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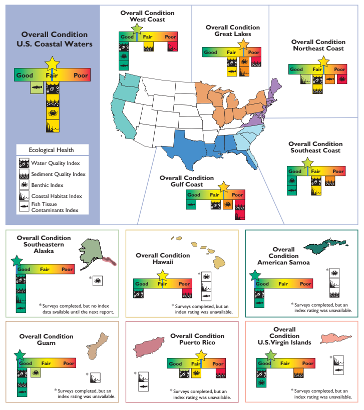
National Coastal Condition Report IV



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List of Acronyms

AOC	Area of Concern
AWQC	Ambient Water Quality Criterion
BEACH	Beaches Environmental Assessment, Closure, and Health Program
CDF	cumulative distribution function
CEC	contaminants of emerging concern
CFMC	Caribbean Fishery Management Council
CMSP Framework	*Interim Framework for Effective Coastal and Marine Spatial Planning*
CPUE	catch per unit effort
DDD	p,p’-diclorodiphenyldichloroethane
DDE	p,p’-diclorodiphenyldichloroethylene
DDT	p,p’-diclorodiphenyltrichloroethane
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorus
EEZ	U.S. Exclusive Economic Zone
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
ERL	effects range low
ERM	effects range medium
ESA	Endangered Species Act
ESRP	Ecosystem Services Research Program
FMP	fishery management plan
FWS	U.S. Fish and Wildlife Service
GCRP	U.S. Global Change and Research Program
GLFC	Great Lakes Fishery Commission
GLNPO	Great Lakes National Program Office
GLOBEC	U.S. Global Ocean Ecosystem Dynamics
GMP	Joint Gulf States Comprehensive Monitoring Program
H´	benthic diversity
IOOS	U.S. Integrated Ocean Observing System
LME	Large Marine Ecosystem
mg/L	milligram per liter
MHI	Main Hawaiian Islands
MMP	Marsh Monitoring Program
NCA	National Coastal Assessment
NCCA	National Coastal Condition Assessment
NCCR	National Coastal Condition Report
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*
NCCR V	*National Coastal Condition Report V*
NFS	NOAA Fisheries Service
NLFA	National Listing of Fish Advisories
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NO_3-N	nitrate as nitrogen
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status & Trends Program
NWHI	Northwestern Hawaiian Islands

NWI	National Wetlands Inventory
NY/NJ	New York/New Jersey
OW	Office of Water
PAH	polycyclic aromatic hydrocarbon
PAR	photosynthetically active radiation
PCB	polychlorinated biphenyl
PCEIS	Pacific Coast Ecosystem Information System
PFMC	Pacific Fishery Management Council
ppb	parts per billion
PPCP	pharmaceuticals and personal care products
ppm	parts per million
QA	quality assurance
S&T	Status and Trends (NWI)
SAV	submerged aquatic vegetation
SOLEC	State of the Lakes Ecosystem Conference
TOC	total organic carbon
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WCPFC	Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific
WWTP	wastewater treatment plant
µg/g	microgram per gram
µg/L	microgram per liter

Executive Summary

National Coastal Condition

Executive Summary

Coastal waters in the United States consist of a variety of habitats, including estuaries, bays, sounds, coastal wetlands, coral reefs, intertidal zones, mangrove and kelp forests, seagrass meadows, and coastal ocean and upwelling areas (i.e., deep water rising to surface). These coastal areas encompass a wide diversity of ecosystems that result from the tidal exchanges that occur between freshwater rivers and saline ocean waters within coastal estuaries. Coastal habitats provide spawning grounds, nursery areas, shelter, and food sources critical for the survival of finfish, shellfish, birds, and other wildlife populations that contribute substantially to the economic health of our nation.

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

To better address questions about national coastal condition, the EPA, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (FWS) 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* (NCCR). This series of reports contains one of the most comprehensive ecological assessments of the condition of our nation's coastal bays and estuaries. The assessment presented in this, the fourth NCCR (NCCR IV) is based on data from more than 3,100 such coastal sites.

The first NCCR (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 the EPA, NOAA, FWS, and U.S. Department of Agriculture. The second NCCR (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 overall. Agencies that contributed data to the NCCR II included the EPA, NOAA, FWS, and the U.S. Geological Survey (USGS). Several state, regional, and local organizations also provided information on the condition of the nation's coasts.

The third NCCR (NCCR III) assessed the condition of the nation's estuaries and coastal embayments, including the coastal waters of Hawaii and Southcentral Alaska, based primarily on data collected by the EPA's National Coastal Assessment (NCA) program in 2001 and 2002. The NCA, NOAA's National Marine Fisheries Service (NMFS) and National Ocean Service (NOS), FWS's National Wetlands Inventory (NWI), and USGS contributed most of the information presented in the NCCR III. The report showed that the overall condition score (2.8) for the nation's coastal waters had improved since 1990, but that overall condition continued to be rated fair. If the national score were recalculated without Alaska and Hawaii, however, the overall condition score would be 2.3 (rated fair to poor; no change from the overall condition score in NCCR II). The NCCR III also presented analysis of temporal changes in coastal condition from 1990 to 2002 for the nation and by region.

This fourth NCCR (NCCR IV) assesses the condition of the nation's estuaries and coastal embayments, including the coastal waters of the conterminous United States, Southeastern Alaska, Hawaii, American

Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands. This assessment is based primarily on the EPA's NCA data collected between 2003 and 2006. The NCA, the NOAA's NMFS and NOS, and the FWS's NWI contributed most of the information presented in this current report. The NCCR IV shows an overall condition score of 3.0 for the nation's coastal waters; although this score has improved substantially since 1990, the overall condition of the nation's coastal resources continues to be rated fair. If the national score were recalculated without Alaska, Hawaii, and the island territories, however, the overall condition score would be 2.5 (rated fair; only a slight improvement from the overall condition score of 2.3 in NCCR III). This report also presents analysis of temporal changes in coastal condition from 1990 to 2006, with regional chapters focusing on changes mainly from 2000 to 2006.

With each NCCR, the collaborating agencies strive to provide a more comprehensive picture of the nation's coastal resources and to communicate these findings to the informed public, coastal managers, scientists, members of Congress, and other elected officials. This NCCR IV builds on the foundation provided by the NCCR I, NCCR II, and NCCR III. In addition to the areas previously assessed in the NCCR III, the NCCR IV provides condition data for Southeastern Alaska, American Samoa, Guam, and the U.S. Virgin Islands (the NCA has not assessed the Pacific island Commonwealth of the Northern Mariana Islands). 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. Although a freshwater ecosystem, the Great Lakes are included as a coastal resource because Congress has treated the Great Lakes states as coastal states in federal coastal legislation.

The NCCR IV presents four main types of data: (1) coastal monitoring data, (2) national coastal-ocean condition data, (3) offshore fisheries data, and (4) advisory and closure 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 the EPA's NCA program, which provides information on the condition of coastal waters for all regions of the United States. The NCA data are stored in the Environmental Monitoring and Assessment Program (EMAP) NCA Database, available online at http://www.epa.gov/emap/nca/html/data/index.html. The NCCR IV uses NCA and other data to evaluate five indices of coastal condition—water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index—in each region of the United States (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Great Lakes, Southeastern Alaska, Hawaii, Puerto Rico, and the U.S. Territories of American Samoa, Guam, and the U.S. Virgin Islands). The resulting ratings for each index are then used to calculate the overall condition ratings for each region, as well as the index and overall condition ratings for the nation. The NCCR IV assessment applies to 30 coastal states (22 ocean states, 6 Great Lakes states, and 2 ocean/Great Lakes states), the Commonwealth of Puerto Rico, and the U.S. island territories (American Samoa, Guam, and the U.S. Virgin Islands) (Figure ES-1). Trends in the NCA data are discussed at the end of this Executive Summary.

Uses of the National Coastal Condition Report (NCCR) Series

The NCCR series is designed to help us understand the questions, “What is the condition of the nation’s coastal waters? Is that condition getting better or worse? How do different regions compare?” These reports, however, cannot represent all individual coastal and estuarine systems of the United States; therefore, their information is based on a limited number of ecological indices and component indicators for which nationally consistent data sets are available to support estimates of ecological condition. The assessments provided, and more importantly, the underlying data used to develop the assessments, can establish a picture of historical coastal conditions at state, regional, or national scales. For example, NCA data have been used to provide insight into the conditions in the estuaries of Louisiana and Mississippi prior to Hurricane Katrina. These data may also be used to help us understand conditions in Gulf of Mexico estuaries prior to the Deepwater Horizon incident and the subsequent BP Oil Spill. However, the methodology and data used in this report were not designed to assess impacts directly related to the BP Oil Spill. This NCCR IV does not include, for example, indicators such as water chemistry, oil-related contaminants (i.e., oil, grease, alkylated PAHs, or volatile organic compounds), dispersant compounds, or other indicators of exposure that might be required in an environmental assessment. Any comparisons to environmental data collected to assess the impact of the BP Oil Spill on Gulf of Mexico estuaries should be limited to the indicators and methods presented in this report and to broad generalizations about coastal condition at state, regional, or national scales.

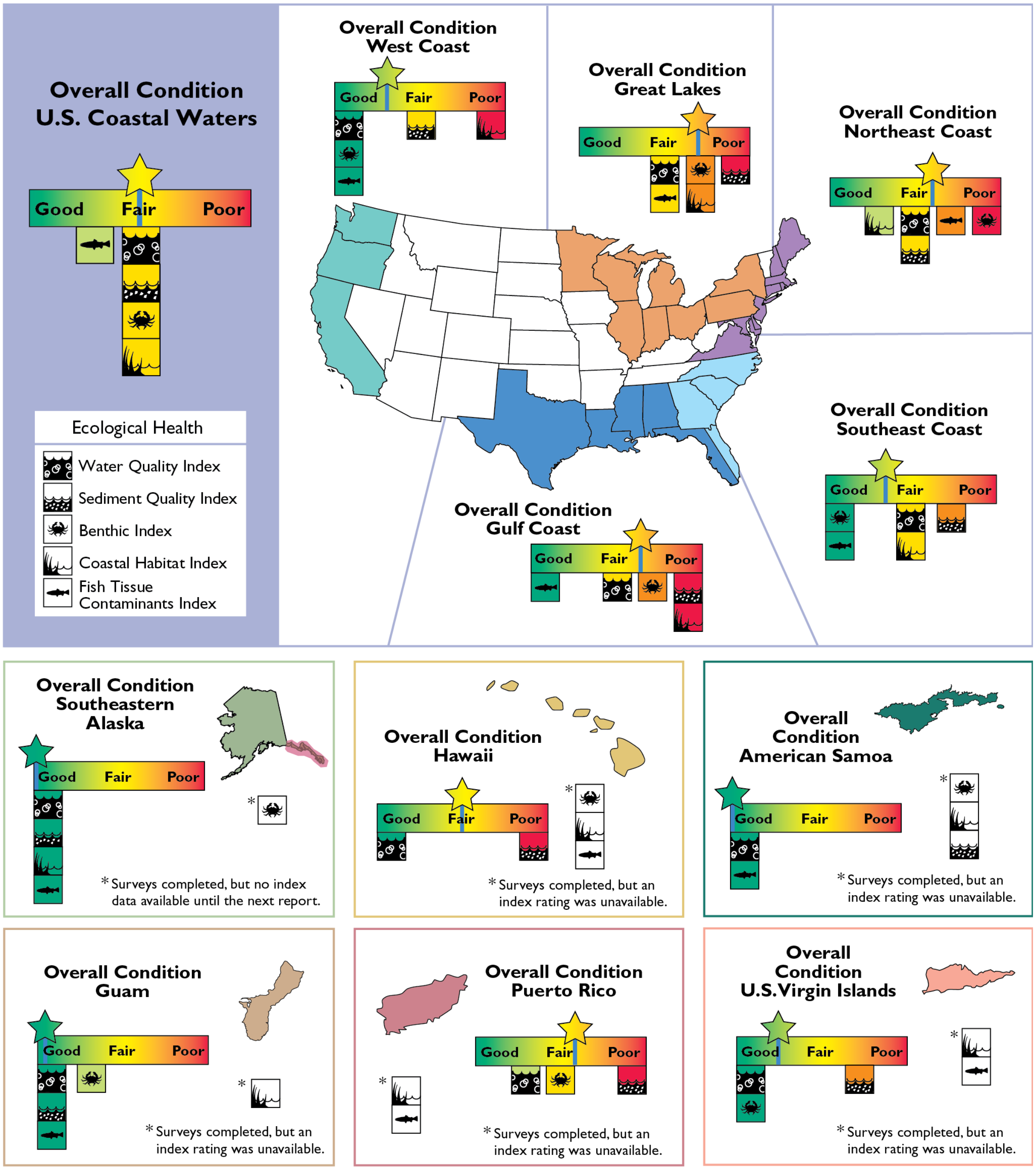


Figure ES-1. Overall national and regional coastal condition based on data collected primarily between 2003 and 2006 (U.S. EPA/NCA).

In addition to rating coastal condition based on coastal monitoring data, the NCCR IV summarizes available information related to offshore ocean condition associated with various coastal-ocean shelf regions, offshore fisheries, state-issued fish consumption advisories in coastal waters, and beach advisories and closures. Although not directly comparable, this information, together with descriptions of individual monitoring programs, helps paint a picture of the overall condition of the nation’s coastal resources.

Summary of the Findings

This report is based on the large amount of monitoring data collected primarily between 2003 and 2006 on the condition of the marine 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 overall condition of coastal waters of the geographic regions assessed in this report, the Southeastern Alaska, American Samoa, and Guam regions are rated good; the West Coast and U.S. Virgin Islands regions are rated fair to good; the Northeast Coast, Southeast Coast, Gulf Coast, Hawaii, and Puerto Rico regions are rated fair; and the Great Lakes region is rated fair to poor.

The major findings of the 2003–2006 study period are as follows:

- The overall condition of the nation's coastal waters is rated fair, with an overall condition score of 3.0 (including Alaska, Hawaii, and the island territories; the overall condition score would be 2.5 [rated fair] if these areas were excluded). The overall condition score and rating is 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 (Tables ES-1 and ES-2). This report also assesses component indicators for the water quality index (i.e., dissolved inorganic nitrogen [DIN], dissolved inorganic phosphorus [DIP], chlorophyll *a*, water clarity, and dissolved oxygen) and the sediment quality index (i.e., sediment toxicity, sediment contaminants, and sediment total organic carbon [TOC]).
- When Alaska, Hawaii, and the island territories are included in the national scores, improvements in the scores are shown for the water quality, coastal habitat, benthic, and fish tissue contaminants indices. However, when the national scores were recalculated without Alaska, Hawaii, and the island territories, the indices show no change or a slight improvement over time.
- The water quality index for the nation's coastal waters is rated fair, with 55% of the nation's coastal area rated good for water quality condition, 36% rated fair, and 6% rated poor.
- The coastal habitat, sediment quality, and benthic indices show the poorest conditions throughout the coastal United States, whereas dissolved oxygen, DIN, and sediment TOC are the component indicators most often rated in good condition throughout the nation.
- Thirteen percent of the NCA stations where fish were caught were rated poor for the fish tissue contaminants index, based on the EPA Advisory Guidance values used to assess the fish tissue contaminants index for this report.

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

Region	Water Quality Index	Sediment Quality Index	Coastal Habitat Index	Benthic Index	Fish Tissue Contaminants Index	Overall Condition
Northeast Coast	3	3	4	1	2	2.6
Southeast Coast	3	2	3	5	5	3.6
Gulf Coast	3[b]	1	1	2	5	2.4
West Coast	5	3	1	5	5	3.8
Great Lakes	3	1	2	2	3	2.2
Southeastern Alaska[d]	5	5	5	—[c]	5	5.0
Hawaii[d]	5	1	—[c]	—[c]	—[c]	3.0
American Samoa[d]	5	—[c]	—[c]	—[c]	5	5.0
Guam[d]	5	5	—[c]	4	5	4.8
Puerto Rico[d]	4	1	—[c]	3	—[c]	2.7
U.S. Virgin Islands[d]	5	2	—[c]	5	—[c]	4.0
United States[e]	3.6	2.6	2.6	2.4	4.0	3.0
United States[f]	3.2	1.8	1.7	2.4	3.7	2.5

[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 2.4 is rated fair to poor; 2.4 to less than 3.7 is rated fair; 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

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

[c] This index was not assessed for this region.

[d] Overall condition scores for Southeastern Alaska, Hawaii, Puerto Rico, and the island territories were based on fewer than the five NCA indices.

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

[f] Scores excluding Alaska, Hawaii, Guam, American Samoa, and U.S. Virgin Islands.

Describing Coastal Condition

The following four types of data are presented in this report:

- **Coastal Monitoring Data**—Coastal monitoring data are obtained from programs such as the EPA's NCA and FWS's NWI, as well as Great Lakes information from the *State of the Great Lakes 2009*. These data are used to rate indices and component indicators of coastal condition for the geographic regions assessed in this report and for the nation. These index scores are then used to calculate overall condition scores and ratings for the regions and the nation. The rating criteria for each index and component indicator in each region are determined based on existing criteria, guidelines, interviews with EPA decision makers and other resource experts, and/or the interpretation of scientific literature.
- **Coastal-Ocean Condition Data**—These data are obtained from a series of offshore studies conducted to assess the status of ecological condition and potential stressor impacts throughout various coastal-ocean (shelf) regions of the United States. For this report, data were available for three of the survey areas: the western U.S. continental shelf (surveyed June 2003), the South Atlantic Bight (surveyed April 2004), and the Mid-Atlantic Bight (surveyed May 2006). Because some of these protocols and indicators are consistent with those used in the EMAP/NCA estuarine surveys, they provide a basis for making comparisons between conditions in offshore waters and those observed in adjacent estuaries.

- **Offshore Fisheries Data**—These data are 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).
- **Advisory Data**—These data are provided to the EPA by states or other regulatory agencies and compiled in nationally maintained databases. The fish consumption advisory data provide information about chemical contaminants in locally caught fish, and beach advisory data provide information about warnings and beach closures associated with the presence of elevated levels of human pathogens at swimming beaches. Warnings and closures affect 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.

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

Region	Water Quality Index[b]	Sediment Quality Index[c]	Benthic Index	Fish Tissue Contaminants Index[d]
Northeast Coast	9	12	31	20
Southeast Coast	13	13	3	8
Gulf Coast	10[e]	19	20	9
West Coast	2	10	7	9
Great Lakes	—	—	—	—
Southeastern Alaska	0	0	—	0
Hawaii	0	18	—	—
American Samoa	0	—	—	4
Guam	7	0	10	0
Puerto Rico	10	20	16	—
U.S. Virgin Islands	0	17	6	—
United States	6	10	19	13

[a] The percent area in poor condition is the percentage of total surface area of estuaries and coastal embayments in the region or the nation (proportional area information not available for the Great Lakes or the coastal habitat index).

[b] The water quality index is based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen.

[c] The sediment quality index is based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

[d] The fish tissue contaminants index is presented as the percentage of monitoring stations where fish were caught (all other regions) and is based on analyses of whole-fish samples (not fillets).

[e] The area in poor condition does not include the hypoxic zone in offshore Gulf Coast waters.

Coastal Monitoring Data

The overall condition of the nation's coastal waters is rated fair (Figure ES-2), based on ratings for the 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 a weighted average of the index scores for each coastal region of the United States, and an average of the national 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.

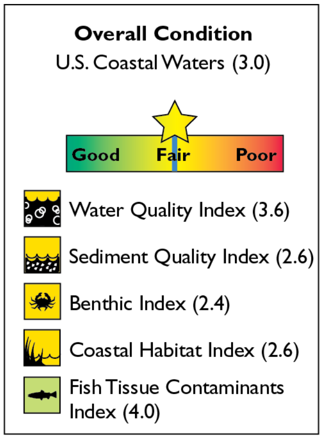


Figure ES-2. The overall condition of U.S. coastal waters is rated fair (U.S. EPA/NCA).

A summary of each national index is presented below.

- **Water Quality Index**—The water quality index for the nation's coastal waters is rated fair. The percent of coastal area rated poor for water quality ranged from 0% in Southeastern Alaska, Hawaii, American Samoa, and the U.S. Virgin Islands to 13% in the Southeast Coast region. Most water quality problems in U.S. coastal waters are associated with degraded water clarity or increased concentrations of DIP or chlorophyll *a*. Low dissolved oxygen concentrations occur in less than 5% of the U.S. coastal area.
- **Sediment Quality Index**—The 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, Hawaii, and Puerto Rico regions; fair to poor for the Southeast Coast and U.S. Virgin Islands regions; fair for the Northeast Coast and West Coast regions; and good for Southeastern Alaska and Guam regions. Many areas of the United States have significant sediment degradation, including elevated concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and metals. Puerto Rico and Hawaii have the largest percentages of coastal area with elevated contaminant concentrations in sediments. The largest percentages of coastal area exhibiting sediment toxicity were in the Northeast Coast, Southeast Coast, Gulf Coast, West Coast, and U.S. Virgin Islands regions. High concentrations of sediment TOC (often associated with the deposition of human, animal, and plant wastes) were observed in 12%, 11%, and 10%, respectively, of the coastal waters of Hawaii, Southeastern Alaska, and Puerto Rico waters.
- **Benthic Index**—The benthic index for the nation's coastal waters is rated fair. The greatest area exhibiting poor benthic condition is observed in the Northeast Coast region, largely due to degraded sediment quality resulting from high sediment toxicity; however, in some cases, poor benthic condition is associated with poor water quality conditions, such as low dissolved oxygen and elevated nutrient concentrations. The Southeast Coast, West Coast, and U.S. Virgin Island coastal regions are rated good for benthic condition. Benthic index data were unavailable for Southeastern Alaska, Hawaii, and American Samoa.

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the United States during a 9- to 12-week period during the summer. Data were not collected during other time periods.

- **Coastal Habitat Index**—The coastal habitat index for the nation's coastal waters is rated fair. Coastal wetland losses from 1780 to 2000 were greater than or equal to 1% per decade in each region. The index is rated poor for the coastal wetland areas of the Gulf Coast and West Coast regions. Coastal habitat data were unavailable for the coastal areas of Hawaii, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands. It should be noted that the coastal habitat scores and ratings for the NCCR IV are similar to those presented in the NCCR III due to a lack of available new data in the proper format for this analysis.

- **Fish Tissue Contaminants Index**—The fish tissue contaminants index for the nation's coastal waters is rated good to fair, with only 13% of the stations where fish were caught rated poor for this index. The fish tissue contaminants index is rated good for the Southeast Coast, Gulf Coast, and West Coast regions, as well as for Southeastern Alaska, American Samoa, and Guam; fair for the Great Lakes region; and fair to poor for the Northeast Coast region. Fish tissue contaminants data were unavailable for the coastal waters of Hawaii, Puerto Rico, and the U.S. Virgin Islands.

Coastal Ocean Condition

Since 2003, a series of offshore studies have been conducted to assess the status of ecological condition and potential stressor impacts throughout various coastal-ocean (shelf) regions of the United States (Figure ES-3). These survey areas cover four of the U.S. LMEs: the California Current, Northeastern U.S. Continental Shelf, Southeastern U.S. Continental Shelf, and Gulf of Mexico. They also coincide with various regional planning areas of the *Interim Framework for Effective Coastal and Marine Spatial Planning* (CMSP Interim Handbook), developed in 2009 by the Interagency Ocean Policy Task Force. Sampling sites are also included within marine protected areas, such as NOAA's National Marine Sanctuaries. Data from these studies were available for inclusion in the present NCCR for three of the five survey areas: the western U.S. continental shelf (surveyed June 2003), South Atlantic Bight (surveyed March–April 2004), and Mid-Atlantic Bight (surveyed May 2006).

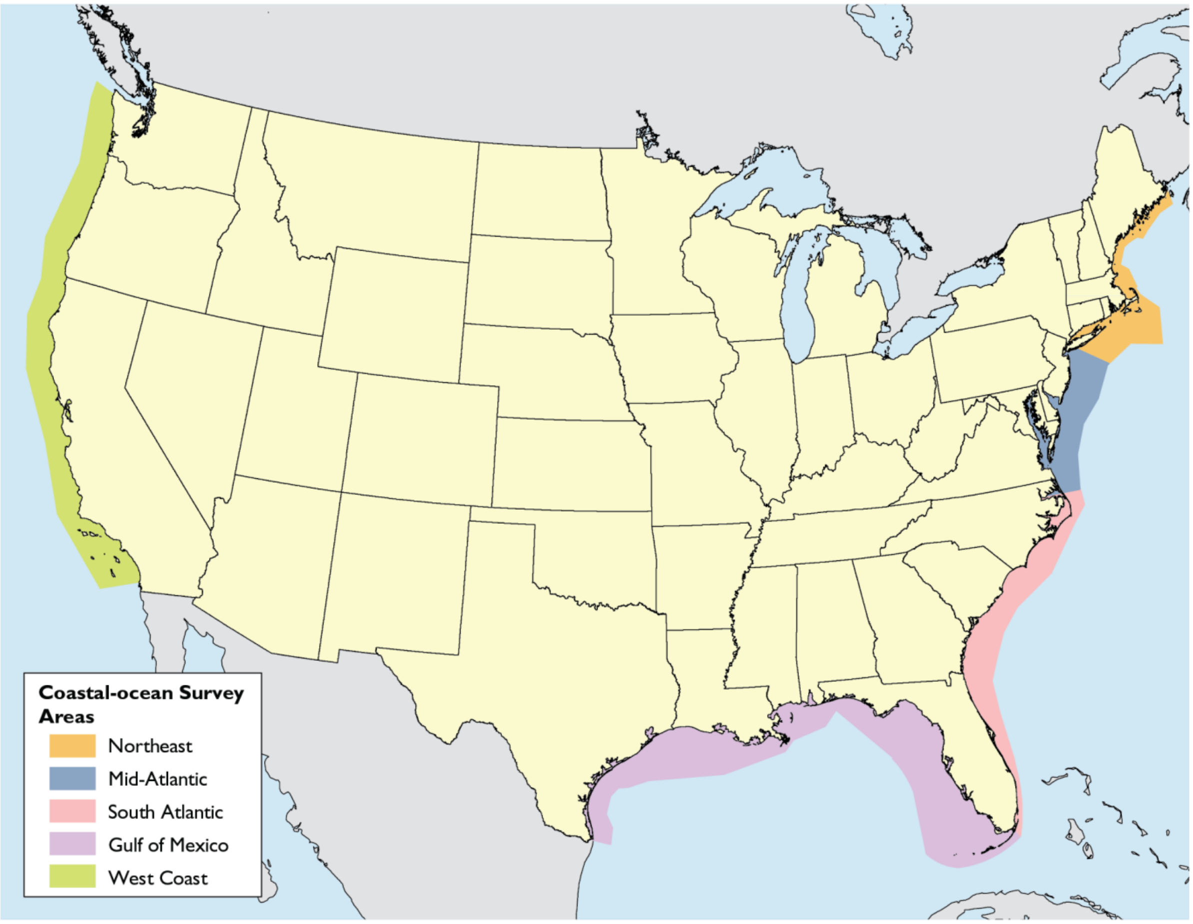


Figure ES-3. Coastal-ocean survey areas.

The studies have applied EMAP/NCA methodologies and indicators, including probabilistic sampling designs and multiple measures of water quality, sediment quality, benthic condition, and fish tissue contamination. Although ratings of good, fair, and poor for many of these indicators could not be assigned to the study areas because of the lack of appropriate cutpoints for offshore waters, the results of the various measurements nonetheless provide valuable information on the status and patterns of key ecological characteristics, as well as a quantitative baseline for evaluating future changes due to natural or human-induced disturbances. Because the protocols and indicators are consistent with those used in previous EMAP/NCA estuarine surveys, these studies also provide a basis for making comparisons between conditions in offshore waters and those observed in adjacent estuaries, thus providing a more holistic account of ecological conditions and processes throughout the inshore and offshore resources of the respective regions. In addition, for some indicators (e.g., concentrations of chemical contaminants and TOC in sediments, dissolved oxygen levels in the water column, human health-risk guidelines for chemical contaminants in fish), cutpoints established previously for estuarine habitats can be used as reasonable surrogate benchmarks for evaluating the biological significance of corresponding offshore levels.

In general, the coastal-ocean waters were much less impacted by human influence than neighboring estuaries. With some exceptions, conditions for most indicators were above estuarine cutpoints for good ratings throughout the majority of the areas surveyed (Figure ES-4).

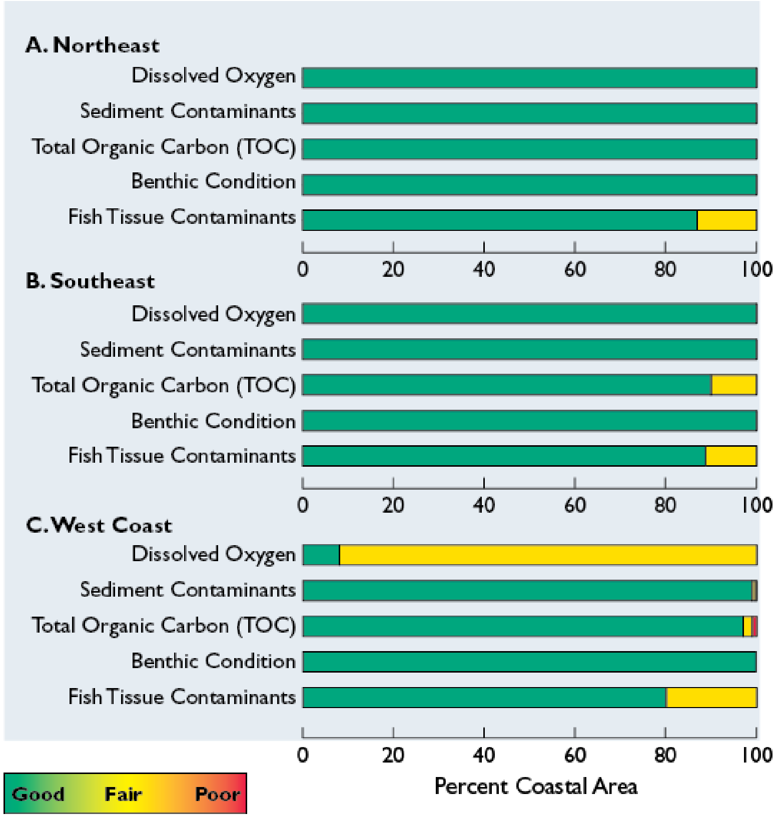


Figure ES-4. Percentage of coastal ocean area achieving each ranking for all indices and component indicators − Northeast (A), Southeast (B), and West Coast (C) regions.

Note: Coastal-ocean results were compared to estuarine cutpoints; refer to corresponding chapters for index and indicator cutpoints. There were no benthic indices for region-wide applications in coastal-ocean waters; thus, the evaluation of benthic condition was based on co-occurrences of reduced values of key benthic attributes and evidence of poor sediment or water quality. Tissue assessments are based on percent of stations where fish were caught.

Large Marine Ecosystem Fisheries

The NMFS fisheries data used in this report were categorized by LMEs. LMEs are defined as large areas of ocean characterized by distinct bathymetry, hydrography, productivity, and trophic relationships. LMEs extend from river basins and estuaries to seaward boundaries of the continental shelf and outer margin of major current systems. Within these waters, ocean pollution, fishery overexploitation, and coastal habitat alteration are most likely to occur.

Globally, 64 LMEs have been defined, accounting for about 80% of global fisheries production. Eleven LMEs are found in the waters bordering U.S. states and island territories around the world (Figure ES-5). The climates of these LMEs vary from arctic to tropical, and their productivities range from low to high, based on global estimates of primary production. Eight of these LMEs also adjoin international borders of other countries. As a result, information about fishery stocks in some of the LMEs (i.e., the Caribbean Sea, Chukchi Sea, West Bering Sea, and Beaufort Sea LMEs) is incomplete. Organizing the NMFS fisheries data by LME allows readers to more easily consider fishery and coastal condition data together. These data are more comparable using LMEs for several reasons. Geographically, LMEs contain both the coastal waters assessed by the NCA program and the U.S. Exclusive Economic Zone waters that contain the fisheries assessed by the NMFS. In addition, the borders of the LMEs coincide roughly with the borders of the NCA regions.

Figure ES-5. U.S. states and island territories are bordered by 11 LMEs.

Fisheries in the United States are critically important, providing socioeconomic benefits that include food, direct and indirect employment, and recreational opportunities. The United States is one of the most productive fishing nations in the world. From 2003 to 2006, commercial fisheries contributed over $14 billion in ex-vessel revenues to the nation's economy. The top five highest-grossing commercial fisheries in value included American lobster ($1.4 billion), sea scallops ($1.3 billion), walleye pollock ($1.1 billion), white shrimp ($770 million), and Pacific halibut ($720 million). Top recreational species included striped bass, croaker, spot, and sea trout.

The U.S. walleye pollock fishery has current landings of nearly 1.6 million metric tons. Since the late 1980s, catches within this fishery have consistently been over 1 million metric tons, and despite annual fluctuations, have increased by over 500,000 metric tons since the late 1990s. Amongst the other top fisheries, the largest increase in landings occurred in the white shrimp fishery. Catches of white shrimp increased from about 15,000 metric tons in the mid 1960s to nearly 70,000 metric tons in 2006. The American lobster fishery has also increased steadily, from 10,000 metric tons in 1950 to just over 40,000 metric tons in 2006. During this same period, catches in the sea scallop fishery increased from 10,000 metric tons to 25,000 metric tons, resurging over the past several years following decreases in the 1990s. Landings in the Pacific halibut fishery underwent a long decrease from the early 1960s to 1980, but increased again with recent landings over 30,000 metric tons.

The NMFS provides regular assessments of the status of fish stocks to determine if a stock is overfished. The status of 33% of U.S. fishery stocks is unknown or has not been defined. Of the 144 known stock groups, 28% are overfished, < 1% are approaching overfished status, 10% are in the process of rebuilding, and 60% are not overfished. The majority of overfished stocks occur among the Northeast U.S. Continental Shelf LME demersal (bottom-dwelling) species. Many of the stocks (37%) that have a known status and have experienced decreases in landings are below the biomass level that would support the maximum sustainable yield because their current population sizes can no longer support past catch levels.

A majority of the stocks classified as overfished are currently under rebuilding plans and have not yet been rebuilt to levels above the overfished threshold. Although rebuilding of overfished stocks can take many years—depending on the stock's natural capacity to grow, its level of depletion, and the specific management measures in place—the process of rebuilding overfished stocks is underway. Overall, the U.S. share of fishery resources has held fairly steady in recent years. The largest increases in commercial landings (tonnage) occurred for Alaskan LME groundfish (bottom-dwelling) fisheries and Pacific Coast and Alaska pelagic (water-column dwelling) fisheries. The largest percentage increases occurred for Atlantic anadromous (migratory) fisheries. In contrast, large decreases in landings (tonnage) occurred for the Southeast U.S. Continental Shelf LME menhaden fisheries and Pacific highly migratory pelagic fisheries. Large percentage decreases also were experienced by Western Pacific invertebrates and in shellfish from the Alaskan LMEs.

