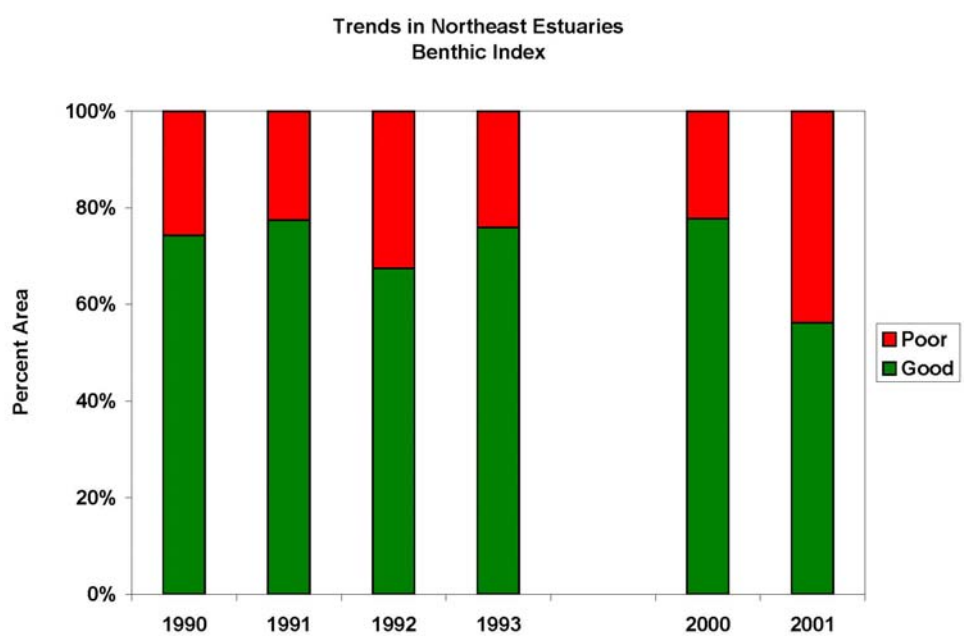

Figure 3-14. Percent area of Northeast Coast coastal waters rated good, fair, or poor for a benthic index measured over two time periods, 1990–1993 and 2000–2001.

Figure 3-15 summarizes changes in the percent area classified as poor in the Northeast Coast coastal area for the six common indicators measured over two time periods, 1990–1993 and 2000–2001. The error bars shown are 95% confidence intervals calculated as described at the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). Note that for all indicators, a slightly greater percentage of coastal area is rated poor in the later time interval; however, none of the differences are significant (based on a jackknifed analysis of variance that considers variable station weighting).

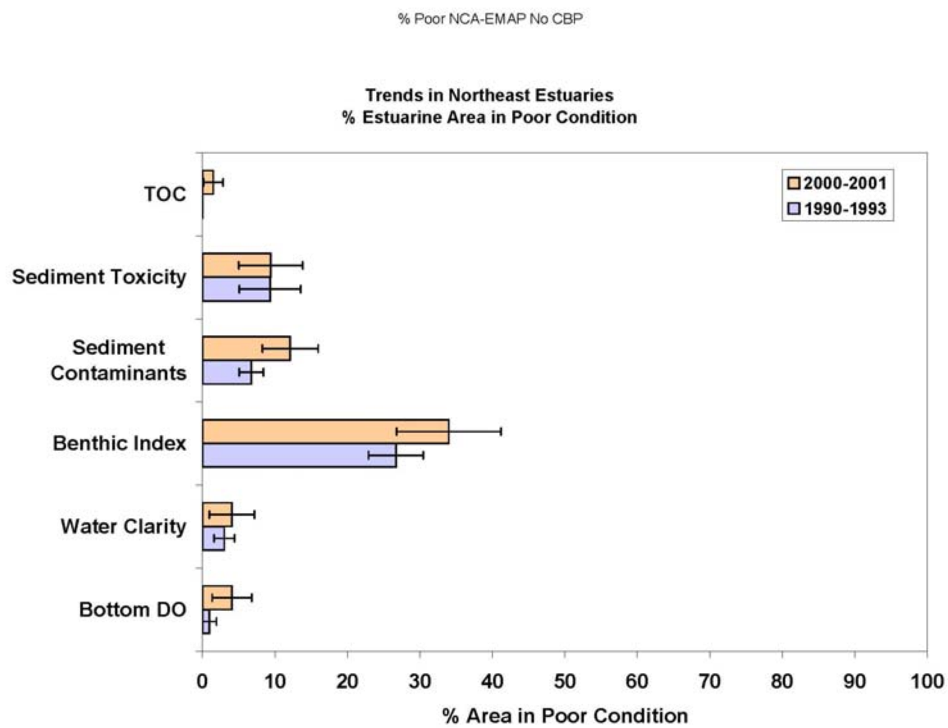

Figure 3-15. Percent area of Northeast Coast coastal waters rated poor for ecological indicators measured over two time periods, 1990–1993 and 2000–2001.

Although data processing was performed to compare areas where sampling overlapped geographically during the 1990–1993 and the 2000–2001 time periods, comparison of some other properties indicated that there were some differences between the samples from the two time periods. The cumulative frequency distribution (CFD) for depth indicates similar water depths were measured by the EMAP-VP (with Block Island and Nantucket Sound samples excluded) and NCA studies; however, Figure 3-16 shows the NCA depth CFD slightly to the right of the EMAP-VP CFD over the range of 20–30 meters, indicating a slightly higher NCA sampling frequency in this depth range. There were much larger differences in the time of year sampled. EMAP-VP sampling started slightly later in the year, but finished earlier than the NCA sampling. In addition, there were significant differences in surface water temperature and salinity. Significantly warmer temperatures were measured by the NCA than by the EMAP-VP, likely due to a higher sampling frequency later in the summer for the NCA than the EMAP-VP. The percent of the coastal area with salinities below 25 ppt were the same in both time periods; however, when the areas with salinities above 25 ppt were compared, the NCA samples exhibited slightly lower salinities.

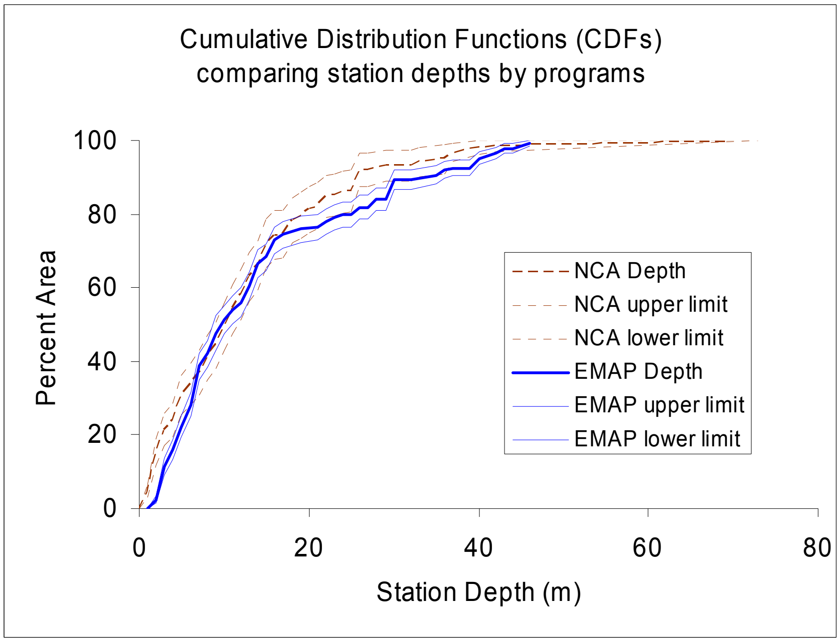

Figure 3-16. Cumulative distribution functions of station depths measured in EMAP-VP and NCA studies. Upper and lower limits are 95% confidence limits.

Northeast Shelf 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 in economic benefits annually from the fisheries of this ecosystem. Management efforts are underway 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 mi^2, and 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 harmful algal blooms (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.

Demersal Fisheries

Northeast Shelf LME demersal (groundfish) fisheries include about 35 species and stocks in waters off New England and the Mid-Atlantic states (NMFS, 2006). 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., NEFMC, MAFMC, ASMFC, individual states, and the Canadian government). Demersal fisheries in New England were traditionally managed primarily using 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.

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 3-17. 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.

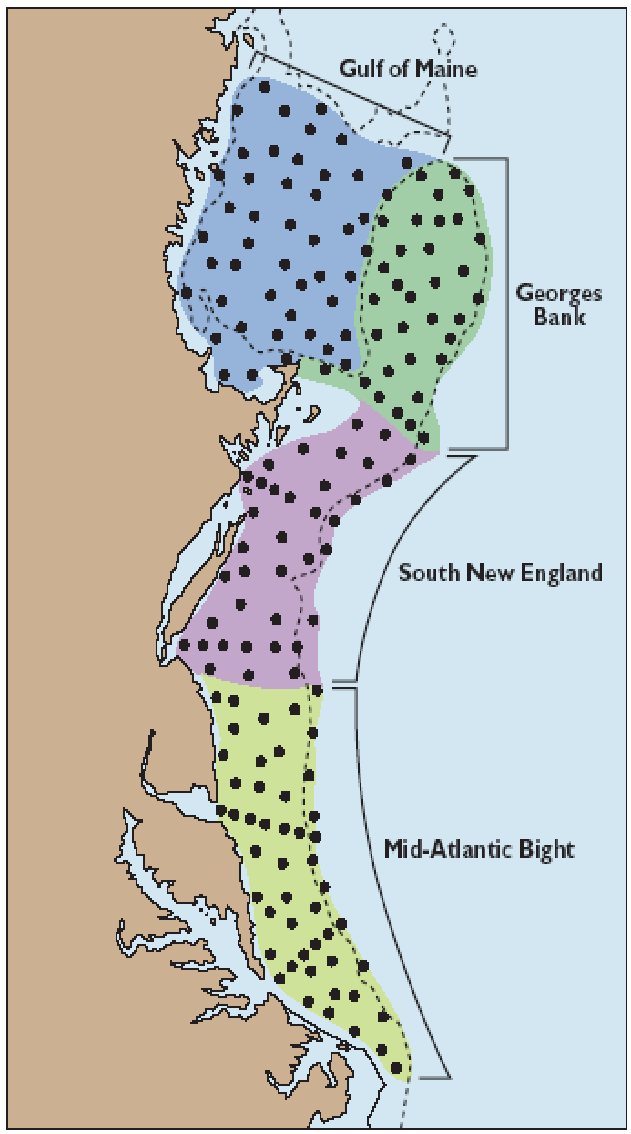

Figure 3-17. Northeast Shelf LME subareas and sampling locations (Sherman et al., 2002).

Principal Groundfish

The principal groundfish group of the Northeast Coastal region includes important species in the cod family (e.g., Atlantic cod, haddock, silver hake, red hake, white hake, and pollock), flounders (e.g., yellowtail, winter, witch, windowpane, Atlantic halibut, and American plaice), ocean pout, and redfish. Recent average yield of these 14 species (representing 19 stocks) have averaged 81,000 mt (74% U.S. commercial, 16% Canadian, and 10% U.S. recreational landings), compared to a combined sustainable yield of about 222,000 mt (Figure 3-18). Current yields are lower than the sustainable yield because many of these stocks are considered overfished and currently rebuilding. Total ex-vessel revenue from the principal U.S. groundfish commercial landings in 2003 was $123 million, compared to $121 million in 2000 and $109 million in 1997 (NMFS, 2006). The Northeast groundfish complex also supports important recreational fisheries for summer flounder, Atlantic cod, winter flounder, and pollock.

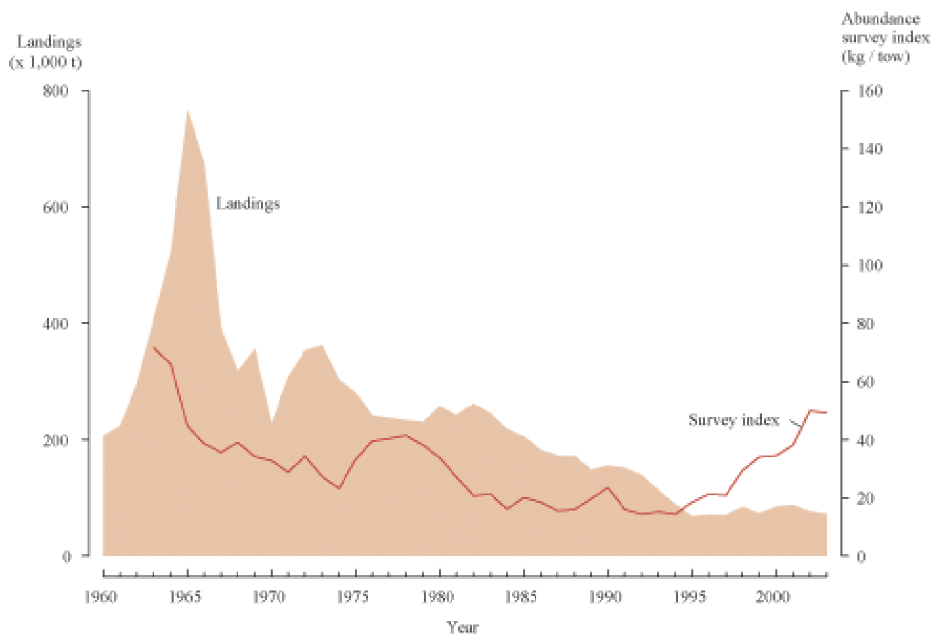

Figure 3-18. Landings in metric tons (mt) and abundance survey index (kg/tow) of principal groundfish, 1960–2003 (NMFS, 2006).

The research vessel survey abundance index for this group of species has fluctuated over time. The groundfish index declined by almost 70% between 1963 and 1974, reflecting substantial increases in exploitation associated with the advent of distant-water fleets (Figure 3-18). Many stocks in this group declined sharply during that period, notably Georges Bank haddock, as well as most silver and red hake and flatfish stocks. Groundfish partially recovered during the mid-to-late 1970s because of reduced fishing effort 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. After reaching a 30-year low in 1992, the index has more than tripled due to rebuilding efforts (NMFS, 2006). The most recent changes in the groundfish index are strongly influenced by the substantial increases observed in the biomass index for redfish since 1996 in the Gulf of Maine subarea, but the increased biomass of haddock and yellowtail flounder in the Georges Bank subarea and of cod in the Gulf of Maine have also influenced the groundfish index (NEFSC, 2001; 2002).

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 (NMFS, 2006). However, for some stocks, including Georges Bank yellowtail flounder and haddock, strong year-classes appearing in 1997 for flounder and in 1998, 2000, and 2003 for haddock, combined with sharp reductions in fishing mortality, led to improved stock conditions (NEFSC, 2002) and resulted in increased landings since 2000. Summer flounder spawning stock biomass, regulated by fishing quotas that shut down the fishery when attained, has increased eight-fold over the past decade. Indications are that the biomasses of scup and black sea bass have also increased (NMFS, 2006).

Management Concerns for Groundfish

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. 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 expansion of 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 who were 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 the fishing effort in the Northeast Shelf LME groundfish fishery (NMFS, 2006).

In 2004, the NEMFC increased rebuilding efforts and implemented a new days-at-sea baseline for each individual. The new baseline allows only 60% of one's days-at-sea to be directed at regulated species in 2004 and 2005, with further reductions scheduled through 2009. The remaining 40% of days can only be used in Special Access Programs that minimize the catch of overfished stocks or in directed fishing where it can be demonstrated that bycatch of overfished stocks is minimal (NMFS, 2006).

Pelagic Fisheries

The Northeast Shelf LME pelagic fisheries are dominated by four species: Atlantic mackerel, Atlantic herring, bluefish, and butterfish. The abundance of mackerel and herring is presently above average, whereas that of bluefish is near average and butterfish is below average. During the early 1970s, the principal Northeast pelagic species (Atlantic mackerel and Atlantic herring) were exploited heavily by foreign fleets, resulting in stocks and fishery yields declining to record low levels by the late 1970s. Due to the exclusion of foreign fleets, abundance and recruitment have increased, leading to stock sizes that are currently at historically high levels (NMFS, 2006).

The long-term population trends for mackerel and herring, as measured by research vessel survey data, have fluctuated considerably during the past 25 years (Figure 3-19). 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 component; however, the index subsequently increased steadily and peaked in 2001 (NMFS, 2006).

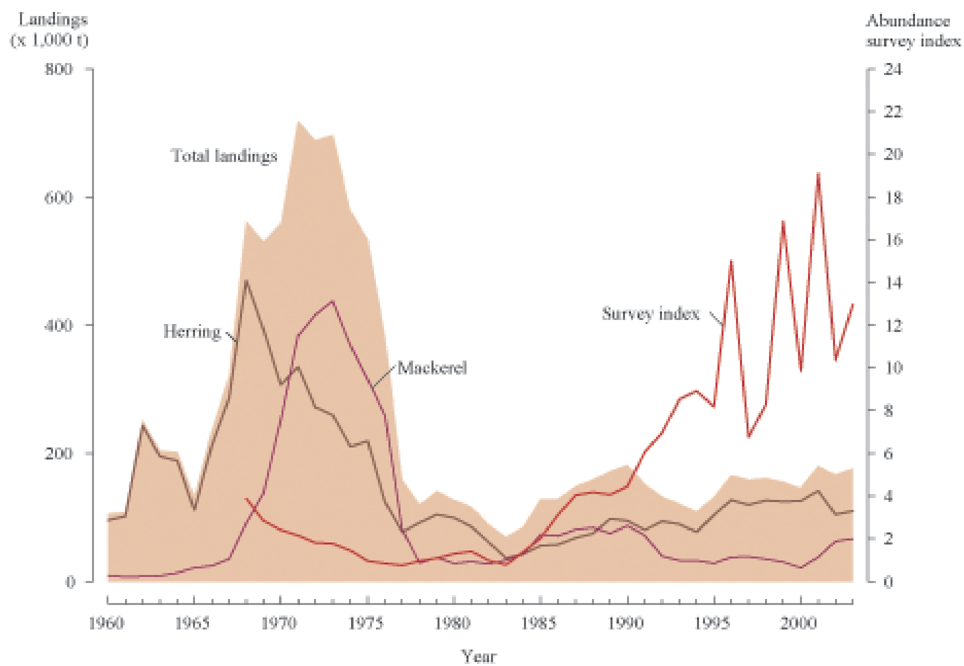

Figure 3-19. Landings in metric tons and abundance survey index (kg/tow) of principal pelagic stocks, 1960–2003 (NMFS, 2006).

Although historical catch data are generally adequate for assessment purposes (except perhaps for bluefish), 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, short life span of butterfish, and current low exploitation rates of 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 underway 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.

Invertebrate Fisheries

Offshore fisheries for crustacean and molluscan invertebrates are the most valuable fisheries of the Northeast Shelf LME, with average ex-vessel revenues of $605 million per year during 2001–2003. The American lobster fishery ranked first in value, with average annual ex-vessel revenues of $287 million during 2000–2002 and $326 million during 2003–2004, and the Atlantic sea scallop fishery ranked second, with average annual revenues of $226 million during 2001–2003. Landings of all other offshore invertebrates contributed roughly $92 million in additional revenue annually (NMFS, 2006).

American Lobster

A recent assessment of American lobster stocks (ASMFC, 2000) indicated that fishing mortality rates for lobster in Gulf of Maine waters were double the overfishing level. For the inshore resource distributed from southern Cape Cod through Long Island Sound and for the offshore stock in the Georges Bank subarea, 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) and during 2000–2002 averaged about 36,600 mt. Although high fishing mortality is a persistent problem in lobster fisheries in the Northeast Shelf ecosystem, recent landings (1997–2002) are the highest observed in the period since 1940 (Figure 3-20) (NMFS, 2006).

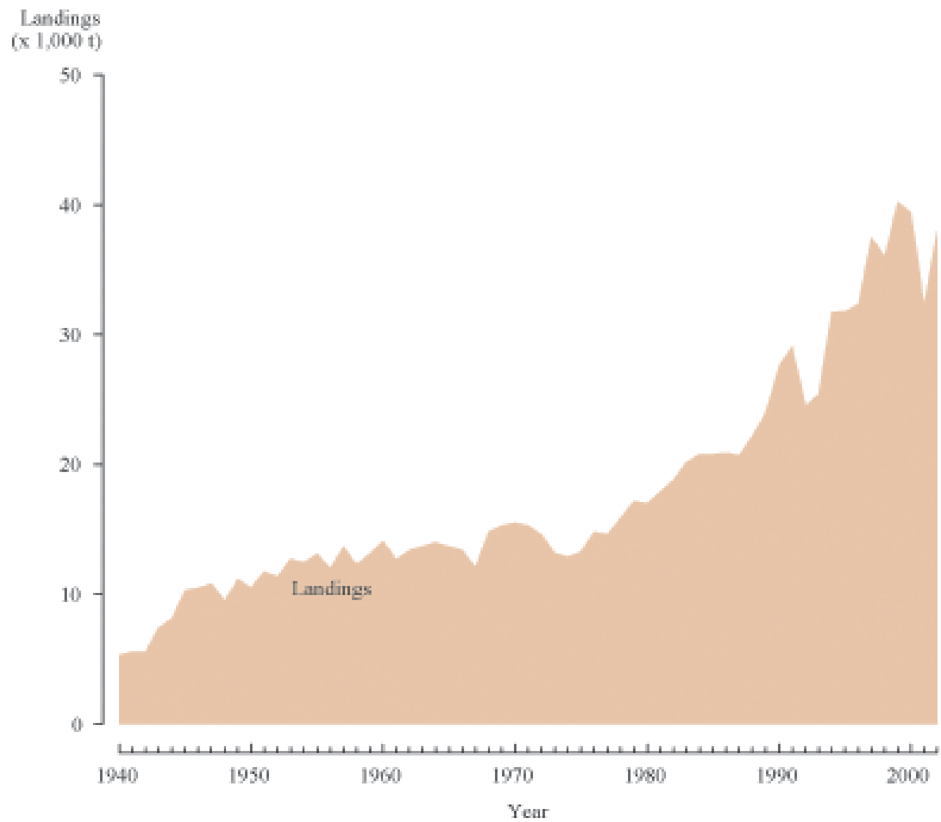

Figure 3-20. American lobster landings in metric tons from 1940–2002 (NMFS, 2006).

Atlantic Sea Scallop

In the United States, sea scallops are harvested in the Northeast Shelf LME from Cape Hatteras, NC, 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 management measures affecting the number of days at sea, vessel crew size, and dredge-ring size were implemented to address concerns about overfishing. 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 (NMFS, 2006).

A recent stock assessment (NEFSC, 2001) 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 (Figure 3-21) and revenues. Annual landings averaged 25,100 my during 2001-2003 and were 29,374 mt in 2004 (NMFS, 2006).

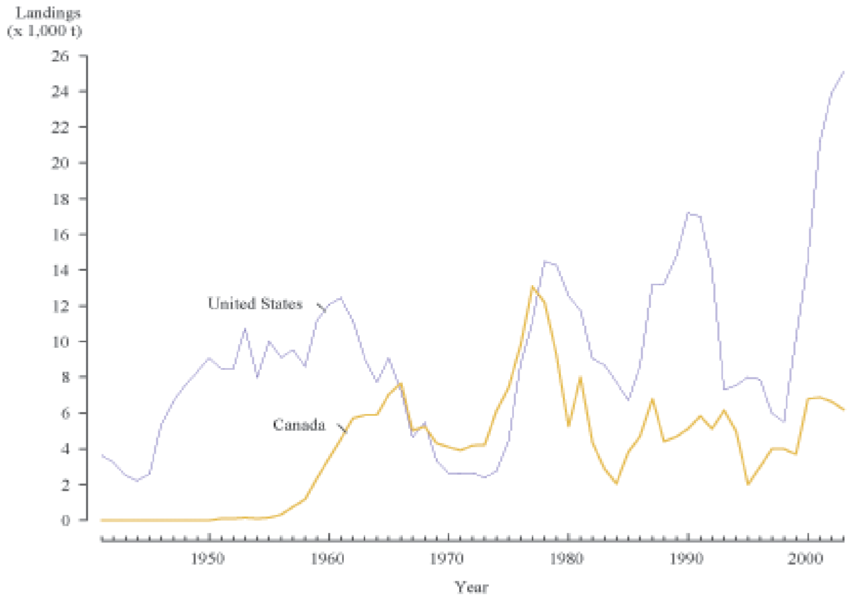

Figure 3-21. Landings of Atlantic sea scallop in the United States and Canada, 1941–2003 (NMFS, 2006).

Assessment and Advisory Data

Fish Consumption Advisories

In 2003, 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 region's coastal area was under fish consumption advisories (Figure 3-22) in 2003, with a total of 37 different advisories active for the estuarine and coastal waters of the Northeast Coast during that year. These advisories were in effect for 10 different pollutants (Figure 3-23). Most of the listings (97%) were, at least in part, caused by PCBs. Boston Harbor was listed for multiple pollutants.

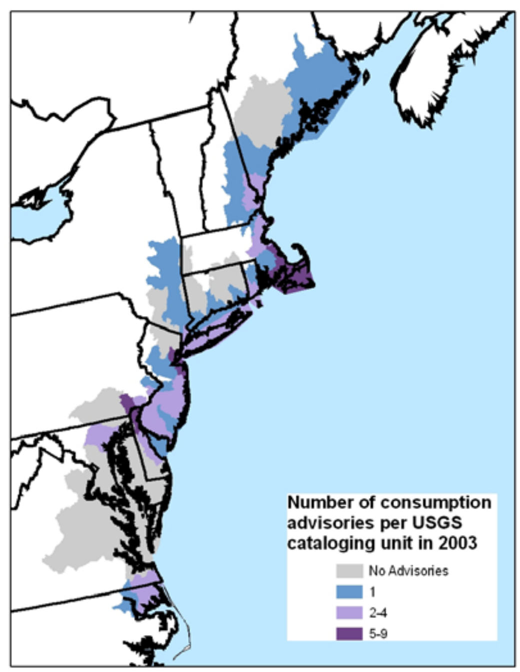

Figure 3-22. The number of fish consumption advisories for the Northeast Coast active in 2003 (U.S.EPA, 2004b).

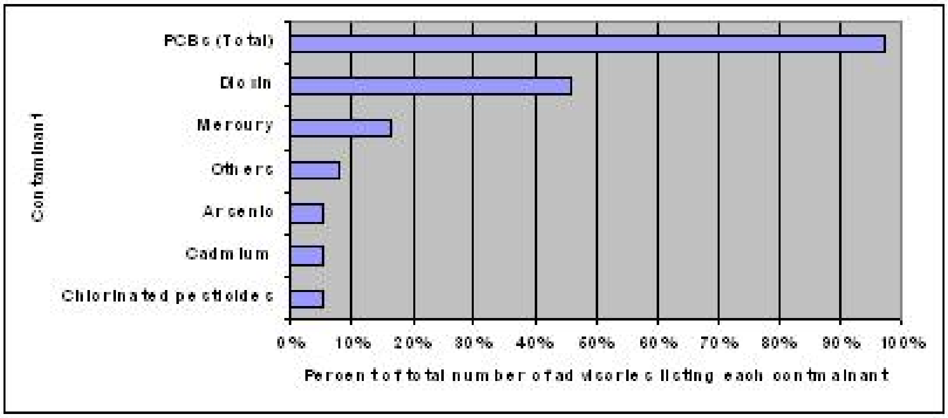

Figure 3-23. Pollutants responsible for fish consumption advisories in Northeast Coast coastal waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S.EPA, 2004b).

These species and/or groups were under advisory in 2003 for at least some part of the Northeast Coast:

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

Source: U.S. EPA, 2004b

Beach Advisories and Closures

Of the 1,684 Northeast Coast beaches in reported to EPA in 2003, only 13.4% (226 beaches) were closed or under advisory for any period of time during that year. The states with the highest percentage of beaches with advisories/closures were Connecticut and New York, where 43.3% and 37% beaches, respectively, were closed or under advisory at least once in 2003. Table 3-1 presents the number of beaches monitored and under advisories/closures for each state. Figure 3-24 shows the percentage of monitored beaches in each county that had at least one advisory or closure in 2003. Maine and Delaware did not report for the 2003 cycle, and Virginia only reported the number of beaches monitored.

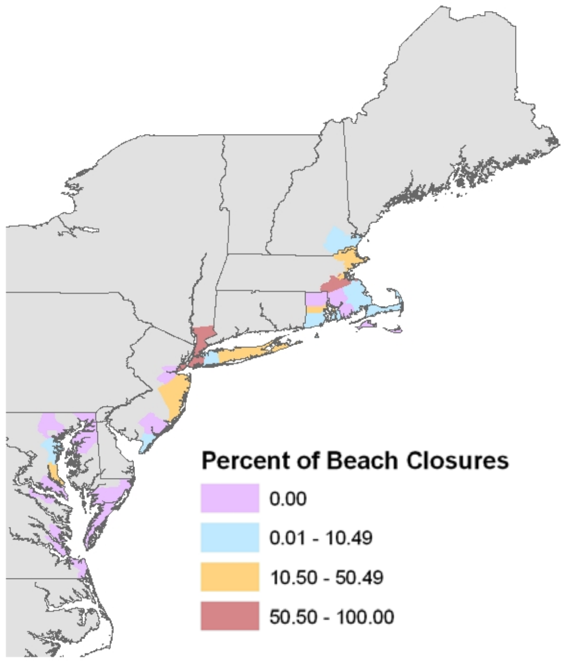

Figure 3-24. Percentage of beaches with advisories or closures by county for the Northeast Coast region (U.S.EPA, 2006).

Table 3-1. Number of Beaches Monitored and with Advisories/Closures in 2003 for Northeast Coastal States (U.S. EPA, 2006)

State	No. of Beaches Monitored	No. of Beaches with Advisories/Closures	Percentage of Beaches Affected by Advisories/Closures
Maine	Not Reported	Not Reported	Not Reported
New Hampshire	12	1	8.3
Massachusetts	736	73	9.9
Rhode Island	208	19	9.1
Connecticut	67	29	43.3
New York	211	78	37.0
New Jersey	324	24	7.4
Delaware	Not Reported	Not Reported	Not Reported
Maryland	88	2	2.3
Virginia	40	Not Reported	Not Reported
TOTALS	1686	226	13.4

The primary reasons for beach advisories and closures implemented at Northeast Coast beaches were elevated bacteria levels or pre-emptive closures associated with rainfall events or sewage-related problems (Figure 3-25). Most beaches had multiple sources of waterborne bacteria that resulted in advisories or closures. Stormwater runoff and sanitary sewer overflows (SSOs) were most frequently identified as sources, and unknown sources accounted for 45% of the response (Figure 3-26).

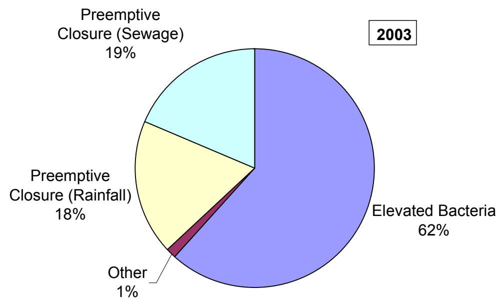

Figure 3-25. Reasons for beach advisories or closures for the Northeast Coast region (U.S. EPA, 2006).

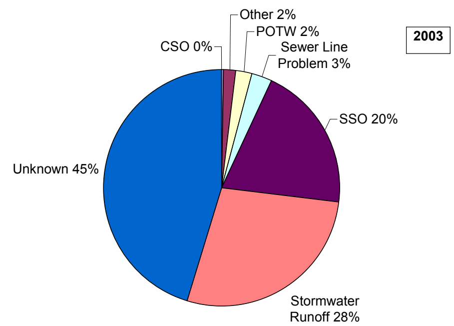

Figure 3-26. Sources of beach contamination for the Northeast Coast region (U.S. EPA, 2006).

Summary

Based on data from NCA, CBP, and NOAA, the overall condition of Northeast Coast coastal area is rated fair to poor. Problems associated with excess nutrients and low levels of oxygen are much less prevalent in the Gulf of Maine than in the waters south of Cape Cod. Clean sediments with low levels of chemical contamination, an absence of acute toxicity, and moderate-to-low levels of sediment TOC are found in 76% of the Northeast Coast region's coastal area. Benthic conditions are considered to be poor in 27% of the Northeast Coast coastal area, often in the vicinity of high human population density. Fish tissue contamination is also a concern in this region, with 31% of the samples rated poor. When EMAP-VP and NCA data on dissolved oxygen, water clarity, sediment contamination, sediment TOC, sediment toxicity, and benthic communities from 1990–1993 and from 2000–2001 were compared, a slightly greater percentage of coastal area was rated poor in the later time interval; however, none of these differences are statistically significant.

NOAA's NMFS manages several fisheries in the Northeast Shelf LME, including principal groundfish (e.g, cod, flounder, ocean pout, and redfish), pelagic fish (e.g, Atlantic mackerel, Atlantic herring, bluefish, and butterfish), and invertebrates (e.g, American lobster and Atlantic sea scallop). Many stocks of principal groundfish in this LME are considered overfished and currently rebuilding. The abundance of mackerel and herring is presently above average, whereas that of bluefish is near average and butterfish is below average. The fishing mortality rates of the region's American lobster are substantially above the overfishing level. There have been substantial increases in scallop biomass in the Northeast Shelf LME since changes were made to the Atlantic scallop fishery management measures in 1994.

Contamination in the coastal waters of the Northeast Coast region has affected human uses of these waters. In 2003, there were 37 fish consumption advisories in effect along the Northeast Coast, most of which were issued for PCB contamination. In addition, approximately 13% of the region's monitored beaches were closed or under advisory for some period of time during 2003. Elevated bacteria levels in the region's coastal waters were primarily responsible for the closures and advisories.

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NCCR III

Chapter 3 Highlights

highlight

Spring 2005 Brings the Most Harmful Algal Bloom to New England in over Three Decades

Alexandrium fundyense is a naturally occurring algal species that forms blooms periodically in the Gulf of Maine. These algae also produce potent neurotoxins that can accumulate in filter-feeding shellfish and pose a threat to higher trophic-level organisms, such as marine mammals and humans. In most years, normal wind and current patterns prevent bloom transport to southern New England's nearshore waters. However, in the spring of 2005, the most severe bloom of this toxic dinoflagellate since 1972 spread from Maine to Massachusetts, reaching as far south as Martha's Vineyard, MA. This exceptionally expansive bloom may have been a result of elevated rainfall and snowmelt in the spring, followed by two unusually late nor'easters in May. Scientists hypothesize that strong winds pushed *Alexandrium* cells down the coast, while nutrients supplied by increased runoff fueled their growth (Anderson et al., 2005).

Consumption of toxin-contaminated shellfish can cause severe illness or death in humans as a result of a syndrome called Paralytic Shellfish Poisoning (PSP). States in the northeast region therefore maintain rigorous shellfish monitoring programs. The 2005 bloom event resulted in extensive—and in some locations unprecedented—closures of shellfish harvesting areas to prevent PSP in human consumers. State closures along the New England coast began as early as mid-May, disrupting shellfish sales during the busiest period of the tourist season (Figure 1). NOAA instituted a closure of approximately 15,000 square miles (Anderson et al., 2005) of federal waters at the request of FDA and was declared a fisheries failure for mitigation of financial impacts on commercial fisherman.

NOAA and NSF, through the interagency Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program, have funded a decade of research on *Alexandrium* in the Gulf of Maine that has advanced understanding of *Alexandrium* bloom ecology and—with research funded through the Monitoring and Event Response for Harmful Algal Blooms (MERHAB) Program—has enhanced event response, forecasting, and mitigation capabilities for coastal managers. For example, new methods based on molecular biology were used for the rapid detection and mapping of *Alexandrium*, providing coastal managers with early warnings of shellfish toxicity (Anderson et al., 2005). These data, combined with oceanographic and meteorological data from ships and moorings, were used in recently developed, coupled biological and physical models to forecast bloom movement and to understand the factors leading to this unusual event.

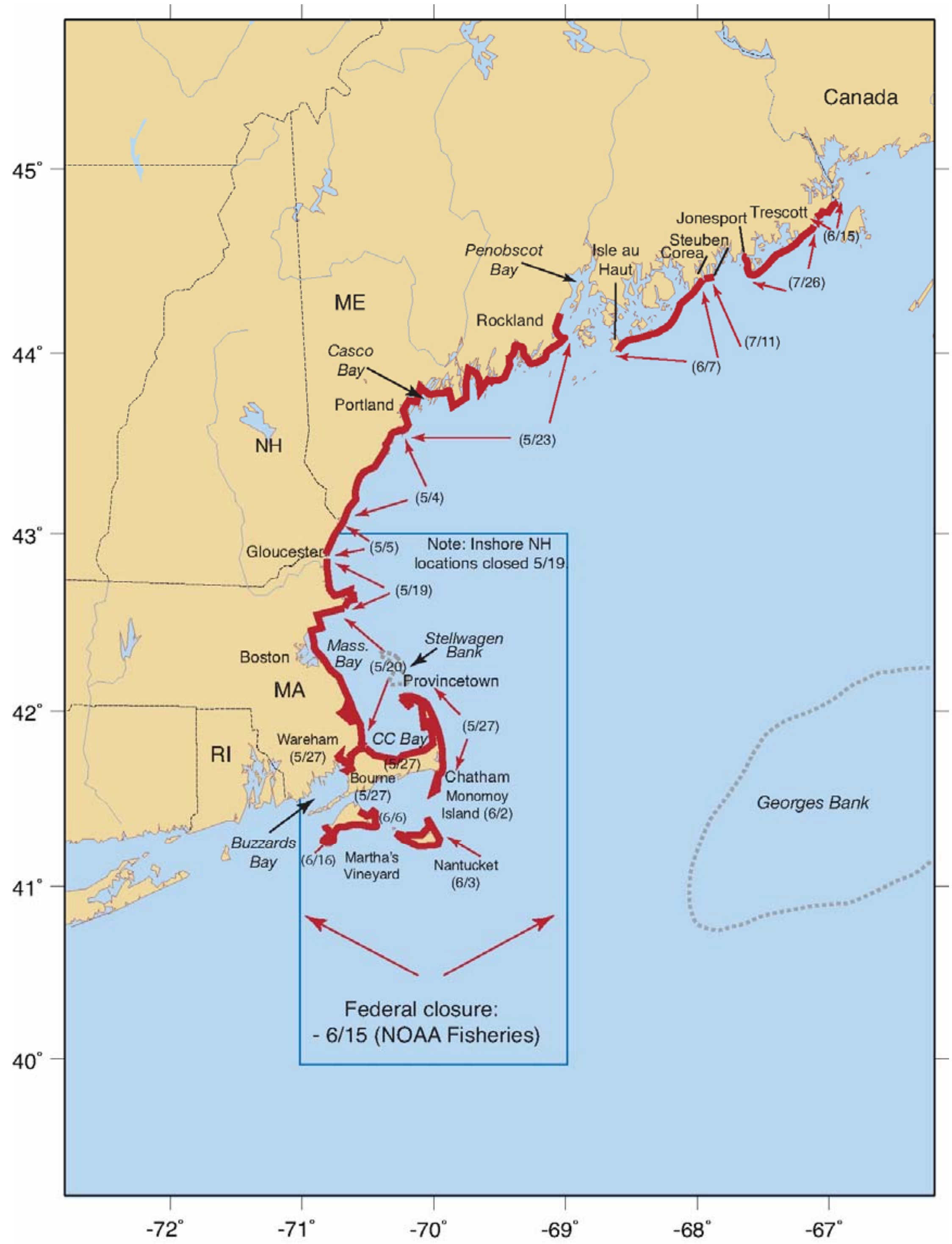

Figure 1. Shellfish closures (red areas) with closure issuance dates in Maine, New Hampshire, and Massachusetts due to PSP toxins during the 2005 *Alexandrium fundyense* bloom and temporary federal closure of offshore waters (blue rectangle) (Anderson et al., 2005).

During the bloom event, emergency support from NOAA funded expanded monitoring, assessment, and prediction of the bloom extent and movement. *Alexandrium* abundance data allowed managers to focus toxin sampling efforts on newly exposed areas as well as on areas that could possibly be reopened for shellfish harvesting. Researchers were also able to collect fish and zooplankton for an investigation into the potential relationship between the food-web transfer of toxins and whale mortalities in the region. Organizations involved in the emergency response to this HAB event included the Woods Hole Oceanographic Institution (WHOI), Massachusetts Division of Marine Fisheries, Massachusetts Water Resources Authority (MWRA), University of Massachusetts Dartmouth Center for Coastal Studies in Provincetown, and the Cooperative Institute for Climate and Ocean Research. Ancillary data from moorings were provided by the Gulf of Maine Ocean Observing System and the USGS's Woods Hole instrumented mooring near the MWRA outfall.

NOAA awarded additional funds to WHOI to sustain monitoring throughout the bloom period and to support post-bloom research. The goals of this research were to improve bloom forecasting to enhance the efficiency of future monitoring and regulation and to understand this particular event by "hindcasting" its causative factors. In addition, because future forecasts will be influenced by the dinoflagellate's cyst "footprint" left by this expansive bloom, scientists have developed new cyst maps and will incorporate these into predictive models to aid bloom forecasting in future years. They will also monitor these new areas to see if *Alexandrium* cells originate from newly deposited cysts next year.

For more information on HABs in New England, see NOAA's Center for Sponsored Coastal Ocean Research May 2005 article, "Worst New England Harmful Algal Bloom in 30 Years" (http://www.cop.noaa.gov/news/fs/ne_hab_200505.html).

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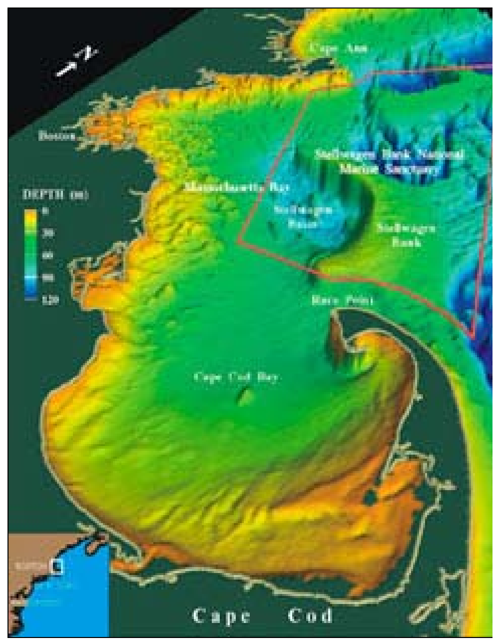
highlight

Implementing System-Wide Monitoring in the NOAA National Marine Sanctuaries

In 2004, the NOAA National Marine Sanctuaries Program launched a System-Wide Monitoring Program (SWiM) for the nation's 13 marine sanctuaries. The goal of SWiM is to provide a consistent approach to the design, implementation, and reporting of environmental conditions from sanctuaries, while allowing for tailored monitoring at individual sanctuary sites. Assessment reports will be developed for each sanctuary at the local level following a consistent model. The reports will serve as building blocks for the system-wide monitoring approach, and will allow for regional and national reports on environmental conditions at larger scales.

Implementation of SWiM began with the development of a guidance document and a pilot assessment report for one site, the Stellwagen Bank National Marine Sanctuary (SBNMS), off the Massachusetts coast. The Stellwagen Bank National Marine Sanctuary is located 3 miles north of Cape Cod and 3 miles southeast of Cape Ann, entirely within federal waters. The pilot assessment report will serve as a model for the remaining 12 sanctuary assessments, and as a means by which to answer questions about the condition of sanctuary resources. These determinations will be key to tracking the condition of marine ecosystems on the scale of individual sanctuaries, groups of sanctuaries, and system wide.



This image was developed using computer visualization software to turn bathymetric maps into a three-dimensional image and is available at: http://stellwagen.noaa.gov/about/setting.html

The SBNMS assessment includes sections that describe sanctuary resources, pressures that threaten the integrity of the marine environment (e.g., human activities), the current state of resources, trends, and management responses to the pressures. The primary purpose of the document is to report on the status and trends of water, habitat, living resources, and archaeological resources, and on the human activities that affect them. Resource status is rated within five categories on a scale from poor to good, and the timelines used for comparison vary from topic to topic (see Table 1). Trends in the status of resources are reported as improving, declining, or remaining the same, and are generally based on observed status changes over the past 5 years. Reports summarizing resource status and trends will be prepared for each marine sanctuary once every 5 years and, when possible, will coincide with the review of sanctuary management plans.

Table 1. National Marine Sanctuary Assessment Report Card Format

Status:

Good	Good/Fair	Fair	Fair/Poor	Poor

Trends:
- ▲ Improving
- — Not Changing
- ▼ Declining

#	Questions/Resources	Explanation	Trends
Water			
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	Captures shifts in conditions arising from changing natural processes and human-induced inputs.	
2	What is the eutrophic condition of sanctuary waters, and how is it changing?	Potential overgrowth and other competitive interactions that can lead to shifts in dominance in assemblages and food webs.	
3	Do sanctuary waters pose risks to human health?	Human health concerns aroused by evidence of contamination in bathing waters or fish intended for consumption, reports of respiratory distress, and other disorders attributable to an increase in HABs.	
4	What are the levels of human activities that may influence water quality, and how are they changing?	Human activities that affect water quality, including direct discharges, non-point source discharges, airborne chemicals, and results of dredging and trawling.	
Habitat			
5	What is the abundance and distribution of major habitat types, and how are they changing?	These key attributes compared with what would be expected without human impacts, such as pollution, trawling, pipelines, fish traps, and dredging.	
6	What is the condition of biologically structured habitats, and how is it changing?	Places where organisms form structures (habitats) on which other organisms depend, including coral reefs, kelp beds, and intertidal assemblages.	
7	What are the contaminant concentrations in sanctuary habitats, and how are they changing?	Risks posed by contaminants within benthic formations, including soft sediments, hard bottoms, and biogenic organisms.	
8	What are the levels of human activities that may influence habitat quality, and how are they changing?	Human activities that degrade habitat quality by affecting structural, biological, oceanographic, or chemical characteristics.	
Living Resources			
9	What is the status of biodiversity, and how is it changing?	The condition of living resources based on expected biodiversity levels and the interactions between species.	
10	What is the status of environmentally sustainable fishing, and how is it changing?	Whether harvesting is occurring at ecologically sustainable levels. Important to know extraction levels and the impacts of removal.	
11	What is the status of nonindigenous species, and how is it changing?	The potential threat posed by nonindigenous species, in some cases by presence, in others by measurable impacts.	
12	What is the status of key species, and how is it changing?	(1) Keystone species on which the persistence of a large number of other species in the ecosystem depend, and (2) other key species, including those that are indicators of ecosystem condition or change, those targeted for special protection efforts, or charismatic species associated with certain areas or ecosystems.	
13	What is the condition or health of key species, and how is it changing?	Measures of condition of key species, important to determining the likelihood that the species will persist and continue to contribute to a vital ecosystem.	
14	What are the levels of human activities that may influence living resource quality, and how are they changing?	Human activities that degrade living resource quality by causing a loss or reduction in species, disrupting critical life stages, impairing various physiological processes, or promoting the introduction of nonindigenous species or pathogens.	
Maritime Archaeological Resources			
15	What is the integrity of maritime archaeological resources, and how is it changing?	The apparent levels of site integrity, previous disturbance, condition of natural deterioration, and prospects for scientific investigation.	
16	Do maritime archaeological resources pose an environmental hazard, and is this threat changing?	Environmental hazards, including leakage of contents/contaminants, such as oil, in aging wrecks.	
17	What are the levels of human activities that may influence maritime archaeological resource quality, and how are they changing?	Human impacts with the potential to affect the quality of resources include looting by divers, damage caused by scuba divers, improperly conducted archaeology that does not fully document site disturbance, anchoring, groundings, and commercial and recreational fishing activities.	

each item assigned a status color & trend symbol

Development of the assessment report card relies on appraisal of the condition of the marine environment, using 17 questions as a guide. The questions were derived from both a generalized ecosystem framework and the NMS mission, and are widely applicable across the system of marine sanctuaries. The role of a framework is not to encourage the same monitoring at all sanctuaries; rather, its primary function is to apply a set of design, implementation, and reporting principles for all monitoring within the NMS Program. Completion of the process will result in a status and trends "report card" for sanctuaries at the local level that can be compiled to provide a snapshot of system-wide conditions. As report cards are updated, time series data will be developed to provide information on changes in the condition of the marine environments over time.

For additional information about SWiM, please visit the National Marine Sanctuaries Web page (http://sanctuaries.noaa.gov/science/monitoring/welcome.html).

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highlight

Zooplankton Boost in the Northeast Shelf Ecosystem

In 2004, NOAA scientists reported a 14-fold increase in the abundance of a key zooplankton species for waters of the Northeast Shelf Large Marine Ecosystem (LME). The boost was linked to a drop in surface temperatures and the subsequent increase in chlorophyll *a* in the area. Coupling zooplankton abundance data with satellite-measured sea temperature and chlorophyll *a* levels revealed a negative correlation between the two (NMFS, 2004).

The boost in zooplankton abundance was attributed almost entirely to the population increase of a single copepod species, *Calanus finmarchicus*. This particular copepod serves as prey for haddock and cod in the early stages of development, as well as for the endangered right whales that inhabit the waters of the Northeast Shelf LME. Phytoplankton constitute a large part of the diet of *Calanus finmarchicus*. As a member of the base of the Northeast LME food web, abundance of *Calanus finmarchicus* can be an indicator of the condition of the ecosystem.

Since 1960, scientists have employed commercial vessels to collect zooplankton abundance data contemporaneously with sea water conditions. The commercial container vessels collect zooplankton population data using continuous plankton recorders (CPRs) on monthly transects between Boston, Massachusetts, and Halifax, Nova Scotia (NMFS, 2004). Comparisons of the 2004 CPR data with the 30-year spring average (1961–1990) showed increased zooplankton populations, decreased salinity, and decreased surface water temperatures (Figure 1).

Recently, scientists have paired CPR data with data obtained by NOAA's satellite-borne AVHRR temperature

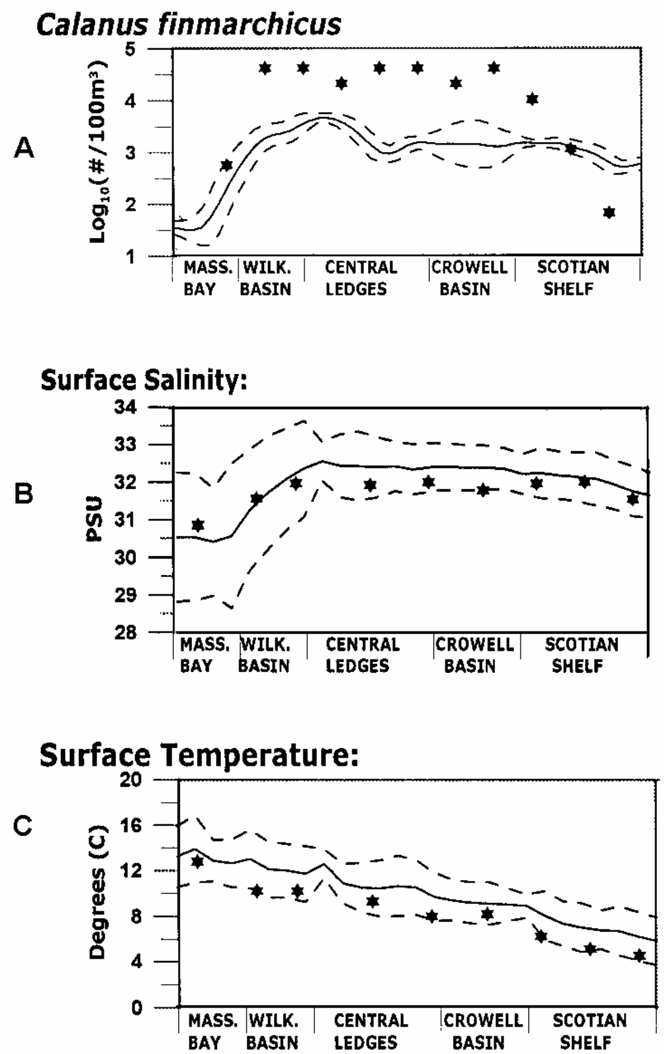

Figure 1. 2004 *Calanus* numbers, sea surface salinity, and sea surface temperatures across the northern Northeast Shelf LME plotted against 1961–1990 average (solid line = average; dashed line = variations from average; stars = actual values from container ship data collected in 2004). (A) Above average abundance of the zooplankton copepod *Calanus finmarchicus*.; (B) Below average salinity. (C) Below average temperature. Source: J. Jossi, NOAA/NMFS, Narragansett, Rhode Island.

sensor and NASA's SeaWiFs chlorophyll sensor for a more robust analysis of Northeast LME conditions. Analysis of these three data sets together indicated that the boost in *Calanus* abundance was related to an incursion of a cold Labrador water mass into the waters of the Northeast Shelf LME. The spring 2004 satellite derived images show broad-scale chlorophyll increases (Figure 2) and lower sea surface temperatures (Figure 3) over the northern area of the ecosystem.

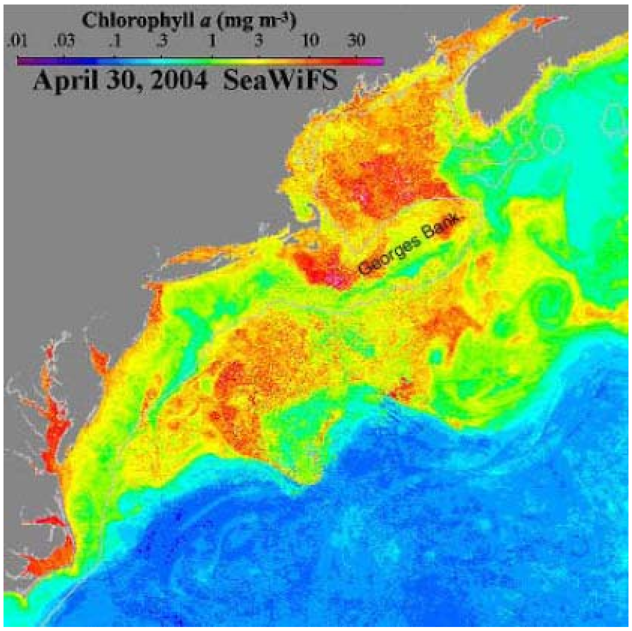

Figure 2. Satellite imagery (SeaWiFs), spring 2004, showing above average chlorophyll in the northern Northeast Shelf LME (J. O'Reilly, NOAA/NMFS, Narragansett, Rhode Island).

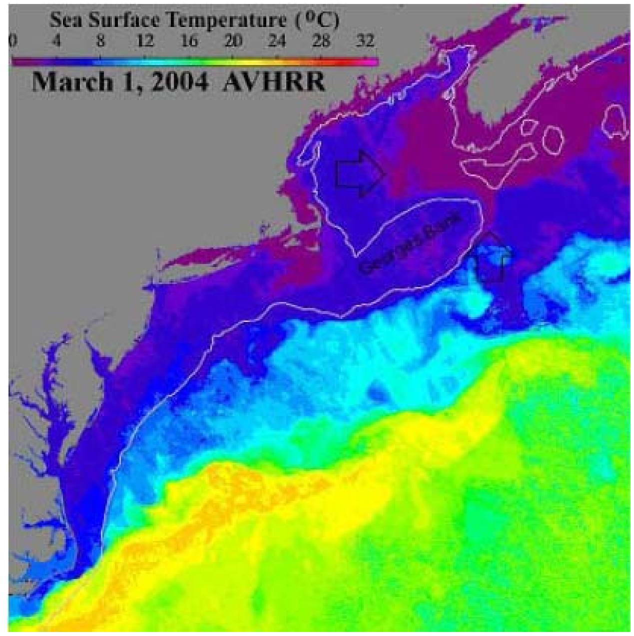

Figure 3. Satellite imagery (AVHRR), spring 2004, showing cooler than average sea surface temperatures in the northern Northeast Shelf LME (J. O'Reilly, G. Wood, NOAA/NMFS, Narragansett, Rhode Island).

In addition, longer time-series data sets from the multi-decadal Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program provided a wider view of the path of the cold water mass. Analysis of the MARMAP database indicated that the 2004 incursion of Labrador water into the northern half of the Northeast Shelf LME was related to events further north, which affected the Scotian Shelf and Newfoundland-Labrador Shelf ecosystems. Canadian scientists report that these ecosystems are under the influence of increasing incursions of cooler water. They suggest that the cooling trend may be the result of a warming of Arctic waters and increasing volumes of lower salinity and cooler ice-melt waters being carried southwestward into the Newfoundland-Labrador and Scotian Shelf ecosystems.

Events such as the 2004 plankton boost provide opportunities for scientists to collect data on ecosystem variables, define potential correlations, and possibly predict future events. Marine scientists in both Canada and the United States are closely monitoring the extent and volume of Labrador water incursions into the large marine ecosystems of the Northwest Atlantic in an effort to better understand the impacts of cooler water on the ecosystems in the Northeast LME.

For more information, contact Kenneth Sherman at Kenneth.Sherman@noaa.gov.

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highlight

Comparing Two Benthic Indices Applied to Monitoring Data from NY/NJ Harbor

Scientists and managers have worked diligently to answer the question "Is this place relatively clean, or is it stressed?" Evaluating a site can involve analyzing the levels of chemical and physical stress in the bottom sediments, and measuring concentrations of chemicals, relative toxicity, and grain size of the sediments. In addition, characterizing the salinity of the overlying water and the structure and composition of the benthic community reflects exposures to chemical and physical stresses. Indices of benthic condition have been developed to examine the complex conditions that exist in the sediments, quantifying those conditions as a single numeric value. To help evaluate the condition of the New York/New Jersey (NY/NJ) Harbor, two different benthic indices, developed independently, were applied to Regional Environmental Monitoring and Assessment Program (REMAP) monitoring data from 1998 (Adams and Benyi, 2003) and compared.

The Virginian Province Benthic Index (Paul et al., 2001) was developed in the EMAP Virginian Province Program for the East Coast of the United States from Cape Cod to the mouth of the Chesapeake Bay. A second benthic index, called the Benthic Index of Biotic Integrity (B-IBI), was developed for the benthic communities of the NY/NJ region (Adams et al., 1998). The approaches used in developing the two indices were quite different. The Virginian Province Benthic Index uses statistical techniques to evaluate appropriate metrics while the B-IBI uses a method developed for freshwater systems of applying values to select metrics based on established criteria derived from reference stations (Figure 1).

Virginian Province Benthic Index, developed using discriminant analysis, is characterized by the following three metrics:

1) Gleason's Diversity Index, adjusted for salinity
2) Expected number of tubificids, adjusted for salinity
3) Abundance of spionid polychaetes (Strobel et al., 1995).

Gleason's Diversity Index measures the variety of invertebrates in the sediment. Tubificids are a type of worm found, but not exclusively, in enriched areas, and salinity adjustment makes the presence of tubificids of great importance in low-saline areas, but not of high importance in estuarine areas. Spionid polychaetes are also a type of worm.

Benthic Index of Biotic Integrity (B-IBI), developed by testing the classification efficiency of candidate measures, is characterized by the following five metrics:

1) Number of species
2) Abundance of species
3) Biomass
4) Percent of total abundance indicative of pollution
5) Percent of total abundance sensitive to pollution.

The B-IBI is similar to the Index of Biotic Integrity developed for freshwater benthic communities by Karr (Kerans and Karr, 1994). Threshold values for these metrics were defined for two salinity ranges (polyhaline and euryhaline) and two sediment types (mud and sand). The B-IBI was calculated by scoring each selected metric depending on the whether its threshold value approximated (5), or deviated slightly (3) or greatly (1) from conditions at the best reference sites. Those metrics were then averaged.

Figure 1. Description of metrics for the EMAP Benthic Index and the Benthic Index of Biotic Integrity.

Sampling stations were selected using a design common in EMAP programs (probabilistic stratified random design) in four sub-basins, each with 28 stations. Benthic macroinvertebrate data from two replicates were averaged, and the Virginian Province Benthic Index and B-IBI were calculated for each station.

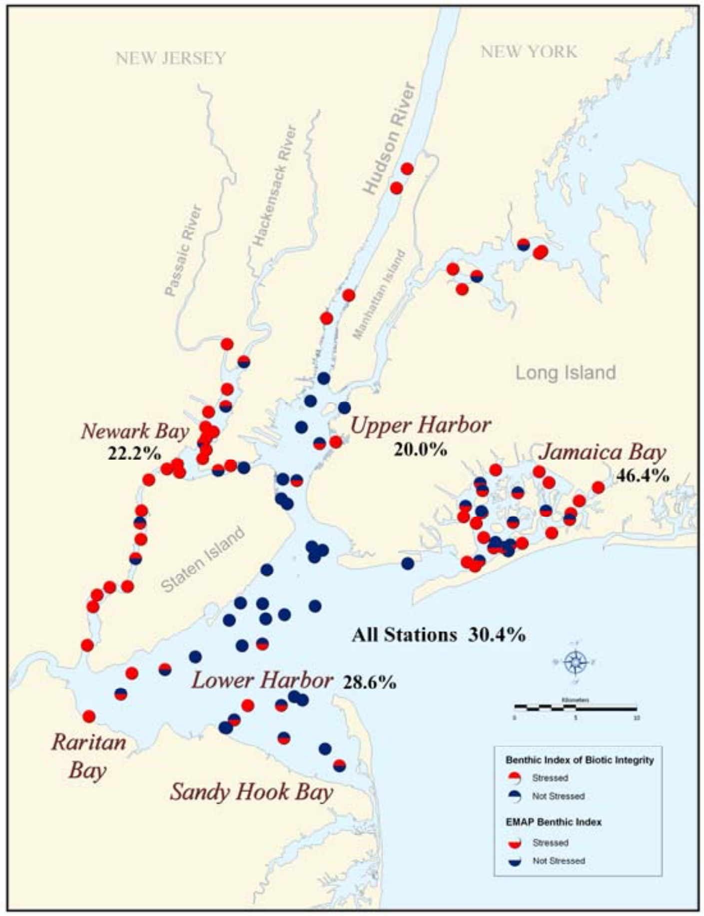

Figure 2. Comparison of percent disagreement between B-IBI and the Virginian Province Benthic Index (EMAP-BI) for the NY/NJ Harbor area.

Overall, disagreement between the Virginian Province Benthic Index and the B-IBI in classifying stressed stations occurred at only 30% of the stations overall. In Figure 2, a filled circle represents each station, with the top half representing the B-IBI and the bottom half representing the Virginian Province Benthic Index. When the circle is a single solid color, both indices agree on the classification, whether stressed or not stressed. However, when the halves of the circle are colored differently, they disagree. The percentage disagreement between indices is included for each sub-basin in Figure 2.

Within the four sub-basins, percentage of stressed sites ranged from a low of 8% to a high of 93% using the B-IBI, and from 32% to 93% using the Virginian Province Benthic Index. In most sub-basins, the percent of stations stressed was similar. For example, in the Upper Harbor, both indices identified 55% of streams in the sub-basin as stressed, and the two indices had the strongest agreement by station. In contrast, in Jamaica Bay, the percent of stressed stations was 46% and 93% for the B-IBI and Virginian Province Benthic Index, respectively. The Virginian Province Benthic Index classified two times as many stations as stressed as did the B-IBI (26 and 13 out of 28, respectively), and the highest percent disagreement between the indices (46%) occurred in Jamaica Bay.

The Virginian Province Benthic Index and B-IBI use different metrics to come to an understanding of a station's ecological health status. Although there might appear to be a fair amount of disagreement between the classification of stations as stressed, the overall agreement in the entire harbor was 70%. In areas where there was disagreement, it is worth examining the reasons for the differences. At stations where the B-IBI indicated stress and the Virginian Province Benthic Index did not, the primary metrics driving the B-IBI were biomass, and pollution-sensitive and pollution-indicative species, none of which are measured in the Virginian Province Benthic Index. Since these two indices are indicators of stress, it would be valuable to examine other metrics, such as chemical concentrations of metals and organics in the sediment, to determine whether chemical stresses are occurring.

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highlight

An Index of Benthic Condition for the Coastal Acadian Biogeographic Province

Indices that combine several benthic community variables have been used by monitoring programs to measure the spatial extent of environmental problems, locate problem areas for further study, assess the effectiveness of remedial programs, and determine whether conditions are improving or deteriorating. For the NCCRII (U.S. EPA, 2004), the U.S. EPA NCA used the Shannon-Wiener H' index, a measure of biodiversity, to evaluate the condition of benthic communities in the Acadian Province (Gulf of Maine). The Virginian Province Benthic Index (Paul et al., 2001) did not work well in this area and, at the time, there were not yet sufficient data to develop an index unique to the Acadian Province. Compared with the Virginian Province (the area south of Cape Cod), the Gulf of Maine is colder, deeper, better oxygenated, and more strongly flushed by tides. For the current report, NCA has used the 2000 and 2001 data to develop a specific Acadian Province benthic index (Hale, in prep.).

During the spring of 2004, the NCA held a workshop in Portsmouth, NH, with Gulf of Maine benthic ecologists to review candidate metrics, discuss preliminary indices, and learn about other available benthic datasets. First, the NCA identified the stations with the highest and lowest benthic environmental quality (BEQ). BEQ was defined as a function of nonbiological components, including sediment contaminants, total organic carbon, sediment toxicity, and concentration of bottom water dissolved oxygen. The aim was to use information from the benthic assemblage data to build an index that could discriminate stations with high and low BEQ. Using the scientific literature, the NCA developed a list of 40 candidate benthic metrics that might be useful, including diversity measures and relative proportions of pollution-indicative or sensitive taxa. The NCA used discriminant analysis with the candidate benthic metrics to identify those that had discriminatory power and to use them to build discriminant functions. Those functions that correctly classified at least 80% of the stations in the calibration data set became candidate benthic indices. Three independent data sets were used to validate the candidate indices and to select the best index: the Massachusetts Water Resources Authority (MWRA) study of Boston Harbor and Massachusetts Bay (Williams et al., 2002), a study in Casco Bay (Larsen et al., 1983), and the NCA 2002 and 2003 data.

The benthic index chosen for this report (87.6% correct classification on calibration data set) is shown in Figure 1. This index correctly classified about three-quarters of the stations in the validation data sets. Figure 2 shows the result of application of this index for sampling sites within the Gulf of Maine. The index identified three categories: high, medium, and low BEQ. The NCA sampled few low or intermediate level saline estuaries in the Acadian Province, so the applicability of the current index in low salinity areas is unknown. This index provides environmental managers a way to assess the health of Gulf of Maine coastal benthic communities, both spatially and temporally. Further refinements and validations will be made as more NCA data become available.

$$Benthic\ Index\,1 = 0.494 \times Shannon + 0.670 \times MN\_ES50_{0.5} - 0.034 \times PctCapitellidae$$

where:

Shannon	=	Shannon-Wiener H′ diversity index
$MN\_ES50_{.05}$	=	Station mean of species tolerance values (Rosenberg et al., 2004)
PctCapitellidae	=	percent abundance of *capitellid polychaetes*

Figure 1. Benthic index used in the NCA 2000–2001 survey.