Advisory Data

For this NCCR IV, advisory data include information on two key areas of public health concern: fish consumption advisories associated with chemically contaminated fish, and beach advisories and closures issued by individual states when the presence of pathogens in water exceeds levels considered potentially injurious to human health. States report information on fish and shellfish advisories issued for locally caught fish harvested from state jurisdictional waters by recreational or subsistence fishers. These data are reported annually to the EPA's National Listing of Fish Advisories (NLFA) database. States, counties, and other local agencies also report beach advisories and closures to the Beaches Environmental Assessment, Closure, and Health (BEACH) PRAWN database (i.e., PRogram tracking, beach Advisories, Water quality Standards, and Nutrients). These data are useful for evaluating the success of state water quality improvement efforts and assessing water quality–related issues of public health concern; however, it should be emphasized that each state monitors and assesses these parameters differently, so it is difficult to make generalized statements about the condition of the nation's coasts based on these data alone. Data from the EPA's NLFA database are presented for calendar year 2006, and data from the BEACH PRAWN database are presented for calendar year 2007.

According to the EPA's NLFA data for 2006, the number of coastal and estuarine waters under fish consumption advisories represents an estimated 75% of the coastal waters of the conterminous United States (Figure ES-6). All of the Great Lakes and their associated connecting waters are currently under at least one fish advisory, and there are 29 fish advisories that cover 100% of the Great Lakes shoreline miles. Although advisories in U.S. estuarine and shoreline waters have been issued for a total of 21 chemical contaminants, most of the advisories issued resulted from four primary chemical contaminants: PCBs; mercury; DDT and its degradation products (p,p'-diclorodiphenyldichloroethane [DDD] and p,p'-diclorodiphenyldichloroethylene [DDE]); and dioxins/furans. These four chemical contaminants were responsible, at least in part, for 79% of all fish consumption advisories in effect for estuarine and coastal marine waters in 2006. These data are provided by states or other regulatory agencies and are compiled in a nationally maintained database. The state agencies contributing these data may use different assessment methods and criteria for assessing the need to issue an advisory; therefore, the data cannot be used to make broad-based comparisons among the different coastal areas.

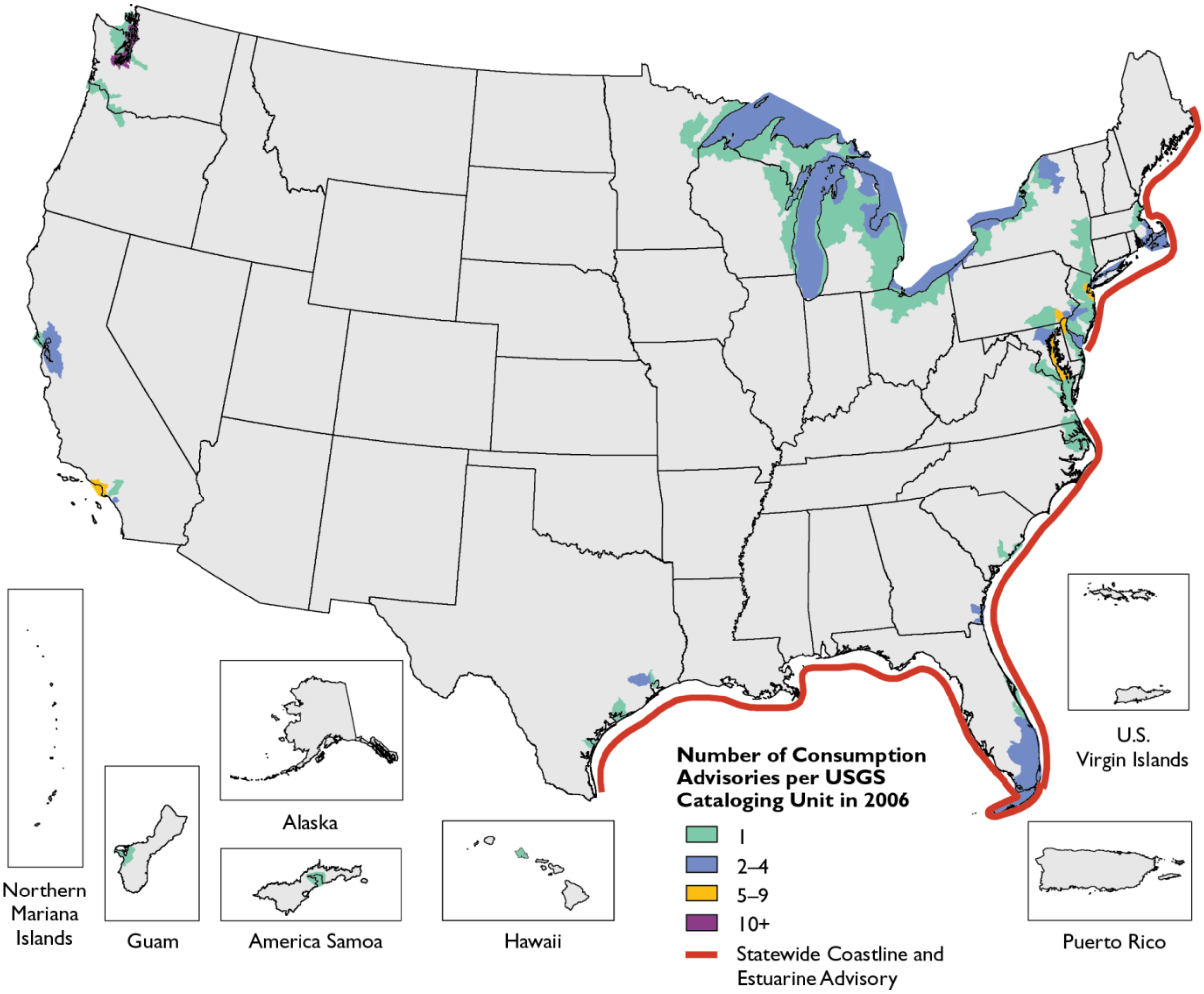


Figure ES-6. The number of fish consumption advisories active in 2006 for U.S. coastal waters.

For the 2007 swimming season, EPA compiled information on 6,237 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 and included agencies in Hawaii, Puerto Rico, the U.S. Virgin Islands, Guam, and American Samoa. These respondents report the results of their local monitoring programs; therefore, the monitoring methods and closure criteria may vary among respondents. The EPA's review of coastal beaches (i.e., U.S. coastal areas, estuaries, the Great Lakes, and the coastal areas of Hawaii and the U.S. territories) showed that, of the 6,237 beaches reported in the survey responses, only 3,647 beaches (58%) were monitored. Of the coastal beaches monitored and reported, 1,170 (or 32%) had an advisory or closing in effect at least once during the 2007 swimming season (Table ES-3). Although beach advisories or closings were issued for a number of different reasons (e.g., elevated bacterial levels in the water, preemptive reasons associated with rainfall events or sewage spills), storm-related runoff was the single most common reason affecting 35% of the monitored beaches. About 50% of beach notifications lasted 2 days or less, about 42% lasted 3 to 7 days, 7% lasted more than 8 days, and only 1% lasted more than 30 days.

Table ES-3. Beach Notification Actions, National, 2004-2008[a]

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	5,208	6,064	6,599	6,237	6,684
Number of monitored beaches	3,574	4,025	3,771	3,647	3,740
Number of beaches affected by notification actions	942	1,109	1,201	1,170	1,210
Percentage of monitored beaches affected by notification actions	26%	28%	32%	32%	32%

[a] This table includes data from Puerto Rico and Hawaii in 2004 and from American Samoa, Guam, Alaska, and the U.S. Virgin Islands beginning in 2005.

Limitations of Available Data

The NCCR IV focuses on coastal regions for which nationally consistent and comparable data are available. Such data are currently available for the conterminous 48 states, Southeastern Alaska, Hawaii, Puerto Rico, and the island territories of American Samoa, Guam, and the U.S. Virgin Islands. Nearly 75% by area of all the coastal waters, 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 the living resources and use attainment of these waters. For this report, coastal monitoring data were only available for the southeastern region of Alaska; for the NCCR III, the southcentral Alaskan region was assessed.

For the first time, coastal monitoring information also is available for the U.S. Virgin Islands and the Pacific island territories (i.e., Guam and American Samoa) 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 represent a set of ecological subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States, with the exception of southern Florida, the Flower Gardens off the Louisiana/Texas coast, and Puerto Rico.

The NCCR IV makes the best use of available data to characterize and assess the condition of the nation's coastal resources. The report, however, does not yet represent all individual coastal and estuarine systems of the United States or all of the appropriate spatial scales (e.g., national, regional, 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. Because this assessment is a "snapshot" of the environment at the time the measurements were collected, some of the uncertainly associated with the measurements is difficult to quantify. Weather impacts such as droughts, floods, and hurricanes can affect results for weeks to months, in addition to normal sampling variability. 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 10 addresses emerging issues and future directions for the national coastal monitoring program. As demand for coastal and marine resources increases due to growing populations and development, ecosystems are affected by the resulting environmental stress. The combination of multiple coastal stressors (e.g., invasive species, hypoxia, emerging contaminants, microbial pathogens, climate change, ocean acidification, sea-level rise) will impact ecosystem function, likely undermining the provision of ecosystem services to our society. Chapter 10 presents the complexities of these combinations of stresses and the need for targeted coastal monitoring efforts.

Comparisons to Other National Coastal Condition Reports

A primary goal of the NCCR 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 was evaluated for potential trends.

Comparing data between the NCCR I, NCCR II, NCCR III, and NCCR IV is complicated because, in some cases, indices and component indicators were changed to improve the assessment. For example, in the NCCR I, three separate indicators (dissolved oxygen, water clarity, and eutrophication) were used for water quality, whereas a single water quality index (composed of five component indicators) 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, NCCR III, and NCCR IV (Table ES-4). For additional information about how these values were recalculated, please refer to Appendix C of the NCCR II, which is available online at http://water.epa.gov/type/oceb/2005_index.cfm.

Table ES-4. Rating Scores[a] by Index and Region Comparing the NCCR I[b], NCCR II, NCCR III[c], and NCCR IV

Region/NCCR Version		Water Quality Index	Sediment Quality Index	Coastal Habitat Index	Benthic Index	Fish Tissue Contaminants Index	Overall Condition
Northeast Coast	NCCR I	1	2	3	1	2	1.8
	NCCR II	2	1	4	1	1	1.8
	NCCR III	3	2	4	1	1	2.2
	NCCR IV	3	3	4	1	2	2.6
Southeast Coast	NCCR I	4	4	2	3	5	3.6
	NCCR II	4	4	3	3	5	3.8
	NCCR III	3	3	3	5	4	3.6
	NCCR IV	3	2	3	5	5	3.6
Gulf Coast	NCCR I	1	3	1	1	3	1.8
	NCCR II	3	3	1	2	3	2.4
	NCCR III	3	1	1	1	5	2.2
	NCCR IV	3	1	1	2	5	2.4
West Coast	NCCR I	1	2	1	3	3	2.0
	NCCR II	3	2	1	3	1	2.0
	NCCR III	5	2	1	5	1	2.8
	NCCR IV	5	3	1	5	5	3.8
Great Lakes	NCCR I	1	1	1	1	3	1.4
	NCCR II	3	1	2	2	3	2.2
	NCCR III	3	1	2	2	3	2.2
	NCCR IV	3	1	2	2	3	2.2

(continued)

Table ES-4. Rating Scores[a] by Index and Region Comparing the NCCR I[b], NCCR II, NCCR III[c], and NCCR IV (continued)

Region/NCCR Version		Water Quality Index	Sediment Quality Index	Coastal Habitat Index	Benthic Index	Fish Tissue Contaminants Index	Overall Condition
Alaska[d]	NCCR I	—	—	—	—	—	—
	NCCR II	—	—	—	—	—	—
Southcentral	NCCR III	5	5	—	—	5	5.0
Southeastern	NCCR IV	5	5	5	—	5	5.0
Hawaii[d]	NCCR I	—	—	—	—	—	—
	NCCR II	—	—	—	—	—	—
	NCCR III	5	4	—	—	—	4.5
	NCCR IV	5	1	—	—	—	3.0
American Samoa[d]	NCCR IV	5	—	—	—	5	5.0
Guam[d]	NCCR IV	5	5	—	4	5	4.8
Puerto Rico[d]	NCCR I	—	—	—	—	—	—
	NCCR II	3	1	—	1	—	1.7
	NCCR III	3	1	—	1	—	1.7
	NCCR IV	4	1	—	3	—	2.7
U.S. Virgin Islands[d]	NCCR IV	5	2	—	5	—	4.0
United States [e]	NCCR I	1.5	2.3	1.6	1.5	3.1	2.0
	NCCR II	3.2	2.1	1.7	2.0	2.7	2.3
	NCCR III[g]	3.8	2.8	1.7	2.1	3.4	2.8
	NCCR IV[f]	3.2	1.8	1.7	2.4	3.7	2.5
	NCCR IV[g]	3.6	2.6	2.6	2.4	4.0	3.0

[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 2.4 is rated fair to poor; 2.4 to less than 3.7 is rated fair; 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

[b] Assessments for Alaska and Hawaii were not reported in the NCCR I or NCCR II. The NCCR I assessment of the Northeast Coast region did not include the Acadian Province (i.e. portion of the region north of Cape Cod). The West Coast ratings in the NCCR I were compiled using data from many different programs.

[c] The West Coast, Great Lakes, and Puerto Rico scores for the NCCR III are the same as NCCR II (no new data for the NCCR III are provided, except for the West Coast benthic index).

[d] Overall condition scores for Alaska, Hawaii, Puerto Rico, and the island territories were based on two to three of the five NCA indices.

[e] The U.S. overall condition score is based on an areally weighted mean of regional scores.

[f] Scores excluding Alaska, Hawaii, Guam, American Samoa, and the U.S. Virgin Islands.

[g] Scores including Alaska, Hawaii, Guam, American Samoa, and the U.S. Virgin Islands.

I = NCCR (adjusted scores from Table C-1 in NCCR II); II = NCCR II; III = NCCR III; IV = NCCR IV

The area covered by the NCA has expanded over time with the addition of Alaska, Hawaii, and the island territories. The southcentral and southeastern regions of Alaska included in the NCCR III and NCCR IV assessments had good water quality and large coastal areas, which would influence the national water quality index scores. (Hawaii and the island territories were also included, but their collective coastal areas were less than 1% of the total U.S. area, so their influence on the national scores was negligible.) We have assessed the changes in national coastal condition over time for both the conterminous United States and for the entire coastal United States, including Alaska, Hawaii, and the island territories. Excluding Alaska, Hawaii, and the island territories, the water quality index score for the NCCR III and NCCR IV would be 3.2 (rated fair), which is the same as the score for the NCCR II water quality index (Table ES-4). Although the water quality index score increased from 1.5 (rated poor) in the NCCR I to

3.2 (rated fair) in the NCCR II, this increase is likely due a change in methods between these two assessments. The water quality assessment method used in the NCCR I was largely reliant on professional judgment for assessing eutrophication rather than on the direct field survey measurements used in subsequent NCCRs. Therefore, if the NCCR I is excluded, this trend assessment demonstrates there has been no significant change in the water quality of U.S. coastal waters since the publication of the NCCR II. If Alaska, Hawaii, and the island territories are included, however, the water quality index score for U.S. coastal waters shows a slight increase from 3.2 (rated fair) in the NCCR II to 3.6 (rated fair) in the NCCR IV.

If Alaska (and Hawaii and the island territories) were excluded from the NCCR III and IV national scores, the sediment quality scores would be 1.6 (rated poor) for the NCCR III and 1.8 (rated poor) for the NCCR IV. Excluding Alaska from the sediment quality scores would result in a decrease in the sediment quality index score from 2.3 (rated fair to poor) in the NCCR I to 1.8 (rated poor) in the NCCR IV, which could be interpreted as a degradation in national sediment quality over time. Including Alaska, Hawaii, and the island territories, however, shows a slight increase in the sediment quality index score from 2.3 (rated fair) in the NCCR I to 2.6 (rated fair) in the NCCR IV. Although this may appear to demonstrate a slight improvement in sediment quality over time, the scores are not significantly different, and the sediment quality index is rated fair in each report.

Without the addition of new information for Alaska, the coastal habitat index score has not changed since the NCCR II (Table ES-4). Some new information was also available to assess coastal habitat changes in the Gulf Coast and the U.S. Virgin Islands; however, the new information did not impact the nationwide index score, and the scores presented in this report are similar to those presented in the NCCR III. Some regional improvements in the coastal habitat index rating occurred in the Northeast Coast region between the NCCR I (rated fair) and the NCCR II (rated good to fair); however, the regions with most of the wetland acreage in the United States (Gulf Coast, Southeast Coast, and Great Lakes) showed little or no change in their index ratings over this time period. With the inclusion of coastal habitat data for Alaska, the national coastal habitat index assessment score increased from 1.7 (rated poor) in the NCCR II to 2.6 (rated fair) in the NCCR IV.

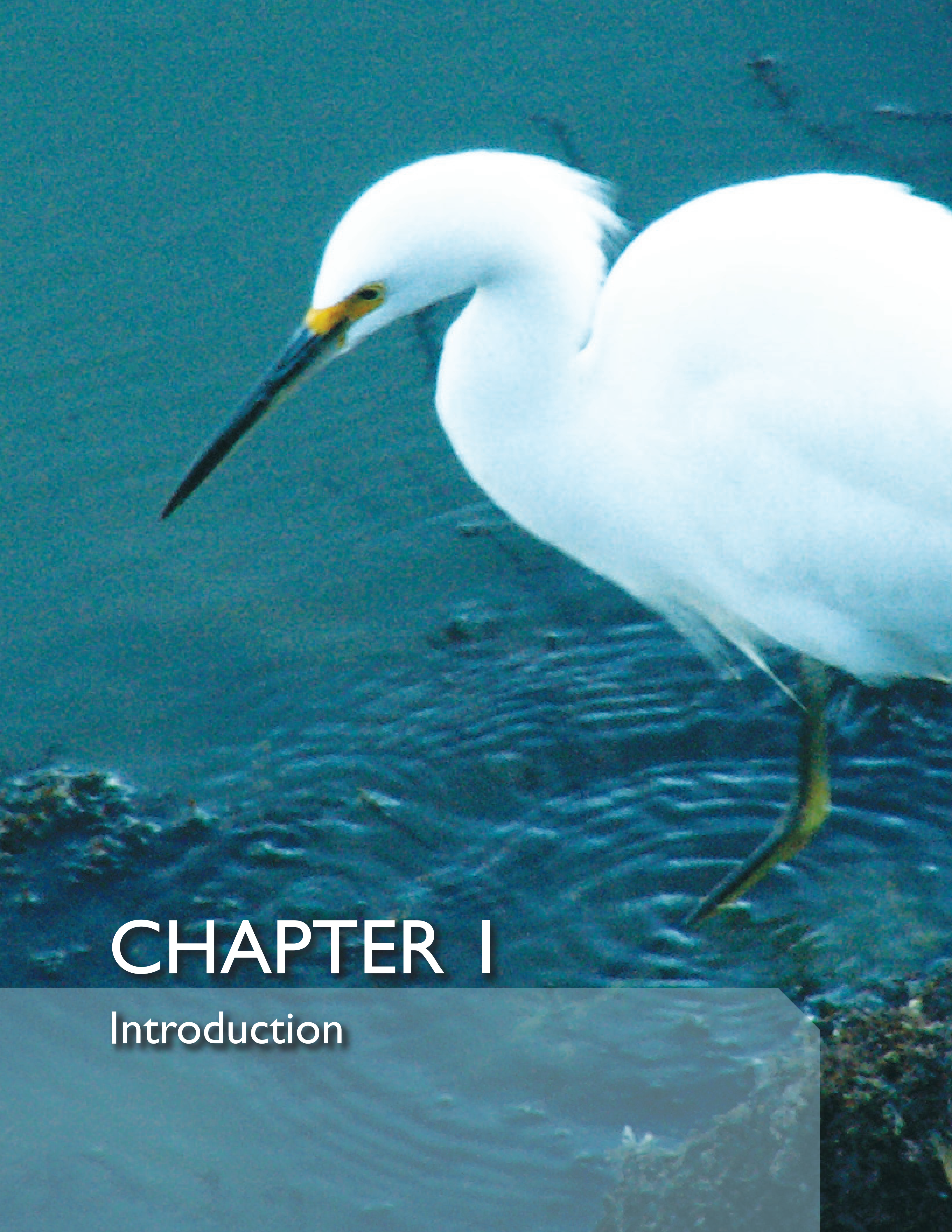
The benthic index, although consistent in concept, is calculated differently for each region of the United States; therefore, the assumption that unsampled regions reflect the same distribution pattern of poor conditions as those sampled is not supported. The national benthic index score has steadily increased over time from 1.5 (rated poor) in the NCCR I to 2.4 (rated fair) in the NCCR IV. Unlike the water quality and sediment quality scores, this increase in score is not unduly influenced by Alaska, as benthic condition data were not available for this region. This assessment demonstrates a positive change in the benthic condition of U.S. coastal waters since the publication of the NCCR I.

The fish tissue contaminants index shows an increase from the NCCR I (3.1; rated fair) to the NCCR IV (4.0; rated good to fair). If the national score were recalculated without Alaska and the island territories, however, the score for NCCR IV would be 3.7 (rated good to fair). In the NCCR I, fish tissue contaminant concentrations were measured only in edible fillets, whereas both the NCCR II and NCCR III measured whole-body concentrations. This NCCR IV measured both fish fillets and whole-body concentrations. Because fillet and whole-body tissues have different absorption rates for contaminants, the inclusion of both types of samples in this assessment could impact the interpretation of results. Currently, however, it is not possible to adjust the NCCR assessments to either fillet or whole-body concentrations and scores. In addition, other changes in geographic coverage may have resulted in the apparent increase in the fish tissue contaminants score over time (e.g., changes in survey design in the West Coast to exclude the riverine portion of the Columbia River; lack of data from Massachusetts waters in the Northeast Coast region; the lack of data from the northern Gulf of Mexico due to the impacts of Hurricane Katrina). At present, a reasonable interpretation of the assessments is that there has been a small improvement in contaminant levels in fish tissue in U.S. coastal waters, with the national fish tissue contaminant index rated fair for the first three NCCRs and fair to good in this report.

Future Efforts

Each consecutive report in the NCCR series has presented an expanded spatial extent of sampling, improved indices, and the current state of coastal monitoring science. Such improvements will continue as the NCA becomes the National Coastal Condition Assessment (NCCA), under the purview of the EPA's Office of Water (OW) for the next NCCR (*National Coastal Condition Report V* [NCCR V]). The NCCA will be part of the National Aquatic Resource Survey program, which is an effort to assess the quality of various U.S. aquatic resources, including lakes, rivers and streams, and wetlands (see http://www.epa.gov/OWOW/monitoring/nationalsurveys.html). As part of this transformation, the NCCA will reflect changing priorities, with greater focus on human health and evolving coastal issues. The NCCA will also include, for the first time, statistical survey sampling in the Great Lakes and updated sampling for the non-conterminous U.S. states and territories (with the exception of Alaska). The latest addition to the NCCR list of indicators under the NCCA is bacterial contamination, which will be added in the NCCR V. This indicator reflects the evolving priorities of the NCCA program under the OW to prioritize human health and a general effort to expand estuarine monitoring efforts to assess other existing and arising coastal issues.

Improvements in coastal programs are occurring on a much greater scale as well. Under a directive from President Barack Obama, an Interagency Ocean Policy Task Force was formed in June 2009 to streamline federal agency decision-making and management of activities in our nation's coastal and ocean waters. The Task Force drafted a set of recommendations that highlighted nine priority areas, including regional ecosystem protection and the integration of ocean-observing systems and data. The NCA program is particularly relevant to this effort because it provides geospatially referenced coastal environmental data that are based on regional ecosystem delineations and integrates information from other federal agencies. The task force also drafted the CMSP Interim Handbook, which provides for a comprehensive and integrated approach to facilitating multiple uses and activities in our coastal waters without undermining the services generated by coastal ecosystems.



CHAPTER 1

Introduction

1. Introduction

This *National Coastal Condition Report IV* (NCCR IV) is the fourth in a series of National Coastal Condition Reports (NCCRs) that assess the condition of the coastal waters (e.g., estuarine, Great Lakes, coastal embayment waters) and offshore fisheries of the United States. The first *NCCR* (*National Coastal Condition Report I* [NCCR I]; U.S. EPA, 2001b) assessed the condition of the nation's coastal waters 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) Status and Trends (S&T) program; and the National Oceanic and Atmospheric Administration's (NOAA's) National Status & Trends (NS&T) Program. The second *NCCR* (*National Coastal Condition Report II* [NCCR II]; U.S. EPA, 2004a) 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 NCA is a national coastal monitoring program implemented at the state level, with rigorous quality assurance (QA) protocols and standardized sampling procedures designed to minimize spatial variability in national and regional estimates of coastal condition. The data provided by the NCA allowed for the development of coastal condition indicators for 100% of the coastal area of the conterminous 48 states and Puerto Rico; annual surveys were conducted from 2000 to 2006. The third *NCCR* (*National Coastal Condition Report III* [NCCR III]; U.S. EPA, 2008c) built upon the previous NCCRs and provided assessments based on data collected in 2001 through 2002. The NCCR III expanded the NCA survey area into the coastal waters of Hawaii and the southcentral portion of Alaska; provided the status of offshore fisheries, beach advisories, and fish advisories; and assessed national and regional trends in coastal condition from the early 1990s to 2002.

This fourth report in the NCCR series is a collaborative effort among EPA, NOAA, and FWS, in cooperation with state, territorial, and tribal agencies. The NCCR IV continues the *NCCR* series by providing updated regional and national assessments of the condition of the nation's coastal waters and expands the assessment area to include the coastal waters of American Samoa, Guam, the U.S. Virgin Islands, and the southeastern portion of Alaska (henceforth referred to as Southeastern Alaska), based primarily on NCA data collected in 2003 through 2006. The assessment of offshore 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 trends in coastal condition from 2000 to 2006 based on the NCA data.

Purpose of This Report

The purpose of the NCCR IV is to present a snapshot of conditions of coastal waters for 2003 through 2006, offshore waters (where available), fisheries in offshore waters, and beach and fish advisories around the United States and its territories. This report is written for the informed public, coastal managers, scientists, members of Congress, and other elected officials. English units are used in most of the report because these units are most familiar and best understood by the target audience in the United States. The NCCR IV 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. Because these assessments are a "snapshot" of the environment at the time the measurements were collected, some of the uncertainly associated with the measurements is difficult to quantify. Weather impacts such as droughts, floods, and hurricanes can affect results for weeks to months, in addition to normal sampling variability. The NCCR IV also examines national and regional trends in coastal condition from 2000 to 2006. This report will serve as a continuing benchmark to analyze the progress of coastal programs and will be followed in subsequent years by reports on more specialized coastal issues. This report also identifies data gaps, emerging issues for coastal managers, and the potential future direction of coastal monitoring efforts.

The NCCR IV includes an updated and expanded assessment of the coastal condition in the Great Lakes, with monitoring data comparable to NCA indicators from the *State of the Great Lakes 2009* report (Environment Canada and U.S. EPA, 2009b), as well as assessments of coastal condition in new NCA survey areas, including American Samoa, Southeastern Alaska, Guam, and the U.S. Virgin Islands. Conditions in offshore coastal ocean waters are also assessed in this report using a probabilistic survey of coastal ocean conditions conducted by NOAA and the EPA in the Northeast Coast, Southeast Coast, and West Coast regions. Data on the status of fisheries from NOAA's NMFS are also summarized. The format of the Beach Advisories and Closures section has been revised to include information on trends in regional beach closures, reasons for actions/pollution sources, and the duration of advisory actions.

The final chapter of this report (Chapter 10) explores emerging issues in coastal monitoring and management, including climate change, hypoxia, invasive species, emerging contaminants, and microbial pathogens. This chapter is not intended to present the most comprehensive or technical information on these issues; rather, it provides summaries to familiarize the reader with key topics and existent programs. Links to additional information are also included.

Why Are Coastal Waters Important?

Coastal Waters Are Valuable and Productive Natural Ecosystems

Coastal waters include estuaries, coastal wetlands, seagrass meadows, coral reefs, intertidal zones, mangrove and kelp forests, and coastal ocean and upwelling areas. 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 nonpoint-source runoff.

These waters provide ecosystem services that benefit human well-being (e.g., water purification and protection against storm surges). Critical coastal habitats provide spawning grounds, nurseries, and shelter, and food for finfish, shellfish, 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, 1998b). The human race is constantly and permanently changing ecosystems, and consequently, the services afforded by those ecosystems. In the past, when human populations were low, ecosystems had the ability to naturally recover from human; thus, the ecosystem services provided to humans were considered free and limitless. However, due to the world's ever-expanding population and more advanced landscape-changing technologies, this is no longer true. Products and processes of nature supply materials for economic development, food, clothing, medicines, even the air we breathe and the water we drink; however, recognizing that these services are not limitless, we need a new way to identify how human management and policies affect ecosystems to ensure that we are better stewards of the environment upon which our very lives and livelihoods depend.

Despite the critical nature of these choices, the ecosystem services listed above are most often not considered in management decisions, due in large part to a lack of proper valuation for these services. In an effort to fill this gap, the EPA's Office of Research and Development created the Ecosystem Services

Research Program (ESRP) to identify, map, model, and quantify ecosystem services. More information on the ESRP is provided in Chapter 10 and can be found online at http://www.epa.gov/ecology/.

Coastal Populations and Economics

Coastal areas are the most developed areas in the United States. The narrow fringe of land that comprises coastal areas—only 17% of the total conterminous U.S. land area—is home to more than 53% of the nation's population (Figure 1-1). In 2006, the total population in U.S. coastal counties was estimated at over 127 million, a 29% increase over 1980. This growth has not been uniform across the United States; the Southeast Coast region has seen the largest population percent increase (78%), while the population in the Great Lakes region has increased by approximately 1% over the same time period. In addition to the sheer numbers of people living on the coast, the majority of the nation's most densely populated areas are located along the coast. The population density of U.S. coastal counties is 183 persons/square miles nationwide, much higher than the national average of 98 persons/square mile for noncoastal counties (NOEP, 2010).

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).

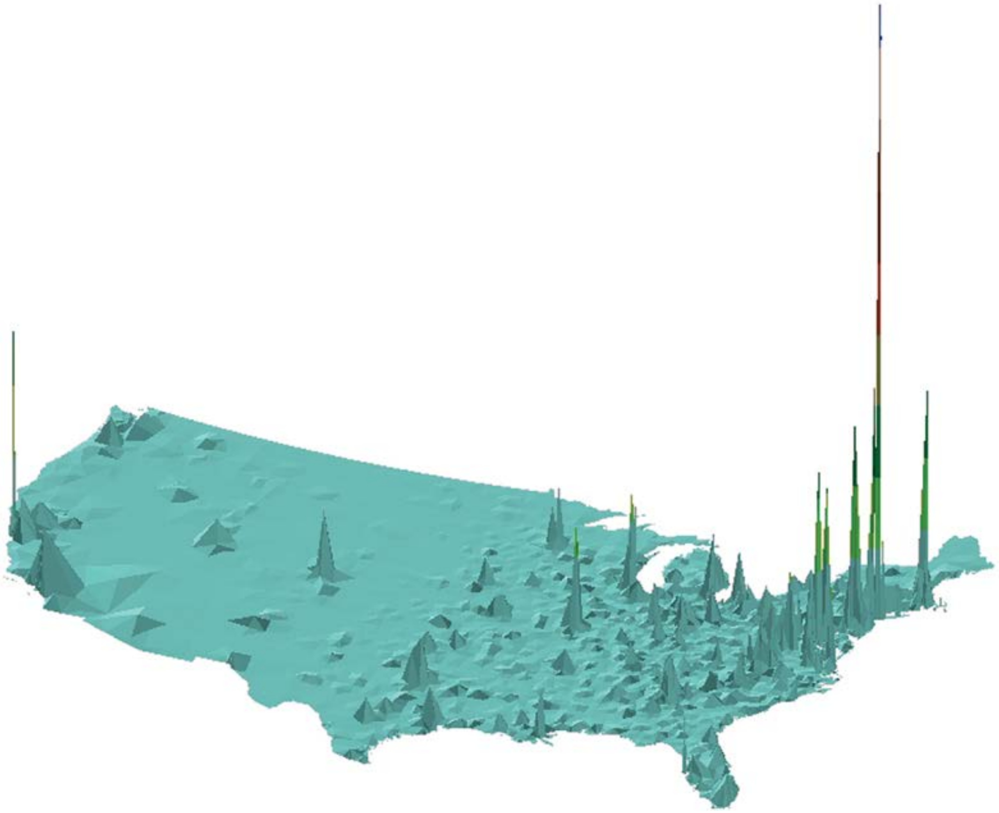


Figure 1-1. Population distribution in the United States based on 2000 U.S. Census Bureau data (U.S. Census Bureau, 2001).

In 2007, the coastal economy supported over 48 million jobs, a 9.7% growth over the previous decade. That year, the coastal states also contributed $11.4 trillion to the U.S. economy (Kidlow et al., 2009). In 2006, the commercial landings of marine species in the United States were approximately 9.5 billion pounds, a landed value of nearly $4 billion. Roughly 30% of the nation’s commercial landings are taken within 3 miles of shore (NMFS, 2007a).

Why Be Concerned about Coastal Condition?

Because a disproportionate percentage of the nation’s population resides in coastal areas, the activities of municipalities, commerce, industry, and tourism create environmental pressures that threaten the very resources that make coastal living desirable. Population pressures include increased solid waste production; higher volumes of urban nonpoint-source runoff; loss of green space and wildlife habitat; declines in ambient water and sediment quality; and increased demands for wastewater treatment, irrigation and potable water, and energy supplies. Development pressures result 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. In addition, new pressures are on the horizon as a result of climate-change impacts and other emerging issues. This report not only discusses the indicators of coastal condition that gauge the extent to which coastal habitats and resources have been altered, but it also addresses connections between coastal condition and the ability of coastal areas to meet human expectations for their use.

Assessment of Coastal Condition

Two sources of coastal information use nationally consistent data-collection designs and methods—EPA’s NCA and FWS’s NWI S&T. The NCA collects data from all coastal areas in the United States, except the Great Lakes region and the Northern Mariana Islands, and these data are representative of all coastal waters. The NWI S&T 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. Four types of data are presented in this report:

- Coastal monitoring data from programs such as EPA’s NCA and FWS’s NWI S&T, along with data from the Great Lakes National Program Office (GLNPO); these data have been analyzed for this report and were used to develop indices of coastal condition.
- Coastal ocean monitoring data from probabilistic surveys conducted by NOAA and the EPA in the Mid-Atlantic Bight, the South Atlantic Bight, and West Coast, covering waters from estuaries to the continental shelf, were assessed using the NCA estuarine indices.
- Fisheries data for Large Marine Ecosystems (LMEs) from NOAA’s NMFS.
- Advisory data provided by states or other regulatory agencies and compiled in national EPA databases.