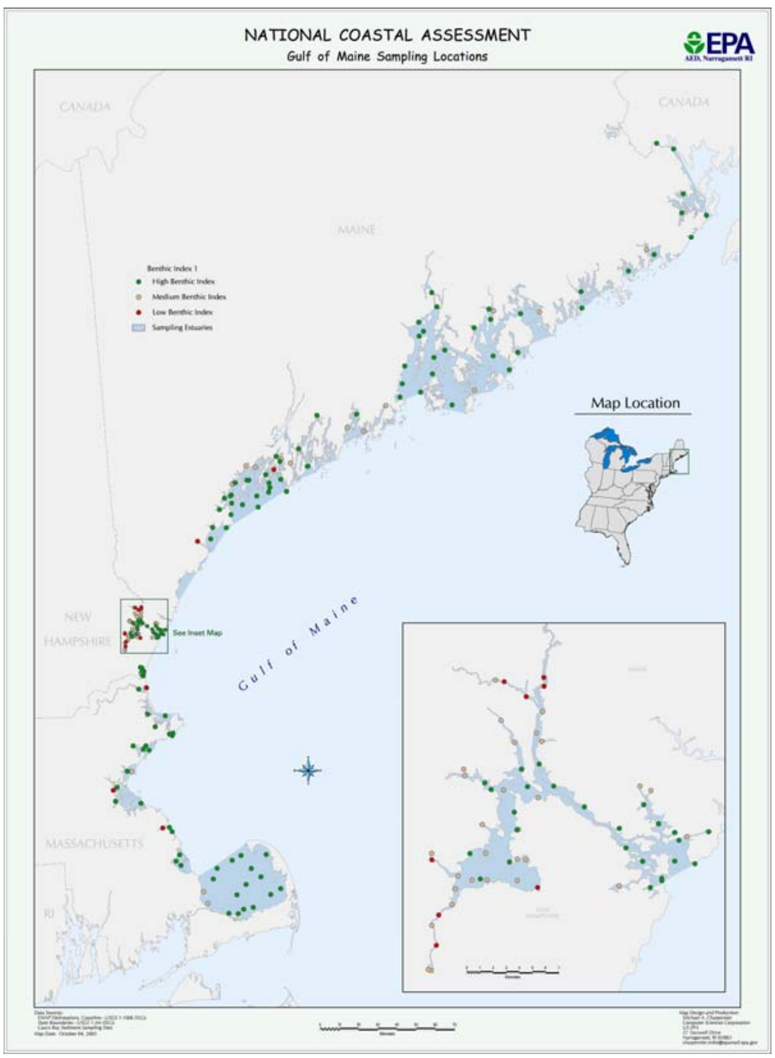

Figure 2. Benthic index scores at NCA monitoring sites (2000–2001).

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Chapter 4

Southeast Coastal Condition

As shown in Figure 4-1, the overall condition of the collective estuaries of the Southeast Coast region is rated fair, with an overall condition score of 3.6. The water quality, sediment quality, and coastal habitat indices for the region are rated fair; the benthic index is rated good; and the fish tissue contaminants index is rated good to fair. Figure 4-2 provides a summary of the percentage of coastal area rated good, fair, poor, or missing for each index and component indicator. This assessment is based on environmental stressor and response data collected by the NCA, in collaboration with state resource agencies, from 294 locations throughout the Southeast Coast coastal waters using comparable methods and techniques. Please refer to Tables 1-23, 1-24, and 1-25 (Chapter 1) for a summary of the criteria used to develop the ratings for each index and component indicator.

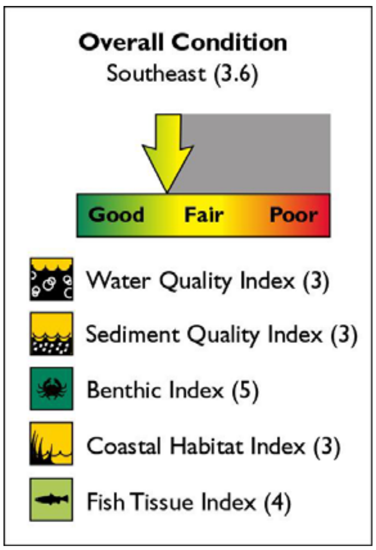

Figure 4-1. The overall condition of Southeast Coast coastal waters is rated fair (U.S. EPA/NCA).

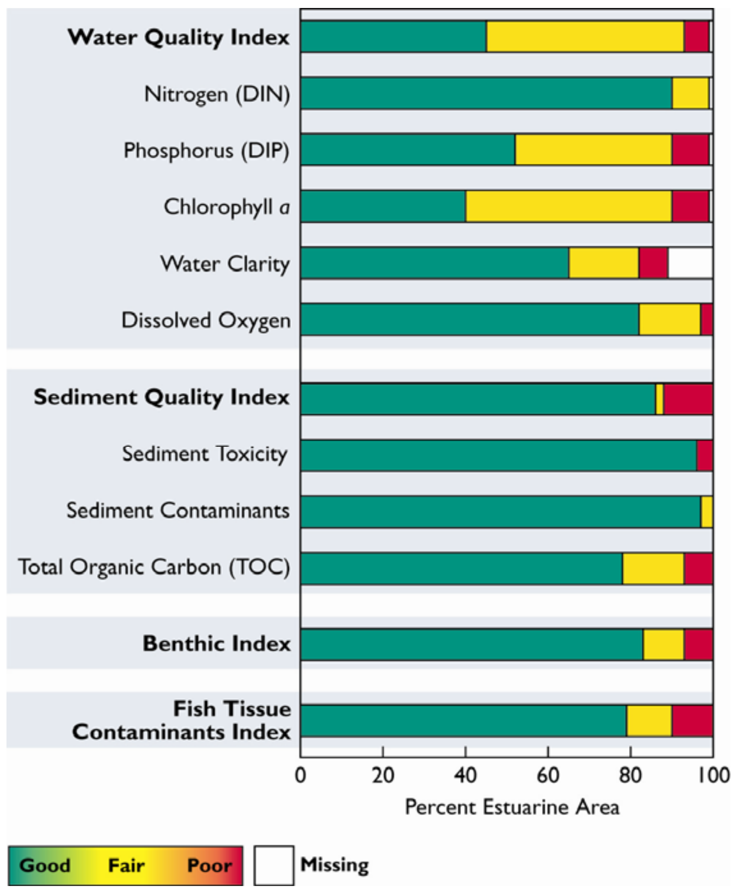

Figure 4-2. Percentage of coastal area achieving each ranking for all indices and component indicators – Southeast Coast region (U.S. EPA/NCA).

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, FL, Savannah, GA, and Charleston, SC; quiet coastal wetlands that provide a habitat for migratory birds and other animals; and important commercial and recreational fishery resources. The coastal resources of the Southeast Coast are diverse and extensive, covering an estimated 4,487 mi^2. The provinces of this region include the Carolinian Province, which extends from Cape Henry, VA, through the southern end of the Indian River Lagoon, as well as the part of the West Indian Province along the east coast of Florida from Indian River Lagoon through Biscayne Bay. This region of the country is referred to as the Southeast Shelf LME. Also included in the Southeast Coast region is North Carolina's Albemarle-Pamlico Estuarine System, one of the largest and most productive aquatic systems in North America. This Albemarle-Pamlico system represents North Carolina's key resource base for commercial fishing, recreational fishing, and tourism. Similarly, the coastal resources of other Southeast Coast states provide the resource base for fishing and tourism industries and generate vast amounts of sales tax income for those states.

Between 1980 and 2003, coastal counties of the Southeast Coast region showed the largest rate of population increase (58%) of any coastal region in the conterminous United States. Florida was largely responsible for this growth, gaining 7.1 million people during this time period, resulting in a 75% increase in population. Figure 4-3 presents population data for Southeast coastal counties and shows that these populations have increased significantly since 1980 (NOAA, 2004). 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 region's resources There is evidence of human-induced stress in some areas of the Southeast Coast region.

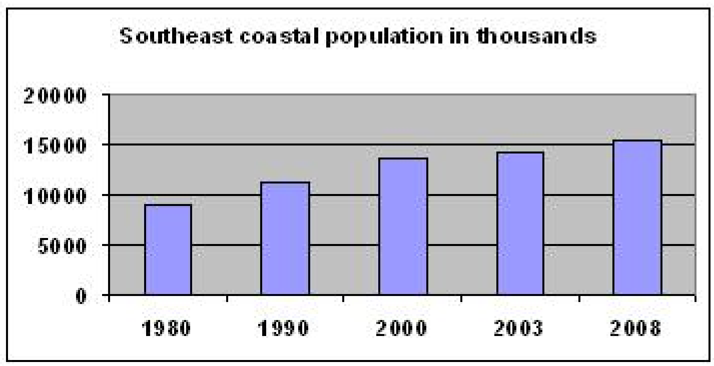

Figure 4-3. Actual and estimated population of coastal counties in the Southeast Coast region from 1980 to 2008 (NOAA, 2004).

Coastal Monitoring Data – Status of Coastal Condition

Water Quality Index

The water quality index for the coastal waters of the Southeast Coast region is rated fair, with only 6% of the coastal area rated poor and 48% of the area rated fair for water quality condition (Figure 4-4). The water quality index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen.

Nutrients: Nitrogen and Phosphorous

The Southeast Coast region is rated good for DIN concentrations because less than 1% of the region's coastal area was rated poor and 9% of the area was rated fair for this component indicator. The Southeast Coast region is also rated good for DIP concentrations, with only 9% of the coastal area rated poor and 52% of the area rated good for this component indicator.

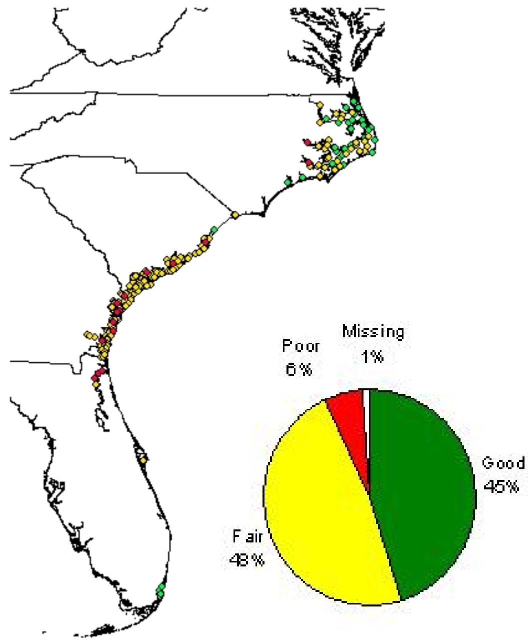

Figure 4-4. Water quality index data for the coastal waters of the Southeast Coast region (U.S. EPA/NCA).

Chlorophyll *a*

The Southeast Coast region is rated fair for chlorophyll *a* because 59% of the coastal area was rated fair and poor, combined, for this component indicator.

Water Clarity

Water clarity in the Southeast Coast region is rated good, with 65% of the coastal area rated good and 7% of the area rated poor for this component indicator. The criteria used to assign water clarity ratings varied across Southeast Coast coastal waters, based on natural variations in turbidity levels and local waterbody management goals (see text box).

The sampling conducted in the EPA NCA survey 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.

Estuarine Systems	Reference Condition for Water Clarity (Percentage of Incident Light Reaching 1 Meter in Depth)
Indian River Lagoon estuarine systems	20%
Albemarle-Pamlico and Biscayne Bay estuarine systems	10%
All remaining Southeast Coast estuarine systems	5%

Dissolved Oxygen

The Southeast Coast region is rated good for dissolved oxygen concentrations, with 15% of the coastal area rated fair, 3% of the area rated poor, and 82% of the area rated good for this component indicator.

Sediment Quality Index

The sediment quality index for the coastal waters of the Southeast Coast region is rated fair, with 86% of the coastal area rated good and 12% of the area rated poor for sediment quality condition (Figure 4-5). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

Sediment Toxicity

The Southeast Coast region is rated good for sediment toxicity, with approximately 4% of the coastal area rated poor and 96% of the area rated good for this component indicator.

Sediment Contaminants

The Southeast Coast region is rated good for sediment contaminant concentrations, with approximately 3% and 97% of the coastal area rated fair and good, respectively, and less than 1% of the area rated poor for this component indicator.

Sediment TOC

The Southeast Coast region is rated good for sediment TOC concentrations, with 78% of the coastal area rated good and only 7% of the area rated poor for this component indicator.

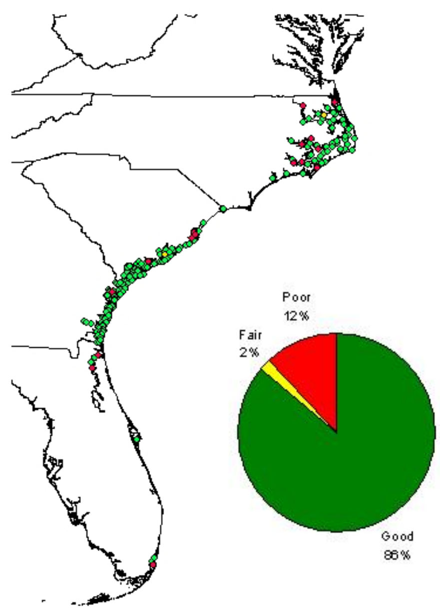

Figure 4-5. Sediment quality index data for the coastal waters of the Southeast Coast region (U.S. EPA/NCA).

Benthic Index

The biological condition of the coastal waters of the Southeast Coast region, as measured by the Southeast Coast Benthic Index, is rated good. Van Dolah et al. (1999) developed the benthic index based on several measures of benthic community condition, including the total number of species and integrated measures of species dominance, species abundance, and abundance of pollution-sensitive taxa. The index shows that 7% of the Southeast Coast region's coastal area was rated poor for benthic condition, 10% of the area was rated fair, and 83% of the area was rated good (Figure 4-6). Areas rated poor included portions of the Neuse River in North Carolina and Medway River in Georgia.

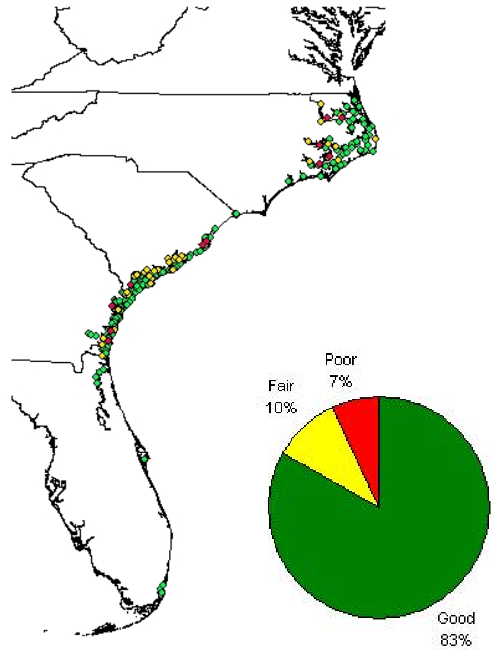

Figure 4-6. Benthic index data for the coastal waters of the Southeast Coast region (U.S. EPA/NCA).

Coastal Habitat Index

The coastal habitat index for the coastal waters of the Southeast Coast region is rated fair. As reported in the NCCR II (U.S. EPA, 2004a), wetlands in the Southeast Coast 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%.

Fish Tissue Contaminants Index

The fish tissues contaminants index for the coastal waters of the Southeast Coast region is rated good to fair. Fish tissue samples were collected at 218 of the 294 NCA sampling sites (74%) in the Southeast Coast region. Figure 4-7 shows that 10% of all sites sampled where fish were caught were rated poor using whole-fish contaminant concentrations and EPA Advisory Guidance values. Total PAHs and total PCBs were the only contaminants with elevated concentrations in fish tissues collected from Southeast Coast coastal waters.

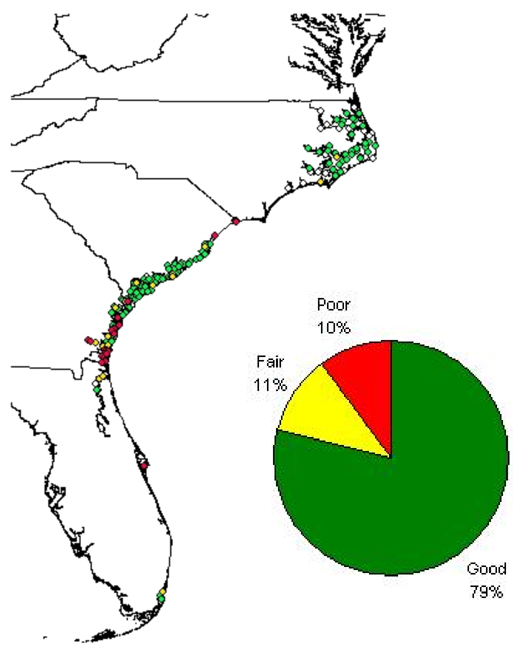

Figure 4-7. Fish tissue contaminants index data for the coastal waters of the Southeast Coast region (U.S. EPA/NCA).

Trends of Coastal Monitoring Data—Southeast Coast Region

Temporal Change in Ecological Condition

EMAP-Estuaries conducted annual surveys of estuarine condition in the Carolinian Province from 1994 to 1997, the results of which were reported in the NCCR I (U.S. EPA, 2001). In 2000, EMAP-NCA initiated annual surveys of estuarine condition in the Southeast Coast region, which includes the Carolinian Province and part of the West Indian Province. The assessment of 2000 data was reported in the NCCR II, and data from 2001 and 2002 are assessed in this current report (NCCR III). The seven years of monitoring data from Southeast Coast estuaries provide an ideal opportunity to investigate temporal changes in ecological condition indicators. The data can be analyzed to answer two basic types of trend questions based on assessments of ecological indicators in Southeast Coast coastal waters: what is the interannual variability in the percentages of area rated good, fair, or poor, and is there a significant change in the percentage of area rated poor from the mid-1990s to the present?

This comparison was conducted using data for the same indicators, collected using similar methods, over the same geographic area. The ecological parameters that can be compared between these time periods include the dissolved oxygen concentrations, water clarity, sediment contaminants, sediment toxicity, and sediment TOC component indicators, and benthic condition. Data supporting these parameters were collected using similar protocols and QA/QC methods. Fish tissue contaminants data were also collected by both surveys during both time periods; however, these data were excluded from this trends analysis because the sample preparation methods were not comparable. The available water quality data on chlorophyll *a* and nutrients from the EMAP-NCA survey (2000) were also excluded because these parameters were not evaluated during the EMAP-Estuaries surveys (1994–1997). In addition, the spatial extent of the EMAP-NCA Southeast data was reduced to match that of the Carolinian Province surveyed during the EMAP-Estuaries study. The Carolinian Province extends from the Virginia-North Carolina state border to the Indian River Lagoon on the east coast of Florida.

Both programs (EMAP-Estuaries and EMAP-NCA) implemented probability-based surveys that support estimations of the percentage of estuarine area rated in good, fair, or poor condition based on the indices and component indicators assessed. Standard errors for these estimates were calculated according to methods listed on the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). The reference values and guidelines listed in Chapter 1 were used to determine good, fair, or poor condition for each index and component indicator from both time periods.

None of the indices or component indicators assessed showed any significant linear trends over time in the percent of estuarine area rated poor (Figures 4-8 through 4-13); however, when the time periods were compared, some differences were observed (Figure 4-14). A significantly greater percentage of the estuarine area was rated poor for sediment contaminants from 1994 to 1997 than from 2000 to 2002 ($z = 2.028$; $p < 0.05$). Similarly, the percentage of estuarine area rated poor for sediment toxicity was significantly greater for the time period from 1994 to1997, than for 2000–2002 ($z=3.67$; $p < 0.05$). In addition, the percentage of estuarine area rated poor was greater in 1994–1997 than in 2000–2002 for all indicators measured with the exception of sediment TOC. Sediment TOC increased slightly from 5.5% to 7.2%, although this increase was not significant ($p < 0.05$). It should be noted that sediment toxicity samples were not collected in 1996, and these data were considered to be missing for 100% of the estuarine area in 1996.

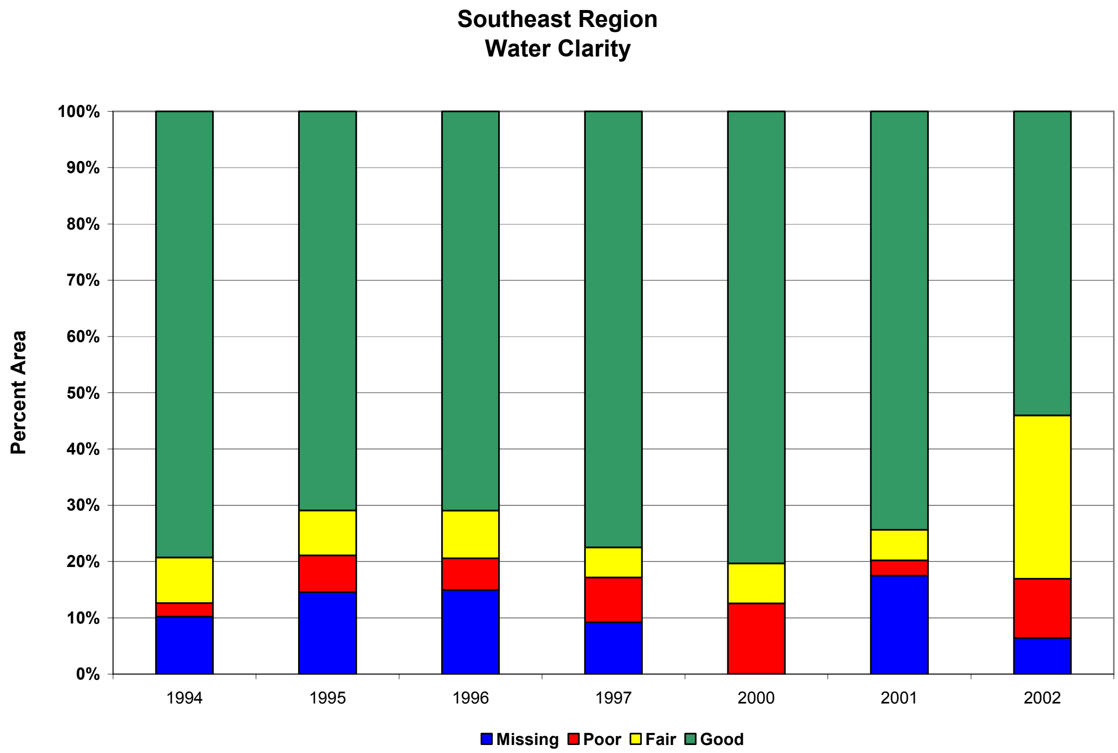

Figure 4-8. Percent area of Southeast Coast coastal waters rated good, fair, poor, and missing for water clarity from 1994 to 2002. No data on water clarity were collected in 1998 or 1999 (U.S. EPA/NCA).

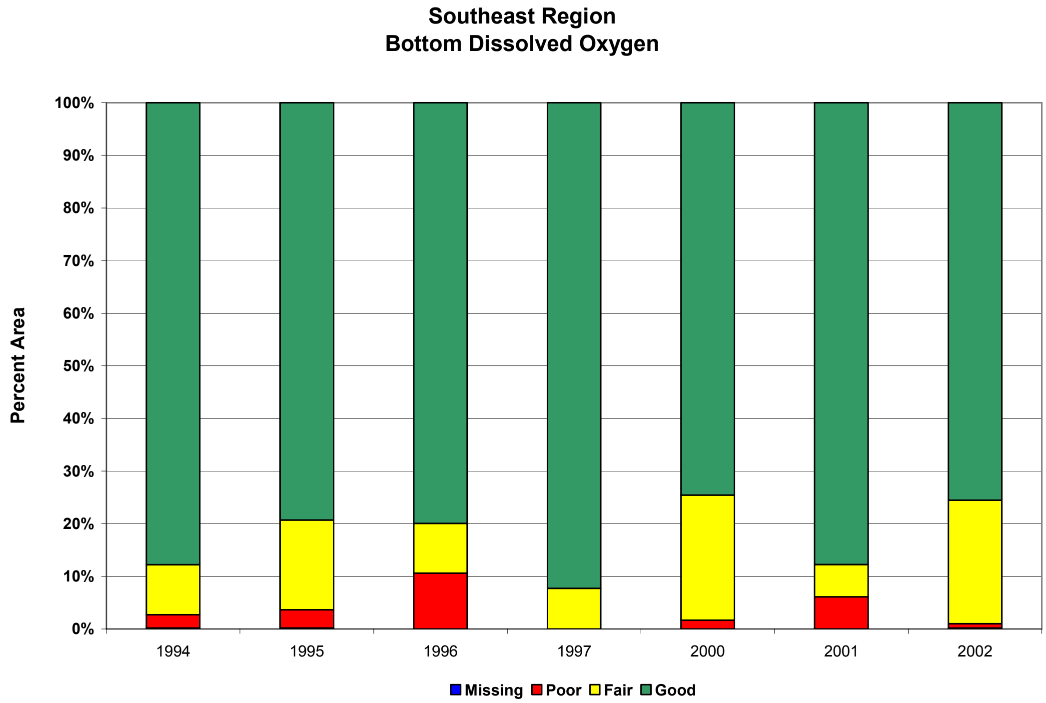

Figure 4-9. Percent area of Southeast Coast coastal waters rated good, fair, poor, and missing for bottom dissolved oxygen concentrations from 1994 to 2002. No data on dissolved oxygen concentrations were collected in 1998 or 1999 (U.S. EPA/NCA).

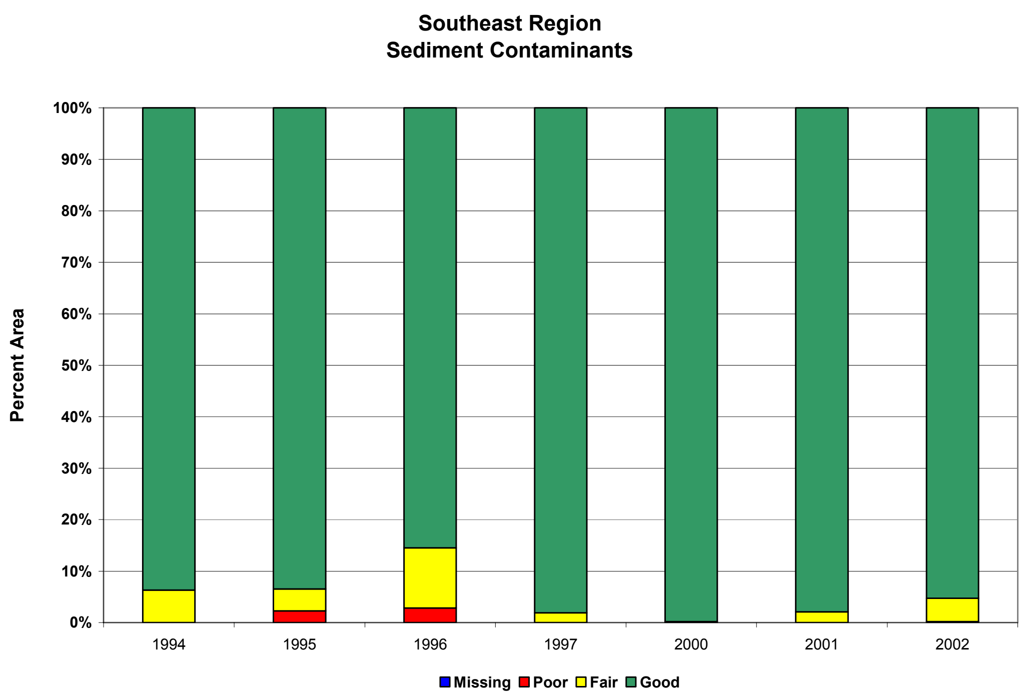

Figure 4-10. Percent area of Southeast Coast coastal waters rated good, fair, poor, and missing for sediment contaminants from 1994 to 2002. No data were collected on sediment contaminants in 1998 or 1999 (U.S. EPA/NCA).

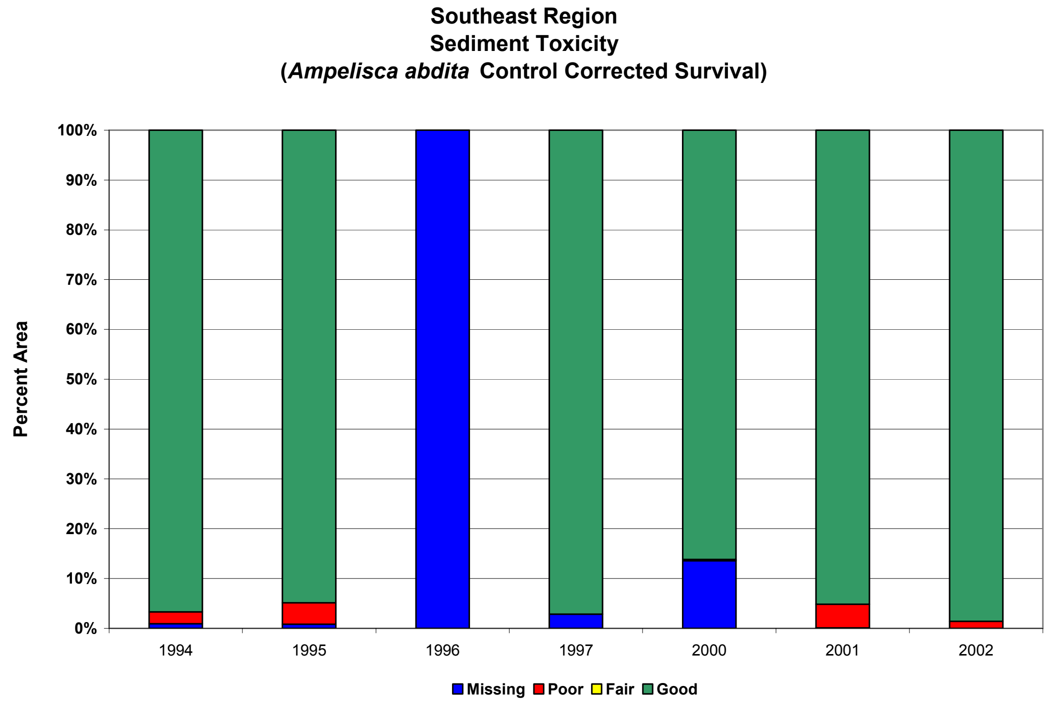

Figure 4-11. Percent area of Southeast Coast coastal waters rated good, fair, poor, and missing for sediment toxicity from 1994 to 2002. No data were collected in 1996, 1998, or 1999 (U.S. EPA/NCA).

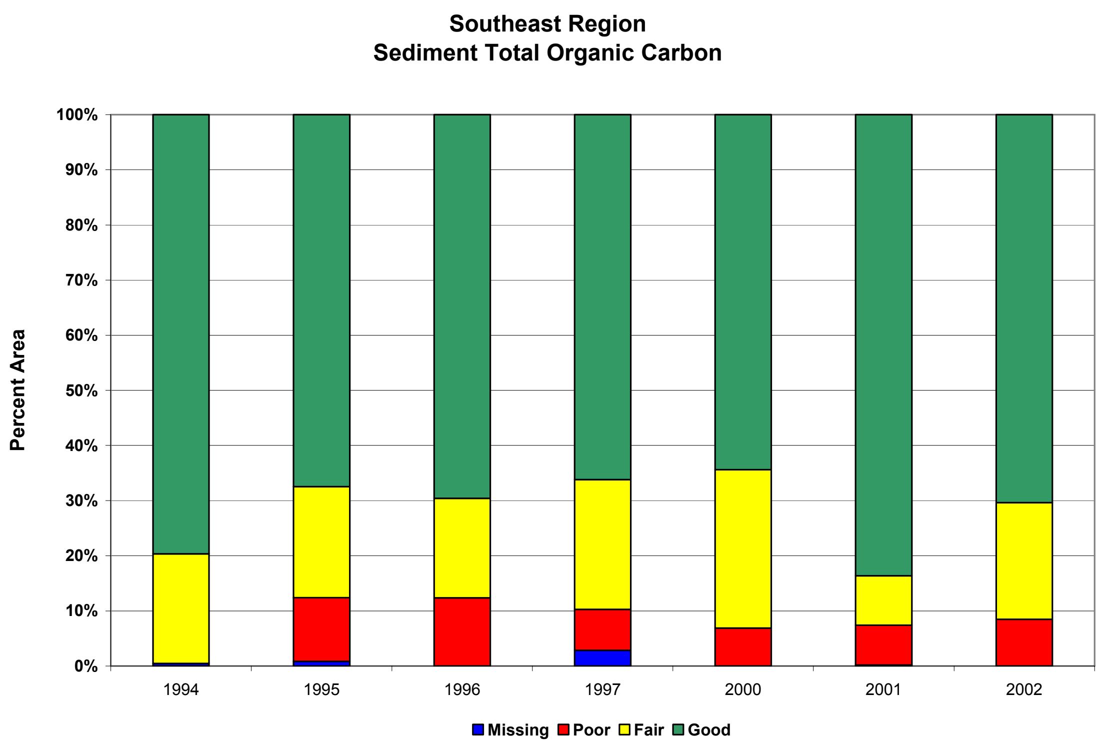

Figure 4-12. Percent area of Southeast Coast coastal waters rated good, fair, poor, and missing for sediment TOC from 1994 to 2002. No data were collected in 1998 or 1999 (U.S. EPA/NCA).

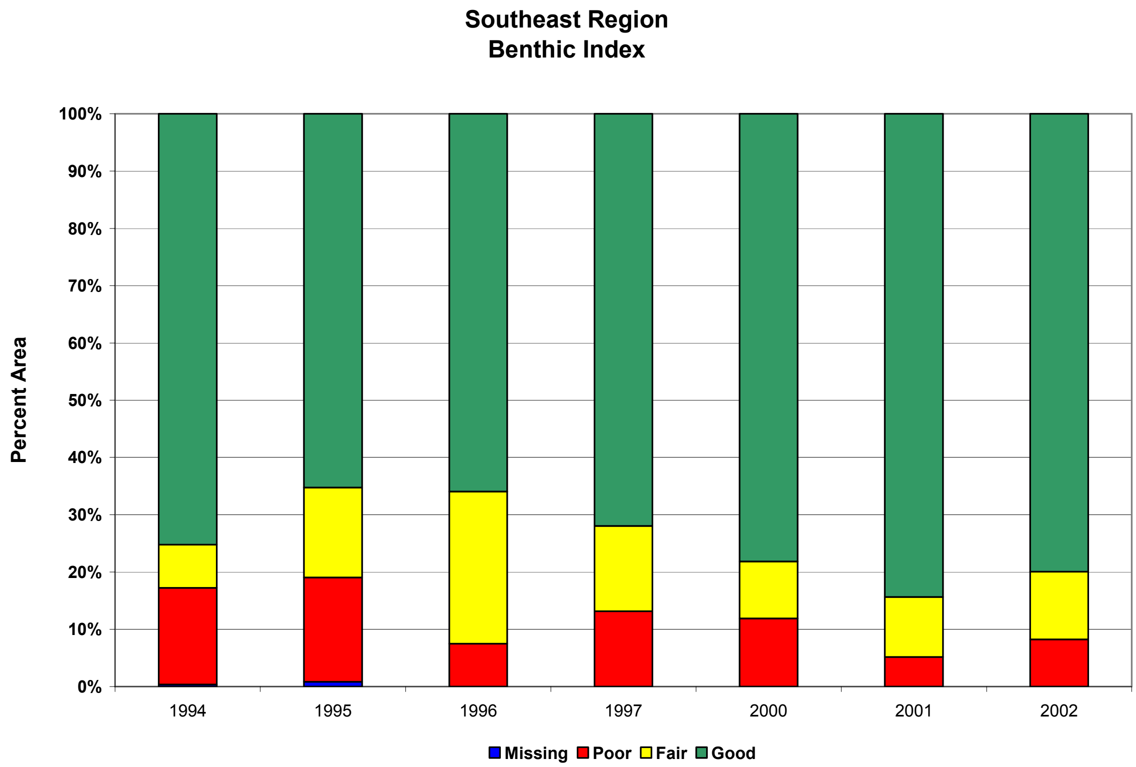

Figure 4-13. Percent area of Southeast Coast coastal waters rated good, fair, poor, and missing for the benthic index from 1994 to 2002. No data were collected in 1998 or 1999 (U.S. EPA/NCA).

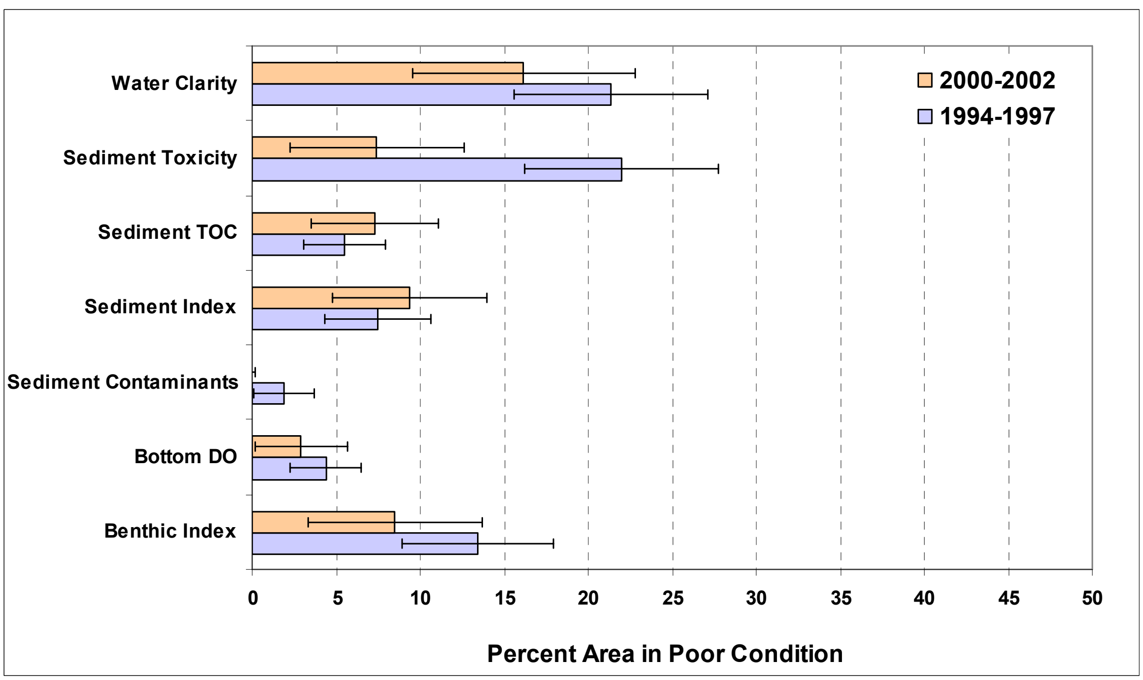

Figure 4-14. Comparison of percent area of Southeast Coast coastal waters in poor condition for ecological indicators between two time periods, 1994–1997 and 2000–2002. Error bars are 95% confidence intervals (U.S. EPA/NCA).

Bottlenose Dolphin Tissue Contaminants

Bottlenose dolphins are apex predators in estuarine and nearshore waters along the Atlantic coast from Long Island, NY, south to Florida and along the coast of the Gulf of Mexico. In many estuaries, bottlenose dolphins are year-round residents, showing a high degree of site fidelity. As such, dolphins can be good indicators of ecosystem contamination, particularly for very persistent pollutants such as PCBs. Total PCB concentrations were measured in blubber from live dolphins sampled along the Atlantic coast between 2000 and 2004 (Hansen et al., 2003). In the Gulf of Mexico, total PCB concentrations were measured in blubber from live dolphins in Sarasota Bay, FL, in 2000–2001 (Wells et al*.,* 2005) and Florida Bay in 2002 (NOAA, 2003), as well as from stranded bottlenose dolphins near St. Joseph Bay, FL, during an unusual mortality event (UME) in 2004 (NIST, 2004). Concentrations of other organic compounds, including polyfluoroalkyl compounds (PFAs) in dolphin blubber and blood, have also been examined.

Female dolphins transfer a majority of their PCB contaminant load to their offspring during lactation, and it is difficult to interpret PCB concentrations from the blubber of female dolphins without knowledge the dolphins' reproductive history. For this reason, total PCB concentrations analyzed in samples collected from male dolphins were used for this analysis. The measured total PCB concentrations were compared to estimated risk values proposed by Schwacke et al. (2002). These risk values correspond with PCB concentrations that are estimated to cause reproductive failure (e.g., stillbirths, calf mortality) in dolphins. Measured total PCB levels of 33 µg/g lipid are considered to be the effective concentration required to induce 50% reproductive failure (EC50). Levels of 51.2 µg/g lipid are considered to be the effective concentration required to induce 90% reproductive failure (EC90).

Figure 1a. Total PCB concentrations measured from the blubber of male dolphins sampled along the U.S. Gulf of Mexico coast between 2000–2004. Green symbols indicate samples with total PCB values below the EC50 (33.0 µg/g lipid), yellow indicates values above the EC50 but below the EC90 (51.2 µg/g lipid), and red indicates values above the EC90. Data sources: Wells et al., (2005) for Sarasota, NOAA (2003) for Florida Bay, National Institute of Standards and Technology (2004) for St. Joseph Bay.

The results of these studies along the Gulf and Atlantic coasts are shown in Figures 1a and 1b, respectively. For sites where many dolphins were sampled (≥ 5), data are also summarized as a pie chart showing the proportion of the samples falling into each category. All of the dolphins sampled from Florida Bay and most of the UME dolphins from St. Joseph Bay showed total PCB concentrations below the EC50. In Sarasota Bay, 27% of dolphins had total PCB concentrations in their tissues above the EC50, but only 9% measured concentrations above the EC90. In the Atlantic Coast estuaries around Charleston, SC, and in Florida's Mosquito Lagoon and the northern portion of the Indian River Lagoon, more than 60% of the male dolphins sampled showed total PCB values above the EC90. In addition, all tissue samples from the New Jersey coast measured PCB concentrations above the EC90, but only a few samples (n=4) were available. Dolphins sampled from estuaries and coastal regions of North Carolina and within the middle portion of the Indian River Lagoon fared better, with no individuals showing PCB concentrations above the EC90. Concentrations of total PCBs were higher than concentrations of other measured organic compounds at all of the sampled sites, and results of analyses of inorganic contaminants (e.g., metals) in dolphin tissues are not yet available.

Recently, scientists have identified other emerging chemical contaminants of concern, including PFAs, in the environment. PFA concentrations were measured in dolphin blood during capture-release studies in Sarasota Bay, FL, and at three Atlantic coast sites (Houde et al., 2005). Differences in PFA levels were observed between sampling sites, but little is known about the potential health effects of these compounds in dolphins. The mean summed PFA concentration (900 ppb wet weight) measured in dolphins from Sarasota, FL, was similar to that measured in dolphins from Indian River Lagoon, FL (800 ppb wet weight), and less than that measured in dolphins from Charleston, SC (1800 ppb wet weight), and Delaware Bay, DE (1600 ppb wet weight). Additional research is needed to determine whether these levels of PFAs put dolphins at increased health risk.

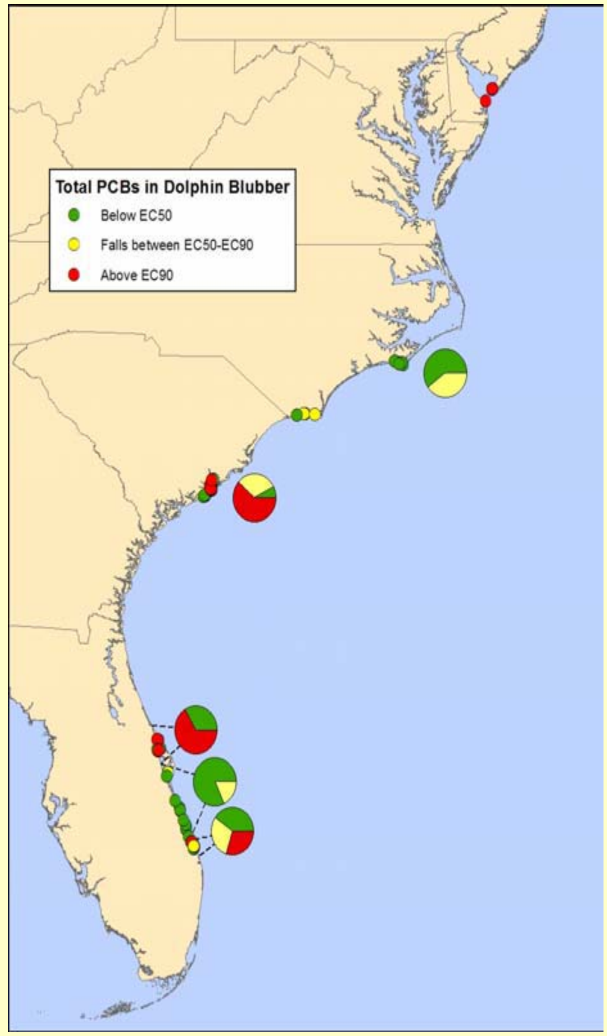

Figure 1b. Total PCB concentrations measured from the blubber of live male dolphins sampled along the U.S. Atlantic Coast between 2000–2004. Green symbols indicate samples with total PCB values below the EC50 (33.0 µg/g lipid); yellow indicates values above the EC50, but below the EC90 (51.2 µg/g lipid); and red indicates values above the EC90. Data sources: Charleston, SC, Indian River Lagoon, FL and Beaufort, NC, data from Hansen et al., (2003) and from the NOAA Center for Coastal Environmental Health and Biomolecular Research and Harbor Branch Oceanographic Institute (unpublished); data for other sites from National Institute for Standards and Technology and NOAA Fisheries (unpublished).

Southeast Shelf Large Marine Ecosystem Fisheries

The portion of the Atlantic coast of the United States that borders the Southeast Shelf LME includes diverse habitats ranging in salinity, flora, and fauna. The coastal area 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 serves as important habitat for waterfowl, reptiles, mammals, fish, and invertebrates, as well as for a diverse array of plants. These estuaries also act as a natural filter to remove pollutants and sediments from upland regions. The Southeast Coast coastal area supports 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

Reef fish are generally found on reef or reef-like, hard-bottom habitats. Dominant reef fish species in the Southeast Shelf LME include red, yellowtail, vermilion, and mutton snappers; red and gag grouper; black sea bass; and greater amberjack. 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 fish fisheries are extremely diverse, have many users (commercial and recreational), and vary greatly by location and species.

Combined commercial and recreational landings of reef fish from the Southeast Shelf LME area have fluctuated since 1976, showing a slightly decreasing trend over time (Figure 4-15). The recent average yield of reef fish species (2001–2003) was 6,407 metric tons. Meanwhile, fishing pressure has increased significantly (NMFS, 2006), with many stocks currently considered overfished. Regulations pertaining to the management of reef fish include prohibitions on the use of fish traps (except pots for black sea bass) and trawl gear, 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. Reef fish are part of a complex, diverse multi-species ecosystem. The long-term effects of harvesting on reefs are not well understood, requiring cautious management controls of targeted fisheries.

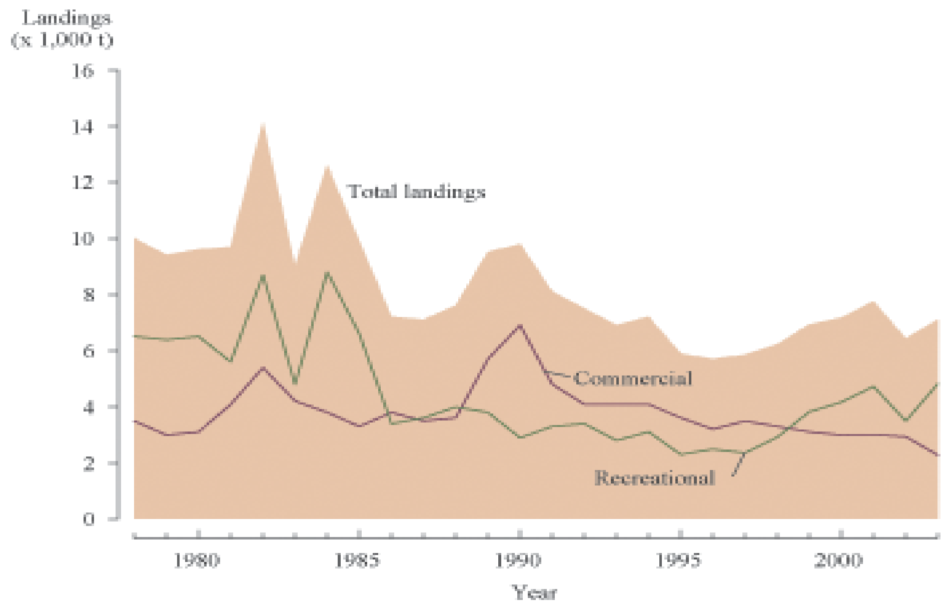

Figure 4-15. South Atlantic coast reef fish landings, 1978–2003, in metric tons (NMFS, 2006).

Sciaenids Fisheries

Fish of the family *Sciaenidae* include 22 species in the Southeast Shelf LME (NMFS, 2006). Some of the more notable members of this family of fish are 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 with almost every type of gear used to fish the coastal waters of the Atlantic.

Of the sciaenid species for which an FMP has been developed, red drum is currently classified as overfished; weakfish is classified as recovered; and there is not enough information available to adequately determine the stock status of the remaining species. Commercial landings of red drum increased rapidly in the mid-1980s when market demand grew suddenly for blackened redfish, a gourmet seafood dish. In addition, large numbers of sciaenids (e.g., small Atlantic croaker, spot, and seatrout) are caught and killed as an incidental catch in Southeast shrimp fisheries. Because much of this bycatch consists of juveniles, mortality from incidental catches may slow the recovery of overfished stocks. Shrimp management regulations require the use of bycatch reduction devices, which shrimpers in the South Atlantic currently use. Use of these devices has contributed to the rebound of some overfished stocks, such as weakfish. Recent declines in spotted seatrout abundance in South Atlantic waters have been attributed to increased coastal development leading to habitat loss and heavy fishing pressure. Regulations for sciaenid fishes in the Atlantic vary by state and range from no restrictions to complicated restrictions based on fish size and bag limits. The populations of several species of sciaenids, most notably Atlantic croaker and spotted seatrout, appear to be closely linked to environmental conditions, resulting in large annual fluctuations in population levels (NMFS, 2006).

Menhaden Fishery

The geographical range of the Atlantic menhaden extends from West Palm Beach, FL, to Nova Scotia, Canada. Menhaden are prey for many fishes, marine mammals, and sea birds and form an important component of the Southeast Shelf and Northeast Shelf ecosystems. Landings and participation in the menhaden fishery (23 factories and more than 100 vessels on the Atlantic coast) increased rapidly after World War II (Figure 4-16), reaching peak harvests between 1953 and 1962, with record landings of 712,100 metric tons in 1956. Sharp declines in landings thereafter resulted in plant closings and vessel reductions. Stock rebuilding occurred during the 1970s and 1980s, and menhaden landings climbed to 418,600 mt in 1983. During the late 1980s and 1990s, the fishery consolidated, primarily because of low product prices. By 1990, participation in the fishery declined to 5 reduction factories and about 37 vessels. In 2003, only 2 reduction plants remained on the Atlantic coast, with a total of 12 vessels. The Virginia portion of Chesapeake Bay is currently the center of the modern menhaden fishery. An active baitfish fishery along the coast, primarily located in Virginia and New Jersey, harvests about 15% to 20% of the amount landed by the industrial fishery. The resource is almost fully utilized, with a maximum sustainable yield of 408,999 mt per year and a recent (2001–2003) average annual yield of 228,000 mt (NMFS, 2006).

Declining fishing effort 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. Currently, several studies examine the role of menhaden in the food web, with the goal of managing forage and predator fish species at a multi-species level (NMFS, 2006).

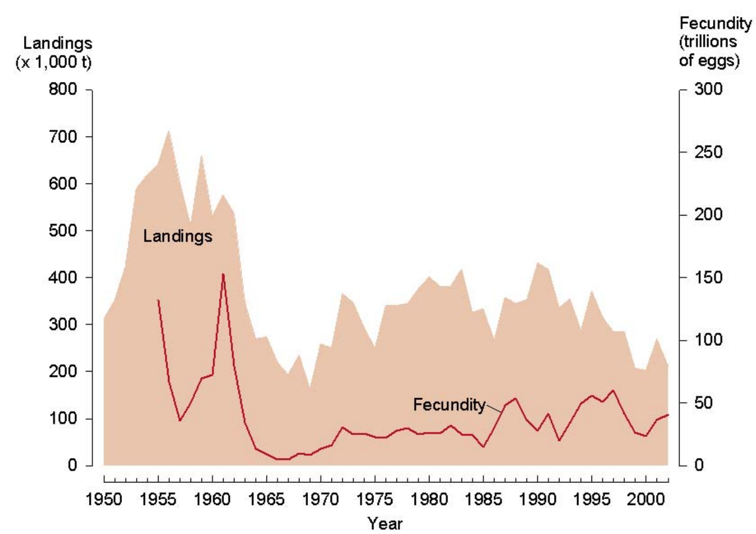

Figure 4-16. Landings of Atlantic menhaden, in metric tons, and fecundity, 1950–2002 (NMFS, 2006).

Mackerel Fisheries

King and Spanish mackerel are two coastal pelagic fishes inhabiting southeastern U.S. waters. Coastal pelagics are fast swimmers that school and feed voraciously, grow rapidly, mature early, and spawn over many months. U.S. and Mexican commercial fishermen have harvested Spanish mackerel since the 1850s and king mackerel since the 1880s.

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 in 1985 and a minimum of 2,570 mt in 1999. In 2001, the total catch was 2,748 mt, and the recent (2000–2001 to 2002–2003) average yield was 2,665 mt. In 2003, the maximum sustainable yield was estimated as 2,680 mt for Atlantic king mackerel stock. On average, the landings are larger for the recreational sector (66%) than for the commercial sector (34%), and landings of king mackerel have been below the total allowable catch limitations since 1986. According to the 1998 and 2003 stock assessments, the 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 (NMFS, 2006).

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 in 1991 and a minimum of 1,406 mt in 1995. In 2001, the total catch was 2,305 mt, and the recent (2000–2001 to 2002–2003) average yield was 2,716 mt. 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 the Southeast Shelf LME Spanish mackerel include minimum size restrictions, gear restrictions, trip limits, and quota allocation. A major recreational fishery exists for Spanish mackerel throughout its range, and percent of landings by recreational anglers has increased to about 50% for the Atlantic stock since the mid-1990s. 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 (NMFS, 2006).

Courtesy of William B. Folsom
Colorful shrimp boat showing turtle extruder devices, South Carolina, 1997. Source: NOAA photo library.

Shrimp Fisheries

The trend in commercial landings of the major shrimp species over the past 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 over-winter 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 (NMFS, 2006).

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 stocks are fully exploited. The recent (2001–2003) average yield of brown, pink, rock, and white shrimp from the Southeast Shelf LME was 10,984 mt (NMFS, 2006).

NMFS catch statistics indicate that commercial shrimp species are being harvested at maximum levels; therefore, 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 (NMFS, 2006).

Assessment and Advisory Data

Fish Consumption Advisories

Ten fish consumption advisories were active in the coastal waters of the Southeast Coast region in 2003 (Figure 4-17). All four coastal states of this region—North Carolina, South Carolina, Georgia, and Florida—had statewide advisories covering all coastal waters to warn citizens against consuming large quantities of king mackerel because of potential mercury contamination. Florida and South Carolina also had 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 in 2003. Most (91%) fish consumption advisories for the Southeast Coast were issued, at least in part, because of mercury contamination (Figure 4-18), 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 Estuarine System.

These species and/or groups were under advisory in 2003 for at least some part of the Southeast Coast:

Almaco jack	Carp	King mackerel	Shark
Atlantic croaker	Catfish	Ladyfish	Silver perch
Black drum	Clams	Largemouth bass	Snowy grouper
Blackfin tuna	Cobia	Little tunny	Spotted seatrout
Blue crab	Crevalle jack	Mussels	Swordfish
Bluefish	Flounder	Oysters	Tilefish
Bowfin	Greater amberjack	Red drum	*Source: U.S. EPA, 2004b*

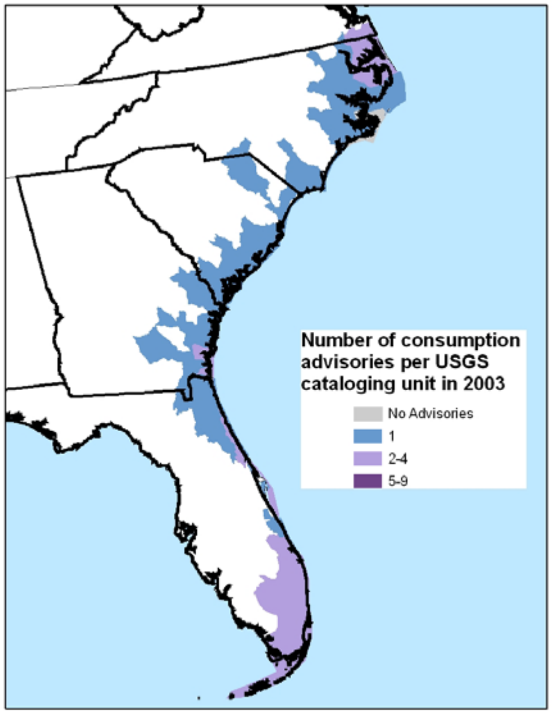

Figure 4-17. The number of fish consumption advisories for the Southeast Coast active in 2003 (U.S.EPA, 2004b).

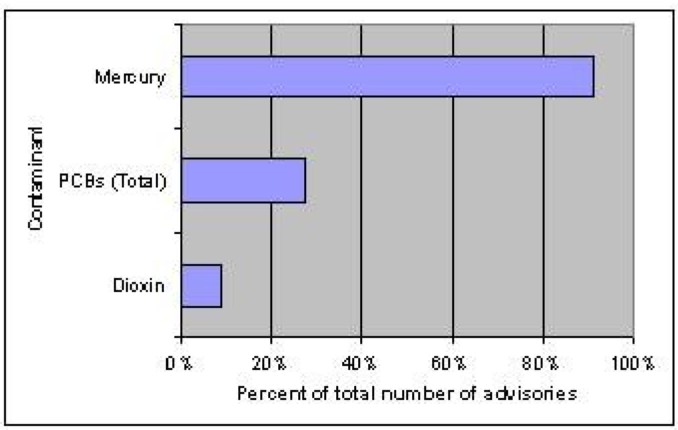

Figure 4-18. Pollutants responsible for fish consumption advisories in Southeast Coast waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S.EPA, 2004b).

Beach Advisories and Closures

Of the 487 Southeast Coast beaches reported to EPA in 2003, only 12% (59 beaches) were closed or under an advisory for any period of time during that year. Table 4-1 presents the number of beaches monitored and the number of beaches under closures or advisories for each state. Figure 4-19 presents advisory and closure percentages for each county within each state.

Table 4-1. Number of Beaches Monitored and Under Advisories/Closures in 2003 for Southeast Coast States (U.S. EPA, 2006)

State	No. of Beaches Monitored	No. Beaches With Advisories/Closures	Percentage of Beaches Affected by Advisories/Closures
North Carolina	222	21	9.5
South Carolina	7	2	28.6
Georgia	37	Not reported	Not reported
Florida (East Coast)	226	36	15.9
TOTALS	492	59	12.0

Most beach advisories and closures were implemented at beaches along the Southeast Coast because of elevated bacteria levels (Figure 4-20). Although stormwater runoff was identified as a source of beach contamination in the Southeast Coast region, unknown sources accounted for 97% of the survey responses (Figure 4-21).

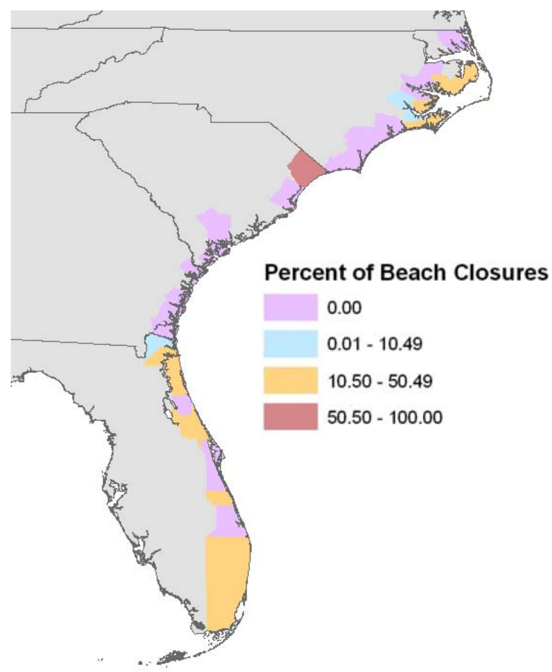

Figure 4-19. Percentage of beaches with advisory or closures by county for the Southeast Coast (U.S.EPA, 2006).

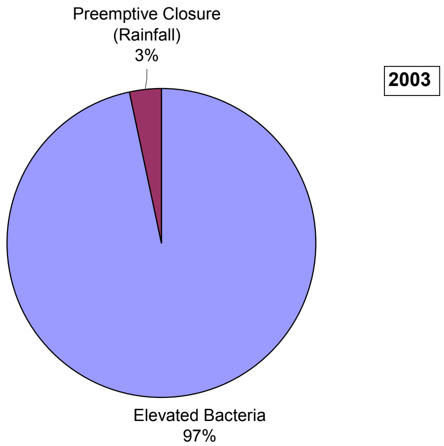

Figure 4-20. Reasons for beach advisories or closures for the Southeast Coast (U.S. EPA, 2006).

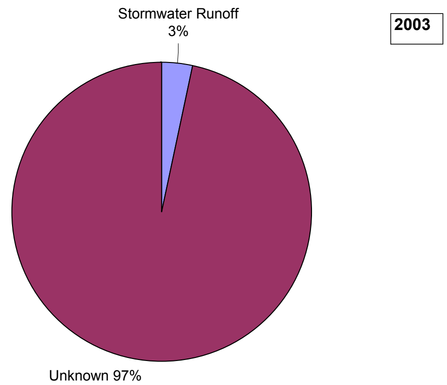

Figure 4-21. Sources of beach contamination for the Southeast Coast (U.S. EPA, 2006).

Summary

Based on data from the NCA, the overall condition of the coastal waters of the Southeast Coast region is rated fair. The NCA monitoring conducted by coastal states in 2001 and 2002 showed that DIN, DIP, and bottom dissolved oxygen concentrations; water clarity; sediment toxicity; sediment contamination; TOC levels; and benthic condition were rated good for Southeast Coast coastal waters. Areas of concern include the water quality index (54% rated fair or poor, combined) and coastal habitat index (rated fair). Although no significant linear trends were observed in the available EMAP data (1994–2001), increasing population growth in this region could contribute to increased susceptibility for water quality degradation in the future.

NOAA's NMFS manages several fisheries in the Southeast Shelf LME, including reef fish, sciaenids, medhaden, mackerel, and shrimp. Landings of reef fish have fluctuated, but are slightly decreasing over time. Fish in the *Sciaenidae* family generally support substantial harvests in the Southeast Shelf LME, but one member, red drum, is currently classified as overfished. The fishing effort for medhaden in this LME has decreased since the 1950s, but NMFS considers this resource to be almost fully utilized. Neither the king nor Spanish mackerel species are considered overfished, but these stocks are at or near their long-term potential yields. Although fishing pressure has increased, the Southeast Shelf shrimp fishery has exhibited a 40-year stable trend.

Contamination in Southeast Coast coastal waters has affected human uses of these waters. In 2003, there were 10 fish consumption advisories in effect along for the Southeast Coast region, most of which were issued for mercury contamination. In addition, 12% of the region's monitored beaches were closed or under advisory for some period of time during 2003. Elevated bacteria levels in the region's coastal waters were primarily responsible for the closures and advisories.

Although the overall condition of Southeast Coast coastal waters is rated fair for 2001-2002, the promotion of a vigilant attitude and the continuation of environmental education would help to protect and preserve this resource.

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NCCR III

Chapter 4 Highlights

highlight

EPA, NOAA, and Southeastern States Assess Ecological Condition in Near-Coastal Shelf Waters of the South Atlantic Bight

A study is under way by the U.S. EPA, NOAA, and partnering southeastern states to assess the condition of aquatic resources throughout near-coastal shelf waters of the South Atlantic Bight (SAB) (Figure 1). Based largely on the concepts and protocols of EPA's Environmental Monitoring and Assessment Program (EMAP), this SAB study may be regarded as an extension of previous EMAP efforts in estuaries and inland waters to these offshore areas, where such information has been limited in the past. A similar effort is also under way in shelf waters along the western coast of the U.S. (see West Coast chapter). The SAB sampling effort includes the probabilistic sampling approach of EMAP to support statistical estimation of the spatial extent of conditions with respect to various measured ecological indicators. Results are intended to serve as a baseline for monitoring potential changes in these indicators over time due to either human or natural factors.

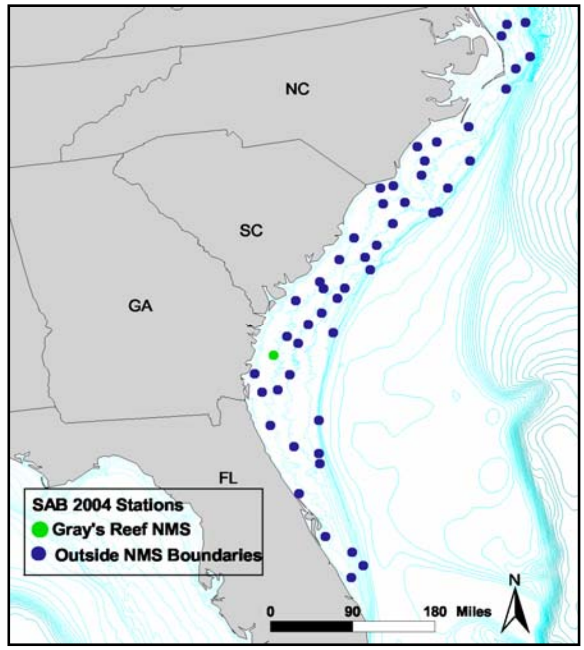

Figure 1. South Atlantic Bight sampling sites (Cooksey, 2004).

Sampling was conducted in April 2004 at 50 random stations from Nags Head, NC to West Palm Beach, FL at depths of about 32.8–328 ft (roughly from just offshore to the outer edge of the continental shelf) (Cooksey, 2004). Data from the 50 stations will allow the assessment of conditions for the SAB offshore region and contribute to broader estimates of conditions at the national level. In addition, a station was included within the Gray's Reef National Marine Sanctuary (GRNMS) located about 21.7 mi off the coast of Georgia (NOAA, 2004). NOAA also has conducted recent site-intensive surveys of condition at multiple stations within the boundaries of the GRNMS itself, using the same protocols as in the present SAB-wide survey (Cooksey et al., 2004; Hyland et al., 2006). Thus, results of these companion surveys (the first conducted in 2000 and the second in 2005) can be integrated with the present regional survey to assess the condition of sanctuary resources within the context of the broader SAB ecosystem.

As in other EMAP efforts, including the present NCCRIII, multiple indicators were measured synoptically at each station to support weight-of-evidence assessments of condition and the examination of associations between biological characteristics and potential environmental controlling factors (U.S. EPA, 2002). Indicators included (1) general water-quality characteristics, (2) habitat condition characteristics, (3) biological condition with a focus on benthic infauna and demersal fish pathology, and (4) stressor exposure levels (Table 1).

Table 1. Environmental Indicators (Cooksey, 2004)

Habitat Condition Indicators	Benthic Condition Indicators
• Salinity	• Infaunal species composition
• Water depth	• Infaunal abundance
• Dissolved oxygen	• Infaunal species richness and diversity
• pH	• External indicators of disease in fish
• Water temperature	• Presence of nonindigenous species
• Total suspended solids	
• Transmittance	
• Sediment grain size	
• Sediment % total organic carbon (TOC)	
• Sediment color/odor	
• Presence of trash/marine debris	
Water Quality Indicators	**Exposure Indicators**
• Chlorophyll a concentrations	• Chemical contaminants in sediment
• Nutrient concentrations (nitrates, nitrites, ammonia, phosphate)	• Chemical contaminants in fish tissues • Low dissolved oxygen condition
	• Organic overenrichment

The consistent and systematic sampling of the different biological and environmental variables across such a large pool of stations provides a tremendous opportunity for learning more about the spatial patterns of these near-coastal aquatic resources and of the processes controlling their distributions, including potential associations between presence of stressors and biological responses. For example, a key environmental concern that the program will address with these data is the extent to which pollutants and other materials are being transported out of major rivers along developed areas of the coast (Figure 2), as is how they may affect biological resources.

Figure 2. St. Simon Sound, Georgia.

The study also demonstrates the benefits of performing science through partnerships that bring together complementary capabilities and resources from a variety of federal, state, and academic institutions. The project is principally funded by the EPA Office of Research and Development. NOAA also is a major partner in the effort, working with EPA to provide overall management and interpretive support, in addition to contributing ship time on the NOAA Ship Nancy Foster. State and academic partners include the North Carolina Department of Environment and Natural Resources, South Carolina Department of Natural Resources, Georgia Department of Natural Resources, Florida Department of Fish and Wildlife, and the College of Charleston.

A final report is expected by summer 2007. It is anticipated that the resulting information on the condition of ecological resources in these deeper near-coastal waters will make a valuable contribution to future NCCRs.

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highlight

Georgia's Marsh Dieback

In March 2002, areas of dying coastal salt marshes were reported to the Georgia Department of Natural Resources (GDNR), Coastal Resource Division (CRD). Marsh grasses (*Spartina alterniflora* and *Juncus roemerianus*) were confirmed as dying, resulting in open mudflats. The affected areas initially reported in Liberty County covered several miles of creekside die-off as well as several acres of receding marsh along the Jericho River.

Largest salt marsh dieback in Georgia, July 2003 at the Jericho River in Liberty County. Photograph courtesy of GDNR.

To date, dead and dying marsh has been reported in all six coastal counties, from the St. Mary's River in Camden County to Tybee Island in Chatham County. The CRD has consulted other states that have experienced similar marsh epidemics (i.e., South Carolina, Louisiana), but the cause(s) in Georgia have not yet been determined. Currently, it has been estimated that 1,000 acres of marsh have been affected, with the vast majority of this acreage in Liberty County.

The Georgia CRD has collaborated with scientists from Savannah State University, Sapelo Island National Estuarine Research Reserve, Grays Reef National Marine Sanctuary, Georgia Sea Grant, the U.S. Army Core of Engineers, University of Georgia Marine Extension Service, University of Georgia Marine Institute, and Skidaway Institute of Oceanography via the Georgia Coastal Research Council (GCRC) to collect data from the dying marsh sites. Marsh samples were analyzed for soil and interstitial salinities, presence of fungi and/or abnormal bacteria, and pH. Other than higher than normal salinities (though not high enough to denude the amount of marshes that have been lost), no abnormal readings have been detected. Also, greenhouse trials were conducted to determine the effects of freshwater and variation in soils. To date, greenhouse sampling results have shown no difference in the *Spartina* plants grown in dead and healthy marsh soils. *Spartina* leaves reveal no abnormal species counts; however, root and rhizome analyses are ongoing.

Georgia CRD and GCRC scientists have developed a standardized methodology for quarterly field sampling. In addition, Savannah State University has established a working laboratory for testing vegetation samples. Researchers are continuing field sampling to monitor and evaluate changes in salinities and vegetation.

The Georgia CRD is cataloging all reports of dying marshes through aerial and on-the-ground photographic documentation, and is responding to concerned citizen reports. The CRD has coordinated public education efforts through press releases to the local media. In addition, the CRD is using Geographic Information System (GIS) software to map and estimate the affected acreage. Currently, the CRD is working with the University of Georgia Marine Extension Service's GIS Specialist to plan and implement GIS classifications in order to delineate and track dieback areas. Scientists from the GCRC have applied for various grants to address certain aspects of the marsh dieback, including monitoring, transplant experiments, and plant tissue analysis studies.

The marsh die-off affects a vital coastal area of the state and has implications for wildlife, fisheries, water quality, navigation, and flood control. Under the Georgia Coastal Marshlands Protection Act (O.C.G.A. 12-5-280 et seq.), the State recognizes that "the coastal marshlands of Georgia comprise a vital natural resource system. The estuarine area…is the habitat of many species of marine life and wildlife and, without the food supplied by the marshlands, such marine life and wildlife cannot survive. The estuarine marshlands of coastal Georgia are among the richest providers of nutrients in the world. Such marshlands provide a nursery for commercially and recreationally important species of shellfish and other wildlife, provide a great buffer against flooding and erosion, and help control and disseminate pollutants. The coastal marshlands provide a natural recreation resource, which has become vitally linked to the economy of Georgia's coastal zone and to that of the entire state. This…system is costly, if not impossible, to reconstruct or rehabilitate once adversely affected." The results of these investigations into the dead marsh issue have long-term implications for the preservation of Georgia's estuaries and the health of Georgia's coastal economy.

Updates regarding the progress made on the marsh dieback issue can be found at the GCRC Web site at http://www.marsci.uga.edu\coastalcouncil or accessed through the Georgia CRD Web site at http://crd.dnr.state.ga.us.

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highlight

South Carolina Oyster Restoration and Enhancement (SCORE) Program

Populations of our native eastern oyster, *Crassostrea virginica*, are declining throughout their range from Canada to South America, with some areas, such as the Chesapeake Bay, at less than 1% of their historic abundance. Oysters not only provide a resource to harvest and enjoy, but also provide a number of ecosystem services, including filtering vast quantities of water, serving as an important habitat for numerous commercial and ecologically important estuarine species, and protecting marsh shorelines from erosion (Figure 1).

Figure 1. Natural South Carolina intertidal reef adjacent to fringing salt marsh.

The purpose of the SCORE program is to restore and enhance oyster resources and habitat by planting recycled oyster shells into the intertidal environment. Volunteers from across the state are helping to strategically place recycled oyster shells, thereby creating new oyster shell habitats for natural recruitment in areas with little or no natural oysters or substrate for settlement. This community-based habitat restoration program is an important endeavor because oysters play a significant ecologic and economic role in South Carolina. It is important for the community to understand that oysters are much more than a seafood treat, and to learn about oysters' biology and the human activities that can influence their well-being. The South Carolina Department of Natural Resources (SCDNR) is also using these small oyster shell reefs (hundreds of bushels of shells) to evaluate approaches for their larger oyster planting program on public grounds, which involves tens of thousands of bushels of recycled shells covering acres of formerly barren intertidal habitat.

The SCDNR is responsible for managing the state's oyster resource habitats. Appropriate management includes the planting of appropriate shell material (cultch) to provide substrate for the oyster larvae settling out of the water column and onto the permanent substrate, where they will reside as adults. The best cultch material is fresh oyster shells, but this material is getting scarce. In order to increase oyster reef habitat at a minimum cost to taxpayers, SCDNR has initiated the SCORE program and a related shell recycling program. Community-based restoration and related monitoring are key components of SCORE.

Some volunteer groups recycle their own shells, but most use shells from the SCDNR's larger Shell Recycling Program, which has numerous locations along the coast (see http://saltwaterfishing.sc.gov/oyster.html). By working together, community members and SCDNR biologists are restoring oyster populations while also (1) enhancing habitat for fish, shellfish, mammals, and birds; (2) improving water quality and the clarity of estuarine areas; and (3) informing and educating children, industry, and the general public.

Unfortunately, there is a nationwide shortage of oyster shells to be used as cultch. A lot of oyster shells go to landfills or are used for decorative purposes (tabby walls) or road bed coverage. SCDNR has initiated an effort to encourage the public to recycle oyster shells at a designated recycling center for use in resource management (Figure 2). As of June 2006, more than 16 recycling centers were open along the South Carolina coast. The recycled shells generated in this fashion are used for restoration and enhancement of shellfish resources, reducing the costs of these activities. South Carolina currently recaptures less than 5% of the shells that could potentially be recycled from oysters consumed each year across the state. Volunteer groups may want to recycle shells as a service project. There is a lot of shell material available from restaurants, caterers, and resorts, so it is important to make the effort to recapture it before it goes to a landfill.

Figure 2. Sun City Volunteers quarantine oyster shells before bagging for use in oyster habitat restoration projects. Photograph courtesy of SCDNR.

The restoration part of the SCORE program works with local citizen groups to conduct habitat restoration projects and then monitor their success over time. From May 2001 to May 2006, a total of 105 reefs at 28 reef sites were completed along the South Carolina coast using more than 13,000 bags (over 275 tons) of oyster shells (Figure 3). Projects involved building new reefs with recycled shells for the recruitment of oyster larvae. As these shell bag reefs begin to recruit new oysters and attract other inhabitants of the estuary, they are also being used as living classrooms and SCDNR research platforms. Volunteer support is critical to monitoring the new reefs throughout the year to increase understanding of how best to restore oyster habitats. Support to date has come from state and federal agencies, foundations, and volunteers, more than 2,000 of whom have been involved in one or more aspects of the program.

Figure 3. SCDNR's largest completed reef at Mt. Pleasant, South Carolina. Photograph courtesy of SCDNR.

More information on SCORE and other oyster-related links are available on SCORE's Web site (http://score.dnr.sc.gov). Shell-recycling information is available on the SCDNR Marine Resource Division's Oyster Recycling Web page (http://saltwaterfishing.sc.gov/oyster.html).

highlight

Responding to Sea Level Rise

Sea level is expected to rise an average of 20 inches in the 21st century; about two to four times the rate observed over the 20th century, (IPCC, 2001). The U.S. Geological Survey (USGS) has divided the U.S. coastline into five categories based on vulnerability to sea level rise (SLR). These categories are based on geomorphology, coastal slope, relative sea level change, shoreline erosion rate, tidal range, and mean wave height (Thieler and Hammar-Klos, 1999). Because of their low lying and gently sloping shorelines, and because the land is subsiding while sea level is rising, the U.S. Southeast and Gulf coasts are the most vulnerable of the nation's coasts. A 20-inch rise in sea level will result in a substantial loss of coastal land. Problems associated with SLR include higher and more frequent flooding of wetlands and low-lying coastal land, affects on coastal ecosystems, increased flooding during severe storms, increased wave energy in near-shore areas, salt water intrusion into coastal freshwater aquifers, breaching of coastal barriers, damage to coastal infrastructure, affects on coastal economies, and coastal erosion and coastal retreat, including dune and cliff erosion. The prediction of shoreline retreat and land loss rates is critical to the planning of future coastal zone management strategies, as well as to assessing biological impacts due to habitat changes and loss.

To assist natural resource managers in mitigating the loss of coastal ecosystems resulting from the existing and predicted acceleration in the rate of SLR, NOAA is developing digital coastal elevation maps with a vertical resolution of 8 inches, coastal flooding models that show the spatial extent of inundation for any projected rate of SLR, and models of ecological response to inundation. The digital elevation maps, hydrological models, and ecological models will be combined to produce forecasts of coastal change as a function of SLR. One very important use of the forecasts for coastal planners is predicting the coastal response to specific proposals for coastal development.

This project has begun along the coast of North Carolina, not only for vulnerable areas, but also for areas whose topography has been mapped by the state using LIDAR (**li**ght **d**etecting **a**nd **r**anging). With its rapidity of acquisition and very high data density, airborne LIDAR is revolutionizing the quantification of coastal change. Based on NOAA tide gauge measurements, the measured rate of relative SLR in North Carolina ranges from 0.07 to 0.17 inches/year, with rates increasing from south to north (NOAA, 2004). The SLR over the past several decades already has had a major impact on North Carolina coastlines. Rates of shoreline recession vary dramatically along the shore and are a function of shoreline type, geometry, and composition; geographic location; size and shape of the associated coastal waterbody; coastal vegetation; water level; and storm frequency and intensity. In addition, the transformation of one ecosystem class to another, forced by SLR, may significantly alter the function of the coastal area. In North Carolina, the majority of the coastal zone is within several feet of current sea level because of low topographic slopes on the coastal plain. As a result, shoreline erosion has consumed almost 50 mi^2 from 1975 to 2000, and as much as 60% of wetlands in northeastern North Carolina (Riggs, 2001).

The coastal flooding model combines the hydrodynamic tide model of Pamlico, Albemarle, Core, and Bogue Sounds and adjacent estuarine and coastal waters with the high-resolution, topographic/bathymetric digital elevation map based on the LIDAR topographic and bathymetric data (NOAA, 2004). The model forecasts the extent of inundation in Pamlico and Bogue Sounds and the Neuse River as a function of SLR (Figure 1).

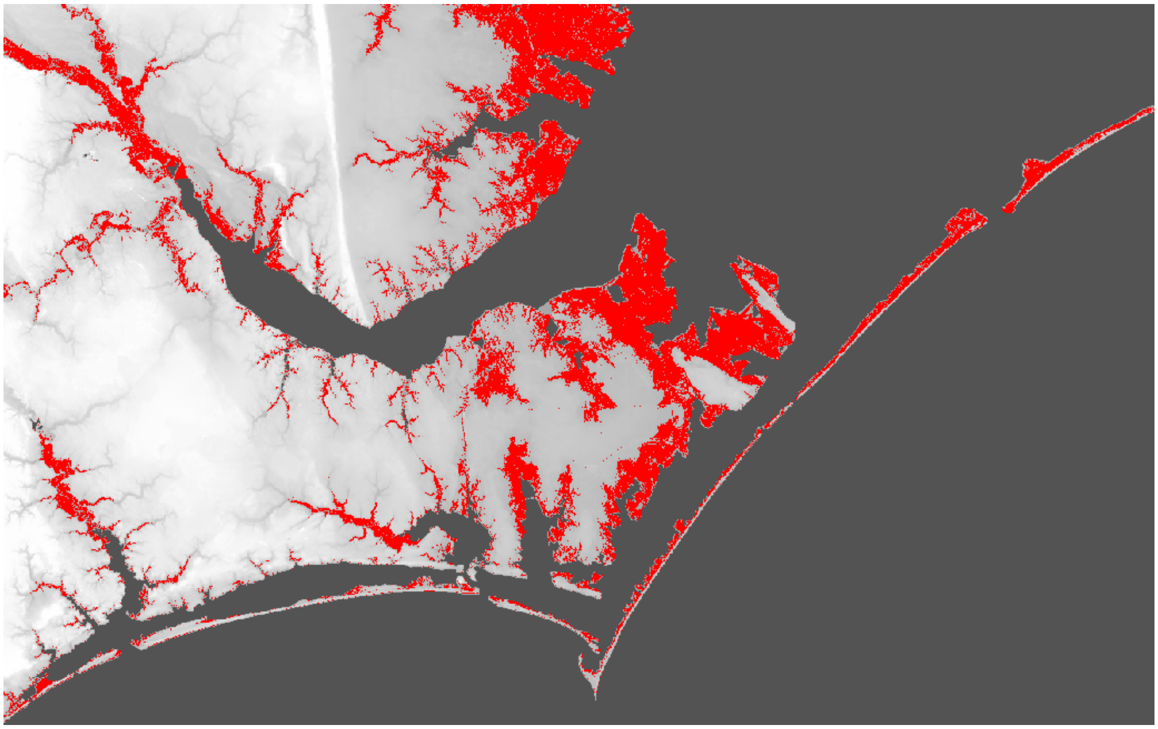

Figure 1. Areas in red along North Carolina Outer Banks, Bogue Sound, Pamlico Sound, and the Neuse River are projected to be inundated by a 40 inch rise in sea level (NOAA, 2004).

Ecological Models

In 2005, NOAA initiated development of ecological models for the area covered by the coastal flooding model. A GIS-based database of shoreline variables including fetch, offshore bottom character, shoreline geometry, height and composition of sediment banks, fringing vegetation, boat wake, soil series, marsh zone width, land form type and location, and elevation will help forecast estuarine shore-zone modification driven by SLR. One type of ecological model will predict the effects of present SLR, increases in storm surge intensity, bulkheads, and breakwaters on net primary and secondary production within five types of habitat: subtidal un-vegetated, submerged aquatic vegetation (SAV), intertidal flat, oyster reef, and marsh. Another will be a spatially distributed model of biomass and accretion on salt marsh platforms based on vegetation responses to changes in mean sea level with sediment accretion. Forecasts of the effects of SLR on forests and forested wetlands will link surface soil salinity to estuarine salinity using soil type maps tied to vegetation/land cover and elevation. Forecasts will be used to determine feedback and transition processes between marshes and forests, and marshes and subtidal environments, and specifically what thresholds are needed to initiate state changes from one zone to another due to salinity, inundation regime, or episodic events.

The coastal flooding ecological models will be integrated with landscape models to assess the impact of land use activities on natural and cultural resources, and will project the loss/alteration of habitat and resulting impact on biodiversity.

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Chapter 5

Gulf Coast Coastal Condition

As shown in Figure 5-1, the overall condition of the coastal waters of the Gulf Coast region is rated fair to poor, with an overall condition score of 2.2. The water quality index for the region's coastal waters is rated fair; the sediment quality, benthic, and coastal habitat indices are rated poor; and the fish tissue contaminants index is rated good. Figure 5-2 provides a summary of the percentage of region's coastal area rated good, fair, poor, or missing for each index and component indicator. This assessment is based on environmental stressor and response data collected by the states of Florida, Alabama, Mississippi, Louisiana, and Texas from 487 locations, ranging from Florida Bay, FL, to Laguna Madre, TX, in 2001 and 2002. Please refer to Tables 1-23, 1-24, and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each of the parameters considered.

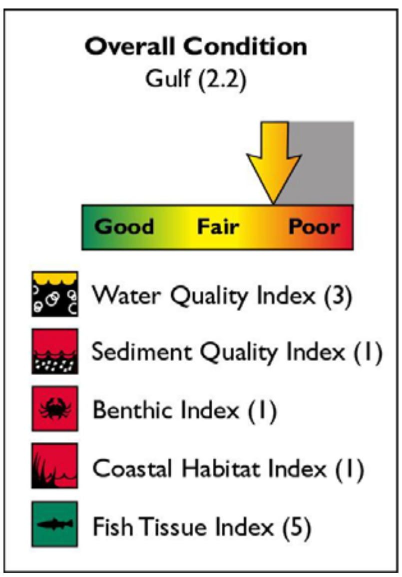


Figure 5-1. The overall condition of the coastal waters of the Gulf Coast region is rated fair to poor (U.S. EPA/NCA).

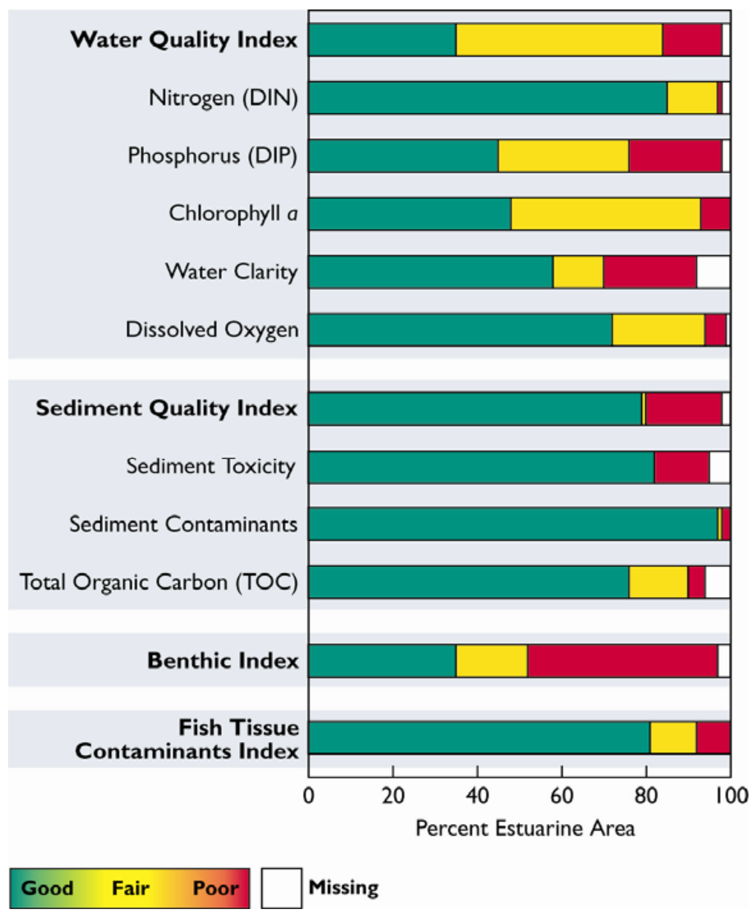


Figure 5-2. Percentage of coastal area achieving each ranking for all indices and indicators–Gulf Coast region (U.S. EPA/ NCA).

The Gulf Coast coastal area in the United States comprises more than 750 estuaries, bays, and sub-estuary systems that are associated with larger estuaries. The total area of the Gulf Coast estuaries, bays, and sub-estuaries is 10,643 mi^2. Gulf Coast estuaries and wetlands provide critical feeding, spawning, and nursery habitat for a rich assemblage of fish and wildlife, including 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. This region's coastal waters also support SAV communities that stabilize shorelines from erosion, reduce non-point source loadings, and improve water clarity.

The coastal waters of the Gulf Coast region are among the most productive natural systems, and the region is second only to Alaska for domestic landings of commercial fish and shellfish. In 2001 and 2002, Gulf Coast commercial fish and shellfish landings totaled 1.5 million mt and were valued at $1.5 billion (NOAA, 2003). The Gulf Coast led the United States in commercial shrimp landings in 2004 with 115,566 mt, accounting for 83% of the total U.S. shrimp landings (NMFS, 2005).

Gulf Coast estuaries are located in two biogeographical provinces: the Louisianian Province and the West Indian Province. The Louisianian Province extends from the Texas-Mexico border east to Anclote Key, FL. The West Indian Province extends from Tampa Bay, FL, on the Gulf Coast to the Indian River Lagoon, FL, on the Atlantic Coast; the portion of this province included in the Gulf Coast region extends from Tampa Bay to Florida Bay. The Gulf Coast region is also referenced as the Gulf of Mexico LME. The coastal waters sampled by NCA in the Gulf Coast range in size from 0.00946 mi^2 (Bayou Chico, FL) to 1,196 mi^2 (Florida Bay, FL).

The population of coastal counties in the Gulf Coast region increased 45% between 1980 and 2003. Coastal counties in Texas and Florida are leading the region in population change. Figure 5-3 presents population data for Gulf Coast coastal counties and shows the increase in population of these coastal counties since 1980 (NOAA, 2004).

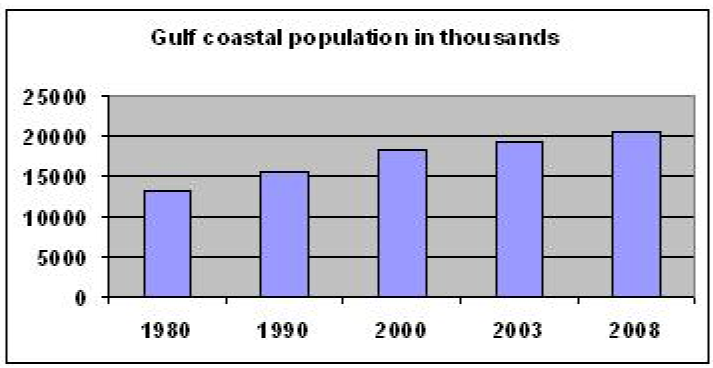


Figure 5-3. Actual and estimated population of coastal counties in Gulf Coast states from 1980 to 2008 (NOAA, 2004).

Coastal Monitoring Data – Status of Coastal Condition

A variety of programs have monitored the coastal waters of the Gulf Coast region since 1991. EMAP focused its coastal monitoring efforts on Gulf Coast coastal waters from 1991 to 1995 (Macauley et al., 1999; U.S. EPA, 1999). The Joint Gulf States Comprehensive Monitoring Program (GMP, 2000) began an assessment in 2000, in conjunction with EPA's Coastal 2000 Program. This partnership has continued as part of the NCA, with coastal monitoring being conducted by the five Gulf Coast states through 2004. In addition, NOAA's NS&T Program has collected contaminant bioavailability and sediment toxicity data from several Gulf Coast sites since the late 1980s (Long et al., 1996).

The sampling conducted in the EPA NCA survey 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.

Water Quality Index

Based on the 2001–2002 NCA survey results, the water quality index for the coastal waters of the Gulf Coast region is rated fair, with 14% of the coastal area rated poor and 49% rated fair for water quality condition (Figure 5-4). The water quality index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Estuaries with poor water quality conditions were found in all five states, but the contributing factors differed among states. In Texas, Louisiana, and Mississippi, poor water

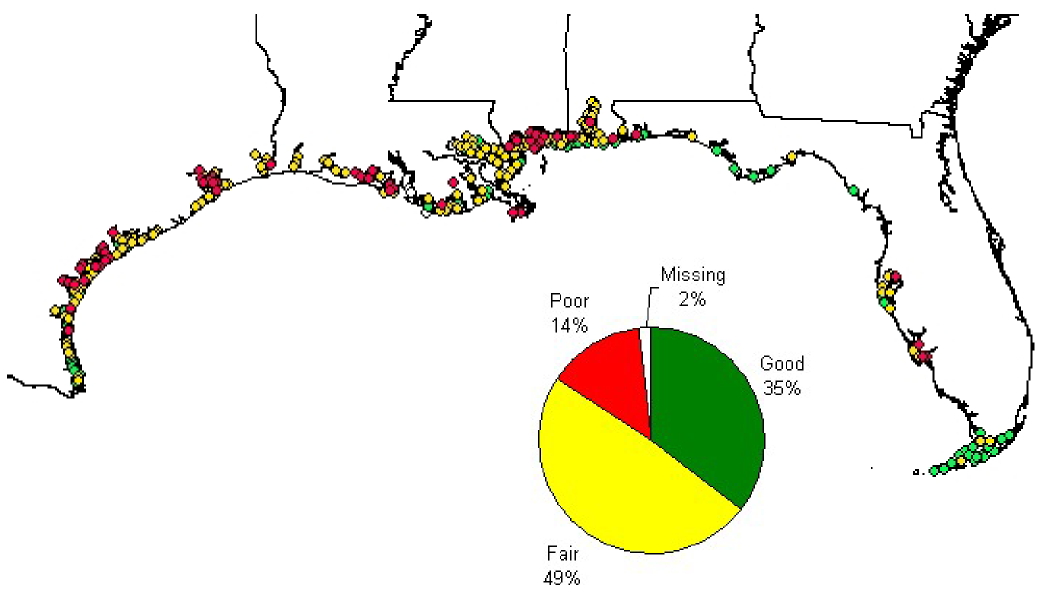


Figure 5-4. Water quality index data for the coastal waters of the Gulf Coast region (U.S. EPA/NCA).

clarity and high DIP concentrations contributed to a poor water quality rating, whereas poor conditions in several Texas bays were also due to high chlorophyll *a* concentrations. Only three sites in Louisiana had high concentrations of both DIN and DIP.

This water quality index can be compared to the results of NOAA's Estuarine Eutrophication Survey (NOAA, 1999), which rated the Gulf Coast as poor for eutrophic condition, with an estimated 38% of the coastal area having a high expression of eutrophication.

Nutrients: Nitrogen and Phosphorus

The Gulf Coast region is rated good for DIN concentrations, but rated fair for DIP concentrations. It should be noted that different criteria for DIN and DIP concentrations were applied in Florida Bay than in other areas of the Gulf Coast region because Florida Bay is considered a tropical estuary. DIN concentrations were rated poor in 1% of the Gulf Coast coastal area, representing three sites in Louisiana's East Bay, Atchafalya Bay, and the Intercoastal Waterway between Huoma and New Orleans, LA. 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 this season. DIP concentrations were rated poor in 22% of the Gulf Coast coastal area, which included sites in Tampa Bay and Charlotte Harbor, FL, where high DIP concentrations occur naturally due to geological formations of phosphate rock in the watersheds and artificially due to significant anthropogenic sources of DIP.

> ***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 2001–2002 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.

Chlorophyll *a*

The Gulf Coast region is rated fair for chlorophyll *a* concentrations, with 7% of the coastal area rated poor and 45% of the area rated fair for this component indicator. It should be noted that chlorophyll *a* concentrations were rated differently in Florida Bay than in other areas of the region because the Bay is considered a tropical estuary. High concentrations of chlorophyll *a* occurred in the coastal areas of all five Gulf Coast states.

Water Clarity

Water clarity in the Gulf Coast region is rated fair, with 22% of the coastal area rated poor for this component indicator. Lower-than-expected water clarity occurred throughout the Gulf Coast region, with poor conditions concentrated in Mississippi, the Coastal Bend region of Texas, and Louisiana. The criteria used to assign water clarity ratings varied across the Gulf Coast coastal waters (Figure 5-5) based on natural variations in turbidity levels, regional expectations for light penetration related to SAV distribution, and local waterbody management goals (see text box).

> 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 areas of the Gulf Coast region have naturally high 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. Although 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 5-5. Map of water clarity criteria used in Gulf Coast coastal waters (U.S. EPA/NCA).

Dissolved Oxygen

The Gulf Coast region is rated fair for dissolved oxygen concentrations, with 5% of the coastal area rated poor for this component indicator. Hypoxia in Gulf Coast waters generally results from stratification, eutrophication, or a combination of these two conditions. Mobile Bay, AL, experiences regular hypoxic events during the summer that often culminate in "jubilees" (i.e., when fish and crabs try to escape hypoxia by migrating to the edges of a waterbody); however, the occurrence of jubilees in Mobile Bay has been recorded since colonial times, and these occurrences are most likely natural events for this waterbody (May, 1973).

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 oxygen concentrations below 5 mg/L in bottom waters as being in fair condition (i.e., threatened).

Although hypoxia is a relatively local occurrence in Gulf Coast coastal waters, the occurrence of hypoxia in the Gulf Coast shelf waters is much more significant. The Gulf of Mexico hypoxic zone is the second-largest area of oxygen-depleted waters in the world (Rabalais et al., 2002). This zone, which occurs in waters on the Louisiana shelf to the west of the Mississippi River Delta, was not assessed by the NCA survey. From 1985 to 1992, the areal extent of bottom hypoxic waters in the zone during mid-summer averaged 3,000 mi^2, and the average area doubled to 6,500 mi^2 between 1993 and 1997 (Rabalais et al., 1999). In the summer of 2000, the area of the Gulf of Mexico hypoxic zone was reduced to 1,700 mi^2, following severe drought conditions in the Mississippi River watershed; however by 2002, the hypoxic zone had again increased in size to 8,500 mi^2 (Figure 5-6). Current hypotheses speculate that the hypoxic zone results from water column stratification that is driven by weather and river flow, as well as from the 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. Annual variability in the area of the hypoxic zone is most likely related to rainfall in the Mississippi River watershed and the effect on river flow. Sediment cores from the hypoxic zone show that algal production in the Gulf of Mexico shelf was significantly lower during 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).

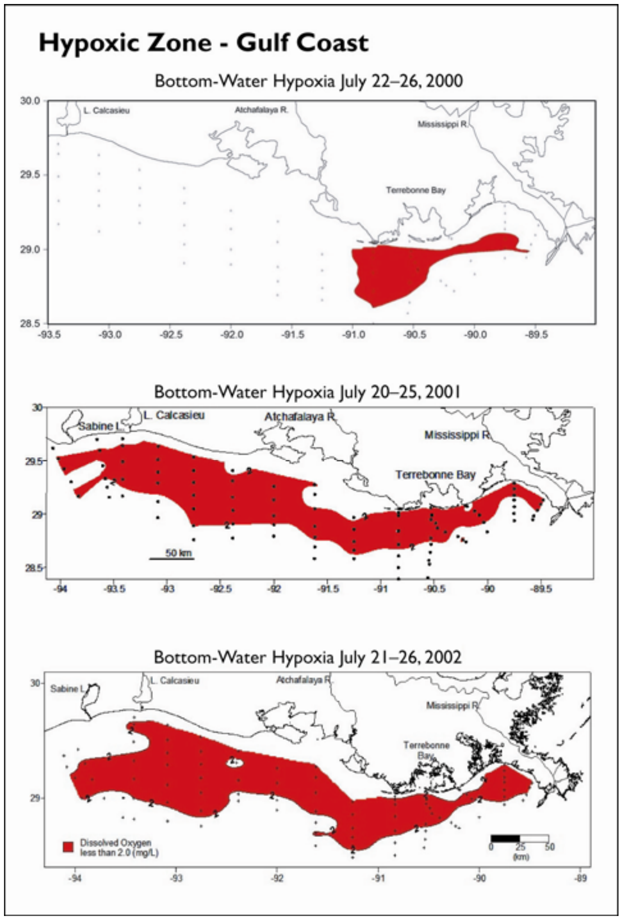


Figure 5-6. Spatial extent of the gulf coast hypoxic zone during July 2000, 2001, and 2002 (U.S. EPA/NCA, based on data provided by Nancy Rabalais, 2003.

Between 1980 an 1996, the Mississippi-Atchafalaya River Basin has discharged an annual average of 952,700 mt of nitrogen as nitrate and 41,770 mt of phosphorus as orthophosphate to the Gulf of Mexico (Goolsby et al., 1999). Nitrate load, which constitutes the bulk of the total nitrogen load from the Mississippi River basin to the Gulf of Mexico, has increased 300% since 1970, with similar increases in phosphorus load (Goolsby et al., 2001). Non-point sources, particularly from the agricultural areas north of the confluence of the Ohio and Mississippi rivers, contribute most of the nitrogen and phosphorus loads to the Gulf of Mexico (Goolsby et al.,1999). The potential importance of phosphorus limitation in the eastern portion of the hypoxic zone has led EPA to call for reductions in both nitrogen and phosphorus loads from the Mississippi-Atchafalya River Basin.

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

Sediment Quality Index

The sediment quality index for the coastal waters of the Gulf Coast region is rated poor, with 18% of the coastal area rated poor for sediment quality condition (Figure 5-7). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

Sediment Toxicity

The Gulf Coast region is rated poor for sediment toxicity, with 13% of the coastal area rated poor for this component indicator. Previous bioeffects surveys by NOAA (Long et al., 1996) and the results reported in the NCCR II (U.S. EPA, 2004a) showed less than 1% toxicity in large estuaries of the Gulf Coast region. Sediment toxicity is commonly associated with high concentrations of metals or organic chemicals with known toxic effects on benthic organisms;

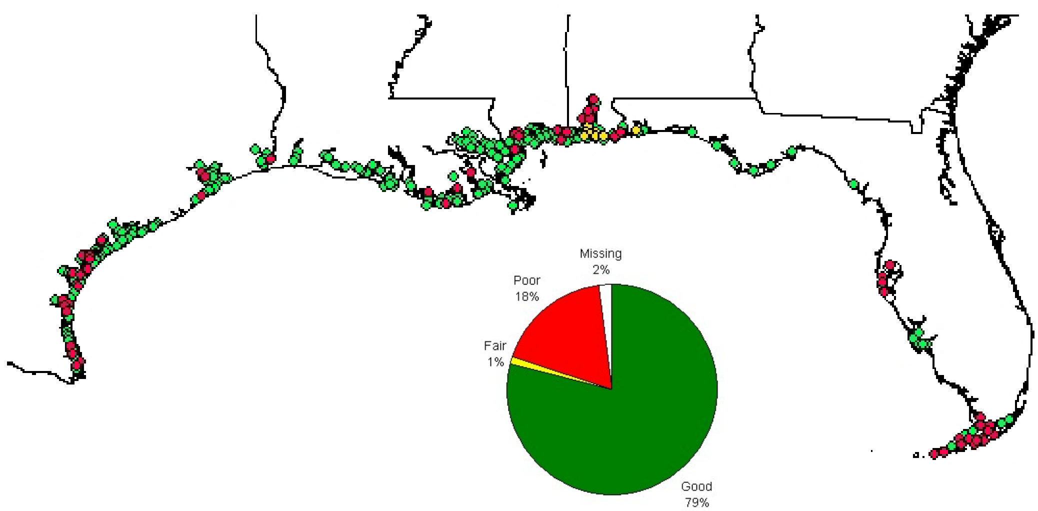


Figure 5-7. Sediment quality index data for the coastal waters of the Gulf Coast region (U.S. EPA/NCA).

however, nine sites in Florida Bay were rated poor for sediment toxicity in the absence of high contaminant concentrations. The toxicity at these sites may have been caused by naturally high levels of hydrogen sulfide in the Bay's organic carbonated sediments, rather than by anthropogenic contamination (G. McRae, Florida Fish & Wildlife Research Institute, personal communication, 2006).

Sediment Contaminants

The sediment contaminants component indicator for the Gulf Coast region is rated good, with 2% of the coastal area rated poor for this component indicator. In addition, one percent of the coastal area was rated fair, primarily in sites located in Alabama and in Pensacola Bay, FL. The sediment contaminants measured in Gulf Coast waters included elevated levels of metals, pesticides, PCB, and, occasionally, PAHs.

Sediment TOC

The Gulf Coast region is rated good for sediment TOC, with only 4% of the coastal area rated poor and 14% rated fair for this component indicator.

Benthic Index

The condition of benthic communities in Gulf Coast coastal waters is rated poor, with 45% of the coastal area rated poor for benthic condition (Figure 5-8). This assessment is based on the Gulf Coast Benthic Index (Engle and Summers, 1999), which integrates measures of diversity and populations of indicator species to distinguish between degraded and reference benthic communities. Most Gulf Coast estuaries showed some level of benthic degradation.

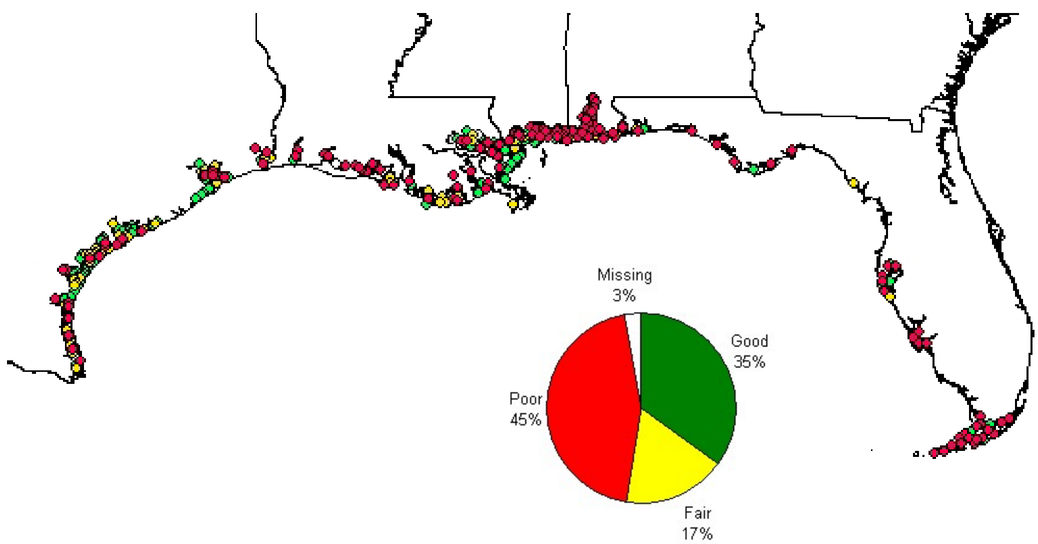


Figure 5-8. Benthic index data for the coastal waters of the Gulf Coast region (U.S. EPA/NCA).

Coastal Habitat Index

The coastal habitat index for the coastal waters of the Gulf Coast region is rated poor. The Gulf Coast region experienced a loss of 7,750 acres of estuarine wetlands from 1990 to 2000, and the long-term, average decadal coastal wetlands loss rate is 0.21%. Coastal wetlands in the Gulf Coast region constitute 66% of the total estuarine wetland acreage in the conterminous 48 states (Dahl, 2003). Although the Gulf Coast region sustained the largest net loss of estuarine wetland acreage during the past decade compared with other regions of the country, the 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 losses along the Gulf Coast.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of the Gulf Coast region is rated good, with 8% of all sites sampled where fish were caught rated poor for fish tissue contaminant concentrations (Figure 5-9). Contaminant concentrations exceeding EPA Advisory Guidance values in Gulf Coast samples were observed primarily in Atlantic croaker, catfish, and pinfish. Commonly observed contaminants included total PAHs, PCBs and DDT, mercury, and arsenic.

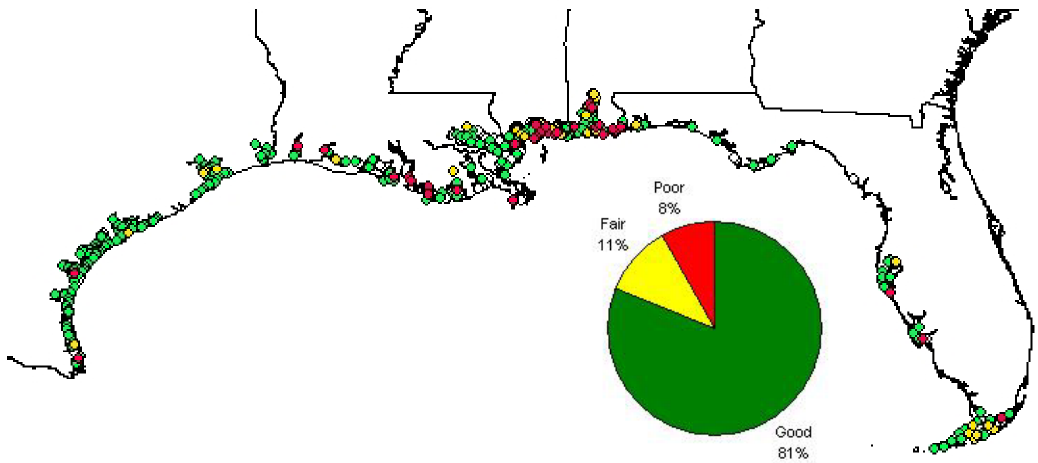


Figure 5-9. Fish tissue contaminants data for the coastal waters of the Gulf Coast region (U.S. EPA/NCA).

Trends of Coastal Monitoring Data– Gulf Coast Region

Temporal Change in Ecological Condition

The coastal condition of the Gulf Coast region has been assessed since 1991. EMAP-Estuaries conducted annual surveys of estuarine condition in the Louisianian Province from 1991 to 1994; this province extends from the Texas-Mexico border to just north of Tampa Bay, FL. The results of these surveys were reported in the NCCR I (U.S. EPA, 2001). EMAP-NCA initiated annual surveys of estuarine condition in the Gulf of Mexico in 2000, and these data were reported in the NCCR II. Data from 2001 and 2002 are assessed in the current report (NCCR III). Seven years of monitoring data from Gulf Coast coastal waters provide an ideal opportunity to investigate temporal changes in ecological condition indicators. These data can be analyzed to answer two basic types of trend questions based on assessments of ecological indicators in Gulf Coast coastal waters: what is the interannual variability in proportions of good, fair, or poor area, and is there a significant change in the proportion of poor area from the early 1990s to the present?

The parameters that can be compared between the two time periods include the dissolved oxygen, water clarity, sediment contaminants, sediment toxicity, and sediment TOC component indicators, and the benthic index. Data supporting these parameters were collected using similar protocols and QA/QC methods. Although EMAP-NCA also evaluated chlorophyll *a* and nutrients as part of its assessment of water quality, these component indicators were not collected during the EMAP-Estuaries surveys from 1991 to 1994. Both programs implemented probability-based surveys that support estimations of percent of estuarine area in good, fair, or poor condition based on the indicators. Standard errors for these estimates were calculated according to methods listed on the EMAP Aquatic Resource Monitoring Web site (http://www.epa.gov/nheerl/arm). The reference values and guidelines listed in Chapter 1 were used to determine good, fair, or poor condition for each index and component indicator from both time periods.

In order to compare indices and component indicators across years from the same geographic area, the spatial extent of the EMAP-NCA Gulf Coast data was reduced to match that of the Louisianian Province monitored by EMAP-Estuaries. Therefore, EMAP-NCA data collected in Florida between Tampa Bay and Florida Bay were excluded from this temporal comparison. In addition, data were missing for some or part of the Gulf Coast during specific time frames. No data were collected from the entire region between 1995 and 1999, and data were not collected from the southern Gulf coast of Florida during 1991–1994.

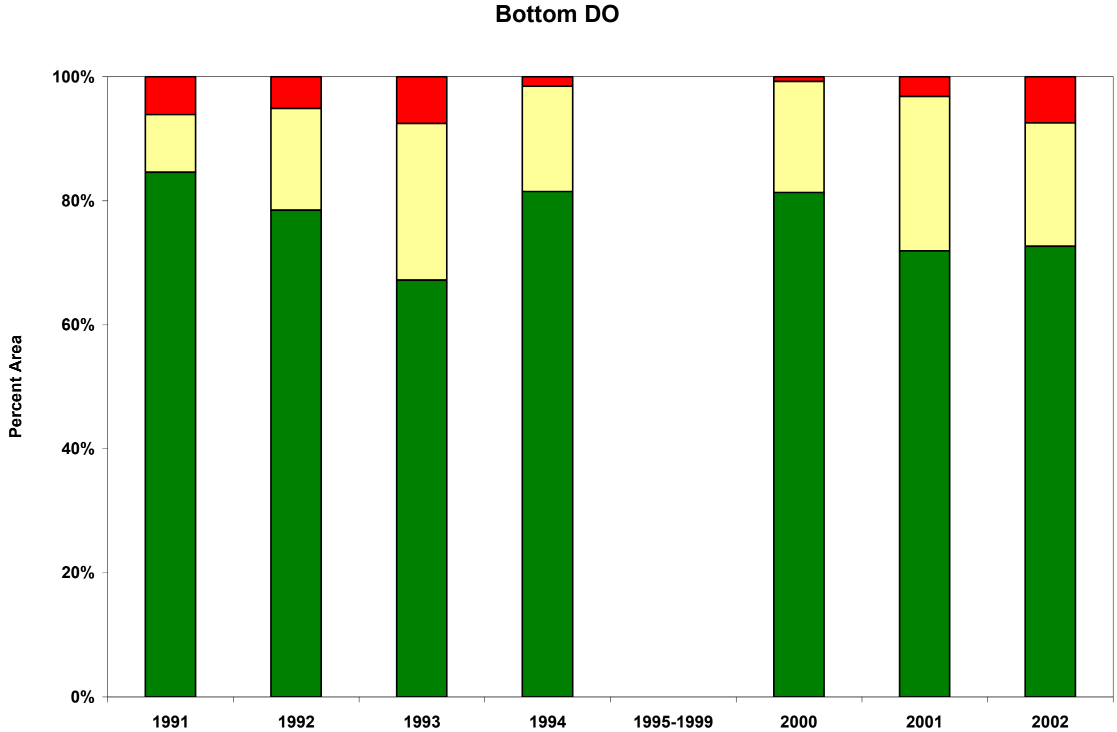
Only dissolved oxygen and water clarity data were available for the comparison of water quality conditions from 1991 to 2002. Neither of these component indicators showed a significant linear trend over time in percent area in poor condition (Figure 5-10). However, when the two time periods were compared, significantly more of the coastal area was rated poor for water clarity in 2000–2002 than in 1991–1994 ($z = 4.252$; $p<0.05$).

Water quality indicators are more likely to be influenced by interannual variation in climate than by long-term trends. To examine the potential effects of interannual variation in climate on dissolved oxygen, the relationship between annual rainfall and the percent area in good condition for dissolved oxygen was examined. The estimated annual rainfall for the Gulf Coast was calculated as the sum of annual estimates for five states – Texas, Louisiana, Mississippi, Alabama, and Florida – using precipitation data available at http://www.ncdc.noaa.gov/oa/climate/research/cag3/state.html. Linear regression resulted in a significant relationship between the percent estuarine area in good condition for dissolved oxygen and annual rainfall estimates ($R^2 = 0.225$; $p < 0.05$). This linear relationship was used to predict the percent estuarine area rated good for dissolved oxygen from 1995 to 1999, when data were not collected (Figure 5-11).

The sediment quality component indicators available for comparison were sediment contaminants, sediment toxicity, and sediment TOC. None of these indicators showed a significant linear trend in the percent estuarine area in poor condition from 1991–2002 (Figure 5-12). There was also no significant difference in the percent area rated poor for these component indicators between the 1991–1994 and 2000–2002 time frames; however, the percent area rated good for sediment contaminant concentrations significantly increased ($R^2 = 0.77$; $p < 0.05$) from 1992–2002, as shown in Figure 5-12. Although the percent area rated poor remained stable, sediment condition has improved in Gulf Coast coastal waters as indicated by a significant decrease ($z = 3.96$; $p < 0.05$) in the total percent area rated poor and fair, combined, from 16.4% in 1991–1994 to 5.9% in 2000–2002.

The benthic index for Gulf Coast coastal waters is a multimetric indicator of the biological condition of benthic macroinvertebrate communities. Biological condition indicators integrate the response of aquatic organisms to changes in water quality and sediment quality over time. Benthic condition degraded from 1991 to 2002 as indicated by a significant decrease in the percent area rated poor from 1991–1994 to 2000–2002 ($z = 4.68$, $p < 0.05$) and a significant negative trend in the percent area rated good ($R^2 = 0.61$; $p < 0.05$) (Figure 5-13).

In summary, sediment quality in Gulf Coast coastal waters improved between the time periods 1991–1994 and 2000–2002, while both water clarity and benthic community condition worsened over these same time periods (Figure 5-14).



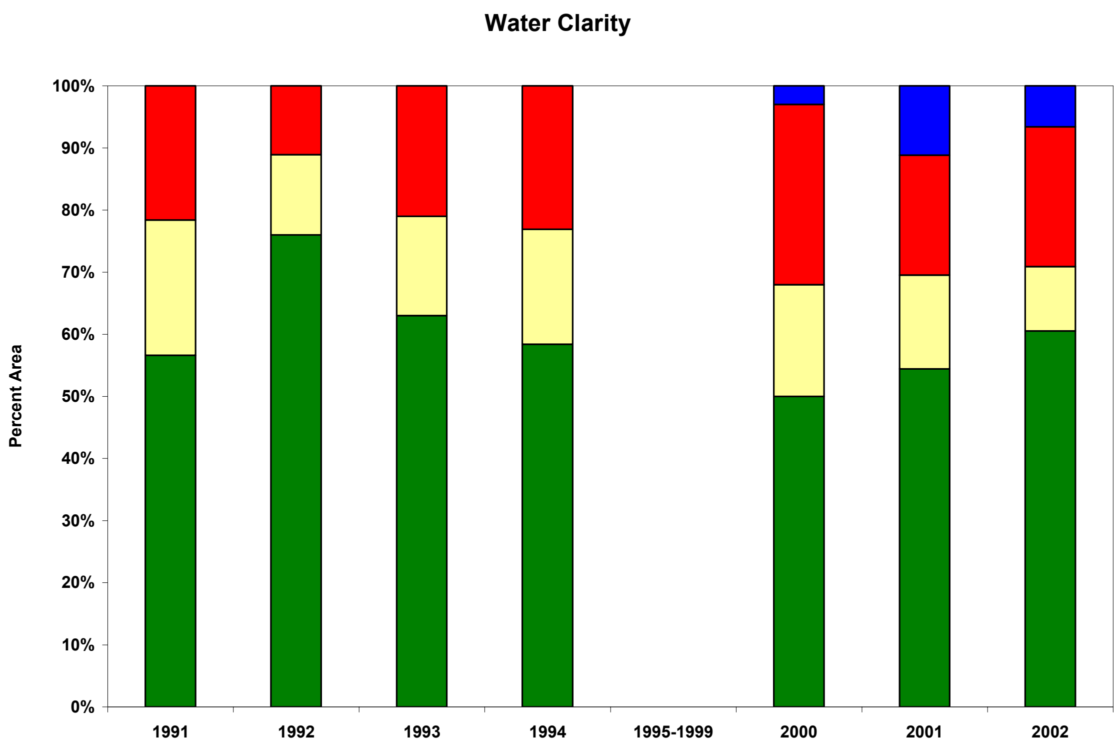


Figure 5-10. Percent area of Gulf Coats coastal waters rated good (green bars), fair (yellow bars), poor (red bars), and missing (blue bars) for bottom dissolved oxygen (top) and water clarity (bottom) from 1991 to 2002. No data were collected from 1995 to 1999 (U.S. EPA/NCA)

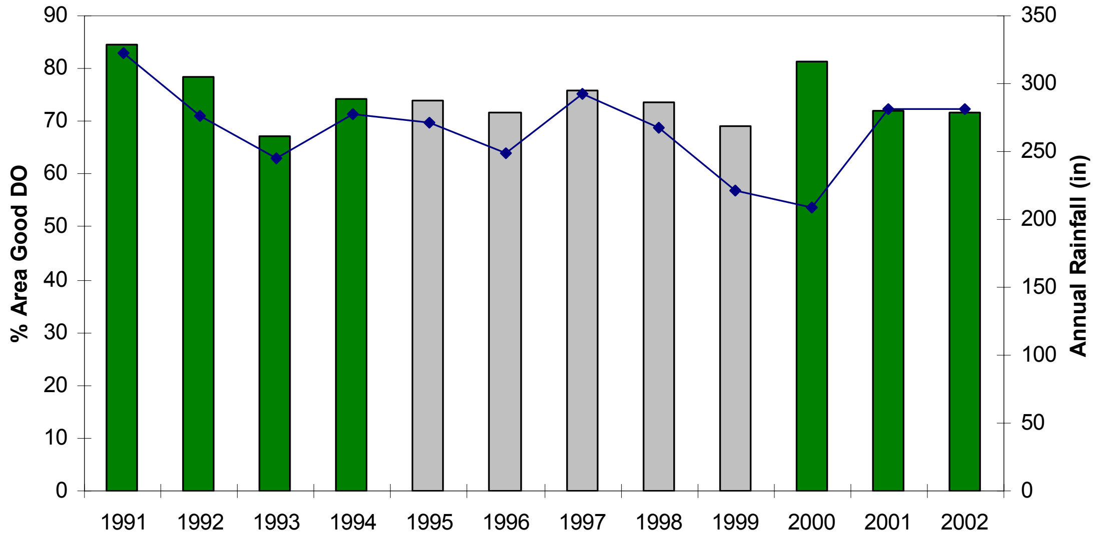


Figure 5-11. Percent area of Gulf Coast coastal waters with bottom dissolved oxygen concentrations > 5 mg/L (rated good – green bars) compared to annual precipitation estimates (blue line) for five Gulf states from 1991 to 2002. Grey bars indicate predicted percent area rated good for bottom dissolved oxygen based on the significant linear relationship between percent area with good dissolved oxygen and rainfall (U.S. EPA/NCA).

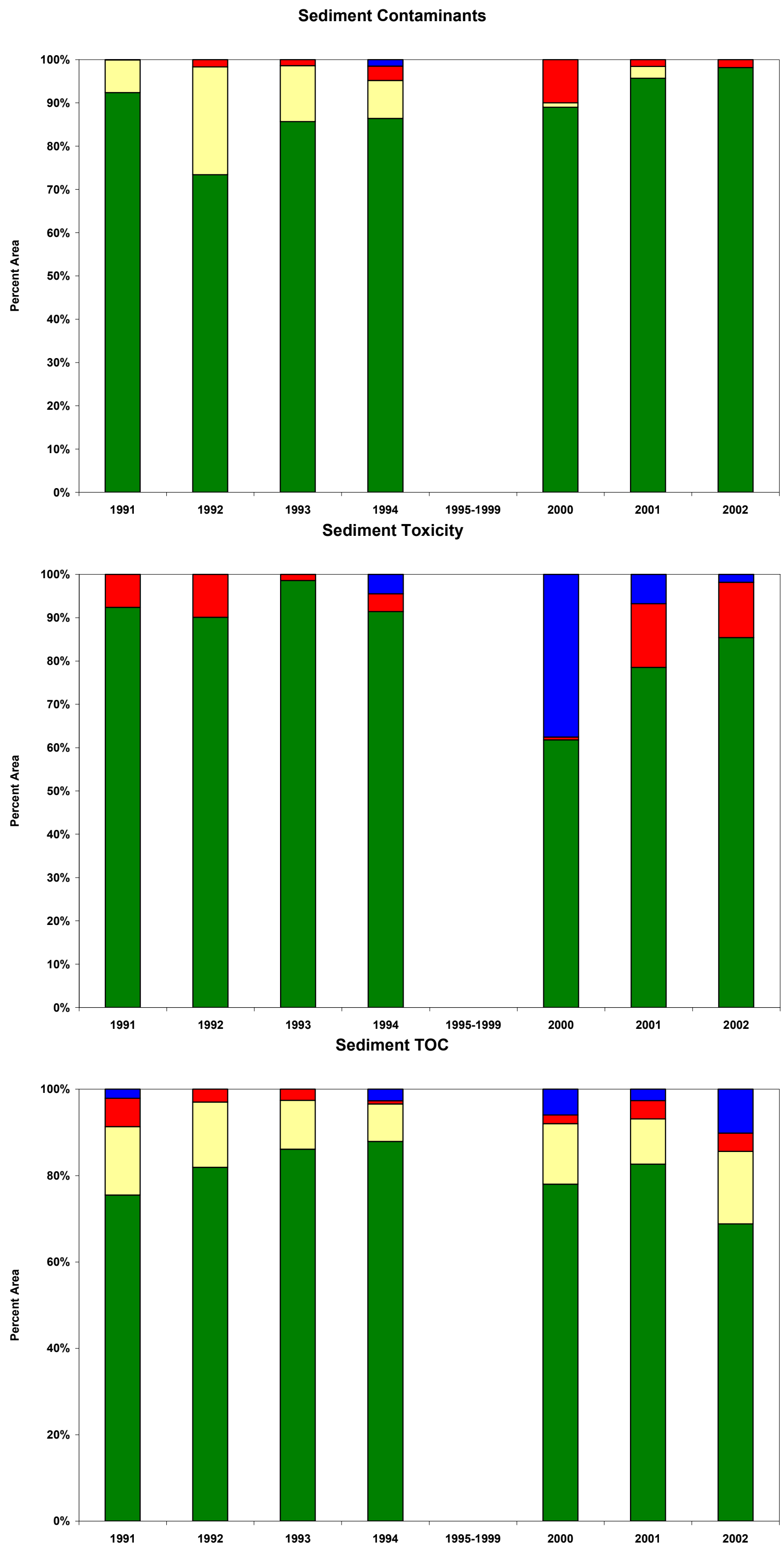


Figure 5-12. Percent area of Gulf Coast coastal waters rated good (green bars), fair (yellow bars), poor (red bars), and missing (blue bars) for sediment contaminants (top), sediment toxicity (middle), and sediment TOC (bottom) from 1991 to 2002. No data were collected from 1995 to 1999 (U.S. EPA/NCA).

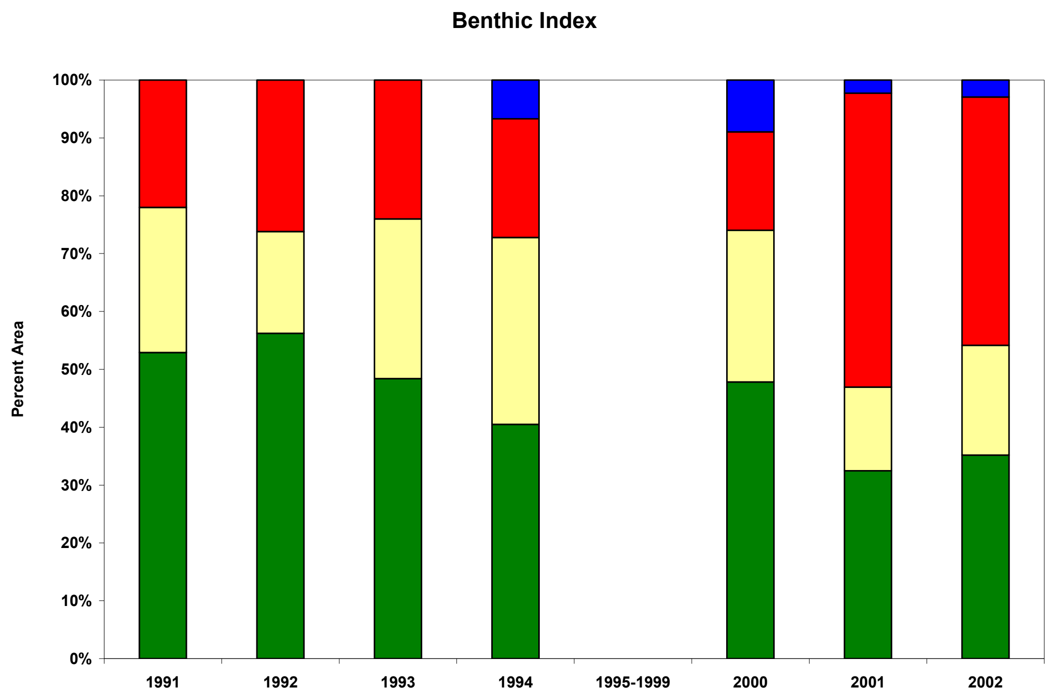


Figure 5-13. Percent area of Gulf Coast coastal waters rated good (green bars), fair (yellow bars), poor (red bars), and missing (blue bars) for benthic community condition from 1991 to 2002. No data were collected from 1995 to 1999 (U.S. EPA/NCA).

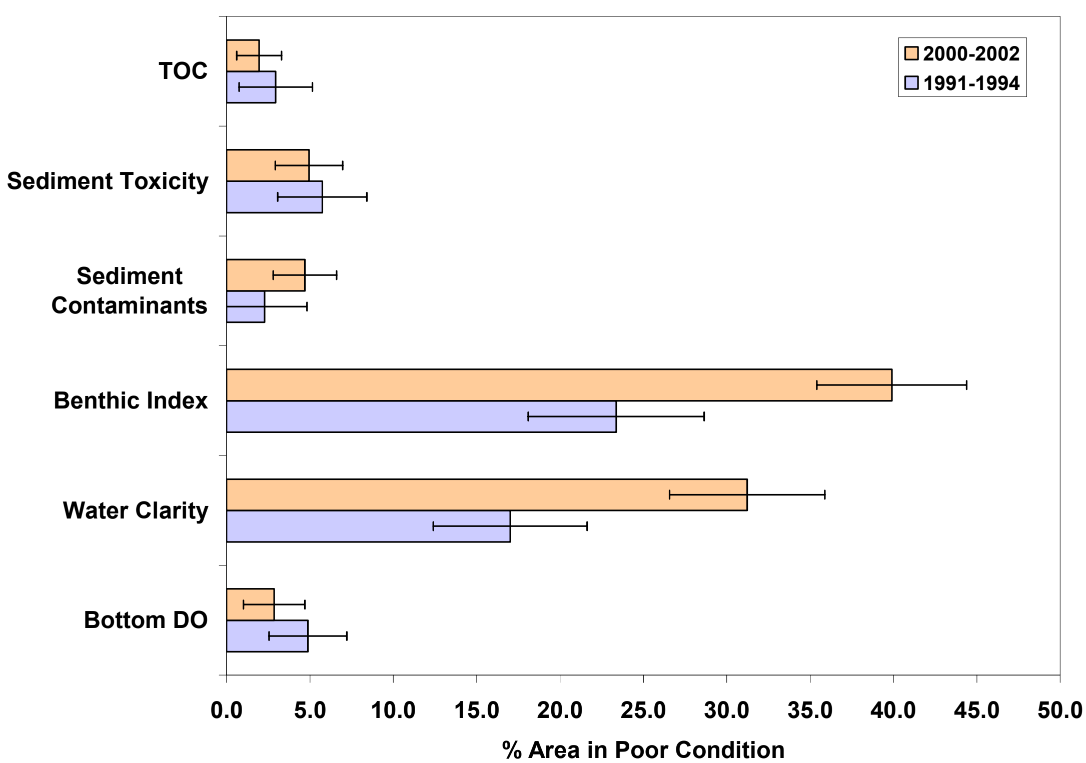


Figure 5-14. Comparison of percent area of Gulf Coast coastal waters in poor condition for ecological indicators between two time periods, 1991–1994 and 2000–2002. Error bars are 95% confidence intervals (U.S. EPA/NCA).

Summary of Marine Mammal Strandings along the Gulf and Southeast Coasts

Strandings of marine mammals are a common event along the U.S. coast between North Carolina and Texas. These events involve both live and dead cetaceans (a type of marine mammal) and can include strandings of individual animals, mass strandings (where a large group of animals strand at the same time), and UMEs, which can be extended, large-scale events with elevated stranding rates. Data on marine mammal strandings are collected by the Southeast Region Marine Mammal Stranding Network, which is a diverse group of non-profit organizations, academic institutions, private research institutions, and state and local agencies that volunteer time to respond to and collect data from stranded marine mammals. Each organization, institution, or agency in the network has a regional area of primary responsibility, but resources are often shared, particularly when responding to mass strandings or UMEs. The network's activities are coordinated through the NMFS Southeast Fisheries Science Center and the Southeast Regional Office with the support of the National Marine Mammal Health and Stranding Response program at NMFS headquarters.

The most commonly stranded species are the bottlenose dolphin (*Tursiops truncatus*) and the dwarf and pygmy sperm whales (*Kogia sp.*). Together, these species have accounted for 73% of the stranded animals, on average, over the last decade. Members of many other cetacean species are stranded throughout the region, including offshore delphinids, sperm whales, and baleen whales. An average of 575 bottlenose dolphins and 40 *Kogia sp.* have stranded each year in the southeast region over the past decade, and the number of animals stranding each year has remained relatively constant throughout that time period (Figure 1). Geographically, the strandings are not distributed evenly and include a number of "hot spots," where the number of animals stranding each year is relatively high. Notable hot spot areas include the Indian River Lagoon system along the central Atlantic coast of Florida; the area around Charleston, SC; and along the entire coastline and estuarine areas of North Carolina (Figure 2). It should be noted that the observed spatial patterns also reflect variations in the ability to detect stranded animals. Along the Gulf Coast of the United States, the complexity of the coastline (including expansive marsh areas) and a generally lower level of local coverage by the stranding network results in notable gaps along the Florida panhandle and the central Louisiana coast (NOAA, 2006b).

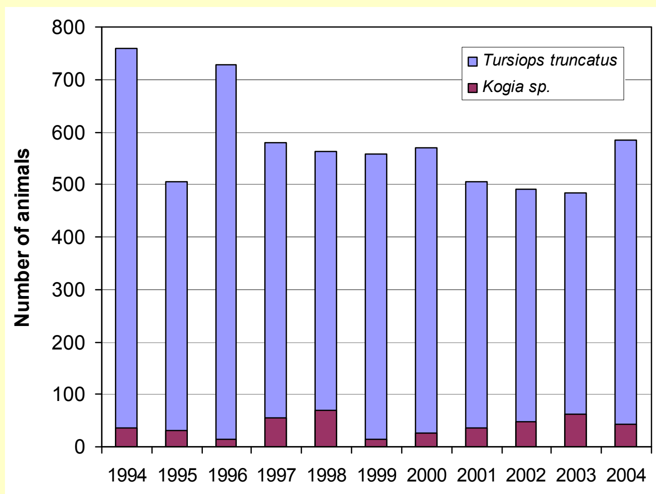


Figure 1. The number of *Tursiops truncatus* and *Kogia sp.* strandings in the southeast region between 1994-2004. These data include only individual stranding events and do not reflect either mass strandings or UMEs. Source: Southeast Region Marine Mammal Health and Stranding Response network.