Why Doesn't This Assessment Use More of the Available Data Sets?

Many other sets of monitoring data are available for estuarine and coastal areas around the United States; however, these data sets were not included in this report for several reasons. Most of these data sets were not collected using a probabilistic survey design and, therefore, are not representative of the entire region covered by the sampling program. For example, the locations of the monitoring stations used to collect the data may have been selected to meet specific program goals, such as monitoring water quality near wastewater-discharge points. Also, these monitoring programs are conducted by different agencies or organizations and use various methods for data collection, analysis, and evaluation. The parameters and time frames monitored may also vary between monitoring programs. Unlike the NCA "snapshot" data, these types of monitoring programs often provide long-term data suitable for assessing program goals or monitoring changes in coastal condition over a longer time period in the areas targeted by these efforts; however, it would be difficult to compare these data sets on a regional or national basis to assess coastal condition or integrate them into the NCCR IV assessment.

This report presents available coastal monitoring information on a national scale for the 30 coastal states, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands; these data are also analyzed by geographic region in seven chapters: Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Great Lakes, Alaska and Hawaii, and the island territories. In most cases, these geographic regions roughly coincide with the borders of the 11 LMEs surrounding U.S. states and island territories (Figure 1-2, Table 1-1). Advisory data for the regions are presented at the end of each chapter. Although inconsistencies in the way different state agencies collect and provide advisory data prevent the use of these data for comparing conditions between coastal areas, the information is valuable because it helps identify and illuminate some of the causes of coastal impairment, as well as the impacts of these impairments on human uses.

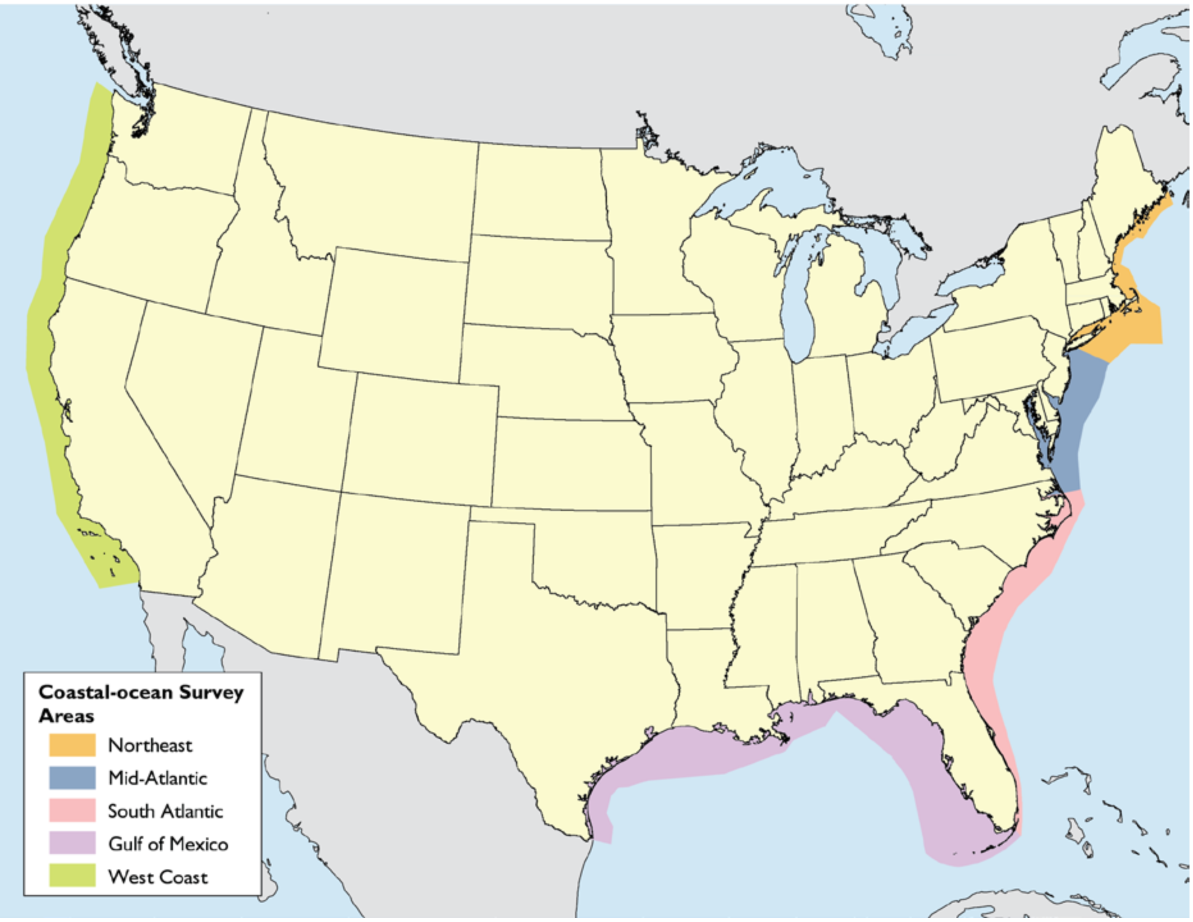


Figure 1-2. Coastal and Large Marine Ecosystem (LME) areas presented in the chapters of this report (U.S. EPA/NCA).

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

NCA Reporting Regions	NOAA 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	East Bering Sea LME, West Bering Sea LME, Gulf of Alaska LME, Chukchi Sea LME, Beaufort Sea LME
Hawaii	Insular Pacific-Hawaii LME
American Samoa	Not in an LME
Guam	Not in an LME
Puerto Rico	Caribbean Sea LME
U.S. Virgin Islands	Caribbean Sea LME

Coastal Monitoring Data

A large percentage of the data used in this assessment of coastal condition comes from EPA's NCA program. The NCA provides representative data on biota (e.g., benthos) and potential environmental stressors (i.e., water quality, sediment quality, and fish tissue bioaccumulation) for all coastal states (except states in the Great Lakes region), American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands (U.S. EPA, 2004a, 2007a, 2008c). The NCA data analyzed for this report were collected from 3,144 sites in 21 coastal states of the conterminous United States, as well as in Southeastern Alaska, Hawaii, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands, during the summers of 2003 through 2006. The NCA data are stored in the EMAP National Coastal Assessment Database, available online at http://www.epa.gov/emap/nca/html/data/index.html. Coastal condition is also evaluated using data from the NWI S&T, which provides information on the status of and trends in the nation's coastal wetlands acreage.

Five primary indices of environmental condition were created using data available from these national 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 coastal characteristics that are valued by society, but they do provide information on both the ecological condition and human use of coastal waters. 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 this report.

Characterizing coastal areas using each of the five indices involved two steps. The first step was to assess condition at an individual monitoring site for each index and component indicator. Each site received a rating of good, fair, or poor for each index and component indicator, depending on the rating cutpoints. The range of values for these cutpoints was determined from literature, best professional judgment, or expert opinion (Table 1-2). In some cases, different value ranges were determined for different regions based on comments from peer reviewers and consultations with state water quality managers. These ranges were reevaluated for each NCCR by groups of experts, including academic scientists, government scientists, and others. Technical workgroups have already begun reassessing these ranges for the NCCR V. For the component indicators and the benthic and fish tissue contaminants indices, the rating at each station (or fish samples analyzed for the fish tissue contaminants index in the Northeast Coast region) was translated to scores (good = 5, fair = 3, poor = 1). For the water quality and sediment quality indices, the ratings for each station were calculated based on how many (and which) component indicators received a poor rating at the station; these ratings were then translated into regional scores.

Table 1-2. Sources of Information to Establish Ranges of Cutpoint Values for Good, Fair, or Poor Ratings

Index	Source
Water Quality Index	Best professional judgment; consultations with experts and selected state water quality managers
Sediment Quality Index	Best professional judgment; consultations with experts and selected state water quality managers
Benthic Index	Engle et al., 1994; Weisberg et al., 1997; Engle and Summers, 1999; Van Dolah et al., 1999; Paul et al., 2001; Hale and Heltsche, 2008
Coastal Habitat Index	Best professional judgment; consultations with experts at U.S. FWS
Fish Tissue Contaminants Index	U.S. EPA, 2000c; consultations with experts
Dissolved Inorganic Nitrogen (DIN) Dissolved Inorganic Phosphorus (DIP) Chlorophyll *a*	Bricker et al., 1999; selected state criteria for chlorophyll *a* in coastal waters

(continued)

Table 1-2. Sources of Information to Establish Ranges of Cutpoint Values for Good, Fair, or Poor Ratings (continued)

Component Indicator	Source
Water Clarity	Smith et al., 2006; best professional judgment; consultations with selected state water quality managers
Dissolved Oxygen	Diaz and Rosenberg, 1995; U.S. EPA, 2000b; selected state criteria for dissolved oxygen in coastal waters
Sediment Contaminants	Long et al., 1995; consultations with experts
Sediment Total Organic Carbon (TOC)	Best professional judgment; consultations with experts and selected state water quality managers
Benthic Diversity (in lieu of benthic index)	Best professional judgment; consultations with experts

The second step was to assign a regional index rating based on the condition of the monitoring sites within the region. An areally weighted cumulative distribution function (CDF) was calculated for each index and component indicator (except for the fish tissue contaminants index) to show what percentage of the area in each region had scores of 1 (poor), 3 (fair), and 5 (good) (Diaz-Ramos et al., 1996). The CDF was calculated for the distribution of sites in each region over all years (2003-2006) cumulatively. Error estimates and 95% confidence intervals were also calculated for the CDF (see Appendix A of the NCCR III for more information). The region was then rated overall as good, fair, or poor for each index or component indicator based on the percent area that was rated good, fair, and poor for each index or indicator. As an example, for a region to be rated poor for the dissolved oxygen component indicator, sampling sites representing more than 15% of the coastal area in the region must have measured dissolved oxygen concentrations less than 2 milligrams per liter (mg/L) and be rated poor. For all of the indices of condition, the “fair” rating can have a score of 2, 3, or 4. This distinction is based on best professional judgment and is used to determine when final scores are “fair to poor” or “good to fair,” rather than just fair. The regional cutpoints (i.e., percentages used to rate each index of coastal 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 cutpoints for determining the regional ratings for the five indices as good, fair, or poor.

Additional information about Environmental Monitoring and Assessment Program (EMAP) survey designs and field, laboratory, and statistical methods can be found online at http://www.epa.gov/nheerl/arm/.

Limitations of Available Data

Throughout the NCCR series, assessments of coastal waters beyond the conterminous United States have been largely limited to localized surveys. In 2004, the NCA was expanded to include the coastal waters of the U.S. territories of American Samoa, Guam, and the U.S. Virgin Islands; the Pacific island Commonwealth of the Northern Mariana Islands is still not included in the NCA. The NCA sampled 49 sites in American Samoa, 50 sites in Guam, and 47 sites in the U.S. Virgin Islands. Additionally, another assessment was conducted of Puerto Rico’s coastal waters, with 50 sites sampled. This assessment provides a critical update of the assessment provided for Puerto Rico in the NCCR II and III, which consisted of sampling conducted in 2000. The coastal ecosystems around the U.S. Virgin Islands, American Samoa, Guam, and Puerto Rico make up only a small portion of the nation’s coastal area, but they represent a unique set of coastal subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States, except for southern Florida and the Flower Gardens off the Texas/Louisiana coast.

Nearly 75% of the area of all the bays, sounds, and estuaries in the United States are located in Alaska, and no national report on coastal condition can be complete without information on the condition of the living resources and ecological health of these waters. In 2004, a survey was conducted of Southeastern Alaska's coastal waters using three of the NCA indices (water quality, sediment quality, and fish tissue contamination). Assessments from these coastal waters, which represent 63% of Alaska's total coastline (Sharma, 1979) and one LME, are included in this report. The benthic and coastal habitat indices for this region could not be evaluated for the NCA. Coastal condition in Alaska is difficult to assess because very little information is available for most of the state to support the type of analysis in this report (i.e., spatial estimates of condition based on the indices and component indicators measured consistently across broad regions). The southeastern coast of Alaska contains mostly fjords, bays, coves, estuaries, and other coastal features that are difficult to access and often inaccessible by road. In order to address these logistical issues, the NCA, EPA Region 10, Alaska DEC, and other state natural resource agencies drafted a sampling design for Alaska in the late 1990s that could be executed in five phases. The NCCR III included results from the first phase in Southcentral Alaska.

The NCCR IV presents results from a survey of Hawaii's coastal waters conducted in 2006. This assessment includes both the water quality and sediment quality indices, providing an update to the results from the 2002 survey presented in the NCCR III. The benthic, coastal habitat, and fish contaminants indices could not be evaluated for the 2006 survey. Although the coastal waters of Hawaii represent only 1% of the state's coastal ocean area, they are ecologically significant and include estuaries that provide critical spawning and nursery grounds for many fisheries. In the Hawaii NCA, the coastal area assessed included spatially limited estuaries and semi-enclosed coastal embayments, with nearshore coral reef habitats that are highly important to Hawaii, both ecologically and economically.

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, local) necessary to comprehensively 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. The developers of this national coastal assessment continue to incorporate new research findings and work with decision makers and coastal experts to improve the assessment methods, indicators, and cutpoints used to interpret coastal condition. These improvements will be reflected in the next National Coastal Condition Report V.

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 concentrations can increase above 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. For further discussion of eutrophication and potential interactions with climate change, see Chapter 10.

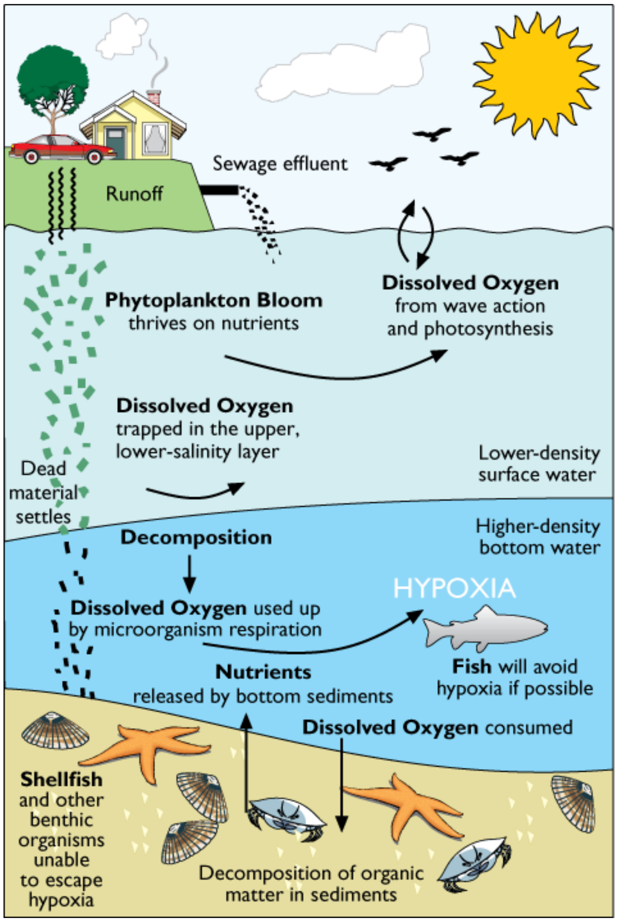


Figure 1-3. Eutrophication can occur when the concentration of available nutrients increases above normal levels (U.S. EPA/NCA).

The water quality index used in this report is intended to characterize degraded water quality conditions, using five component indicators. It does not isolate a particular agent of degradation, nor does it consistently identify sites experiencing occasional or infrequent hypoxia (i.e., low dissolved oxygen conditions), nutrient enrichment, or decreased water clarity. As a result, a rating of poor for the water quality index means that the site exhibited poor condition on the date sampled and is more likely to have 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 at other times. Thus, increased or supplemental sampling would be needed to assess the level of variability in the index at a specific site.

Nutrients: Nitrogen and Phosphorus

Nitrogen and phosphorus are necessary and natural nutrients required for the growth of phytoplankton, the primary producers that form the base of the food web in coastal waters; however, excessive levels of nitrogen and phosphorus 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 the tidal–freshwater parts of estuaries.

In most regions, NCA data were only available for the dissolved inorganic forms of nitrogen and phosphorus (i.e., DIN and DIP), which were determined chemically through the collection of filtered surface water at each site. DIN and DIP represent the portion of the total nitrogen and phosphorus pool in estuarine and coastal waters that remains once these nutrients have been sorbed to sediments or assimilated by phytoplankton, benthic microalgae, or higher aquatic plants. Although DIN and DIP alone are not adequate indicators of the trophic state or water quality of coastal waters, susceptibility to eutrophication may be indicated when high concentrations of DIN and DIP are observed along with high chlorophyll *a* levels, poor water clarity, or hypoxia. In Guam, nutrient levels were assessed using nitrate-nitrogen and DIP. Coastal monitoring sites were rated good, fair, or poor for DIN in most regions and for nitrate-nitrogen in Guam and DIP; these ratings are based on the cutpoints shown in Tables 1-3 and 1-4. The site ratings were then used to calculate an overall rating for each region.

Table 1-3. Cutpoints for Assessing Dissolved Inorganic Nitrogen (DIN)[a]

Area	Good	Fair	Poor
Northeast Coast, Southeast Coast, Gulf Coast, and Guam[a] sites	< 0.1 mg/L	0.1–0.5 mg/L	> 0.5 mg/L
West Coast, Alaska, and American Samoa sites	< 0.35 mg/L	0.35–0.5 mg/L	> 0.5 mg/L
Hawaii, Puerto Rico, U.S. Virgin Islands, 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 50% or less of the coastal area is in good condition.	More than 25% of the coastal area is in poor condition.

[a] In Guam, the cutpoints apply to concentrations of nitrate-nitrogen.

Table 1-4. Cutpoints for Assessing Dissolved Inorganic Phosphorus (DIP)

Area	Good	Fair	Poor
Northeast, Southeast, and Gulf Coast sites	< 0.01 mg/L	0.01–0.05 mg/L	> 0.05 mg/L
West Coast, Alaska, and American Samoa sites	< 0.07 mg/L	0.07–0.1 mg/L	> 0.1 mg/L
Hawaii, Puerto Rico, U.S. Virgin Islands, and Florida Bay sites	< 0.005 mg/L	0.005–0.01 mg/L	> 0.01 mg/L
Guam sites	< 0.025 mg/L	0.025–0.1 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 50% or less of the coastal area is in good condition.	More than 25% of the coastal area is in poor condition.

The National Coastal Assessment (NCA) monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

Chlorophyll a

One of the symptoms of degraded water quality condition is the increase of phytoplankton biomass 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 the 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 cutpoints shown in Table 1-5. The site ratings were then used to calculate an overall chlorophyll *a* rating for each region.

Table 1-5. Cutpoints for Assessing Chlorophyll *a*

Area	Good	Fair	Poor
Northeast Coast, Southeast Coast, Gulf Coast, West Coast, and Alaska sites	< 5 μg/L	5–20 μg/L	> 20 μg/L
Hawaii, Puerto Rico, U.S. Virgin Islands, Guam, American Samoa, 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 50% or less of the coastal area is in good condition.	More than 20% of the coastal area is in poor condition.

Water Clarity

Clear waters are generally valued by society for aesthetics and recreation. In many coastal waters, water clarity is important for light penetration to support submerged aquatic vegetation (SAV), which provides essential habitat for the resident biota. Water clarity is affected by physical factors such as wind and/or other forces that suspend sediments and particulate matter in the water; by chemical factors that influence the amount of dissolved organics measured as color; and by phytoplankton levels in a waterbody. The naturally turbid waters of estuaries, however, can also be valuable to society. Turbid waters can support healthy and productive ecosystems by supplying building materials for maintaining estuarine habitats (e.g., coastal wetlands) and providing food and protection to resident organisms; however, turbid waters can be harmful to coastal ecosystems if sediment loads 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. A Secchi disk may also be used to determine the depth to which ambient light penetrates the water column. Local variability in water clarity occurs between the different regions within an estuary, as well as at a single location in an estuary, due to tides, storm events, wind mixing, and changes in incident light. The probabilistic nature of the NCA study design accounts for this local variability when the results are assessed on larger regional or national scales. Water clarity also varies naturally among various parts of the nation; therefore, the water clarity component indicator is compared to regional reference conditions at 1 meter. The regional reference conditions were determined by examining available data for each of the U.S. regions (Smith et al., 2006). Reference conditions for a site rated poor 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, Mississippi, South Carolina, Georgia, and Delaware Bay), and 20% for regions of the country with significant SAV beds or active programs for SAV restoration (Laguna Madre; the Big

Bend region of Florida; the region from Tampa Bay to Florida Bay; the Indian River Lagoon; portions of Chesapeake Bay; Hawaii; American Samoa; Guam; Puerto Rico; and the U.S. Virgin Islands). Table 1-6 summarizes the rating cutpoints for water clarity for each monitoring station and for the regions.

Table 1-6. Cutpoints for Assessing Water Clarity

Area	Good	Fair	Poor
Sites in coastal waters with naturally high turbidity	> 10% light at 1 meter	5–10% light at 1 meter	< 5% light at 1 meter
Sites in coastal waters with normal turbidity	> 20% light at 1 meter	10–20% light at 1 meter	< 10% light at 1 meter
Sites in coastal waters that support SAV	> 40% light at 1 meter	20–40% light at 1 meter	< 20% light at 1 meter
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 50% or less of the coastal area is in good 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 conditions occur as a result of large algal blooms that sink to the bottom, where bacteria use oxygen as they degrade the algal mass. In addition, low dissolved oxygen conditions 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. The cutpoint 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 different cutpoints, 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 (Diaz and Rosenberg, 1995; U.S. EPA, 2000b). Because so many state agencies use higher concentrations, the NCA evaluated the proportion of waters that have dissolved oxygen concentrations between 5 and 2 mg/L in bottom waters as being in fair condition (i.e., threatened).

These low levels of oxygen (hypoxia) or a lack of oxygen (anoxia) most often occur in bottom waters and affect the organisms that live in the sediments. 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 dissolved oxygen conditions in the nation's coastal waters, it is difficult to interpret whether any poor conditions in this snapshot are representative of eutrophication or the result of natural physical processes. In addition, the snapshot may not be representative of all summertime periods, such as variable daily conditions (see text box). Unless otherwise noted, the dissolved oxygen data presented in this report were collected by the NCA at a depth of 1 meter above the sediment at each station (e.g., surface dissolved oxygen was measured in Southeastern Alaska). Dissolved oxygen concentrations at individual monitoring sites and over regions were rated good, fair, or poor using the cutpoints shown in Table 1-7.

Table 1-7. Cutpoints 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% of the coastal area is in good condition.	5% to 15% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.	More than 15% of the coastal area is in poor condition.

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 collected 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. NCA sampling does not address the duration of hypoxic events because each station is sampled on only 1 day during the summer. In addition, year-to-year variations in estuarine dissolved oxygen levels 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.

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 water quality index was rated good, fair, poor, or missing using the cutpoints shown in Table 1-8. A water quality index was then calculated for each region using the criteria shown in Table 1-9.

Table 1-8. Cutpoints for Determining the Water Quality Index Rating by Site

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

Table 1-9. Cutpoints for Determining the Water Quality Index Rating by Region

Rating	Cutpoints
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 50% or less of the coastal area is in good 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 may have adverse effects on 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.

The NCA collected sediment samples, measured the concentrations of chemical constituents and TOC in the 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.

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, *Alternative Views for a Sediment Quality Index*). 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 (i.e., 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.

Guidelines for Assessing Sediment Contamination (Long et al., 1995)

ERM (Effects Range Median)—Determined values 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 effects range median (ERM) and effects range low (ERL) values to calculate the sediment quality index because the index is also based on actual measurements of toxicity. Because ERMs are defined as the concentration above which negative effects are likely to occur in 50% of the samples, 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). In a database generated in the EPA National Sediment Quality Survey (U.S. EPA, 2001d), 2,761 samples were evaluated with matching sediment chemistry and 10-day amphipod toxicity. Of the 762 samples with at least one ERM exceedance, 48% were toxic, and of the 919 samples without any ERLs exceedances, only 8% were toxic (Ingersoll et al., 2005). These data also showed a consistent pattern of increasing incidence of toxicity as the numbers of ERMs that were exceeded increased. Although these analyses are consistent with the narrative intent of ERMs to indicate an incidence of toxicity of about 50% and ERLs to indicate an incidence of toxicity of about 10%, some 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 shown to be toxic in bioassays.

Sediment Toxicity

Researchers applied a standard 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 (U.S. EPA, 1995a). Survival was measured relative to that of amphipods exposed to uncontaminated reference sediment. Although sediment samples from Guam were also tested with the same amphipod as was used in other regions, this toxicity test may not be suitable in the predominantly sandy sediments. Therefore, sediment toxicity scores for Guam were determined differently (see Chapter 9) from the other regions, and the rating was not included in the national assessment.

The cutpoints for rating sediment toxicity based on amphipod survival for each sampling site are shown in Table 1-10. Table 1-11 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 1-10. Cutpoints for Assessing Sediment Toxicity by Site

Rating	Cutpoints
Good	The amphipod survival rate is greater than or equal to 80% of the control group's survival rate.
Poor	The amphipod survival rate is less than 80% of the control group's survival rate.

Table 1-11. Cutpoints for Assessing Sediment Toxicity by Region

Rating	Cutpoints
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 1-12). 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. The cutpoints for rating sediment contaminants at individual sampling sites are shown in Table 1-13, and Table 1-14 shows how these data were used to create regional ratings for the sediment contaminants component indicator.

Table 1-12. ERM and ERL Guidelines for Sediment (Long et al., 1995)

Metal[a]	ERL	ERM
Arsenic	8.2	70
Cadmium	1.2	9.6
Chromium	81	370
Copper	34	270
Lead	46.7	218
Mercury	0.15	0.71
Nickel	20.9	51.6
Silver	1	3.7
Zinc	150	410
Acenaphthene	16	500

(continued)

Table 1-12. ERM and ERL Guidelines for Sediment (Long et al., 1995) (continued)

Analyte[b]	ERL	ERM
Acenaphthylene	44	640
Anthracene	85.3	1,100
Flourene	19	540
2-Methylnaphthalene	70	670
Naphthalene	160	2,100
Phenanthrene	240	1,500
Benz(a)anthracene	261	1,600
Benzo(a)pyrene	430	1,600
Chrysene	384	2,800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5,100
Pyrene	665	2,600
Low molecular-weight PAH	552	3,160
High molecular-weight PAH	1,700	9,600
Total PAHs	4,020	44,800
4,4 ’-DDE	2.2	27
Total DDT	1.6	46.1
Total PCBs	22.7	180

[a] Units are µg/g dry sediment, equivalent to parts per million (ppm)

[b] Units are ng/g dry sediment, equivalent to parts per billion (ppb)

Table 1-13. Cutpoints for Assessing Sediment Contaminants by Site

Rating	Cutpoints
Good	No contaminant concentrations exceeded the ERM, and fewer than five contaminant concentrations exceeded ERLs.
Fair	No contaminant concentrations exceeded the ERM, and five or more contaminant concentrations exceeded the ERLs.
Poor	At least one contaminant concentration exceeded the ERM.

Table 1-14. Cutpoints for Assessing Sediment Contaminants by Region

Rating	Cutpoints
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, including dominance of pollution-tolerant species (Pearson and Rosenberg, 1978). 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 levels can sometimes result in the release of these TOC-bound and unavailable contaminants. Regions of high TOC content are also 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 cutpoints for rating TOC at individual sampling sites are shown in Table 1-15, and Table 1-16 shows how these data were used to create a regional ranking.

Table 1-15. Cutpoints for Assessing Sediment TOC by Site (concentrations on a dry-weight basis)

Rating	Cutpoints
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 1-16. Cutpoints for Assessing Sediment TOC by Region

Rating	Cutpoints
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, fair, or poor for each site using the cutpoints shown in Table 1-17. The sediment quality index was then calculated for each region using the cutpoints shown in Table 1-18.

Table 1-17. Cutpoints for Determining the Sediment Quality Index by Site

Rating	Cutpoints
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 rated fair.
Poor	One or more of the component indicators is rated poor.

Table 1-18. Cutpoints for Determining the Sediment Quality Index by Region

Rating	Cutpoints
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 50% or less of the coastal area is in good condition.
Poor	More than 15% of the coastal area is in poor condition.

Benthic Index

The worms, clams, mollusks, crustaceans, and other invertebrates that inhabit the bottom substrates of coastal waters 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 disturbance 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 stresses, salinity fluctuations, and sediment disturbance and serve as reliable indicators of coastal environmental quality. To distinguish degraded benthic habitats from natural, healthy benthic habitats, EMAP and the 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; Paul et al., 2001; Hale and Heltshe, 2008). 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 sediment samples taken from a waterbody contain a wide variety of benthic 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 fell below a certain threshold.

Not all regions included in this report have developed benthic indices. Indices for the West Coast, Alaska, Hawaii, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands are under development and were unavailable for reporting at this time. In these regions, benthic community diversity or species richness were determined for each site as surrogates for the benthic index. Values for diversity or richness were compared with salinity regionally to determine if a significant relationship existed. This relationship was not significant for Southeastern Alaska and Hawaii, and no surrogate benthic index was developed; therefore, benthic community condition was not assessed for these regions. For West Coast estuaries, a highly significant ($p < 0.0001$) linear regression between log species richness and salinity was found for the region, although variability was high ($R^2 = 0.33$). A surrogate benthic index was calculated by determining the expected species richness from the statistical relationship to salinity and then calculating the ratio of observed to expected species richness. Poor condition was defined as less than 75% of the expected benthic species richness at a particular salinity. A provisional assignment of benthic community condition for Guam was made by inspection of benthic community indicators, such as soft sediment infaunal species richness and total abundance. A regression of species richness versus percent fines in the sediments indicated that a significant negative relationship was present. Sediments with more than 10% fines generally had decreased species richness and abundance, sometimes markedly so. Break points in the distribution of species richness and total abundance were used to assign condition scores. For example, stations with species richness less than 12/sample and abundance less than 50/sample were considered in poor condition. The data from Puerto Rico and the U.S. Virgin Islands showed no significant relationship between benthic diversity or species richness and salinity; however, a different approach was used to assess benthic condition in this region. Benthic diversity (H’) was used as a surrogate for a benthic index for Puerto Rico and the U.S. Virgin Islands by determining the mean and 95% confidence limits for diversity in unstressed benthic habitats (i.e., sites with no sediment contaminants, low TOC, and absence of hypoxia). Poor benthic condition was then defined as observed diversity less than 75% of the lower 95% confidence limit of mean diversity for unstressed habitats. Benthic data were not collected for American Samoa. Table 1-19 shows the good, fair, and poor rating cutpoints for the different regions of the country, which were used to calculate an overall benthic condition rating for each region.

Table 1-19. Cutpoints for Assessing the 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 is 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[a]	Benthic index score is less than 0.0.
Southeast Coast sites	Benthic index score is greater than 2.5.	Benthic index score is between 2.0 and 2.5.	Benthic index score is less than 2.0.
Gulf Coast sites	Benthic index score is greater than 5.0.	Benthic index score is between 3.0 and 5.0.	Benthic index score is less than 3.0.
West Coast sites (compared to expected diversity)	Benthic index score is more than 90% of the lower limit (lower 95% confidence interval) of expected mean diversity for a specific salinity.	Benthic index score is between 75% and 90% of the lower limit of expected mean diversity for a specific salinity.	Benthic index score is less than 75% of the lower limit of expected mean diversity for a specific salinity.
Southeastern Alaska, Hawaii, and American Samoa sites	NA[b]	NA[b]	NA[b]
Guam sites	Species richness is greater than 20 per sample, and abundance is greater than 100 per sample.	Either species richness or abundance is in the good range, and neither indicator is in the poor range.	Species richness is less than 12 per sample, and abundance is less than 50 per sample.
Puerto Rico and U.S. Virgin Islands 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.	Benthic index score is between 75% and 90% of the lower limit of mean diversity in unstressed habitats.	Benthic index score is less than 75% of the lower limit of mean diversity in unstressed habitats.
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 50% or less of the coastal area is good condition.	More than 20% of the coastal area is in poor condition.

[a] By design, this index discriminates between good and poor conditions only.

[b] Benthic condition was not assessed in these regions.

Coastal Habitat Index

Coastal wetlands are the vegetated interface between the aquatic and terrestrial components of coastal ecosystems and serve many purposes. Wetlands are beneficial because they can filter and process residential, agricultural, and industrial wastes, thereby improving surface water quality. Wetlands buffer coastal areas against storm and wave damage. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife. Many species 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, subsidence, hurricanes, floods). In the late 1970s and early 1980s, the country was losing wetlands at an estimated rate of almost 300,000 acres per year (Dahl et al., 1991). The Clean Water Act, state wetland protection programs, and programs such as Swampbuster (U.S. Department of Agriculture [USDA]), have helped decrease wetland losses to an estimated 70,000 to 90,000 acres per year. Strong wetland protection is important nationally; 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, 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; tidal flats, such as macroalgal flats, shoals, spits, and bars). This index does not include subtidal SAV, coral reefs, subtidal oyster reefs, worm reefs, artificial reefs, or freshwater/palustrine wetlands (except for those associated with the Great Lakes). The data for the coastal habitat index were derived from the NWI S&T program (see http://www.fws.gov/wetlands/Status-and-Trends/index.html for more information). The NWI S&T program employs rigorous, standardized survey methods to provide periodic estimates of the status and trends in wetland acreage for the United States (Dahl, 2011). Because the NWI S&T assessments are based on remotely sensed imagery, there are inherent limitations in the ability to detect certain kinds of wetlands (e.g., small wetlands less than one acre, submerged wetlands, and certain forested wetlands) (Dahl, 2011). It should be noted that the NWI S&T data used in this assessment do not distinguish between natural and created wetlands and that most created wetlands do not have all the functions of natural wetlands (NAS, 2001). For more information about wetlands, refer to EPA's wetlands web site at http://www.epa.gov/owow/wetlands.

Estimates of estuarine intertidal wetland acreage from 1990 and 2000 for all coastal states in the Northeast, Southeast, and West Coast regions have not changed since the NCCR III. Gulf Coast wetland area estimates were updated for 1998 and 2004 from Stedman and Dahl (2008). Coastal wetland acreage for Alaska represents the entire state (not just the Southeastern Alaska region). Data on wetland area were not available for American Samoa or Guam, and data on recent changes in wetland area were not available for Hawaii or Puerto Rico. Recent coastal wetland loss was estimated as the proportional change in regional coastal wetland area over the most recent decade. The historic, long-term, decadal loss rate was calculated as the proportion of total wetland acreage change from 1780 to 1980, divided by the number of decades (this represents all wetlands in coastal states, not just coastal wetlands; Dahl, 1990). The regional value of the coastal habitat index was calculated as the average of these two loss rates (historic and recent). The national value of the coastal habitat index is a weighted mean that reflects the most recent estimate of the extent of wetlands existing in each region, which is different than the distribution of the extent of coastal area. Table 1-20 shows the rating cutpoints used for the coastal habitat index. Although a 1% loss rate per decade may seem small (or even acceptable), continued wetland losses at this rate cannot be sustained indefinitely and still leave enough wetlands to maintain their present ecological functions.