One of the primary goals of the stranding network is to assess the underlying causes for stranding events. Extensive data-collection protocols and training efforts exist to allow network members to record observations on each stranded animal, collect tissue samples, and conduct

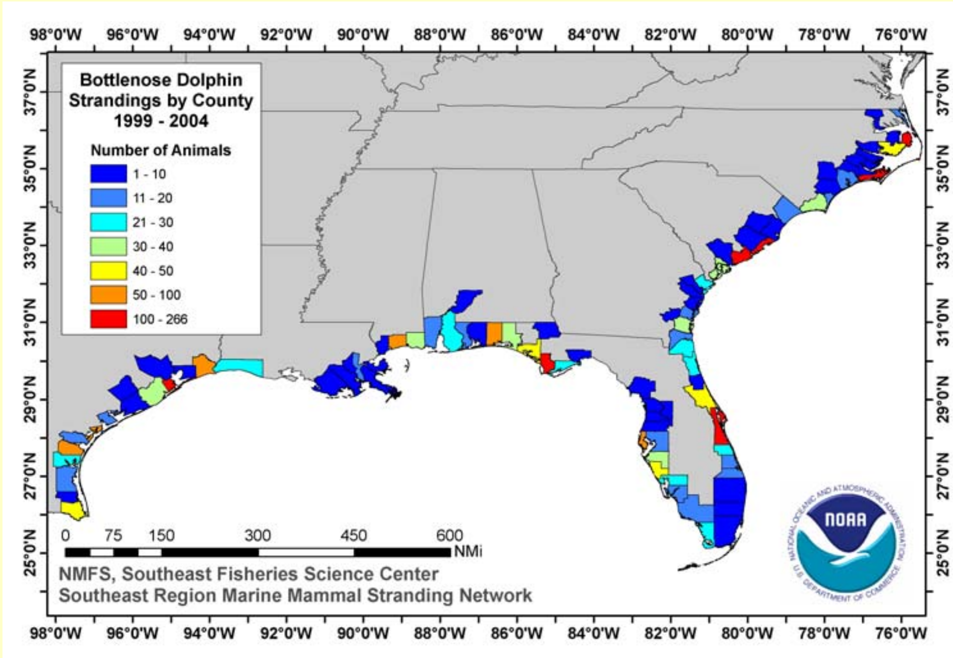


Figure 2. Individual bottlenose dolphin strandings by county in the Southeast between 1999 and 2004. The number of events recorded in each county reflects both the rate of strandings and the ability of the local network to detect stranding events. Source: Southeast Region Marine Mammal Health and Stranding Response network.

autopsies to provide information on the health and physiological condition of animals, where possible. In addition, carcasses are examined to determine if human interactions (primarily with fisheries) resulted in mortality. For 52% of stranded bottlenose dolphins, it was not possible to determine if human interaction contributed to the stranding because of the carcass's state of decomposition. Evidence of human interactions was documented for 9% of total number of animals stranded between 1999 and 2004 (Figure 3). Other causes for marine mammal strandings may include predation, disease, exposure to environmental toxins or pollutants, and juvenile and neonate morality. Directly identifying a cause for an event is often difficult, and evaluating the correlations between strandings and environmental conditions, human activities, habitat quality, exposure to pollutants, and other factors is a major research effort within NMFS (NOAA, 2006b).

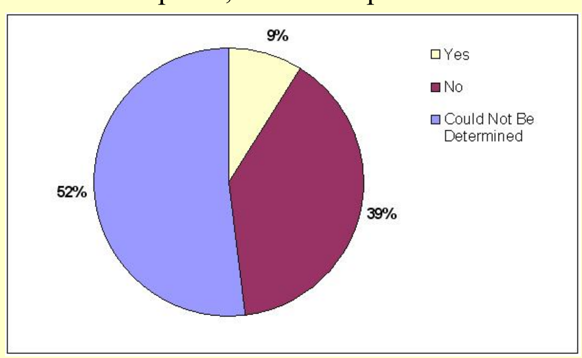


Figure 3. Individual *Tursiops truncatus* strandings categorized by human interaction category between 1999 and 2004. Source: Southeast Region Marine Mammal Health and Stranding Response network.

Gulf of Mexico Large Marine Ecosystem Fisheries

The Gulf of Mexico LME bordering the United States has a diverse range of habitats, including 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 Alabama, western Florida, 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 coastal waters is very dynamic, with constant tidal fluctuations and varying levels of runoff. Gulf Coast coastal waters serve as important habitat for waterfowl, reptiles, mammals, fish, invertebrates, and a diverse number of plants, and act as a natural filter to remove pollutants and sediments from upland regions. These coastal waters also maintain diverse aquatic communities and complex food webs in an irreplaceable nursery system, which 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 hurricanes by a long, thin system of barrier islands extending roughly end-to-end from western Florida to Texas. This natural system of islands is composed primarily of unconsolidated sand, shell, and gravel deposited and re-deposited 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 beaches and maritime marshes on the seaward and inshore sides, to fresh or brackish marshes in the low inland areas; to dunes, shrubs, and forests in the upland areas.

The portion of the Gulf of Mexico LME located 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, 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, numerous eddies, meanders, and intrusions are produced and affect much of the hydrography and biology of the Gulf. A diversity of fish eggs and larvae are transported in the Loop Current, which tends to concentrate and transport early life stages of fish toward estuarine nursery areas, where the young can reside, feed, and develop to maturity.

Reef Fish Resources

Reef fishes include a variety of species (e.g., grouper, amberjack, snappers, tilefish, rock and speckled hind, hogfish, and perches) that live on coral reefs, artificial structures, or other hard-bottom areas. Reef fish fisheries are associated closely with fisheries for other reef animals, including spiny lobster, conch, stone crab, corals, and living rock and ornamental aquarium species. Reef fish share many long life-history characteristics and are vulnerable to overfishing due to slow growth and maturity, ease of capture, large body size, and delayed reproduction. Currently, about 100 species in the Southeast Shelf, Gulf of Mexico, and Caribbean LMEs are managed as a unit by the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management councils. Combined commercial and recreational landings of reef fish from the 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 (NMFS, 2006).

NOAA prohibits the use of fish traps, roller trawls, and power heads on spear guns 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 for bag limits, size limits, and commercial and recreational seasons. This plan is expected to provide stability and predictability in this important fishery for both industry and consumers. Other regulations pertaining to the management of reef fish within the 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, which prohibit the harvest of any species, at two ecological reserves near the Dry Tortugas off south Florida, and the Madison-Swanson and Steamboat Lumps off west-central Florida.

Of the dominant reef fish 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, multi-species system. The long-term harvesting effects on reef fish are not well understood and require cautious management controls of targeted fisheries and th bycatch from other fisheries within the U.S. waters of the Gulf of Mexico LME.

Menhaden Fishery

Gulf menhaden are found from Mexico's Yucatan Peninsula to Tampa Bay, FL. This species forms large surface schools that appear in nearshore Gulf Coast waters from April to November. Although no extensive coast-wide migrations are known, some evidence suggests that older fish move toward the Mississippi River delta. Gulf menhaden may live to age 5, but most of specimens landed are 1 to 2 years old. Landing records for the Gulf Coast menhaden fishery date back to the late 1800s, although the data up to World War II are incomplete. During the 1950s through the 1970s, the commercial fishery grew in terms of the number of reduction plants and vessels, and landings generally increased with considerable annual fluctuation (Figure 5-15). Record landings of 982,800 mt occurred in 1984 and subsequently declined to a 20-year low of 421,400 mt in 1992. This decline was primarily due to low product prices, consolidation within the menhaden industry, and a concurrent decrease in the commercial fishing effort in the northern Gulf of Mexico LME and the number of vessels and fish factories dedicated to this fishery. Landings in recent years (1998–2002) are less variable, ranging between 486,200 and 684,300 mt, with 574,500 mt landed in 2002. Average landings from 2001–2003 were 564,000 mt. Historically, the geographical extent of Gulf Coast menhaden fishing ranged from the Florida Panhandle to eastern Texas, and the current extent of the fishery ranges from western Alabama to eastern Texas, with about 90% of the harvest occurring in Louisianna waters (NMFS, 2006).

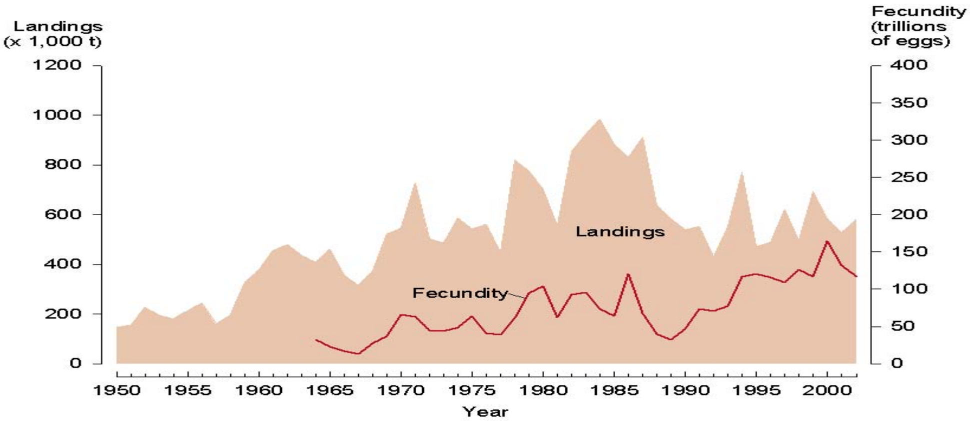


Figure 5-15. Landings in metric tons (mt) and fecundity of menhaden, 1950-2002, Gulf of Mexico LME (NMFS, 2006).

The 1999 stock assessment indicates that the menhaden stock is healthy and that catches are generally below long-term maximum sustainable yield estimates of 717,000 to 753,000 mt (NMFS, 2006). A comparison of recent fishing mortality estimates to biological reference points does not suggest overfishing.

Mackerel Fisheries

King Mackerel

King mackerel have been fished commercially by U.S. fishermen since the 1880s over a geographical extent ranging from the Chesapeake Bay southward into the Gulf of Mexico. The total catch of king mackerel along the Gulf Coast averaged 3,467 mt per fishing year from 1981 to 2000, with maximum landings of 5,599 mt in 1982 and minimum landings of 1,368 mt in 1987. In 2001, the total catch was 3,649 mt, with the recreational sector accounting on average for 62% of the total catch. From 1986 to 1996, landings were consistently above the total allocated catch, and by 1997, the Gulf of Mexico Fisheries Management Council had increased the total allocated catch to 4,812 mt. Until recently, the Gulf king mackerel stock was considered overfished because of previous overexploitation of the fishery, and since 1985, the stock has been managed under rigid rebuilding schedules. In 2003, maximum sustainable yield for the king mackerel stock in the Gulf of Mexico LME was estimated at 5,175 mt. Results from the 2004 stock assessment suggest that the stock is not overfished and that overfishing is not occurring. At present, the commercial fishery for Gulf of Mexico LME king mackerel has restrictions on minimum size, regional quota allocations, trip catch limits, and gear restrictions. Although controlling the harvest of recreational fisheries is complex and the degree of compliance is not clear, the recreational fishery is regulated with restrictions on minimum size and bag limits (NMFS, 2006).

Spanish Mackerel

U.S. and Mexican commercial fishermen have fished for Spanish mackerel since the 1850s. The fishery began in the waters off of New York and New Jersey, but has shifted southward over time to southern U.S. Atlantic and Gulf of Mexico waters. A major recreational fishery also exists for Spanish mackerel throughout its range, and the percent of landings by recreational anglers has increased to account for about 80% of Gulf landings for the stock. The total catch of Spanish mackerel in the Gulf of Mexico LME averaged 2,081 mt per fishing year from 1984 to 2001, with maximum landings of 4,586 mt in 1987 and minimum landings of 995 mt in 1996. Catches dropped substantially (about 50%) in 1995–1996 because of a gill-net ban in Florida waters, where a major portion of the commercial catch took place. In 2001, total catch was 1,737 mt. Since 1989, the landings of Gulf Coast Spanish mackerel have been consistently below the total allocated catch, and total landings have been about 50% of the total allocated catch since 1995. The 2003 stock assessment indicated that the stock is currently exploited at the optimum long-term yield level, but not overfished. At present, management restrictions for the commercial fishery of Spanish mackerel in the Gulf of Mexico LME include minimum size restrictions and quota allocation, plus gear restrictions in state waters. Minimum size and daily bag restrictions are in place for the recreational fishery. Current issues affecting this stock involve mainly the bycatch of juveniles in the shrimp trawl fishery (NMFS, 2006).

Shrimp Fisheries

Penaeid shrimp have been fished commercially since the late 1800s. Brown, white, and pink shrimp are found in all U.S. Gulf Coast waters shallower than approximately 395 ft. Most of the offshore brown shrimp catch is taken at depths of about 130–260 ft, white shrimp in waters 66 ft deep or less, and pink shrimp in waters approximately 130–200 ft deep. Brown shrimp are most abundant in the waters off the coast between Texas and Louisiana, and the greatest concentration of pink shrimp is in the waters off the coast of southwestern Florida (NMFS, 2006).

Catches of brown, white, and pink shrimp in the Gulf of Mexico LMEs have varied over the years (Figure 5-16). Gulf of Mexico brown and white shrimp catches increased significantly from the late 1950s to around 1990, but catch levels during most of the 1990s were below these maximum values. In 2000, catch levels in 2000 were extremely good for both species, with near record levels reported. Catches in 2001–2003 returned below these record catch levels, but were still well-above average for both species. Pink shrimp catches remained stable until about 1985 and then declined to an all-time low in 1990. During the mid-1990s, catches

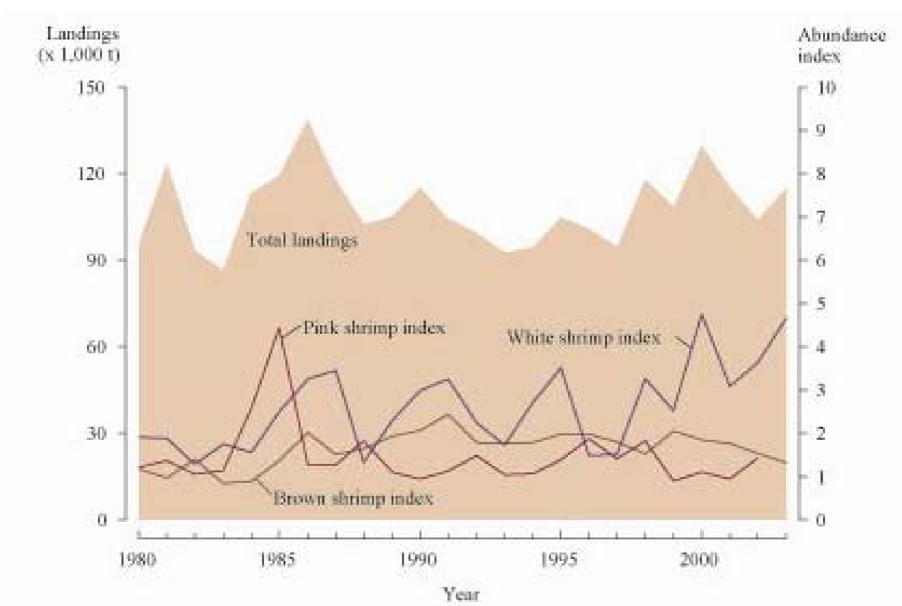


Figure 5-16. Shrimp landings in metric tons (mt) and abundance index from the U.S. Gulf of Mexico LME, 1980–2003. The abundance index is calculated by dividing the current level of reproductive shrimp by the over-fishing level (NMFS, 2006).

increased above average levels but have again shown a moderate declining trend in recent years. The numbers of young brown, white, and pink shrimp entering the fisheries have generally reflected the level of catch for each species (NMFS, 2006).

Recruitment overfishing has not been evident in the Gulf of Mexico for any of the shrimp stocks. The number of young brown shrimp produced per parent increased significantly until about 1991 and has remained near or slightly below that level during most years. White and pink shrimp have not shown any general trend. Although pink shrimp stocks rebounded from the low values experienced in the early 1990s, they have started to decline again in recent years. The brown shrimp increase appears related to marsh habitat alterations due to coastal sinking and a sea-level rise in the northwestern Gulf. These alterations cause the intertidal marshes to be inundated with water for longer periods of time, allowing the shrimp to feed for longer periods within the marsh area. Both factors have also expanded estuarine areas, created more marsh edges, and provided more protection from predators. As a result, the nursery function of these marshes has been greatly magnified, and brown shrimp production has expanded. However, continued subsidence will lead to marsh deterioration, an ultimate loss of supporting wetlands, and the impairment of currently high fishery yields (NMFS, 2006).

Catch rates for both brown and white shrimp were at high levels for the 2001 harvesting season. Landings in 2004 were up 1% from the 2003 landings of 115,566 mt, and the Gulf of Mexico's landings were the nation's largest with 116,519 mt and 83% of the national total. 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. Regulations in the Gulf of Mexico Shrimp Fishery Management Plan restrict shrimping by closing two shrimping grounds. There is a seasonal closure of fishing grounds off Texas for brown shrimp and a closure off Florida for pink shrimp. Size limits also exist for white shrimp caught in Federal waters and landed in Louisiana. 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 hypoxic zone in Louisiana, may cause future declines in the shrimp harvest (NMFS, 2006).

Impact of Hurricanes Katrina and Rita

Since mid-September 2005, NOAA/NMFS has undertaken surveys of the northern Gulf of Mexico LME in areas affected by Hurricanes Katrina and Rita to assess the quality of marine resources used in seafood products and to determine if these events resulted in changes in the abundance or distribution of important shrimp, crab, and finfish species. NMFS will re-survey the northern Gulf area periodically to determine the abundance of species and examine the potential for nursery area disruptions caused by habitat damage in coastal wetlands. Data obtained from the Gulf of Mexico abundance survey conducted in October and November 2005 provides a baseline from which to evaluate short-term impacts of the storms and long-term recovery actions. NMFS evaluated wetlands restoration projects underway in the Louisiana wetlands and barrier islands after the hurricanes. Eight of nine projects functioned as designed to protect and begin to restore degraded habitats. However, approximately 100 mi^2 of wetlands in the southeastern Louisiana marshes were lost because of Hurricane Katrina. Studies are underway to evaluate the effect of Hurricane Katrina on the fishery value of shallow wetland nurseries (NMFS, 2006).

NOAA announced in January 2006 that Hurricanes Katrina and Rita did not cause a reduction in fish and shrimp populations in the offshore areas of the Gulf of Mexico. The annual survey of shrimp and bottom fish completed in November 2005 showed that some species, such as the commercially valuable and overfished red snapper, had a higher abundance in 2005 than the average calculated for the period of 1972 to 2004. The survey also showed that the abundance of Atlantic croaker doubled. Overall abundance of shrimp and bottom fish increased by about 30% from 2004 levels, largely due to increases in Atlantic croaker, white shrimp and red snapper populations. The reduction in fishing activities in the Gulf of Mexico since the hurricanes could be a factor contributing to the abundance increases for some of the shorter-lived species (NOAA, 2006a).

Assessment and Advisory Data

Fish Consumption Advisories

In 2003, 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. The statewide king mackerel advisories covered all coastal and estuarine waters in Florida, Mississippi, Louisiana, and Alabama, but covered only coastal shoreline waters in Texas. 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 2003 (Figure 5-17).

Fish consumption advisories placed on specific waterbodies included additional fish species. Florida had six 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 5-18 shows the number of advisories issued along the Gulf Coast for each contaminant.

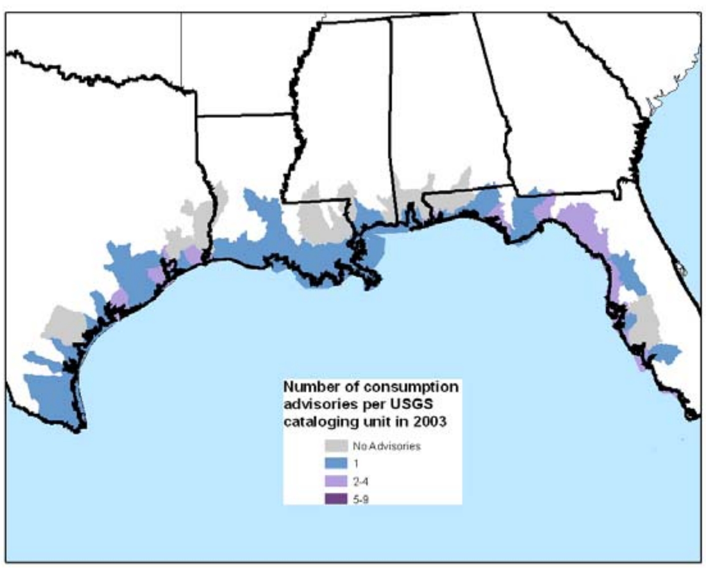


Figure 5-17. The number of fish consumption advisories for the Gulf Coast active in 2003 (U.S.EPA, 2004b).

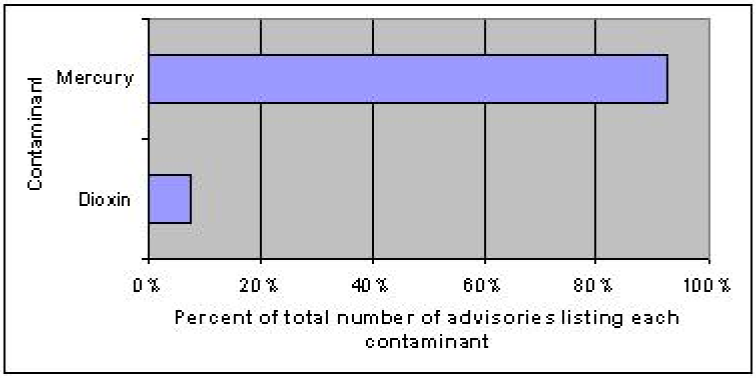


Figure 5-18. Pollutants responsible for fish consumption advisories in Gulf Coast coastal waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S.EPA, 2004b).

Summary of fish and shellfish under human consumption advisories in 2003 for at least some part of the Gulf Coast:

Barracuda	Gag grouper	Red drum
Blue crab	Greater amberjack	Shark
Bluefish	Crevalle jack	Snook
Catfish	King mackerel	Spanish mackerel
Crab	Ladyfish	Spotted seatrout
Cobia	Little tunny	Wahoo
Gafftopsail catfish	Permit	*Source: U.S. EPA, 2004b*

Beach Advisories and Closures

Of the 596 coastal beaches in the Gulf Coast reported to EPA, 23.2% (138 beaches) were closed or under an advisory for some period of time in 2003. Table 5-1 presents the numbers of beaches monitored and under advisory or closure for each state. As shown in the table, Florida's west coast had the most beaches with advisories or closures, and Louisiana did not report any data for EPA's 2003 survey. Figure 5-19 presents advisory and closure percentages for each county within each state.

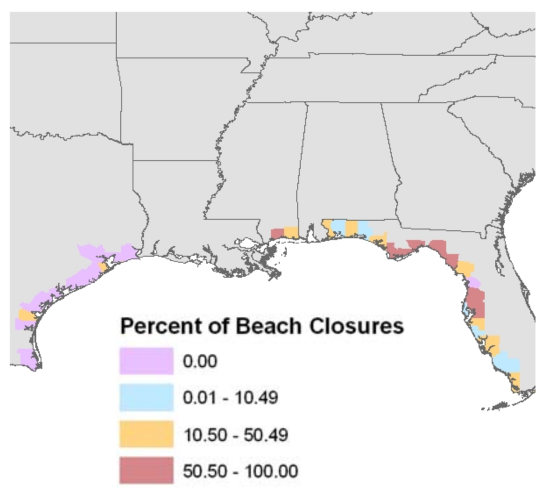


Figure 5-19. Percentage of beaches with advisory or closures by county for the Gulf Coast (U.S.EPA, 2006).

Table 5-1. Number of Beaches Monitored and Under Advisories/Closures in 2003 for Gulf Coast States (U.S. EPA, 2006)

State	No. of Beaches Monitored	No. of Beaches With Advisories/Closures	Percentage of Beaches Affected by Advisories/Closures
Florida (Gulf Coast)	407	103	25.3
Alabama	25	10	40.0
Mississippi	9	6	66.7
Louisiana	Not reported	Not reported	Not reported
Texas	155	19	12.3
TOTALS	596	138	23.2

Most beach advisories and closings were implemented at coastal beaches along the Gulf Coast because of elevated bacteria levels (Figure 5-20). Wildlife was reported as a source, and unknown sources accounted for 99% of the responses (Figure 5-21).

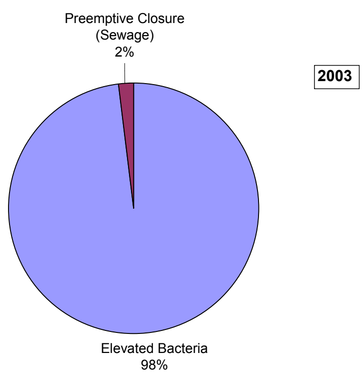


Figure 5-20. Reasons for beach advisories or closures for the Gulf Coast (U.S. EPA, 2006).

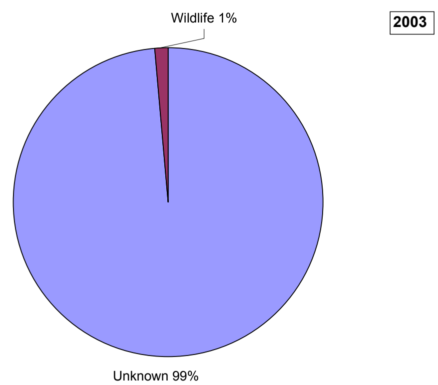


Figure 5-21. Sources of beach contamination for the Gulf Coast (U.S. EPA, 2006).

Summary

Based on the indicators used in this report, ecological conditions in Gulf Coast coastal waters are fair to poor. Coastal wetland loss, sediment quality, and benthic condition are rated poor in Gulf Coast coastal waters for 2001–2002, and water quality was also of concern (rated fair). Benthic index values were lower than expected in 45% of Gulf Coast coastal sediments. Although elevated sediment contaminant concentrations were found in only 2% of sediments, 13% of sediments were toxic. Decreased water clarity and elevated DIP observed in more than 22% of the coastal area, and elevated levels of chlorophyll *a* were observed in 9% of the area. DIN and dissolved oxygen concentrations rarely exceeded guidelines. The overall condition rating of 2.2 in this report represents a slight decrease from the rating of 2.4 observed in the previous report (NCCR II), but still represents an improvement in overall condition since the early 1990s. Some of this improvement may be the result of modification of the water quality index to include nitrogen, phosphorus, and chlorophyll *a*. Increasing population pressures in this region of the country warrant 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.

NOAA's NMFS manages several fisheries in the Gulf of Mexico LME, including reef fishes, medhaden, mackerel, and shrimp. Of the dominant reef fishes, red snapper and red grouper are currently overfished, and the gan and greater amberjack are approaching an overfished condition. These issues are being addressed with regulatory measures and stock rebuilding plans. The medhaden stock in this LME is healthy, and catches are generally below the long-term maximum sustainable yield estimates. The Gulf king or Spanish mackerel are currently not overfished, but the Spanish mackerel stock is exploited at its optimum long-term yield. Recruitment overfishing is not evident in any of the Gulf shrimp stocks; however, all three of the commercial shrimp species are being harvested at maximum levels. Loss of habitat has the potential to cause future reductions in shrimp catch.

Contamination in Gulf Coast coastal waters has affected human uses of these waters. In 2003, there were 13 fish consumption advisories in effect along the Gulf Coast. Most of these advisories were issued for mercury contamination. In addition, 23% of the region's monitored beaches were closed or under advisory for some period of time during 2003. Elevated bacteria levels in the region's coastal waters were primarily responsible for the closures and advisories.

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NCCR III

Chapter 5 Highlights

highlight

Mobile Bay National Estuary Program Habitat Strategic Assessment for Coastal Alabama

Figure 1. Mobile-Tensaw River Delta Wetlands-Mobile, AL. Photograph courtesy of Mobile Bay NEP.

The Mobile Bay National Estuary Program (NEP) led a strategic assessment process to examine habitat needs and deficiencies in coastal Alabama. The goal was to identify, examine, and prioritize sites of particular sensitivity, rarity, or value for potential acquisition and/or restoration using a multi-species approach. This assessment resulted in the identification of 17 priority sites for acquisition (or other conservation protection options) and more than 30 other sites/habitat types where restoration and/or enhancement are considered necessary. Identification of sites for acquisition or where restoration was considered necessary was based in part on data developed in Efroymson Coastal Alabama Conservation Workshops held in December 2003 and March 2004 in a partnership between the Mobile Bay NEP and The Nature Conservancy. This assessment can be used by the state and other government organizations to more effectively guide resource management activities in coastal Alabama. Indeed, some state and local agencies and organizations have already acquired or are working to acquire certain sites on the priority site list. Similarly, restoration activities are underway or are being planned in a number of the identified areas.

The need for such an assessment arose from the lack of coordination and communication among the many organizations and government agencies actively pursuing habitat acquisition, preservation restoration, and management activities in the Mobile Bay area. Through the strategic assessment process, the contributions of existing preservation and management programs and the capabilities of all agencies and organizations involved in these programs are coordinated and maximized.

Figure 2. Robinson Island and Sea Grass beds in Orange Beach, AL. Photograph courtesy of Al Browder, Olsen Associates.

The process was organized by the Mobile Bay NEP to carry out habitat action plans contained in its CCMP and was funded by the EPA's Gulf of Mexico Program. The assessment involved an active partnership with The Nature Conservancy in hosting a workshop to examine conservation targets, including ecological systems and species, stresses, threats, and possible conservation strategies. This information provided critical background for subsequent workshops where sites for acquisition, protection, and restoration, as well as strategies for accomplishing these activities were discussed. Other participants in this strategic assessment covered a wide spectrum of federal, state, and public and private interest groups, including the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the USDA's Natural Resources and Conservation Service, the Mississippi–Alabama Sea Grant Consortium, the Alabama Department of Conservation and Natural Resources, the Alabama Forest Resources Council, the Weeks Bay NERR, the Mobile and Baldwin County governments, the Mobile Bay Audubon Society, the Dauphin Island Bird Sanctuary, the Alabama Coastal Foundation, the Alabama Power Company, and other local conservationists and realtors.

Although long–term success will be judged on the degree to which identified sites are protected or restored, short-term results are promising. For example, sites identified in the habitat strategic assessment have also been included as priorities for acquisition in recent state planning documents in response to the Coastal and Estuarine Land Protection (CELP) Program. Furthermore, efforts to create a coastal habitat restoration database are in progress. The Mississippi–Alabama Sea Grant Consortium initiated this database and funded its development to track on-going restoration projects. The Mobile Bay NEP will be responsible for managing and maintaining the database as part of its data management system. Finally, a steering committee called the Coastal Habitats Coordinating Team has been created to promote a continuing focus on habitat needs. The Mobile Bay NEP will work to develop the public–private partnerships necessary to effectively conserve critical habitats throughout coastal Alabama.

Figure 3. Coastal Marsh-Dauphin Island, AL.

Habitat conservation, protection, and restoration are very much a community concern in coastal Alabama. The development of effective partnerships and tools, such as the strategic assessment process, helped the Mobile Bay NEP better utilize and target existing capabilities, resources, and funding for achieving habitat goals and assist in coordinating and maximizing various individual organization efforts.

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Mobile Bay National Estuary Program (http://www.mobilebaynep.com)

Gulf of Mexico Program—Alabama Habitat Strategic Assessment Workshop (http://www.epa.gov/gmpo/projects/ala-habitat_intro.html)

highlight

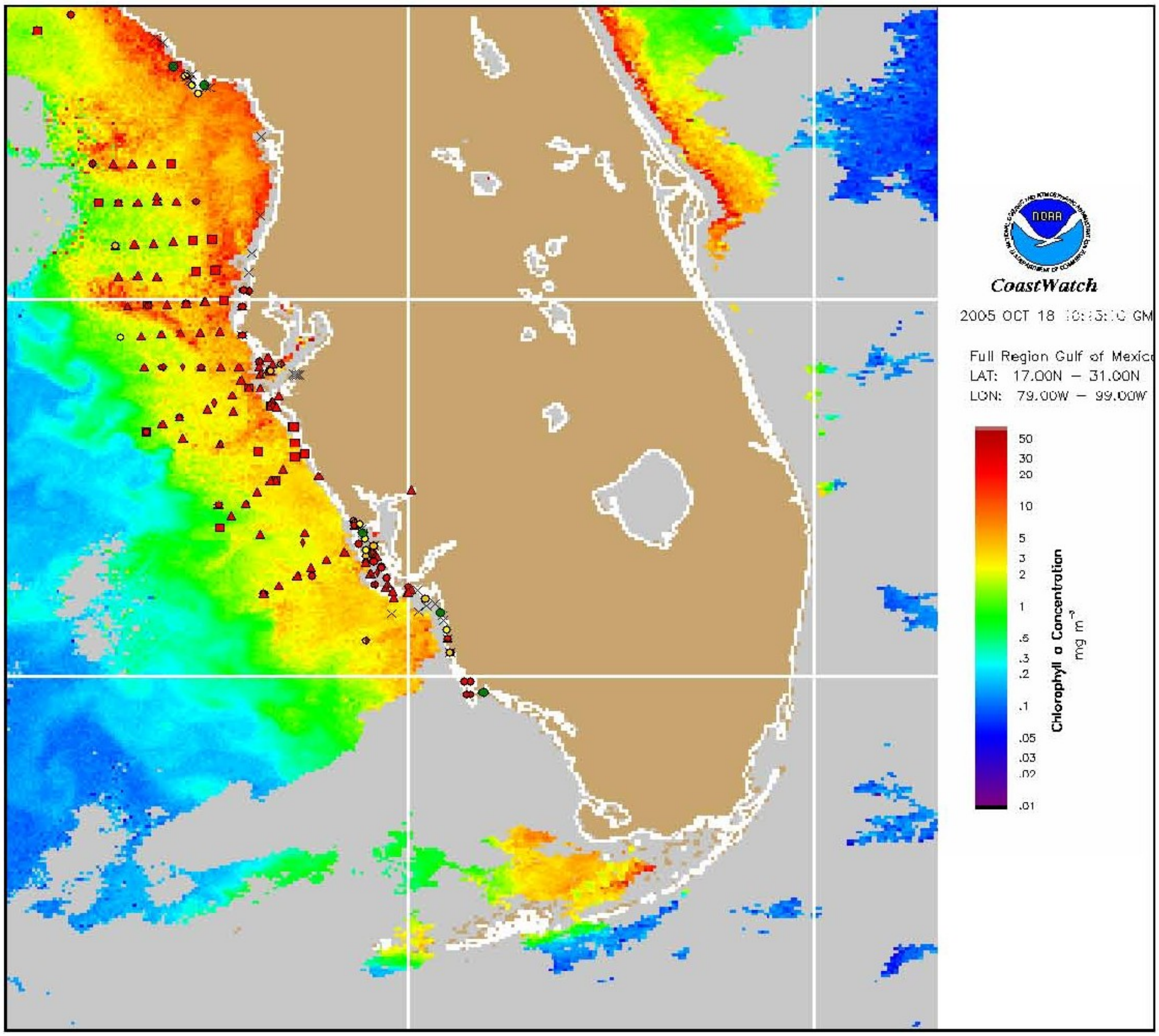
Gulf of Mexico Harmful Algal Blooms

Karenia brevis, often called the Florida Red Tide, is a phytoplanktonic organism that has been implicated HABs throughout the Gulf of Mexico. In U.S. waters, the blooms occur almost annually in the fall along the West Florida shelf and less frequently in the Florida Panhandle, Alabama, or Texas. Only once has a bloom occurred in Mississippi and Louisiana. In addition to discoloring the water, *Karenia brevis* produces brevetoxins, which are potent neurotoxins that can contaminate shellfish and cause neurotoxic shellfish poisoning in humans (FWRI, 2007). Also, *Karenia brevis* can form aerosols along beaches that cause human respiratory problems and can kill fish, marine mammals, turtles, and birds. As a result, these blooms have major impacts on human health, tourism, shellfish industries, and ecosystems.

In January 2005, an unusually early and large bloom of *Karenia brevis* began on the West Florida shelf, resulting in fish kills and respiratory irritation in beachgoers. From March to July, 32 of the 57 manatee deaths in this area were confirmed positive for brevetoxins. This mortality event, following similar events in previous years, is casting doubt on the sustainability of the southwest Florida manatee subpopulation. In early summer 2005, the bloom receded to a small area in southern Tampa Bay, but then a unique set of oceanographic conditions led to the bloom expanding offshore and being trapped near the bottom. The toxins produced by the algae killed fish and bottom-dwelling organisms, and the dead organisms decayed, using up bottom water dissolved oxygen. A large area of anoxic and hypoxic bottom water was created, resulting in additional animal mortalities in an area of more than 2,162 mi^2 located west of central Florida. The last time a similar event occurred was in 1971. Dissolved oxygen levels returned to normal after Hurricane Katrina re-aerated the water in late August, but the *Karenia brevis* bloom persisted (NOAA, 2005a). Unusually high marine turtle mortalities were reported in July and continued into September. At about the same time, a *Karenia brevis* bloom occurred in the Florida Panhandle, closing shellfish harvesting areas for an extended period of time. In September, *Karenia brevis* blooms were also reported along the south Texas coast.

Many agencies and institutions are involved in addressing this HAB problem. NOAA, EPA, and the State of Florida, in partnership with academic institutions, local governments, and business organizations, have undertaken major initiatives to understand and predict the occurrence of *Karenia brevis* blooms, improve monitoring and early warning identification of bloom events, investigate the effects on threatened species, and test newly developed control strategies. The Office of Natural Research (ONR) and Mineral Management Service (MMS) have also contributed to studies of optics, physical oceanography, and modeling. NSF and NIEHS have funded studies related to the nutrient sources for blooms and the effects of brevetoxins on human health.

In the last few years, there have been many advances in our understanding of *Karenia brevis*. In 1999, NOAA, with ground-truthing data provided by the HAB monitoring program conducted by the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute, began developing a system which utilizes satellite imagery to help detect and monitor blooms. By 2004, this effort had significantly expanded and included models for projecting transport of the HABs using improved analysis of satellite data and meteorological conditions to predict likely impacts of the HABs. In October 2004, the forecast effort in Florida became operational as NOAA's Gulf of Mexico Harmful Algal Bloom Forecasting System. The system produces a HAB Forecasting System Bulletin, which is now provided twice a week on an operational basis to federal, state, and local officials. The bulletin contains a written summary and analysis of bloom's levels and extent, which are also illustrated in maps (see figure). The bulletin is a resource used to guide sampling efforts, assist in management decisions, and provide information to the public (NOAA, 2007). As of September 2005, more than 70 bulletins were provided to state and local managers during the 2005 HAB event, with more than 90% of the bulletins being used.



Map from Gulf of Mexico HAB Bulletin for October 20, 2005 (NOAA, 2005b). Chlorophyll concentration from satellite with HAB areas shown by red polygon(s); cell concentration sampling data from September 30, 2005 shown as red squares (high), red triangles (medium), red diamonds (low b), red circles (low a), orange circles (very low b), yellow circles (very low a), green circles (present), and black "X" (not present).

The recently completed NOAA- and EPA-funded regional Florida project studied the occurrence and causes of *Karenia brevis* blooms for 5 years and developed a coupled physical–biological model to better understand environmental factors controlling blooms. Although the physiological and optical properties, bloom maintenance, termination, and transport of *Karenia brevis* are better understood, the nutrient sources supporting blooms, and the trophic transfer and affects of brevetoxins on higher trophic levels require further study.

Other efforts related to *Karenia brevis* HABs are also underway. Several agencies have supported the development of an optical sensor that can discriminate between *Karenia brevis* and most other phytoplankton (NOAA, 2005a). The sensor can be deployed on ships and Autonomous Underwater Vehicles for mapping and on moorings for continuous, real-time monitoring. NOAA is supporting the use of these new optical sensors as part of a networked system of autonomous sampling platforms, incorporating physical/chemical- and bio-sensor packages to provide data for predictive models and to guide statewide adaptive field sampling. An effort is planned by NOAA to implement these as part of the dataset for the HAB Forecasting System Bulletin. In addition, after a series of laboratory feasibility studies, a recent field pilot project was conducted to test the efficacy of spraying a clay slurry on a *Karenia brevis* bloom to make the cells fall to the bottom without releasing their toxin. Although similar methods have been used in Asia, this was the first time a control method was tested under field conditions in the United States.

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highlight

Project Greenshores Shoreline Restoration Project

The shoreline along Bayfront Parkway on Pensacola Bay in Florida has long been subjected to pressures from human activities. In the 19th century, the area was filled with wharfs and teeming with ships transporting timber from the forests of northwest Florida. Much of the bayfront and adjacent marsh areas were filled in and shorelines were hardened. In fact, privately and city-owned plots with streets are delineated into the bay. As is the case in many historic coastal communities, stormwater treatment is lacking in this older part of town, with stormwater directly entering the bay.

Figure 1. Aerial view of Project GreenShores shoreline restoration area along the Bayfront Parkway on Pensacola Bay in Florida.

Although the shoreline has been significantly altered over time, the project area supported some submerged aquatic vegetation until the 1950s; therefore, there seemed to be enormous potential existed for a successful habitat restoration and enhancement project that would increase public awareness of the native species and habitats within the Pensacola Bay System. Project GreenShores (PGS) Sites 1 and 2 focus on the highly visible area of Bayfront Parkway, at the north end of the Pensacola Bay Bridge, as the stage for a large-scale multi-habitat restoration project. Approximately 15 acres of subtidal and intertidal zones at Site 1 have been restored with oyster reefs, submerged aquatic vegetation, and emergent vegetation. As of

August 2005, Site 2 had been designed, partially funded, and was in the final permitting stages. Site 2 will continue the shoreline restoration project to the west along Bayfront Parkway, and add an additional 38 acres of emergent vegetation, oyster reefs, tidal channels, and submerged aquatic vegetation.

Monitoring at Site 1 has shown an expanding oyster population and an increasing abundance and diversity of fish and birds. The reef has become populated with many typical reef species, including blennies and gobies, stone crabs, blue crabs, anemones, and shrimp. Juvenile stone crabs have been observed and oyster spat are readily apparent. Schools of baitfish, gray snapper, mullet, sheepshead, flounder, redfish, and speckled trout have all been documented around the reef and in the marsh. In addition, recreational use of the area has increased, with more fishermen, canoers/kayakers, and bird watchers taking advantage of the newly created habitat and the productivity in the area.

Education has been a key focus of the restoration project. Local television, newspapers, and various civic and school groups have featured the project as it has progressed, providing an opportunity to reach members of the public beyond the thousands who drive by it every day. A grant-funded educational cruise aboard the *American Star* has hosted more than 4,000 students and civic group members. These cruises feature a visit to the site, an opportunity to "seed-the-reef" with oyster shell, and worksheets for teachers to use as follow-up lessons to reinforce the learning experience.

A unique component of this habitat restoration project has been the community partnership support that has developed as the project progressed. More than 60 partners have contributed to the PGS restoration effort, including local businesses, state and local government, federal/state/local granting organizations, citizen groups and individuals. Contributions have ranged from volunteer time and expertise, to no- or low-cost supplies and equipment, to financial support. These cooperative and volunteer activities have resulted in a project that has provided many members of the community with a sense of ownership in Project GreenShores and are a focal point for teaching students and community members about environmental issues.

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Florida Department of Environmental Protection–Northwest.

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highlight

Assessing the Ecological Condition of the Estuaries of Veracruz, Mexico

The influence of stressors, either natural or anthropogenic, on the coastal waters of the Gulf of Mexico (GOM) does not abate across political boundaries. To fully understand the ecological condition of GOM estuaries, the entire coastline needs to be assessed, including estuaries in both the United States and Mexico. In May 2002, the EPA undertook an international technology transfer activity with the Mexican State of Veracruz to transfer information about the NCA survey methodologies and to assist the State in collecting information to assess the condition of its estuarine GOM waters. During the summer of 2002, representatives from EPA trained and assisted Mexican biologists in the application and implementation of the NCA probability-based survey design. Data were collected to support the same indicators as those collected by NCA for the northern GOM so that comparisons between the ecological indicators of these two GOM areas could be made. The joint U.S./Mexico team sampled 50 probability-based stations over a 3-week period. The samples were split between EPA and the Office of Subsecrataria de Medio Ambiente Gobierno del Estado de Veracruz. Water quality and sediment quality indices were calculated using the data collected during the survey.

The water quality index was rated poor for 75% of the coastal area sampled in Veracruz, rated fair for 24%, and good for 1% (Figure 1). Poor water clarity, high levels of chlorophyll *a*, and elevated concentrations of DIP and DIN contributed to the poor water quality. Poor water quality was spread uniformly throughout the State. Inadequate treatment of sewage and municipal runoff are the candidate sources for these elevated levels.

In contrast to the water quality index, only 1% of the Veracruz survey area had poor sediment quality, primarily a result of sediment contamination (Figure 2). Sampled sediments were rated poor primarily due to exceedances of the ERL level for a variety of chemical contaminants, including PAHs, mercury, cadmium,

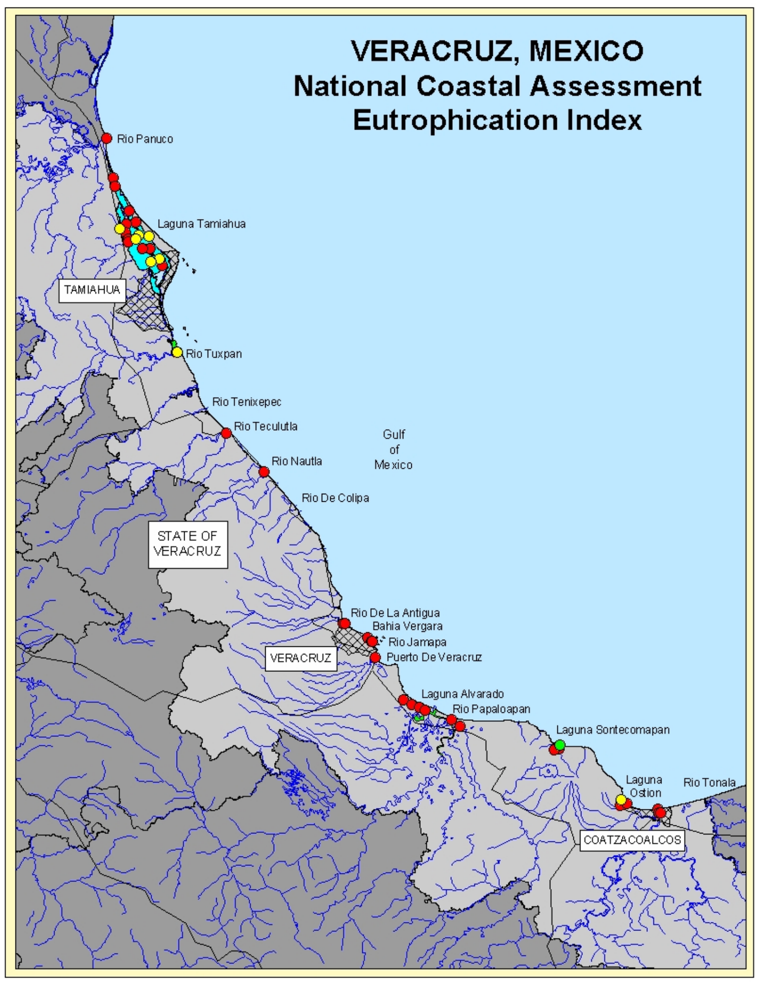

Figure 1. Eutrophication index data for the Gulf Coast estuaries of Veracruz, Mexico.

chromium, copper, arsenic, silver, and zinc. The percent of total organic carbon and toxicity of the sediment to marine amphipods made only minor contributions to the poor rating of the sediment quality. Industry in the State of Veracruz is concentrated around ports in the southern portion of the State. The elevated concentrations of PAHs and metals contributing to poor sediment quality were detected only in southern ports, such as Laguna Sontecomapan and Laguna Ostion, supporting petrochemical and pharmaceutical industries.

The inclusion of the Mexican State of Veracruz in the assessment of coastal estuaries represents a significant step towards assessing estuarine condition throughout the Gulf of Mexico. Discussions are underway with the Mexican government to include other Gulf Coast Mexican states in this ecological monitoring program.

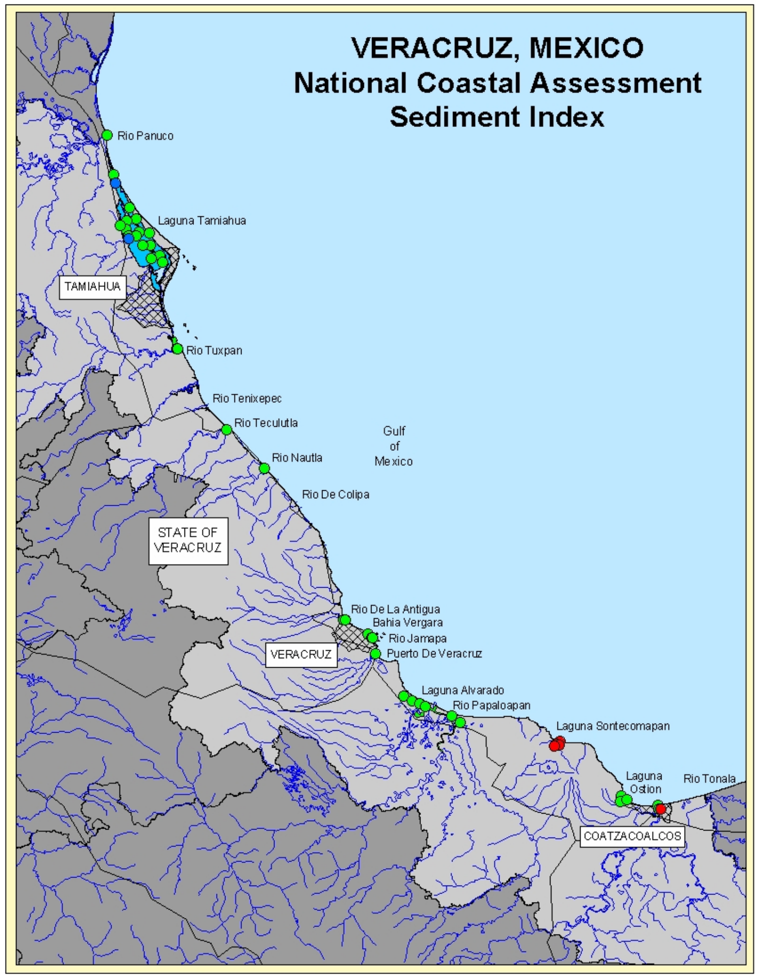

Figure 2. Sediment quality index data for Gulf Coast estuaries of Veracruz, Mexico.

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Chapter 6

West Coastal Condition

As shown in Figure 6-1, the overall condition of the coastal waters of the West Coast region is rated fair; the water quality index is rated fair; the sediment quality index is rated fair to poor; the coastal habitat and fish tissue contaminants indices are rated poor; and the benthic index is rated good. These ratings were primarily driven by NCA survey results for the Puget Sound and San Francisco Bay estuarine systems, which together represent a large percentage of the total estuarine area of the West Coast region. The watersheds surrounding these two systems, together with coastal watersheds in southern California, also have the highest population densities in the West Coast region. In contrast, the majority of smaller estuarine systems along the West Coast were estimated to be in better condition. Figure 6-2 provides a summary of the percentage of estuarine area rated good, fair, poor, or missing for each index and component indicator. This assessment of West Coast coastal waters is based on environmental stressor and response data collected by NCA, in collaboration with NOAA's NS&T Program, from 210 sites in 1999 and 171 sites in 2000 as part of a pilot project. Please refer to Tables 1-23, 1-24, and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

Although the majority of the data discussed in this chapter were also presented in the NCCR II (U.S. EPA, 2004a), this report presents slightly different rating results for the West Coast region. During the interval between the publication of the NCCR II and the NCCR III, benthic community

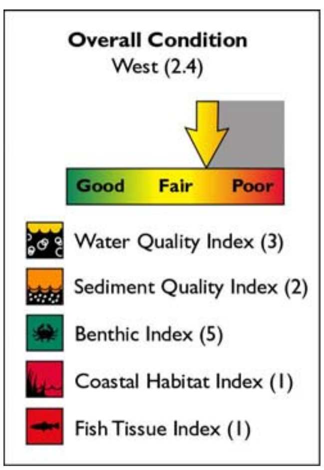


Figure 6-1. The overall condition of coastal waters of the West Coast region is rated fair (U.S. EPA/NCA).

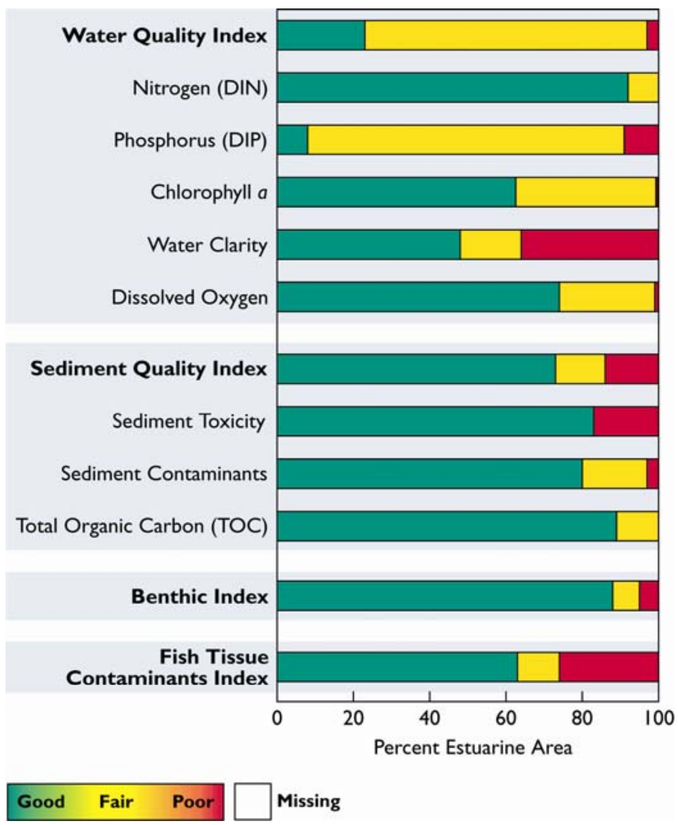


Figure 6-2. Percentage of coastal area achieving each ranking for all indices and indicators –West Coast region (U.S. EPA/ NCA).

data collected in 2000 from San Francisco Bay became available, and all benthic community data collected from estuaries during 2000 (Puget Sound, Columbia River, San Francisco Bay) were included in this NCCR III assessment. As a result of the inclusion of these new data, the overall condition rating for the coastal waters of the West Coast region changed from a rating of fair to poor, with an overall condition score of 2.2 (NCCR II), to the current rating of fair, with an overall condition score of 2.4. The benthic index rating for the region also changed from a rating of fair (NCCR II) to the current rating of good. In addition, water column means, rather than surface sample results, were inadvertently used in the NCCR II assessment of the DIN, DIP, and chlorophyll *a* data collected during 1999 and 2000. Although a reassessment of these data resulted in changes to the percent area rated good, fair, and poor for these component indicators and for the water quality index, the ratings for the water quality index and component indicators remain unchanged from those presented in the NCCR II. Data QC and refinement since the NCCR II also caused some slight differences in the percent area rated good, fair, or poor for the other indices and component indicators assessed in this report.

The West Coast coastal area comprises more than 410 estuaries, bays, and sub-estuary systems that are associated with larger estuaries. The size range of these coastal waterbodies on the West Coast is illustrated by five order-of-magnitude size classes of the systems sampled by EMAP/NCA—from 0.0237 mi^2 (Yachats River, OR) to 2,551mi^2 (Puget Sound and the Strait of Juan de Fuca). The total coastal area of the West Coast estuaries, bays, and sub-estuaries is 3,940 mi^2, 61.5% of which is made up of three large estuarine systems—the San Francisco Estuary, Columbia River, and Puget Sound (including the Strait of Juan de Fuca). Sub-estuary systems associated with these large systems make up another 26.8% of the West Coast coastal area. The remaining West Coast coastal waterbodies combined comprise only 11.7% of the total coastal area of the West Coast region.

West Coast coastal waters are located in two provinces: the Columbian Province and the Californian Province. The Columbian Province extends from the Washington-Canada border south to Point Conception, CA. Within the United States, the Californian Province extends from Point Conception south to the Mexican border. There are major transitions in the distribution of human population along the West Coast, with increased population density occurring in the Seattle-Tacoma area of Puget Sound, around the San Francisco Bay, and generally around most of the estuaries of southern California. In contrast, the region of coastline north of the San Francisco Bay through northern Puget Sound has a much lower population density.

The coastal waters of the West Coast region represent a valuable resource that contributes to local economies and enhances the quality of life for those who work, live, and visit these areas. In the West Coast states of California, Oregon, and Washington, the majority of the population lives in coastal counties. The coastal population of the West Coast region increased 47% between 1980 and 2003 to a total of 37.5 million (Figure 6-3), and 2003–2008 population growth rates for the counties bordering the San Diego, San Francisco, and Puget Sound estuaries are projected to be more than 40% (NOAA, 2004). These growth rates suggest that human pressures on West Coast coastal resources will increase substantially in future years.

Coastal Monitoring Data – Status of Coastal Condition

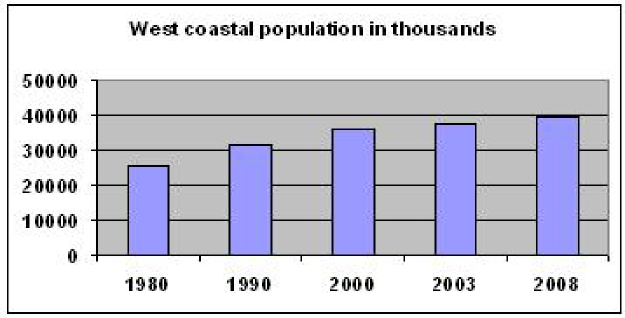


Figure 6-3. Population of coastal counties in West Coast states from 1980 to 2008 (NOAA, 2004) (U.S. EPA/NCA).

Relatively few national programs monitor the coastal waters of the West Coast region. NOAA's National Estuarine Eutrophication Assessment (NOAA, 1998) examined a number of eutrophication variables for West Coast coastal waters through the use of a survey questionnaire. In addition, NOAA's NS&T Program collects data for several western locations along the West Coast (Long et al., 2000), but these sites are not representative of all West Coast coastal waters. EMAP-like surveys have also been completed in the Southern California Bight (SCB) (SCCWRP, 1998). In comparison with these geographically focused studies, the NCA sampled small western estuaries in 1999 and 2001 (Oregon only), large estuaries in 2000, the intertidal areas of small and large estuaries in 2002, and the continental shelf in 2003. A reassessment of coastal condition along the West Coast was conducted in 2004 for the NCA. Unfortunately, most of these data are not yet available for use in this report; therefore, this section focuses on the assessment of data collected in small and large West Coast coastal waterbodies from 1999 to 2000 only.

> The sampling conducted in the EPA NCA survey 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.

Water Quality Index

The water quality index for the coastal waters of the West Coast region is rated fair, with 74% of the coastal area rated fair and 3% rated poor for water quality condition (Figure 6-4). The water quality index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. The areas rated poor for water quality condition were found primarily in California. The only sampling site outside California with poor water quality was located in southern Hood Canal, WA. Low ratings for the water quality index were driven primarily by high DIP concentrations and poor water clarity.

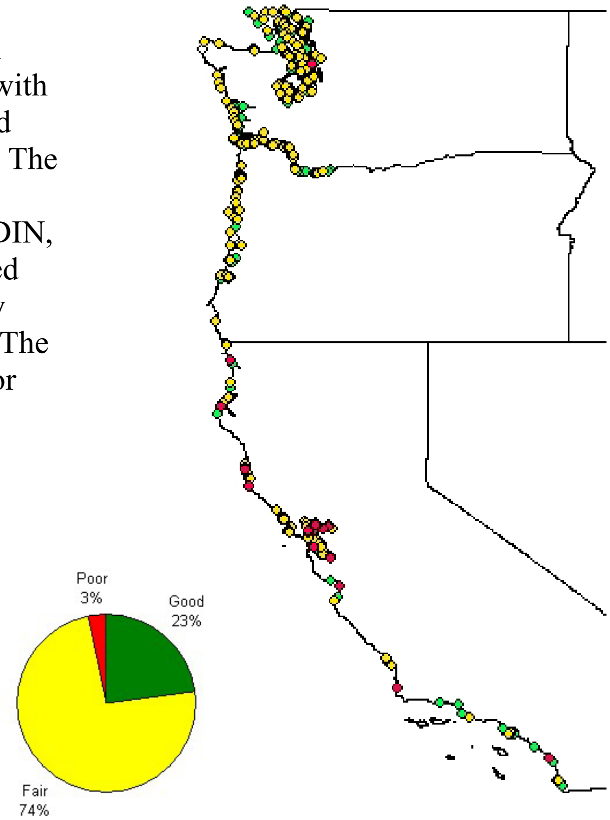


Figure 6-4. Water quality index data for the coastal waters of the West Coast region (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The West Coast region is rated good for DIN concentrations, with 8% of the coastal area rated fair and less than 1% of the area rated poor for this component indicator. The West Coast region is rated fair for DIP concentrations, with 83% of the coastal area rated fair and 9% rated poor for this component indicator. Upwelling may be an important contributing factor to the DIN and DIP concentrations measured in the coastal waters of the West Coast region during the summer.

Chlorophyll *a*

The West Coast region is rated good for chlorophyll *a* concentrations, with 37% of the coastal area rated fair for this component indicator. Less than 1% of the area was rated poor for chlorophyll *a* concentrations, with poor sites located in California and Washington (southern Hood Canal).

Water Clarity

Water clarity is rated poor for the West Coast region, with approximately 36% of the coastal area rated poor and 16% of the area rated fair for this component indicator. The same criteria were used to assess water clarity across the region, with a sampling site receiving a rating of poor if less than 10% of surface illumination was measured at a depth of 1 meter. The results of the 2000–2001 NCA assessment are consistent with those made by the NOAA Eutrophication Survey (NOAA, 1998), which reported high turbidity in 20 of the 38 West Coast estuaries surveyed.

Dissolved Oxygen

The West Coast region is rated good for dissolved oxygen concentrations, with 25% of the coastal area rated fair for this component indicator. Approximately 1% of the coastal area was rated poor for dissolved oxygen concentrations, with poor sites located in some sub-estuaries of Puget Sound (Dabob Bay and southern Hood Canal). Puget Sound is a deeper, fjord-like system and may often have low dissolved oxygen concentrations in bottom waters.

Sediment Quality Index

The sediment quality index for the coastal waters of the West Coast region is rated fair to poor, with 14% of the coastal area rated poor for sediment quality condition (Figure 6-5). The sediment quality index was developed based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Elevated metal concentrations in San Francisco Bay and high metal and organic concentrations in the harbors and bays of the Puget Sound system (e.g., Duwamish River, Commencement Bay) impacted the sediment quality index rating. Toxic sediments collected at sites within Puget Sound, the Columbia River, and Willapa Bay were the second-most important contributor to the areal estimate of poor condition for the West Coast region. In addition, several other areas had either elevated sediment contaminant concentrations or high sediment toxicity (e.g., Smith River in northern California, Los Angeles Harbor), but these areas constituted a relatively small percentage of the West Coast coastal area.

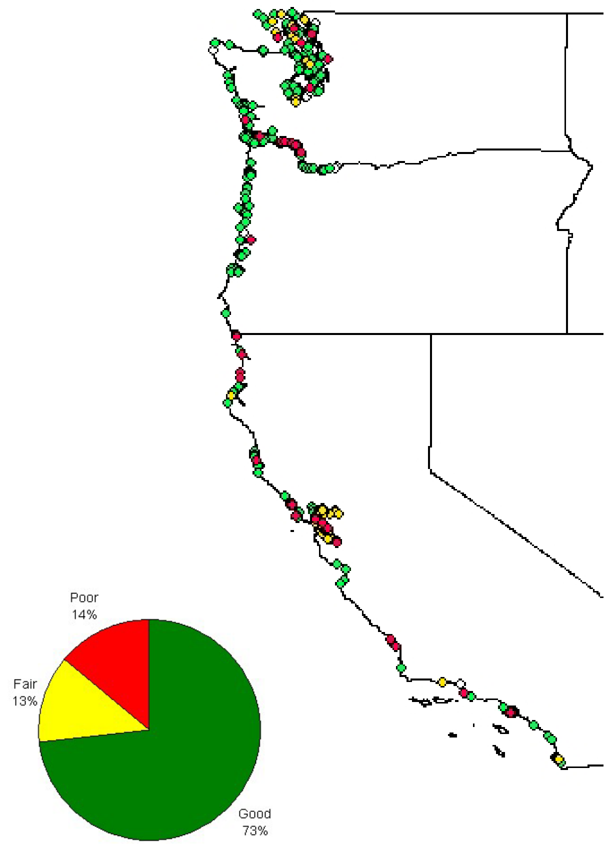


Figure 6-5. Sediment quality index data for the coastal waters of the West Coast region (U.S. EPA/NCA).

Sediment Toxicity

The West Coast region is rated poor for sediment toxicity, with 17% of the coastal area rated poor for this component indicator.

Sediment Contaminants

The West Coast region is rated good for sediment contaminant concentrations, with 17% of the coastal area rated fair and 3% rated poor for this component indicator. Elevated levels of DDT; chromium, mercury, copper, or other metals; PAHs; or PCBs were primarily responsible for poor ratings at West Coast sampling sites.

Sediment TOC

The West Coast region is rated good for sediment TOC, with 11% of the coastal area rated fair and none of the area rated poor for this component indicator.

Benthic Index

Benthic condition in West Coast coastal waters is rated good, with 7% of the coastal area rated fair and 5% rated poor (Figure 6-6). Although several efforts are underway and indices of benthic community condition have been developed for sections of the West Coast (e.g., Smith et al., 2001), there is currently no single benthic community index applicable for the entire West Coast region. 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 benthic condition. This approach requires that species richness be predicted from salinity. A significant linear regression between log species richness and salinity was found for the region, although it was not strong ($r^2 = 0.43$, $p < 0.01$).

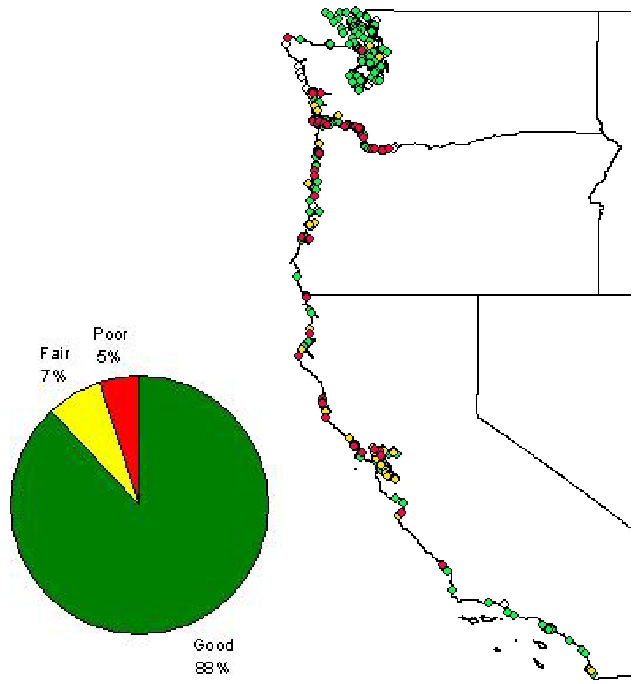


Figure 6-6. Benthic index data for the coastal waters of the West Coast region (U.S. EPA/NCA).