Table 1-20. Cutpoints for Determining the Coastal Habitat Index

Rating	Cutpoints
Good	The index value is less than 1.0.
Fair	The index value is between 1.0 and 1.25.
Poor	The index value is greater than 1.25.

The NWI S&T 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.

The NWI S&T estimates represent regional assessments and do not apply to individual sites or individual wetlands. There are agencies and organizations addressing wetland status and trends at local, regional, and national levels. Efforts are also underway to improve how wetland conditions and losses are tracked at multiple spatial scales. Although no updates can be provided at this time for the coastal habitat index, the U.S. Fish and Wildlife Service (FWS) developed a report (Stedman and Dahl, 2008) on coastal wetland trends for the eastern United States. This report is available online at http://www.fws.gov/wetlands/Status-and-Trends/index.html. The EPA and its partners are also working on the first-ever national survey on the condition of the U.S. wetlands. The survey will be designed to provide regional and national estimates of the ecological integrity and biological condition of wetlands. The report is due to be released in 2013. For more information, see http://www.epa.gov/Wetlands/survey/.

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 over time. When predators consume contaminated organisms, they may accumulate the levels of contaminants in the organisms they consume. The same accumulation of contaminants may occur when humans consume fish with contaminated tissues. Contaminant residues can be examined in the fillets, whole-body portions, or specific organs of target fish, shellfish, or other (e.g., sea cucumbers) species and compared with EPA risk-based advisory guidance values (U.S. EPA, 2000c) for use in establishing fish advisories.

For the NCA surveys, fish sampling was conducted at all monitoring stations where this activity was feasible. At all sites where sufficient fish tissue was obtained, contaminant burdens were determined in fillet or whole-body samples. The target species typically included demersal (bottom-dwelling) and slower-moving pelagic (water column-dwelling) species (e.g., finfish, shrimp, lobster, crab, sea cucumbers; collectively referred to as "fish" in this report) that are representative of each of the geographic regions (Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Southeastern Alaska, American Samoa, and Guam). These intermediate, trophic-level (position in the food web) species are often prey for larger predatory fish of commercial value (Harvey et al., 2008). Where available, 4 to 10 individual fish from each target species at each sampling site were analyzed by compositing fish tissues from the same species.

Although the EPA risk-based advisory guidance values were developed to evaluate the health risks of consuming market-sized fish fillets, they also may be used to assess the risk of contaminants in whole-body fish samples as a basis for estimating advisory determinations—an approach currently used by many state fish advisory programs (U.S. EPA, 2000c). Under the NCA program, EPA is also using these advisory guidance values as surrogate benchmark values for fish health in the absence of comprehensive ecological thresholds for contaminant levels in juvenile and adult fish. The NCA compared contaminant concentrations in whole-body and fillet samples to the EPA advisory guidance values used by states as a basis for setting fish advisories for recreational fishers (Table 1-21) (U.S. EPA, 2000c). This comparison provides an assessment of the potential exposure of fish populations to biologically available contaminants in the environment. The reader should also refer to the text boxes on pages 1-37 and 1-38 of this chapter for further explanation of the differences between the fish tissue contaminants index and state fish consumption advisories.

Table 1-21. Risk-based EPA Advisory Guidance Values for Recreational Fishers (U.S. EPA, 2000c)

Contaminant	EPA Advisory Guidelines Concentration Range (ppm)[a]	Health Endpoint
Arsenic (inorganic)[b]	0.35–0.70	non-cancer
Cadmium	0.35–0.7	non-cancer
Mercury (methylmercury)[c]	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
PAHs (benzo(a)pyrene)	0.0016–0.0032	cancer[d]
PCB	0.023–0.047	non-cancer

[a] Range of concentrations associated with non-cancer and cancer health endpoint risk for consumption of four 8-ounce fish meals per month.

[b] Inorganic arsenic concentrations were estimated to be 2% of the measured total arsenic concentrations (U.S. EPA, 2000b).

[c] The conservative assumption was made that all mercury is present as methylmercury because most mercury in fish and shellfish is present primarily as methylmercury and because analysis for total mercury is less expensive than analysis for methylmercury (U.S. EPA, 2000b).

[d] A non-cancer concentration range for PAHs does not exist.

The rating for each site was based on the measured concentrations of these contaminants within the fish tissue samples; see Table 1-22 for the fish tissue contaminants index site-rating cutpoints. For example, the risk-based EPA advisory guidance values for mercury range from 0.12 to 0.23 parts per million (ppm) of mercury in fish tissue. If the NCA measured a concentration in fish that was less than 0.12 ppm of mercury, then the monitoring station from which the fish were caught was rated good. If the contaminant concentration was within the guidance value range, the monitoring station was rated fair, and if the mercury concentration exceeded 0.23 ppm, then the monitoring station where the fish were caught was rated poor. Unlike the other indices and component indicators where regional ratings were based on the percent of the service area in a particular rating category, the regional rating for the fish tissue contaminants index was based on the percentage of monitoring stations, where fish were caught, that were in poor or fair condition. The fish tissue contaminants index regional rating was based on percent of sites rather than percent area because target fish species were not caught at a large proportion of sites in each region, which invalidated the computation of percent area and associated uncertainty. Table 1-23 shows how these ratings were used to create a regional index rating.

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

Rating	Cutpoints
Good	For all chemical contaminants listed in Table 1-21, the measured concentrations in fish tissue fall below the range of the EPA Advisory Guidance[a] values for risk-based consumption associated with four 8-ounce meals per month.
Fair	For at least one chemical contaminant listed in Table 1-21, the measured concentration in fish tissue 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 1-21, the measured concentrations in fish tissue 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.

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

Table 1-23. Cutpoints for Determining the Fish Tissue Contaminants Index by Region

Rating	Cutpoints
Good	Less than 10% of the monitoring stations where fish were caught are in poor condition, and more than 50% of the monitoring stations where fish were caught are in good condition.
Fair	10% to 20% of the monitoring stations where fish were caught are in poor condition, or 50% or less of the monitoring stations where fish were caught are in good condition.
Poor	More than 20% of the monitoring stations where fish were caught are in poor condition.

Summary of Rating Cutpoints

The rating cutpoints used in this report are summarized in Table 1-24 (primary indices) and Tables 1-25 and 1-26 (component indicators).

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

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 one is rated fair.	**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: One component indicator is rated poor, or two or more component indicators are rated fair.	**Fair:** Between 10% and 20% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.
Poor: Two or more component indicators are rated poor.	**Poor:** More than 20% of the coastal area is in poor condition.

(continued)

Table 1-24. NCA Indices Used to Assess Coastal Condition (continued)

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.	**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: No component indicators are rated poor, and the sediment contaminants indicator is rated fair.	**Fair:** Between 5% and 15% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.
Poor: One or more component indicators are rated poor.	**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 and were determined using regionally dependent benthic index scores (see Table 1-19)	**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 50% or less of the coastal area is in good condition. **Poor:** More than 20% of the coastal area is in poor condition.

Coastal Habitat Index:
This index is based on historic (1780–1980) and recent (1990–2000) data on estuarine intertidal wetland acreage for all coastal states (except American Samoa, Guam, and Puerto Rico).

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 to create a coastal habitat index value.	**Good:** The coastal habitat index value is less than 1.0. **Fair:** The coastal habitat index value is between 1.0 and 1.25. **Poor:** The coastal habitat index value is greater than 1.25.

(continued)

Table 1-24. NCA Indices Used to Assess Coastal Condition (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 1-21, the measured concentrations in tissue fall below the range of the EPA Advisory Guidance[a] values for risk-based consumption associated with four 8-ounce meals per month.	**Good:** Less than 10% of the monitoring stations where fish were caught are in poor condition, and more than 50% of the monitoring stations where fish were caught are in good condition.
Fair: For at least one chemical contaminant listed in Table 1-21, the measured concentration in tissue falls within the range of the EPA Advisory Guidance values for risk-based consumption associated with four 8-ounce meals per month.	**Fair:** 10% to 20% of the monitoring stations where fish were caught are in poor condition, or 50% or less of the monitoring stations where fish were caught are good condition.
Poor: For at least one chemical contaminant listed in Table 1-21, the measured concentration in tissue 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.	**Poor:** More than 20% of the monitoring stations where fish were caught are in poor condition.

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

Table 1-25. NCA Cutpoints 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 (Northeast, Southeast, Gulf, Guam[a]), 0.35 mg/L (West, Alaska, American Samoa), or 0.05 mg/L (tropical[b]).	**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: Surface concentrations are 0.1–0.5 mg/L (Northeast, Southeast, Gulf, Guam), 0.35–0.5 mg/L (West, Alaska, American Samoa), or 0.05 –0.1 mg/L (tropical).	**Fair:** 10% to 25% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.
Poor: Surface concentrations are greater than 0.5 mg/L (Northeast, Southeast, Gulf, Guam, West, Alaska, American Samoa) or 0.1 mg/L (tropical).	**Poor:** More than 25% of the coastal area is in poor condition.

(continued)

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

Dissolved Inorganic Phosphorus (DIP)

Ecological Condition by Site	Ranking by Region
Good: Surface concentrations are less than 0.01 mg/L (Northeast, Southeast, Gulf), 0.025 mg/L (Guam), 0.07 mg/L (West, Alaska, American Samoa), or 0.005 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: Surface concentrations are 0.01–0.05 mg/L (Northeast, Southeast, Gulf), 0.025–0.1 mg/L (Guam), 0.07–0.1 mg/L (West, Alaska, American Samoa), or 0.005–0.01 mg/L (tropical).	**Fair:** 10% to 25% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.
Poor: Surface concentrations are greater than 0.05 mg/L (Northeast, Southeast, Gulf), 0.1 mg/L (Guam, West, Alaska, American Samoa), or 0.01 mg/L (tropical).	**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 American Samoa, Guam, 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: Surface concentrations are between 5 µg/L and 20 µg/L (between 0.5 µg/L and 1 µg/L for American Samoa, Guam, tropical ecosystems).	**Fair:** 10% to 20% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.
Poor: Surface concentrations are greater than 20 µg/L (greater than 1 µg/L for American Samoa, Guam, tropical ecosystems).	**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.	**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: 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	**Fair:** 10% to 25% of the coastal area is in poor condition, or 50% or less of the coastal area is in combined fair and poor condition.
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.	**Poor:** More than 25% of the coastal area is in poor condition.

(continued)

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

Dissolved Oxygen

Ecological Condition by Site	Ranking by Region
Good: Bottom-water concentrations (or surface-water concentrations in Alaska) are greater than 5 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: Bottom-water concentrations (or surface-water concentrations in Alaska) are between 2 mg/L and 5 mg/L.	**Fair:** 5% to 15% of the coastal area is in poor condition, or 50% or less of the coastal area is in good condition.
Poor: Bottom-water concentrations (or surface-water concentrations in Alaska) are less than 2 mg/L.	**Poor:** More than 15% of the coastal area is in poor condition.

[a] Nutrients in Guam were assessed using nitrate-nitrogen rather than DIN.

[b] Tropical ecosystems include Hawaii, Puerto Rico, U.S. Virgin Islands, and Florida Bay sites.

Table 1-26. NCA Cutpoints 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[a] is less than or equal to 20% of the control group’s mortality rate.	**Good:** Less than 5% of the coastal area is in poor condition.
Poor: Mortality is greater than 20% of the control group’s mortality rate.	**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 values.

Ecological Condition by Site	Ranking by Region
Good: No contaminant concentrations exceed the ERM, and fewer than five contaminant concentrations exceed ERL values.	**Good:** Less than 5% of the coastal area is in poor condition.
Fair: No contaminant concentrations exceed the ERM, and five or more contaminant concentrations exceed ERL values.	**Fair:** 5% to 15% of the coastal area is in poor condition.
Poor: One or more contaminant concentrations exceeds the ERM.	**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%.	**Good:** Less than 20% of the coastal area is in poor condition.
Fair: The TOC concentration is between 2% and 5%.	**Fair:** 20% to 30% of the coastal area is in poor condition.
Poor: The TOC concentration is greater than 5%.	**Poor:** More than 30% of the coastal area is in poor condition.

[a] 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; good to fair = 4; fair = 3; fair to poor = 2; and poor = 1. In calculating the overall condition score for a region, the indices are weighted equally because of the lack of a defendable, more-than-conceptual rationale for uneven weighting. The Southeast Coast region, for example, received the following scores:

Indices	Score
Water Quality Index	3
Sediment Quality Index	2
Benthic Index	5
Coastal Habitat Index	3
Fish Tissue Contaminants Index	5
Total Score Divided by 5 = Overall Score	18/5 = 3.6

The overall condition and index scores for the nation are calculated based on an areally 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 proportional 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. 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 2.4 is rated fair to poor; 2.4 to less than 3.7 is rated fair; 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

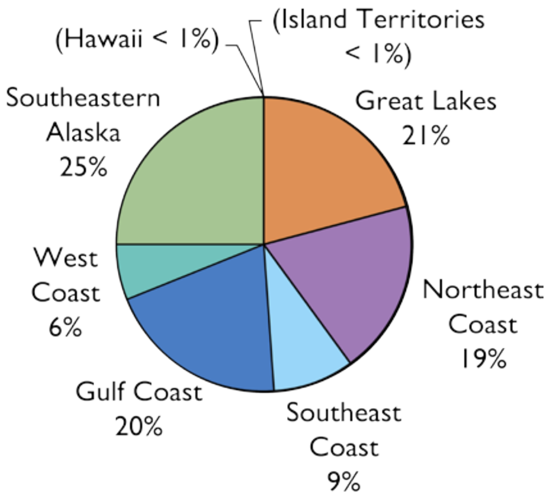


Figure 1-4. Percentage of coastal area contributed by each geographic region assessed in this report (U.S. EPA/NCA).

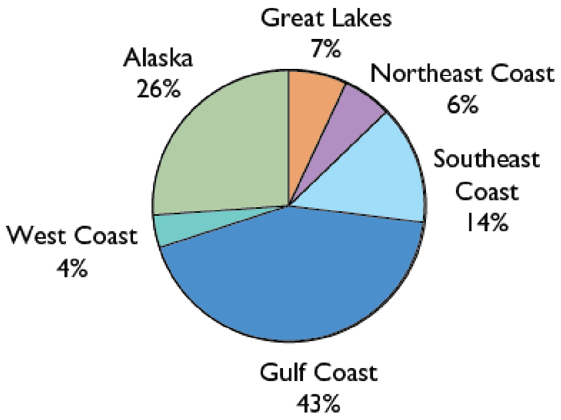


Figure 1-5. Percentage of coastal wetland area contributed by each geographic region assessed in this report (U.S. EPA/NCA).

Trends of Coastal Monitoring Data

Trends in coastal condition are presented in the regions (i.e., Northeast Coast, Southeast Coast, Gulf Coast, West Coast, Hawaii, and Puerto Rico) where sufficient data were available for this analysis. Trends in the proportion of estuarine area that was rated poor for each indicator were evaluated for each region by comparing annual estimates or estimates for specific time periods. The statistical significance of trends was determined using the Mann Kendall test. The statistical significance of any observed difference in the estimates of poor condition between two time periods was determined by performing pair-wise comparisons of the 95% confidence intervals (i.e., estimated error) on the proportion of area rated poor.

Coastal Ocean Monitoring Data

The newest addition to the NCCR series, resulting from a collaboration between NOAA and the EPA, is the presentation of coastal ocean monitoring data for the Mid-Atlantic Bight, South Atlantic Bight, and the West Coast. These surveys may be regarded as an extension of the NCA efforts in estuaries and coastal embayments to offshore areas, where such information has been limited in the past. Samples were collected from offshore coastal ocean waters (the area between estuaries and the outward boundaries of the continental shelf) for 49 stations in the Mid-Atlantic Bight in 2006, 50 stations in the South Atlantic Bight in 2004, and 257 stations on the West Coast in 2003. The assessments employed the methodologies (e.g., probabilistic-sampling design) and many of the same indices and component indicators used throughout the EMAP/NCA projects and presented in the NCCRs, including indices and component indicators for water quality, sediment quality, benthic condition, and fish tissue contaminants. Using the NCA methods and indices allows statistically valid and meaningful comparisons between the condition of estuarine and adjacent ocean waters. The results of these offshore surveys are intended to serve as a baseline for monitoring potential changes in these indicators over time, due to either human or natural factors. The consistent sampling of these variables across such a large number of stations provides an opportunity for learning more about the spatial patterns of near-coastal resources and the processes controlling their distributions, including potential associations between the presence of stressors and biological responses.

For coastal ocean waters, the water quality index was not assessed as a whole; however, the same five component indicators were assessed: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Although no indicator rating cutpoints exist for coastal ocean levels of DIN, DIP, chlorophyll *a*, and dissolved oxygen, the measured values for these indicators were compared to the NCA cutpoints to determine the percentage of coastal ocean area in good, fair, or poor condition for each component indicator for comparison purposes. DIN/DIP ratios were calculated as an indicator of which nutrient may be controlling primary production. A ratio above 16 is indicative of phosphorus limitation, whereas a ratio below 16 is indicative of nitrogen limitation (Geider and La Roche, 2002).

The concentration of total suspended solids (TSS) was used to assess the water clarity component indicator in coastal ocean waters. Although not a measure of turbidity *per se*, the amount of TSS in the water column has a direct effect on water clarity by causing the scattering or attenuation of light. As the concentration of TSS increases, the water becomes more cloudy or turbid. Excessive turbidity and TSS in the water column can be harmful to marine ecosystems and detract from the aesthetic quality of coastal areas. TSS levels were also measured in estuarine waters as part of the NCA, but TSS is not used to assess the water clarity component indicator in estuaries.

The sediment contaminants and sediment TOC component indicators were used to assess sediment condition in coastal ocean waters. Neither the sediment quality index as a whole nor the sediment toxicity contaminant component indicator was assessed in coastal ocean waters. The sediment contaminants component indicator was assessed by comparing concentrations of the same suite of sediment contaminants (e.g., metals, pesticides, PAHs, PCBs) measured in other EMAP/NCA studies, including the 2003–2006 estuarine surveys contaminants, with ERM and ERL sediment quality guideline values (Long et al., 1995). In the absence of rating cutpoints specific to coastal ocean sediments, the NCA cutpoints were used to determine the percentage of coastal ocean area in each rating category. Sediment TOC was assessed based on sediment grain size and the concentrations of TOC in the sediment samples. High levels of TOC in sediments can serve as an indicator of adverse conditions and are often associated with increasing proportions of finer-grained sediment particles (i.e., silt-clay fraction) that tend to provide greater surface area for sorption of both organic matter and other chemical pollutants. Although organic matter in sediments is an important source of food for benthic fauna, an overabundance of TOC can cause reductions in species richness, abundance, and biomass due to oxygen depletion and buildup of toxic by-products (ammonia and sulfide) associated with the breakdown of these materials.

Benthic indices specific to the coastal ocean waters of the Mid-Atlantic Bight, South Atlantic Bight, and West Coast have not been developed; therefore, benthic condition in these waters was assessed using the density of offshore fauna, the mean number of taxa, and the mean diversity (Shannon H' calculated with base-2 logarithms). These measurements were then compared to similar measurements taken by the NCA. In addition, samples of macrobenthic infauna were analyzed for the presence of non-indigenous species. For the Mid-Atlantic Bight and South Atlantic Bight surveys, benthic species lists were examined for presence of non-indigenous species by comparison to the U.S Geological Survey (USGS) Non-indigenous Aquatic Species Database (USGS, 2010). For the West Coast offshore survey, benthic species lists were examined for presence of non-indigenous species in the offshore shelf environment by using the Pacific Coast Ecosystem Information System (PCEIS) classification scheme, a geo-referenced database of native and non-indigenous species of the Northeast Pacific (Lee et al., 2008).

In order to assess the fish tissue contaminants index in coastal ocean waters, concentrations of a suite of metals, pesticides, and PCBs were compared to risk-based EPA advisory guidelines for recreational fishers (U.S. EPA, 2000c).

Along with assessments of water quality, fish contaminants, and benthic condition, the sections on coastal-ocean monitoring include comparisons between estuaries and offshore waters. These comparisons provide a critical reflection of the acute pressures on estuarine ecosystems due to closer proximity to land-based sources of pollutants and other stressors. Contaminants that tend to become concentrated in estuaries are more dispersed in offshore waters, a trend that is reflected in the overall good condition of these waters compared to varying quality of estuaries. Although offshore ecosystems provide habitat for all types of species and levels of the food web, from phytoplankton and zooplankton to large predatory fish, the numbers of species that rely on estuaries for various life stages are numerous. Furthermore, many of the species that eventually inhabit offshore waters utilize estuaries during critical life stages. The comparisons between estuarine and offshore condition, therefore, enhance our understanding of complex ecosystem functions from the shoreline to open water.

The offshore surveys demonstrate 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 was principally funded by the NOAA's National Centers for Coastal Ocean Science and conducted aboard NOAA vessels. As a partner in this effort, the EPA provided technical support to NOAA in the development of survey designs, assistance in the field, and data analysis.

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 NOAA's NMFS. LMEs extend from river basins and estuaries to the seaward boundaries of continental shelves and the outer margins of major current systems. Within these waters, ocean pollution, fishery overexploitation, and coastal habitat alteration are most likely to occur. Sixty-four LMEs surround the continents and most large islands and island chains worldwide and produce 80% of the world's annual marine fishery yields; 11 of these LMEs are found in waters adjacent to the conterminous United States, Alaska, Hawaii, Puerto Rico, and U.S. island territories.

LMEs are areas of ocean characterized by distinct bathymetry, hydrography, productivity, and trophic relationships.

The NMFS fisheries data were organized by LME to allow readers to more easily consider fisheries and estuarine condition data together. Geographically, LMEs contain both the estuaries assessed by the NCA and the U.S. Exclusive Economic Zone (EEZ) waters containing the fisheries assessed by NMFS. In addition, the borders of the LMEs coincide roughly with the borders of the NCA regions. When considered together, these two data sets provide insight into the condition of U.S. marine waters.

This report presents the offshore fisheries data by LME through 2006. The index period was limited to 2006 because the timeframe is more consistent with the coastal condition and advisory data presented in this report. This temporal consistency allows the reader to consider all types of data together to get a clearer "snapshot" of conditions in U.S. coastal waters. Within each chapter, bar graphs present the top commercial fisheries for each LME, with landings and values totaled for the 2003 to 2006 period. The landings are presented in metric tons, unless otherwise noted. The values are in terms of ex-vessel revenues, which are landings at dockside prices prior to any onshore handling, processing, or re-selling.

Interactions between Fisheries and Coastal Condition

Freshwater and saltwater coastal areas are constantly changing as a result of both human and natural forces, which make these areas both resilient and fragile in nature (National Safety Council, 1998). The ecosystems in these areas are interconnected, and stressors on one of these systems can affect the other systems. For example, water quality in freshwater streams and rivers is vital to providing a healthy environment, particularly for anadromous (migratory) fish species such as salmon that are born in freshwater streams, migrate to the ocean as juveniles, utilize the ocean environment as they mature into adults, and return to the streams of their birth to spawn and ultimately die. Good water quality in the spawning areas is required to ensure development of the young. Good water quality is also important for the species that are spawned and develop as juveniles in estuaries, where fresh and salt waters mingle, interact, and are refreshed with the tidal change. When water quality in these upstream freshwater areas is negatively impacted, the survival of juvenile fish in the estuarine nursery areas may decrease, ultimately affecting the offshore fishery stocks of adults for these species.

The coastal and offshore waters, as well as the resources they contain, face many stressors. For example, land-based stressors include increasing coastal population growth, coupled with inadequate land-use planning and increasing inputs of pollutants from the development of urban areas and from agricultural and industrial activities. Pollutant inputs to our freshwater, estuarine, and near-coastal waters include excessive amounts of nutrients from land runoff; toxic chemical contaminants discharged from point sources; nonpoint-source runoff; accidental spills; and deposition from the atmosphere. Degradation or loss of habitat (e.g., loss of wetland acreage), episodes of hypoxia, and pressures from overfishing by both recreational and commercial fisherman also impact these coastal ecosystems and the species they nurture. Offshore in the EEZ, stressors come from oil spills, overexploitation of fishery stock resources, and/or habitat loss associated with damage to benthic communities (e.g., macroalgal forests, coral reefs) from fishing activities or development of mineral and energy resources.

The linkage between the stressors in the freshwater rivers and estuaries and the coastal ocean is shown in Figure 1-6. Aquatic and estuarine fisheries resource managers direct their efforts to preserving water quality conditions; maintaining important spawning and nursery areas associated with wetlands, marshes, and SAV beds; and regulating fishing pressure by recreational and commercial fishermen. In contrast, offshore fisheries managers direct their efforts to managing the exploitation of commercial fishery resources of the adult stocks. Outside the EEZ, fisheries managers have less control over the fishery stocks unless established by international treaties. These combined efforts to reduce pollution, maintain habitat quality, and manage fisheries help to ensure that healthy fishery stocks can be maintained for many years into the future.

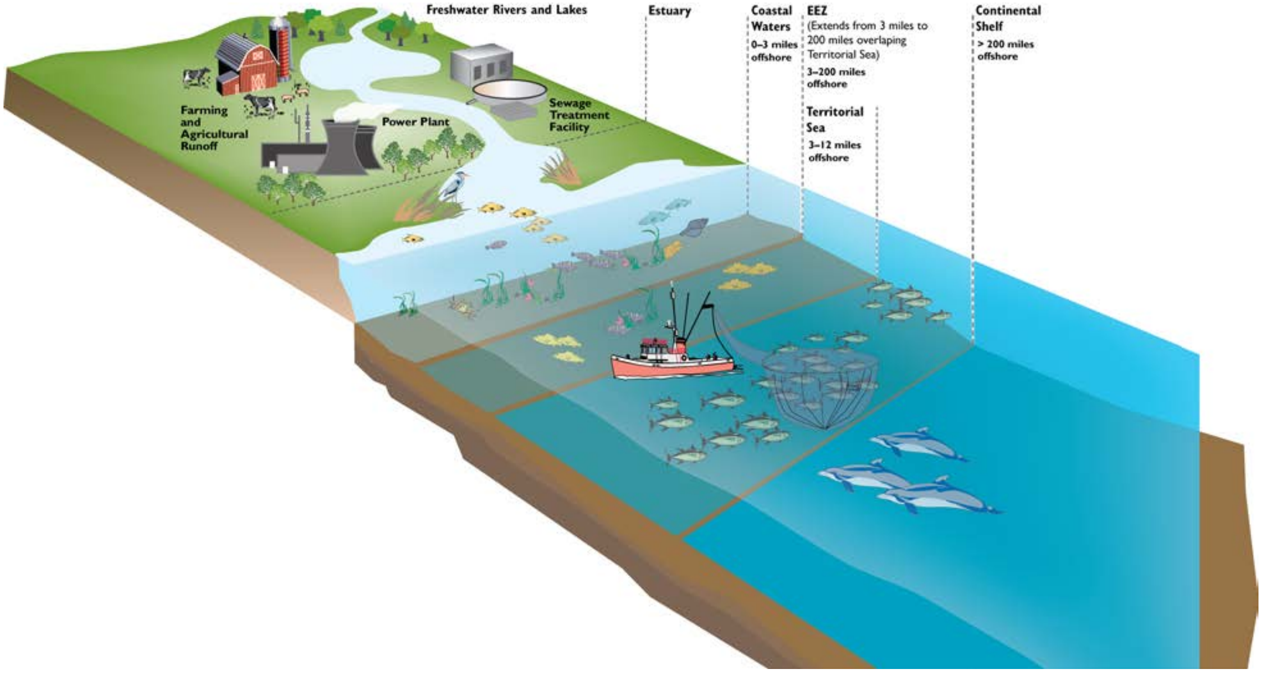


Figure 1-6. Linkages between the stressors in freshwater systems, estuaries, and the coastal ocean (U.S. EPA/NCA).

Fishery Management and Assessment

Ultimately, the Secretary of Commerce has management responsibility for most marine life in U.S. waters and has entrusted the management of these resources to NOAA's NMFS. Most of the NMFS's management and conservation responsibilities are derived from the following acts of Congress:

- Magnuson-Stevens Fishery Conservation and Management Act regulates fisheries within the EEZ
- Endangered Species Act (ESA) protects species that are in danger of extinction or likely to become an endangered species
- Marine Mammal Protection Act regulates the taking of marine mammals
- Fish and Wildlife Coordination Act authorizes the collection of fisheries data and coordination with other agencies for environmental decisions affecting fisheries management regions
- Federal Power Act provides concurrent responsibilities with the FWS on protecting aquatic habitat (NMFS, 2009b).

The NMFS regulates fisheries in the waters located 3 to 200 nautical miles offshore of the United States in an area known as the EEZ. The waters located landward of the EEZ (0–3 nautical miles offshore) are managed by coastal states and multistate fisheries commissions. Fishery resources in the EEZ are managed largely through Fishery Management Plans (FMPs). FMPs may be developed by the NMFS or by fishery management councils (e.g., Pacific Fishery Management Council, New England Fishery Management Council, Gulf of Mexico Fishery Management Council) through extensive consultation with state and federal agencies, affected industry sectors, public interest groups, and, in some cases, international science and management organizations (NMFS, 2009b).

Various data sources are used to assess fishery stocks in the EEZ. Catch-at-age fisheries data are reported to the NMFS by commercial and recreational fisheries on the quantity of fish caught; the individual sizes of fish and their basic biological characteristics (e.g., age, sex, maturity); the ratio of fish caught to time spent fishing (i.e., catch per unit effort [CPUE]); and other factors. The NMFS also conducts direct resource surveys using specialized fishery research vessels to calculate the abundance index (i.e., estimated population size) for some species. The NMFS analyzes these data using several metrics to gain an understanding of the status and trends in U.S. fishery stocks. These metrics include the following:

- **Landings/Catch**—*Landings* are the number or pounds of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points where fish are brought to shore. *Catch* is the total number or pounds of fish captured from an area over some period of time. This measure includes fish that are caught, but released or discarded. The catch may take place in an area different from where the fish are landed.
- **Fishing Mortality Rate**—The *fishing mortality rate* is the rate at which members of the population perish due to fishing activities.
- **Yields (various)**—The *maximum sustainable yield* is the largest average catch or yield that can continuously be taken from a stock under existing environmental conditions. The *recent average yield* is the average reported fishery landings for a recent timeframe. The *long-term potential yield* is the maximum *long-term average yield* that can be achieved through conscientious stewardship. The *near-optimum yield* is based on the *maximum sustainable yield* as modified by economic, social, or ecological factors to provide the greatest overall benefit to the nation, with particular consideration for food production and recreational opportunities.
- **Overfishing/Overfished**—According to the Magnuson-Stevens Fishery Conservation and Management Act of 1996, a fishery is considered *overfished* if the stock size is below a minimum threshold, and *overfishing* occurs if a stock's fishing mortality rate is above a maximum level.

These thresholds and levels are associated with maximum sustainable yield-based reference points and vary between individual stocks, stock complexes, and species of fish.

- **Utilization**—The degree of *utilization* is determined by comparing the present levels of fishing effort and stock abundance to those levels necessary to achieve the long-term potential yield. A fishery can be classified as underutilized, fully utilized, over utilized, or unknown (NMFS, 2009b).

Once the status of a fishery is assessed, resource managers may employ various management tools to regulate where, when, and how people fish, thus protecting and sustaining our nation's fishery resources so that marine resources continue as functioning components of marine ecosystems, afford economic opportunities, and enhance the quality of life for U.S. citizens (NOAA, 2007b). When deemed necessary, fishery resource managers can employ a variety of different tools to regulate harvest, depending on the fish or shellfish species involved. These fishery management tools include the following:

- **Daily bag or trip catch limits** that reduce or increase the number of fish caught per day or per trip, respectively
- **Size limits** that impose minimum fish lengths that limit harvest to adults, thereby protecting immature or juvenile fish
- **Seasonal closures** that prohibit commercial and/or recreational harvesting of specific fish or shellfish stocks during the spawning period
- **Limited access programs** that prevent increased fishing participation by reducing the number of fishing vessels through vessel buyout programs, placing a moratorium on new vessel entrants into a fishery, or establishing a permitting system for commercial fishermen
- **Gear restrictions** that limit the use of certain types of equipment or mandate increases in regulated net mesh size, thereby protecting the habitat from damage or excluding juveniles from harvesting through the use of larger net mesh sizes, respectively
- **Time and area closures** that prohibit harvesting of specific fish stocks in specific fishing grounds or limit the allowable number of days at sea for fishing for certain types of vessels (e.g., trawl or gill-net) to protect habitat of juveniles or spawning species or to reduce total catch
- **Harvest quotas** that limit the number of fish of a particular species that can be harvested annually from a particular region, thereby preventing overfishing
- **Establishment of Marine Protected Areas** within which the harvest of all species is prohibited.

Through the use of these fishery management tools, the NMFS makes stewardship decisions and provides support for rebuilding stocks through science-based conservation and resources management to ensure that marine fishery resources continue as healthy, sustainable, and functioning components of marine ecosystems (NOAA, 2007b). Unless otherwise noted, the 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, 2009b), 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.

Advisory Data

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 National Listing of Fish Advisories (NLFA) program and the Beaches Environmental Assessment, Closure, and Health (BEACH) Program, maintain databases that are repositories for information that addresses the condition of the coast as it relates to public health. These are also are important factors in the public's perception of coastal condition. The data for these programs are collected by multiple state agencies and reported to the EPA, and data collection and reporting methods differ among states. In addition, advisories are precautionary and may not reflect regional condition. Because of these inconsistencies, data generated by these programs are not included in and are not comparable to the regional estimates of estuarine condition.

National Listing of Fish Advisories

States, U.S. territories and commonwealths, and tribes have primary responsibility for protecting their residents from the health risks of consuming contaminated, non-commercially caught fish and shellfish. Resource managers at the state, territory, commonwealth, or tribal level 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, individuals with compromised immune systems). These advisories inform the public that high concentrations of chemical contaminants (e.g., mercury, 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 2006 NLFA is a database—available from the EPA and searchable on the Internet at http://www.epa.gov/waterscience/fish—that contains fish advisory information provided to the EPA by the states, territories, commonwealths, and tribes. The NLFA database can generate national, regional, and state maps that illustrate any combination of advisory parameters.

How the NCA fish tissue contaminants index differs from the state fish advisory data

The results of the NCA fish tissue contaminants index provide a different picture of chemical contamination in fish than the results obtained from the state fish consumption advisory programs. The main difference between these two programs is that the NCA is designed to be a nationally consistent *ecological* assessment of contaminant concentrations in fish tissue in a variety of *ecologically* important target species. In contrast, the state fish advisory programs are designed to identify fish tissue contaminant concentrations in fish species that are locally consumed by recreational fishers that may be harmful to *human health* and warrant issuance of a fish advisory. These programs differ in several other ways, including the contaminants analyzed, type of fish samples analyzed, and health benchmarks used in the assessment. These differences are discussed in greater detail below and are summarized in the table.