Coastal Habitat Index

The coastal habitat index for the coastal waters of the West Coast region is rated poor. From 1990 to 2000, the West Coast experienced a loss of 1,720 acres (0.53%) of the region's wetlands (NWI, 2002). The long-term, average decadal loss rate of West Coast wetlands is 3.4%. Although the absolute magnitude of the acreage lost for the West Coast region was less than the losses noted in other regions of the United States, the relative percentage of existing wetlands lost in the West Coast region was the highest nationally. West Coast 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.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of the West Coast region is rated poor. Based on whole-fish contaminant concentrations and EPA Advisory Guidance values, 26% of all sites sampled where fish were caught were rated poor and 11% were rated fair (Figure 6-7). The contaminants found most often in fish tissue samples included total PCBs and DDTs, although elevated mercury levels were occasionally detected.

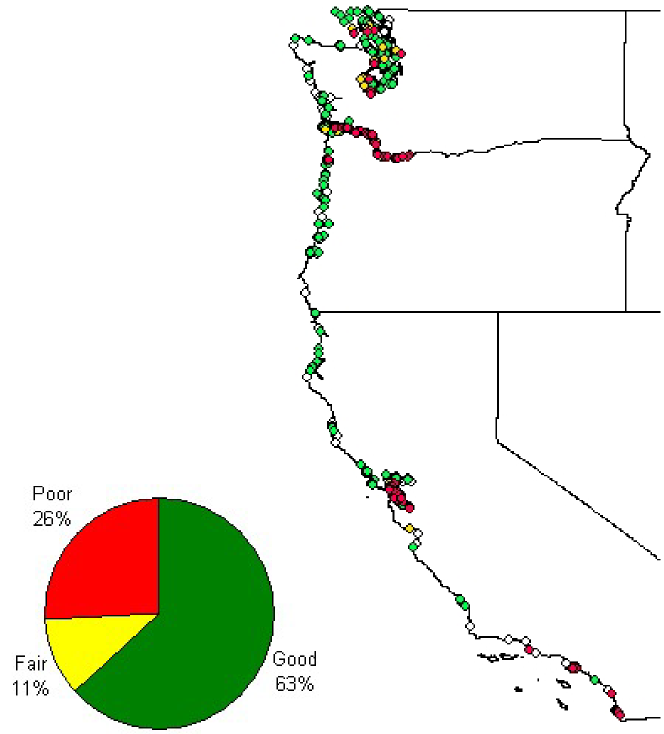


Figure 6-7. Fish tissue contaminants data for the coastal waters of the West Coast region (U.S. EPA/NCA).

Trends of Coastal Monitoring Data – West Coast Region

Temporal Change in Ecological Condition

As a pilot project, the NCA survey of the West Coast region was initially designed to develop trends in condition. The region was reassessed in 2004–2006 to determine trends, but these data were unavailable for inclusion in this report; therefore, a regional assessment of trends for West Coast coastal condition is not possible at this time.

Three local monitoring programs have sampled significant percentages of the coastal area of the West Coast region for periods up to nearly 35 years, and these programs measure many of the same parameters (e.g., sediment contaminants) as the NCA. The Puget Sound Ambient Monitoring Program (PSAMP) conducted annual assessments of sediment contamination, sediment properties, and benthic community composition at 10 fixed sites from 1989 through 2000. The principal agency conducting the sediment assessment is the Washington State Department of Ecology (WSDE), which was also the lead agency for the 1999–2000 NCA survey in Washington. Within San Francisco Bay, the Regional Monitoring Program for Trace Substances (RMP) has monitored chemical contaminant levels in water, sediments, and biota since 1993. The longest-running monitoring study in the region has been conducted primarily by the Los Angeles County Sanitation Districts to assess the conditions of sediment, benthic and fish communities, as well as the levels of chemical contaminants in fish, for a series of sites on the Palos Verdes Shelf within the SCB. Although these long-term monitoring data have been collected from fixed stations, probability-based assessments within the SCB have also been conducted.

Changes and Trends in Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program, 1989–2000

As part of the PSAMP, the WSDE sampled sediments at 10 fixed sites, which were chosen from a variety of habitats and geographic locations in Puget Sound (Figure 6-8). Sediments from each site were analyzed for particle size, organic carbon content, and sediment contaminant concentrations, as well as the types and abundances of benthic organisms. Samples were collected each spring between 1989 and 2000; however, samples collected between 1997 and 1999 were not analyzed for sediment contaminant concentrations. Changes in sediment condition over the 1989–2000 time period provide evidence for both human-driven and naturally occurring influences on the marine ecosystem (Partridge et al., 2005).

Figure 6-8. Locations of the 10 long-term PSAMP sediment monitoring stations in Puget Sound (Courtesy of Washington State Department of Ecology).

Human-Driven Changes

The PSAMP analyzed sediment samples for more than 120 contaminants, such as priority pollutant and ancillary metals, and as organic compounds, such as PAHs, chlorinated pesticides, and PCBs. The most notable changes in sediment chemistry were in metal and PAH concentrations.

The concentrations of most metals did not change significantly over the study period; however, those that did change generally decreased. Significant decreases were observed in copper across all stations and in metals in general at stations in Port Gardner and Budd Inlet (Partridge et al., 2005). Freshwater and estuary sediment metal concentrations nationwide have exhibited similar declines since the mid-1970s. These trends may reflect decreases in emissions to air and water from municipal and industrial sources following the implementation of federal clean-water and air regulations; however, despite these improvements, metal concentrations remain above sediment quality guidelines in many urban bays of Puget Sound, emphasizing the need for continued monitoring and cleanup (Lefkovitz et al., 1997; Mahler et al., 2004).

The concentrations of most PAH compounds did not change significantly during the PSAMP study period; however, most of those that did change increased in concentration. Significant increases in benzofluoranthene levels were observed throughout the study area, and increases in PAH concentrations were observed at sites in Bellingham Bay, Port Gardner, and Anderson Island. In contrast, there was a significant decrease in PAH concentrations at the Point Pully site (Partridge et al., 2005). These results are consistent with nationwide trends. After peaking between the mid-1940s and the 1960s, nationwide PAH levels in sediment core samples decreased through the 1980s and have more recently increased. It is believed that the early declines in PAH concentrations can be attributed to the switch from coal to oil and natural gas for home heating, improvements in industrial emissions controls, and increases in the efficiency of power plants, whereas more recent increases have been linked to increasing urban sprawl and vehicle traffic in urban and suburban areas (Lefkovitz et al., 1997; Van Metre et al., 2000; Van Metre et al., 2005). Recent studies by the USGS have also measured high PAH concentrations in stormwater runoff from parking lots sealed with coal-tar-based asphalt sealants (Mahler et al., 2005).

Naturally Occurring Changes

From 1989 through 1995, the amount of fine-grained sediment (percent silt) at the Strait of Georgia site varied between 25% and 50%. Between 1995 and 1997, the percent silt rose to approximately 90%, then declined to about 50% between 1998 and 2000. During the PSAMP study, the benthic community in the Strait changed from one characterized by the annelid worm species (*Prionospio*, *Pholoe*, and *Cossura*) to one consisting primarily of *Cossura*, a mobile burrower that tolerates living in a wide range of sediment grain sizes, and finally to one dominated by the bivalve mollusks *Macoma* and *Yoldia*, also active burrowers (Figure 6-9) (Partridge et al., 2005).

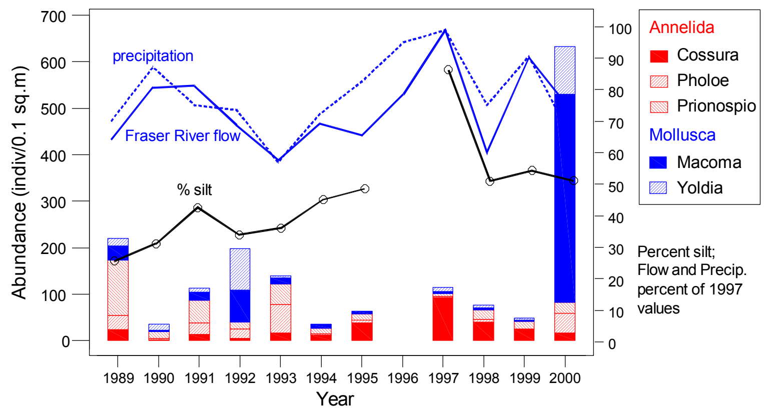


Figure 6-9. Changes in percent silt and abundance of dominant annelids and mollusks at the Strait of Georgia station, along with patterns in Fraser River flow and precipitation at the Vancouver International Airport. (River flow and precipitation displayed as percent of highest value) (Source of river flow and precipitation data: Environment Canada).

Examination of the flow and discharge plume of British Columbia's Fraser River, which can carry heavy sediment loads into the Strait of Georgia, suggested a possible cause for the observed changes. Annual rainfall, Fraser River flow volumes, and the percent silt at the Strait of Georgia site all exhibit similar temporal patterns. It is hypothesized that the changes in the sediment community observed in the Strait of Georgia were driven by above-average precipitation in 1996–1997, which increased the flow in the Fraser River and resulted in increased deposition of fine sediments in northern Puget Sound. Changes in grain size are known to influence community structure (Partridge et al., 2005).

Changes in the Strait of Georgia's sediment community in response to naturally occurring variation in rainfall and river flow clearly show the value of long-term monitoring for understanding the effects of stressors on the Puget Sound ecosystem. Understanding these processes at a local scale can help with assessments of similar changes in other regions. For example, the sediment-community changes observed in the Strait of Georgia may hold the key to understanding recent declines in San Juan Island eelgrass populations. Acting on the results of the PSAMP sediment monitoring program, investigators from the University of Washington and the USGS are conducting sediment surveys to determine if the decline in eelgrass abundance can also be linked to the deposition of fine-grained sediments from the Fraser River (Partridge et al., 2005).

The PSAMP's long-term monitoring provides a vital record of sediment conditions in Puget Sound and gives insight into the effects of both natural and human-driven stressors on the estuary. The fixed "sentinel" stations monitored in this program can raise red flags, highlighting important environmental changes the affect Puget Sound. These results are critical for guiding the policy and regulatory decisions needed to effectively manage and maintain the environmental health of Puget Sound. General information and data generated from this survey can be accessed from WSDE's Marine Sediment Monitoring Web site: http://www.ecy.wa.gov/programs/eap/mar_sed/msm_intr.html

Trends in Environmental Condition in San Francisco Bay

San Francisco Bay (Figure 6-10) has had the benefit of several long-term monitoring programs, including the RMP, sampling and analysis by the USGS, and the Interagency Ecological Project (IEP). The RMP has investigated chemical contamination in the water, sediments, and biota of the Bay since 1993 and provides data on spatial patterns and long-term trends for use in management of the estuary (SEFI, 2003). The USGS has 35 years of water quality data, including data on parameters such as chlorophyll, nutrients (phosphorus and nitrogen), suspended sediments, and dissolved oxygen. These data provide a record of biological and chemical changes in the Bay, such as improvements in dissolved oxygen concentrations in the South Bay and changes in phytoplankton production in Suisun Bay (USGS, 2006). The IEP has monitored fisheries and the effects of freshwater diversions on the biota of the Bay and the Sacramento-San Joaquin Delta since 1971 (IEP, 2006). Recent IEP data have shown drastic declines in important Delta fish species, such as striped bass, delta smelt, and longfin smelt (Hieb et al., 2005). Other local, state, and national programs, such as the Bay Protection and Toxic Cleanup Program, the state Mussel Watch Program, Coastal Intensive Sites Network (CISNet), EMAP, and the NOAA NS&T Program have also provided data on the water, sediments, and biota of San Francisco Bay.

Figure 6-10. Map of San Francisco Bay (Courtesy of San Francisco Estuary Institute).

Current and historical activities have contributed PCBs, pesticides, and mercury and other heavy metals (e.g., silver and copper) to the sediments of San Francisco Bay. Although many of these contaminants have been banned, they are persistent in the environment, biomagnify through the food web, and bioaccumulate in fish and wildlife. The highest concentrations of sediment contaminants are most often found at the urbanized edges of the Bay, and the distribution of contaminants is primarily driven by two factors: inputs from industrial and military sources near San Jose and the South San Francisco, Oakland, and East Bay shorelines and the distribution of fine particles to which these contaminants are sorbed. Many of the areas with high concentrations of PCBs, DDT, and/or chlordane in sediment correspond to areas of the estuary (e.g., South San Francisco Bay, San Pablo Bay, and along the East Bay shorelines) with high percentages of fine sediments (Connor et al., 2004).

Mercury contamination in the Bay dates back to 19th century mining practices, and sediment cores from the South Bay reflect the historic changes in concentrations over time (SEFI, 2004). Pre-mining concentrations were about four to five times lower than today's concentrations (Conaway et al., 2003). A peak in mercury concentration occurred during the early to mid-20th century, coinciding with the height of mining activities at the New Almaden Mercury Mine. This mine was the richest mercury mine in the state and is located on the Guadalupe River, which drains into the South Bay.

Contaminant levels in fish and wildlife have been the main concerns regarding the TMDLs being developed by the San Francisco Bay Regional Water Quality Board. For example, 25 years after the ban on the use of PCBs in California, concentrations in some Bay sport fish remain 10 times higher than human health consumption guidelines (Davis et al., in prep). Fish contaminants data have also been analyzed to determine whether there have been long-term changes in contaminant levels. Over the long term, concentrations of lipid-normalized DDTs in leopard shark, shiner, and white croaker suggest statistically significant declines in concentrations from 1994 to 2003 (Figure 6-11) (Connor et al., 2004). No long-term trends have been detected in lipid-normalized PCB data. PCB levels in leopard shark, white croaker, and striped bass were higher in 1994 compared to other years, but interannual variation since 1994 has fluctuated without a clear decline. Mercury concentrations in striped bass have shown no decline during the period from 1970–2003 (Figure 6-12) (Greenfield et al., 2005).

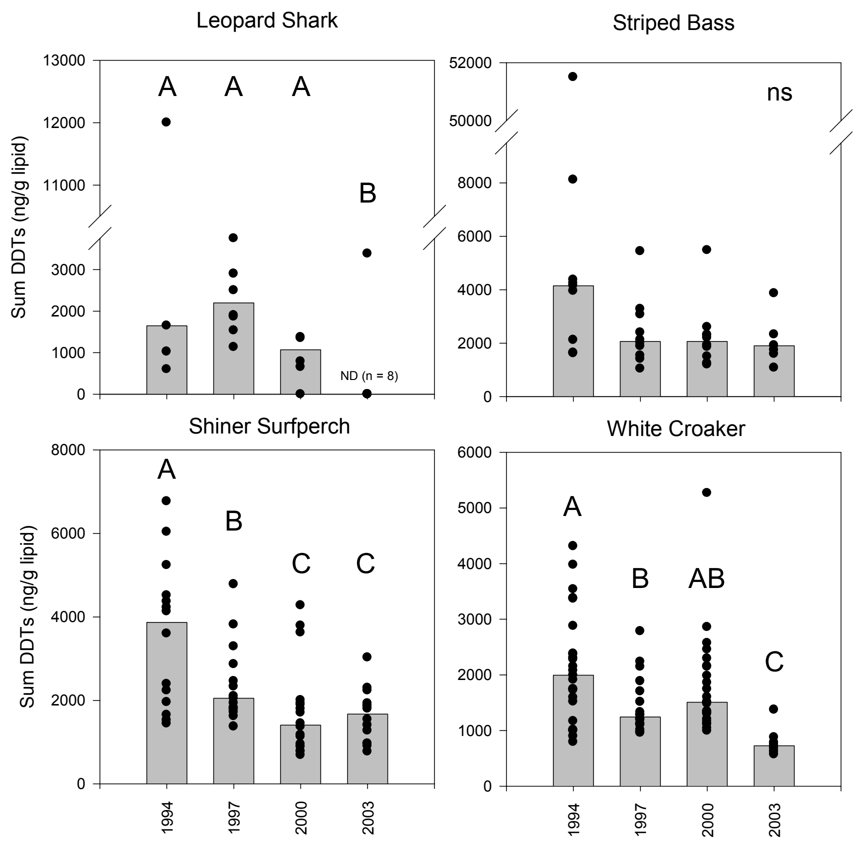


Figure 6-11. Total DDT concentrations in leopard shark, shiner surfperch, striped bass, and white croaker in ng/g lipid weight 1994–2003. Letter differences denote years that are statistically significantly different. (Courtesy of San Francisco Estuary Institute.)

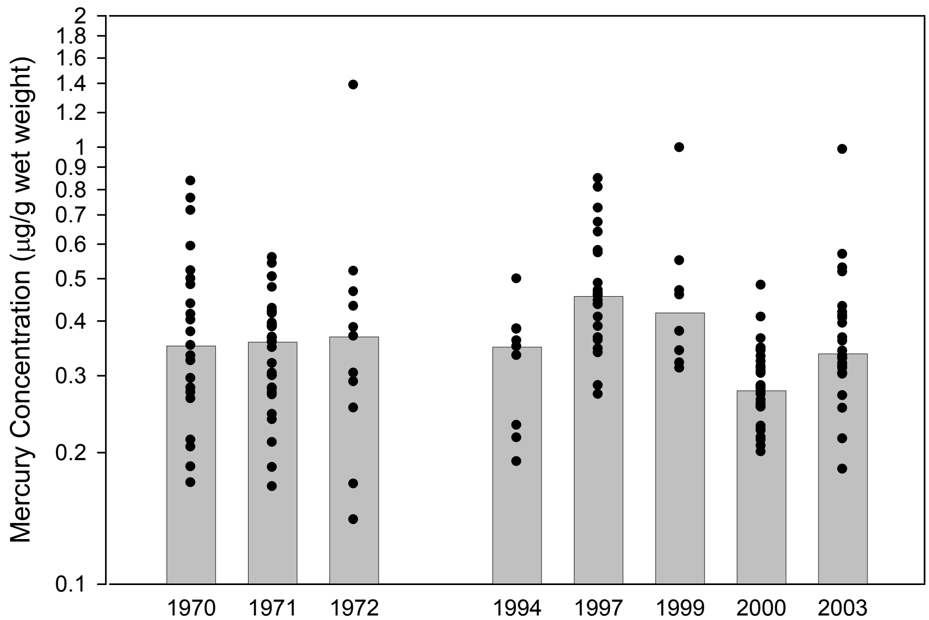


Figure 6-12. Mercury concentrations in ug/g wet weight in striped bass from 1970–2003. Concentrations expressed as an average for a 55 cm fish. (Courtesy of San Francisco Estuary Institute.)

Declining concentrations of PCBs in transplanted mussels have suggested that there have been improvements in water quality in the Bay. Linear regression analyses have shown exponential declines in PCB concentrations in mussels at most transplant locations from 1980 to 2003. Similar declines in concentrations of legacy pesticides have also been seen in Bay transplanted mussels (Davis et al., in prep).

Other contaminants have shown more declines. Copper concentrations in water, clams, and sediments from the South Bay declined from 1979 to 2003. RMP water data show statistically significant declines in copper concentrations at all historical South Bay stations, and USGS data show corresponding declines in copper concentrations measured in the clam *Macoma balthica* and in sediments from the South Bay. Declines of copper in *Macoma* have been correlated with declines in copper in effluents from the Palo Alto wastewater treatment plant located in the South Bay (SFEI, 2004).

Primary production in San Francisco Bay has historically been light-limited because of the waterbody's turbidity (SEFI, 2004). In recent years, chlorophyll levels in the southern reaches of the Bay have increased (Figure 6-13), which may be due to increased light penetration (SFEI, 2006). A South Bay suspended-sediment model, developed by USGS, predicts that increases in wetland area (as proposed under the South Bay Salt Pond Project) could result in increased sediment deposition onto wetlands and a subsequent decrease in suspended sediments in the water column (Shellenbarger et al., 2004). The resulting increase in light penetration could cause higher phytoplankton productivity. In the northern reaches of the Estuary, chlorophyll concentrations have dramatically decreased in Suisun Bay (Figure 6-14) sites since the invasion of the freshwater clam *Potamocorbula* in 1986. The high abundance of this filter-feeding clam has resulted in declines in chlorophyll in Suisun Bay, from an average of 9.8 mg/L (pre-invasion) to 2.1 mg/L (post-invasion) (SFEI, 2003).

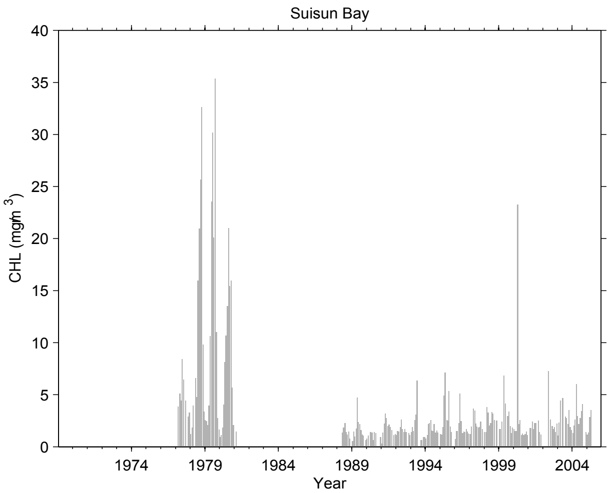


Figure 6-13. Chlorophyll *a* concentrations in South Bay 1977–2004. (Courtesy of San Francisco Estuary Institute).

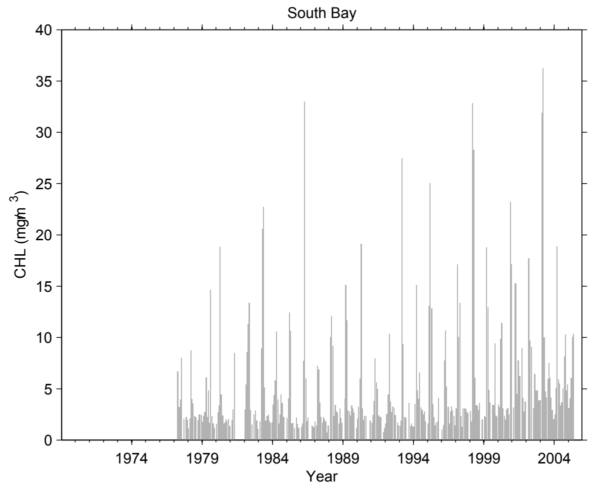


Figure 6-14. Chlorophyll *a* concentrations in Suisun Bay 1977–2004. (Courtesy of San Francisco Estuary Institute).

Trends in Coastal Sediment Condition in the Southern California Bight: A Clean Water Act Success Story

The SCB is the most densely populated coastal region in the nation, and its municipalities rely upon coastal waters for the disposal of treated wastewater. Nineteen Publicly Owned Treatment Works (POTWs) discharge 1,200 million gallons per day to the SCB. Of these POTWs, the Los Angeles County Sanitation Districts Joint Water Pollution Control Plant (JWPCP), which discharges to the Palos Verdes Shelf, is one of the largest in volume and industrialization.

Prior to the Clean Water Act of 1972, the primary goal for treatment systems was public health protection. Following the Clean Water Act, treatment processes and outfall designs were upgraded with the goal of also protecting aquatic life in the ambient environment. During the next 30 years, mass emission rates of effluent-suspended solids and contaminants were reduced as industrial waste source control measures and treatment plant upgrades were implemented. In addition, receiving-water monitoring programs were instituted to assess the effects of discharge on the condition of the nearshore environment. The monitoring program established along the Palos Verdes Shelf area near the outfall of the JWPCP has the longest consistent record of monitoring receiving waters in the SCB, allowing assessment of the environmental response to effluent quality improvements (LACSD, 2006). This monitoring has been conducted primarily by the Los Angeles County Sanitation Districts. The location of the outfall and receiving water monitoring sites discussed below are shown in Figure 6-15.

By 1970, the historic discharge had contaminated the seafloor of the Palos Verdes shelf with organic matter and chemicals (e.g., metals and chlorinated hydrocarbons). Organic loading resulted in sediment hypoxia and hydrogen sulfide in surface sediment porewaters. Potentially toxic metals and synthetic organic compounds, notably DDT and PCBs, were at levels in the sediments well above those typically associated with biological effects. These alterations were severe enough to sharply degrade the benthic communities over the entire shelf (Steinberger and Stein, 2004).

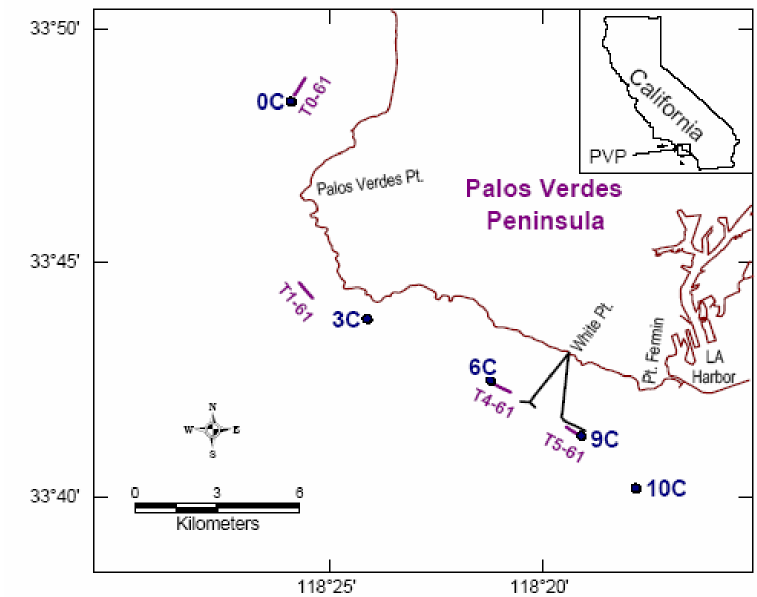


Figure 6-15. JWPCP outfall system and monitoring sites within the Southern California Bight. Stations indicated with C in the station ID are benthic monitoring stations, while those with T in the station ID are trawl collection stations. (Southern California Coastal Water Research Project).

As effluent contaminant emissions decreased from 1970 onward, so did the levels of organic matter, metals, chlorinated hydrocarbons, and other contaminants in the upper layers of seafloor sediments. Examples of sediment quality trends are shown in Figure 6-16. Similar reductions have been observed for other contaminants, including numerous metals and other chlorinated hydrocarbons (Steinberger and Stein, 2004).

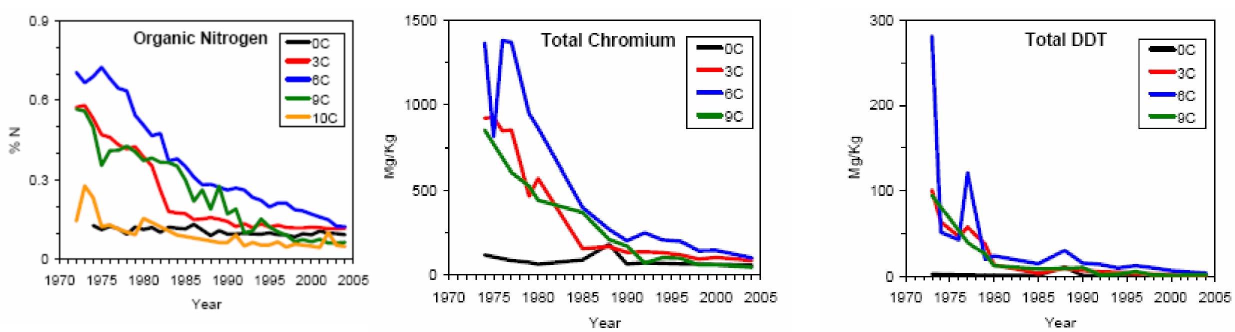


Figure 6-16. Trends in sediment quality represented by changes in concentrations of organic nitrogen, total chromium, and total DDT in sediment samples in the Southern California Bight, 1972–2004. (Southern California Coastal Water Research Project).

The unfavorable sediment conditions that developed over decades degraded benthic communities in much of the Palos Verdes shelf. Impacts were greatest near the outfall, where pollution-tolerant species dominated. Species richness was extremely low, crustaceans and echinoderms were rare, and many benthic species common to reference areas were conspicuously absent. Over time, the severity of biological effects lessened as sediment conditions improved (LACSD, 2006). This pattern of response is summarized by the Benthic Response Index (BRI) (Smith et al., 2001), which is a regional assessment tool calculated as the abundance of pollution-tolerant species within a sample. Whereas loss in community function, and even loss of the community altogether, was apparent at all sampling stations in the 1970s, even the sites closest to the outfall had only minor deviation from reference condition by the late 1990s (LACSD, 2006).

As with the benthic communities, the demersal (bottom-dwelling) fish communities on the Palos Verdes shelf exhibited evidence of community-level impacts in the 1970s. Near-outfall sites were characterized by smaller populations, lower biomass, fewer species, and less diversity than at sites distant from the discharge. Many species that were rare in the 1970s have become more abundant and widespread in the past two decades. Previously abundant pollution-tolerant species that had been associated with the discharge have declined (LACSD, 2006). These trends are summarized by an index of demersal fish biointegrity, the Fish Response Index (FRI) (Allen et al., 2001), with index values below 45 indicating reference biointegrity. The FRI has fallen over time (Figure 6-17), with all sites near the outfall currently within reference condition (LACSD, 2006).

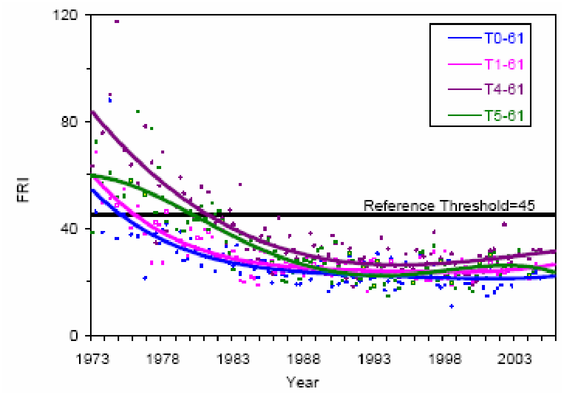
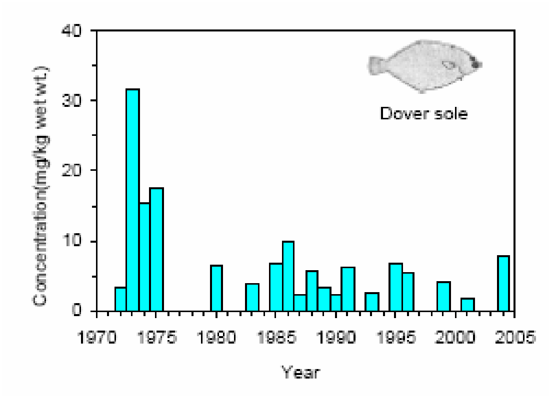


Figure 6-17. Trends in the condition of the demersal fish community in the Southern California Bight, 1972–2004, as represented by Fish Response Index. (Southern California Coastal Water Research Project).

Another indicator of pollution-related impacts within demersal fish communities is fin erosion. This disease manifests as the degeneration of fins and is thought to result from a complex set of causes, including contact with contaminated sediments, low dissolved oxygen environments, and secondary bacterial infections. In the past, fin erosion was commonly observed among demersal fish off Palos Verdes. Thirty-one of 69 species collected off the Palos Verdes Peninsula during 1969–1972 trawl surveys exhibited fin erosion, with Dover sole showing the highest incidence. This flatfish species prefers muddy bottoms, where it feeds on benthic organisms. Fin erosion was most commonly found on specimens from near-outfall sampling sites and was rare in specimens from the most distant sampling site. Fin erosion virtually disappeared from Dover sole and all other species of demersal fish collected off Palos Verdes by 1988 (LACSD, 2006).

In the SCB, DDT and PCBs are the persistent synthetic chlorinated hydrocarbons of greatest concern. DDT inputs to the JWPCP sewer system ended in 1971, and other sources of this chlorinated hydrocarbon have been eliminated. Use of PCBs was prohibited in 1979, and this compound has been virtually undetected in effluent since 1986 (Steinberger and Stein, 2004). However, the persistence of these legacy pollutants in the buried reservoir of historically contaminated sediments results in their continued appearance in the food web and tissues of local sea life. Although tissue burdens in local fish have fallen over time (Figure 6-18), levels in some species are still sufficiently high to justify consumption advisories (LACSD, 2006).



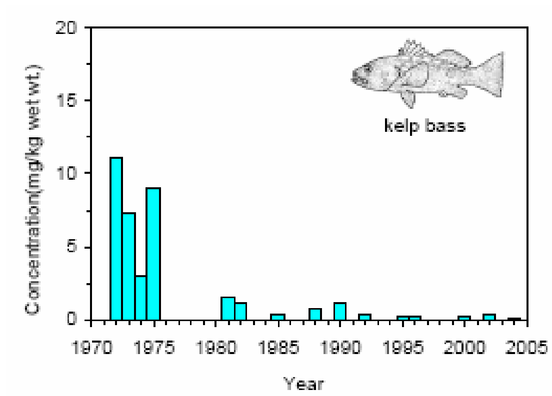


Figure 6-18. Trends in the median concentration of DDT in muscle tissue of Dover sole and kelp bass in the Southern California Bight, 1972–2004. (Southern California Coastal Water Research Project).

The long-term monitoring results on the Palos Verdes shelf cumulatively provide evidence of the effectiveness of the Clean Water Act. There is clear linkage between reductions in discharge from the POTW and improvements in sediment quality, which in turn has led to improvements in the biological integrity of the system. Although the example provided was for a single facility, similar patterns have been observed at each of the other POTWs in southern California that maintain monitoring programs. The JWPCP typifies the successful response by POTWs in the SCB to the challenges presented by the Clean Water Act. Population in the coastal plain is expected to increase substantially over the next 30 years and pressure on the local marine environment may increase. The requirements of the Clean Water Act will continue to assure that the gains of the past 30 years are sustained, and the monitoring programs associated with those facilities will provide a means of assessing that success.

Overall Trends

Monitoring of fixed stations over an 11-year period in Puget Sound has shown that the general trend for metals in the sediments has been to decrease with time. Among the 10 priority pollutant metals sampled at 10 stations, a total of 39 cases (single metal at a single location) exhibited statistically significant differences over time. Of these 39 cases, 4 exhibited significant increases, and the rest were significantly decreasing. The Puget Sound PAH data demonstrates that different types of pollutants may have differing temporal trajectories. In contrast to the metals, of the 45 cases where a significant temporal trend in PAH concentrations was detected, 41 instances were increases. The Puget Sound benthic monitoring data also strongly suggest that natural environmental variability can have impacts on certain environmental indicators, such as sediment grain size and benthic community composition. Separation of such natural sources of variation from anthropogenic changes remains a significant challenge for interpretation of long-term monitoring data.

The data from the long-term monitoring programs within San Francisco Bay present a mixed picture of changes over time. As was the case in Puget Sound, sediment copper concentrations have generally declined. PCBs have shown declines in mussel tissue used in a monitoring program since the 1970s, but have shown no decline in the decade since 1994 in samples of various fish tissues. In contrast, DDT and chlordane pesticides have declined in the same fish species over the same time period. Of continued concern in San Francisco Bay is the fact that there is no indication of decreases of mercury over a 30-year period. In contrast, some stations in Puget Sound had significant decreases in sediment concentrations of mercury over only a decade.

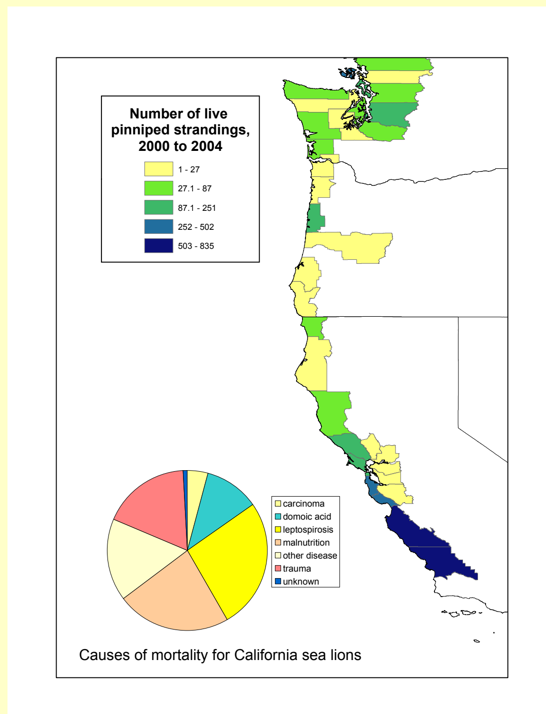
The long-term data from the monitoring of fixed stations in the SCB was more focused on the evaluation of system responses near point sources of pollutants from POTWs, in contrast to the more regional assessments reported from Puget Sound and San Francisco Bay; therefore, the trends described tended to be much clearer. Reductions in effluent contaminant levels from the early 1970s onward have reduced the amount of organic matter, metals, and organic contaminants, such as DDT, in the surface sediments. The benthic infaunal and demersal fish communities have both responded favorably to these reductions in pollutant loads. As was the case in San Francisco Bay, the levels of organic contaminants (DDT, PCBs) in fish tissues have decreased over time, but in both regions, there is a highly persistent legacy of these pollutants in the sediments that continue to accumulate in fish at levels sufficient to require consumption advisories.

The temporal trends in benthic pollutants within these three large coastal areas of the West Coast of the United States demonstrate a number of significant reductions over periods of monitoring ranging from one to three decades. The increasing trend for PAH concentration with time in Puget Sound is potentially a result of the large increases in human population in the region. Observation of increasing trends for pollutants indicates that there is still a major need for programs that address existing problems, as well as for programs to prevent environmental conditions from getting worse over time.

Marine Mammal Strandings Along the West Coast

California (King, 1983). These marine mammals share their habitat with humans and consume many of the same fish species. California sea lions (*Zalophus californianus*), Pacific harbor seals (*Phoca vitulina richardsii*), and northern elephant seals (*Mirounga angustirostris*) are the pinniped species that commonly come ashore or "strand" on West Coast beaches when they are ill or in distress. Members of the Southwest and Northwest regions of the National Marine Mammal Health and Stranding Network respond to these strandings when they occur along the California and Oregon/Washington coasts, respectively. The Network was formalized by the 1992 Amendments to the Marine Mammal Protection Act (MMPA) and is managed by the NMFS. Live stranded animals are admitted for care to rehabilitation centers, and investigations

From 2000 to 2004, a total of 4,804 live pinnipeds were stranded along the West Coast. The graphic shows that the majority of animals stranded along the California coast (64%), compared to Oregon (7%) and Washington (29%). The highest proportion of animals were stranded in central California, and these animals were most commonly sea lions (75%), followed by elephant seals (18%) and harbor seals (7%).



(NOAA, 2006)

Major causes of mortality for California sea lions included leptospirosis (26%), malnutrition (23%), trauma (18%), domoic acid toxicity (11%), and carcinoma (1%). Domoic acid is a biotoxin produced by some marine algae. This acid binds to receptors in the brain and is responsible for amnesic shellfish poisoning in humans (Teitelbaum et al., 1990). Large numbers of sea lion strandings associated with domoic acid toxicity now occur off the coast of California frequently. The first UME was documented along in 1998 (Scholin et al., 2000). During that year, approximately 400 sea lions died with clinical signs of domoic acid toxicosis. California sea lions are high-level predators that feed on species (e.g., anchovies, sardines, hake, rockfish, salmon, and market squid) that often enter the human seafood market. Since 1998, recurrent toxin-producing events have occurred on a regular basis and have affected hundreds of animals. The detection of domoic acid in California sea lions dying along California's coast is helping to raise public awareness of the presence of this biotoxin in a variety of seafood species. These concerns are exacerbated by increasing reports of HABs that threaten both human and marine life safety (U.S. Commission

West Coast Large Marine Ecosystem Fisheries

California Current Large Marine Ecosystem Fisheries

Salmon Fisheries

Pacific salmon in the California Current LME 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 freshwater rivers on their spawning migrations. All species are also harvested by Native American tribes for subsistence and ceremonial purposes. From 1995 through 1997, the average annual commercial salmon catch was 13,100 mt, providing revenues averaging almost $22 million at dockside. From 2001 through 2003, the annual commercial salmon catch averaged 19,000 mt and provided revenues averaging approximately $26 million at dockside (Figure 6-19). If recreationally caught fish are valued at a conservative $20/fish, the 2001–2003 average catch of 1.2 million fish would have been worth about $24 million annually. For all species, there is excess fishing power and overcapitalization of the fishing fleets. Although harvest rates in recent years have been held near or below levels that would produce the maximum sustainable yield, environmental conditions in the 1980s and 1990s resulted in generally poor ocean survival rates for Chinook and coho salmon stocks, as well as some individual stocks of the other species.

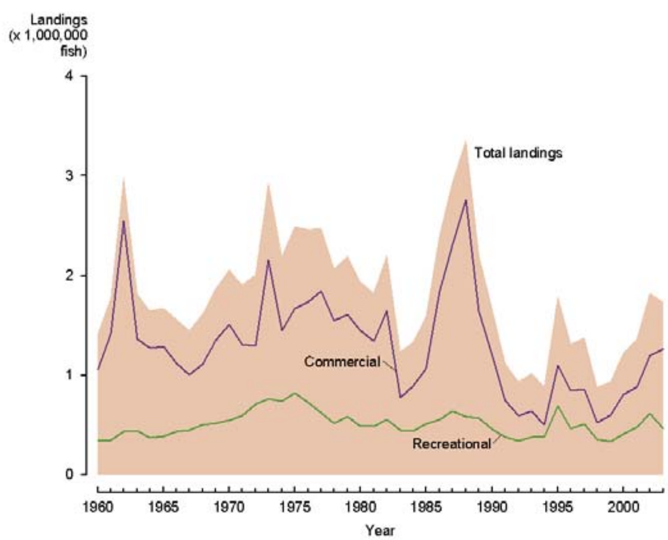


Figure 6-19. Chinook salmon landings in individual fish, 1960–2003 (NMFS, 2006).

Following coast-wide status reviews for all species of salmon and anadromous trout, numerous evolutionarily significant units (ESUs) of all species except pink salmon have been listed as threatened or endangered under the U.S. Endangered Species Act. The management of this resource is complex, involving many stocks originating from various rivers and jurisdictions. Ocean fisheries are managed primarily by gear restrictions, minimum size limits, and time and area closures, although harvest quotas and cumulative impact quotas have also been placed on individual fisheries in recent years. Pacific salmon in the California Current LME depend on freshwater habitat for the 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 U.S. Army Corps of Engineers, EPA, Bonneville Power Administration, state resource agencies, Native American tribes, municipal utility districts, agricultural water districts, private timber companies, and landowners.

Ecosystem Considerations

Coho salmon abundance reached a peak in 1976 and suffered a dramatic decline through the late 1990s. Chinook salmon abundance has also generally declined since the mid-1970s, although there was a brief increase in chinook salmon abundance in the late 1980s. These declines affected both hatchery and natural stocks and appeared to indicate a period of declining ocean survival. These declines were also coincident with a change in the oceanographic regime off the West Coast that occurred around 1978. Since then, the coastal waters off California, Oregon, and Washington, where many chinook and coho salmon stocks mature, have been warmer and less productive than they were during the period from 1950 to 1978. The decline in ocean productivity off the Pacific Coast appears to be linked to increased productivity in the Gulf of Alaska. The abundances of sockeye, pink, and chum salmon, which migrate further offshore than chinook and coho salmon, were relatively stable or increasing during the same period that chinook and coho salmon populations declined. For sockeye salmon, Fraser River runs were strong through the mid-1990s, but ocean conditions have caused a large proportion of the fish to migrate north of Vancouver Island, where they are unavailable to U.S. fisheries. In addition, the late run of sockeye salmon has been entering the river as much as six weeks earlier in the year than runs occurring prior to 1996, and this early river entry has been associated with high pre-spawning mortality. This phenomenon has concerned fishery managers and resulted in severe restrictions on harvest in sockeye fisheries.

Within the past few years, marine conditions again became favorable for chinook and coho salmon. In 1999, water temperatures were lower than normal off the coasts of California, Oregon, and Washington. In 2000, the marine plankton assemblages in the Pacific Northwest shifted from species characteristic of temperate regions to species more characteristic of sub-arctic regions, and baitfish became abundant. Until 2005, marine conditions remained favorable for the growth and survival of all salmon species in the Pacific Northwest; however, California Current LME coho and Chinook salmon landings from the June 2005 surveys were lower than in June 1998, during El Niño.

Pacific salmon are particularly vulnerable to habitat degradation because of their dependence on freshwater habitat for spawning and juvenile rearing. Dam construction, logging, agriculture, grazing, urbanization, and pollution have degraded freshwater habitat throughout their range. Water extraction and flow manipulation for hydropower, irrigation, flood control, and municipal needs directly compete with salmon for the freshwater on which they depend. As the human population in the western United States continues to increase, so will the pressures on salmon habitat. The continued existence of salmon in harvestable quantities is a tribute to the resilience of these fish.

Pelagic Fisheries

Several stocks of small pelagic fish species support fisheries along the California Current LME. 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. Populations of these small pelagic fish, such as Peruvian anchovy and Japanese sardine, tend to fluctuate widely. 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, and catches from the mid-1940s to mid-1950s averaged only 20,000 mt per year. Catches declined and remained low before starting to increase in 1965 after the sardine collapse. Together with catches from Mexico, the total catch increased to 250,000 mt per year during 1975–1980, but declining thereafter due to significant price reductions for fishmeal. Low prices and market problems continue to prevent a significant U.S. reduction fishery for anchovy.

Northern anchovy landings in California have fluctuated more in response to market conditions than to stock abundance. Landings by the United States have varied and have been used mostly for live bait and other non-reduction uses. The biomass trend for the anchovy resource hit a peak of 1.6 million mt in 1973 and declined steadily to 392,000 mt by 1994. The current yield for the Unites States is 25,000 mt or 30% of the maximum sustainable yield, although recent catches have been much lower (about 8,500 mt) due to a lack of commercial markets.

All these pelagic fishery resources are currently under management. The well being of ecologically related species in the California Current LME is important in the management of these resources. For example, the endangered brown pelican depends on anchovy as a critical food source, and so to protect the balance, the fishery management plan has specified a threshold for determining optimum-yield that prevents depletion of the anchovy and provides adequate forage for marine fishes, mammals, and birds.

Groundfish Fisheries

The groundfish fishery of the California Current LME is conducted along the entire coastlines of Washington, Oregon, and California and includes a diverse range of habitats and species. The fishery has four sectors: commercial limited entry, commercial open access, recreational, and tribal.

In recent years, a number of dramatic changes have occurred in the Pacific Coast groundfish fishery. In the past five years, nine stocks have been declared overfished, and the implementation of rebuilding plans for these stocks have sharply curtailed fishing opportunities for those species and for associated species throughout nearly all sectors of the fishery. As a result, allowable harvests and landings are at or near historical lows for many species. One of the overfished stocks (Pacific hake) has since been declared rebuilt, but rebuilding for many of the other stocks is expected to take decades. In addition to rebuilding plans for the recovery of overfished stocks, many strides have been made to improve management of the groundfish fishery. These include the completion of a trawl permit buy-back to reduce fishing capacity, implementation of a coast-wide observer program to monitor bycatch, and expansion of groundfish resource surveys.

In 2003, U.S. commercial landings of Pacific Coast groundfish totaled 168,987 mt, generating $60.2 million in ex-vessel revenue. Groundfish landings are dominated by Pacific hake, which accounted for 84% of the fishery's total landed weight in 2003. However, with its low unit value, Pacific hake only accounted for 29% of the fishery's revenue. The groundfish fishery's most valuable component is the "Dover sole-shortspine thoryhead-longspine thornyhead-sablefish" complex, which accounted for nearly $29 million, or 48%, of all groundfish revenue in 2003. The trawl fleet (including Pacific hake) comprises the largest gear component of the fishery, generating 72% of the ex-vessel revenue.

Although traditional management measures such as annual catch quotas have been in place for up to 20 years, some groundfish stocks have declined during that period to less than 25% of their estimated unfished levels. At least three primary factors have contributed to these declines. First, during the 1980s and into the 1990s, little information was available on the life history and productivity of many groundfish species, and target harvest rates were based upon knowledge of the productivity of other species. This was a reasonable approach in light of the absence of species-specific information, but it turned out that harvest rates were overly optimistic for most of the long-lived, slow-growing rockfishes (Figure 6-20). Additionally, resource survey information was insufficient to estimate stock abundances with adequate precision, and with no observer program in place, there was no way to verify that the total catch, including bycatch, did not exceed the intended level. Finally, a decline in the basic productivity of the California Current LME from 1977 until the late 1990s (including 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) coincided with increases in groundfish harvests in the late 1970s. It is likely that this decline in productivity contributed to the decline in overall abundance and recruitment of groundfish species.

Figure 6-20. Quillback rockfish. Source: Alaska Fisheries Science Center, NOAA/NMFS.

Assessment and Advisory Data

Fish Consumption Advisories

In 2003, 24 fish consumption advisories were in effect for the estuarine and coastal waters of the West Coast region (Figure 6-21). A total of 21% of the estuarine square miles on the West Coast were under advisory in 2003, and all of the estuarine area under advisory was located within the San Francisco Bay/Delta region or within Puget Sound. Only 10% 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 the coastal shoreline of Washington's Puget Sound. None of the West Coast states (California, Oregon, or Washington) had statewide coastal advisories in effect during 2003. Although Oregon did not list any fish consumption advisories for estuarine or coastal waters in 2003, there is a fish consumption advisory for the Lower Columbia River (which forms the border between Washington and Oregon) issued by the State of Washington for all species due to PCBs, dioxins, and DDT.

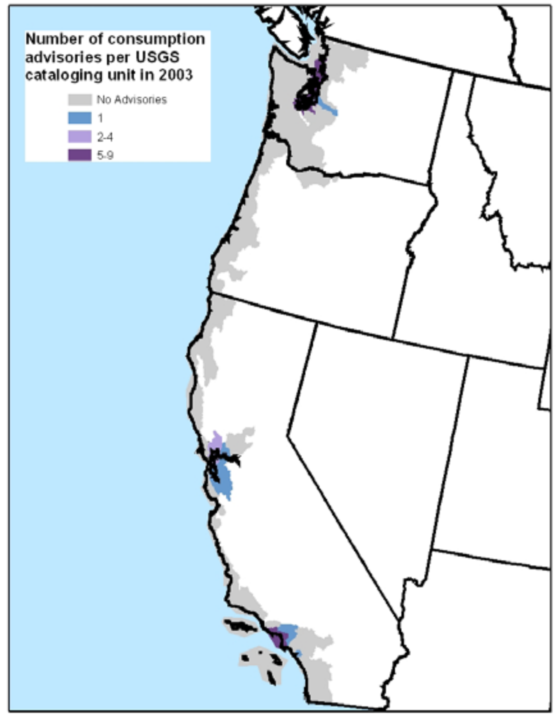


Figure 6-21. The number of fish consumption advisories for the West Coast active in 2003 (U.S.EPA, 2004b).

Seventeen different contaminants or groups of contaminants were responsible for West Coast fish advisories in 2003, and 13 of those contaminants were listed only in the waters of Puget Sound and bays emptying into the Sound. These contaminants were arsenic, chlorinated pesticides, creosote, dioxin, industrial and municipal discharge, metals, multiple contaminants, PAHs, pentachlorophenol, pesticides, tetrachloroethylene (PCE), 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 Bay was covered by one of these advisories.

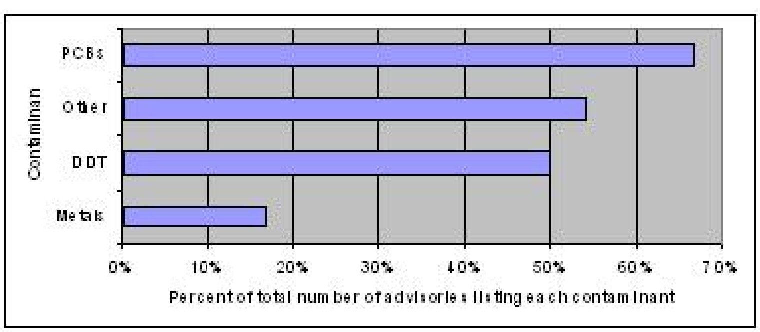


Figure 6-22. Pollutants responsible for fish consumption advisories in West Coast coastal waters. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S.EPA, 2004b).

The following fish and shellfish species and groups were under advisory in at least some part of the coastal waters of the West Coast in 2003:

Black croaker	Gobies	Shellfish
Bivalves	Kelp bass	Striped bass
Bullhead	Queenfish	Surfperch
Clams	Rockfish	White croaker
Corbina	Sculpin	*Source: U.S. EPA, 2004b*
Crab	Shark	

Beach Advisories and Closures

Of the 499 monitored coastal beaches in the West Coast region reported to EPA for 2003, 33.5% (167 beaches) were closed or under an advisory for some period of time during that year. Table 6-1 presents the number of beaches monitored and under advisories or closures for each state. California reported the greatest number of monitored beaches to the EPA survey (430), as well as the most beaches with at least one advisory or closure in 2003 (156). It should be noted that the total number of beaches with 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. Figure 6-23 presents advisory and closure percentages for each county within each state.

Most of the advisories implemented on the West Coast were reported as due to elevated bacteria (53%), although many (42%) of the advisories were due to other reasons (Figure 6-24). Most beaches had multiple sources of waterborne bacteria that resulted in advisories or closures. Unknown sources accounted for 66% of the responses from West Coast beaches (Figure 6-25).

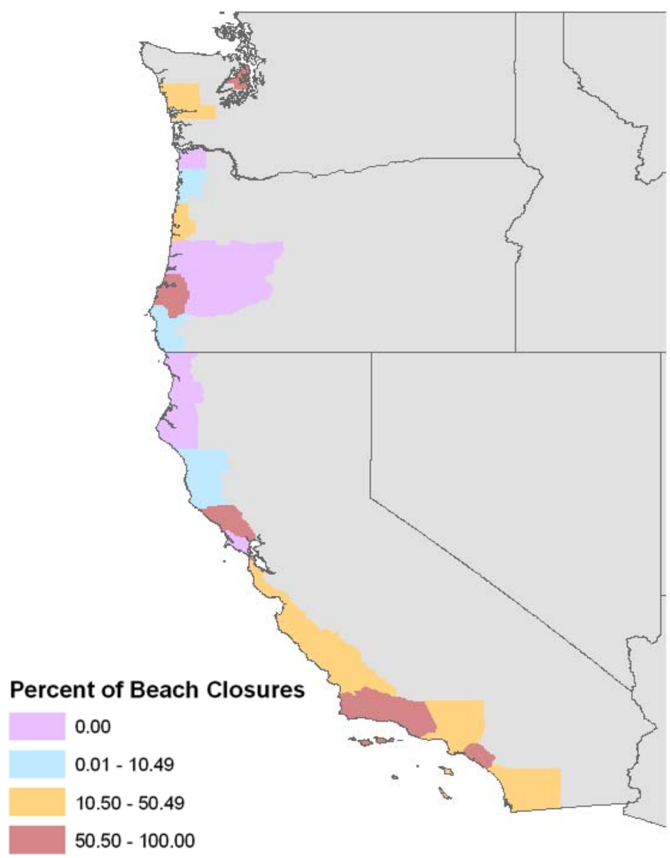


Figure 6-23. Percentage of beaches with advisory or closures by county for the West Coast (U.S.EPA, 2006).

Table 6-1. Number of Beaches Monitored and Under Advisories/Closures in 2003 for the West Coast (U.S. EPA, 2006)

State	No. of Beaches Monitored	No. of Beaches with Advisories/Closures	Percentage of Beaches Affected by Advisories/Closures
California	430	156	36.3
Oregon	58	7	12.1
Washington	11**	4	36.4
TOTALS	499	167	33.5

** Washington did not report number of beaches for 2003. The number of beaches monitored in 2004 is presented here (U.S. EPA, 2005).

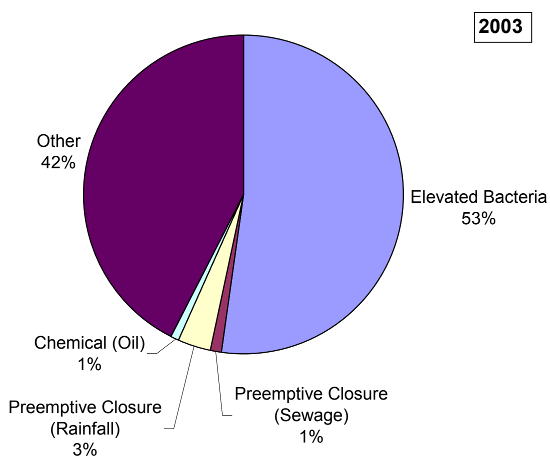


Figure 6-24. Reasons for beach advisories or closures for the West Coast (U.S. EPA, 2006).

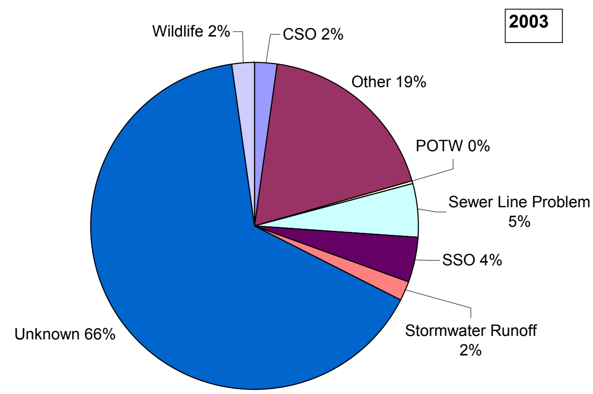


Figure 6-25. Sources of beach contamination for the West Coast (U.S. EPA, 2006).

Summary

Based on data from the NCA, the overall condition of West Coast coastal waters is rated fair. Additional benthic community data have become available since the NCCR II and were included in the analysis for this report; other data have been refined. As a result, the overall condition score and the benthic index rating for the West Coast region have changed since the NCCR II, and the percent of coastal area rated good, fair, or poor has been refined for several indices and component indicators.

Currently, NCA data for the West Coast region are only available for 1999 and 2000, and long-term trends in coastal condition cannot be evaluated. However, local monitoring programs have been used to examine long-term trends for several areas of the region. As measured by the PSAMP, no significant changes in the concentrations of most metals and PAHs in the sediments of Puget Sound occurred over time; however, where significant changes were observed, metal concentrations decreased and PAH levels increased. The PSAMP also observed changes in the percent silt over time, and these changes affected Puget Sound's benthic community composition. In San Francisco Bay, levels of DDT in some finfish species have declined over time due to natural environmental variation, although no trends have been observed for PCB or mercury concentrations in finfish. PCB levels in transplanted mussels have decreased in the Bay, and copper concentrations have decreased in water, clams, and sediment. Chlorophyll *a* levels have shown increasing trends in the northern reaches of San Francisco Bay and deceasing trends in the Bay's southern reaches. Since 1970, conditions in the SCB have improved, and levels of organic matter, metals, chlorinated hydrocarbons, and other contaminants have decreased in sediments. Benthic and demersal fish communities have improved in the region, and DDT and PCB concentrations in fish have decreased.

NOAA's NMFS manages several fisheries in the California Current LME, including salmon, pelagic fish, and groundfish. Landings of the five species of Pacific salmon within the California Current LME are near or below the maximum sustainable yield, and most of these species are listed as threatened or endangered. Pacific salmon are particularly vulnerable to habitat degradation due to human-induced pressures, such as construction, logging, and urbanization. Ocean conditions in the 1980s and 1990s resulted in decreased abundances of Chinook and coho salmon in this LME. During the same time period, abundances of sockeye, pink, and chum salmon were either stable or increasing. Populations of the pelagic fish in this LME tend to fluctuate widely, and both anchovy and sardine landings are low due to market constraints. Nine stocks of California Current LME groundfish have been declared overfished in the past 5 years, and only one of these stocks is considered rebuilt.

Contamination in West Coast coastal waters has affected human uses of these waters. In 2003, there were 24 fish consumption advisories in effect along the West Coast, most of which were issued for PCBs contamination. In addition, 33.5% of the region's monitored beaches were closed or under advisory for some period of time during 2003. Elevated bacteria levels in the region's coastal waters were primarily responsible for the closures and advisories.

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NCCR III

Chapter 6 Highlights

highlight

Development of Sediment Quality Objectives in California

An often overlooked benefit of the partnership between the EPA NCA and the states is the development of assessment tools. The California State Water Resources Control Board is required by State law to develop sediment quality objectives (SQOs). This task has proven to be difficult both for EPA nationally and for many individual states throughout the country. California is making progress toward developing direct effects SQOs in large part because of the data generated through probability-based, regional monitoring efforts supported by the EMAP, the EMAP Western Pilot Project, and the National Coastal Assessment beginning in 1999.

The State of California has proposed using a multiple line of evidence approach to SQOs, based upon a measure of exposure and two measures of biological condition. The three indicators that are being proposed are sediment contaminant concentrations, sediment toxicity, and benthic community condition (Figure 1). Data from bays and estuaries on the West coast collected as part of the EMAP Western Pilot Program have provided an unbiased, synoptic dataset to test various approaches. These data have been merged with other high quality, site-specific datasets. Approximately half of the data are being used to evaluate the utility of various measures of exposure, toxicity, and benthic community structure to assess sediment condition. The other half of the dataset will be used to validate the approach for statewide application.

A summary of the process for developing and ultimately for implementing these sediment quality objectives can be found on CalEPA State Water Resources Control Board's Web site (www.swrcb.ca.gov). For more information contact Chris Beegan at (916) 341-5577.

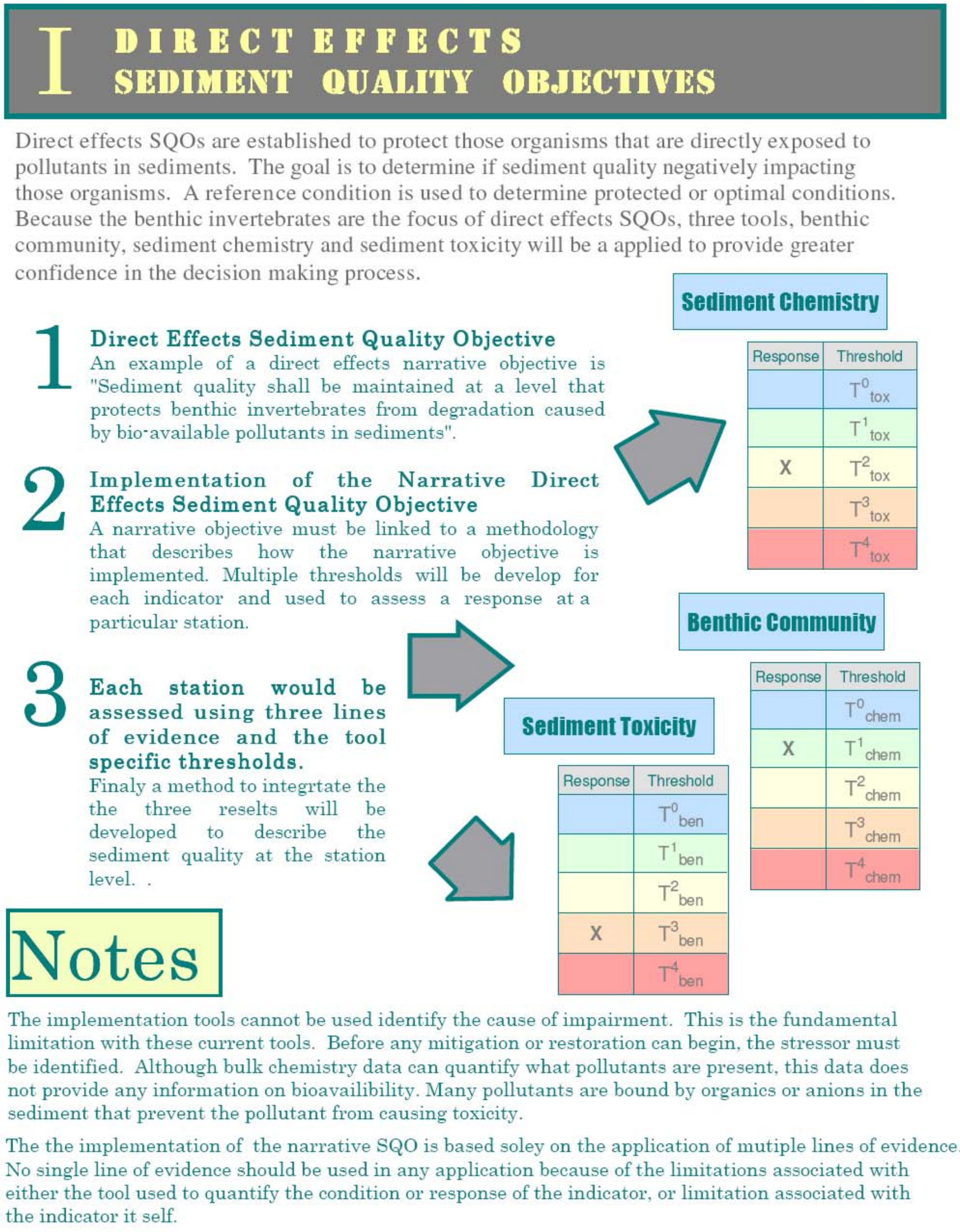

Figure 1. The implementation pathway for California's direct effects, sediment quality objectives.

highlight

EPA, NOAA, and West Coast States Assess Ecological Condition of Near-Coastal Waters Along the Western U.S. Continental Shelf

An effort is underway by EPA, NOAA, and West Coast states to assess condition of aquatic resources in near-coastal waters along the western U.S. continental shelf (Figure 1). The study is based largely on the protocols of EPA's EMAP and thus may be regarded as an extension of previous EMAP efforts in estuaries and inland waters to these offshore areas, where such information has been limited in the past. This near-coastal monitoring effort included the probabilistic sampling approach of EMAP to support statistical estimation of the spatial extent of condition with respect to various measured ecological indicators (U.S. EPA, 2002; U.S. EPA 2004). Results are intended to serve as a baseline for monitoring potential changes in these indicators over time due to either human or natural factors.

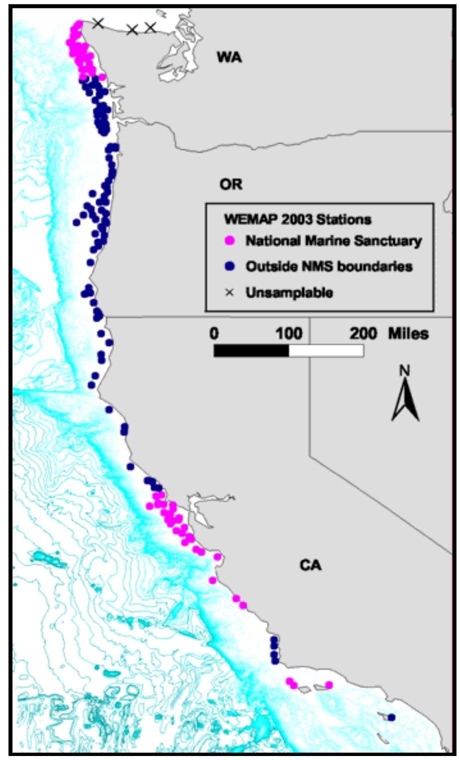

Figure 1. EMAP sampling sites.