- The NCA analyzes each fish sample for a uniform suite of contaminants in all estuaries nationally. In contrast, individual states monitor for specific contaminants, but each state selects the contaminants of concern for a particular waterbody based on land-use practices in the watershed, identified sources of pollution, and available state resources. Therefore, some states may monitor for mercury and pesticides, while other states monitor for select heavy metals and PCBs.
- The NCA analyzes both juvenile and adult fish, most often as whole specimens, because this is the way fish would typically be consumed by predator species. This approach is appropriate for an ecological assessment. In contrast, most state programs assess the risk of contaminant exposure to human populations and, therefore, analyze primarily the fillet tissue (portion most commonly consumed by the general population). States may also conduct chemical analyses of whole fish or specific organs in areas where certain populations such as Native Americans, Southeast Asians, or other ethnic groups consume whole fish or other fish tissues. The use of whole-fish samples can result in higher concentrations of those contaminants (e.g., p,p'-diclorodiphenyltrichloroethane (DDT), PCBs, dioxins and other chlorinated pesticides) that are stored in fatty tissues and lower concentrations of contaminants (e.g., mercury) that accumulate primarily in the muscle tissue. In contrast, the states' practice of typically analyzing fillet samples can result in higher concentrations of those contaminants that tend to concentrate in the muscle tissue and lower concentrations of those contaminants that are typically stored in fatty tissues, which are not included in a fillet sample.
- The NCA analyzes fish from a variety of species from intermediate trophic levels found in estuaries and coastal marine waters; these species are often prey species for many commercially valuable predator species. In addition, the NCA analyzes both juvenile and adult fish. In contrast, state programs typically analyze only the larger marketable-sized specimens (adults) of the fish or shellfish species that are consumed by members of the local population for making fish advisory determinations. These fish species are often predators (e.g., bluefish, striped bass, king mackerel) at the top of the estuarine or coastal food web and are more likely to have bioaccumulated higher concentrations of contaminants than some of the target species sought by the NCA program.

Summary of Differences Between State Fish Consumption Advisory Programs and NCA Fish Sampling Approach

Elements	State Fish Advisory Programs	NCA
Fish species and sizes sampled	Sample marketable-sized adult fish, with a focus on those species consumed by the local fish-eating population.	Samples target species (unique to each geographic region) that includes demersal or slow-moving pelagic species from intermediate trophic levels, including all sizes and ages (juveniles and adults) of fish in an ecosystem.
Type of fish samples analyzed	Analyze primarily fillet tissue samples (edible portion) to assess human health concerns. Analysis of whole-body fish or other tissue types is conducted when the local consumer's culinary preference is to eat whole fish or body parts other than the fillet sample.	Analyzes primarily whole-body samples to assess the health of the ecosystem. Some fish fillet sampling has been conducted and will be conducted in future assessments.
Number and sample types analyzed	Analyze chemical contaminant residues in both individual fish and composite samples of varying numbers of adult fish. The number of fish used per composite is set by the state conducting the analyses.	Typically analyzes chemical contaminant residues in composite samples of fish of the same species. Composite samples may contain 4 to10 juvenile and adult fish.
Contaminants analyzed in tissues	Individual states monitor for any contaminant or suite of contaminants that are of concern to human health in a particular waterbody in their jurisdiction. The extent of analyses is often dependent on available state resources.	Monitors for a specific suite of contaminants at all sites nationally, including the following: • 23 PAH compounds, • 21 PCB congeners, • 6 DDT derivatives and metabolites, • 14 chlorinated pesticides (other than DDT), and • 3 metals (including mercury).
Health benchmark values used	Use EPA-recommended fish consumption advisory values to identify fish species of human-health concern and to develop fish advisories.	Uses EPA-recommended fish consumption advisory values as surrogate values to assess health of the ecosystem in the absence of comprehensive ecological thresholds.

Beach Advisories and Closures

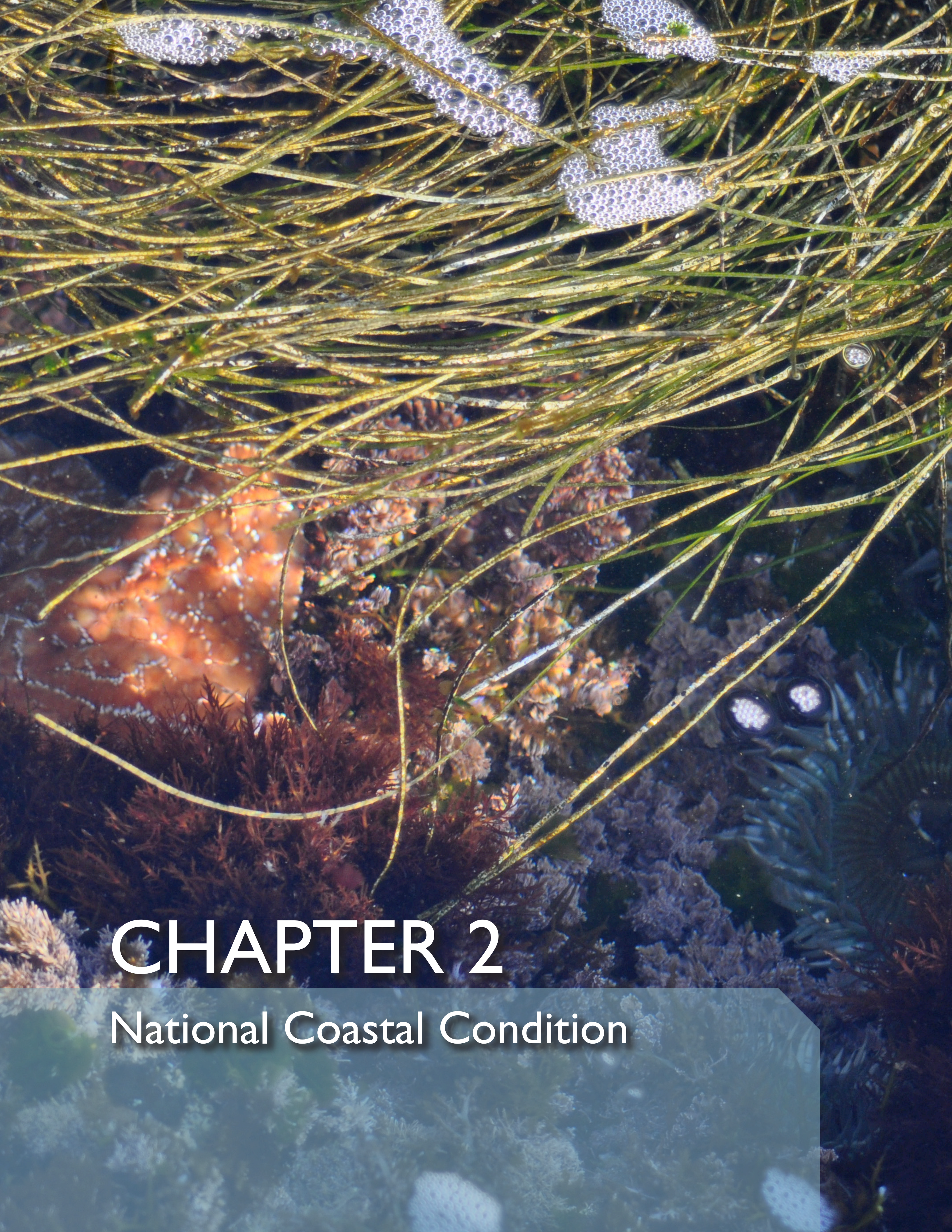
As venues for numerous recreational activities and vacation destinations, beaches provide services that generate vast amounts of revenue for local communities. Therefore, the health of beaches is of paramount importance to the United States. However, there is concern about the risks posed by disease-causing bacteria in recreational waters. As part of its commitment to protect the public at beaches, the EPA established its BEACH Program in 1997, working with state and local governments to monitor and document the condition of the nation's beaches.

From 1997 to 2002, beach monitoring was conducted on a voluntary basis; however, Congress passed the Beaches Environmental Assessment and Coastal Health Act (BEACH Act) of 2000, mandating coastal and Great Lakes states and territories to report to the EPA on beach monitoring and to provide notification data for their coastal recreational waters. Under this Act, the EPA is also required to maintain an electronic monitoring and notification database of state monitoring data. These data include the number, duration, and reasons for notification actions that are issued when bacteria levels at swimming beaches exceed human health exposure standards. It should be noted that notifications often are issued on a precautionary basis and are, therefore, not indicative of an actual contamination event. More information on the BEACH Program and monitoring is available online at http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Due to the changes in monitoring procedures under the BEACH Act, data from 1997 to 2002 are not comparable to the data from 2003 onward. Uniform and consistent reporting procedures for States began in 2004, allowing a degree of inter-annual comparability from 2004 to 2008 (the latest date for which data were available at the time of writing). Therefore, the presentation of BEACH Program information has changed from the NCCR III format. This report presents monitoring efforts and notification actions from 2004 to 2008, where data were available. Any year-to-year comparisons are limited by changes in intra-state monitoring and reporting processes, QA procedures, and state funding to monitoring programs that all affect state reporting of beaches information. The data for 2006 are incomplete; therefore, the reasons for, and duration of, beach advisories are presented for 2007.

For more information you can visit the following Web sites:

- EPA BEACH Program homepage: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm
- BEACH Act: http://www.epa.gov/waterscience/beaches/rules/act.html
- Reference to differences in state reporting beginning in 2003: http://www.epa.gov/waterscience/beaches/seasons/2005/index.html
- National Beach Guidance and Required Performance Criteria for Beach Grants: http://www.epa.gov/waterscience/beaches/grants/guidance/
- Find your beach: http://iaspub.epa.gov/waters10/beacon_national_page.main



CHAPTER 2

National Coastal Condition

2. National Coastal Condition

As shown in Figure 2-1, the overall condition of the nation's coastal waters is rated fair, with an overall condition score of 3.0. The fish tissue contaminants index is rated good to fair, and the water quality, sediment quality, benthic, and coastal habitat indices are all rated fair. Figure 2-2 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on environmental stressor and response data collected between 2003 and 2006 from 3,144 sites in the coastal waters of the coastal states of the conterminous United States; Southeastern Alaska; Hawaii; American Samoa; Guam; Puerto Rico; and the U.S. Virgin Islands (Figure 2-3).

> Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

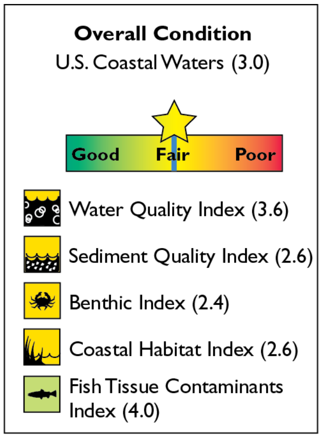


Figure 2-1. The overall condition of U.S. coastal waters is rated fair (U.S. EPA/NCA).

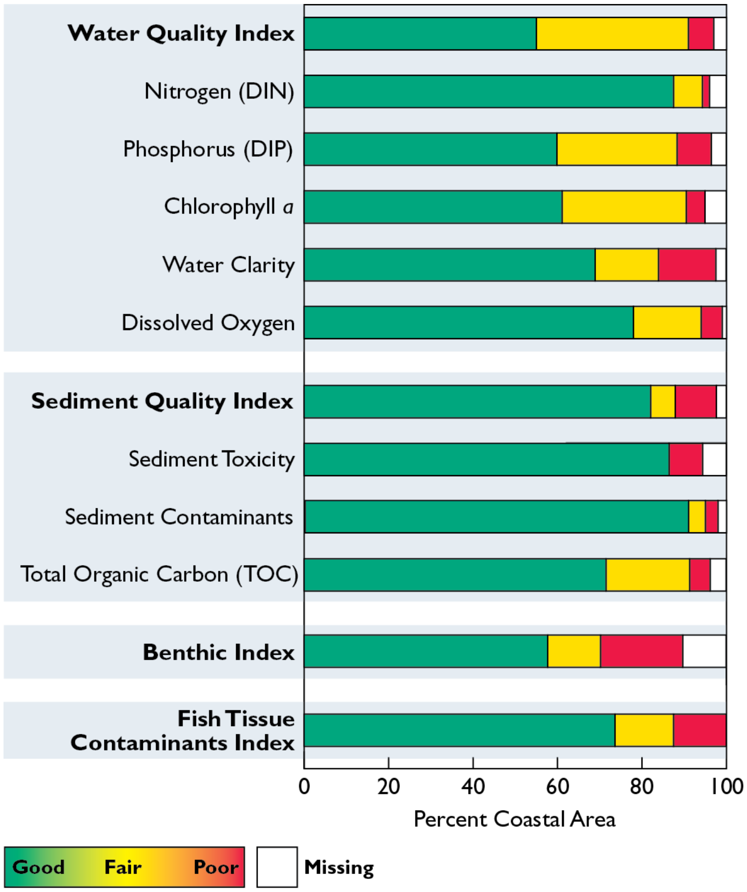


Figure 2-2. Percentage of coastal area achieving each ranking for all indices and component indicators—United States (U.S. EPA/NCA).

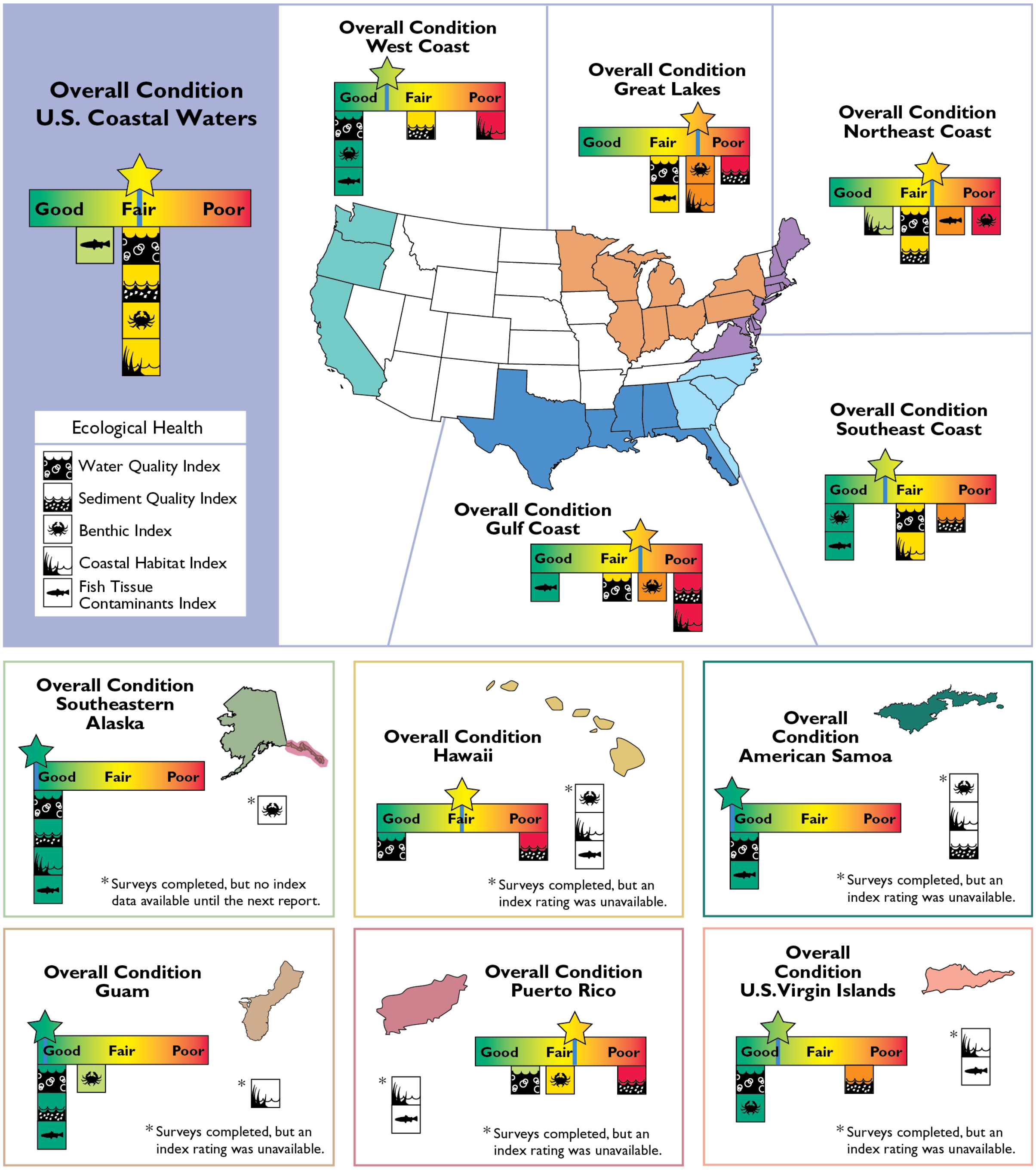
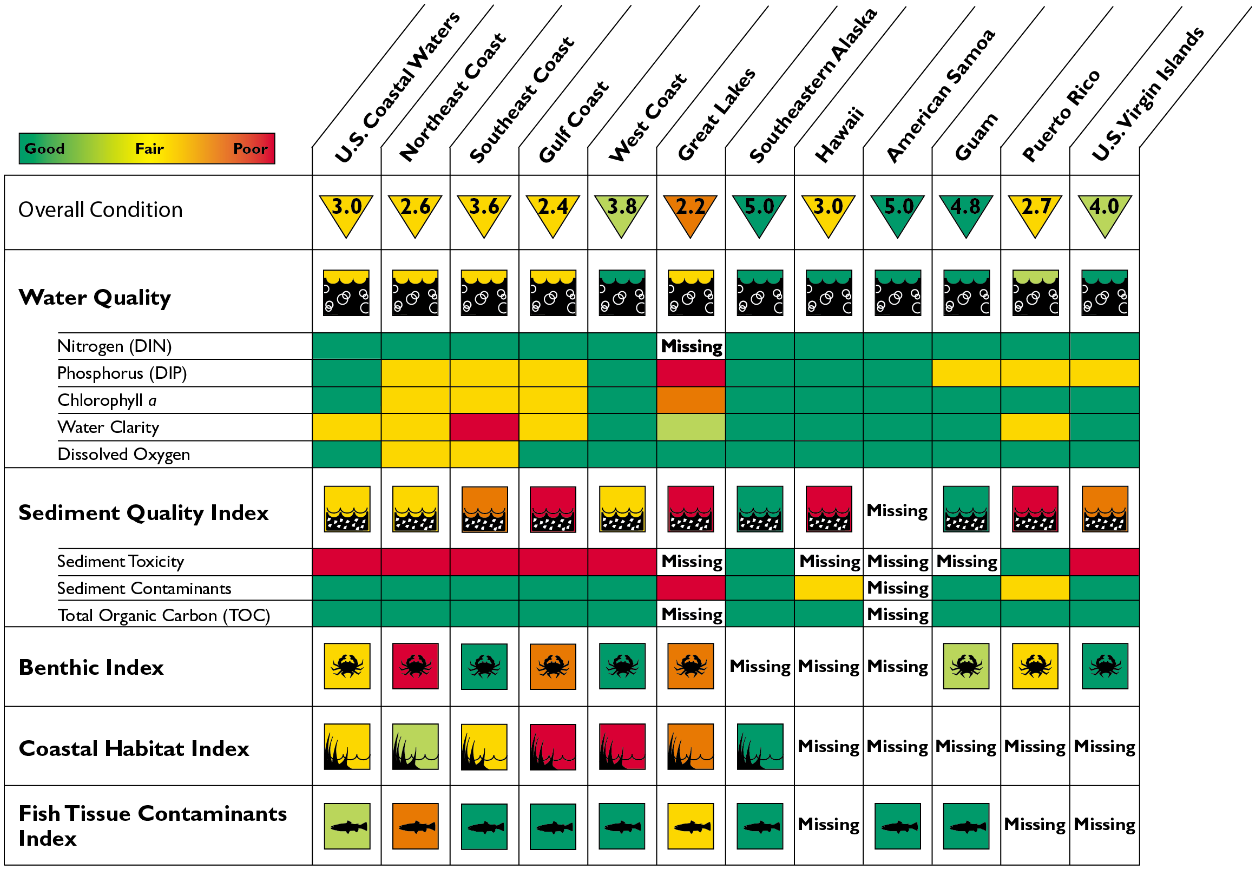


Figure 2-3. Overall national and regional coastal condition based on data collected primarily in 2003 to 2006 (U.S. EPA/NCA).

The condition of U.S. coastal waters was determined for this report by combining assessments from the Northeast Coast, Southeast Coast, Gulf Coast, Great Lakes, and West Coast regions of the conterminous United States with those from Southeastern Alaska, Hawaii, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands (see 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.

Figure 2-4 summarizes the national (including Southeastern Alaska, Hawaii, and the island territories) and regional condition of the nation's coastal waters. The water quality index and its component indicators are predominantly rated fair or good for regions throughout the nation. The water clarity component indicator in the Southeast Coast region and the DIP and chlorophyll *a* indicators in the Great Lakes region are the exceptions. The sediment quality index is rated poor for the Gulf Coast, Puerto Rico, Hawaii, and Great Lakes regions; fair to poor for the Southeast Coast region and the U.S. Virgin Islands; fair for the Northeast and West Coast regions; and good for Southeastern Alaska and Guam. The benthic index shows that biological conditions are rated poor in the coastal waters of the Northeast Coast region; fair to poor in the Gulf Coast and Great Lakes regions; fair in Puerto Rico; good to fair in Guam; and good in the coastal waters of the West Coast and Southeast Coast regions and the U.S. Virgin Islands (benthic condition ratings were not available for Southeastern Alaska, Hawaii, or American Samoa). The fish tissue contaminants index is rated fair to poor for the coastal waters of the Northeast Coast region; fair for the Great Lakes region; and good for the Gulf, West, and Southeast coast regions; Southeastern Alaska; Guam; and American Samoa. Fish tissue contaminants data were not available for Hawaii, Puerto Rico, or the U.S. Virgin Islands.



	U.S. Coastal Waters	Northeast Coast	Southeast Coast	Gulf Coast	West Coast	Great Lakes	Southeastern Alaska	Hawaii	American Samoa	Guam	Puerto Rico	U.S. Virgin Islands
Overall Condition	🟨 3.0	🟨 2.6	🟨 3.6	🟨 2.4	🟢 3.8	🟧 2.2	🟩 5.0	🟨 3.0	🟩 5.0	🟩 4.8	🟨 2.7	🟢 4.0
Water Quality	🟨	🟨	🟨	🟨	🟩	🟨	🟩	🟩	🟩	🟩	🟢	🟩
Nitrogen (DIN)	🟩	🟩	🟩	🟩	🟩	Missing	🟩	🟩	🟩	🟩	🟩	🟩
Phosphorus (DIP)	🟩	🟨	🟨	🟨	🟩	🟥	🟩	🟩	🟩	🟨	🟨	🟨
Chlorophyll *a*	🟩	🟨	🟨	🟨	🟩	🟧	🟩	🟩	🟩	🟩	🟩	🟩
Water Clarity	🟨	🟨	🟥	🟨	🟩	🟢	🟩	🟩	🟩	🟩	🟨	🟩
Dissolved Oxygen	🟩	🟨	🟨	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Sediment Quality Index	🟨	🟨	🟧	🟥	🟨	🟥	🟩	🟥	Missing	🟩	🟥	🟧
Sediment Toxicity	🟥	🟥	🟥	🟥	🟥	Missing	🟩	Missing	Missing	Missing	🟩	🟥
Sediment Contaminants	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟨	Missing	🟩	🟨	🟩
Total Organic Carbon (TOC)	🟩	🟩	🟩	🟩	🟩	Missing	🟩	🟩	Missing	🟩	🟩	🟩
Benthic Index	🟨	🟥	🟩	🟧	🟩	🟧	Missing	Missing	Missing	🟢	🟨	🟩
Coastal Habitat Index	🟨	🟢	🟨	🟥	🟥	🟧	🟩	Missing	Missing	Missing	Missing	Missing
Fish Tissue Contaminants Index	🟢	🟧	🟩	🟩	🟩	🟨	🟩	Missing	🟩	🟩	Missing	Missing

Figure 2-4. Overall national and regional coastal condition, 2003–2006 (U.S. EPA/NCA).

The population of the nation's coastal counties (including island territories) increased by 28 million people between 1980 and 2006 (Figure 2-5), constituting a 27% growth rate. Because the land area of the nation's coastal counties comprises roughly 17% of the U.S. total land area, coastal population increases are frequently accompanied by larger population density increases and greater demands for limited resources. In 2006, the population density in the nation's coastal areas was 182 persons/square mile

(Figure 2-6) compared to a density of 88 persons/square mile for non-coastal areas (NOEP, 2010; U.S. Census Bureau, 2010). Figure 2-6 shows the distribution of the U.S. coastal population in 2006.

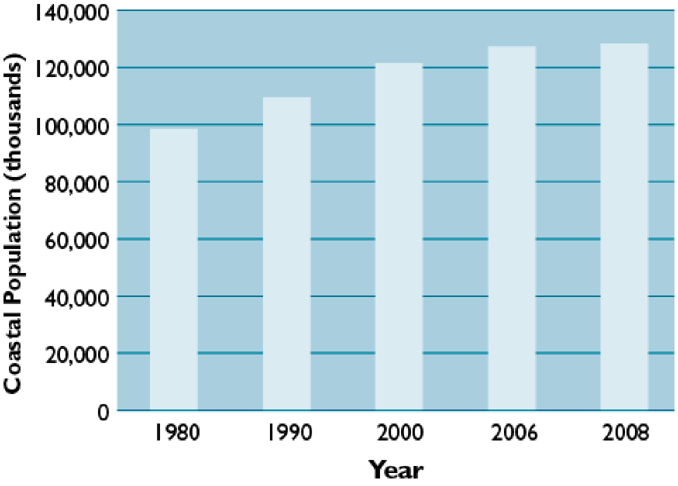


Figure 2-5. Population of U.S. coastal counties and island territories, 1980–2008 (NOEP, 2010).

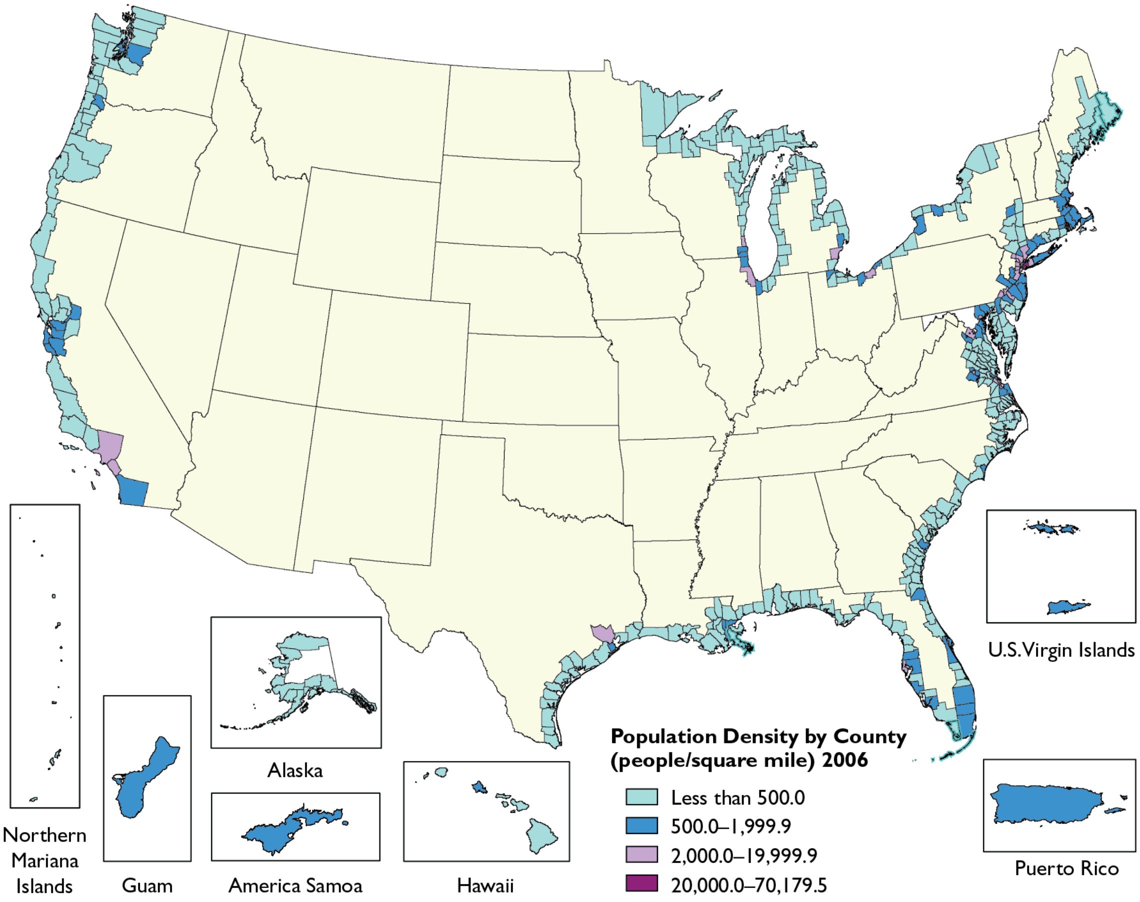


Figure 2-6. Population density in the nation's coastal counties in 2006 (NOEP, 2010; U.S. Census Bureau, 2010).

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 these two types of Great Lakes data are not presented in this section, the Great Lakes regional index and component indicator scores are included in the national scores. Chapter 7 provides further details of the monitoring data for the Great Lakes.

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the United States during a 9- to 12-week period during the summer. Data were not collected during other time periods.

Water Quality Index

The water quality index for the nation's coastal waters is rated fair, with 6% of the coastal area rated poor and 36% 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, 42% of the nation's coastal waters experienced a moderate-to-high degree of water quality degradation and were rated fair or poor. Fair condition was generally characterized by degradation in water quality response variables (i.e., increased chlorophyll *a* concentrations or decreased dissolved oxygen concentrations). Although poor condition may also be characterized by some degradation in response variables, it was more likely to be characterized by degradation due to environmental stressors (e.g., increased nutrient concentrations or reduced water clarity). Although none of the regions outlined in this report were rated poor for water quality, the Southeast Coast had the highest proportion of coastal area rated poor for this index (13%), followed by the Gulf Coast (10%), Puerto Rico (10%), and Northeast Coast (9%) regions. The Southeast Coast region had the lowest proportion of coastal area (22%) rated good for water quality.

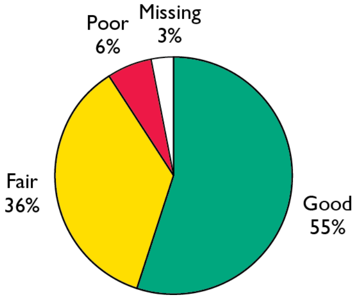


Figure 2-7. Water quality index data for the nation's coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The nation's coastal waters are rated good for DIN concentrations, with only 2% of the coastal area rated poor. The highest percentage of coastal area rated poor for DIN concentrations occurred in the Northeast Coast (5%) region. U.S. coastal waters are rated good for DIP concentrations, with 8% of the coastal area rated poor for this component indicator and 28% of the area rated fair. Elevated DIP concentrations were often observed in the coastal waters of all regions except Southeastern Alaska, Hawaii, American Samoa, and the U.S. Virgin Islands.

Chlorophyll *a*

The nation's coastal waters are rated good for chlorophyll *a* concentrations, with 4% of the coastal area rated poor and 30% of the area rated fair for this component indicator. No regions of the country are rated poor for chlorophyll *a* concentrations. The Southeast, Northeast, and Gulf coast regions had less than 50% of their areas rated good for chlorophyll *a* concentrations and were rated fair. Regions that experienced large expanses of poor condition for chlorophyll *a* concentrations included the Southeast Coast (12%), the Gulf Coast (7%), and Puerto Rico (8%).

Water Clarity

The nation's coastal waters are rated fair for water clarity, with 14% of the U.S. coastal area rated poor for this component indicator. Sites with poor water clarity were distributed throughout the country, but the regions with the greatest proportion of total coastal area rated poor for water clarity were the Gulf Coast (21%) and the Southeast Coast (26%) regions. Three different reference conditions were established for assessing water clarity conditions in U.S. coastal waters (see Chapter 1 for additional information). Table 2-1 shows the cutpoints for rating a site in poor condition for water clarity in estuary systems with differing levels of natural turbidity.

Table 2-1. Regional Guidelines to Determine Poor Water Clarity Condition in Estuaries.

Percentage of Ambient Surface Light That Reaches a Depth of 1 Meter	Coastal Areas
< 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, Laguna Madre); desiring to reestablish SAV (e.g., Tampa Bay); or having tropical waters (Hawaii and the island territories).
< 10%	The remainder of the country.

Dissolved Oxygen

Dissolved oxygen conditions in the nation's coastal waters are rated good, with less than 5% (4.6%) of the coastal area rated poor and 16% rated fair for this component indicator. The Southeast Coast region showed the greatest proportion of coastal area (11%) experiencing low dissolved oxygen concentrations.

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 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 (Paerl et al., 1998: Bergondo et al., 2005; Deacutis, 2006), 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 a score of 2.6 and 10% of the coastal area rated poor for sediment quality (Figure 2-8). The sediment quality index was 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

(20%), followed by the Gulf Coast (19%) and Hawaii (18%) regions. Although there were no areal estimates for poor sediment condition in the Great Lakes region (see Chapter 7 for more information), local, non-probabilistic surveys of that region resulted in a sediment quality index rating of poor. Southeastern Alaska and Guam were the only regions that were rated good for sediment quality.

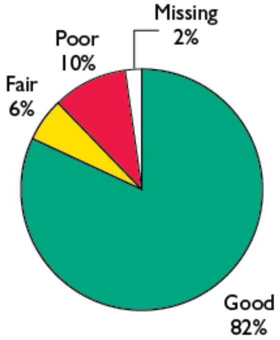


Figure 2-8. Sediment quality index data for the nation's coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The sediment toxicity component indicator for the nation's coastal waters is rated poor, with 8% of the U.S. coastal area rated poor for this component indicator. Sediment toxicity was observed most often in sediments of the West Coast (16%) and Gulf Coast (15%) regions. Sediment toxicity ratings were not available for the Hawaii, Great Lakes, or American Samoa regions. The sediment toxicity assessment for Guam differed from that of other regions (see Chapter 9 for more information) and was not included in the national assessment.

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 4% of the coastal area. The highest proportion of area rated poor for sediment contaminants occurred in Puerto Rico (10%) and Hawaii (6%). 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 5% of the U.S. coastal area rated poor for this component indicator. All regions were rated good for TOC.

Benthic Index

The benthic index for the nation's coastal waters is rated fair, with a score of 2.4 and 19% 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 Northeast Coast (31%), Gulf Coast (20%), and Puerto Rico (16%) regions. The Southeast Coast, West Coast, and U.S. Virgin Islands are the only regions where benthic condition was rated good. Data were unavailable to assess the integrity of the benthic communities in Southeastern Alaska, Hawaii, and American Samoa.

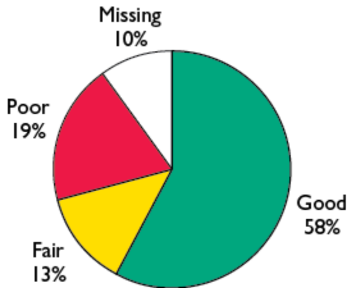


Figure 2-9. Benthic index data for the nation's coastal waters (U.S. EPA/NCA).

Coastal Habitat Index

Coastal habitat condition in the United States was rated fair with a score of 2.6, based on a weighted average of regional scores (including the Great Lakes). The coastal habitat index ratings for most regions outlined in this report are similar to those reported in the NCCR III because more recent data on coastal habitat conditions for all regions were not available for this report. Stedman and Dahl (2008) updated the coastal wetland area estimates for the Atlantic, Gulf, and Great Lakes coasts for 1998 and 2004; however, only the updated estimates for the Gulf Coast could be included in our regional and national assessments of coastal habitats. The estimates from Stedman and Dahl (2008) for the Atlantic Coast were not split into Northeast and Southeast coasts, and the estimates for the Great Lakes included a much larger area than what is considered coastal for the purposes of this report (greater than 8 million acres of freshwater wetlands in coastal watersheds were reported by Stedman and Dahl [2008] while only 535,584 acres of coastal wetlands are reported in Chapter 7). 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 the 1990s to 2000s. Table 2-2 shows the change in wetland acreage from the 1990s to 2000s; the mean long-term, decadal wetland loss rate from 1780 to 1980; and the coastal habitat index value for each region. It is important to note that the mean decadal wetland loss rate is for total areas of all wetlands in coastal states, while the current wetland change rate is for coastal wetlands only (i.e., estuarine intertidal vegetated and non-vegetated wetlands in all regions except for the Great Lakes, where coastal wetlands include fringing freshwater wetlands). The estimates for Alaska represent coastal wetlands for the entire state, not just the Southeast region. Recent coastal wetland loss rates were high in the U.S. Virgin Islands (−8.93%), Gulf Coast (−1.13%), and West Coast (−0.53%). The coastal habitat index was rated poor for the Gulf and West coasts, fair to poor for the Great Lakes, fair for the Southeast Coast, fair to good for the Northeast Coast, and good for Alaska. The coastal habitat rating for the United States was calculated as the average of the regional scores weighted by the current proportion of coastal wetland area in each region.

Table 2-2. Changes in Marine and Estuarine Wetlands, 1780–1990 and 1990–2000 (Dahl, 1990, 2010)

Coastline or Area	Coastal Wetland Areas [a] (acres) Ca. 1990s	Coastal Wetland Areas [a] (acres) Ca. 2000s	Coastal Wetland Area Change (acres - %) Ca. 1990s–2000s	Mean Decadal Loss Rate Area Loss Rate [b] Ca. 1780s–1990s	Index Value
Northeast Coast [c]	452,310	451,660	-650 (0.14%)	-1.95%	1.05
Southeast Coast [c]	1,107,370	1,105,170	-2,200 (-0.20%)	-2.00%	1.10
Gulf Coast [d]	3,519,570	3,479,650	-39,920 (-1.13%)	-2.50%	1.82

(continued)

Table 2-2. Changes in Marine and Estuarine Wetlands, 1780–1990 and 1990–2000 (Dahl, 1990, 2010) (continued)

Coastline or Area	Coastal Wetland Areas [a] (acres) Ca. 1990s	Coastal Wetland Areas [a] (acres) Ca. 2000s	Coastal Wetland Area Change (acres - %) Ca. 1990s–2000s	Mean Decadal Loss Rate Area Loss Rate [b] Ca. 1780s–1990s	Index Value
West Coast [c]	320,220	318,510	-1,710 (-0.53%)	-3.40%	1.97
Great Lakes [e]	535,584	No change	N/A	-2.55%	N/A
Alaska [c]	2,132,900	2,132,000	-900 (-0.04%)	-0.01%	0.03
Hawaii [e]	31,150	No change	N/A	-0.60%	N/A
Puerto Rico [e]	17,300	No change	N/A	N/A	N/A
U.S. Virgin Islands [f]	1,131	1,030	-101 (-8.93%)	N/A	N/A

[a] Coastal wetlands include estuarine intertidal wetlands (sum of estuarine non-vegetated and vegetated wetlands) for all regions except the Great Lakes (which include all freshwater coastal wetlands).

[b] Calculated as the proportion of total wetland acres existing in the 1780s that were lost by the 1980s (Dahl, 1990) divided by 20 (number of decades, 1780 to 1980).

[c] Coastal wetland area estimates for the Northeast, Southeast, and West coasts and Alaska are for 1990 and 2000 (Dahl, 2010). The estimates for Alaska are for the entire state.

[d] Coastal wetland area estimates for the Gulf Coast are for 1998 and 2004 (Stedman and Dahl, 2008)

[e] Coastal wetland area estimates for the Great Lakes, Hawaii, and Puerto Rico represent current status for total wetlands; no change estimates were available (Dahl, 2010)

[f] Coastal wetland area estimates for the U.S. Virgin Islands are for 1990 and 2005 (Dahl, 2010)

The coastal habitat index value is the average of the mean long-term decadal loss rate of coastal wetlands (1780–1980) and the present decadal loss rate of coastal wetlands (1990–2000).

Fish Tissue Contaminants Index

The fish tissue contaminants index for the nation’s coastal waters is rated good to fair. Figure 2-10 shows that 13% of all stations where fish were caught demonstrated contaminant concentrations in fish tissues above EPA Advisory Guidance values and were rated poor. The NCA examined whole-body composite samples, as well as fillets (typically 4 to 10 fish of a target species per station), for specific contaminants from 1,623 stations throughout the coastal waters of the United States (excluding Hawaii, Puerto Rico, and the U.S. Virgin Islands). Stations in poor and fair condition were dominated by samples with elevated concentrations of total PCBs, total DDT, total PAHs, and mercury. In the Northeast Coast region, 20% of the stations where fish were caught were rated poor for fish tissue contaminant levels, and 20% were rated fair. All other regions except the Great Lakes received good ratings for the fish tissue contaminants index. Tissue contaminants data were not available for Hawaii, Puerto Rico, or the U.S. Virgin Islands.

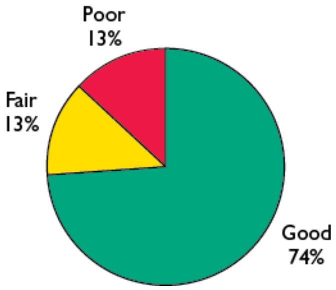


Figure 2-10. Fish tissue contaminants index data for the nation’s coastal waters (U.S. EPA/NCA).

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 (Figure 2-11) were first surveyed concurrently. Annual surveys of coastal condition were conducted in the Virginian Province from 1990 through 1993 and 1997 through 1998; in the Louisianian Province from 1991 through 1994; in the Carolinian Province from 1995 through 1997; and in the West Indian Province in 1995. Beginning in 2000, the coastal waters of all regions of the United States (exclusive of the Great Lakes, Alaska, Hawaii, and the island territories) have been surveyed and assessed annually. In 2001, the NCCR I was produced and included information for the period 1990 through 1996 from the Virginian, Carolinian, West Indian, and Louisianian provinces (the Acadian, Californian, and Columbian provinces; island territories; Alaska; and Hawaii were largely excluded from this report). In 2004, the NCCR II included an assessment of all of the coastal ecosystems in the conterminous United States and Puerto Rico for the period 1997 through 2000. The NCCR III provided an assessment of the entire continental United States, including Southcentral Alaska, Hawaii, and Puerto Rico, for the years 2001 and 2002. This NCCR IV provides an assessment of the entire continental United States, including Southeastern Alaska, Hawaii, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands, for the years 2003 to 2006.

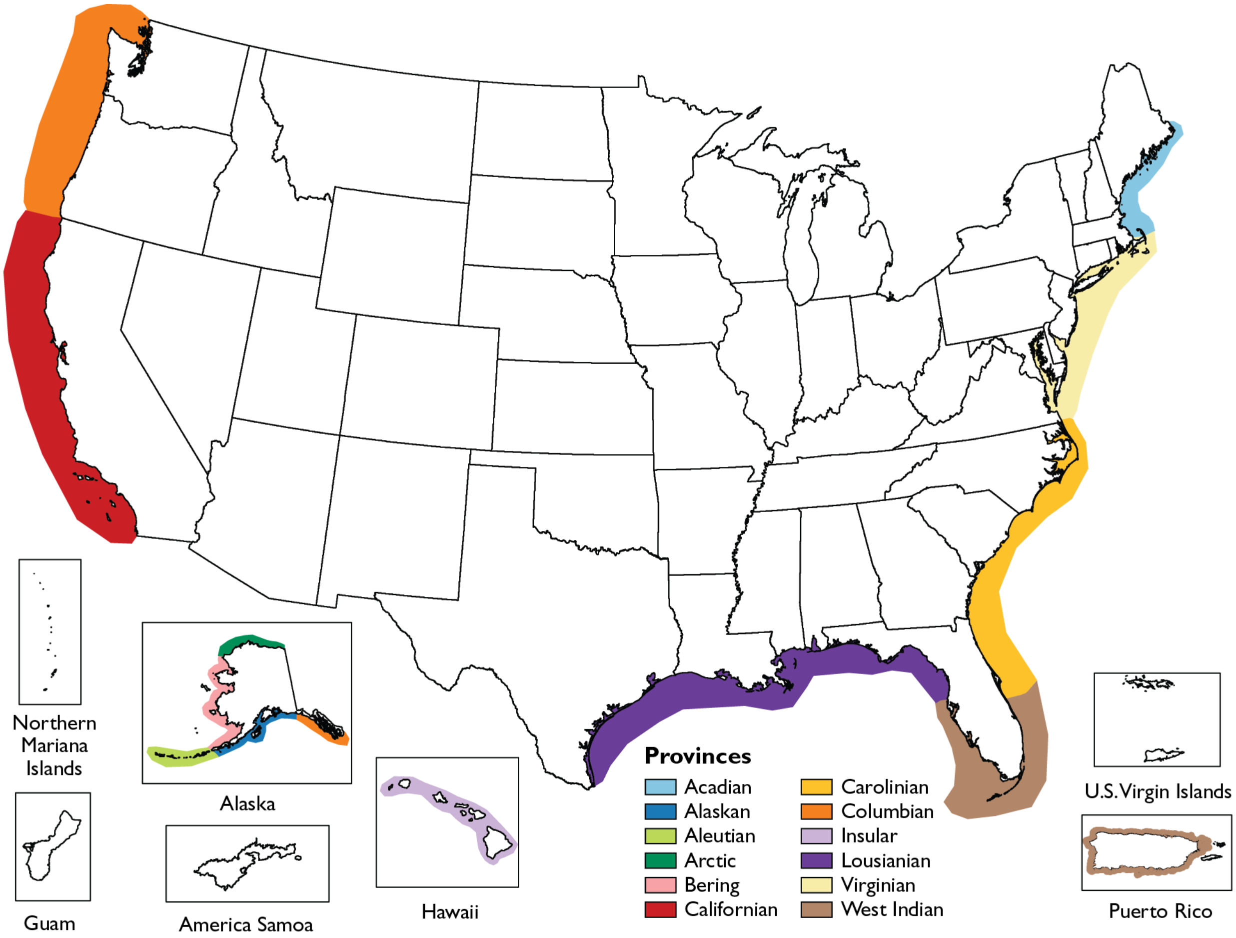


Figure 2-11. EMAP coastal marine provinces (U.S. EPA).

A traditional trend analysis cannot be performed on the data presented in the NCCR series because the underlying population (i.e., the coastal resources included in the survey) has changed for each assessment; however, estimates have been made for the overall condition of U.S. coastal waters in each assessment. If it is assumed 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 2-3 shows the primary index and overall condition scores from the four NCCRs for each region and for the nation (including Alaska, Hawaii, and the island territories, which were included in the past two reports [NCCR II and NCCR III]).

Table 2-3. Rating Scores[a] by Index and Region Comparing the NCCR I[b], NCCR II, NCCR III[c], and NCCR IV

Region/NCCR Version		Water Quality Index	Sediment Quality Index	Coastal Habitat Index	Benthic Index	Fish Tissue Contaminants Index	Overall Condition
Northeast Coast	NCCR I	1	2	3	1	2	1.8
	NCCR II	2	1	4	1	1	1.8
	NCRR III	3	2	4	1	1	2.2
	NCCR IV	3	3	4	1	2	2.6
Southeast Coast	NCCR I	4	4	2	3	5	3.6
	NCCR II	4	4	3	3	5	3.8
	NCCR III	3	3	3	5	4	3.6
	NCCR IV	3	2	3	5	5	3.6
Gulf Coast	NCCR I	1	3	1	1	3	1.8
	NCCR II	3	3	1	2	3	2.4
	NCCR III	3	1	1	1	5	2.2
	NCCR IV	3	1	1	2	5	2.4
West Coast	NCCR I	1	2	1	3	3	2.0
	NCCR II	3	2	1	3	1	2.0
	NCCR III	5	2	1	5	1	2.8
	NCCR IV	5	3	1	5	5	3.8
Great Lakes	NCCR I	1	1	1	1	3	1.4
	NCCR II	3	1	2	2	3	2.2
	NCCR III	3	1	2	2	3	2.2
	NCCR IV	3	1	2	2	3	2.2
Alaska[d]	NCCR I	—	—	—	—	—	—
	NCCR II	—	—	—	—	—	—
Southcentral	NCCR III	5	5	—	—	5	5.0
Southeast	NCCR IV	5	5	5	—	5	5.0
Hawaii[d]	NCCR I	—	—	—	—	—	—
	NCCR II	—	—	—	—	—	—
	NCCR III	5	4	—	—	—	4.5
	NCCR IV	5	1	—	—	—	3.0
American Samoa[d]	NCCR IV	5	—	—	—	5	5.0
Guam[d]	NCCR IV	5	5	—	4	5	4.8
Puerto Rico[d]	NCCR I	—	—	—	—	—	—
	NCCR II	3	1	—	1	—	1.7
	NCCR III	3	1	—	1	—	1.7
	NCCR IV	4	1	—	3	—	2.7
U.S. Virgin Islands[d]	NCCR IV	5	2	—	5	—	4.0

(continued)

Table 2-3. Rating Scores[a] by Index and Region Comparing the NCCR I[b], NCCR II, NCCR III[c], and NCCR IV (continued)

Region/NCCR Version		Water Quality Index	Sediment Quality Index	Coastal Habitat Index	Benthic Index	Fish Tissue Contaminants Index	Overall Condition
United States[e]	NCCR I	1.5	2.3	1.6	1.5	3.1	2.0
	NCCR II	3.2	2.1	1.7	2.0	2.7	2.3
	NCCR III	3.8	2.8	1.7	2.1	3.7	2.8
	NCCR IV	3.6	2.6	2.6	2.4	4.0	3.0

[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 2.4 is rated fair to poor; 2.4 to less than 3.7 is rated fair; 3.7 to 4.0 is rated good to fair; and greater than 4.0 is rated good.

[b] AK and HI were not reported in the NCCR I or NCCR II. The NCCR I assessment of the Northeast Coast region did not include the Acadian Province. The West Coast ratings in the NCCR I were compiled using data from many different programs.

[c] The West Coast, Great Lakes, and Puerto Rico scores for the NCCR III are the same as NCCR II (no new data for the NCCR III except for the West Coast benthic index).

[d] Overall condition scores for Alaska, Hawaii, Puerto Rico, and the island territories were based on two to three of the five NCA indices.

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

The area covered by the NCA has expanded over time with the addition of Alaska, Hawaii, and the island territories. The southcentral and southeastern regions of Alaska included in the NCCR III and NCCR IV assessments had good water quality and large coastal areas, which would influence the national water quality index scores. (Hawaii and the island territories were also included, but their collective coastal areas were less than 1% of the total U.S. area, so their influence on the national scores was negligible.) We have assessed the changes in national coastal condition over time for both the conterminous United States and for the entire coastal United States, including Alaska, Hawaii, and the island territories. Excluding Alaska, Hawaii, and the island territories, the water quality index score for the NCCR III and IV would be 3.2 (rated fair), which is the same as the score for the NCCR II water quality index (Table 2-4). Although the water quality index score increased from 1.5 (rated poor) in the NCCR I to 3.2 (rated fair) in the NCCR II, this increase is likely due a change in methods between these two assessments. The water quality assessment method used in the NCCR I was largely reliant on professional judgment for assessing eutrophication, rather than on the direct field survey measurements used in subsequent NCCRs (U.S. EPA, 2008c). Therefore, if the NCCR I is excluded, this trend assessment demonstrates there has been no significant change in the water quality of U.S. coastal waters since the publication of the NCCR II. If Alaska, Hawaii, and the island territories are included, however, the water quality index score for U.S. coastal waters shows a slight increase from 3.2 (rated fair) in the NCCR II to 3.6 (rated fair) in the NCCR IV (Table 2-5).

Table 2-4. U.S. Index Rating Scores for the NCCR I (1990–1995), NCCR II (1996–2000), NCCR III (2001–2002), and NCCR IV (2003–2006) National Coastal Condition Assessments Without Alaska, Hawaii, Guam, American Samoa, or the U.S. Virgin Islands.

Category	NCCR I	NCCR II	NCCR III[a]	NCCR IV[b]
Water Quality Index	1.5	3.2	3.2	3.2
Sediment Quality Index	2.3	2.1	1.6	1.8
Coastal Habitat Index	1.6	1.7	1.7	1.7
Benthic Index	1.5	2.0	2.1	2.4
Fish Tissue Contaminants Index	3.1	2.7	2.9	3.7
Overall Condition	2.0	2.3	2.3	2.5

[a] NCCR III scores, excluding Alaska and Hawaii. Please note that Guam, American Samoa, and U.S. Virgin Islands were not assessed as part of NCCR III; therefore, no data are available for these areas.

[b] NCCR IV scores, excluding Alaska, Hawaii, Guam, American Samoa, and U.S. Virgin Islands.

Table 2-5. U.S. Index Rating Scores for the NCCR III (2001–2002) and NCCR IV (2003–2006) National Coastal Condition Assessments With Alaska, Hawaii, Guam, American Samoa, and the U.S. Virgin Islands.

Category	NCCR III[a]	NCCR IV[b]
Water Quality Index	3.8	3.6
Sediment Quality Index	2.8	2.6
Coastal Habitat Index	1.7	2.6
Benthic Index	2.1	2.4
Fish Tissue Contaminants Index	3.7	4.0
Overall Condition	2.8	3.0

[a] NCCR III scores, including Alaska and Hawaii (except for coastal habitat index). Please note that Guam, American Samoa, and U.S. Virgin Islands were not assessed as part of NCCR III; therefore, no data are available for these areas.

[b] NCCR IV scores, including Alaska, Hawaii, Guam, American Samoa, and U.S. Virgin Islands.

If Alaska (and Hawaii and the island territories) were excluded from the NCCR III and NCCR IV national scores, the sediment quality scores would be 1.6 (rated poor) for the NCCR III and 1.8 (rated poor) for the NCCR IV (see Table 2-4). Excluding Alaska from the sediment quality scores would result in a decrease in the sediment quality index score from 2.3 (rated fair to poor) in the NCCR I to 1.8 (rated poor) in the NCCR IV, which could be interpreted as a degradation in national sediment quality over time. Including Alaska, Hawaii, and the island territories, however, shows a slight increase in the sediment quality index score from 2.3 (rated fair) in the NCCR I to 2.6 (rated fair) in the NCCR IV (Table 2-5). Although this may appear to demonstrate a slight improvement in sediment quality over time, the scores are not significantly different, and the sediment quality index is rated fair in each report.

Without the addition of new information for Alaska, the coastal habitat index score has not changed since the NCCR II (Table 2-4). Some new information was also available to assess coastal habitat changes in the Gulf Coast (Stedman and Dahl, 2008) and the U.S. Virgin Islands; however, the new information did not impact the national index score, and the scores presented in this report are similar to those presented in the NCCR III. Some regional improvements in the coastal habitat index rating occurred in the Northeast Coast region between the NCCR I (rated fair) and the NCCR II (rated good to fair); however, the regions with most of the wetland acreage in the United States (Gulf Coast, Southeast Coast, and Great Lakes) showed little or no change in their index ratings over this time period. With the inclusion of coastal habitat data for Alaska, the national coastal habitat index assessment increased from 1.7 (rated poor) in the NCCR II to 2.6 (rated fair) in the NCCR IV (Table 2-5).

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 national benthic index score has steadily increased over time from 1.5 (rated poor) in the NCCR I to 2.4 (rated fair) in the NCCR IV. Unlike the water quality and sediment quality index scores, this increase in score is not unduly influenced by Alaska, as benthic condition data were not available for the Alaska region. This assessment demonstrates a positive change in the benthic condition of U.S. coastal waters since the publication of the NCCR I.

The fish tissue contaminants index shows an increase from the NCCR I (3.1; rated fair) to the NCCR IV (4.0; rated good to fair) (Table 2-4). If the NCCR III and NCCR IV national scores were recalculated without Alaska, Hawaii, and the island territories, the fish tissue contaminants scores would be 2.9 (rated fair) in the NCCR III and 3.7 (rated good to fair) in the NCCR IV (Table 2-5). In the NCCR I, fish tissue contaminant concentrations were measured only in edible fillets, whereas in both the NCCR II and NCCR III, only whole-body samples were analyzed. In the NCCR IV, both fish fillets and whole-body concentrations were measured. Because fillet and whole-body tissues have different absorption rates for contaminants, the inclusion of both types of samples in this assessment could impact the interpretation of results. Currently, however, it is not possible to adjust the NCCR assessments to either fillet or whole-body concentrations and scores. In addition, other changes in geographic coverage may have resulted in the apparent increase in the fish tissue contaminants score over time (e.g., changes in survey design in the West Coast to exclude the riverine portion of the Columbia River; lack of data from Massachusetts in the Northeast Coast; lack of data from the northern Gulf of Mexico due to the impacts of Hurricane Katrina).At present, a reasonable interpretation of the assessments is that there has been a small improvement in contaminant levels in fish tissue in U.S. coastal waters, with the national fish tissue contaminant index rated fair for the first three NCCRs and fair to good in this report.

Coastal Ocean Condition—Continental United States

Since 2003, a series of offshore studies have been conducted to assess the status of ecological condition and potential stressor impacts throughout various coastal-ocean (shelf) regions of the United States (Figure 2-12). These survey areas cover four of the U.S. LMEs: California Current, the Northeastern U.S. Continental Shelf, the Southeastern U.S. Continental Shelf, and the Gulf of Mexico. They also coincide with various regional planning areas of the *Interim Framework for Effective Coastal and Marine Spatial Planning* (CMSP Interim Handbook), developed recently by the Interagency Ocean Policy Task Force (2009). Sampling sites are also included within marine protected areas, such as NOAA's National Marine Sanctuaries (NMSs). Data from these studies were available for inclusion in the present NCCR for three of the survey areas: the western U.S. continental shelf (survey conducted June 2003), the South Atlantic Bight (survey conducted March–April 2004), and the Mid-Atlantic Bight (survey conducted May 2006).

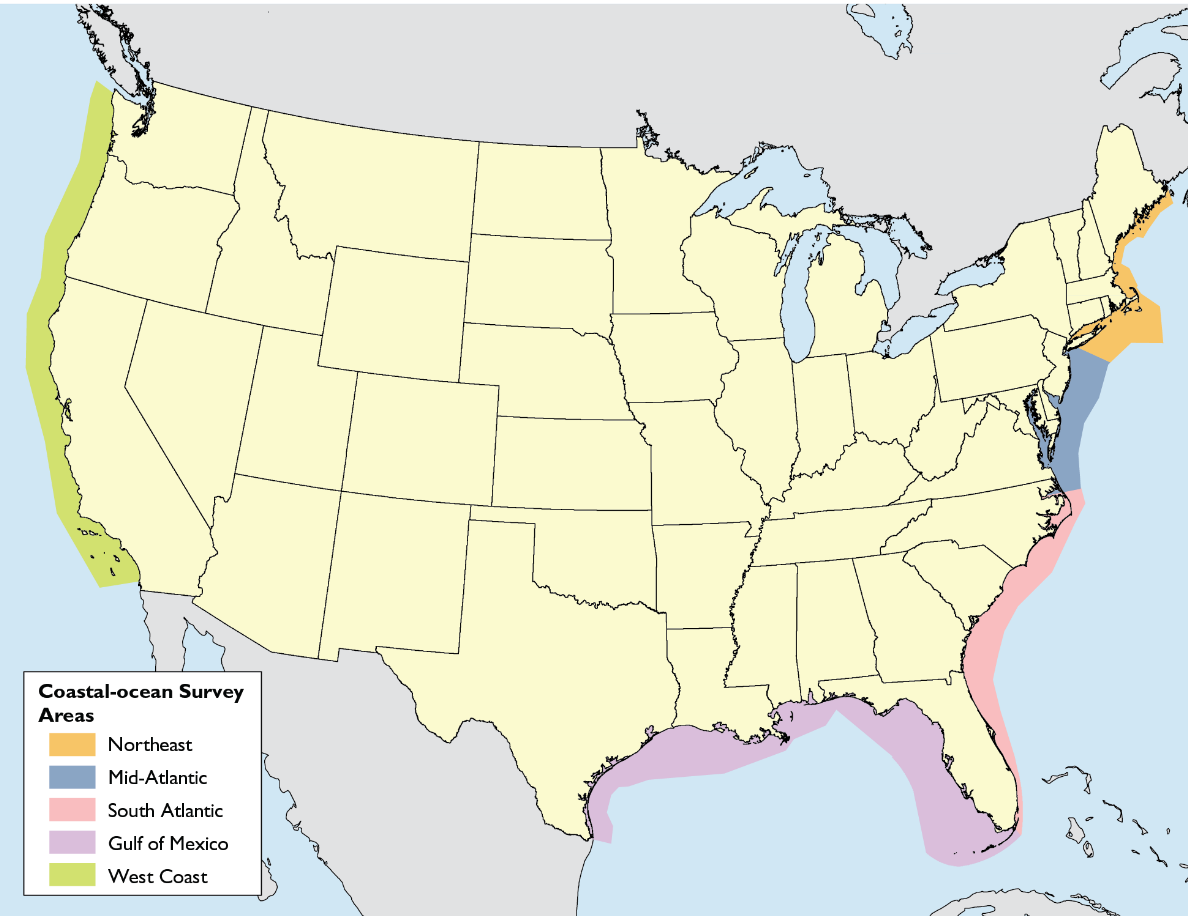


Figure 2-12. Coastal-ocean survey areas.

The studies have applied EMAP/NCA methodologies and indicators, including probabilistic sampling designs and multiple measures of water quality, sediment quality, benthic condition, and fish tissue contamination. Although ratings of good, fair, and poor for many of these indicators could not be assigned to the study areas due to the lack of appropriate cutpoints for offshore waters, results of the various measurements nonetheless provide valuable information on the status and patterns of key ecological characteristics and a quantitative baseline for evaluating future changes due to natural or human-induced disturbances. Because the protocols and indicators are consistent with those used in previous EMAP/NCA surveys, the studies also provide a basis for making comparisons between conditions in offshore waters and those observed in neighboring coastal waters, thus providing a more holistic account of ecological conditions and processes throughout the inshore and offshore resources of the respective regions. In addition, for some indicators (e.g., levels of chemical contaminants and TOC in sediments, dissolved oxygen levels in the water column, human health-risk guidelines for chemical contaminants in fish), cutpoints established previously for coastal waters could be used as reasonable surrogate guidelines for evaluating the ecological status of coastal-ocean waters.

In general, the coastal-ocean waters were much less impacted by human influence than neighboring coastal waters. With some exceptions, conditions for most indicators were above NCA cutpoints for good ratings throughout the majority of the coastal-ocean survey areas (Figure 2-13).

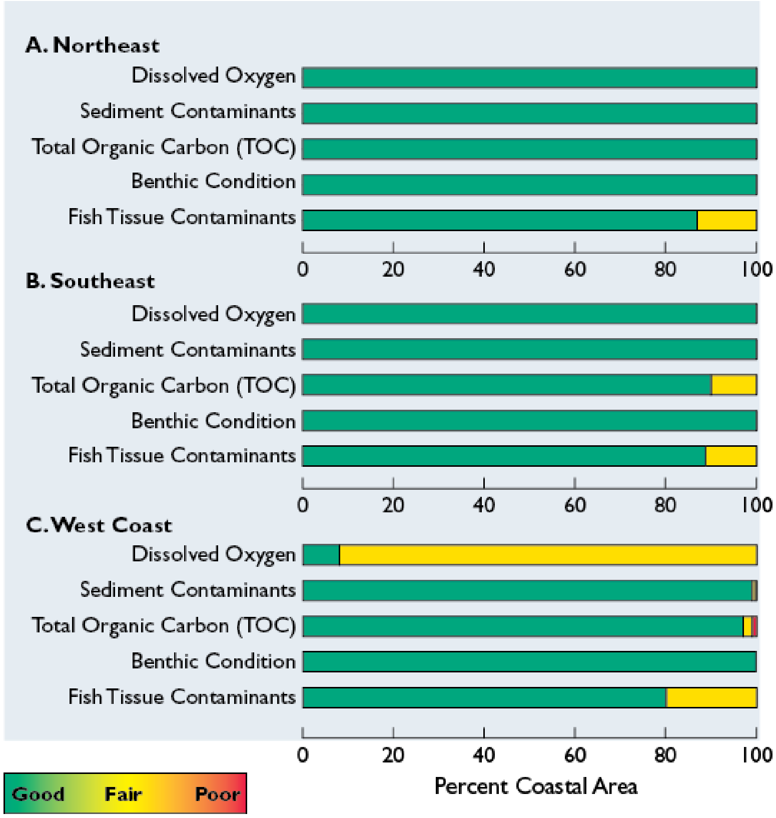


Figure 2-13. Summarized assessment of multiple indices and indicators of ecosystem health for Southeast Coast (A), Northeast Coast (B), and West Coast (C) offshore survey areas.

Note: Refer to corresponding chapters for indicator cutpoints.
Note: There were no benthic indices for region-wide applications in offshore waters; thus, the evaluation of benthic condition was based on co-occurrences of reduced values of key benthic attributes and evidence of poor sediment or water quality. Tissue assessments are based on the percent of stations where fish were caught.

In the 2006 Mid-Atlantic Bight assessment, there were no major indications of poor sediment or water quality at any of the 49 sampling sites. The dissolved oxygen, sediment contaminants, and sediment TOC component indicators were rated good in 100% of the coastal-ocean survey area, based on the NCA cutpoints. Three of the stations where fish were caught were rated fair based on concentrations of methylmercury and/or PCBs in fish tissue; however, none of the stations were rated poor. An analysis of potential biological impacts (see text box titled *Evaluating Offshore Benthic Condition*) revealed no major evidence of an impaired benthos linked to measured stressors and 100% of the survey area was rated as having good benthic condition. In addition, no non-indigenous species were observed in any of the offshore benthic samples, though two species (oligochaete *Branchiura sowerbyi* and clam *Corbicula fluminea*) were observed in corresponding northeastern estuaries sampled as part of NCA efforts in 2003–2006, and offshore occurrences of such species have been documented in the literature (e.g., reports of the non-indigenous tunicate *Didemnum* sp. colonizing portions of the shelf off New England and northern mid-Atlantic Bight [Cohen, 2005; Kott, 2004]).

Similarly, the 2004 South Atlantic Bight offshore assessment (50 sampling sites) showed no major evidence of poor sediment or water quality. The dissolved oxygen and sediment contaminants component indicators were rated good in 100% of the survey area, based on the NCA cutpoints. The majority (90%) of the area was rated good for sediment TOC, with the remaining 10% rated fair. The fish tissue contaminants index was rated fair at two of the stations where fish were caught based on concentrations of methylmercury in fish tissue; however, none of the sites were rated poor. Benthic condition was rated good in 100% of the survey area. In addition, no non-indigenous species appeared in any of the offshore benthic samples. Three species—*Corbicula fluminea* (Asian clam), *Petrolisthes armatus* (green porcelain crab), and *Rangia cuneata* (Atlantic rangia)—were found in corresponding southeastern estuarine samples collected during NCA 2000–2004 surveys, and there have been increasing reports in the literature of other non-indigenous species, such as the lionfish *Pterois sp.* invading offshore waters along the southeastern United States (Hare and Whitfield, 2003).

The 2003 West Coast offshore assessment (257 sampling sites) also showed no major evidence of poor water quality, and there were indications of poor sediment quality only in limited areas. The dissolved oxygen component indicator was rated fair in 92% of the survey area, with the remaining area rated good. The majority of the survey area (97%) was rated good for sediment TOC, with 2% of the area rated fair and less than 1% rated poor. For the sediment contaminants indicator, 99% of the survey area was rated good, less than 1% was rated fair, and less than 1% was rated poor. None of the 50 stations where fish were caught were rated poor, although 10 stations were rated fair based on concentrations of cadmium total PCBs in fish tissue. Benthic condition was rated good in slightly under 100% of the area, reflecting limited evidence of an impaired benthos linked to poor sediment or water quality. There was only one station off Los Angeles, representing 0.02% of the survey area, where low benthic species richness and abundance were accompanied by high sediment contamination. In addition, 13 non-indigenous species, represented mostly by spionid polychaetes and the ampharetid polychaete *Anobothrus gracilis* were observed in offshore benthic samples, though in limited numbers (1.2% of the identified species) and were less common than in corresponding West Coast coastal waters.

NOAA's five NMSs along the West Coast also appeared to be in good ecological condition, based on the measured indices and component indicators, with no evidence of major anthropogenic impacts or unusual environmental qualities compared to nearby non-sanctuary waters. Benthic communities in sanctuaries resembled those in corresponding non-sanctuary waters, with similarly high levels of species richness and diversity and low incidence of non-indigenous species. Most oceanographic features were also similar between sanctuary and non-sanctuary locations. Exceptions (e.g., higher concentrations of some nutrients in sanctuaries along the California coast) appeared to be attributable to natural upwelling events in the area at the time of sampling. In addition, sediments within the sanctuaries were relatively uncontaminated, with none of the samples having any measured chemical in excess of corresponding ERM values (although there were some cases where chemicals exceeded ERL values).