Sampling was conducted successfully in June 2003 at 146 stations from the Straits of Juan de Fuca, WA, to Pt. Conception, CA, at depth ranging from 30–120 m (100–395 ft) (Cooksey et al., 2003). A stratified random sampling design was used, with 50 stations positioned off each of the states of Washington, Oregon, and California. The resulting nesting of sampling sites across varying spatial scales will enable the assessment of condition at state, regional, and national levels, similar to EMAP applications in shallower estuarine systems. In addition, 60 of the 150 stations were located within NOAA National Marine Sanctuaries, with 30 of these stations located within the Olympic Coast NMS off the coast of Washington and the remaining 30 stations are distributed among the four other West Coast sanctuaries (Gulf of the Farallones, Cordell Bank, Monterey Bay, and Channel Islands), all off the California coast. Thus, the design will allow comparison of condition in sanctuaries to surrounding, nonsanctuary areas of the shelf (Cooksey et al., 2003).

As in other EMAP efforts (present NCCR3 and U.S. EPA, 2002), multiple indicators were measured synoptically at each station to support the weight of evidence assessments of condition and the examination of associations between biological characteristics and potential environmental controlling factors (Table 1). These environmental indicators include the following:

- General water-quality and habitat condition indicators
- Stressor levels measured as exposure indicators
- Biological condition indicators (with a focus on benthic infauna and demersal fish pathology).

Table 1. Environmental Indicators. (Source: Cooksey et al., 2003.)

Habitat Condition Indicators	Benthic Condition Indicators
• Salinity (S) • Water depth • Dissolved oxygen (DO) • pH • Water temperature (T)	• Infaunal species composition • Infaunal abundance • Infaunal species richness and diversity • External indicators of disease in fishes • Presence of nonindigenous species
• Total suspended solids	**Exposure Indicators**
• Transmittance • Sediment grain size • Sediment % total organic carbon (TOC) • Sediment color/odor • Presence of trash/marine debris	• Chemical contaminants in sediment • Chemical contaminants in fish tissues • Low DO condition • Organic over-enrichment
Water Quality Indicators	
• Chlorophyll *a* concentrations • Nutrient concentrations (nitrates, nitrites, ammonia, phosphate)	

The consistent sampling of these variables across such a large number of stations provides a tremendous opportunity for learning more about the spatial patterns of near-coastal resources and processes controlling their distributions, including potential associations between presence of stressors and biological responses. For example, one question that we hope to address with these data is the extent to which pollutants and other materials are being transported out of major rivers along the coasts, such as the Columbia River plume (Figure 2) and their potential effects on biological resources.

Figure 2. Columbia River plume (14 nautical miles offshore, June 2003). Photograph courtesy of Washington Department of Ecology.

The study also demonstrates the benefits of performing science through partnerships that bring together complementary capabilities and resources from a variety of federal, state, and academic institutions. The project is principally funded by EPA's Office of Research and Development. NOAA is also a major partner in the effort, contributing overall management and interpretive support, in addition to providing ship time on the NOAA Ship McARTHUR II. The Northwest Fisheries Science Center of NOAA has also provided field support and analysis of fish pathologies on the June 2003 survey, in addition to providing fish for contaminant analysis from samples collected through the NOAA West Coast Slope Survey fisheries assessment program. State and academic partners include the Washington Department of Ecology, Oregon Department of Environmental Quality, Moss Landing Marine Laboratories, and the Southern California Water Resources Research Project (SCCWRP). A separate companion survey led by SCCWRP also assessed condition in shelf waters of the Southern California Bight using similar methods and indicators. Data from the two surveys will be integrated to provide a comprehensive assessment of ecological condition of near-coastal waters along the majority of the U.S. western continental shelf between the Canadian and Mexican borders.

A final report is expected by the end of 2007. It is anticipated that the resulting information on the condition of ecological resources in these deeper near-coastal waters will make valuable contributions to future reports in the NCCR series.

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Chapter 7

Great Lakes Coastal Condition

As shown in Figure 7-1, the overall condition of the coastal waters of the Great Lakes region between 2001 and 2002 was rated fair to poor, with an overall condition score of 2.2. The water quality and fish tissue contaminants indices for the Great Lakes are rated fair, the sediment quality index is rated poor, and the coastal habitat and benthic indices are rated fair to poor. The overall condition and index ratings were derived from indicator findings and the ecological condition of the St. Lawrence River, each of the five Great Lakes, and the St. Clair River-Lake St. Clair-Detroit River Ecosystem presented in the document *State of the Great Lakes 2003* (SOLEC, 2003), the fifth biennial report issued jointly by the governments of Canada and the United States. No additional assessment data were collected for the 2001–2002 time period since the results presented in NCCR II; therefore, the condition estimates presented in this chapter remain unchanged from that report. The next National Coastal Condition Report (NCCR IV) will present and discuss data presented in the report *State of the Great Lakes 2005* (SOLEC, 2005) to generate updated condition estimates.

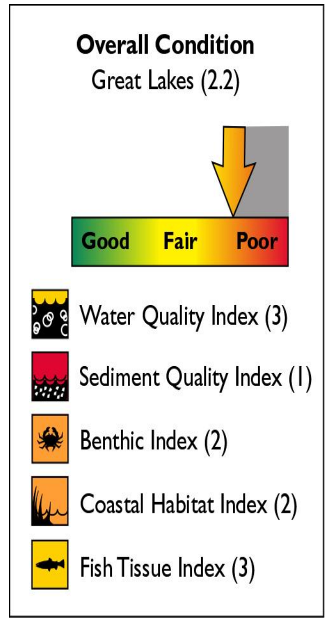

Figure 7-1. The overall condition of the coastal waters of the Great Lakes region is rated fair to poor (SOLEC, 2003).

The 158 coastal counties of the Great Lakes region support a third of the region's population and represent the third-largest coastal population in the nation. The population of Great Lakes coastal counties increased only 6% (1.5 million people) between 1980 and 2003 (Figure 7-2) (NOAA, 2004).

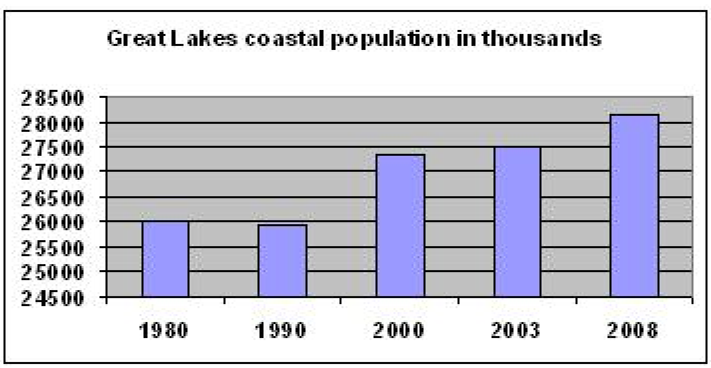

Figure 7-2. Actual and estimated population of coastal counties in the Great Lakes region from 1980 to 2008 (NOAA, 2004).

Coastal Monitoring Data – Status of Coastal Condition

Although an extensive monitoring network exists for the Great Lakes region, Great Lakes monitoring is not directly comparable to monitoring conducted under NCA for coastal estuaries and marine waters. The GLNPO uses best scientific judgment to select monitoring sites that represent the overall condition of the Great Lakes, whereas the NCA survey uses a probabilistic survey design to represent overall ecosystem condition and to attain a known level of uncertainty. The two programs use different methods, and spatial estimates of coastal condition cannot be assigned to the Great Lakes because they would be inconsistent and incomparable with those calculated for the other marine coastal regions of the United States. The GLNPO and Great Lakes scientists assess the overall status of eight ecosystem components of the Great Lakes, some of which are similar to NCA indices and indicators. The results of these efforts, along with relevant technical information are available from two Web sites: the SOLEC site available at http://www.epa.gov/grtlakes/solec/ and the GLNPO site available at http://www.epa.gov/glnpo/. These results were used to quantify and categorize NCA condition indices and component indicators for the Great Lakes in the NCCR II and will be summarized briefly in the following sections. The condition values are based primarily on expert opinion and were integrated with other regional condition data to evaluate the overall condition of the nation's coastal environment.

Water Quality Index

The NCCR II assessment combined several SOLEC indicators (e.g., eutrophic condition, water clarity, dissolved oxygen levels, phosphorus concentrations) into a water quality index to allow for comparison of water quality condition estimates for the Great Lakes with the NCA water quality index for U.S. estuaries. The NCCR II rated the Great Lakes water quality as fair. Of the four SOLEC indicators used to develop the water quality index, eutrophic condition was rated fair to poor, phosphorus concentrations were rated fair, water clarity was rated good to fair, and dissolved oxygen concentrations were rated good. It should be noted that low dissolved oxygen levels continue to be a problem in the central basin of Lake Erie during the late summer.

Sediment Quality Index

The NCCR II assessment indicated that, for the SOLEC indicators measured, the primary problem in the Great Lakes coastal waters was degraded sediment quality. The sediment quality index for the coastal waters of the Great Lakes region is rated poor, with sediment contamination contributing to the poor condition assessed in many harbors and tributaries and affecting the beneficial uses at all 31 of the GLNPO's Areas of Concern (AOC) throughout the region (Figure 7-3). Contaminated sediments also are the leading cause of fish consumption advisories for this regoion and serve as a source of contaminants to open water as a result of sediment resuspension activities (SOLEC, 2003).

Figure 7-3. Great Lakes Areas of Concern (AOCs) (GLNPO, 2004).

Benthic Index

The benthic condition of the Great Lakes as measured by benthic community health was rated fair to poor in the NCCR II. The rating was based on results of GLNPO's benthic invertebrate monitoring and surveillance monitoring programs. Populations of the benthic invertebrates *Diporiea* (in cold deepwater habitats) and *Hexagenia* (in mesotrophic habitats) were used for evaluating benthic heath because of their importance at the base of the Great Lakes food web (Figure 7-4).

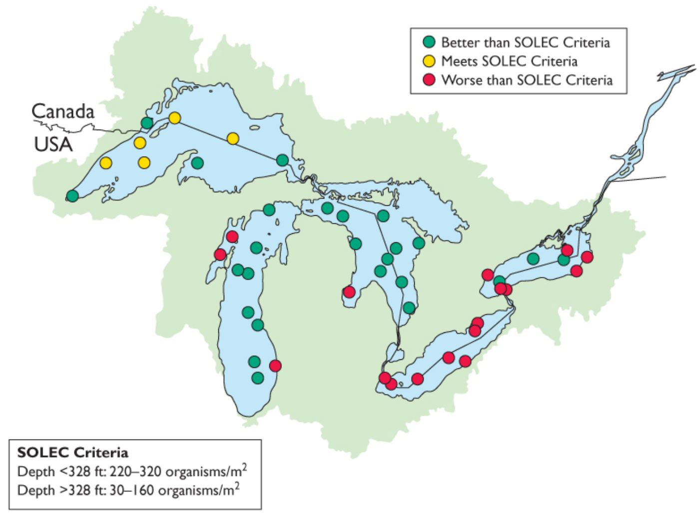

Figure 7-4. Diporiea abundance in relation to SOLEC criteria (GLNPO, 1998).

Coastal Habitat Index

More than one-half of the Great Lakes coastal wetlands were lost between 1780 and 1980, with the largest losses in Ohio (90%) and the smallest in Minnesota (42%) (Figure 7-5). The coastal habitat index used to assess the condition of Great Lakes wetland condition in the NCCR II was based on amphibian abundance and diversity, wetland-dependant diversity and abundance, areal extent of coastal wetlands by type, and the effects of water level fluctuations. Based on these measures, the coastal habitat index for the Great Lakes region is rated fair to poor.

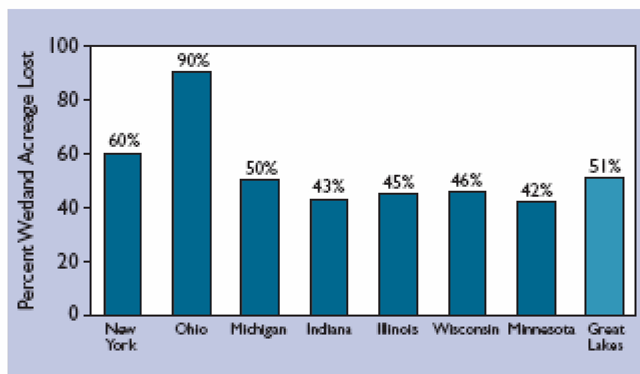

Figure 7-5. Percent coastal wetland habitat loss from 1780 to 1980 by state and for the Great Lakes overall (Turner and Boesch, 1988; Dahl, 1990).

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of the Great Lakes region is rated fair, as reported in the NCCR II. Fish advisory programs are well established in the Great Lakes states 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 present at levels that trigger fish advisories in all five Great Lakes. Great Lakes scientists rate 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 rated individually based on PCB concentrations and the corresponding fish advisory category; the final overall rating is an average of all five individual ratings (SOLEC, 2003).

Trends of Coastal Monitioring Data – Great Lakes Region

The NCCR II rated the overall condition of the Great Lakes as fair to poor for the period 1998 through 2000. No additional assessment data for the Great Lakes were collected in 2001 and 2002, the time period of the current report, therefore the analysis of trends in environmental condition estimates for the Great Lakes cannot be made at this time.

Assessment and Advisory Data

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 8 states bordering the Great Lakes had a total of 30 fish consumption advisories in effect in 2003 for the waters and connecting waters of the Great Lakes. During 2003, every Great Lake had at least one advisory, and advisories covered 100% of the Great Lakes shoreline (Figure 7-6). Michigan, which borders four of the five Great Lakes and encompasses four of the six connecting waterbodies, issued the largest number of advisories (13).

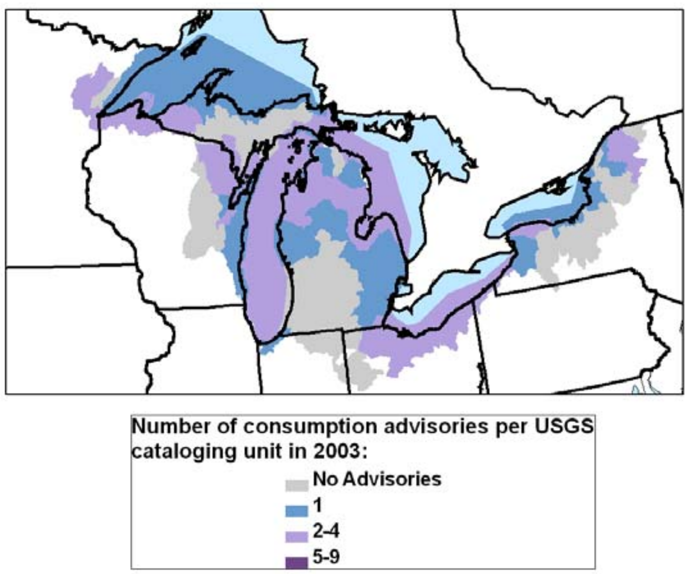

Figure 7-6. Fish consumption advisories were in effect for 100% of U.S. Great Lakes shoreline waters in 2003 (U.S. EPA, 2004b).

Great Lakes fish consumption advisories were issued for six pollutants: mercury, mirex, chlordane, dioxins, PCBs, and DDT. All of the advisories listed PCBs, and one-half (50%) also listed dioxins (Figure 7-7). Lake Superior, Lake Michigan, and Lake Huron were under advisory for at least four pollutants each in 2003 (Table 7-1); however, some of the advisories were of limited geographic extent, and advisories in most locations were applied primarily to larger, older individual fish high in the food chain.

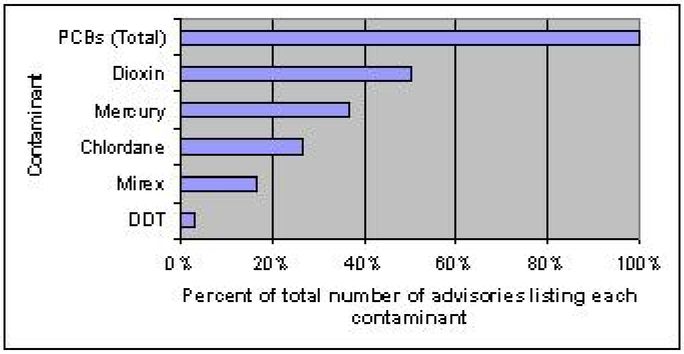

Figure 7-7. Great Lakes advisories were issued for six contaminants. An advisory can be issued for more than one contaminant, so percentages may not add up to 100 (U.S. EPA, 2004b).

Table 7-1. Fish Advisories Issued for Contaminants in Each of the Great Lakes (U.S. EPA, 2004b)

Great Lakes	PCBs	Dioxins	Mercury	Chlordane	DDT	Mirex
Lake Superior	●	●	●	●		
Lake Michigan	●	●	●	●	●	
Lake Huron	●	●	●	●		
Lake Erie	●	●	●			
Lake Ontario	●	●				●

Species and/or groups under fish consumption advisory in 2003 in at least one of the Great Lakes or connecting waters:

American eel
Black crappie
Bloater
Blue catfish
Bluegill sunfish
Bowfin
Brook trout
Brown bullhead
Brown trout
Burbot
Channel catfish
Chinook salmon
Chub
Coho salmon
Common carp
Freshwater drum
Gizzard shad
Lake herring
Lake sturgeon
Lake trout
Lake whitefish
Largemouth bass
Longnose sucker
Northern hogsucker
Northern pike
Pink salmon
Quillback carpsucker
Rainbow trout
Rock bass
Round goby
Silver redhorse
Siscowet trout
Smallmouth bass
Smelt
Splake trout
Steelhead trout
Walleye
White bass
White perch
White sucker
Yellow perch

Source: U.S. EPA, 2004b.

Beach Advisories and Closures

Of the 513 coastal beaches along the Great Lakes reported to EPA, only 33.6% (179 beaches) were closed or under an advisory for some period of time in 2003. Table 7-2 presents the number of beaches monitored and the number of beaches that were closed or under advisory for each state. The highest percentage of beaches closed or under advisory occurred in Ohio, with 100% of monitored beaches reporting at least one public beach notification in 2003 (Table 7-2). Neither Pennsylvania nor Ohio reported the number beaches monitored or advisories/closures issued in 2003. Figure 7-8 presents advisory and closure percentages for each county within each state.

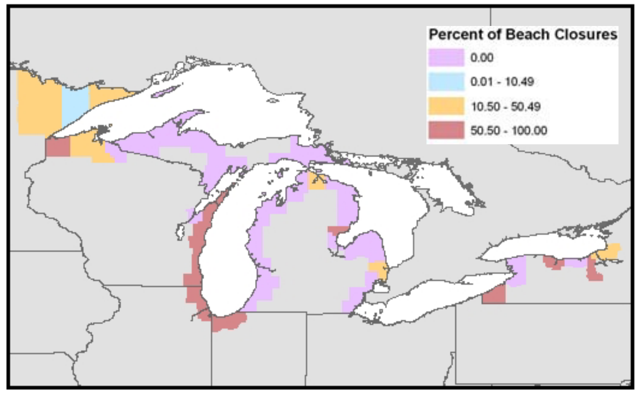

Figure 7-8. Percentage of monitored beaches on the Great Lakes with at least one advisory or closure (U.S. EPA, 2006).

Most beach advisories and closures were implemented at coastal beaches along the Great Lakes because of elevated bacteria levels (Figure 7-9). Some beaches had multiple sources of waterborne bacteria that resulted in advisories or closures. Unknown sources accounted for 89% of the responses (Figure 7-10).

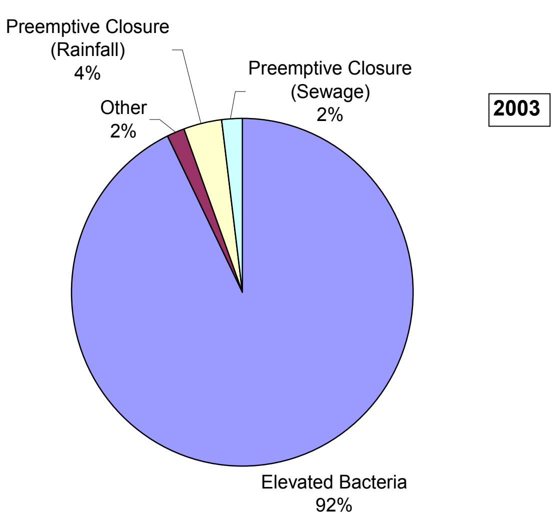

Figure 7-9. Reasons for beach advisories or closures for the Great Lakes (U.S. EPA, 2006).

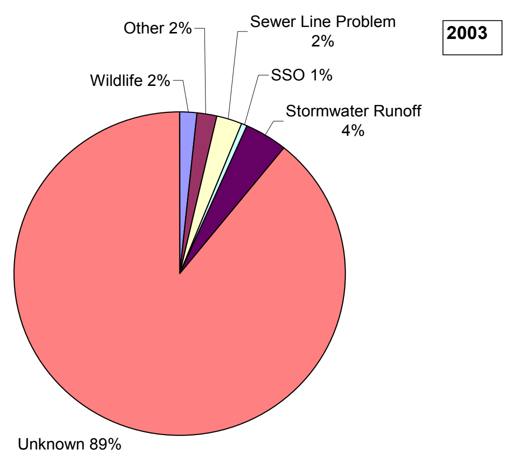

Figure 7-10. Sources of beach contamination for the Great Lakes (U.S. EPA, 2006).

Table 7-2. Number of Beaches Monitored and Beaches with Advisories/Closures in 2003 for Great Lakes Coastal States (U.S. EPA, 2006)

State	No. of Beaches Monitored	No. of Beaches With Advisories/Closures	Percentage of Beaches Affected by Advisories/Closures
Minnesota	27	5	18.5
Wisconsin	111	76	68.5
Illinois	46	33	71.7
Indiana	25	18	72.0
Michigan	276	10	3.6
Ohio	20	20	100
Pennsylvania	Not reported	Not reported	Not reported
New York	28	17	60.7
TOTALS	533	179	33.6

Summary

Although the Great Lakes has an extensive monitoring network with respect to objectives, design, and approaches, Great Lakes monitoring is not directly comparable with monitoring done by the NCA for estuarine and coastal waters. For example, GLNPO monitoring sites are at locations selected according to best scientific judgment to represent the overall condition of the Great Lakes, whereas the NCA survey monitoring sites are at locations selected using a probabilistic sampling design to yield direct, representative estimates of overall condition with known levels of uncertainty. Consequently, coastal condition spatial estimates that are consistent and comparable with those prepared for the marine coastal regions surveyed by NCA cannot be calculated for the Great Lakes. Instead, best professional judgment of knowledgeable scientists was 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 to poor using available assessment information. Future reports in the NCCR series will use the NCCR as 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 future assessments will be used as a basis to compare and integrate the overall condition of the Great Lakes with other coastal resources in this report.

Contamination in the Great Lakes has affected human uses of these waters. In 2003, there were 30 fish consumption advisories covering 100% of the shoreline of the Great Lakes. Most of these advisories were issued for PCB contamination. In addition, 33.6% of the region's monitored beaches were closed or under advisory for some period of time during 2003. Elevated bacteria levels in the region's coastal waters were primarily responsible for the closures and advisories.

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NCCR III

Chapter 7 Highlights

highlight

Residual Ballast Water and Sediments Pose Aquatic Nuisance Species Threats to the Great Lakes Ecosystem

A 3-year, multi-institutional, study completed in 2005 characterized a previously overlooked threat of nonindigenous aquatic species introductions by foreign commercial shipping into the Great Lakes ecosystem. The study was funded by the Great Lakes Protection Fund, NOAA, EPA, and the U.S. Coast Guard. The study examined both types of ballast-related threats to the Great Lakes: the regulated discharge of ballast water from vessels entering the Great Lakes from foreign ports; and the unregulated discharge from vessels, which enter the Great Lakes with no-ballast on board (NOBOB), but which subsequently take on and then discharge lake water and thereby release biota and sediment resuspended within ballast tanks. The project team included scientists from NOAA, University of Michigan, University of Windsor (Canada), Old Dominion University, and the Smithsonian Institution, as well as a ship-operations expert (Philip T. Jenkins and Associates, Ltd.) from Canada.

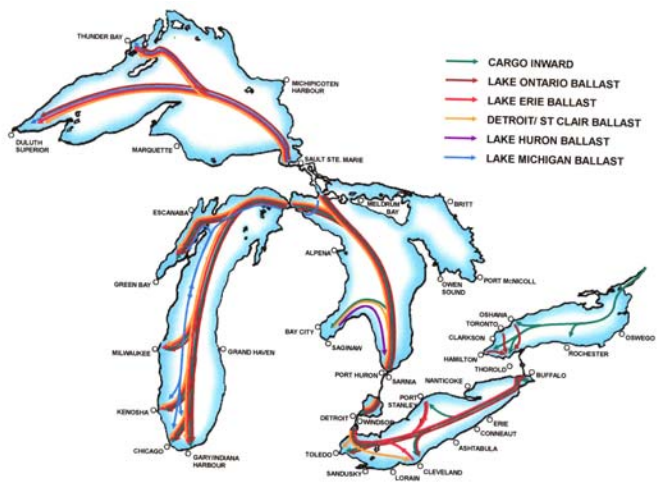

Figure 1. Pattern of transit routes of commercial shipping in the Great Lakes and areas of ballast operation (Aquatic Sciences, Inc., 1996).

NOBOB vessels are ships loaded to capacity with cargo and therefore carry no declarable ballast-on-board; however, these empty ballast tanks may hold residual water and sediment containing live organisms, their resting stages, and microorganisms, including human pathogens. Once in the Lakes, NOBOB vessels have to ballast with Great Lakes water as they offload cargo, allowing the water to mix with the foreign residuals in the ballast tanks. As outbound cargo is subsequently loaded onto these ships, the mixed ballast water containing the foreign residuals will be discharged. Ballast operations often occur at multiple ports within the Lakes during any single overseas ship transit (Figure 1), providing several opportunities for foreign organisms to be discharged. On average, about 90% of ocean-going ships entering the Great Lakes are NOBOBs and are thus not covered by the ballast water exchange regulations implemented in 1993 by the U.S. Coast Guard. These regulations require that pumpable ballast water from foreign sources must be exchanged with open-ocean water and have a salinity exceeding 30 parts per thousand.

The results of three ballast water exchange experiments conducted within this study demonstrated that exchange can be highly effective in reducing the concentration of organisms entrained with coastal ballast water. Based on changes in the concentration of salinity and rhodamine dye, the exchange efficacy with regard to the water mass ranged from 80–100%. The efficacy of exchange in removing biological specimens was more variable; however, both among and within vessels. The majority of taxa evaluated experienced changes in density between -85 % and -100% in the exchange tanks. Comparison across target taxa indicates that in most cases, ballast water exchange efficacy was >90%. Results of experiments to determine the additional benefits of "salinity shock" (replacing low salinity or freshwater ballast taken on in-port with open-ocean seawater) were highly variable depending on taxa and the form in which they are found in ballast tanks, and should be regarded with caution. The study concluded that ballast water exchange is an imperfect, but generally beneficial management practice in the absence of more effective and consistent treatment options (Johengen et al., 2005).

The team surveyed 103 NOBOB vessels about their ballast management practices and boarded 42 of those vessels to enter and sample residual water and sediment in 82 ballast tanks (Figure 2). About one-third of the 103 surveyed vessels entered the Great Lakes with freshwater residual ballast. Ships in this condition present the most serious threat of inoculation of new freshwater organisms into the Great Lakes ecosystem. The survey found the total amount of residuals (water plus sediment) per ship ranged from negligible to 200 tonnes (t), with sediment accumulation generally averaging between 10–15 t.

Figure 2. Ballast sampling includes collection of water and sediment samples to examine the diverse collection of phytoplankton and other invertebrate fauna (Great Lakes NOBOB Assessment Program, NOAA).

The presence of one or more microbial pathogens was detected in 26 of the 42 ships sampled, but the research method only determined presence, not absolute concentrations, so the study cannot definitively assign a human health risk. In general, microbial concentrations in ballast residuals covered ranges bracketing those typically found in natural aquatic environments. Although there was no evidence that the health risk is particularly high, the study suggests that a more thorough assessment of the range and frequency of concentrations of pathogens in ballast tank discharges and closer examination of their human-health implications are required.

A diverse assemblage of phytoplankton and invertebrate biota was found in the residual ballast water and sediments sampled, including several species nonindigenous to the Great Lakes. More than 80% of the samples produced significant phytoplankton growth when inoculated in freshwater media. From these grow-out experiments, 41 nonindigenous taxa were reported, although concentrations tended to be <5% of the total in most trials. The average propagule supply of new nonindigenous freshwater and brackish copepods and cladocerans potentially entering in residual sediments and water was estimated at 2.6×10^7 and 2.1×10^5 individuals per year, respectively. The density of invertebrate resting stages in ship sediments was also examined and ranged from 4.0×10^4 to 9.1×10^7 resting stages/ton of sediment.

Seventy-six distinct taxa were hatched and identified from resting eggs separated from sediment residuals, including 21 nonindigenous species.

The study concluded that results of the microbial, phytoplankton, and invertebrate analyses confirm that NOBOB vessels are vectors for nonindigenous species introductions to the Great Lakes Basin. Several lines of evidence indicated a decrease in organism abundance in ballast residuals with increasing salinity of residual water and/or flushing with open-ocean water. In addition, tanks that were regularly flushed with small amounts of open-ocean water had, in general, accumulated or retained less sediment. These findings suggest that regular flushing of the tanks with seawater may reduce (but not eliminate) the invasion risk associated with residual ballast material in NOBOB ballast tanks. In 2005, the U.S. Coast Guard issued a new policy asking NOBOB vessels entering the Great Lakes to take steps as appropriate to increase the salinity of their residual ballast water to >30 ppt by saltwater flushing, if not by ballast water exchange. In 2006, Canada began enforcing new regulations that all water in ballast tanks of ships arriving from overseas (including the residual water in NOBOBs) must have a salinity >20 ppt, achieved by ballast water exchange or saltwater flushing, in order for those ships to discharge their ballast water in the Great Lakes.

While the study provided a more comprehensive scientific basis for developing new policies and for identifying possible preventive measures and treatments, the authors recognized that managing the risk posed by NOBOB vessels is a complex problem, they suggested that such policies and solutions are best developed by participation and cooperation among all involved constituencies, including regulatory agencies, the scientific community, the shipping industry, and the public. New regulations must be carefully considered and constructed to be practicable, enforceable, and verifiable or they are likely to be ineffective.

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highlight

International Field Years on Lake Erie (IFYLE) Program

A long-term goal of NOAA is to provide enhanced ecosystem forecasts that predict patterns of biological, physical, and chemical variables in response to natural and human-induced changes to the system (e.g., extreme natural events, climate change, land and resource use, pollution, invasive species, fisheries impacts), across a variety of spatial and temporal scales. These forecasts ultimately should benefit coastal communities, including the Great Lakes, by providing the foundation for

- Improved decision-making for resource stewardship
- Mitigation of potentially hazardous human activities
- Reduced impacts of natural hazards
- Enhanced communication between scientists and managers
- More effective prioritization of science.

Water quality and ecosystem health issues persist within the Great Lakes that are of concern to the user community and researchers, and which remain a challenge to Great Lakes resource management. These include, but are not limited to, harmful algal blooms (HABs), reduced oxygen availability (hypoxia/anoxia), and introduction of exotic species, all of which have the potential to negatively influence food web dynamics, native biodiversity, and biological production (e.g., fisheries yield). Clearly, development of tools that provide reliable forecasts of the Great Lakes ecosystem and its chemical, biological, and physical subsystems would help resource agencies choose among potential management options.

To improve our ability to provide reliable ecosystem forecasts in the Great Lakes, the NOAA Great Lakes Environmental Research Laboratory (NOAA-GLERL) has been working toward development of an integrated (multi-agency), multidisciplinary research program for Lake Erie that deals with important management issues, such as HABs, hypoxia/anoxia, and fish production. Four attributes make Lake Erie ideal for developing a pilot ecosystem-forecasting framework. First, Lake Erie is small relative to coastal marine systems and the other Great Lakes, so cost-effective, field sampling can be performed to test hypotheses over the entire lake. Second, a wealth of historical monitoring and research data has been compiled for this system, which can be used for model parameterization/calibration, validation, and ecological scenario testing. Third, several predictive physical models exist for Lake Erie (watershed-hydrology and hydrodynamics models). Finally, a large research and policy infrastructure (e.g., Lake Erie Millennium Network, Lake Erie Lakewide Management Plan) already exists, which will facilitate efforts to develop truly integrative, multidisciplinary programs aimed at conducting the needed research for ecosystem forecasting.

This effort to develop a large-scale, integrative research program on Lake Erie was begun in 2005 with NOAA Ship Support. In turn, the International Field Years on Lake Erie (IFYLE) Program was initiated. This program derives largely from research hypotheses, ideas, and needs generated at a large, international Lake Erie Science Planning Workshop, hosted by NOAA-

GLERL on March 4–5, 2004, which discussed the following three important issues: (1) anoxia/hypoxia, (2) HABs, and (3) coupling physics with forecasts of fish production. A description of the workshop's goals and accomplishments can be found at http://www.glerl.noaa.gov/rsch/erie/workshops/workshop_final2004.pdf.

The three primary objectives of the IFYLE program are to

- Quantify the spatial extent of hypoxia across the lake (Figure 1) and gather information that can help forecast its timing, duration, and extent
- Assess the ecological consequences of hypoxia to the Lake Erie food web, including bacteria, phytoplankton, microzooplankton, mesozooplankton, and fish
- Identify factors that control the timing, extent, and duration of HABs (including toxin formation) in Lake Erie, as well as enhance our ability to use remote sensing as a tool to rapidly map HAB distributions in the Lake.

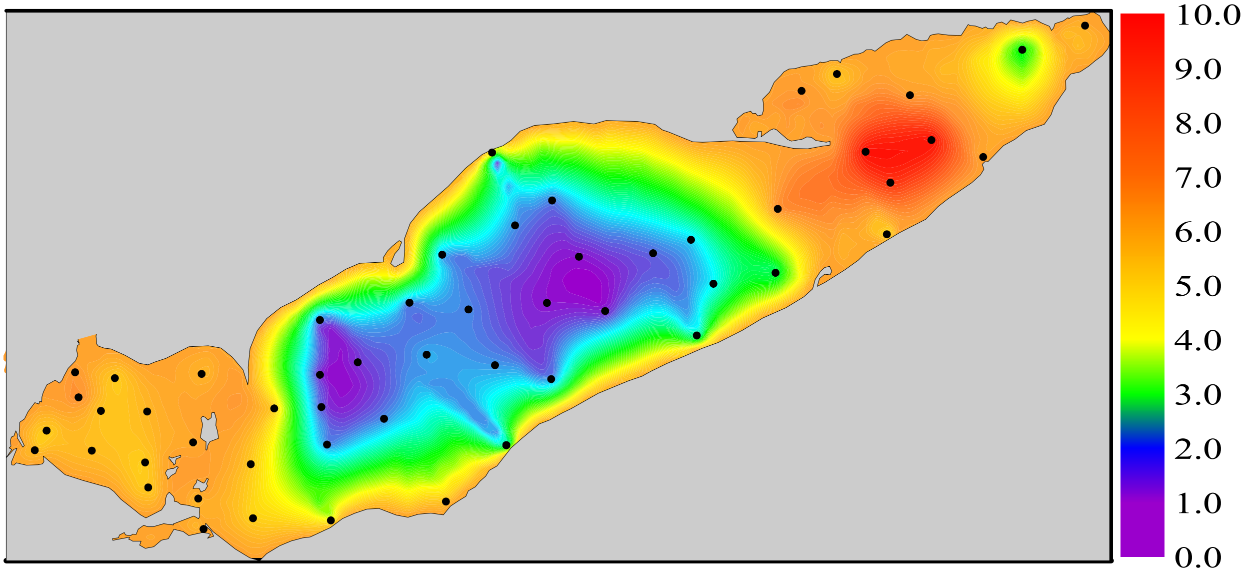


Figure 1. Preliminary estimation of dissolved oxygen concentrations (mg/L) in Lake Erie during September 7–11, 2005. Sampling stations are denoted with black dots. Note the large area of bottom hypoxia (i.e., dissolved oxygen levels < 3 mg/l) in central Lake Erie, which can be stressful to fish. The thickness of this low-oxygen layer ranged from 1 to 7 m above the lake bottom (surface waters had sufficient oxygen). (Source: Stuart Ludsin, NOAA, GLERL).

The IFYLE program has become the largest international, multidisciplinary research effort of its kind in Lake Erie's history, costing ~$5 million and involving ~ 40 scientists from NOAA, academia, and private institutions throughout North America, Canada, and Europe. This program can truly be considered integrative, given involvement by numerous U.S. and Canadian universities and federal, state, and provincial agencies, and serves as an example of how NOAA and other federal agencies are fulfilling the Presidential Executive Order (#13340) (Woolley, et. al., 2004) to execute the Great Lakes Regional Collaboration among agencies. Vessel support comes primarily from NOAA Ship Support, the EPA-GLNPO, and NOAA-GLERL, whereas the National Sea Grant College Program and the Ohio and New York Sea Grant College programs funded external researchers. Environment Canada deployed several moorings to collect physical data in collaboration with this program, while the USACE provided continuous dock space for NOAA vessels. In addition, the project has been offered in-kind support (e.g., historic data, technical assistance with determining the age of fish, vessel support) from all of the state and provincial fishery management agencies on the lake, including the Ohio Department of Natural Resources, the New York State Department of Environmental Conservation, the Michigan Department of Natural Resources, the Pennsylvania Fish and Boat Commission, and the Ontario Ministry of Natural Resources.

The 2005 field program centered on determining the factors regulating the distribution of oxygen concentrations in Lake Erie (Figure 1) and the consequences of low oxygen on the abundance, distribution, and condition of fish and their prey. The remainder of 2005 and all of 2006 were devoted to sample processing, data analysis, testing and refining hypotheses, and building models that can be used for both understanding and forecasting purposes. During 2007, we expect to conduct another intensive field season, with more focused sampling objectives.

For additional information on the IFYLE program, see http://www.glerl.noaa.gov/ifyle/, or contact Dr. Stuart A. Ludsin (Stuart.Ludsin@noaa.gov) and Dr. Stephen B. Brandt (Stephen.B.Brandt@noaa.gov), co-coordinators of the IFYLE program, Ann Arbor, MI.

References

John Woolley and Gerhard Peters, *The American Presidency Project* [online]. Executive Order 13340 - Establishment of Great Lakes Interagency Task Force and Promotion of a Regional Collaboration of National Significance for the Great Lakes. May 18, 2004. Santa Barbara, CA: University of California (hosted), Gerhard Peters (database). Web site: http://www.presidency.ucsb.edu/ws/?pid=61434.

Chapter 8

Coastal Condition for Alaska, Hawaii, and Island Territories

Currently, very little routine monitoring of coastal resources occurs in Alaska, Hawaii, and the island territories of the Pacific or Caribbean regions. EPA Regions 2 (Puerto Rico and U.S. Virgin Islands), 9 (Hawaii, Guam, the Northern Mariana Islands, and American Samoa), and 10 (Alaska), as well as the attendant state resource agencies, conduct some water quality monitoring, but it is often irregular and focused on specific locations or site-specific pollution problems. No consistent monitoring programs cover all the coastal resources in these states, territories, and commonwealths. Efforts conducted through EPA's NCA are starting to fill this void for Alaska (ongoing), Hawaii, Puerto Rico, the U.S. Virgin Islands, Guam, and American Samoa; however, no plans are currently in place to survey conditions associated with the Northern Mariana Islands. This chapter briefly describes the surveys and presents the assessment findings from monitoring conducted in south-central Alaska and in Hawaii during 2002. The southeastern region of Alaska was surveyed in 2004, and there are plans to assess the vast Aleutian Islands region of Alaska in 2006–2007. Puerto Rico, the U.S. Virgin Islands, Guam, and American Samoa were assessed in 2004–2005, and Hawaii will be resurveyed in 2006; however, the results of these were not available for inclusion in this report.

Alaska

The overall condition of Alaska's south–central coastal waters is rated good, based on three of the indices assessed by NCA (Figure 8-1). The water quality, sediment quality, and fish tissue contaminants indices for Alaska are each rated good, and the NCA was unable to evaluate the benthic and coastal habitat indices. Figure 8-2 provides a summary of the percentage of coastal area rated good, fair, poor, or missing for each index and component indicator. This assessment is based on environmental stressor and response data collected from 55 locations along Alaska's south-central coastline in 2002. Please refer to Tables 1-23, 1-24, and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

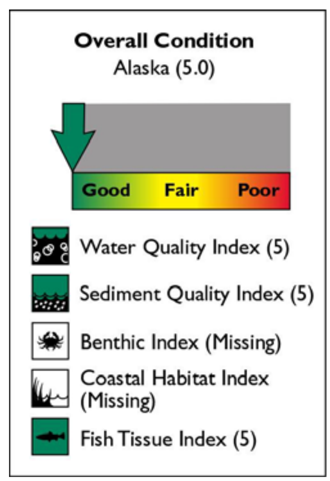


Figure 8-1. The overall condition of Alaska's south-central coastal waters is rated good (U.S. EPA/ NCA).

Alaska has a marine shoreline length of approximately 45,000 miles, constituting more than 50% of total U.S. coastline miles. The surface area of coastal bays and estuaries in Alaska is 33,211 mi^2. Much of the southeast and south-central Alaska coast is very convoluted, resulting from the formation of hundreds of bays, estuaries, coves, fjords, and other coastal features. Most of Alaska's extensive coastline is inaccessible by road, which makes a statewide coastal monitoring program both extremely difficult and expensive.

Alaska's coastal resources are generally in pristine or near-pristine condition due to Alaska's low population density, the distance between most of its coastline and major urban or industrial areas, and limited agriculture activities. This condition provides a unique opportunity for the NCA to collect a baseline data for Alaska's coastal regions from which to assess future changes. This baseline information gained will help environmental and resource managers keep Alaska's ecosystems healthy during a time when increasing levels of resource development are expected. Contaminant concentrations have been measured at levels significantly lower than those in the rest of the coastal United States; however, contaminants such as persistent organic pollutants (POPs) and mercury have been observed accumulating in the Alaska marine food web, raising ecological and human health risk concerns (AMAP, 2004a; 2004b). In a recent report, POPs were identified as a particular concern in Alaska, in part because of the subsistence lifestyle of many Native Alaskan communities (Chary, 2000).

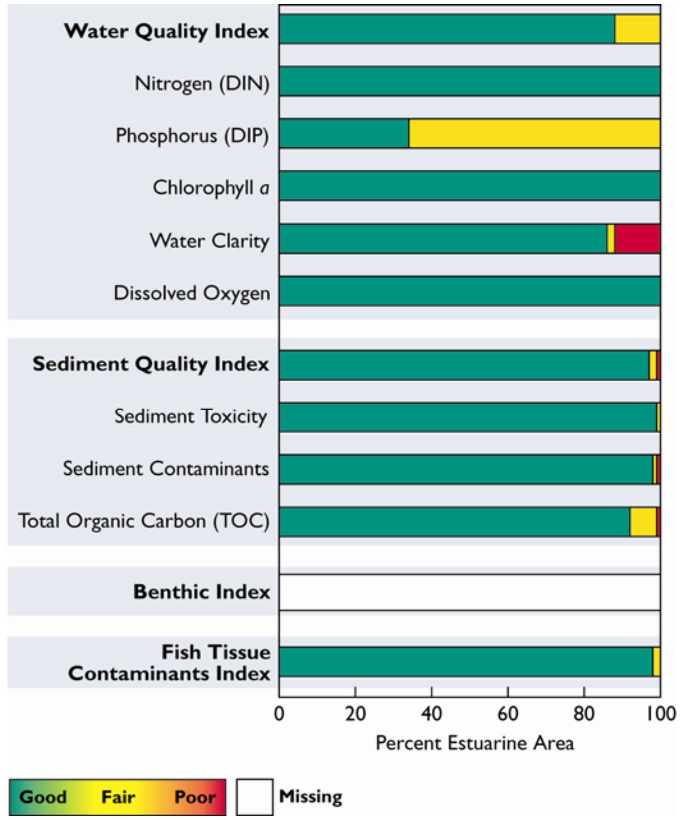


Figure 8-2. Percentage of coastal area achieving each ranking for all indices and indicators–Alaska's south-central coast (U.S. EPA/ NCA).

Although localized pollution sources exist in Alaska, long-range atmospheric and oceanic transport from more developed population and industrial centers are believed to be responsible for the majority of the contaminants deposited in Alaska. In addition, the coastal environment in Alaska may represent long-term sinks for POPs and mercury due to the processes of cold condensation and the polar solar sunrise effect (AMAP, 2004a; 2004b). For example, even though this region has a low human population density, Steller sea lions and sea otters in the Aleutian Islands exhibit high levels of POPs and methylmercury compared to specimens from other regions, such as California and Southeast Alaska (Bacon et al., 1999; Barron et al., 2003). Overall, the Arctic, including Alaska's coastal arctic region, is now seen as a potential sink for significant amounts of bioavailable mercury (Ebinghaus et al., 2004). Rapid economic development in Asia coupled with the long-range atmospheric transport of contaminants suggest the potential for increasing levels of some contaminants in Alaska (Wright et al., 2000; AMAP, 2004a; 2004b).

Between 1980 and 2003, coastal counties along the Alaskan Coast showed the largest rate of population increase (63%) of any coastal region in the entire United States. In addition, the population of Matanuska-Susitna County grew by more that 200%, which was the third-largest population change in the nation over that period of time. Figure 8-3 presents population data for Alaskan coastal counties since 1980 (NOAA, 2004).

Coastal Monitoring Data – Status of Coastal Condition

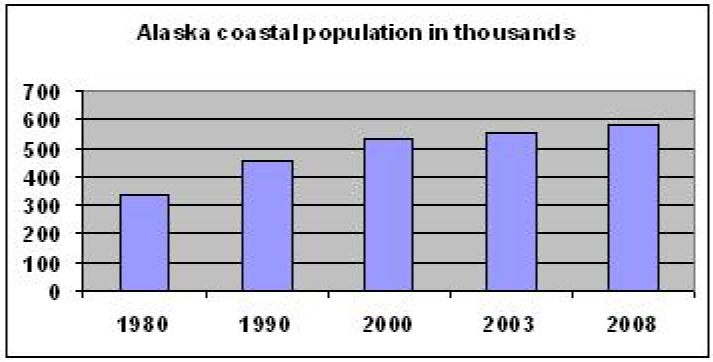


Figure 8-3. Actual and estimated population of coastal counties in Alaska from 1980 to 2008 (NOAA, 2004).

In 2001, the NCA developed a sampling design in conjunction with Alaska Department of Environmental Conservation (ADEC) and EPA Region 10 to assess all of the coastal resources in Alaska by monitoring 250 sites spread throughout the state. Because of the geographic expanse of Alaska, the reduced sampling window in Arctic regions, and the unique fiscal and logistical challenges of sampling the state's coastal resources, it was 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 phases—southeastern Alaska, south-central Alaska, the Aleutian Islands, the Bering Sea, and the Arctic region (Figure 8-4). Each sampling phase surveys one of these five areas, and the target schedule for the completion of statewide surveys would be 5 to 10 years. Before this collaboration between Alaska's resource agencies and EPA, ADEC routinely assessed only about 1% of the state's coastal resources, focusing its efforts on waterbodies known or suspected to be impaired (ADEC, 1999). In June 2005, ADEC released its *Water Quality Monitoring and Assessment Strategy* and *Environmental Monitoring & Assessment Program Implementation Strategy* to guide its stewardship of Alaska's marine and freshwater resources (ADEC, 2005b; 2005a).

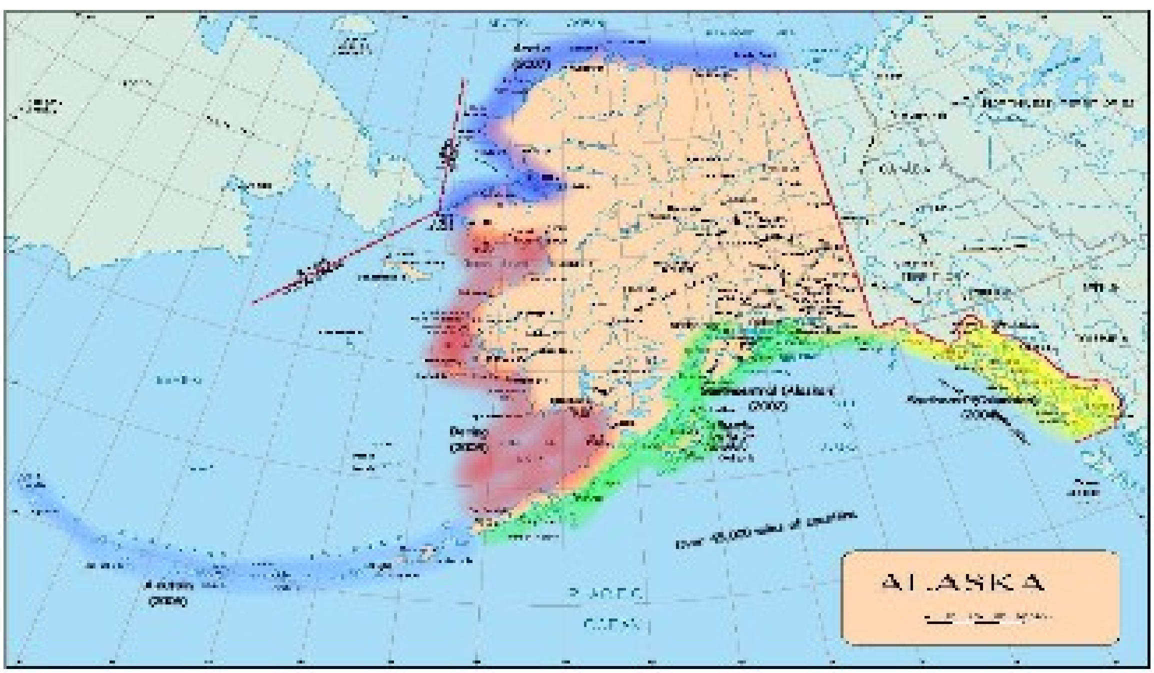


Figure 8-4. Five Alaskan provinces used in the NCA sampling design (ADEC).

The sampling conducted by the EPA's NCA 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.

In 2002, Alaska's south-central Coast (Alaskan Province) was selected as the first portion of the state to be assessed by the NCA because of the importance of this area's major estuarine resources (Prince William Sound and Cook Inlet) to aquatic living resources, as well as to the local and state economies. Due to the long distances between sites (even in this reduced area), the surveys were conducted using a large (100-foot), ocean-going research vessel equipped with a powered skiff for shallow water work. The survey collected data at sites with approximate depths ranging from 13 to 1,155 feet. Many of the shallowest stations occurred in nearshore areas of Cook Inlet known for wide intertidal depth fluctuations and extensive sediment depositional zones. The deepest stations occurred in Prince William Sound. A draft report on the 2002 sampling effort in south-central Alaska was produced by ADEC in September 2005 and is currently in review.

The environmental index and indicator data collected during the survey of the south-central region correspond to the parameters that will be collected in future surveys of the other regions. Alaska's southeastern coast (Juneau and the island passage area) was assessed by NCA in 2004, and a report on the results of this survey's will be produced in 2007.

Water Quality Index

The water quality index for the coastal waters of south-central Alaska is rated good. This index was developed based on measurement of five component indicators: surface DIN and DIP concentrations, chlorophyll *a*, water clarity, and bottom dissolved oxygen. Most (88%) of the coastal area was rated good for water quality condition, with the remainder of the area rated fair (Figure 8-5). Fair conditions were largely due to elevated DIP concentrations or low water clarity measurements, both of which are likely the result of naturally occurring conditions and not human influences.

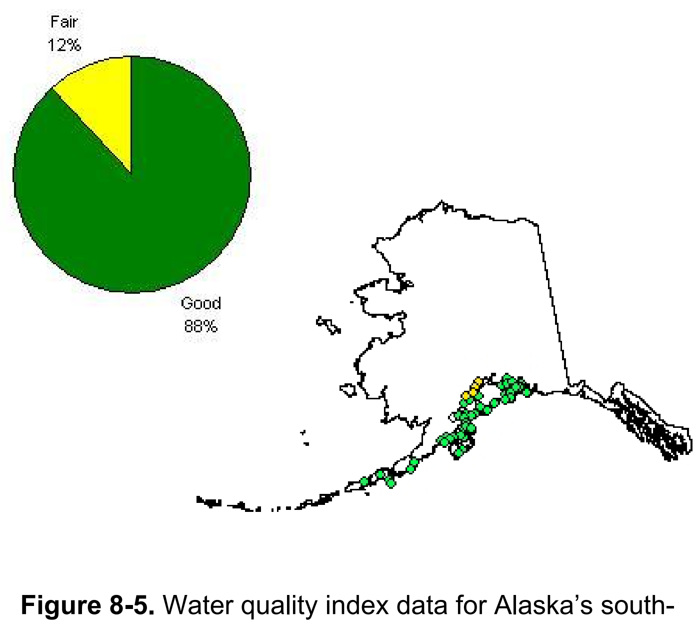


Figure 8-5. Water quality index data for Alaska's south-central coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

DIN concentrations in the coastal waters of south-central Alaska are rated good, with 100% of the coastal area rated good for this component indicator. DIP concentrations are rated fair for south-central Alaska's coastal waters, with 66% of the coastal area rated fair. Historic data suggest that, on a seasonal basis, a significant upwelling influence of deeper Gulf of Alaska waters supplies nutrients to the lower waters of Cook Inlet. This seasonal supply of nutrients may account for the high productivity rates measured in late summer, which result in some of the most productive high-latitude shelf waters in the world (Larrance et al., 1977; Sambrotto and Lorenzen, 1986).

Chlorophyll *a*

Chlorophyll *a* concentrations in south-central Alaska's coastal waters are rated good, with 100% of the coastal area rated good for this component indicator. Although no areas of Alaska showed high concentrations of water column chlorophyll *a*, this may not indicate low, land-based loading of nitrogen and phosphorus. Many Alaskan waters have large intertidal areas, so nutrient utilization by benthic algae may be of greater importance than nutrient uptake by phytoplankton; however, data are not currently available to address this issue.

Water Clarity

Water clarity in the coastal waters of south-central Alaska is rated fair, with 12% of the coastal area rated poor for this component indicator. Water clarity was rated poor at a sample site if light penetration at 1 meter was less than 10% of surface illumination. The coastal area rated poor represents only four sites, which were located in the Upper Cook Inlet area. At these sites, very high loadings of glacial river sediments occur during the summer peak-flow period. Three of the area's primary glacial rivers (the Knik, Matanuska and Susitna rivers) have a combined peak discharge of about 24 million gallons/second in July and August and contribute, on average, more than 250,000 lb of suspended sediment per day to Upper Cook Inlet (MMS, 1996, 1995). These waters then mix with the more saline waters in Cook Inlet and flow along the western edge of the Inlet to Shelikof Strait. Thus, the low levels of light penetration observed at the four sampling sites are indicative of naturally occurring conditions representing summer high-flow inputs of suspended sediments at the time of sampling. During the period of low flow in the winter, glacial river inputs and suspended sediment loadings significantly decrease. In addition, the large tidal amplitude occurring along the south-central Alaska coast may contribute to re-suspension of deposited glacial river suspended sediments.

Dissolved Oxygen

Dissolved oxygen conditions in the coastal waters of south-central Alaska are rated good, with 100% of the coastal area rated good for this component indicator. Although conditions in the south-central Alaska region appear to be generally good for dissolved oxygen, measured values reflect daytime conditions, and it is possible that some areas may still experience hypoxic conditions at night.

Sediment Quality Index

The sediment quality index for the coastal waters of south-central Alaska is rated good, with only 1% of the coastal area exceeding thresholds for sediment toxicity, sediment contaminants, or sediment TOC (Figure 8-6). There were very few instances where any of the component indicators were rated either fair or poor.

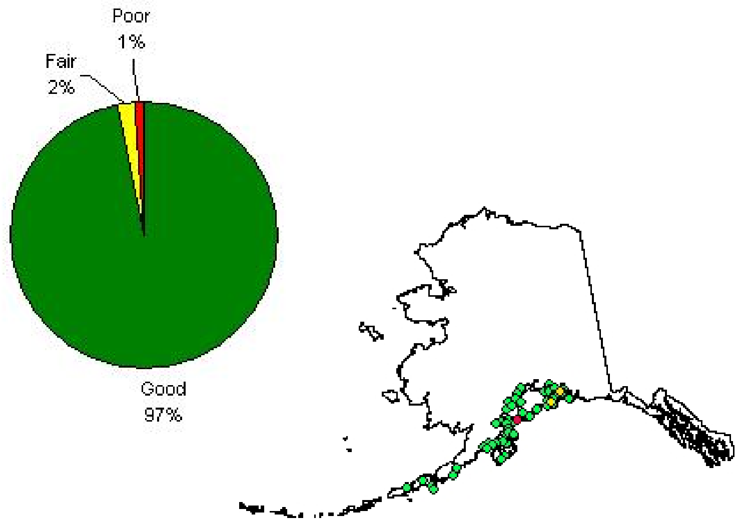


Figure 8-6. Sediment quality index data for Alaska's south-central coastal waters (U.S. EPA/NCA).

Sediment Toxicity

Sediment toxicity for south-central Alaska's coastal waters is rated good, with only 1% of the coastal area rated poor. Sediment toxicity was determined using a static 10-day acute toxicity test with the amphipod *Ampelisca abdita*. Although use of *Ampelisca* standardizes the sediment toxicity test within the EMAP-NCA process, this test may or may not reflect the actual response of the specific benthic organisms indigenous to Alaska. The State of Alaska has yet to select specific benthic species for use in sediment toxicity studies, but considers the EMAP work important in supporting future efforts to develop a sediment toxicity test for Alaska. One of the areas rated poor for sediment toxicity also had the highest chromium and nickel concentrations of any of the areas sampled in south-central Alaska during this survey. These trace metals are likely elevated due to the historic chromium mining operations in this area. The other area rated poor for sediment toxicity exhibited the highest percent TOC measurement (6.43%) of any NCA site sampled in south-central Alaska. These elevated TOC measurement were influenced by the large amount of decomposing eelgrass mixed in with this sediment sample. Elevated trace metal and TOC levels have been shown to be detrimental to some benthic organisms.

Sediment Contaminants

The coastal waters of south-central Alaska are rated good for sediment contaminant concentrations, with 1% of the coastal area rated good and 1% of the area rated fair for this component indicator. It should be noted that this evaluation of sediment contamination excluded nickel because the ERM value for this metal has a low reliability for areas of the West Coast, where high natural crustal concentrations of nickel exist (Long et al., 1995). A study of metal concentrations in cores collected along the West Coast determined the range of historic background concentrations of nickel to be 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 of Alsaka's coastal waters. In addition, only one exceedance was counted if a site exceeded the ERL for low molecular weight PAHs, high molecular weight PAHs, and/or total PAHs to ensure that the analysis was not biased by PAHs. The area rated poor was located in Chrome Bay and exhibited elevated levels of chromium. The area rated fair was located in

Prince William Sound, where elevated levels of metals (chromium, copper, zinc) and individual PAHs were detected.

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 TOC

The coastal waters of south-central Alaska are rated good for the TOC component indicator. One site, representing about 1% of the area of the south-central Alaska's coastal waters, was rated poor. The poor rating at this site was influenced by the large amount of decomposing eelgrass present in this sediment sample. Another 7% of the coastal area was rated fair. These sites are spatially separated, span a range of depths, and may contain elevated levels of organic matter deposited from natural rather than anthropogenic sources.

Benthic Index

The benthic index for the coastal waters of south-central Alaska could not be evaluated. Although several efforts are underway 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 benthic community index applicable for south-central Alaska. In lieu of a benthic index for south-central Alaska, 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. This approach requires that species richness can be predicted from salinity, and, in the case of the Alaska survey data, the regression was not significant.

Coastal Habitat Index

Although estimates of habitat loss are available for Alaska as a whole, data were not available to correspond with the geographic region sampled by NCA survey; therefore, a coastal habitat index could not be calculated for the coastal waters of south-central Alaska.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of south-central Alaska is rated good. Two-percent of the sites where fish were caught were rated fair due to mercury concentrations within the range of concern measured in one fish (Figure 8-7).

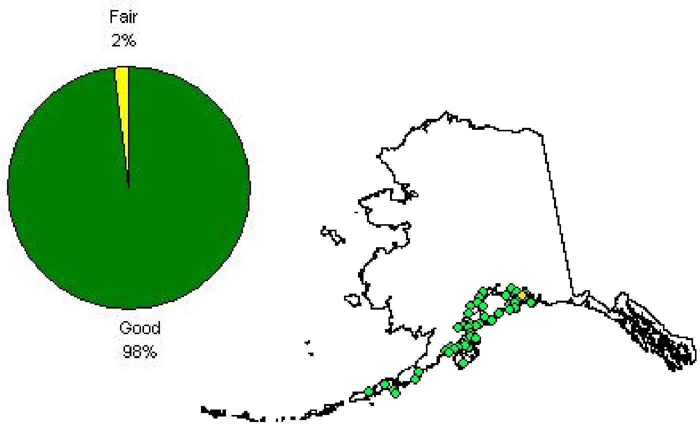


Figure 8-7. Fish tissue contaminants index data for Alaska's south-central coastal waters (U.S. EPA/NCA).

Trends of Coastal Monitoring Data – Alaska

The 2002 NCA survey of Alaska's south-central coastal waters was the first probabilistic survey of its kind in the state. 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 were collected through this program. Although much of these data remain difficult to locate, a summary may be found in Hood and Zimmerman (1986). Numerous assessments have also been conducted along the portion of Alaska coastline affected by the Exxon *Valdez* oil spill in 1989, and this area continues to be monitored. In addition, 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, and measured contaminants in intertidal mussels and sediments as part of its Mussel Watch Program. Due to a lack of comparable data in the region, trends could not be evaluated for Alaska's south-central coastal waters at this time.

Large Marine Ecosystem Fisheries Gulf of Alaska and East Bering Sea

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 conditions 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.

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 the inshore transport of crab larvae to coarse, shallow water habitats in inner Bristol Bay, which serve as nursery areas for red king crabs to find refuge among biogenic structures (Rosenkranz et al., 1998; 2001). Timing and composition of the plankton blooms may also be important because red king crab larvae prefer to consume diatoms (phytoplankton), whereas Tanner crab larvae prefer copepod nauplii (zooplankton).

Salmon Fisheries

A number of factors have contributed to the high abundance of Pacific salmon currently in the Gulf of Alaska ecosystem. 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 LME may be underway, possibly reflecting the downturn in abundance of Alaska salmon runs observed in 1996 and 1997. Historical commercial landings show a distinct cyclic pattern of alternating high and low harvests, often lasting decades. Much of this fluctuation is now believed to be due to interdecadal climate oscillations in the ocean environment that affect marine survival of juveniles (NMFS, 2006). A pattern associated with Alaska's cyclic salmon harvest is an inverse production regime with abundance levels of California Current LME salmon.


Southeast Alaska Chinook salmon (NOAA/NMFS).

All five species of Alaska salmon (pink, sockeye, chum, coho, and Chinook) are fully utilized, and stocks in most regions of the LMEs have rebuilt to near or beyond previous high levels. Although there has been a high abundance of salmon, there are issues of serious concern for these stocks, especially for some species and regions. Stocks in western Alaska, especially Chinook and chum salmon, have generally been at depressed levels since the mid-1990s. Some of the same issues implicated in the declines of California Current salmon stocks in the Pacific northwest are of concern in certain areas of Alaska, including overfishing, incidental take of salmon as bycatch in other fisheries, and loss of freshwater spawning and rearing habitats (NMFS, 2006).

Alaska commercial salmon harvests generally have increased during the lpst three decades. After reaching record-low catch levels in the 1970s, most populations rebounded, and fisheries in recent years have been at or near all-time peak levels in many regions of the ecosystems. The record-high commercial landings of 218 million salmon in 1995 were 17% higher than the previous record of 196 million salmon in 1994. Throughout the mid- to late 1990s, recreational and subsistence fishermen harvested between 2 and 3 million salmon annually (NMFS, 2006).

Beach seining for juvenile pink and chum salmon (NOAA/NMFS, Northwest Fisheries Science Center).

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 LME, spawning fish concentrate mainly off southeast Alaska in Prince William Sound and around the Kodiak Island-Cook Inlet area. In the East Bering Sea LME, the centers of abundance are in northern Bristol Bay and Norton Sound.

The Gulf of Alaska ecosystem herring industry began as early as 1878, when 30,000 pounds were marketed for human consumption. The fishery expanded rapidly in the late 1800s and early 1900s, with markets shifting from salt-cured herring to reduction products for fishmeal and oil. By 1934, the catch from the Gulf of Alaska LME alone had reached a record 140,000 mt. The East Bering Sea LME fishery began in the late 1920s, initially with a small salt-cure plant in Dutch Harbor. A large foreign offshore fishery developed in the 1950s and peaked in 1970 at over 145,000 mt. It then fell off sharply to 16,000 mt in 1975. Since 1977, Bering Sea herring have been harvested primarily in inshore sac roe fisheries, and catches have risen slowly, but steadily, since that time. A portion of the Bering Sea harvest is taken as bycatch in the offshore federally managed groundfish fishery. Retention of herring in these fisheries is prohibited, with regulations limiting herring bycatch to no more than about 1,000 mt annually (NMFS, 2006).

Currently, the herring populations in both LMEs remain at moderate levels and are in relatively stable condition, with the exception of the Prince William Sound and Cook Inlet areas. Populations of Prince William Sound herring continue to be depressed from a disease outbreak in 1993. In more recent years, Alaska herring harvests have averaged about 35,000 mt, with a value averaging around $10 million (NMFS, 2006).

Groundfish Fisheries

The groundfish complex is the most abundant of all fishery resources in the Gulf of Alaska and the East Bering Sea LMEs, with a biomass of more than 26.4 million mt. From 1999 to 2001, groundfish catches averaged 1.8 million mt. Prior to 1976, the only groundfish species of significant commercial value to domestic fisheries was Pacific halibut, with foreign fisheries harvesting most other targeted commercial species. 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 (NMFS, 2006).

The average East Bering Sea LME (including the Aleutian Islands) groundfish catch from 2001–2003 was just over 1.9 million mt, compared to the 1997 catch of 1.74 million mt. The dominant species harvested were walleye pollock (76%), Pacific cod (10%), yellowfin sole (4%), Atka mackerel (3%), and rock sole (2%) (NMFS, 2006).

Groundfish biomass has been maintained at relatively high levels since implementation of the Magnuson-Stevens Act. Walleye pollock produce the largest catch of any single species inhabiting the U.S. EEZ. The Eastern Bering Sea stock can be considered to be slightly underutilized because its catch quota has been reduced from its full current yield to reduce the risk of overfishing and to mitigate the food competition with species that prey on pollock, including marine birds and the endangered Steller sea lion (NMFS, 2006).