The lack of concordance between reduced benthic attributes and measures of poor sediment or water quality suggest that all three coastal-ocean assessment regions were in generally good condition biologically, with lower-end values of biological attributes representing parts of a normal reference range controlled by natural factors. Alternatively, it is possible that for some of these coastal-ocean sites, the lower values of benthic variables reflect symptoms of disturbance induced by other unmeasured stressors. In an effort to be consistent with the underlying concepts and protocols of earlier EMAP and NCA efforts, the indicators in this study included measures of stressors, such as chemical contaminants and symptoms of eutrophication, which often are associated with adverse biological impacts in shallower estuarine and inland ecosystems. However, there may be other sources of human-induced stress in these offshore systems, particularly those causing physical disruption of the seafloor (e.g., commercial bottom trawling, cable placement, minerals extraction) that pose greater risks to living resources and that have not been captured adequately. Future monitoring efforts in these offshore areas should include indicators of such alternative sources of disturbance.

Evaluating Offshore Benthic Condition

Multi-metric benthic indices are often used as indicators of pollution-induced degradation of the benthos (see review by Diaz et al., 2004). An important feature is the ability to combine multiple biological attributes into a single measure that maximizes the ability to distinguish between degraded vs. non-degraded benthic condition, while accounting for the influence of natural controlling factors. Although a related index has been developed for the southern California mainland shelf (Smith et al., 2001) and several estuarine regions (e.g., Weisberg et al., 1997; Llansó et al., 2002a and 2002b for mid-Atlantic states and Chesapeake Bay; Van Dolah et al., 1999 for southeastern estuaries), there is currently no such index available for region-wide applications in any of the three offshore survey areas. In the absence of a benthic index, efforts were made to assess potential stressor impacts on the benthos by looking for co-occurrences of reduced values of key biological attributes (numbers of taxa, diversity, and abundance) and synoptically measured indicators of poor sediment or water quality. Low values of species richness, H′, and density were defined for the purpose of this analysis as the lower 10th percentile of observed values within a region. Evidence of poor sediment or water quality was defined as less than or equal to 1 chemical in excess of corresponding ERMs; TOC greater than 5%; or dissolved oxygen in near-bottom waters < 2 mg/L (based on estuarine evaluation guidelines).

Large Marine Ecosystem Fisheries

LMEs are defined as large regions, on the order of 77,000 square miles or greater, extending from river basins and estuaries to continental shelf margins and the outer edges of major current systems. LMEs have distinct bathymetry, hydrography, productivity, and trophically linked populations. Sixty-four LMEs have been defined globally, which account for about 80% of global fisheries production. The assessment and management of LMEs is based on five modules: 1) productivity, 2) fish and fisheries, 3) pollution and ecosystem health, 4) socioeconomics, and 5) governance.

Eleven LMEs are found in the waters bordering U.S. states and island territories around the world (Figure 2-14). The climates of these LMEs vary from arctic to tropical, and their productivities range from low to high, based on global estimates of primary production (i.e., phytoplankton). Some of these LMEs (i.e., the Northeast U.S. Continental Shelf, Caribbean Sea, Gulf of Mexico, California Current, Gulf of Alaska, Chukchi Sea, West Bering Sea, and Beaufort Sea LMEs) border multiple countries. As a result, information about fishery stocks in some of the LMEs (e.g., the Caribbean Sea, Chukchi Sea, West Bering Sea, Beaufort Sea LMEs) is incomplete. In addition, several of the U.S. island territories in the Pacific Ocean are not located within an LME. The fisheries in the waters surrounding these territories are managed on a regional level, with the Insular Pacific-Hawaiian LME as the NMFS Western Pacific Region.

Figure 2-14. U.S. states and island territories are bordered by 11 LMEs (NOAA, 2007a).

The nation's interests in the ocean and our coasts support a growing number of significant and often competing uses and activities, including commercial, recreational, cultural, energy, scientific, conservation, and homeland and national security activities. Combined, these activities profoundly influence and benefit coastal, regional, and national economies and cultures. Human uses of the ocean and coasts are expanding at a rate that challenges our ability to plan and manage them under the current sector-by-sector approach.

As mentioned previously in this chapter, in 2009, the White House Council of Environmental Quality established the priority objectives of the CMSP Interim Handbook (*Interim Framework for Effective Coastal and Marine Spatial Planning*). The framework articulates national goals for the CMSP and describes how coastal and marine plans will be regional in scope and developed cooperatively among regional governance structures and federal, state, tribal, and local authorities, with substantial stakeholder and public input. The CMSP is a comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial-planning process, based on sound science, for analyzing current and anticipated uses of ocean and coastal areas in the United States. This approach identifies areas most suitable for various types or classes of activities in order to reduce conflicts among uses, minimize environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives. Given the importance of conducting the CMSP from an ecosystem-based perspective, combined with the likely involvement of existing regional governance structures in developing plans, a consistent planning scale with which to initiate the CMSP is at the LME scale (see http://www.lme.noaa.gov/). Since NCA data are largely aligned with the spatial extent of the LMEs, they may also be incorporated into the CMSP Interim Handbook.

Fisheries in the United States are critically important, providing numerous socioeconomic benefits, including food, direct and indirect employment, and recreational opportunities. From 2003 to 2006, commercial fisheries in the United States generated nearly $14 billion in ex-vessel revenues. The highest-grossing fishery during this period was American lobster, which generated over $1.4 billion. Two other invertebrate species also ranked within the top five fisheries, sea scallops and white shrimp, which yielded over $1.3 billion and over $770 million, respectively. Two demersal (bottom-dwelling) species, both caught on the West Coast, also are within the top five commercial fisheries in the United States: the walleye Pollock and the Pacific halibut, which generated over $1.1 billion and $720 million, respectively, from 2003 to 2006. Figure 2-15 outlines the revenues and landings of the top U.S. commercial fisheries. In 2004, the United States ranked third for fishery landings and fourth for exports, internationally. The Alaskan LME complex is the most productive regional ecosystem in the United States, with an average yield over 2.6 million tons from 2004 through 2006, mostly generated within the groundfish (bottom-dwelling) fisheries (i.e., Pacific halibut, walleye pollock, Pacific cod, rockfishes, and flatfishes). Top recreational species are striped bass, croaker, spot, and sea trout (NMFS, 2010).

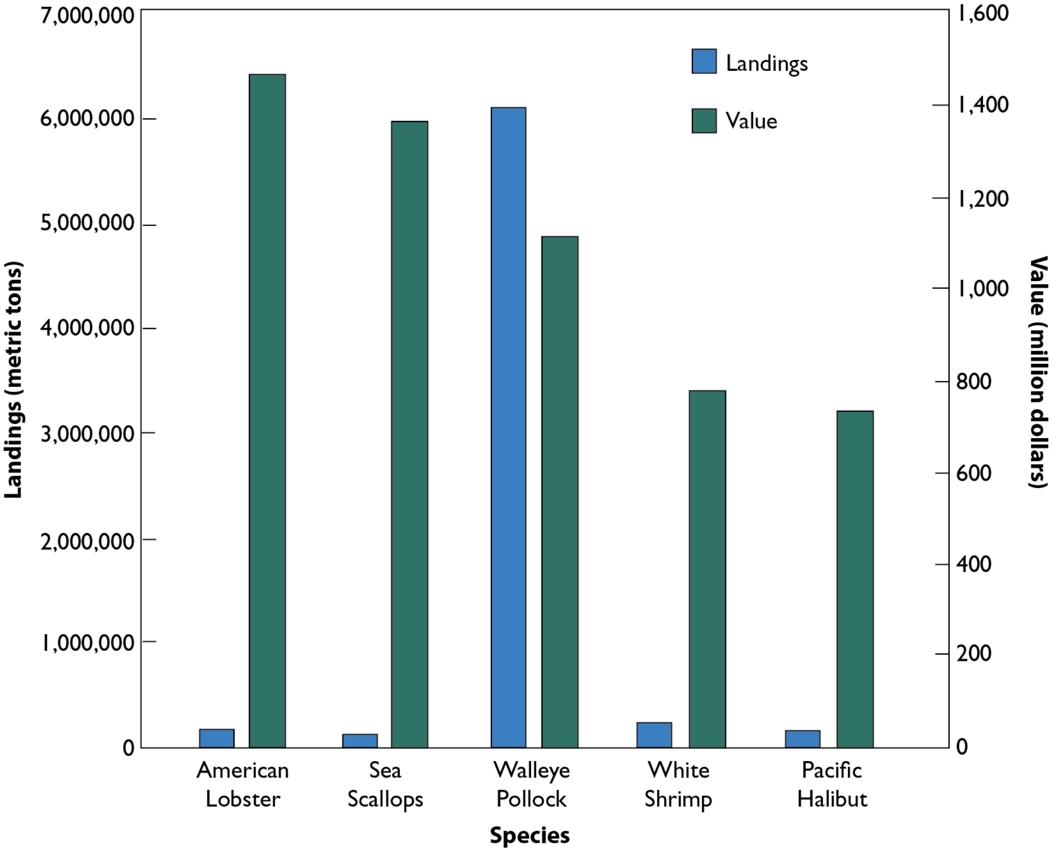


Figure 2-15. Top commercial fisheries in the United States: landings (metric tons) and value (million dollars) from 2003 to 2006 (NMFS, 2010).

The NMFS provides regular assessment of fish stock status to determine a stock's health (i.e., if it is overfished or not). The status of 33% of U.S. fishery stocks is unknown or undefined. Of the 144 known stock groups, 28% are overfished, 10% are rebuilding, less than 1% is approaching overfished, and 60% are not overfished. The majority of overfished stocks occur among the Northeast U.S. Continental Shelf

LME demersal (bottom-dwelling) species. Many of the stocks (37%) that have a known status and have experienced declines in landings are below the biomass level that would support the maximum sustainable yield (NMFS, 2009b). Landings for a significant portion of the stocks decreased because their population sizes can no longer support historical catch levels.

A majority of the stocks classified as overfished are currently under rebuilding plans and have not yet been rebuilt to above the overfished threshold. Although rebuilding of overfished stocks can take many years—depending on the stock's intrinsic natural capacity to grow, its initial level of depletion, and the specific management measures in place—the process of rebuilding overfished stocks is underway. Overall, the U.S. share of fishery resources has held fairly steady in recent years, with, average catches from 2004–2006, including commercial, recreational, and discards, at 61% of the estimated U.S. maximum sustainable yield. The largest increases in terms of tonnage occurred for Alaskan LME groundfish fisheries (156,930 metric tons) and Pacific Coast and Alaska pelagic fisheries (52,784 metric tons). In terms of percentage, Atlantic anadromous (migratory) fisheries also had a significant increase (77%). Large tonnage declines occurred for Southeast U.S. Continental Shelf LME menhaden fisheries (−208,000 metric tons) and Pacific highly migratory pelagic fisheries (−108,158 metric tons). Large percentage decreases were also experienced by Western Pacific invertebrates (−100% due to fishery closure) and shellfish (−50%) from the Alaskan LMEs (NMFS, 2009b).

Figure 2-16 shows landings of the walleye pollock commercial fishery in the United States from 1965 to 2006. The walleye pollock and the other top U.S. fisheries are displayed on separate graphs because catches of pollock are too large to show on the same scale as the rest of the top U.S. fisheries. The U.S. pollock fishery, which largely began in the mid-1980s, has current landings of nearly 1.6 million metric tons. Since the late 1980s, this fishery has had landings over 1 million metric tons, and despite annual fluctuations, landings have increased by over 500,000 metric tons since the late 1990s (NMFS, 2010).

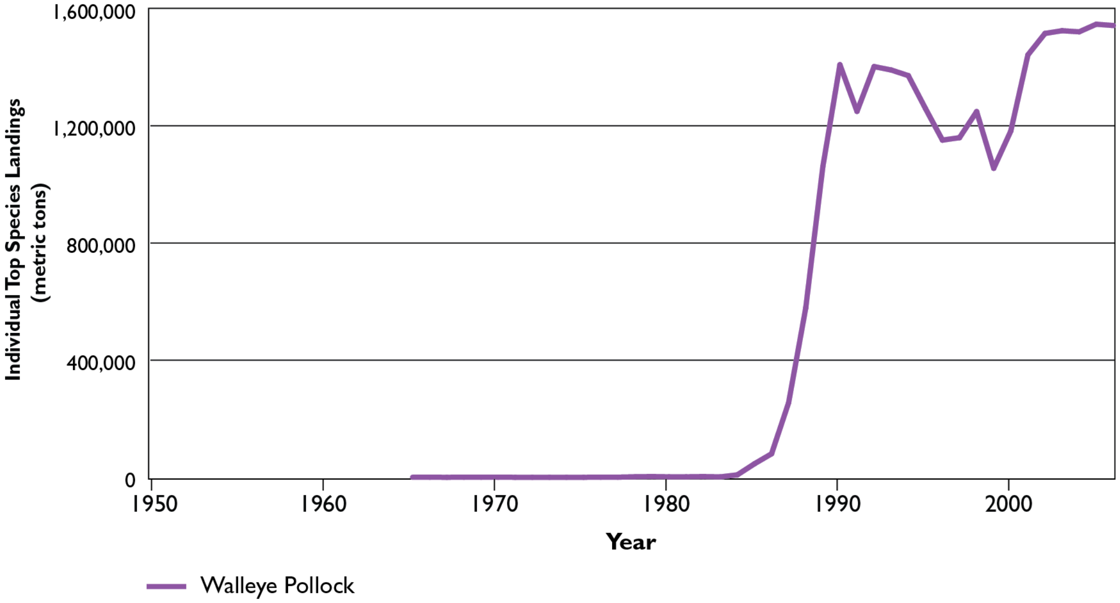


Figure 2-16. Landings of the total U.S. walleye pollock commercial fishery from 1965 to 2006, metric tons (NMFS, 2010).

Landings in the other top U.S. commercial fisheries are presented in Figure 2-17. All three invertebrate fisheries represented (American lobster, sea scallop, and white shrimp) have had increased catches since 1950. Amongst the four fisheries represented in Figure 2-17, the largest increase in landings occurred in the white shrimp fishery (for which data were not available from 1950 to 1961 and from 1972 to 1977).

Catches of white shrimp increased from 15,000 metric tons in 1962 to nearly 70,000 metric tons in 2006. The American lobster fishery increased steadily from 10,000 metric tons in 1950 to just over 40,000 metric tons in 2006. During this same period, catches in the sea scallop fishery increased from 10,000 metric tons to 25,000 metric tons, resurging over the past several years following declines in the 1990s. Landings in the Pacific halibut fishery underwent a long decline from the early 1960s to 1980, but increased again with recent landings over 30,000 metric tons (NMFS, 2010).

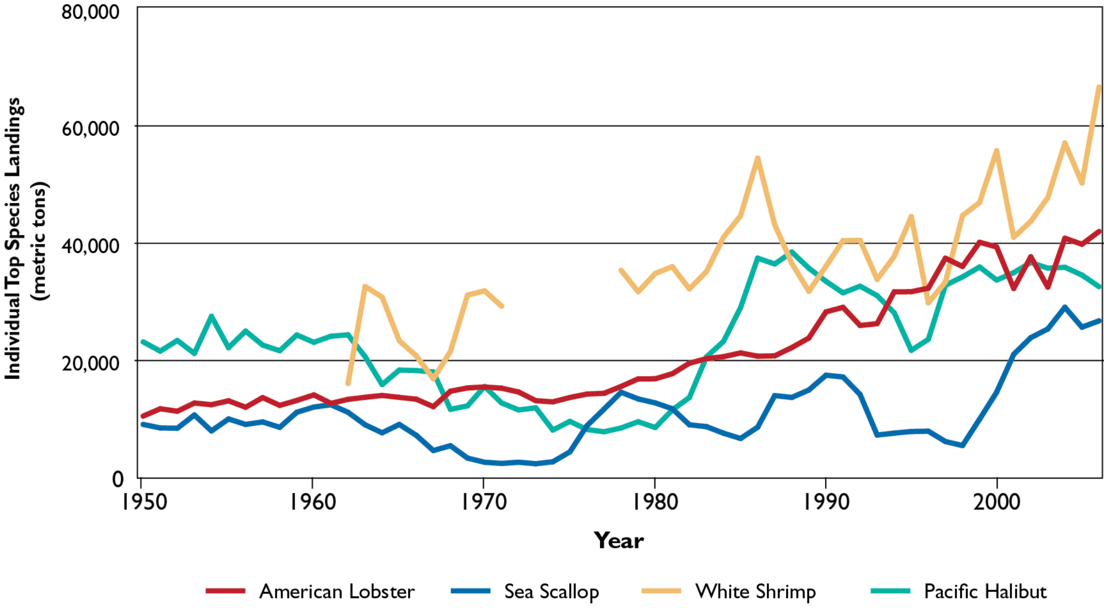


Figure 2-17. Landings of the top U.S. commercial fisheries from 1950 to 2006, metric tons (NMFS, 2010).

Advisory Data

Fish Consumption Advisories

A total of 117 fish consumption advisories were in effect for the estuarine and coastal marine waters of the United States in 2006, including about 75% of the coastal waters of the conterminous 48 states (Figure 2-18). In addition, 29 fish consumption advisories were in effect for the Great Lakes and their connecting waters. An advisory may represent one waterbody or one type of waterbody within a state's jurisdiction and may cover one or more species of fish. Some advisories are issued as a single statewide advisory for all estuarine or marine waters within a state (Table 2-6). 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 (e.g., bluefish, 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 (U.S. EPA, 2007c). Figure 2-18 shows the number of fish consumption advisories active in 2006 for U.S. coastal waters (U.S. EPA, 2007c).

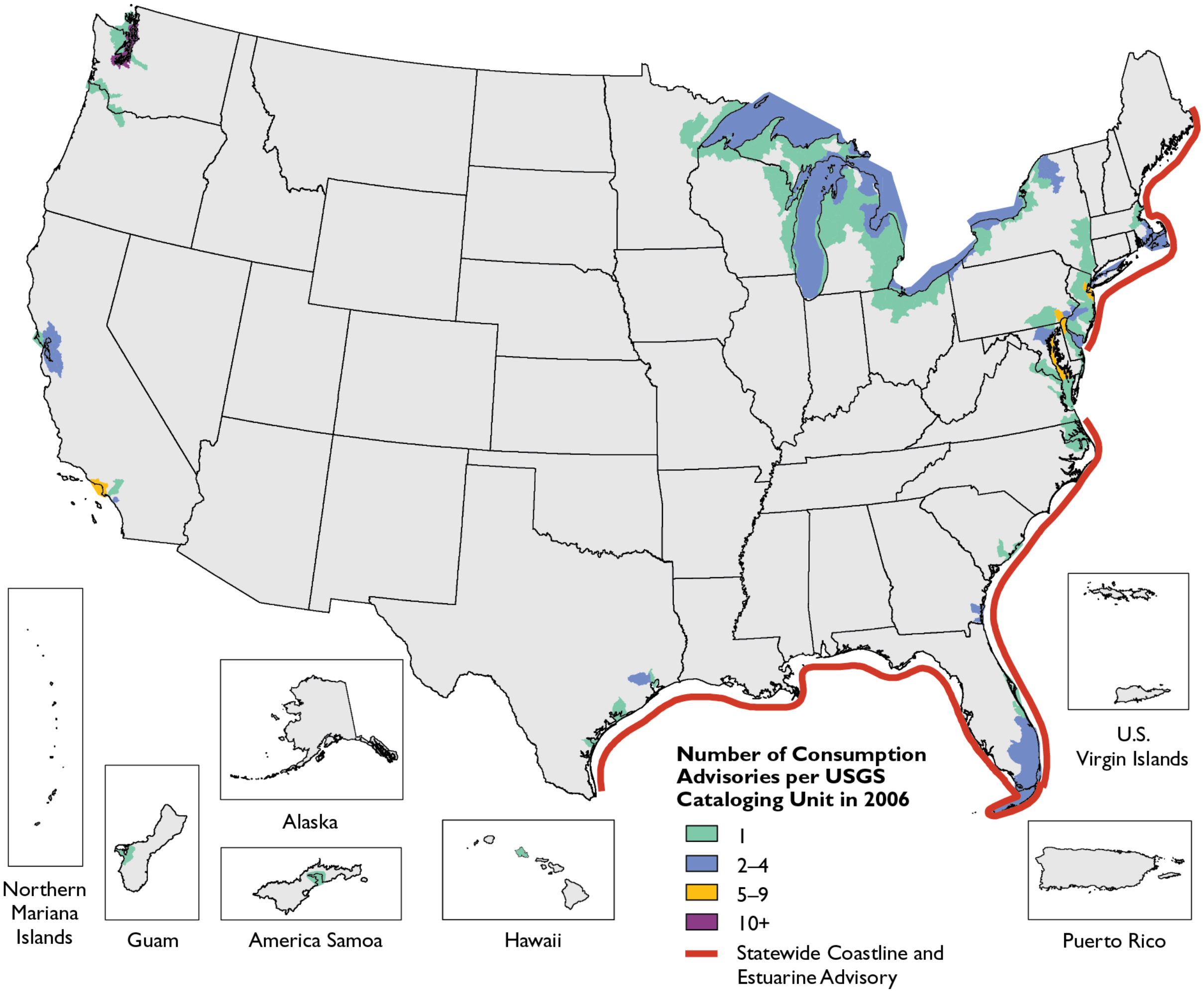


Figure 2-18. The number of fish consumption advisories active in 2006 for U.S. coastal waters (U.S. EPA, 2007c).

The number and geographic extent of advisories can serve as indicators of the level of contamination in estuarine and marine fish and shellfish, but a number of other factors also must 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, Great Lakes, and coastal marine waters have been issued for a total of 21 individual chemical contaminants, most advisories issued have resulted from four primary contaminants (i.e., PCBs; mercury; p,p'-diclorodiphenyltrichloroethane [DDT] and its degradation products [p,p'-diclorodiphenyldichloroethane (DDD) and p,p'-diclorodiphenyldichloroethylene (DDE)]; and dioxins/furans) or have not identified the specific contaminant (Figure 2-19; Tables 2-7 and 2-8). The four primary chemical contaminant groups were responsible, at least in part, for 79% of all fish consumption advisories in effect in U.S. estuarine and coastal marine waters in 2006, while unspecified contaminants effected 19% of all estuarine and coastal marine advisories. The four major chemical contaminants are biologically accumulated (bioaccumulated) in the tissues of aquatic organisms to concentrations many times higher than concentrations in sea water (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, 2007c, 2004b).

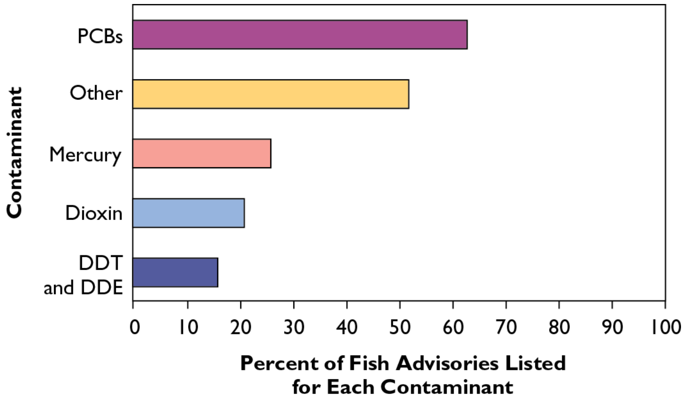


Figure 2-19. Pollutants responsible for fish consumption advisories in U.S. coastal and estuarine waters.

An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2007c).

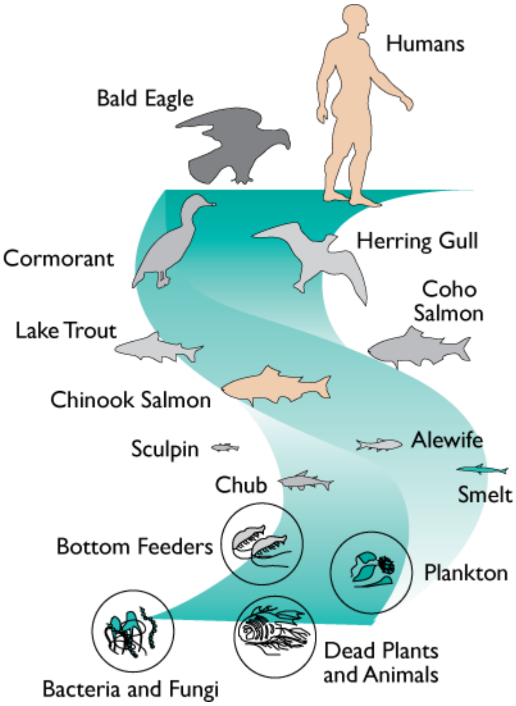


Figure 2-20. Bioaccumulation process (U.S. EPA, 1995b).

Table 2-6. Summary of States[a] with Statewide Fish Advisories for Coastal and Estuarine Waters (U.S. EPA, 2007c)

State	Pollutants	Species under Advisory
Alabama	Mercury	King mackerel
Connecticut	PCBs	Bluefish Lobster (tomalley/hepatopancreas) Striped bass
Florida	Mercury	Almaco jack Atlantic croaker Atlantic spadefish Atlantic stingray Atlantic thread herring Barracuda Black drum Black grouper Blackfin tuna Bluefish Bluntnose stingray Bonefish Cobia Crevalle jack Dolphin Fantail mullet Florida pompano Gafftopsail catfish Gag grouper Gray snapper Greater amberjack Gulf flounder Hardhead catfish Hogfish King mackerel Ladyfish Lane snapper Little tunny Lookdown Mutton snapper Pigfish Pinfish Red drum Red grouper Red snapper Sand seatrout Scamp Shark Sheepshead Silver perch Skipjack tuna Snook

(continued)

Table 2-6. Summary of States[a] with Statewide Fish Advisories for Coastal and Estuarine Waters (U.S. EPA, 2007c) (continued)

State	Pollutants	Species under Advisory
Florida (continued)	Mercury (continued)	Snowy grouper Southern flounder Southern kingfish Spanish mackerel Spot Spotted seatrout Striped mojarra Striped mullet Tarpon Tripletail Vermillion snapper Wahoo Weakfish White grunt White mullet Yellowedge grouper Yellowfin tuna Yellowtail snapper
Georgia	Mercury	King mackerel
Louisiana	Mercury	Blackfin tuna Cobia Greater amberjack King mackerel
Maine	Dioxins, Mercury, PCBs	Bluefish King mackerel Lobster (tomalley/hepatopancreas) Shark Shellfish Striped bass Swordfish Tilefish All other fish
Massachusetts	Mercury, PCBs	Bluefish King mackerel Lobster (tomalley/hepatopancreas) Shark Swordfish Tilefish Tuna

(continued)

Table 2-6. Summary of States[a] with Statewide Fish Advisories for Coastal and Estuarine Waters (U.S. EPA, 2007c) (continued)

State	Pollutants	Species under Advisory
Mississippi	Mercury	King mackerel
New Hampshire	Mercury, PCBs, Dioxins	Bluefish King mackerel Lobster (tomalley/hepatopancreas) Shark Striped bass Swordfish Tilefish Tuna All other shellfish All other ocean fish
New Jersey	PCBs, Dioxins	American eel Bluefish Lobster (tomalley/hepatopancreas) Striped bass
New York	Cadmium, Dioxins, PCBs (Total)	Blue crab (hepatopancreas) Lobster (tomalley/hepatopancreas)
North Carolina	Mercury	Almaco jack Banded rudderfish Black drum Blue marlin Cobia Crab-dungeness Crevalle jack Croaker Dolphin Flounder Gag grouper Greater amberjack Grouper Halibut Herring Jacksmelt King mackerel Ladyfish Little tunny Lobster Orange roughy Oysters Pacific cod Perch Pollock Pompano Red drum Red grouper

(continued)

Table 2-6. Summary of States[a] with Statewide Fish Advisories for Coastal and Estuarine Waters (U.S. EPA, 2007c) (continued)

State	Pollutants	Species under Advisory
North Carolina (continued)	Mercury (continued)	Salmon Scallops Shark Sheepshead Shrimp Snowy grouper Southern kingfish Spanish mackerel Spot Spotted seatrout Swordfish Tilefish Tripletail Tuna White grunt Whitefish
Rhode Island	PCBs, Mercury	Bluefish Shark Striped bass Swordfish
South Carolina	Mercury	King mackerel Swordfish
Texas	Mercury	King mackerel

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

Table 2-7. The Four Bioaccumulative Contaminants Responsible, at Least in Part, for 79% of Fish Consumption Advisories in Estuarine and Coastal Waters in 2006—U.S. Coastal Waters (Marine) (U.S. EPA, 2007c)

Contaminant	Number of Advisories	Comments
PCBs	74	Seven northeastern states (CT, MA, ME, NH, NJ, NY, RI) had statewide advisories.
Mercury	30	Twelve states (AL, FL, GA, LA, MA, ME, MS, NC, NH, RI, SC, TX) had statewide advisories in their coastal marine waters; six of these states also had statewide advisories for estuarine waters. Nine states and the Territory of American Samoa had advisories for specific portions of their coastal waters.
DDT, DDD, and DDE	14	All DDT advisories in effect were in California (12), Delaware (1), or the Territory of American Samoa (1).
Dioxins and furans	25	Statewide dioxin advisories were in effect in four states (ME, NH, NJ, NY). Six states and the Territory of Guam had dioxin advisories for specific portions of their coastal waters.
Not specified	22	The majority (18) of the advisories issued for non-specific contaminants are new advisories for Washington's Puget Sound. The additional four advisories apply to other specified coastal waters in CA, FL, and WA.

Table 2-8. The Four Bioaccumulative Contaminants Responsible, at Least in Part, for 79% of Fish Consumption Advisories in Estuarine and Coastal Waters in 2006—U.S. Great Lakes Waters (U.S. EPA, 2007c)

Contaminant	Number of Advisories	Comments
PCBs	29	Six states (MI, MN, NY, OH, PA, WI) had PCB advisories for all five Great Lakes and several connecting waters.
Mercury	13	Three states (MI, PA, WI) had mercury advisories in their Great Lakes waters for Lakes 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 effect 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

How many notification actions were reported nationally between 2004 and 2008?

Table 2-9 presents the number of total beaches, number of monitored beaches, number of beaches affected by notification actions, and percentage of monitored beaches affected by notification actions nationally between 2004 and 2008. During this time, between 26% and 32% of the monitored beaches were affected by notification actions. Although the percentage of monitored beaches affected by notification actions remained at approximately 32% between 2006 and 2008, the number of notification actions has increased as monitoring efforts have increased (U.S. EPA, 2009d). Fluctuations in total and monitored beaches may be a result of alterations to state funding for monitoring, beach consolidation or splitting, or implementation of new QA procedures. In addition to reported increases in microbial contamination, inter-annual changes in notification actions may be a result of seasonal weather conditions or changes to the reporting or monitoring processes. For information on the EPA performance criteria for state, tribal, or local governments for beach notification or monitoring programs, see http://www.epa.gov/waterscience/beaches/grants/guidance/.

Table 2-9. Beach Notification Actions, National, 2004–2008[a] (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	5,208	6,064	6,599	6,237	6,684
Number of monitored beaches	3,574	4,025	3,771	3,647	3,740
Number of beaches affected by notification actions	942	1,109	1,201	1,170	1,210
Percentage of monitored beaches affected by notification actions	26%	28%	32%	32%	32%

[a] This table includes data from Puerto Rico and Hawaii in 2004 and from American Samoa, Guam, Alaska, and the Virgin Islands beginning in 2005.

What pollution sources impacted monitored beaches?

Table 2-10 presents the numbers and percentages of monitored beaches nationally affected by various pollution sources for 2007, developed by aggregating notification actions by state. Although advisories and closures were issued for a number of different reasons, storm-related runoff was the most common single reason, affecting 35% of the monitored beaches in 2007. Various unidentified, unknown, and not investigated pollution sources affected 66% of total monitored beaches (U.S. EPA, 2009d).

Table 2-10. Reasons for Beach Advisories, Nationally, 2007[a] (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Storm-related runoff	1,267	35%
Other and/or unidentified sources	1,061	29%
No known pollution sources	698	19%
Pollution sources not investigated	644	18%
Wildlife	279	8%
Sanitary/combined sewer overflow	127	4%
Boat discharge	99	3%
Septic system leakage	69	2%
Non-storm related runoff	66	2%
Agricultural runoff	28	1%
Publicly-owned treatment works	28	1%
Sewer line leak or break	27	1%
Concentrated animal feeding operations	9	< 1%

Note: A single beach advisory may have multiple pollution sources.

[a] Data from Puerto Rico, the Virgin Islands, American Samoa, Guam, and the Northern Mariana Islands was not available for this year.

How long were the 2007 beach notification actions?

Although 32% of monitored beaches nationally were subject to a notification action in 2007, these advisories were not long lasting. About 50% of beach notification actions in the United States lasted 2 days or less, and just over 40% of the notifications were issued for a period lasting between 3 to 7 days. The remaining 7% of actions were issued for more than 8 days, although only 1% lasted above 30 days (U.S. EPA, 2009d).

More information on the EPA's BEACH Program is available online:

- BEACH homepage: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm/.
- Annual national summaries: http://www.epa.gov/waterscience/beaches/seasons/.