Groundfish abundance in the Gulf of Alaska has increased since 1977, peaking at 5.3 million mt in 1982 and 1988, and most recently in 1997 at 5.49 mt. Abundance since then has remained relatively stable, fluctuating between about four and five million mt. The average yield for 2001–2003 for Gulf of Alaska groundfish was nearly 200,000 mt. Gulf of Alaska groundfish catches have ranged from a low of 129,640 mt in 1978 to a high of 352,800 mt in 1984. Groundfish catches are dominated by walleye pollock, followed by Pacific cod, flatfish, and rockfish. Groundfish catches since 1989 have fluctuated around 200,000 mt. Pollock abundance increased dramatically during the 1970s, peaked in the mid-1980s, and subsequently declined. Current abundance is similar to stock size in the early 1970s. Current evidence suggests that extreme variation in pollock abundance is primarily a result of environmental forcing. Pollock are carefully managed due to concerns about fisheries impacts on endangered and threatened Steller sea lions, as pollock are a major prey item of Steller sea lions in the Gulf of Alaska. Sea lion protection measures include closed areas around rookeries and "haul outs"; apportionment of the western-central Gulf of Alaska pollock total allowable catch among three years and four seasons; and the use of a more conservative harvest policy to determine the acceptable biological catch. Pollock in this area are considered fully utilized, and Pacific cod is considered healthy and fully utilized. In general, flatfish are abundant, largely due to great increases in arrowtooth flounder biomass, and underutilized due to halibut bycatch considerations. Rockfish (slope rockfish, pelagic shelf rockfish, thornyhead rockfish, and demersal shelf rockfish) are conservatively managed due to their long life spans and consequent sensitivity to over-exploitation (NMFS, 2006).

Shellfish Fisheries

Major shellfish fisheries were developed in the 1960s in the Gulf of Alaska LME and subsequently expanded to the East Bering Sea LME. Shellfish landings in 2003 generated an estimated ex-vessel value of $181.6 million, compared with the ex-vessel value of $151 million in for 1997; king and snow crabs account for a majority of this value ($161 million). To protect the crab resource and to maintain product quality, quotas, seasons, and size and sex limits restrict catches, with landings limited to large male crabs. Seasonal closures are set to avoid fishing during times when crabs are molting or mating, and during soft-shell periods. Since 1999, exploratory fisheries on new deep-water stocks of scarlet king crab, grooved Tanner crab, and triangle Tanner crab have begun; however, they have produced only minor landings to date (NMFS, 2006).

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 in the two major LMEs of Alaska. Alaska crab resources are fully utilized. In 2004, two Alaska crab stocks (Blue king crab, St. Matthew Island; Tanner crab, Eastern Bering Sea) were determined to be overfished. There are rebuilding plans for these species, and fishing of these species is not allowed.

The northern pink shrimp is the most important of the five species that comprise Alaska shrimp landings. The domestic shrimp fishery in western Alaskan waters is currently at a low level, and shrimp abundance is too low in the Bering Sea to support a commercial fishery. The western Gulf of Alaska LME 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 LMEs are not well understood (NMFS, 2006).

Assessment and Advisory Data

Fish Consumption Advisories

No consumption advisories were in effect for chemical contaminants in fish and shellfish species harvested in Alaskan waters in 2003 (U.S. EPA, 2004b).

Beach Advisories and Closures

Alaska did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006b).

Hawaii

The overall condition of Hawaii's coastal waters is rated good based on two of the indices assessed by NCA (Figure 8-8). The water quality index is rated good, and the sediment quality index is rated good to fair. The NCA was unable to evaluate the benthic, coastal habitat, or fish tissue contaminants indices for Hawaii's coastal waters. Figure 8-9 provides a summary of the percentage of coastal area rated good, fair, poor, or missing for each index and component indicator. This assessment is based on environmental stressor and response data collected by the NCA, in conjunction with state agencies, Region 9, and the University of Hawaii, from 79 locations along the islands of the Hawaiian chain in 2002. Please refer to Tables 1-24 and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

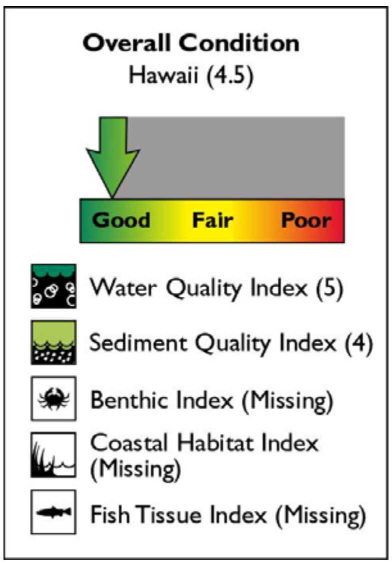


Figure 8-8. The overall condition of Hawaii's coastal area is rated good (U.S. EPA/ NCA).

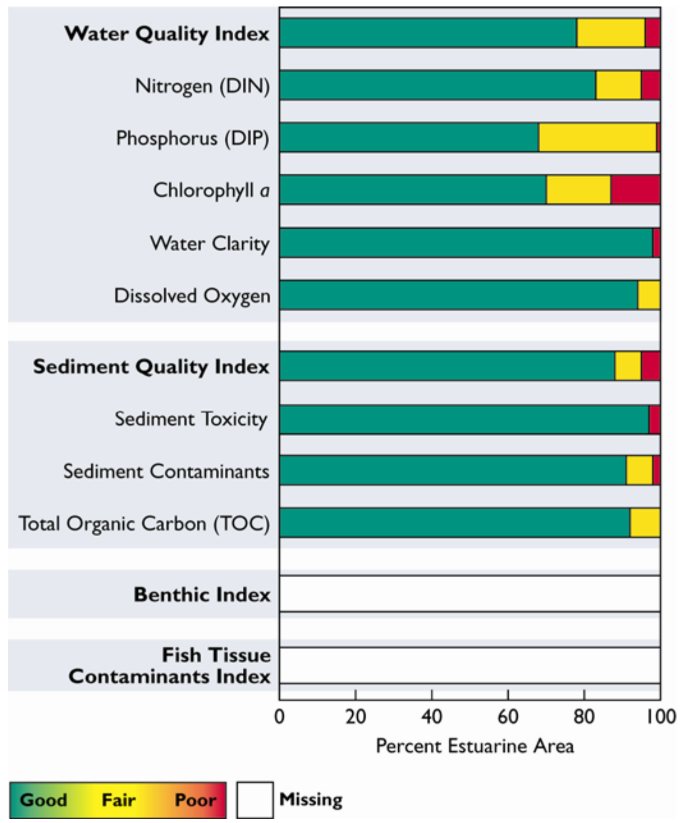


Figure 8-9. Percentage of coastal area achieving each ranking for all indices and indicators –Hawaii (U.S. EPA/ NCA).

The Hawaiian Islands are the most isolated archipelago in the world. This isolation has resulted in Hawaii's flora and fauna having the highest percentage of endemic species anywhere in the world. This singular distinction has a downside: Hawaii has suffered the greatest number of known extinctions of fauna and flora during the past 200 years due to the development and westernization of the islands (Loope, 1998).

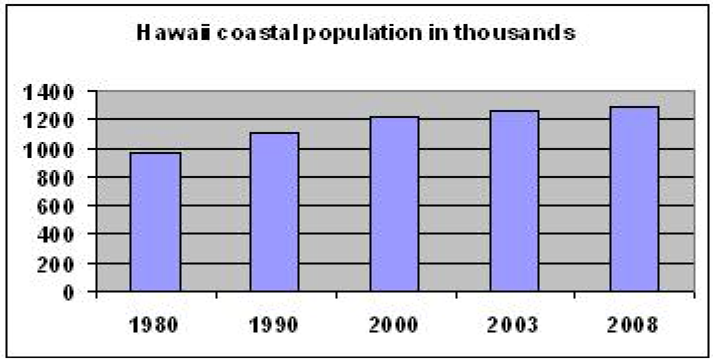


Figure 8-10. Actual and estimated population of Hawaii from 1980–2008 (NOAA, 2004).

The human population of Hawaii has fluctuated over time. Following contact with the West, disease took its toll on the native population of the islands, and there were less than 60,000 individuals remaining by the 1870s. By 1900, the total population had grown to 154,000 people, primarily through the importation of labor for agriculture. Figure 8-10 shows that the population of Hawaiian coastal counties increased by 0.3 million people (30%) between 1980 and 2003 (NOAA, 2004). As of 2004, Hawaii's population exceeded 1.2 million people, and more than 90% of residents lived in urban centers (U.S. Census Bureau, 2006). Because of the relatively small land area of the Hawaiian Islands, development, increases in population, and economic growth have all exacerbated the impacts to native ecosystems. Human population growth in Hawaii is a principal driver for many ecological stressors (e.g., habitat loss, pollution, and nutrient enhancement), which may alter coastal ecosystems and affect the sustainability of coastal ecological resources. Increased globalization of the economy is a major driver influencing the introduction of exotic species into Hawaiian ports and harbors.

Estuaries represent less than 1% of the coastal ocean area around the Hawaiian Islands, and these are best developed on the older islands (Kauai and Oahu). Most of these estuaries are small, occupying less than a half mi^2. Historically, estuarine waters were more important. In the Moiliili-Waikiki-Kewalo districts of Honolulu on Oahu, approximately 48% of the land area was occupied by wetland/estuarine habitat in 1887. Today, these aquatic features are absent, and the remaining estuarine waters are channelized conduits that rapidly transport stormwater runoff to the sea. Pearl Harbor, which is the largest remaining Hawaiian estuary, has a water surface area of approximately 22 mi^2 and is one of the country's largest naval ports. Sedimentation problems associated with land-use changes may be especially acute in the coastal areas of Hawaii because of the combination of steeply sloped coastal watersheds, high seasonal rainfall, and agricultural and other land development (Cox and Gordon, 1970; Meier et al., 1993).

Estuaries serve as important nursery habitat for a number of commercial and recreational Hawaiian fishery resources. These aquatic features also act as natural biological filters by sequestering sediments and pollutants adsorbed to particulate materials, thus lessening the impact of stormwater runoff on adjacent coral reefs. The development of the hinterland surrounding most of Hawaii's largest estuaries, combined with concurrent pollution and alien species introductions, has resulted in tremendous changes to the abundance and species composition of important coastal communities. Causal mechanisms responsible for these changes have not been quantitatively defined, and the rate of these changes has not been measured.

Coastal Monitoring Data – Status of Coastal Condition

The principal population and commercial center for Hawaii is located on the south shore of Oahu in an area encompassing Pearl Harbor, the Port of Honolulu, and several other estuaries or embayments. These coastal systems are highly altered and surrounded by a high-density, urban setting. The rest of the Hawaiian Islands has a much lower population density. Although one might presume that the magnitude of anthropogenic impacts would be highest in the urbanized estuaries of Oahu, this hypothesis needs to be rigorously tested.

Hawaii does not yet have a comprehensive coastal monitoring program. Some monitoring occurs in Oahu and is planned for adjacent coral reef ecosystems; however, most coastal resource monitoring is targeted to address specific bays and/or issues such as non-point source runoff and offshore discharges. For example, Mamala Bay has been sampled intensively to examine WWTP outfalls from Oahu into the Bay. This sampling showed that the discharge areas were not statistically different from reference areas; however, data were lacking to interpret these findings in a statewide or regional context (Swartz et al., 2002). In 2002, the NCA, in conjunction with state agencies, Region 9, and the University of Hawaii, conducted the first comprehensive survey of the coastal condition of Hawaii. The survey sampled 50 stations spread across the main islands and 29 stations concentrated along the south shore of Oahu within the urbanized estuaries, including Pearl Harbor and Honolulu Harbor. For this assessment, the coastal area assessed included semi-enclosed coastal embayments and true estuaries.

The sampling conducted in the EPA NCA Survey 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.

Water Quality Index

The water quality index for Hawaii's coastal waters is rated good. This index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Most (78%) of the coastal area was rated good for water quality condition, 4% of the area was rated poor, and 18% was rated fair (Figure 8-11). Most cases of fair condition were driven by elevated concentrations of DIP and chlorophyll *a*. The finding that 22% of the area has either poor or fair water quality should be considered preliminary. As described below, water clarity measurements were not obtained at many stations. Determination of an acceptable level for DIP concentrations may also require further consideration.

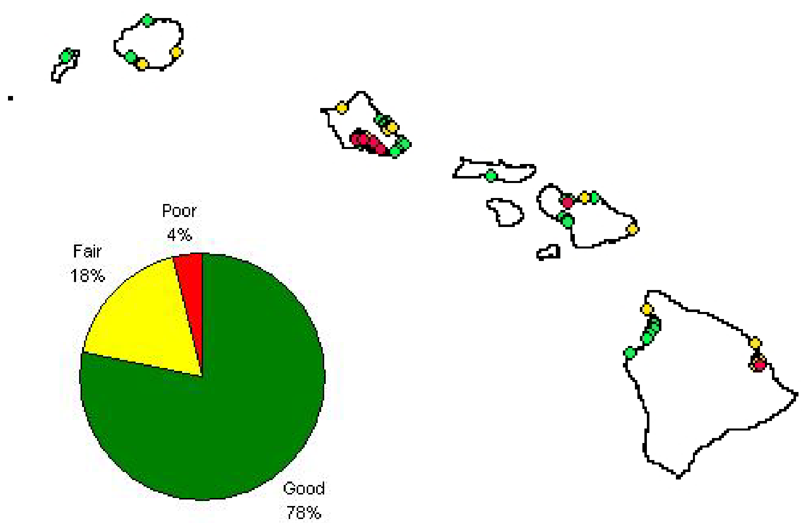


Figure 8-11. Water quality index data for Hawaii's coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

Hawaii's coastal waters are rated good for DIN concentrations, with only 5% of the coastal area rated poor and 12% rated fair for this component indicator. Sites with high nitrogen levels tended to be located in harbors or urban estuaries. For example, areas of the Ala Wai Canal in downtown Honolulu, Kahalui Harbor, and Hilo Bay exhibited elevated DIN concentrations.

Hawaii's coastal waters are also rated good for DIP concentrations, with 31% of the coastal area rated fair for this component indicator. Only 1% of the coastal area, representing one site in Pearl Harbor, received a poor rating for DIP concentrations.

Chlorophyll *a*

Hawaii's coastal waters are rated fair for chlorophyll *a* concentrations, with 13% of the coastal area rated poor and 17% rated fair for this component indicator. Approximately two-thirds of sites rated poor for chlorophyll *a* concentrations were located within the urbanized estuaries of Honolulu on the island of Oahu.

Water Clarity

Water clarity in Hawaii's coastal waters is rated good. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 20% of surface illumination. Approximately 2% of the coastal area was rated poor for this component indicator, and 98% of the area was rated good. In Hawaii, estimates of water clarity were obtained using a Secchi disk. At more than half of the stations, the Secchi disk was still visible at the bottom, and a valid reading of Secchi depth for estimating water clarity could not be obtained; therefore, these estimates of water clarity have a high degree of uncertainty and should be considered preliminary. Given the situation of having the Secchi disk visible at the bottom, it is likely that the estimate of good condition for water clarity is conservative.

Dissolved Oxygen

Dissolved oxygen conditions in Hawaii's coastal waters are rated good, with none of the coastal area rated poor and 6% of the area rated fair for this component indicator. The area rated fair was associated with sampling stations located in Pearl Harbor (2 sites) and Keechi Lagoon. At each of these stations, the dissolved oxygen concentrations were just below 5 mg/L. Although conditions in Hawaii appear to be generally good for dissolved oxygen, measured values reflect daytime conditions, and some areas with restricted circulation may still experience hypoxic conditions at night.

Sediment Quality Index

The sediment quality index for Hawaii's coastal waters is rated good to fair, with 5% of the coastal area rated poor and 7% of the area rated fair for sediment quality condition (Figure 8-12). Poor sediment quality ratings were primarily a result of metal and organic contaminant concentrations in the urbanized estuaries on the south shore of Oahu. Amphipod toxicity at two sites (one on Oahu and one on Kauai) was the second-most important contributing factor to the areal estimate of poor condition. Areas rated fair for sediment condition were almost exclusively associated with elevated levels of sediment contaminants, primarily metals and individual PAHs, within the ports, harbors, and canals of Honolulu on Oahu.

Sediment Toxicity

Hawaii's coastal waters are rated good for sediment toxicity, with 3% of the coastal area rated poor and 97% of the area rated good for this component indicator. Toxic sediments were found at only two sites (Wahiawa Bay, Kauai, and Kaneohe Bay, Oahu), and sediment samples from these sites also exhibited elevated levels of arsenic and DDT, respectively. Since no other sediment contaminant concentrations were elevated at these sites, it is unclear whether the sediment toxicity was directly caused by the contamination.

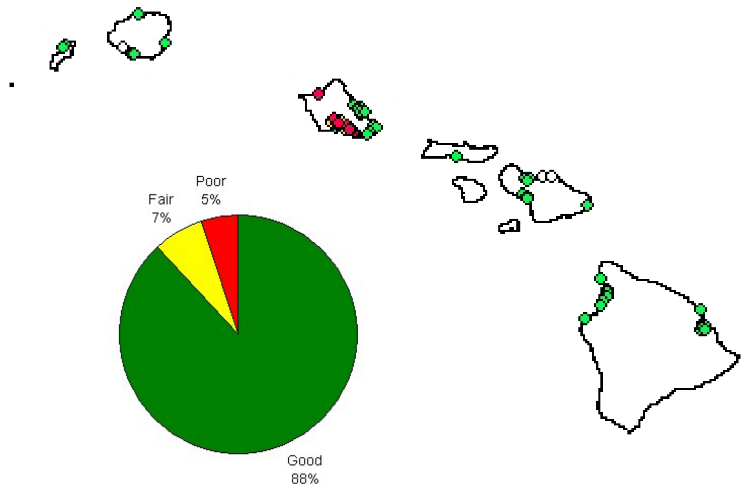


Figure 8-12. Sediment quality index data for Hawaii's coastal waters (U.S. EPA/NCA).

Sediment Contaminants

Hawaii's coastal waters are rated good for sediment contaminant concentrations, with 2% of the coastal area rated poor and 7% of the area rated fair for this component indicator. Six of the 7 sites rated poor were located in the urbanized estuaries of Oahu, and the remaining site was located in Paukaulia Stream on the north shore of Oahu. Primarily, these sites exhibited elevated levels of copper and mercury; however, high concentrations of chromium and PAHs were found in sediments collected from Paukaulia Stream and Honolulu Harbor, respectively. All of the sites rated fair were located in the urbanized estuaries of Oahu and were primarily rated fair due to elevated concentrations of metals (e.g., chromium, copper, lead, mercury, silver, zinc) and some individual PAHs.

It should be noted that this evaluation of sediment contamination in the Hawaiian Coastal waters nickel because the ERM value for this metal has a low reliability for areas of the West Coast, where high natural crustal concentrations of nickel exist (Long et al., 1995). A study of metal concentrations in cores collected along the West Coast determined the range of historic background concentrations of nickel to be 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. In addition, it should be noted that only one exceedance was counted if a site exceeded the ERL for LMW PAHs, HMW PAHs, and/or total PAHs to ensure that the analysis was not biased by PAHs.

Sediment TOC

The coastal waters of Hawaii are rated good for TOC. A total of 8% of the coastal area was rated fair, and none of the area was rated poor. The majority of sites that were rated fair for

TOC were located within Pearl Harbor, which is both extensively modified and has a restricted connection to the ocean. Sites in Reeds Bay and Hilo Bay on the island of Hawaii were also rated fair.

Benthic Index

Sediment condition in Hawaii's coastal waters as measured by a benthic index could not be evaluated. As was the case for Alaska, a benthic condition index for Hawaii is not currently available. In lieu of a benthic index for Hawaii, 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. This approach requires that species richness be predicted from salinity, and, in the case of the Hawaii survey data, the regression was not significant.

Coastal Habitat Index

Estimates of coastal habitat loss are not available for Hawaii; therefore, a coastal habitat index could not be calculated. It is clear that there have been major alterations and losses of coastal wetlands in Hawaii. Modification of coastal wetlands prior to western contact was probably generally limited to the conversion of these marshes into taro cultivation ponds. Later, agricultural activities (e.g., cattle ranching and sugarcane/pineapple production) in the islands modified or eliminated many coastal wetlands. Commercial and military navigation projects also resulted in losses of wetlands on Kauai, Maui, Oahu, and Hawaii; however, perhaps the most extensive loss of coastal wetlands occurred as the result of housing and resort construction following World War II, heavily impacting wetlands on Oahu (Meier et al., 1993).

Fish Tissue Contaminants Index

The NCA survey of Hawaii did not produce estimates of contaminant levels in fish. Instead, a preliminary feasibility study was conducted to determine whether sea cucumbers could be utilized to assess tissue body burdens. Samples of two species of sea cucumbers were analyzed for tissue contaminant levels in the pilot method-development effort. Some heavy metals (e.g., mercury, cadmium, and silver) were undetected in sea cucumber tissue samples. PCBs and DDT were detected at low levels in some tissue samples, whereas PAHs and other pesticides were not detected. These results have a high degree of uncertainty because the total sample size was small and analytical issues were present with the tissue matrix. As a result, a fish tissue contaminant index could not be calculated for Hawaii.

Large Marine Ecosystem Fisheries Insular Pacific-Hawaiian Ecosystem

The Insular Pacific-Hawaiian ecosystem supports a variety of fisheries in both the Northwestern Hawaiian Islands (NWHI) and the Main Hawaiian Islands (MHI). In 2006, the NWHI were designated as a U.S. National Monument. The islands extend from 160 miles northwest of Kauai into the Pacific Ocean approximately 1,200 miles. They cover nearly 140,000 mi^2 of ocean, and include 70% of the tropical, shallow-water coral reefs in U.S. waters. Commercial and recreational harvest of precious coral, crustaceans, and coral reef species are prohibited in monument waters and commercial fishing is being phased out over a 5-year period. Commercial activities within state waters in the area were banned in 2005.

Invertebrate Fisheries

The dominant invertebrate species include lobsters, shrimp, squid, octopus, and precious corals, and in addition, many species in state, territorial, commonwealth, and remote island waters. Most of these fisheries are small scale and regulated only by the island fisheries agencies in the region. The NWHI lobster trap fishery is the major commercial marine invertebrate fishery in the western Pacific. A small-scale, primarily recreational, fishery for different species of lobster exists in the MHI, American Samoa, Guam, and the Northern Mariana Islands. A deepwater shrimp resource is found throughout the Pacific islands, but currently is relatively unexploited. A resource of deep-water precious coral (gold, bamboo, and pink corals) and shallower water coral (black) exists in Hawaii and possibly other western Pacific areas. A short-lived, domestic precious coral fishery operated in Hawaii from 1974 to 1979, but there was no significant precious coral harvest for 20 years until 1999 through 2001 (NMFS, 2006). The NWHI lobster fishery and the Hawaii precious coral fishery are the only invertebrate fisheries managed by NMFS in this area.

Northwestern Hawaiian Islands Lobster

A commercial lobster trap fishery operated in the NWHI from the mid-1970s through 1999. It was a multi-species fishery, primarily targeting the Hawaiian spiny lobster and slipper lobster. Three other species, green spiny lobster, ridgeback slipper lobster, and Chinese slipper lobster were also caught in low abundances (NMFS, 2006). Historically, traps set at the deeper depths caught slipper lobster, while the shallower sets caught spiny lobster. In later years, slipper lobsters (particularly at Maro Reef) have been caught at shallow depths, presumably caused in part by the fishing pressure on spiny lobsters and the availability of suitable habitat formerly occupied by spiny lobster.

The estimated populations of spiny and slipper lobsters declined dramatically from the mid-1980s through the mid-1990s. Much of this decline has been attributed to a shift in oceanographic conditions affecting recruitment in the mid-1980s. Although oceanographic conditions have returned to a more typical long-term state and the fishery has been closed since 2000, recent NMFS research surveys have not indicated any increase in spiny lobster populations at Necker Island or Maro Reef. While variability in oceanographic conditions may have contributed to the decline of NWHI spiny lobster, improvements in our understanding of the spatial structure of the NWHI spiny lobster population, the dynamics of larval transport, and commercial fishery data suggest that spiny lobster populations in the NWHI constitute a metapopulation and that a suite of factors (both anthropogenic and biotic) contributed to the observed decline (NMFS, 2006).

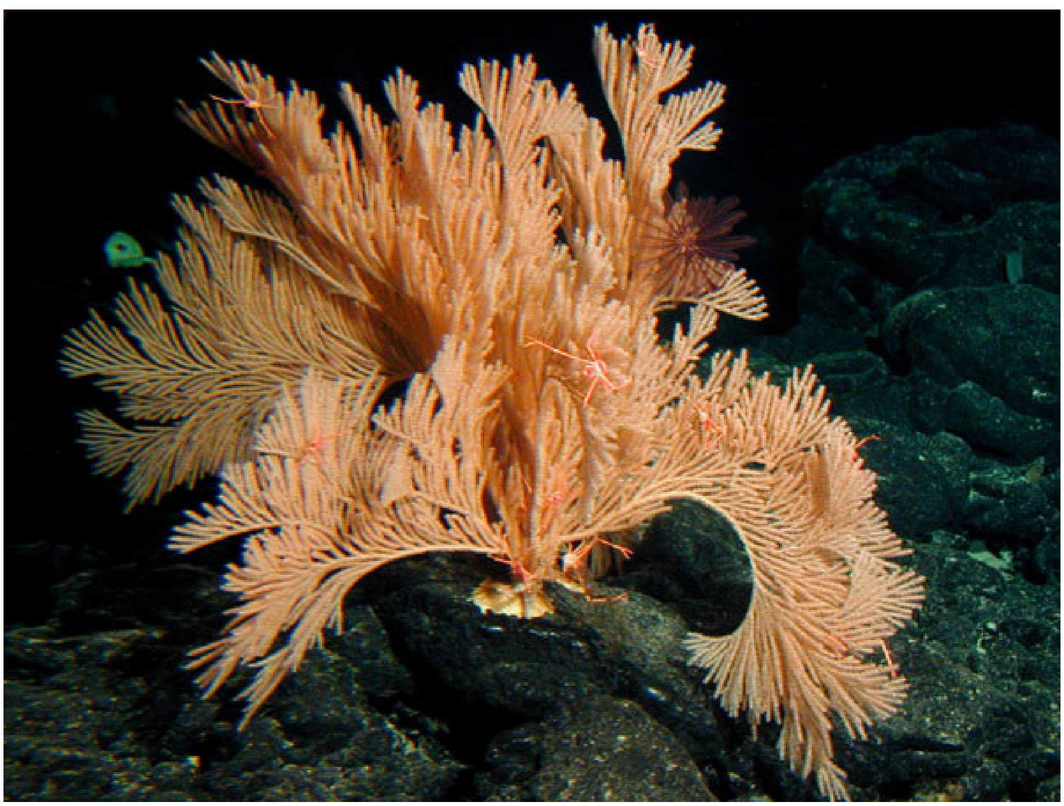
> A metapopulation is a group of populations inhabiting discrete patches of suitable habitat that are connected by the dispersal of individuals between patches; the degree of isolation for local populations may vary depending on the distance between habitat patches.

Precious Coral

For the first time since the mid-1970s, deepwater precious corals (pink, gold, and bamboo corals) were harvested commercially from 1999 to 2001. A single company collected corals at the established coral bed of Makapu'u, Oahu, and in the exploratory bed off Keahole, Hawaii. The allowable harvest quotas were not filled in either location. Although the fishery remains open, the company has suspended harvesting due to the high cost of operating submarines and the low bid price for coral. The only shallow water coral species currently harvested are black corals. Black corals are collected by three independent divers working at depths less than 260 ft; all within the Au'au channel, Maui (NMFS, 2006).

In 2000 and 2001, scientists surveyed all known precious coral beds in the Hawaiian Archipelago using the submersibles of the Hawaii Undersea Research Laboratory. These surveys provided the first real insight as to the relative abundance of precious corals across the archipelago. Post-harvest inspections of the coral beds at Makapu'u and Keahole found numerous live colonies and little evidence of damage associated with harvesting. The 2001 survey of the Makapu'u bed will be compared with a pre-harvest survey data collected at Makapu'u in 1997 to evaluate possible harvesting impacts (NMFS, 2006). Both divers and submersibles also surveyed the black coral bed of the Au'Au channel in 2000 and 2001. Submersible surveys at depths below 260 ft observed an invasive species of soft coral (*Carijoa riisei*) overgrowing black coral trees. At depths shallower than 260 ft, divers surveyed the size structure of black coral trees and their associated fish assemblages. A follow-up survey of size structure was conducted in 2004 and will be used to revisit the harvesting regulations presently in place.

Activities related to the precious coral fishery could possibly interfere with the endangered Hawaiian monk seal. Studies of monk seal foraging patterns using seal-mounted satellite tags documented a small number of seals visiting sites with deep-water precious coral beds (Parrish et al., 2002). Seals were recorded visiting black coral beds on successive nights to



Deep-sea coral on seamount in Northwest Hawaiian Islands (NOAA Office of Ocean Exploration).

feed on eels hiding amongst the corals. These and other studies of seal diving and foraging behavior have spurred concern that coral harvesting might impact the seals' use of the deepwater fish community. In 2003, a seal was observed by a submersible at a depth of about 1,750 ft near precious coral, further strengthening the link between seals and precious coral beds.

Bottom Fish and Armorhead Fisheries

The western Pacific bottom fish fishery geographically encompasses the Insular Pacific-Hawaiian ecosystem which includes the MHI, the NWHI, Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa. In contrast, pelagic armorhead are 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 Date Line and extends to the northernmost portion of the NWHI.

Bottom Fish

The Guam, Commonwealth of the Northern Mariana Islands, American Samoa, and MHI bottom fish fisheries employ relatively small vessels on one-day trips close to port; either part-time or sport fishermen take much of the catch. In contrast, bottom fish in the NWHI are fished by full-time fishermen on relatively large vessels that range far from port on trips of up to 10 days. Fishermen use the hand-lining technique in which a single weighted line with several baited hooks is raised and lowered with a powered reel. The bottom fish fisheries are managed jointly by the Western Pacific Fishery Management Council and territorial, commonwealth, or state authorities (NMFS, 2006).

In Hawaii, the bottom fish species fished include several snappers (ehu, onaga, opakapaka, and uku), jacks (ulua and butaguchi), and a grouper (hapu'upu'u). In the more tropical waters of Guam, Commonwealth of the Northern Mariana Islands, and American Samoa, the fisheries include a more diverse assortment of species within the same families as in Hawaii, as well as several species of emperors. These species are found on rock and coral bottoms at depths of 170-1,350 ft. Catch weight, size, and fishing effort data are collected for each species in the five areas. However, the sampling programs vary in scope between the areas. About 90% of the total catch is taken in Hawaii, with the majority of the catch taken in the MHI. Stock assessments, although somewhat limited, indicate that the spawning stocks of several important MHI species (ehu, hapu'upu'u, onaga, opakapaka, and uku) are at only 5–30% of unfished levels. Onaga and ehu presently appear to be the most stressed among MHI bottom fish species (NMFS, 2006).

Pelagic Armorhead

The commercial seamount fishery for armorhead was started by bottom-trawl vessels of the former Soviet Union in 1968. During 1969, Japanese trawlers entered this fishery, and by 1972 the catch-per-unit-effort (CPUE; based on Japanese data) peaked at 54 metric tons (t) per hour. The United States has never been a participant in this fishery. By the end of 1975, the two foreign fleets had harvested a combined cumulative total of 1,000,000 t of pelagic armorhead. Facing a steady decline in CPUE beginning in 1972, the former Soviet fleet left the fishery after 1975. The combined catch index for all seamounts has remained depressed since the late 1970s. The inclusion in 1977 of the southermost seamounts (Hancock Seamounts) into the EEZ allowed for a small portion of the fishery to be managed in a limited way. A preliminary fishery management plan (FMP) was developed that year and provided for limited foreign harvesting at the Hancock Seamounts under a permit system during 1978–84. However, catches remained low, and all fishing ceased after 1984. Under the FMP for the bottom fish and seamount groundfish fisheries of the Western Pacific Region, a 6-year fishing moratorium was imposed on the Hancock Seamounts in 1986. The moratorium was extended for three additional 6-year periods, the latest starting in 2004 and ending in 2010. (NMFS, 2006).

The seamount groundfish fishery has targeted just one species--the pelagic armorhead. Since 1976, Japanese trawlers fishing the seamounts in international waters beyond the Hancock Seamounts have conducted this fishery almost exclusively. The fishing grounds comprising the Hancock Seamounts represent less than 5% of the total fishing grounds. The maximum sustainable yield is 2,123 t, but recovery to these former levels has not yet occurred. The primary issue for the armorhead seamount fishery is how to implement some form of management on an international basis to provide conditions conducive to stock recovery. (NMFS, 2006).

Standardized stock assessments were conducted during 1985–93. Research cruises focused on Southeast Hancock Seamount, and the armorhead stock was sampled with bottom long lines and calibrated against Japanese trawling effort. Catch rates vary, but have not shown the increases expected after the fishing moratorium was implemented. 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 (NMFS, 2006).

Assessment and Advisory Data

Fish Consumption Advisories

Since 1998, the State of Hawaii has advised the general population not to consume fish or shellfish caught in the Pearl Harbor area on the island of Oahu due to PCB contamination (Figure 8-13). In addition to the existing estuarine advisory, a statewide advisory took effect in 2003. The new statewide advisory targets sensitive populations (e.g., pregnant women, nursing mothers, and children), and provides data on mercury contamination for several species of marine fish (U.S. EPA, 2004b).

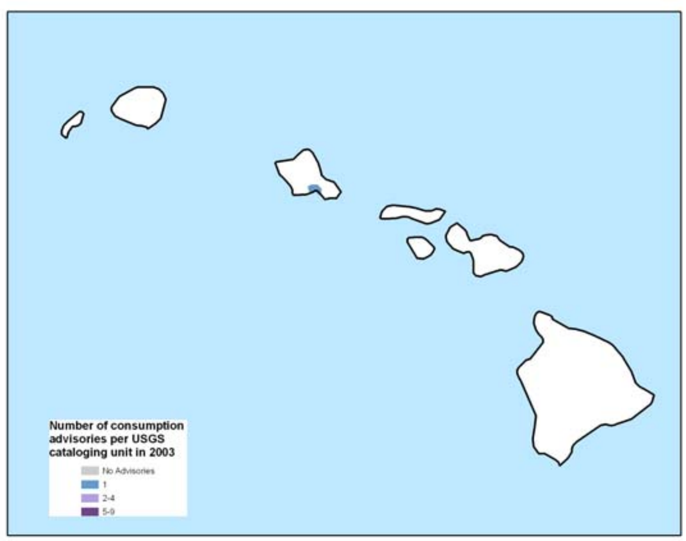


Figure 8-13. Fish consumption advisory for Hawaii, location approximate. Hawaii also has a statewide advisory for marine fish consumption by sensitive populations, not mapped (U.S. EPA, 2004b).

Beach Advisories and Closures

Hawaii did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006b).

Puerto Rico

Coastal Monitoring Data – Status of Coastal Condition

The overall condition for Puerto Rico's coastal waters presented in the NCCR II (U.S. EPA, 2004a) was poor based on three of the indices used by NCA (Figure 8-14). The water quality index is rated fair, and the sediment quality and benthic indices are rated poor. NCA was unable to evaluate the coastal habitat or fish tissue contaminants indices for Puerto Rico. Figure 8-15 provides a summary of the percentage of coastal area rated good, fair, poor, or missing for each index and component indicator. This assessment was based on the results of sampling conducted at 50 sites in 2000. Please refer to Tables 1-23, 1-24, and 1-25 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

Although another NCA sampling event for Puerto Rico occurred in 2004, these results are not yet available for publication and will be presented in the NCCR IV. This section of the

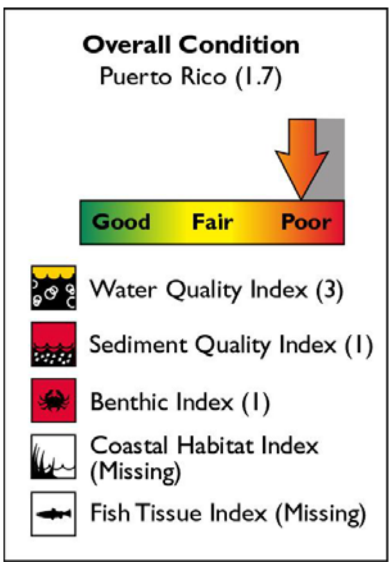


Figure 8-14. The overall condition of Puerto Rico's coastal area is rated poor (U.S. EPA/NCA).

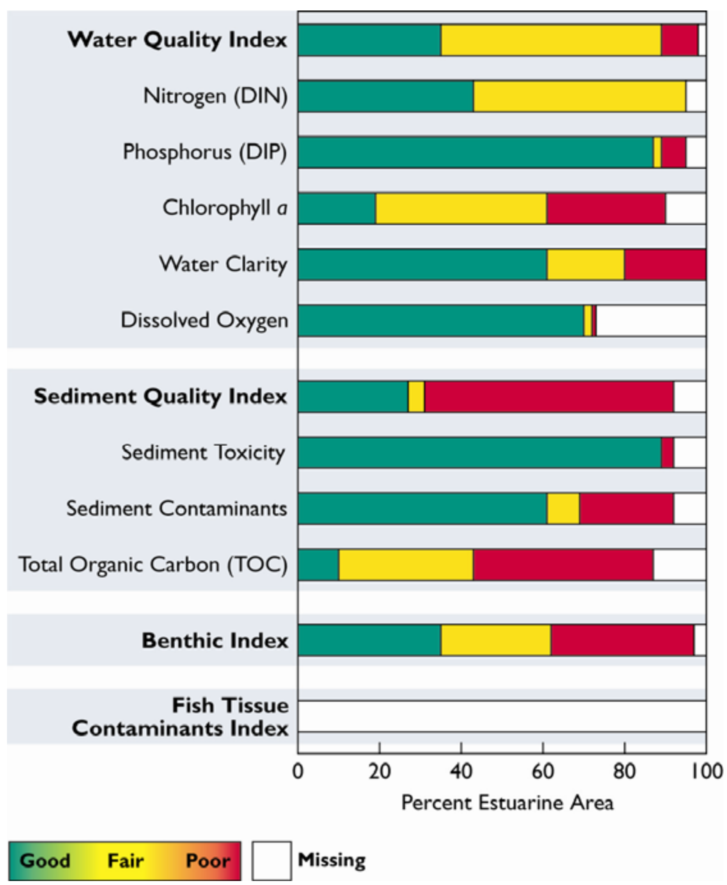


Figure 8-15. Percentage of area receiving each ranking for all indices and component indicators – Puerto Rico (U.S. EPA/NCA).

NCCR III summarizes the results that were presented in NCCR II. The NCCR II assessment indicated that, for the indices and indicators measured, the primary problems in Puerto Rico's coastal waters are degraded sediment quality, degraded benthos, and some areas of poor water quality. Puerto Rico estuaries with consistently low scores for the water quality, sediment quality, and benthic indices include San Juan Harbor, the Cano Boquerón, Laguna del Condado, and Laguna San Jose.

Water Quality Index

As described in the NCCR II, the water quality index for Puerto Rico's coastal waters is rated fair. This water quality index was developed using five water quality indicators: DIN and DIP concentrations, chlorophyll *a* concentrations, water clarity, and dissolved oxygen levels. Although only 9% of the coastal area was rated poor, 63% of the area was rated poor and fair, combined (Figure 8-16). Nutrients levels were rated fair and good for DIN and DIP, respectively. Low scores for chlorophyll *a* (poor) and water clarity (fair) contributed to the overall rating. Dissolved oxygen concentrations in Puerto Rico coastal waters were rated good. Estimates showed that only 1% of bottom waters have hypoxic conditions (< 2 mg/L) on a continuing basis in late summer; however, dissolved oxygen data were missing for 27% of the coastal area.

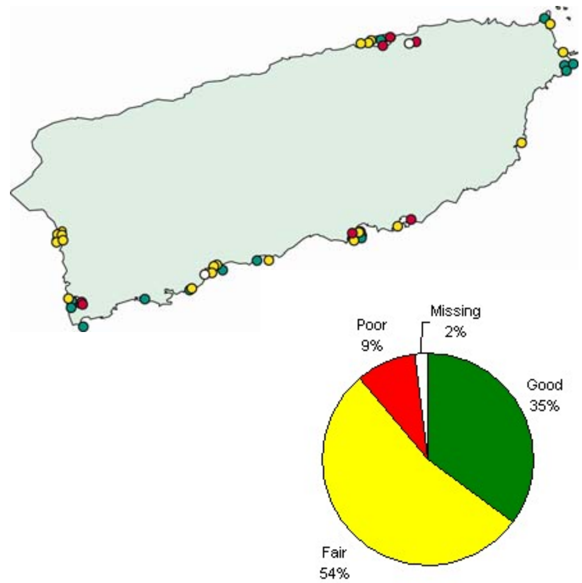


Figure 8-16. Water quality index data for the coastal waters of Puerto Rico (U.S. EPA/NCA).

Sediment Quality Index

Overall, sediment quality in Puerto Rico's coastal waters was rated poor. A sediment quality index was developed for Puerto Rico coastal waters using three sediment quality component indicators: sediment toxicity, sediment contaminants, and sediment TOC. More than 60% of Puerto Rico's coastal area was rated poor for one or more of the component indicators (Figure 8-17). Puerto Rico's sediment toxicity was rated good because only 3% of the coastal area contained sediments that were toxic to the test organism. The sediment contaminants component indicator was rated poor in 23% of the coastal area. Puerto Rico

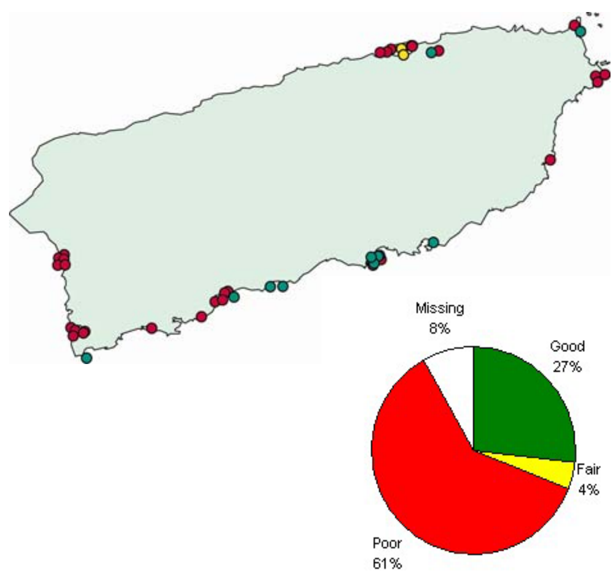


Figure 8-17. Sediment quality index data for the coastal waters of Puerto Rico (U.S. EPA/NCA).

sediments were also rated poor overall with respect to sediment TOC. In this area, elevated TOC values are often associated with contributions to the waterbody's organic loads from untreated wastewater, agricultural runoff, and industrial discharges; however, occasionally, these levels are associated with natural processes in mangrove estuaries.

Benthic Index

The benthic index for Puerto Rico's coastal waters is rated poor. Thirty-five percent of estuarine sediments had low benthic diversity (Figure 8-18). Currently, no benthic community index has been developed for Puerto Rico. As a surrogate for benthic condition, the benthic samples were evaluated by using standard 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 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 Puerto Rico data showed no significant relationships between benthic diversity and either salinity or silt-clay content; therefore, benthic diversity was used to directly evaluate benthic condition.

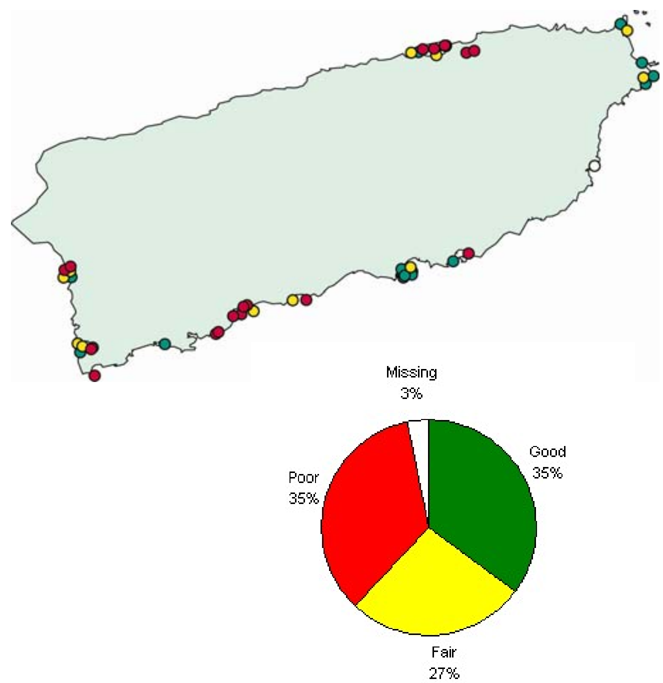


Figure 8-18. Benthic index data for the coastal waters of Puerto Rico (U.S. EPA/NCA).

Coastal Habitat Index

Estimates of coastal habitat loss are not available for Puerto Rico; therefore, the coastal habitat index could not be calculated.

Fish Tissue Contaminant Index

Estimates of fish tissue contaminants are not available for Puerto Rico; therefore, the fish tissue contaminant index could not be calculated. In conjunction with the San Juan Bay Estuary Program, fish tissue sampling was conducted in the San Jose Lagoon, and the results are available in the *National Estuary Program Coastal Condition Report* (NEP CCR) (U.S. EPA, 2006a).

Large Marine Ecosystem Fisheries

There is no information available for the LMEs surrounding Puerto Rico.

Assessment and Advisory Data

Fish Consumption Advisories

Puerto Rico did not report fish consumption advisory information to EPA in 2003 (U.S. EPA, 2004b).

Beach Advisories and Closures

Puerto Rico did not report monitoring, advisory, or closing information for any beaches in 2003 (U.S. EPA, 2006b).

American Samoa, Guam, Northern Mariana Islands, U.S. Virgin Islands

Coastal Monitoring Data – Status of Coastal Condition

American Samoa, Guam, the Northern Mariana Islands, and the U.S. Virgin Islands were not assessed by NCA in 2001 or 2002. American Samoa, Guam, and the Northern Mariana Islands are located in the Pacific Ocean (Figure 8-19), and the U.S. Virgin Islands are found in the Caribbean Sea (Figure 8-20).

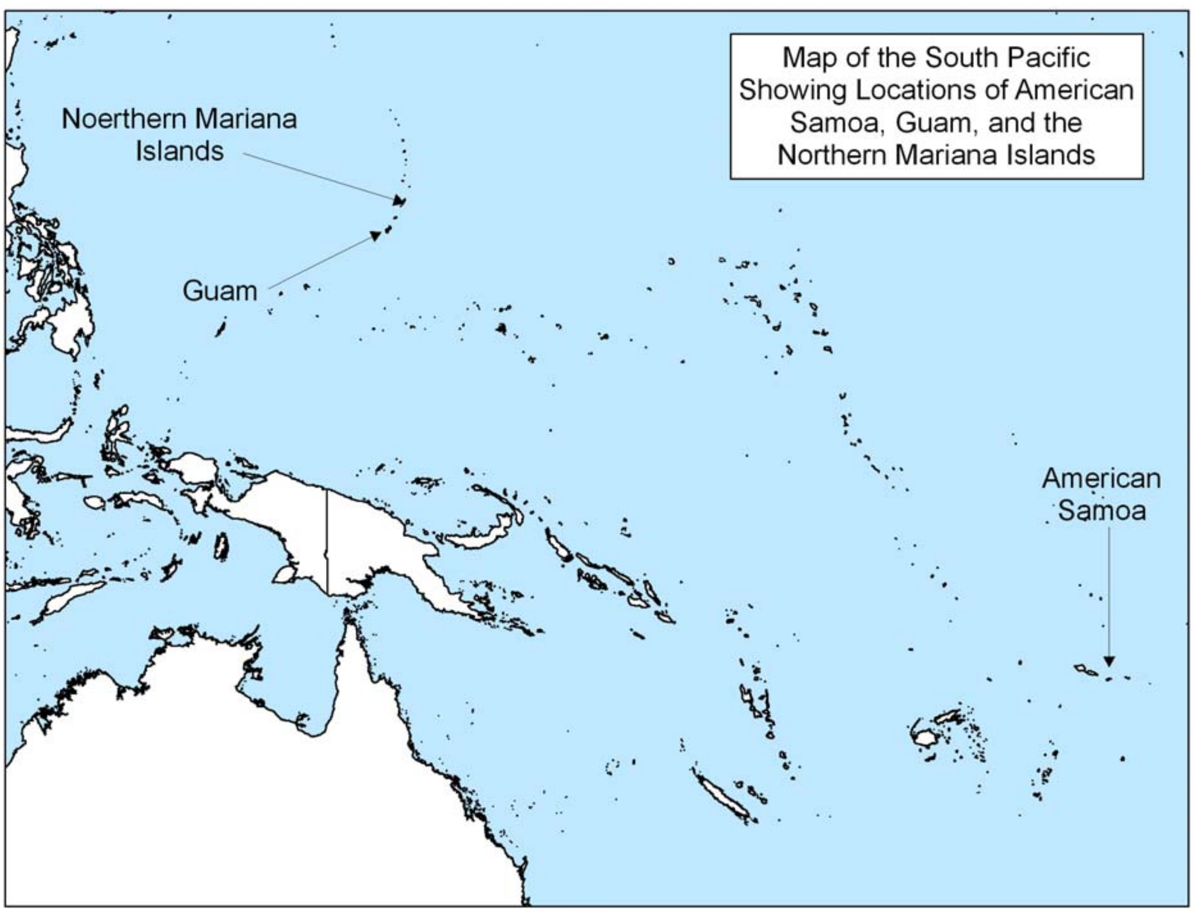


Figure 8-19. Locations of the Pacific island territories.

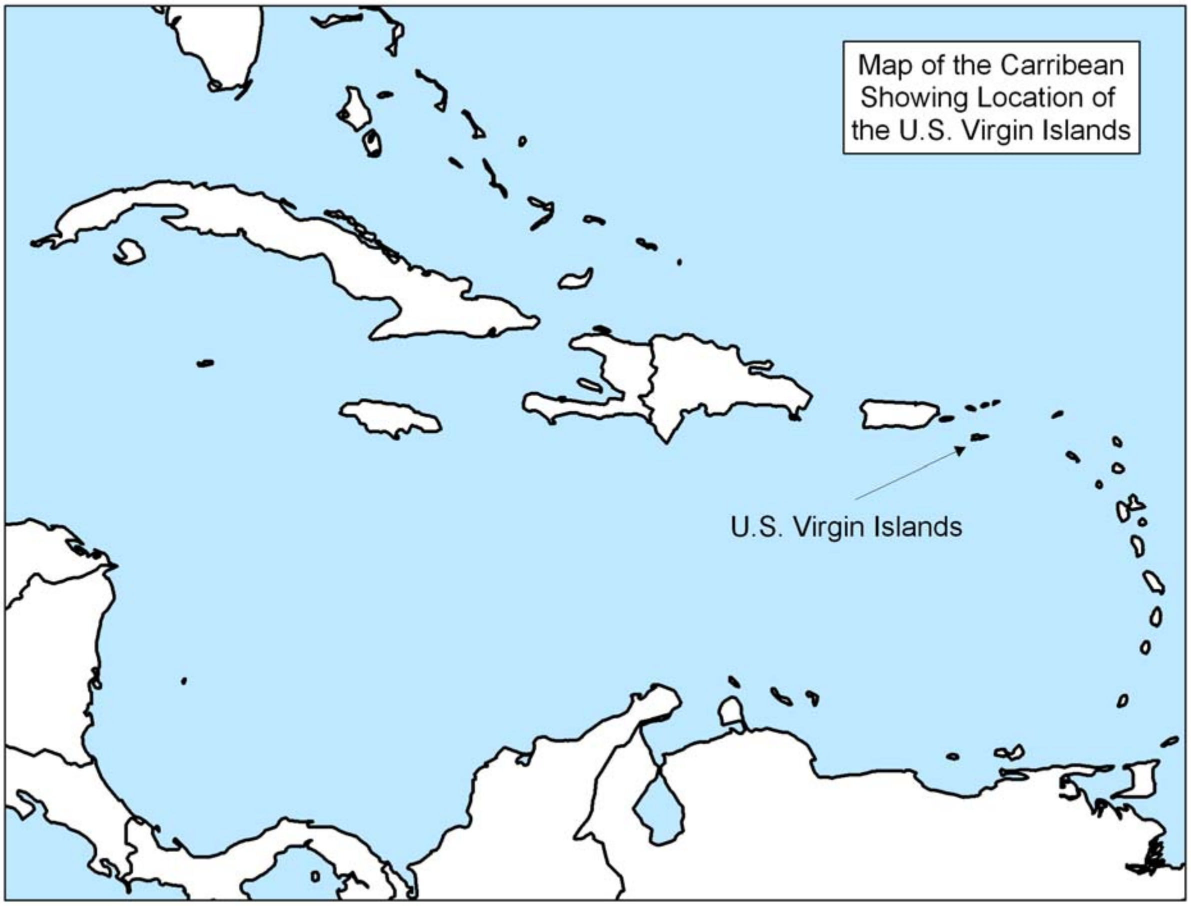


Figure 8-20. Location of Carribean island territory.

Large Marine Ecosystem Fisheries

The Insular Pacific-Hawaiian LME includes the waters surrounding Guam, the Northern Mariana Islands, and American Samoa. These fisheries were discussed in the Hawaii section of this chapter. There is no information available for LMEs surrounding the U.S. Virgin Islands.

Assessment and Advisory Data

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 (Figure 8-21). 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. Guam, the Northern Mariana Islands, and the U.S. Virgin Islands did not report fish consumption advisory information to EPA in 2003 (U.S. EPA, 2004b).

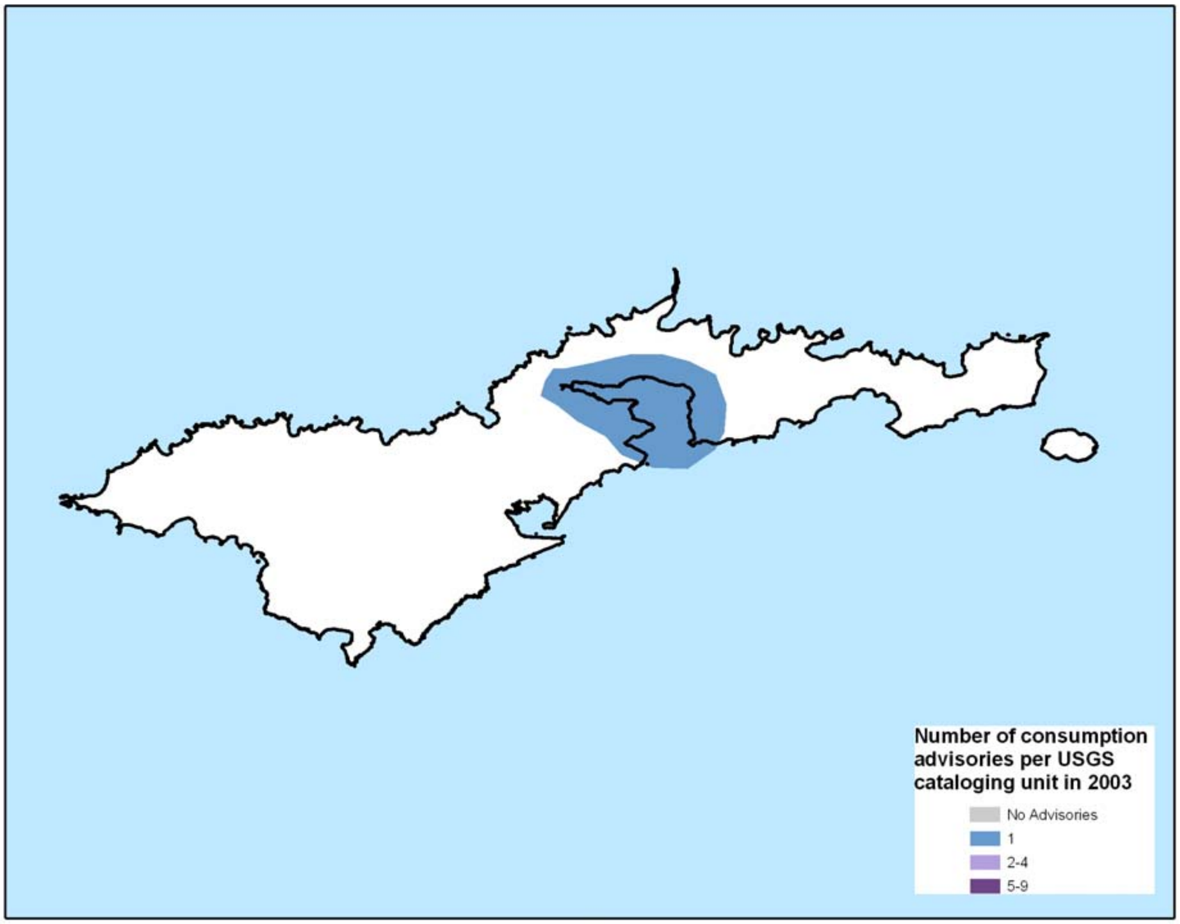


Figure 8-21. Fish consumption advisory for American Samoa, location approximate (U.S. EPA, 2004b).

Beach Advisories and Closures

American Samoa, Guam, the Northern Mariana Islands, and the U.S. Virgin Islands did not report monitoring or closing information for any beaches in 2003 (U.S. EPA, 2006b).

Summary

During 2002, NCA conducted sampling along the south-central coastline of Alaska and in the bays and estuaries of Hawaii. Puerto Rico was assessed by NCA in 2000, and those results were presented in the NCCR II and are summarized here. Sampling was conducted in Guam, American Samoa, and the U.S. Virgin Islands in 2004–2005; however, these results were not included in the NCCR III. Currently, no plans have been made to assess the Northern Marianas Islands.

Based on the NCA data, overall condition is rated good along Alaska's south-central coast, good in Hawaii's bays coastal waters, and poor in the coastal waters of Puerto Rico. The water quality, sediment quality, and fish tissue contaminants indices were rated good for south-central Alaska. All of the indicators, except for DIP and water clarity, are also rated good for Alaska, and DIP and water clarity are rated fair. The coastal habitat and benthic indices were not assessed along Alaska's south-central coastline. In Hawaii, the water quality index is rated good and the sediment quality index is rated fair to good. Chlorophyll *a* is the only indicator rated fair for Hawaii ; the rest of the indicators are rated good. The coastal habitat, benthic, and fish tissue contaminants indices were not assessed in Hawaii during 2002. As reported in the NCCR II, Puerto Rico's water quality index is rated fair, and the sediment quality and benthic indices are rated poor. The coastal habitat and fish tissue contaminants indices were not assessed in Puerto Rico. Trends in NCA data could not be evaluated for Alaska, Hawaii, or Puerto Rico.

NOAA's NMFS manages several fisheries in the LMEs bordering Alaska, Hawaii, Guam, the Northern Mariana Islands, and American Samoa. No information is available for the LMEs surrounding the U.S. Virgin Islands or Puerto Rico. The East Bering Sea LME and the Gulf of Alaska LME surround Alaska, and NMFS manages the salmon, herring, groundfish, and shellfish fisheries in these waters. In general, salmon and crab resources are fully utilized, East Bering Sea groundfish stocks are slightly underutilized; herring and Gulf of Alaska groundfish stocks are relatively stable; and shrimp stocks are low. The Insular Pacific-Hawaiian LME includes the waters around Hawaii, Guam, the Northern Mariana Islands, and American Samoa, and the NMFS manages invertebrate, bottom fish, and pelagic armorhead fisheries in these waters. The lobster and pelagic armorhead fisheries are closed or under a fishing moratorium; the coral fishery is open, but only shallow-water, black coral is being harvested; and limited stock assessments indicate that MHI spawning stocks of bottom fish are at 5% to 30% of unfished levels.

Contamination in the coastal waters of Hawaii and American Samoa has affected human uses of these waters. In 2003, there was one fish consumption advisory in effect for Pearl Harbor, HI, and one in effect for Inner Pago Pago Harbor, American Samoa. Hawaii's advisory was for PCBs, and American Samoa's advisory was for chromium, copper, DDT, lead, mercury, zinc, and PCBs. Alaska, Puerto Rico, Guam, the Northern Mariana Islands, and the U.S. Virgin Islands did not report fish consumption advisory information to EPA in 2003. None of these areas reported beach monitoring, advisory, or closure information to EPA for 2003.

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NCCR III

Chapter 8 Highlights

highlight

The Condition of Coral Reefs in Puerto Rico and the U.S. Virgin Islands

The current condition of coral reef ecosystems in Puerto Rico and the U.S. Virgin Islands (USVI) (hereafter known as the U.S. Caribbean) was summarized recently in a report entitled - *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005* (NOAA, 2005). The report contains quantitative results of assessment and monitoring activities conducted in shallow water coral reef ecosystems by federal, state, territory, commonwealth, non-government, private, and academic partners. Additionally, it is based primarily on recent, quantitative monitoring data collected *in situ* in each of 14 jurisdictions, including the U.S. Virgin Islands, Puerto Rico, Florida, Navassa Island, Flower Garden Banks, and other banks in the Gulf of Mexico, Hawaii, Northwestern Hawaiian Islands, U.S. Pacific Remote Island Areas, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, and the Freely Associated States (FAS) of the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau.

Coral reef ecosystems in the U.S. Caribbean comprise a mosaic of habitats that host a large diversity of marine organisms, including coral and other hardbottom areas, seagrass beds, and mangroves. These biologically rich ecosystems provide important services to coastal areas (e.g., shoreline protection) and support valuable socio-economic activities (e.g., fishing and tourism); however, coral reefs are also affected directly and indirectly by these activities. Coral reefs generally form three types of reef structures: fringing reefs, patch reefs, or spur and groove reefs, and these are distributed around the islands (Adey, 1975; Hubbard, Gladfelter and Bythell, 1993; Garcia-Sais et al., 2003). Recent estimates of the spatial extent of coral reef ecosystems from Landsat satellite imagery indicate that coral reef ecosystems in Puerto Rico and the USVI potentially cover about 2,646 km^2 (1,022 mi^2) within the 10 fathom (60 ft) depth contour or 7,627 km^2 (2,945 mi^2) within the 100 fathom (600 ft) depth contour (Rohmann et al., 2005).

Coral reef ecosystems in the U.S. Caribbean face several threats, including climate change, diseases, tropical storms; coastal development and runoff; coastal pollution; tourism and recreation; fishing; and ships, boats, and groundings. Point and non-point source discharges into the marine environment remain a major concern and may be contributing to an increase in the abundance and incidence of coral diseases, such as black band disease. Where they exist, rivers represent the main sources of pollutants and sediments to coastal waters (CH2M Hill, Inc., 1979; Anderson and MacDonald, 1998; IRF, 1996; IRF, 1999).

In Puerto Rico, the highest cover of live corals generally occur on reefs located on the leeward side of the islands (e.g., Desecheo, Mona); at offshore islands (e.g., Vieques, Culebra, Cayo Diablo); and along the south and west coast of the main island (e.g., La Boya Vieja, and Tourmaline). Boulder star coral, *Montastrea annularis,* is the dominant coral species on reefs with relatively high coral cover, whereas the great star coral (*Montastrea cavernosa*), massive starlet coral (*Siderastrea* spp.), and finger coral (*Porites astreoides*) constitute the main coral assemblage of degraded reefs. Coral reefs with high live coral cover generally exhibit relatively high abundance and a diverse assemblage of zooplanktivorous fishes (*Chromis* spp., *Clepticus* spp., *Stegastes partitus*), whereas coral reefs with low live coral cover are dominated numerically by dusky damselfish (*Stegastes dorsopunicans*) (Garcia-Sais et al., 2005).

In the USVI, current assessments indicate that marine water quality is good, but it is declining because of increases in point and non point sources of pollution. Generally, coral cover on reefs is low relative to the abundance of macro- and filamentous algae, which indicate a possible phase-shift from coral-dominated reefs to algal dominated reefs. Additionally, dense stands of elkhorn coral (*Acropora palmata*) that were once the dominant shallow water species coral in some areas four decades ago, have not recovered (Jeffrey et al., 2005).

Several management actions have been taken to conserve coral reef ecosystems in the U.S. Caribbean. Marine protected areas (MPAs) have been established or expanded throughout Puerto Rico and the USVI to provide varying levels of protection for resources and to serve as fishery management tools. Puerto Rico's Department of Natural and Environmental Resources recently revised fisheries laws to halt major reductions in recreational and commercial catches that have declined as much as 70% between 1979 and 1990 (Jeffrey et al., 2005). In the USVI, 3,250 mooring buoys have been installed to reduce ship groundings and protect benthic habitats from anchor damage from commercial and recreational boat usage. Recent monitoring data from MPAs in both Puerto Rico and the USVI suggest that commercially important reef fishes such as red hind grouper (*Epinephelus guttatus*) are increasing in size and abundance within reserve boundaries (Jeffrey et al., 2005; Nemeth, 2005).

Although these management actions have had some success in protecting coral reef ecosystems, they could be more effective with greater enforcement. Current coral reef ecosystem conditions would improve further with

- A reduction in the number and intensity of the major threats affecting coral reefs;
- Greater enforcement of existing MPAs and regulations that govern resource use and extraction; and
- Increased environmental education and awareness among island residents and visitors.

Additionally, coral reef ecosystems in the U.S. Caribbean would benefit substantially from stronger coordination and collaboration among the federal and territorial agencies, and non-governmental organizations that have an interest in marine conservation in these islands.

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highlight

The NCA Survey of Guam – 2004

The island of Guam is an unincorporated territory of the United States, with a population of approximately 155,000 residents on the 212 mi^2 island. The entire island of Guam is classified as a coastal zone. Practically all residences are served by public/military community water supply systems, with a large number of single-family dwellings using individual septic tank/leaching field systems. Approximately 1.4 million tourists visit Guam annually, largely drawn by Guam's tropical climate and clean, recreational, fresh, and marine waters**.** Guam's EPA currently monitors some indicators of the physical and chemical condition of marine receiving waters; however, the lack of quantitative baseline information for water, sediment, and tissue pollutant concentrations limits the ability to provide a comprehensive assessment of receiving waterbodies. The establishment of long-term comprehensive monitoring programs is needed as a first step toward developing any program of pollution abatement and habitat restoration. As a first step in this process, Guam's EPA has participated in the NCA survey program.

The Guam component of the NCA survey is based on a combination of the procedures and methods of the NCA, coupled with specialized methods for sampling hard bottom habitats such as coral reefs, first developed and used by the 2002 NCA assessment for the state of Hawaii (Nelson et al., 2006). Thus, the Guam NCA assessment is consistent with the broader NCA survey program, while taking into account modifications that have been developed for tropical coral reef island environments.

Major modifications to the NCA indicator list include the following:

- Replacement of fish trawls used for fish community assessments, which are very destructive to coral reef communities, with visual census protocols in conjunction with reef and pelagic fish standing stock estimates
- Replacement of fish sampling with sea cucumber or crab sampling for tissue chemical contaminant analyses
- Addition of storm wave impact estimates
- Addition of water column analyses for assessment of microbial contamination
- Addition of hard-bottom benthic habitat monitoring using transect and quadrat measurements of the percent cover of macroinvertebrate and algal composition on rock outcrops and coral substrates.

An additional parameter under consideration for future monitoring is coral disease identification.

The Guam NCA assessment included such standard NCA indicators as water column nutrients, bottom dissolved oxygen concentrations, water clarity, sediment and tissue chemistry, and the identification of soft bottom benthic communities.

The coastal resource definition for the Guam NCA survey encompasses all waters from mean low water to the 60 feet depth contour, having salinity greater than 0.5 psu. Within the depth contour, two sampling strata were created. The estuary stratum consisted of estuaries and more protected embayments, while the nearshore stratum consisted of the more open coastlines of the island. The exception to the depth criterion is Apra Harbor, a special study area in Guam where water depth often exceeds 60 feet. Within Apra Harbor, a modified sampling procedure was utilized to sample only for water column parameters, sediment contaminants, and benthic infauna at stations with depths greater than 60 feet. The Guam NCA assessment is designed to be conducted during the island's wet season, July through December, in even numbered years. The sampling program used a joint field team with fisheries experts from the staff of the Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam, together with staff scientists from the Monitoring Program of the Guam EPA.

The field sampling for the Guam NCA was initiated in November 2004 and was completed in August 2005. High seas proved to be a major challenge to conducting field work in the near-coastal area of Guam, with rough weather often being generated by tropical typhoons in the region. In spite of an attempt to use grab samplers in the deepest areas of Apra Harbor, five stations could not be sampled with the vessel available due to excessive depth and strong currents, and alternate stations were added as replacements. All dropped stations were at a depth greater than 120 feet. During the NCA assessment, 50 stations were successfully sampled (Figure 1). Samples collected during the study period are still undergoing analyses.

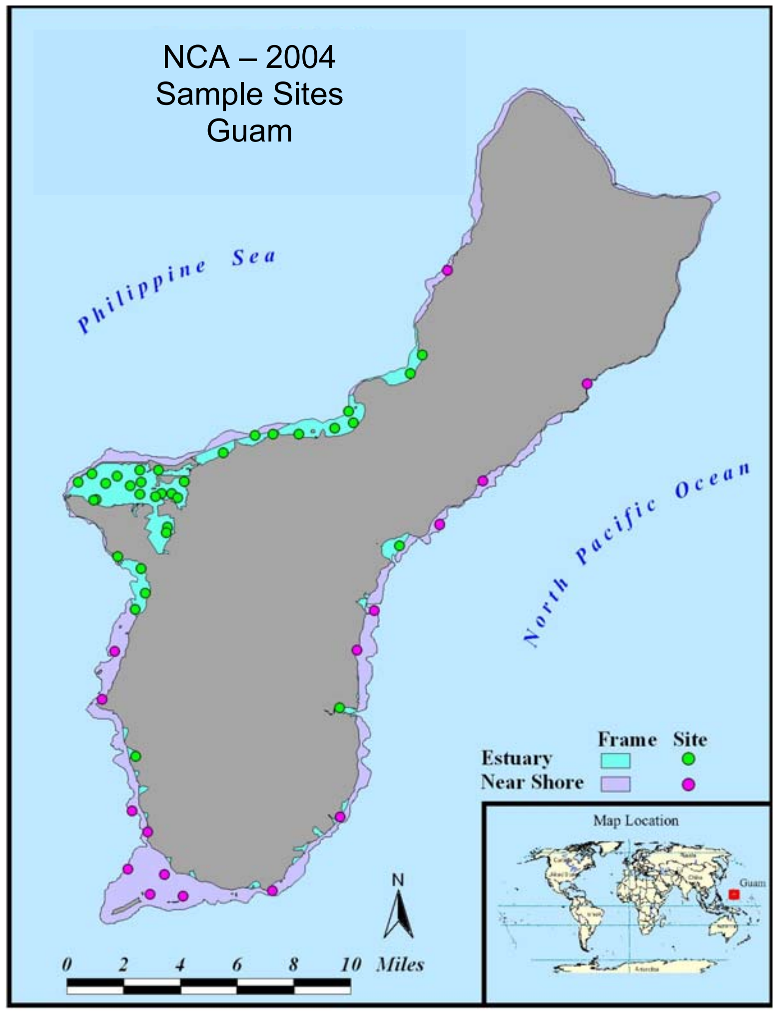

Figure 1. Estuarine and nearshore sampling stations used in the 2004 NCA survey of the island of Guam.

The Guam NCA assessment represents a major effort on the part of Guam EPA to improve its approach to monitoring of the coastal resources of the island. The effort would not have been possible without the collaboration and support of scientists from the NCA survey program and the Environmental Monitoring and Assessment Program (EMAP), the staff of EPA Region 9 Pacific Islands Office, and the dedicated personnel from multiple agencies of the Government of Guam, who together accomplished this difficult mission.

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highlight

The NCA Survey of the Aleutian Islands, Alaska (2006–2007)

Within the region know as the "Cradle of Storms," the Aleutian Islands stretch over a 1,180-mile span of ocean, jutting westward from the Alaska Peninsula to form an arc that separates the North Pacific Ocean from the Bering Sea. The Aleutian Islands are the exposed peaks of a submerged mountain range. Along the southern edge of the island arc is a curving submarine trench, with depths as great as 24,930 feet, and extending across the North Pacific for 1,990 miles from the Gulf of Alaska to Kamchatka Peninsula. The Aleutian Islands rose from the volcanic activity resulting from the convergence of the Pacific and North American tectonic plates. Today, this region is one of the most seismically and volcanically active regions in the world, and new islands are still being created.

The marine environment around the Aleutian Islands consists of highly productive and biologically diverse marine ecosystems. Significant upwelling occurs in this region, bringing nutrients to the surface and creating a green belt of high levels of primary and secondary production along the Aleutian Arc. As a consequence, numerous species of fish, mollusks, crustaceans, birds, and marine mammals live in this region. Fisheries harvests in this region provide more than 50% of the nation's harvest and around 10% of the global marine harvest of fish and shellfish (ADCED 2003). The Aleutian Islands are also within the major migratory pathways of many food species (e.g., fish, marine mammals) used for subsistence by the Aleut Natives.

Although the Aleutians may seem remote, there are numerous areas in the region that have been contaminated with petroleum products, as well as with PCBs and several heavy metals. Many contaminated sites originated with World War II and subsequent Cold War activities. Pollutants from Pacific Rim countries are delivered to the Aleutians by the wind and ocean currents and pose potential threats to the marine ecosystem. Amchitka Island, mid-way along the Aleutian Arc, was the site where the United States conducted its largest underground nuclear tests, and leakage of radionuclides from this nuclear testing legacy into the marine environment remains a long-term concern.

A major Pacific shipping route leads to transits of hundreds of ships a year between the West Coast and Asia through the Aleutian Island chain. As the Arctic ice pack recedes due to climate change, a major increase in shipping through this region is expected to occur as the northern sea routes open up for longer periods. Increased shipping traffic has the potential for increasing environmental impacts. For example, in 2004, the M/V Selendang Ayu lost an estimated 424,000 gallons of Intermediate Fuel Oil and 18,000 gallons of marine diesel fuel, in addition to its cargo of 66,000 tons of soybeans (ADEC, 2005; IMC, 2005; USCG, 2005).

The NCA survey of the Aleutian Islands was accomplished in the summer of 2006, with personnel from the Alaska Department of Environmental Conservation (ADEC) in the lead role and support from personnel from the University of Alaska Fairbanks and other state and federal agencies. The Aleutian component of the NCA survey is based on a combination of the procedures and methods of the NCA, coupled with specialized methods for sampling hard-bottom habitats, first developed by the 2002 NCA assessment in the state of Hawaii. A total of

50 randomly selected sites (Figure 1) within the depth contour of 0-60 feet are to be sampled, from 2006 through 2007 (25 sites per year). The 2-year duration of the sampling effort is dictated by the long cruising distances between sampling stations and the difficult logistics of sampling in the Aleutian Islands.

The extent and effects of numerous anthropogenic stressors, ranging from impacts of commercial fisheries to invasive species, need to be understood if resource managers are to preserve and protect the ecological diversity of this region. The EMAP-NCA survey in the Aleutian Islands will provide the ADEC with the ability to assess the current ecological status and, as future assessments are completed, to assess trends in contaminant levels and ecosystem changes in the region.

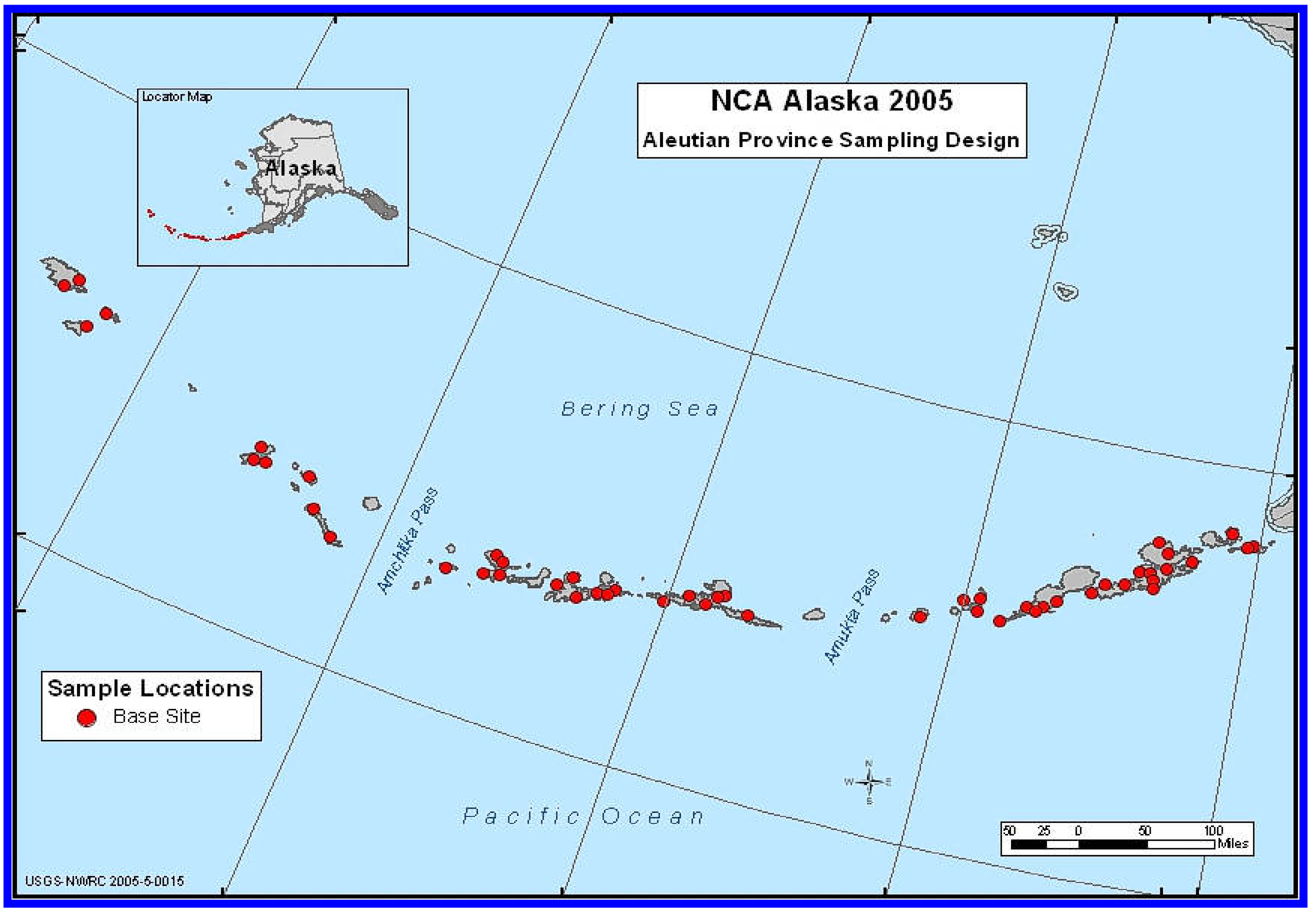

Figure 1. Sampling locations for the 2006–2007 EMAP NCA survey of the Aleutian Islands.

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Chapter 9

Health of Narragansett Bay for Human Use

The previous chapters of this report addressed the condition of the nation's coasts in terms of how well they meet ecological criteria. A related, but separate consideration is how well coasts are meeting human expectations in terms of the goods and services they provide for transportation, development, fishing, recreation, and other uses. Human use does not necessarily compromise ecological condition, but there are inherent conflicts between human activities (e.g., marine transportation) that alter the natural state of the coast and activities (e.g., fishing) that rely on the bounty of nature. The emphasis in this chapter is on human uses and how well they are met. For uses that are not being fully met, the question arises as to how the shortfall is related to coastal condition as described by ecological indicators.

Because this approach relies on local information, it can be pursued only at the level of individual estuaries. The corresponding chapter in the NCCR II centered on Galveston Bay, TX; in this report, the chosen estuary is Narragansett Bay, RI. This choice is to a large extent dictated by the availability of data, and Narragansett Bay is an estuary for which long-term data exist on the abundance of commercial and recreational fishes. Fishing is not the only human use of an estuary, but it is an important use thought to be strongly connected with ecological indicators.

Overview of Narragansett Bay

Narragansett Bay (Figure 9-1), which includes the Providence and Seekonk rivers, is approximately 48 miles long, 37 miles wide, and 132 mi^2 in area (Ely, 2002). Although the Bay lies almost entirely within Rhode Island, a small portion of northeastern Mount Hope Bay is located within Massachusetts. The Bay's watershed includes all five Rhode Island counties (Bristol, Kent, Newport, Providence, and Washington), as well as four counties (Worcester, Norfolk, Bristol, and Plymouth) in Massachusetts. The total area of the watershed is 1,820 mi^2 (Ries, 1990), and approximately 40% of this area is located in Rhode Island (Crawley et al., 2000). The three main rivers that drain into Narragansett Bay are the Pawtuxet, Blackstone, and Taunton rivers.

This chapter will examine the human uses of the Bay (bounded at its seaward end by a line running southwest from Sakonnet Point to Point Judith) and its watershed. Data associated with Block Island and the coast of mainland Rhode Island running along Block Island Sound from Point Judith to the Connecticut state line will not be included in this assessment.

Development Uses of Narragansett Bay

Development uses are human activities that alter the natural state of Narragansett Bay and its watershed. Some of the most important of these activities are land-use changes and development in the Bay's watershed, marine transportation, and point-source discharges of cooling water and wastewater to the Bay.

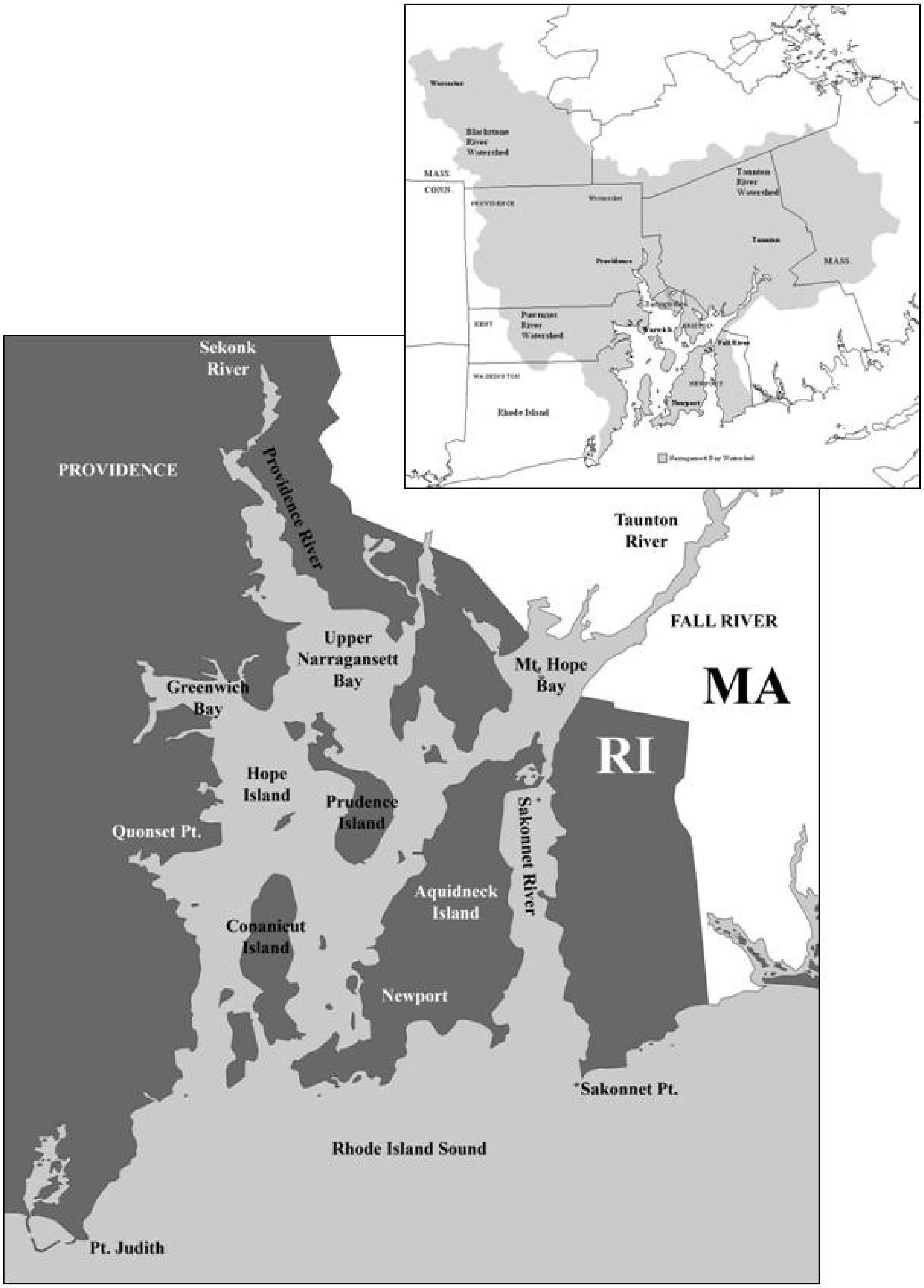

Figure 9-1. Narragansett Bay watershed and surrounding counties (U.S. EPA/NCA).

Land Use Changes and Development

By the 18th century, a merchant economy had developed to replace agriculture as the primary economic force in Rhode Island. The deep, sheltered harbors and availability of fresh water helped to spur the transformation of Newport into one of the premier centers for maritime trade and shipbuilding. By the middle of the 19th century, another transformation had occurred; the rivers draining into Narragansett Bay were being used to provide both power and transportation for a rapidly developing industrial economy. Textile mills, metalworking operations, and jewelry manufacturing plants lined many of the watershed's rivers (Crawley et al., 2000); however, by the 20th century, industrial production had declined, in part due to the migration of textile industries to the south. Currently, land use in the Narragansett Bay watershed is divided among a number of categories (Table 9-1). The largest categories of developed land are residential and agricultural.

Table 9-1. Land Use in the Narragansett Bay Watershed

Land Use	Area (mi^2)	Percent
Residential	216.6	20.1
Agricultural	76.7	7.1
Commercial	20.7	1.9
Recreational	19.4	1.8
Institutional	16.7	1.5
Industrial	13.4	1.2
Transportation and Utilities	10.7	1.0
Roads	10.2	0.9
Commercial/Industrial Mix	2.3	0.2
Urban Vacant	6.9	0.6
Gravel Pits and Quarries	8.4	0.8
Waste Disposal	4.4	0.4
Wetlands, Water, Barren	203.3	18.8
Forest	470.4	43.6

Source: (Crawley et al., 2000).

Throughout the 20th century, the counties in the Narragansett Bay watershed have been a popular place to live (Figure 9-2). The human population in the watershed doubled between 1900 and 1980. As the population has moved from urban areas to the more suburban and rural parts of the watershed due to the advent of better transportation and changing lifestyles, the population has declined since 1980 in several cities, including East Providence, Warwick, Newport, Barrington, and Woonsocket in Rhode Island, and Worcester and Taunton in Massachusetts (Burroughs, 2000; Crawley et al., 2000). Although the rate of population growth in Rhode Island has been slow since 1980, residential development, particularly single-family homes, has increased markedly (Rhode Island Department of Administration, 2000). Currently, the watershed's population is estimated at approximately 1.8 million people (Save the Bay, Inc., 2006), and residential land accounts for more than 20% of the area, representing the largest area of any developed land use category in the watershed (Crawley et al., 2000).

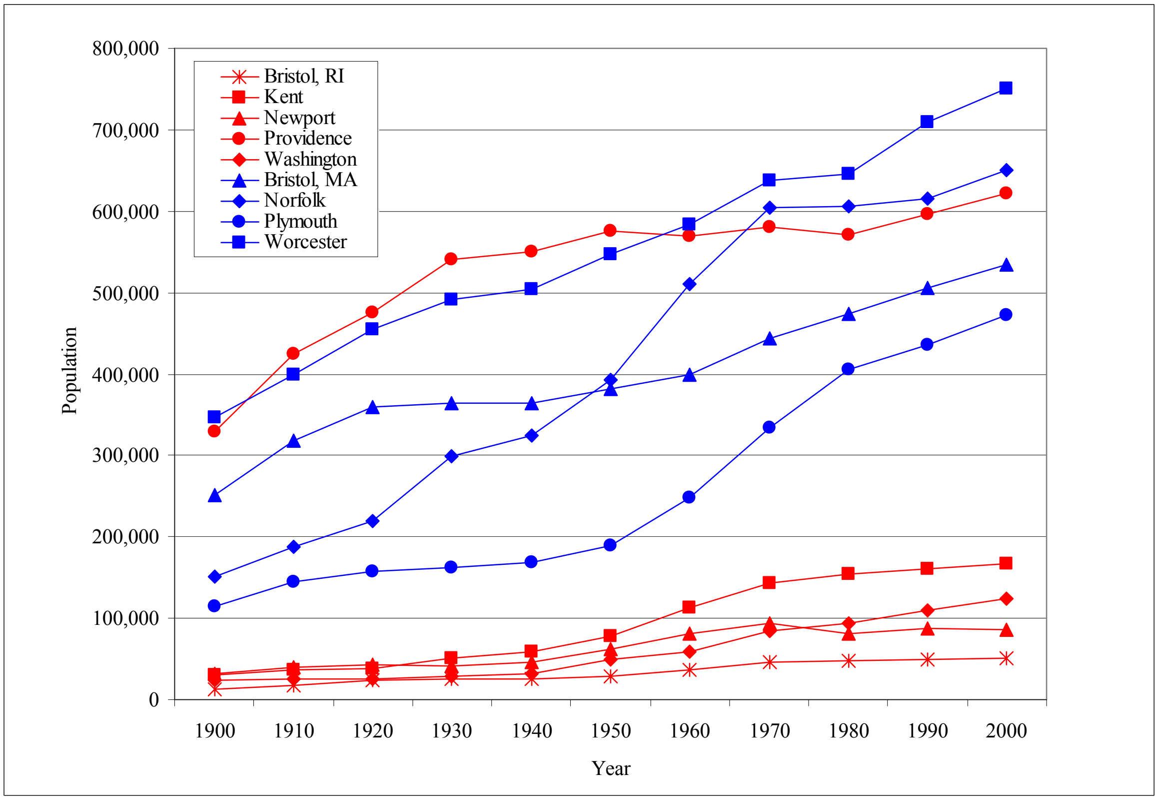

Figure 9-2. Population trends in the Narragansett Bay watershed counties (U.S. Census Bureau, 2001).

The approximately 77 mi^2 of farmland in the Narragansett Bay watershed represents around 7% of the total land area (Crawley et al., 2000). Major agricultural crops in Rhode Island and Massachusetts include corn and turf. Although Newport County, RI, has the highest percentage (15%) of agricultural area in the watershed, Worcester County, MA, has the greatest number of acres (104,000 acres) dedicated to agriculture (USDA, 2004a; 2004b). It should be noted that these data are presented on a county level and may include agricultural area located within the county, but outside of the Narragansett Bay watershed.

Although the economy of Rhode Island has moved towards a mix of service industries, specialized businesses, and tourism and recreation since World War II, industrial operations remain in the area. Industry accounts for a little over 1% of the land area in the Narragansett Bay watershed (Crawley et al., 2000). According to the Economic Census, the manufacturing industry in Rhode Island produced $10.5 billion in sales and employed more than 75,000 people in 1997 (U.S. Census Bureau, 2000b). The computer manufacturing and electronics, fabricated metal, electrical equipment and appliances, and textile industry sectors offered the major employment opportunities in the region (U.S. Census Bureau, 2000a; 2000b). For example, manufacturing in Worcester County, MA, accounts for $11.3 billion annually and employs 61,000 people, primarily in computer, metal fabrication, and chemical manufacture. In Bristol County, MA, computer, electronics, and primary metal manufacturing activities accounted for $7.7 billion in 1997 and employed more than 49,000 people (U.S. Census Bureau, 2000a).

Marine Transportation

Marine transportation is integral to the economy of Narragansett Bay. There are two main shipping channels (Providence River and Quonset/Davisville) and three public ports (Providence, Fall River, and Quonset/Davisville). The majority of commercial marine vessels entering Narragansett Bay carry petroleum products. In 1997, 86% of the 8.78 million mt of cargo entering Narragansett Bay were petroleum products, primarily fuel oil and gasoline carried on barges. Cruise ships and ferries are also an important part of the economy of Narragansett Bay, and the number of cruise ships heading to Newport, RI, has increased since 1994 (Anderson et al., 2000).

Recently, the citizens of Rhode Island were faced with three marine transportation issues. Since last dredged in 1971, the Providence Ship Channel had become so shallow and narrow that the U.S. Coast Guard restricted the passage of two-way ship traffic and deep-draft vessels in the upper portion of the Channel within the Providence River. As a result of these restrictions, petroleum products had to be transferred from tankers into barges before delivery to Providence Harbor. Dredging was required to return the Channel to its authorized 40-foot depth and increase the efficiency of marine transportation to the Harbor. After some debate, dredging operations began in April 2003 and were completed in January 2005, resulting in the removal of 6 million cubic yards of sediment (USACE, 2001; 2005). A second issue concerned the development of a container ship terminal at the former U.S. Naval facility at Quonset Point in North Kingstown (Ardito, 2002). The project was dropped in 2003, and other plans are being developed for the area. Finally, there have been a number of proposals to develop liquid natural gas (LNG) terminals at various locations in Narragansett Bay. Safety, security, and environmental concerns have been raised over the transport and storage of LNG.

Point-Source Discharges

Narragansett Bay is also used to receive point-source discharges of cooling water, industrial wastewater, and municipal wastewater. EPA reports that there are 54 major point-source dischargers in the Narragansett Bay watershed (Figure 9-3) (U.S. EPA, 2005b). The largest of these dischargers is the Brayton Point power plant in Somerset, MA. Brayton Point is the largest fossil fuel power plant in New England and produces approximately 6% of the region's electricity (Ardito, 2002). This plant uses approximately 800 million gallons of water from the Bay per day as cooling water; after the water is used, warm discharge water is discharged to the Bay. Studies have shown that the discharge of heated water from the Brayton Point facility to the Bay has contributed to the collapse of the Mount Hope Bay winter flounder fishery. In recognition of this possible conflict between competing human uses, renewal of the plant's discharge permit contains provisions to decrease water withdrawals from the Bay by 94% and reduce the annual heat discharge by 96% (U.S. EPA, 2003). The next largest point-source facility in the watershed is the Dominion Energy power plant in Providence, RI, with a discharge flow of approximately 260 million gallons per day (U.S. EPA, 2005b).

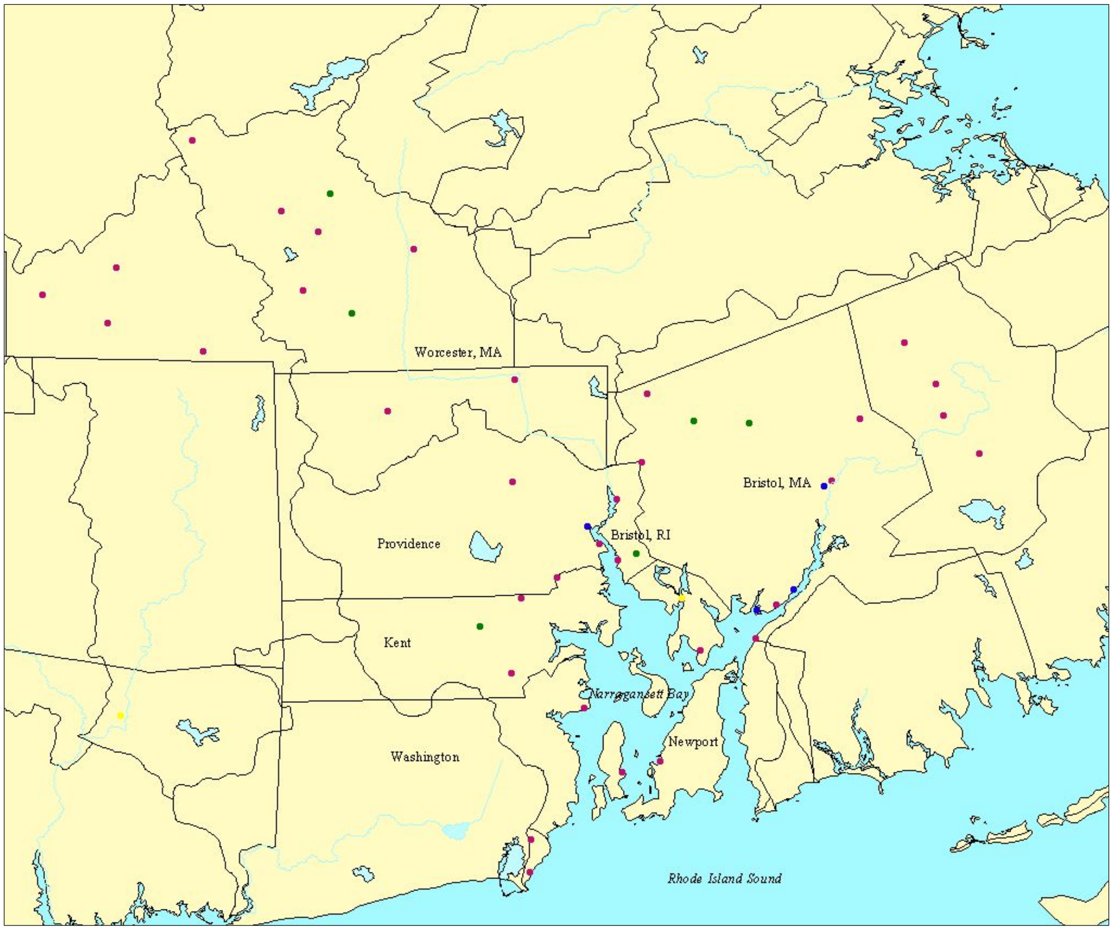

Figure 9-3. Major point sources in the Narragansett Bay watershed: seafood processor (yellow), industry (green), power plant (blue), wastewater treatment plant (red) (U.S. EPA, 2005b).

Wastewater from industrial and municipal sources is also discharged from point sources located within the Narragansett Bay watershed. A number of paint/pigment manufacturers, seafood processors, and petroleum bulk stations and terminals operate in Rhode Island and discharge industrial wastewater to the Bay and its watershed. The majority of the other large point-source dischargers are wastewater treatment plants (WWTPs). There are ten major WWTPs in the watershed with design capacities of more than 10 million gallons per day; three plants are located in Massachusetts (Worcester, Brockton, and Fall River), and seven are located in Rhode Island (Field's Point [Providence], Bucklin's Point [East Providence], East Providence, Cranston, West Warwick, Woonsocket, and Newport) (U.S. EPA, 2005b). Although the total population of the watershed has continued to increase, the number of area residents using these WWTPs has remained steady over the past 30 years (Nixon et al., 2005).

Industrial and municipal wastewater can contribute heavy metals to the Bay. In the context of detailing metal inputs to Narragansett Bay, Nixon (1995) described the history of development and industrialization in Rhode Island from colonial times to the present. Metal inputs began to decline remarkably after about 1960. Some of this decrease can be attributed to the state's changing economic base, but increasing controls on metal releases from a variety of sources, upgrades to STPs, and the cessation of sewage sludge dumping in the Bay has also contributed to the decline (Nixon, 1995).

Nitrogen and phosphorus are other pollutants that can enter the Bay through point-source discharges of industrial and municipal wastewater. Nixon et al. (2005) examined nitrogen and phosphorus inputs to the Bay from the direct discharge of municipal wastewater, as well as inputs from the some of the Bay's tributaries, which provide insight into contributions from upstream point and non-point sources of nitrogen and phosphorus (including WWTPs). Overall, nitrogen inputs to the Bay have not increased in recent decades, and phosphorus inputs have decreased. The study also concluded that these tributaries contributed 1.5 times more nitrogen and 2.7 times more phosphorus than the combined discharges from the area's three largest WWTPs (Nixon et al., 2005); however, a large portion of the nutrient load to these tributaries comes from other municipal WWTPs.

Nutrients, including nitrogen and phosphorus, support algal growth and are essential to marine life; however, high levels of nutrients can lead to excessive algal growth. The subsequent decay of this plant matter consumes oxygen and lowers dissolved oxygen concentrations in the waterbody. Bergondo et al. (2005) and Deacutis et al. (2006) found that summer oxygen measurements in both deep and shallow waters in certain areas of upper Narragansett Bay can drop below 2 mg/L (a level that is intolerably low to some organisms when maintained over short periods [hours]). These hypoxic conditions are due to nutrient-induced algal growth coupled with the lower mixing rates that occur during neap tides, which are periods of low wind and strong stratification that isolate deep water from surface waters. Bergondo et al. (2005) also reviewed dissolved oxygen measurements collected since 1959 during summertime neap tides in the deep waters of upper Narragansett Bay. Low (< 3 mg/L) dissolved oxygen concentrations were only observed in 18% of the measurements, indicating that the presently observed conditions are likely a relatively new feature of Narragansett Bay. Further information on dissolved oxygen levels in Narragansett Bay are available at http://www.geo.brown.edu./georesearch/insomniacs. In recognition of the low oxygen levels in the upper Bay and their connection with nutrient levels, the Rhode Island Department of Environmental Management (RIDEM) has initiated a program to reduce nitrogen concentrations in effluent from WWTPs (RIDEM, 2005b).

Amenity-Based Uses of Narragansett Bay

Amenity-based uses depend on the natural resources of Narragansett Bay and include accessing the shoreline, swimming, boating, and commercial and recreational fishing. Over time, many of these uses have been impacted by human activities and population pressures in the watershed.

Amenity-based uses contribute economic and recreational value to the area's residents. For example, more than 12 million people visit the Bay area each year (Save the Bay, Inc., 2006), contributing to the area's major tourism industry. In 1998, this industry was second only to health services in terms of total wages for the area, and 30% of tourism was based on amenity-based uses of Narragansett Bay (Colt et al., 2000). Colt et al. (2000) estimate that the great economic value of the Bay's tourism industry is probably far exceeded by its recreational value to area residents.

Public Access

The Rhode Island Constitution (Article I, Section 17) states that "The people shall continue to enjoy and freely exercise all rights of fishery, and privileges of the shore, to which they have been heretofore entitled under the charter and usages of the state…'Privileges of the shore' include 'fishing from the shore, the gathering of seaweed, leaving the shore to swim in the sea, and passage along the shore.'" Nonetheless, Bay access is limited because most of the area landward of high tide is privately owned. Although there are 16 miles of public beaches (Colt et al., 2000), most of the Bay's 256-mile shoreline is not publicly accessible (Ely, 2002; Allard Cox, 2004). Of the 80 licensed beaches of Narragansett Bay, 10 are operated by the state or a town and 70 are privately owned (RIDOH, 2005). Some of the private and town-owned beaches are open to the public for a fee. In 1978, the Rhode Island Coastal Resources Management Council (CRMC) began to establish public rights-of-way to the coast. Of the 252 locations described in the guidebook *Public Access to the Rhode Island Coast* (Allard Cox, 2004), 191 access rights-of-way established by the CRMC cross otherwise private lands to areas where, depending on the particular right-of-way, the public can reach areas for viewing nature, fishing, swimming, or launching a boat.

Beaches

Bacterial contamination in Narragansett Bay has resulted in periodic closures of licensed private and public beaches. These closures are due to exceedances of bacterial standards and are generally associated with stormwater runoff after rainstorms in the northern, more populated part of the Bay. For example, episodic closures occur near Providence due to overflows from combined storm and sanitary sewers. In other areas, periodic closures occur due to spills. Table 9-2 lists the number of licensed beaches in each county and the number of closings/advisories issued for 2001 to 2004. The Rhode Island Department of Health maintains a Web site (http://www.ribeaches.org/closures.cfm) listing current beach closures. In addition, a general advisory has been issued to discourage swimming and other full-body contact activities in the Providence River portion of upper Narragansett Bay because "These waters are directly affected by pollution inputs due to heavy rains and discharges from area wastewater treatment facilities. Water contact should be avoided for a minimum of 3 days after heavy rainfall" (RIDOH, 2005). A combined sewer overflow (CSO) project is underway in Providence to create a tunnel that will divert up to 62 million gallons of storm water for later treatment rather than allowing it to flow directly into the Bay (Samons, 2002).

Table 9-2. Number of Licensed Beaches and Closure/Advisory Days

County	Number of beaches	Closure/Advisory Days			
		2004	2003	2002	2001
Providence	1	38	0	6	15
Bristol	4	16	132	9	4
Kent	4	3	55	67	26
Newport	18	192	39	21	13
Washington*	44	2	79	0	4

*Washington county beaches include those along Rhode Island Sound
Source: (NRDC, 2005)

Boating

The number of registered boats in Rhode Island increased from about 29,000 in 1993 to 41,000 in 2002 (NBEP, 2002), and it is probably fair to assume that most are used in Narragansett Bay. In 1988, there were 13,500 slips and moorings in Narragansett Bay (Colt et al., 2002). New docks and marinas are disallowed along 70% of the statewide Rhode Island shoreline (Rhode Island CRMC, 1996), and the number of slips and moorings has not risen in proportion to boat registrations (Liberman, 2005). As a result, most boaters in Narragansett Bay must tow boats to one of the 32 public or 12 private boat ramps, many of which have no or limited space for parking cars and trailers (Allard Cox, 2004; RIDEM, 2005c).

Fishing

Fishing is a popular, rewarding recreational and commercial activity in Narragansett Bay. Although the Bay supports commercial and recreational fishing, the species sought and landed have changed over time.

Commercial Fishing

In 1880, Narragansett Bay supported a variety of commercial fisheries, including alewife, tautog, scup, lobster, and winter flounder. As time passed, however, the Bay's commercial fisheries grew smaller as offshore fishing increased. By the 1960s, Narragansett Bay no longer supported a large commercial finfish fishery (Oviatt et al., 2003). Currently, the annual commercial fish catch for Rhode Island fetches more than $70 million (RIDEM, 2005a). The great bulk of these commercial landings consists of fish caught in Rhode Island Sound or further offshore; however, Narragansett Bay remains commercially important for shellfish. An estimated 10–20% of Rhode Island's total lobster landings are caught in the Bay (Ely, 2002). In addition, the state's quahog fishery is contained mostly within the Bay, with average landings of 1.5 million pounds for the period 1990–2004 and a value of $7.5 million (NOAA, 2005a).

Although the causes for many of the declines in the Narragansett Bay fisheries are unknown, some of them can be traced to changes in environmental conditions (Ardito, 2003; Oviatt et al., 2003). For example, habitat loss can play a key role in fisheries decline. Eelgrass beds are critical habitat for bay scallops. Narragansett Bay once supported a large, commercial bay scallop fishery. In 1880, more than 300,000 bushels of bay scallops were harvested from Narragansett Bay, a quantity that would be worth more than $33 million on today's wholesale market. However, in 2003, the bay scallop landings from the Bay were nonexistent. The loss of this fishery can be traced to the loss of the scallop's habitat – eelgrass beds (Ardito, 2003). Eelgrass beds were widespread in Narragansett Bay as late as the 1860s, and historical accounts record eelgrass beds at the head of the Bay in the lower Providence River. During the 1930s, wasting disease—a widespread infection partly attributed to the slime mold *Labryinthula zosterae*— decimated Atlantic coast eelgrass populations, including those in Narragansett Bay (Short et al., 1987). The Bay's eelgrass beds continued to shrink throughout the 20th century, due largely to decreased light penetration from nutrient pollution and algae growth (Ardito, 2003; Lipsky, 2003). Approximately 100 acres of eelgrass remain in Narragansett Bay today (Save the Bay, Inc., 2006). Many former scallop-harvesting areas of the Bay now support the quahog fishery (Ardito, 2003).

Recreational Fishing

About 300,000 sport anglers seek finfish and shellfish in Rhode Island's marine waters (RIDEM, 2005a). Since 1981, the NMFS has maintained a database (NOAA, 2005b) containing information gathered from a survey on recreational catches. It should be noted that this database shows data on a statewide level and combines catches in the Bay with those reported in Rhode Island's sounds. In the 24-year period from 1981 to 2004, the NMFS recreational survey showed that the total annual number of fish caught annually fluctuated with no overall trend (Figure 9-4). The median recreational catch since 1981 has been 2 million fish, and nine species have been among the five most commonly reported recreationally caught fish (Table 9-3) (NOAA, 2005b). On the basis of information from the RIDEM, an estimated one-third to one-half of the state's recreational catch is taken from within the Bay as opposed to Rhode Island Sound, Block Island Sound, or from areas further offshore (Ely, 2002). Narragansett Bay's recreational fishery is estimated at more than $300 million per year (NBEP, 2006)

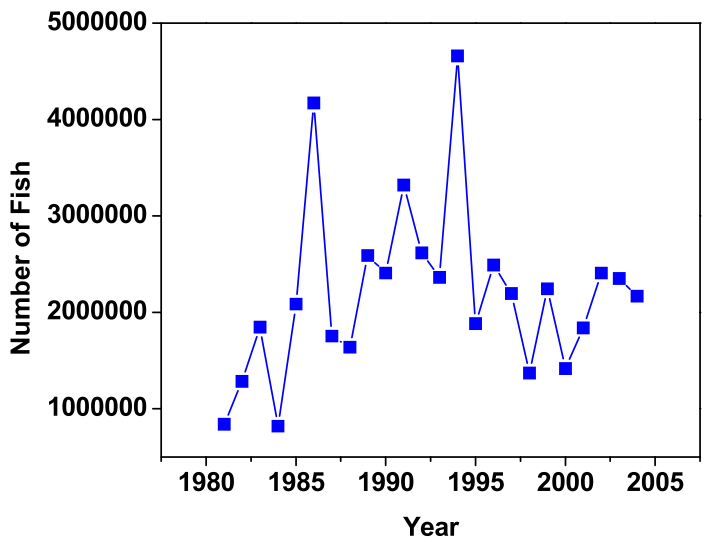

Table 9-3. The Most Commonly Reported Recreationally Caught Fish in Narragansett Bay Between 1981 and 2004 (NOAA, 2005b)

Fish Species	Number of years species was listed in the top 5
Bluefish	24
Scup	24
Winter flounder	11
Striped bass	10
Summer flounder	10
Tautog	10
Herrings	6
Cunner	7
Atlantic mackerel	5

Estimates of Fish and Shellfish Abundance

Data from systematic trawls and estimates of recreational fish landings have been used to monitor shifts in species abundance in Narragansett Bay. The University of Rhode Island (URI) has maintained a weekly fish trawl at Fox Island since the 1960s (Oviatt et al., 2003). RIDEM has also conducted fishery-independent estimates of fish abundances in the Bay using biannual (spring and fall) systematic trawling of Narragansett Bay, Rhode Island Sound, and Block Island Sound. Starting in 1990, the Narragansett Bay biannual trawling was augmented with monthly trawling at 12 stations randomly selected from a pre-set grid (Lynch, 2005). The NMFS recreational survey database (NOAA, 2005b) supplies information on recreation landings in Rhode Island, and these data are used in conjunction with trawl data to provide additional insight into species abundance shifts.

The species that dominated the URI weekly fish trawl at Fox Island in the 1960s and 1970s were sea robins, winter flounder, and windowpane flounder. These species comprised a much smaller portion of the catch in the 1980s and a very small portion in the 1990s. The opposite trend was observed for crabs and lobsters, which were a very small part of the total in the 1960s, but grew to dominate the Fox Island catch in the 1990s (Oviatt et al., 2003).

Figure 9-5 and Table 9-4 combine data on annual numbers of fish taken in RIDEM biannual trawl surveys with the recreational catch numbers from the NMFS database. It should be noted that these two sets of data were collected over different geographic regions. The RIDEM data used in this analysis was collected in Narragansett Bay, whereas the NMFS data set includes recreational landings from Rhode Island coastal sounds. This comparison is not ideal, but is necessary because NMFS does not segregate their data to distinguish landings in Narraggansett Bay from those outside of the Bay. The graphs in Figure 9-5 plot the annual numbers of six species commonly caught by the RIDEM trawls and the landings by recreational anglers from the NMFS database. These graphs reflect the large year-to-year variability in annual catch data, which is characteristic of many species, and provide the opportunity to evaluate the different results obtained using the two sampling methods: trawls (RIDEM) vs. recreational hook-and-line fishing (NMFS). Table 9-4 displays data for the 20 species with the highest median annual RIDEM trawl catch numbers over 1979–2004 and for the 12 species that were most commonly taken by recreational anglers between 1981 and 2004. Some of the commonly trawled species are not taken by recreational anglers, and the median NMFS recreational catch numbers for these species are listed as "none" in the table. Conversely, two of the species commonly taken by anglers, striped bass and Atlantic mackerel, are often absent in RIDEM trawls (medians of zero indicate no fish of that species were collected during more than half of the years). Table 9-4 also shows whether trawl catch or recreational landing numbers exhibited an increasing (I) or decreasing (D) trend over the time period. Although this correlation was an objective definition of trends, similar conclusions can be made by simply looking at the time series in Figure 9-5 for several of the species (i.e., winter flounder, tautog, and cunner catches are decreasing, while summer flounder are increasing). It should be noted that the species and data listed in Table 9-4 are based on long-term data sets; therefore, species exhibiting large catch numbers over the short term were excluded. For example, menhaden were present at high numbers (median of 9,800 fish) in RIDEM trawls collected between 1999 and 2004; however, this species does not appear in Table 9-4 because the median number of fish collected in trawls over the long-term (1979–2004) is only 18. Furthermore, although long-term data may show decreasing trends, some individual species (e.g., tautog and winter flounder) may be increasing over shorter time scales (i.e., 2001 to 2006) (personal communication, Lynch, 2006).

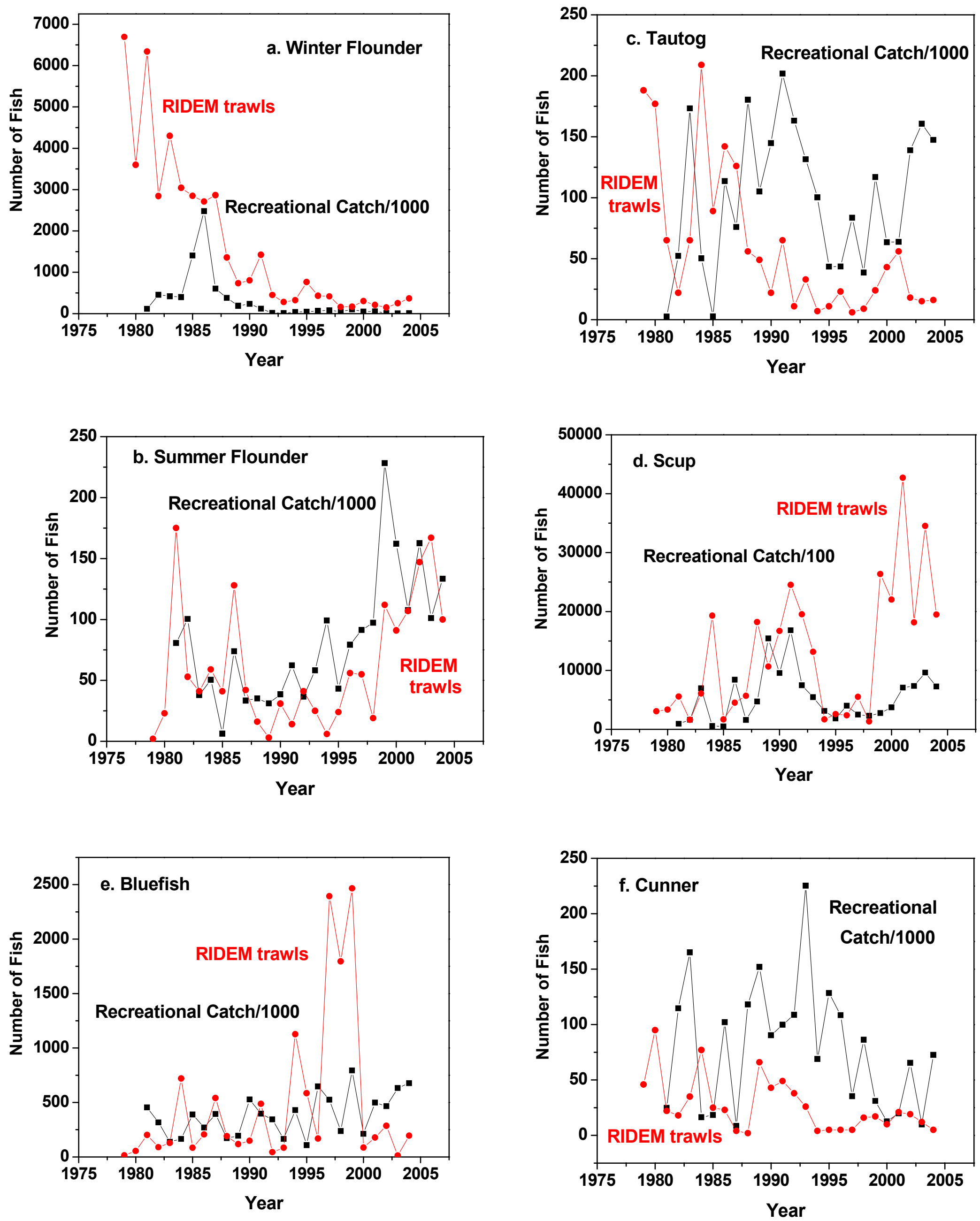

Figure 9-5. Number of fish of six species annually taken in RIDEM trawls (red) in Narragansett Bay and number reported by recreational anglers to NMFS (black) in Narragansett Bay and the Rhode Island coastal sounds (based on data from Lynch, 2005 and NOAA, 2005b).

Table 9-4. Comparison of the Most Commonly Harvested Fish Species during RIDEM Trawls Conducted from 1979–2004 in Narragansett Bay and Recreational Fishing Efforts Reported to NMFS from 1981–2004 in Narragansett Bay and the Rhode Island Coastal Sounds (Lynch, 2005; NOAA, 2005b)

Species	RIDEM		Recreational[a]	
	median	trend[b]	median	trend[b]
Bay anchovy	31,000		none	
Scup	8,400		440,000	
Longfin squid	3,800		none	
Butterfish	2,600	I	none	
Winter flounder	750	D	89,000	D
Weakfish	470		1,700	D
Atlantic herring	440	I	70,000	I
American lobster	350		none	
Bluefish	180		39,000	
Skates	190		13,000	
Windowpane flounder	120	D	none	
Alewife	80	I	none	
Atlantic moonfish	72	I	none	
Blueback herring	60		**[c]	
Red hake	56	D	none	
Summer flounder	42		77,000	I
Tautog	38	D	100,000	
Spotted hake	26		none	
Cunner	20	D	79,000	
Striped searobin	20		16,000	
Striped bass	0	I	85,000	I
Atlantic Mackerel	0		29,000	

[a] Recreational landings included fish caught in Rhode Island and Block Island sounds.
[b] Trends are indicated as increasing (I) or decreasing (D) if Spearman rank correlation coefficient between numbers of fish and year was greater than 0.5 or less than -0.5, respectively.
[c] Blueback herring are probably included in the recreational landings for “herring.”

All of the fish species caught in Narragansett Bay forage in the Bay, and some of these species also spawn in the Bay; however, most species spawn offshore and move into the Bay as part of their annual migration. The species that spawn in Narragansett Bay would seem to be most sensitive to environmental quality in the Bay. Two of the species that spawn in the Bay (e.g., tautog and winter flounder) are recreationally important and have exhibited decreasing abundances. In addition to fishing pressure, tautog and winter flounder population declines are possibly related to the summertime hypoxia reported in the upper portions of the Bay (Bergondo et al., 2005; Deacutis, in press), but these declines could also be related to large-scale environmental changes unrelated to any human use of Narragansett Bay. For example, species shifts in parts of North America and Europe have been correlated with cyclic climate changes induced by the North Atlantic Oscillation (Drinkwater et al., 2003). In addition, a steady rise in sea surface water temperature has been observed since the mid-1960s in coastal waters of the northeastern United States (Nixon et al., 2004). If these temperature patterns are representative of the water column as a whole, winter flounder populations could be impacted. Under experimental conditions, warmer water decreased the survival rates of winter flounder eggs. These results were attributed to increased predation on the eggs by sand shrimp (Keller and Klein-MacPhee, 2000; Taylor and Danila, 2005).

Fishery Restrictions

Regardless of the cause for decreasing abundance of any species, removal of fishing pressure should benefit the population. The abundance of winter flounder is so low in Narragansett Bay that recreational or commercial harvest of this species is prohibited in parts of the Bay (RIDEM, 2005a). Because of concentrations of bacteria in water indicative of mammalian fecal material and the fact that mollusks are often eaten raw, 34% of the Bay was permanently closed to shellfishing in 2005 and another 16% was closed for some period after rainfall events (RIDEM, 2005a). In the absence of these closures, the quahog landings may have been greater.

Narragansett Bay encompasses estuarine and coastal areas in both Rhode Island and Massachusetts. Although no waterbody-specific fish advisories are in effect for Narragansett Bay, both of these states have issued fish consumption advisories for all estuarine and coastal waters within their respective jurisdictions, including the waters of Narragansett Bay (U.S. EPA, 2005a). Table 9-5 summarizes the fish consumption advisories covering Narragansett Bay and includes information on the contaminants for which the advisories have been issued, the fish and shellfish species covered in the advisory, and the population (general population or sensitive subpopulation) for whom the advisory has been issued.

Table 9-5. Fish Consumption Advisories in Effect for Narragansett Bay in 2004 (U.S. EPA, 2005a)

Waterbody name	State	Chemical contaminant	Populations targeted by the advisory	Fish species under advisory
Statewide – all estuarine and coastal marine water	Massachusetts	Mercury	NCSP	King mackerel Shark Swordfish Tilefish Tuna (steaks)
		PCBs	NCSP	Bluefish
			NCGP	Lobster (tomalley)
Statewide – all estuarine and coastal marine waters	Rhode Island	Mercury	NCSP	Striped bass Bluefish Shark Swordfish
		PCBs	NCSP	Striped bass Bluefish
			RGP	Striped bass
			CFB	Striped bass 26–37” in length

NCSP = No-consumption recommended for sensitive populations (pregnant and nursing women and children)
NCGP = No-consumption recommended for the general population
RGP = Restricted consumption for the general population to one meal/month
CFB = Commercial fishing ban

Fish consumption advisories are issued based on the level of a chemical contaminant detected in the fish tissue. The PCB advisories have been in effect since 1993 (Rhode Island) and 1994 (Massachusetts), whereas the mercury advisories were first issued in 2001(Massachusetts) and 2002 (Rhode Island). For two popular recreational species, striped bass and bluefish, the states advise sensitive populations against consuming any of these fish because of the levels of mercury and total PCB concentrations in their tissues (Rhode Island) or because of PCBs in their tissues (Massachusetts). In addition, the State of Massachusetts advises all members of the general population against consuming the heptatopancreas tissue (tomalley) of lobster because of elevated concentrations of PCBs in this tissue. The State of Rhode Island also recommends that members of the general population limit consumption to one meal per month of striped bass because of the PCB levels in this fish tissue (U.S. EPA, 2005a). In addition, a commercial fish ban was in effect for all striped bass from 26–37 inches in length (U.S. EPA, 2005a); however, this ban has been lifted (personal communication, Deacutis, 2006).

It is important to note that fish advisories are issued by state governments; therefore, some differences between state advisories may occur in estuarine areas that span state borders. It should also be understood that many species of fish, such as striped bass and bluefish, are highly migratory in nature. The mercury and PCB concentrations bioaccumulated in the tissues of these species are not solely derived from chemical contamination in Narragansett Bay, but have been accumulated from exposure to contamination along the species' migratory routes, which includes many of the estuaries and coastal areas of the Northeast.

Are Human Uses Being Met by Narragansett Bay?

Human uses are being met by Narragansett Bay, but, as with most any other estuaries, there are some shortcomings. Development uses are presently met, but there is controversy. Earlier plans to build a container ship terminal at Quonset Point have been dropped, but plans are being pursued to develop LNG terminals at various locations in Narragansett Bay. In order to decrease the frequency and spatial extent of summertime hypoxia in the deep waters of the upper Bay, nitrogen inputs are being reduced by increasing the level of treatment required at WWTPs from secondary to tertiary treatment.

Rhode Islanders and tourists relish the Bay's natural amenities. The shoreline is public in Rhode Island, and, while ready access to most of it is enjoyed by property owners, an increasing number of public access points are being established. Boat registrations indicate that the popularity of boating is on the rise; however, participants in this activity would benefit from improved access points. The availability of slips and mooring space has not kept pace with the rise in boat registrations, and many of the shore access points do not have parking space for boat trailers.

Bacterial contamination causes periodic beach closures and is the basis of a permanent advisory against recreational water contact in the Providence River. Closures generally occur after storm events carry runoff into the Bay. In Providence, a CSO project is proceeding to capture storm water before it enters the Bay. The successful completion of this project may lead to the removal of a permanent advisory against recreational water contact in some areas. Bacteria are also the cause of permanent shellfish bed closures in over 34% of Bay waters, with an additional 16% of the area closed after storms. These closures are effectively removing some predation on quahogs in the closed areas, and these populations may be serving as the seed stock to sustain the quahog fishery in the rest of the Bay (Oviatt et al., 2003).

The Rhode Island commercial fishery has moved offshore during the past 50 years. With the exception of the quahog and small lobster fisheries, the Bay no longer supports a major commercial fishery; however, the recreational fishery attracts over 300,000 anglers each year and is a major part of Rhode Island's tourist industry. Although winter flounder dominated the recreational catch in the early 1980s, the abundance of this species has been decreasing since the late 1980s, and there is a current ban on harvesting winter flounder in most of the Bay. The total annual number of all fish species harvested recreationally has been relatively constant (no positive or negative trend), and the decrease in the catch of bottom fish (e.g., winter flounder and tautog) has been countered by the increase in catch of summer flounder and pelagic fish (e.g., bluefish and striped bass). Because the total recreational catch has remained relatively constant, winter flounder population declines have not decreased the overall value of Narragansett Bay to recreational anglers.

Although recreational catches remain relatively constant in the Bay, fish advisories first issued for PCBs in the 1990s and for mercury in early 2000s remain in effect. These advisories recommend that sensitive populations (pregnant and nursing women and young children) not consume any of the listed species from the Bay. In addition, advisories in effect for the general population recommend no consumption of lobster tomalley (Massachusetts) and restricted consumption of striped bass (Rhode Island). These advisories restrict uses of Narragansett Bay's fishery resources.

Human Uses and NCA Environmental Indicators

As reported in the NEP CCR (U.S. EPA, 2006), the overall condition of Narragansett Bay is rated poor based on the four NCA indices of estuarine condition (Figure 9-6). The water quality index for Narragansett Bay is rated fair, the benthic index is rated fair to poor, and the sediment quality and fish tissue contaminants indices are both rated poor. Figure 9-7 provides a summary of the percentage of estuarine area rated good, fair, poor, or missing for each parameter considered. Please refer to Table 1-24, 1-25, and 1-26 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator. This environmental assessment is based on data from 56 NCA sites sampled in the Narragansett Bay Estuary Program (NBEP) estuarine area in 2000 and 2001.

In general, the water quality, sediment quality, and benthic index data demonstrate a north-to-south gradient, with poorer conditions found in the northern, more populated portion of the estuary. These findings are consistent with the human uses being compromised in the same portion of the Bay. The fish tissue contaminants index was rated poor for 91% of the fish and shellfish samples collected from the Bay, and all whole-fish samples surveyed contained quantities of PCBs that exceeded or fell within EPA's Advisory Guidance values for fish consumption. These results were consistent with the fish advisories issued for the Bay. It should be noted that migratory fish species can bioaccumulate contaminants across a wide geographic range; therefore, high contaminant concentrations measured in fish collected in Narragansett Bay are not necessarily indicative of high levels of pollution in the Bay. This index is best examined in context with other environmental indicators.

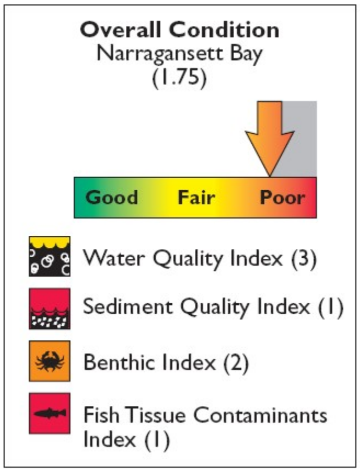

Figure 9-6. The overall condition of the NBEP estuarine area is poor (U.S. EPA/NCA).

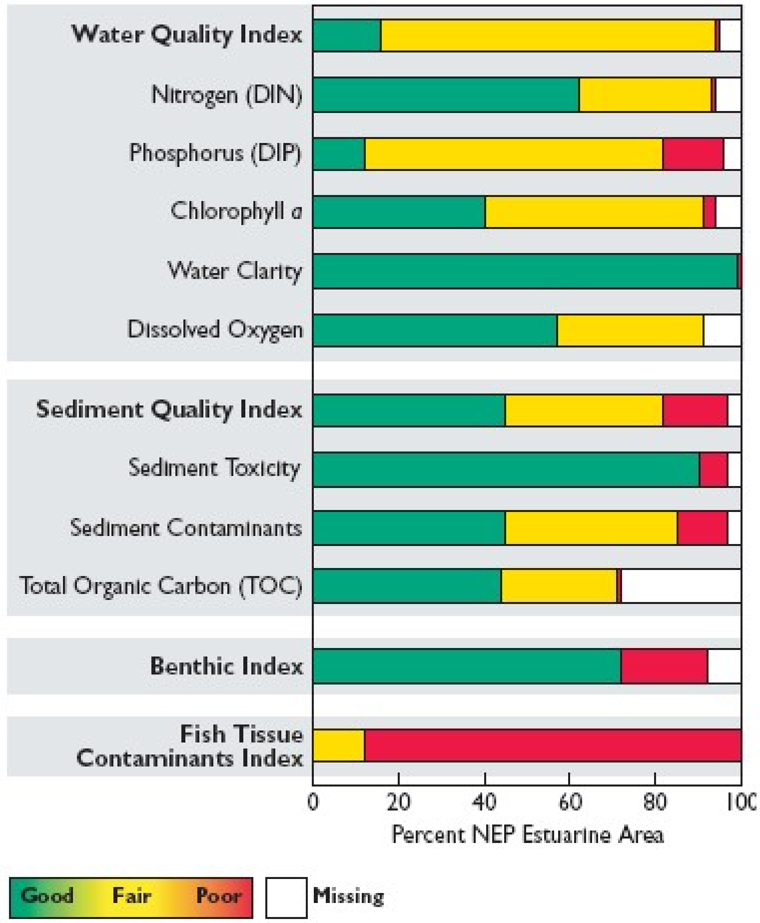

Figure 9-7. Percentage of estuarine area achieving each rating for all indices and component indicators—Narragansett Bay (U.S. EPA/NCA).

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NCCR III

Chapter 9 Highlight

highlight

Summer Dead Zone Kills Billions of Narragansett Bay Mussels

During the summer of 2001, hypoxia caused fish kills, foul odors, and closed beaches throughout Rhode Island's Narragansett Bay (Lawton, 2006). At the same time, scientists discovered a massive die-off of blue mussels (*Mytilus edulis*), which are a foundation species and vital to the health of the Bay. Oxygen depletion in bottom waters suffocates sea life, particularly sedentary bottom dwellers, such as the blue mussels, that are unable to leave the area. These species are frequently keystones of coastal ecosystems, providing water filtration and circulation, as well as a refuge for other species (Altieri and Witman, 2006). Therefore, declines in bivalve populations may result in the inability to avoid future hypoxic events.

One month before the 2001 hypoxia event occurred, surveys of nine mussel reefs in Narragansett Bay revealed healthy, densely packed mussels covering the sea floor. As the summer progressed, researchers noted the highest reductions in mussel densities on reefs where dissolved oxygen concentrations were lowest. One of the nine reefs studied experienced complete mussel extinction, and seven more were severely depleted. Approximately 4.5 billion mussels or about 80% of the reefs' populations died that summer. In the fall of 2002, one year after the die-off event, only one of the nine mussel reefs was recovering its mussel population. (Altieri and Witman, 2006).

Dead Zone
A distinct band of dead mussels washed ashore along Narragansett Bay (Photograph courtesy of Brown University and John Witman).

In order to help assess the effects of the die-off on the Bay, Altieri and Witman calculated the filtering capacity of mussels on the reefs. Before the 2001 hypoxic event, healthy mussel populations took approximately 20 days to filter the equivalent of the entire volume of Narragansett Bay. During the summer of 2001, the filtering capacity of the nine mussel reefs studied declined by more than 75%, increasing the number of days to filter the volume of the Bay to approximately 79 days (Altieri and Witman, 2006).

Fertilizer and sewage spills into coastal waters often initiate hypoxic events by carrying large amounts of nutrients into estuarine waters. Paired with warm summer temperatures and a lack of water circulation, nutrient pulses to the estuary create ideal conditions for exponential increases in phytoplankton populations, resulting in massive algae blooms. As the algae from the blooms die, they sink to the bottom, and bacteria consume them along with dissolved oxygen, creating "dead zones" (Lawton, 2006).

By consuming phytoplankton, suspension feeders such as bivalve mollusks have the potential to control eutrophication that ultimately fuels the development of hypoxic events (Officer et al., 1982); however, bivalves are frequently casualties of hypoxia when algae blooms grow too large, reducing filtration capacities. Decreased filtration may lead to increased occurrences of hypoxia and further mortality of suspension feeders such as bivalve mollusks' therefore, these catastrophic hypoxia events and their resulting localized extinctions may trigger a downward spiral, with coastal zones less able to handle environmental degradation (Altieri and Witman, 2006). For example, with mussel populations severely depleted, Narragansett Bay may lose the ability to prevent future dead zones from forming. This is what has occurred in Southeast Coast estuaries as a result of the near extinction of oysters (*Crassostrea virginica*), which in turn contributed to further hypoxia and failure of oyster populations to recover (Ulanowicz and Tuttle, 1992; Lenihan and Peterson, 1998).

The loss of a foundation species such as the blue mussel, which filters water and provides food and habitat for other estuarine organisms, can have a significant, long-lasting effect on the local Narragansett Bay ecosystem; however it is not an isolated incident. According to a 2004 United Nations Environment Program report (UNEP, 2004), the number of coastal areas affected by hypoxia worldwide has doubled since 1990. Dead zones similar to those experienced in Narragansett Bay can also be found along the East Coast of the United States, in European coastal waters, and off the coasts of Australia, Brazil, and Japan. One of the largest dead zones occurs annually in the Gulf of Mexico near the mouth of the Mississippi River Delta, where the hypoxic zone has been know to extend along the coastline covering up to 8,500 mi^2, an area the size of New Jersey (Rabalais et al., 2002).

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