Summary

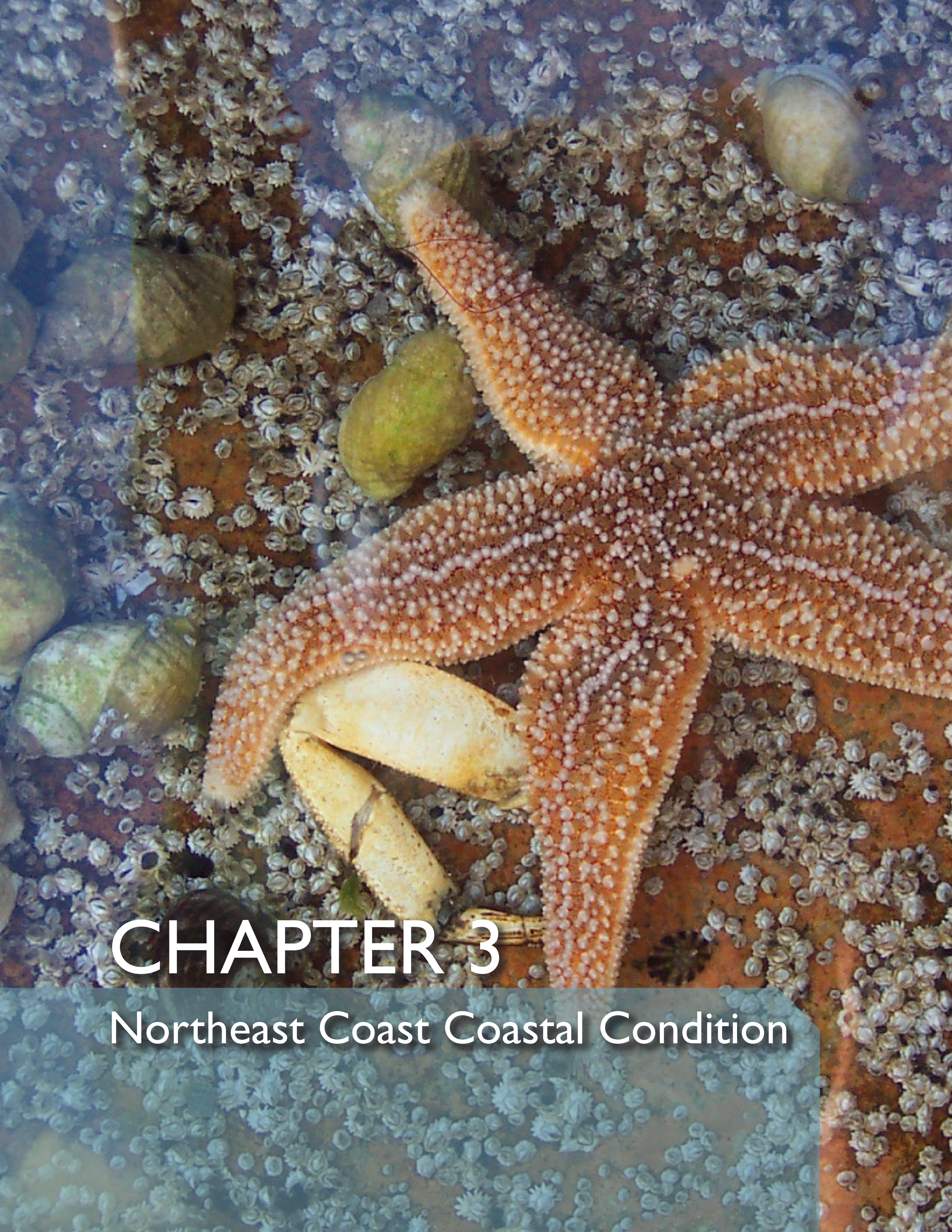
Based on data collected between 2003 and 2006 from the coastal waters of the coastal states of the conterminous United States, Southeastern Alaska, Hawaii, American Samoa, Guam, Puerto Rico, and U.S. Virgin Islands, the overall condition of the nation's coastal waters is rated fair. The water quality index and its component indicators are predominantly rated fair or good for regions throughout the nation, although 42% of the nation's coastal waters experienced a moderate-to-high degree of water quality degradation and were rated fair or poor, resulting in an overall national water quality rating of fair. The sediment quality index for the nation's coastal waters is rated fair, with 10% of the coastal area rated poor for sediment quality. The benthic and coastal habitat condition indices are both rated fair for the nation's coastal waters, while the fish tissue contaminants index is rated good to fair.

A traditional trend analysis cannot be performed on the data presented in the NCCR series because the coastal resources included in the survey have changed for each assessment; however, the overall condition scores for each region have either remained the same or improved since the first NCCR was released in 2001 (with the exception of Alaska, Hawaii, and the island territories, where only one or two scores are available). Similarly, the national overall coastal condition score has improved, from 2.0 with the first NCCR to 3.0 with this fourth edition of the NCCR (or from 2.0 to 2.5, if the scores from NCCR III and IV were recalculated without Alaska, Hawaii, and the island territories).

Since 2003, a series of offshore studies have been conducted to assess the status of ecological condition and potential stressor impacts throughout various coastal-ocean regions of the United States. In general, results of the offshore studies have shown that these coastal-ocean waters are much less impacted by human influence than neighboring estuaries. With some exceptions, conditions for most indicators were above estuarine cutpoints for good ratings throughout the majority of the survey areas. Results of biological sampling were generally good, but sources of human-induced stress such as commercial bottom trawling, cable placement, and minerals extraction are suspected, and future monitoring efforts in these offshore areas should include indicators of these types of disturbances.

Fisheries in the United States are critically important, providing numerous socioeconomic benefits, including food, direct and indirect employment, and recreational opportunities. From 2003 to 2006, the highest grossing fishery in the nation was American lobster, which generated over $1.4 billion. Two other invertebrate species, sea scallops and white shrimp, also ranked within the top five fisheries. The walleye pollock and the Pacific halibut, both caught on the West Coast, round out the list of the top five commercial fisheries in the United States from 2003 to 2006. Of the 144 known fisheries stock groups, 28% are overfished, 10% are rebuilding, less than 1% is approaching overfished, and 60% are not overfished. The majority of overfished stocks occur among the Northeast region demersal species. Although rebuilding of overfished stocks can take many years depending on the stock's intrinsic natural capacity to grow, its initial level of depletion, and the specific management measures in place, the process of rebuilding overfished stocks is underway.

Contamination in the coastal waters of the United States has affected human uses of these waters. A total of 117 fish consumption advisories were in effect for the estuarine and coastal marine waters of the United States in 2006, including about 75% of the coastal waters of the conterminous 48 states. In addition, 29 fish consumption advisories were in effect for the Great Lakes and their connecting waters. Although statewide coastal advisories have placed a large proportion of the nation's coastal waters under advisory, these advisories are often issued only for the larger-size classes of predatory species. Fish advisories in U.S. estuarine, Great Lakes, and coastal marine waters have been issued for a total of 21 individual chemical contaminants, but most advisories are for PCBs, mercury, DDT and its degradation products, and dioxins/furans. The percentage of monitored beaches affected by notification actions remained at approximately 32% between 2006 and 2008, but the number of notification actions has increased as monitoring efforts have increased. Beach advisories and closures were issued for a number of different reasons, but storm-related runoff was the most common single reason, affecting 35% of the monitored beaches in 2007.



CHAPTER 3

Northeast Coast Coastal Condition

3. Northeast Coast Coastal Condition

As shown in Figure 3-1, the overall condition of the coastal waters of the Northeast Coast region is rated fair, with an overall condition score of 2.6. The coastal habitat index for the Northeast Coast region is rated good to fair, the water quality and sediment quality indices are rated fair, the fish tissue contaminants index is rated fair to poor, and the benthic index is rated poor. Figure 3-2 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on data collected primarily in 2003 through 2006 from 1,119 water, 1,024 sediment, and 902 benthic monitoring locations throughout the Northeast Coast coastal waters.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

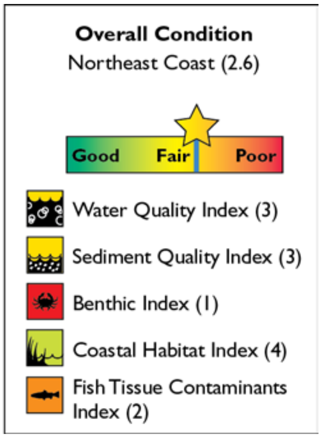


Figure 3-1. The overall condition of Northeast Coast coastal waters is rated fair (U.S. EPA/NCA).

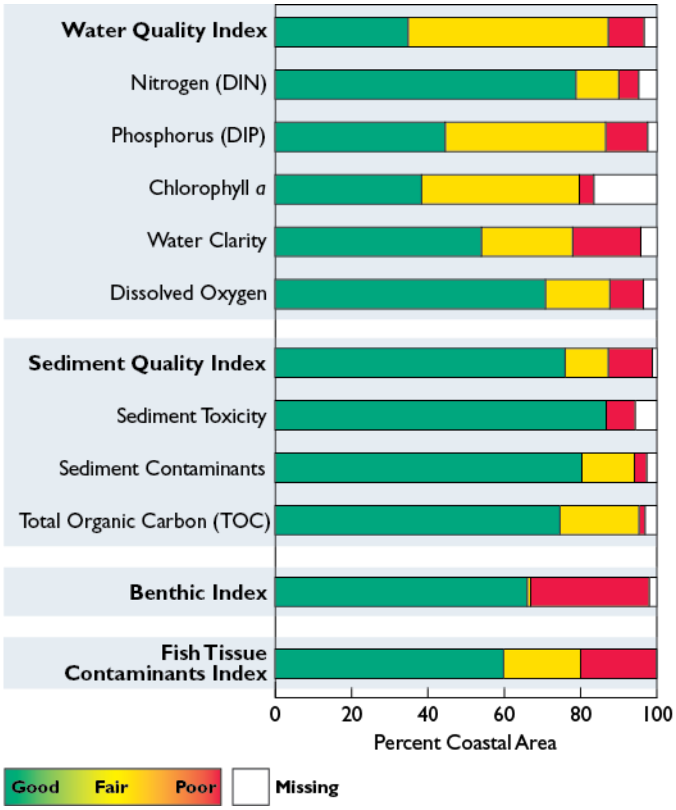


Figure 3-2. Percentage of coastal area achieving each ranking for all indices and component indicators—Northeast Coast region (U.S. EPA/NCA).

The Northeast Coast refers to the coastal and estuarine waters of Maine through Virginia, including Chesapeake Bay. A great diversity in landscapes and aquatic habitats is evident along this coastline, so much so that the region is divided into two biogeographical provinces—the Acadian Province and the Virginian Province. The Acadian Province lies north of Cape Cod, MA, comprising lands scoured by glaciers thousands of years ago. The region is currently a mountainous, forested landscape, with thin soils and relatively small watersheds that drain quickly to rocky coasts. The estuaries of the Acadian Province are small, deep, open to the sea, and subject to large tidal ranges of 7 to 13 feet, which promote effective tidal mixing. This combination of small watersheds, open estuaries, and rapid flushing times protects the Acadian Province coastline somewhat from landscape alteration and urban pollution. In contrast, the Virginian Province—Cape Cod through Chesapeake Bay—was less directly affected by glaciers and now features expansive watersheds that are drained by large riverine systems such as the Hudson, Delaware, and Susquehanna rivers. The major estuaries of the Virginian Province are comprised of drowned river basins that filled with water and sediment as the sea level rose following the ice age. They are relatively shallow and poorly flushed, with tidal ranges less than 7 feet (less than 3 feet in Chesapeake Bay). As a consequence, the Virginian Province estuaries are very vulnerable to the pressures of a highly populated and industrialized coastal region. This chapter reports on the condition of the Northeast Coast as a whole, but will highlight differences in the two provinces. Note, however, that Chesapeake Bay, the largest estuary in the nation, represents nearly 60% of the coastal area in the Northeast; therefore, the area-weighted statistical summaries are heavily influenced by this major estuary.

The Northeast Coast region is the most densely populated coastal region in the United States. In 2006, the coastal population of the Northeast Coast region was the largest in the country, with 43.2 million people, representing 33% of the nation's total coastal population. Although coastal counties along the Northeast

Coast showed one of the lowest percent increases in population (17%) between 1980 and 2006, the region gained the second-largest number of people (almost 7 million) of all U.S. regions during this time (Figure 3-3). Over the same time period, the population density in the coastal counties of the Northeast Coast has also increased by about 18%, from 713 to 841 persons per square mile. Figure 3-4 presents population density data for the Northeast Coast region's coastal counties in 2006 (NOEP, 2010).

Although the data presented in this chapter are summarized on a regional level, they are publicly accessible and can be used to summarize conditions by biogeographic province, state, and—where sufficient data are available—waterbody. The *National Estuary Program Coastal Condition Report* (U.S. EPA, 2006) is an example of how these data may be assessed at a finer scale.

The NCA monitoring data used in this assessment were based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Data were not collected during other time periods.

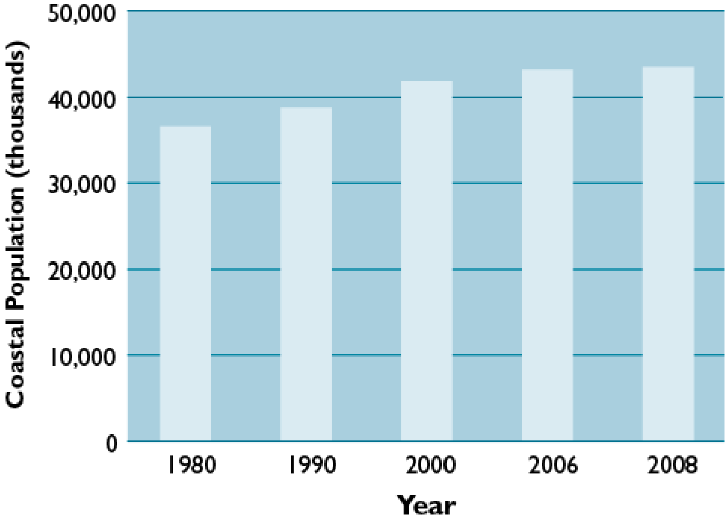


Figure 3-3. Population of coastal counties in Northeast Coast states, 1980–2008 (NOEP, 2010).

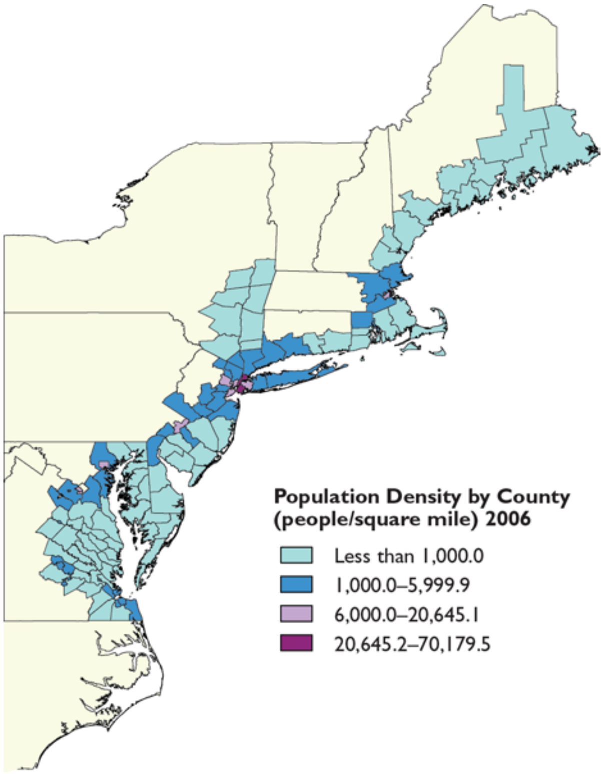


Figure 3-4. Population density in the Northeast Coast region's coastal counties in 2006 (NOEP, 2010).

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 primarily sampled during the summer months of 2003 through 2006 by states participating in the NCA. However, there were exceptions to this scheme. Stations in northern Maine and in Connecticut tributaries sampled in 2002 were also included in the analysis to provide complete coverage at these locations. Also, only NCA data collected in 2005 and 2006 were available to evaluate Chesapeake Bay. Generally, the Northeast Coast is rated in terms of the percentage of coastal area in good, fair, or poor condition, or for which data were missing. 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 stations where tissue samples were analyzed.

The sampling conducted in the EPA NCA survey has been designed to estimate the percent of coastal area (nationally or in a region) 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 would be required to define temporal variability and to confirm environmental condition at specific locations.

Water Quality Index

The water quality index for the coastal waters of the Northeast Coast region is rated fair, with 9% of the coastal area rated poor and 53% 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. Differences in the water quality index were evident along the Northeast

Coast, and patterns have remained remarkably consistent compared with the previous two NCCRs (U.S. EPA, 2004a, 2008c).

> Eutrophication refers to a process in which the nutrient supply to a waterbody increases over time, resulting in enhanced growth of aquatic plants, especially algae (for other definitions, see http://toxics.usgs.gov/definitions/eutrophication.html). If eutrophication is gradual, the consumer community (e.g., fish, benthic organisms, bacteria) can benefit from the added nourishment. Increasingly, however, human activity is over-enriching estuaries with nutrients, especially nitrogen nutrients, and plants create more food than can be immediately consumed. The excess plant material can result in problems such as diminished water clarity and depleted dissolved oxygen. The NCA program gauges the extent of harmful eutrophication by measuring five component indicators that represent different stages of the process. These indicators include two measures of nutrient enrichment (concentrations of DIN and DIP), a measure of available plant material (concentrations of chlorophyll *a*), and two indications of adverse effects of eutrophication (water clarity and dissolved oxygen levels). Not all of these warning signs would be evident at the same time, so a water quality index is created from the five component indicators. For instance, a station is considered to be adversely affected by eutrophication if two of the component indicators are rated poor (see Chapter 1 for a full explanation of the water quality index).

The water quality index exhibits a strong gradient along the Northeast Coast (Figure 3-5). Good conditions predominate in the well-mixed, open estuaries of the Acadian Province, whereas fair conditions were more likely found in the poorly flushed, highly settled Virginian Province estuaries that are more susceptible to eutrophication. Pockets of poor water quality are apparent at stations in Great Bay, NH; Narragansett Bay, RI; Long Island Sound; New York/New Jersey (NY/NJ) Harbor; the Delaware Estuary; and the western tributaries of Chesapeake Bay. These hot spots largely reflect patterns of population density (see Figure 3-4) and industrial and agricultural activity in the Northeast.

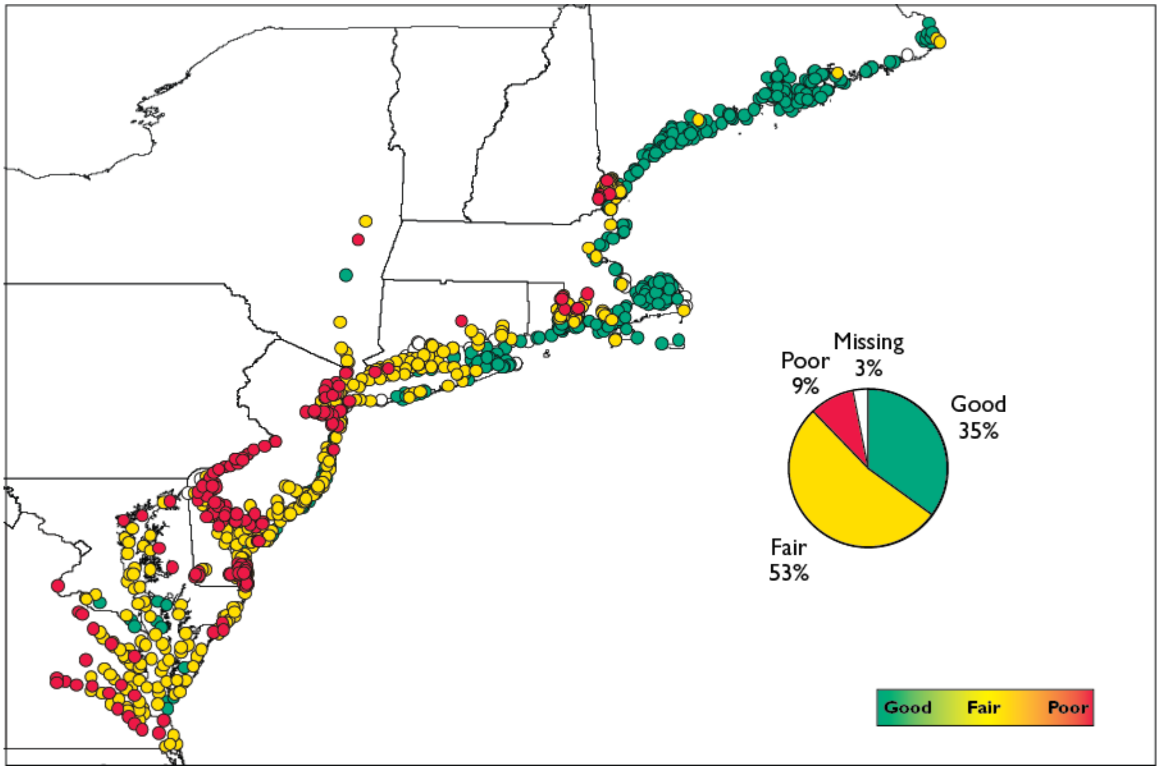


Figure 3-5. Water quality index data for Northeast Coast coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The Northeast Coast region is rated good for DIN concentrations, with only 5% of the coastal area rated poor. Poor DIN concentrations (i.e., moderate to high concentrations ranging from 0.5 to 2 mg/L) were largely confined to stations in NY/NJ Harbor, the Delaware River, and the Delaware Inland Bays. The region is rated fair for DIP concentrations, with 53% of the coastal area in fair or poor condition for this component indicator. DIP concentrations rated fair (i.e., 0.01 to 0.05 mg/L) were uniformly distributed throughout the Northeast Coast region, while concentrations rated poor (i.e., 0.05 to .2 mg/L) were found at stations in Great Bay, NH; Narragansett Bay, RI; Long Island Sound; NY/NJ Harbor; the Delaware River; and the Delaware Inland Bays. Good conditions for DIN and DIP were found in Chesapeake Bay, except for a few western tributaries. At first glance, these results seem to suggest that DIP is a more serious problem than DIN in the Northeast Coast region because a greater area of the region is rated poor for the DIP component indicator; however, the high DIP levels are less important because the limiting nutrient, DIN, is depleted and the potential for further plant growth is low. Given such complexities, these DIN and DIP nutrient metrics may be best interpreted as indicators of potential, additional eutrophication in estuaries, rather than measures of nutrient status at the time of measurement.

Although both DIN and DIP can contribute to the adverse effects of eutrophication, DIN is usually of primary concern in estuaries because it is the "limiting nutrient," i.e., the first critical component to be depleted, thereby halting further plant production.

Chlorophyll *a*

The Northeast Coast region is rated fair for chlorophyll *a* concentrations because less of the coastal area is rated good than is rated fair and poor, combined. Generally, the broad pattern of chlorophyll *a* concentrations is similar to that of nutrients, with chlorophyll *a* levels much higher in the south (i.e., the Virginian Province) than in the north (i.e., Acadian Province). High chlorophyll *a* levels are generally expected at nutrient-rich sites, and this is the case in much of the Northeast Coast coastal waters, especially in the Maryland Coastal Bays and Chesapeake Bay tributaries. However, there is little apparent correlation in the Chesapeake Bay main stem, Delaware Bay, or NY/NJ Harbor areas. Such inconsistent relationships between nutrients and chlorophyll *a* highlight the complex dynamics of algal blooms in coastal waters. For instance, chlorophyll *a* levels in the Delaware Estuary are relatively low, despite very high dissolved nutrient concentrations, likely because naturally poor water clarity (caused by sediments suspended by wave action) hinders algal growth. The opposite is evident in much of Chesapeake Bay, where dissolved nutrients are scarce, while chlorophyll *a* concentrations are high. Here, it is likely that that the nutrients have already been removed from the water and incorporated into biomass.

Water Clarity

The Northeast Coast region is rated fair for water clarity, with 18% of the coastal area rated poor and another 24% rated fair. In this assessment, the cutpoints used to define good, fair, and poor water clarity varied for different estuarine systems (Table 3-1), depending on the natural conditions of and the restoration goals for the waterbody. For example, large portions of the shallow Delaware Estuary have naturally low water clarity due to wave action; therefore, the least stringent cutpoints are used to assess water clarity. In contrast, more stringent cutpoints are applied to Chesapeake Bay, where restoration of bay grass habitat is an important goal. Further information regarding water clarity in Chesapeake Bay is available online at: http://www.chesapeakebay.net/waterclarity.aspx?menuitem=14656. Water clarity at monitoring stations along the Northeast Coast was largely rated good, with the notable exception of monitoring stations in Chesapeake Bay, particularly the western tributaries, and the tidal fresh regions of Delaware Estuary.

Table 3-1. Cutpoints Used to Define Poor Ratings at a Monitoring Station in the Northeast Coast Region

Coastal Areas	Cutpoints for a Poor Rating (Percentage of Ambient Light that Reaches 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 17% of the coastal area in fair condition and 9% of the area in poor condition. Most of the monitoring stations in this region were rated good for dissolved oxygen; however, there were a few exceptions. Fair dissolved oxygen levels were evident at some stations in Long Island Sound and Narragansett Bay, RI. The lowest concentrations of dissolved oxygen were measured at monitoring stations located in Long Island Sound and the isolated, deep channels of the Chesapeake Bay main stem. Episodic depletion events (dissolved oxygen < 2 mg/L) in upper Narragansett Bay have been documented during short time periods by other monitoring programs (Deacutis, 2006), and 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). Although not reflected by the data collected for this assessment, other areas of the Northeast Coast routinely experience low dissolved oxygen levels due to prevailing wind events, or in the pre-dawn hours, when respiration may deplete available oxygen reservoirs.

Sediment Quality Index

The sediment quality index for the coastal waters of the Northeast Coast region is rated fair, with 12% of the coastal area in poor condition and 11% in fair condition (Figure 3-6). This index is based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Fair and poor sites are evident throughout the Northeast Coast region, with hot spots located in Great Bay, NH; Narragansett Bay, RI; Long Island Sound; the NY/NJ Harbor; the Upper Delaware Estuary; and the western tributaries of Chesapeake Bay. 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.

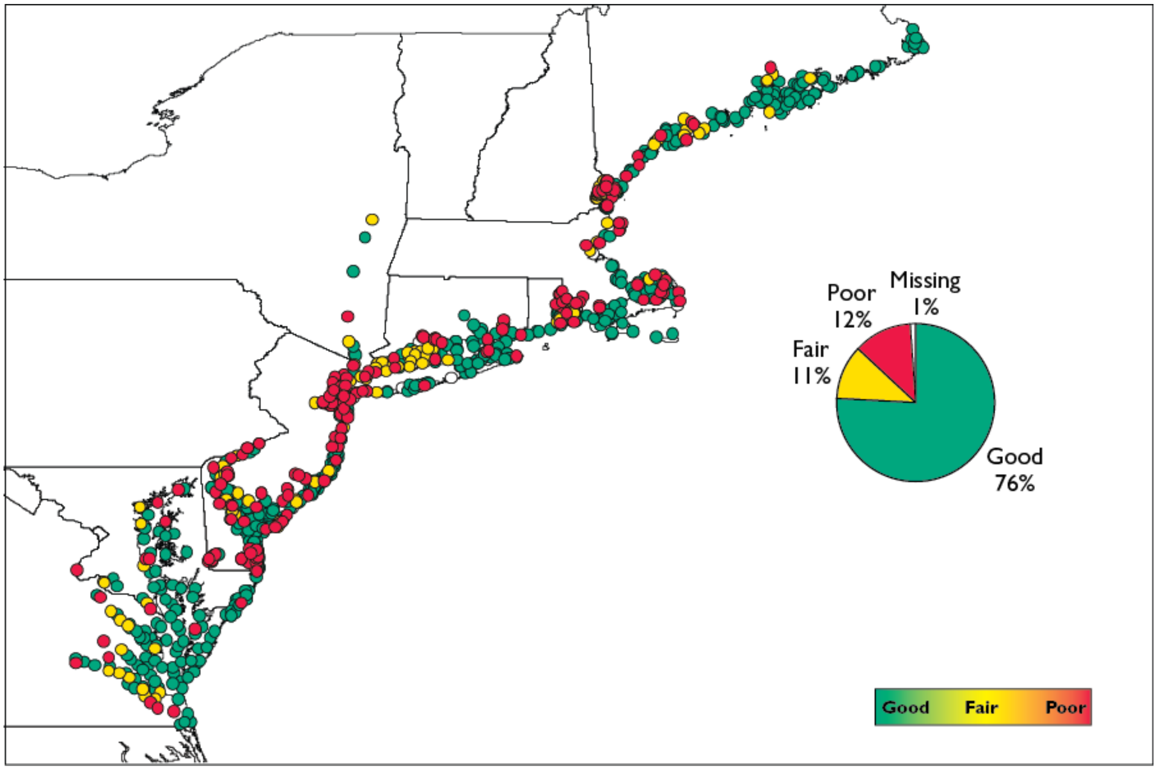


Figure 3-6. Sediment quality index data for Northeast Coast coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The Northeast Coast region is rated poor for sediment toxicity, with 8% of the coastal area rated poor for this component indicator. Sites rated poor are concentrated in Cape Cod Bay, MA; Narragansett Bay, RI; NY/NJ Harbor; and the tidal-fresh parts of Delaware Bay and coastal New Jersey. Relatively few of the poor sites are evident along the northern shore of Maine or in Chesapeake Bay.

Sediment Contaminants

The Northeast Coast region is rated good for sediment contaminant concentrations, with 3% of coastal area rated poor and 14% of the area rated fair for this component indicator. The spatial distribution of the sediment contaminants indicator mirrors that of the sediment quality index, with the monitoring stations rated poor for this component indicator clustering primarily near major urban centers, but also located along the mid-Maine coast and the western tributaries of Chesapeake Bay. Elevated levels of metals (particularly arsenic, chromium, mercury, nickel, silver, and zinc), PCBs, and DDT were primarily responsible for the poor sediment contaminant ratings.

Guidelines for Assessing Sediment Contamination (Long et al., 1995)

ERM (Effects Range Median)—Determined values 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.

Although a relationship between toxicity and sediment contamination seems logical, there appears to be little correlation between the two measures in the Northeast Coast region. Of the 62 sites that were rated poor for the sediment contaminants component indicator, only 15% were also rated poor for sediment toxicity. Conversely, of the 87 sites rated poor for the sediment toxicity component indicator, only 10% were also rated poor for sediment contaminants. In short, there is little evidence that the chemical contaminants measured for this evaluation are the cause of the toxicity measured by this test. It is possible that these results may indicate that high concentrations of contaminants are immobilized by sequestering agents, such as sulfides or organic carbon, and are not readily available to biota (DiToro et al., 1991; U.S. EPA, 1993; Daskalakis and O'Conner, 1994).

Sediment TOC

The Northeast Coast region is rated good for the sediment TOC component indicator, with only 2% of the coastal area rated poor and an additional 20% rated fair. The spatial distribution of stations rated good, fair, or poor for this component indicator is similar to the distribution of station ratings for the sediment quality index and the sediment contaminants indicator. In fact, the association of stations rated fair or poor for both the sediment contaminants and sediment TOC component indicators is strong. Ninety-six percent of the sites that showed some level of contamination (i.e., exceeded the ERL for at least one chemical) were rated fair or poor for sediment TOC. Only 1% of the stations rated good for TOC were rated poor for sediment contaminants. Metals were more likely than organic contaminants to associate with the organic matter. The close pairing of pollutants and organic material is not unusual, as the contaminants tend to adsorb or chemically bind to organic matter and accumulate together in quiescent "depositional spots." This scavenging of toxicants is a two-edged sword—beneficial if the contaminants are permanently sequestered in carbon-rich sediments, but detrimental if the contaminated sediments are consumed by benthic organisms and the toxicants enter the food web.

Benthic Index

The Northeast Coast region is rated poor, with 31% of the coastal area rated poor for benthic condition (Figure 3-7). Separate benthic indices were developed to evaluate the unique benthic communities in the Acadian Province (i.e., north of Cape Cod) and the Virginian Province (i.e., south of Cape Cod). The Acadian Province Benthic Index (Hale and Heltshe, 2008) has three rating categories (good, fair, and poor), whereas the Virginian Province Benthic Index (Paul et al., 2001) has only good and poor categories. Considered individually as provinces, the Acadian Province fares relatively well, with 93% of the area reporting good benthic condition, compared with the Virginian Province, where only 60% of area received a good rating. Poor benthic conditions are particularly evident at monitoring stations in Casco Bay, ME; Great Bay, NH; Narragansett Bay, RI; Long Island Sound; NY/NJ Harbor; coastal New Jersey; the Delaware Estuary; the Delaware Inland Bays; and Chesapeake Bay.

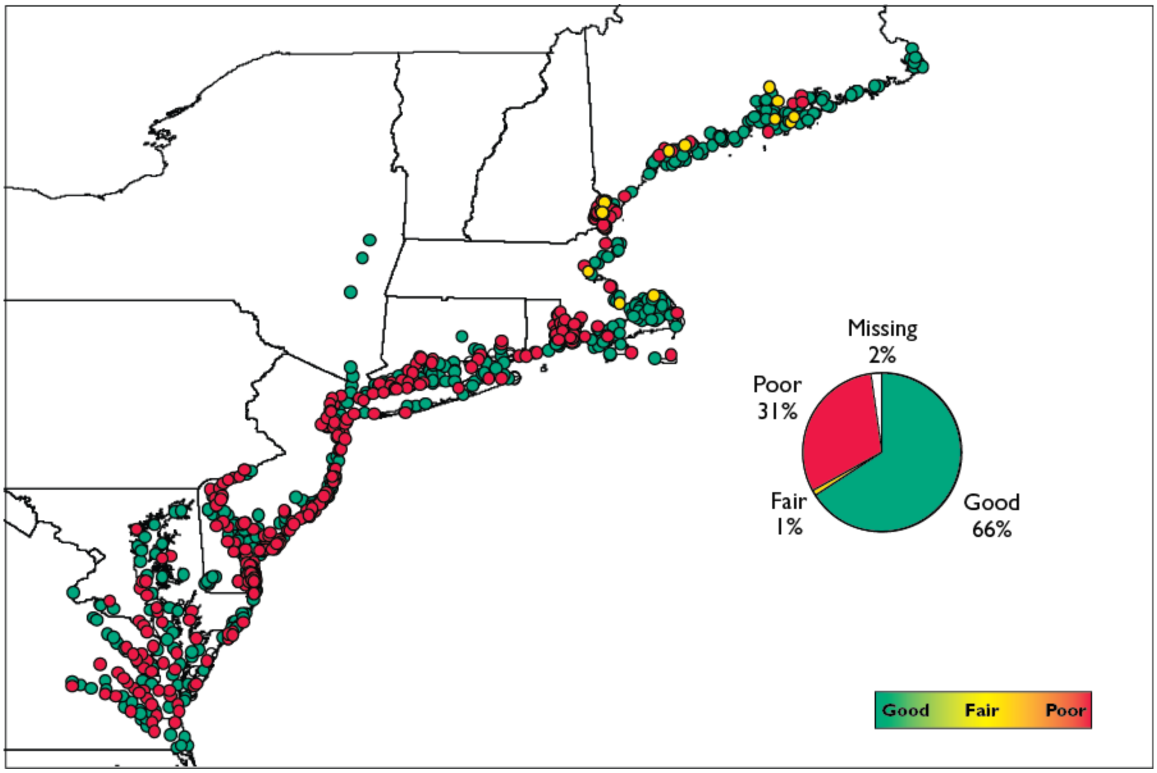


Figure 3-7. Benthic index data for Northeast Coast coastal waters (U.S. EPA/NCA).

Coastal Habitat Index

Wetlands are threatened by many human activities, including loss and destruction due to land development, eutrophication, and the introduction of toxic chemicals. Losses can also result from land subsidence, sea-level rise, and the introduction and spread of exotic species (e.g., Asian shore crab). Ecologists estimate that more than one half of the coastal wetlands of the Northeast Coast region 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 of coastal wetlands between 1990 and 2000, which amounts to a loss of 0.14% over 10 years. The rate of wetland loss for this time period was the lowest percent loss for all regions of the conterminous United States. Based on the calculated coastal habitat index value, 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 fair to poor based on concentrations of chemical contaminants found in composites of whole-body fish, lobster, and fish fillet samples. Twenty percent of the sites sampled where fish were caught were rated poor, and an additional 20% were rated fair based on comparison to EPA advisory guidance values (Figure 3-8). The poor sites were largely congregated in Great Bay, NH; Narragansett Bay, RI; Long Island Sound; NY/NJ Harbor; and the upper Delaware Estuary. Elevated concentrations of PCBs were responsible for the impaired ratings for a large majority of sites. Moderate to high levels of DDT were detected in samples collected from sites located in the Hudson, Passaic, and Delaware rivers, and moderate mercury contamination was evident in samples collected from sites in Great Bay, NH; Narragansett Bay, RI; and the Hudson River.

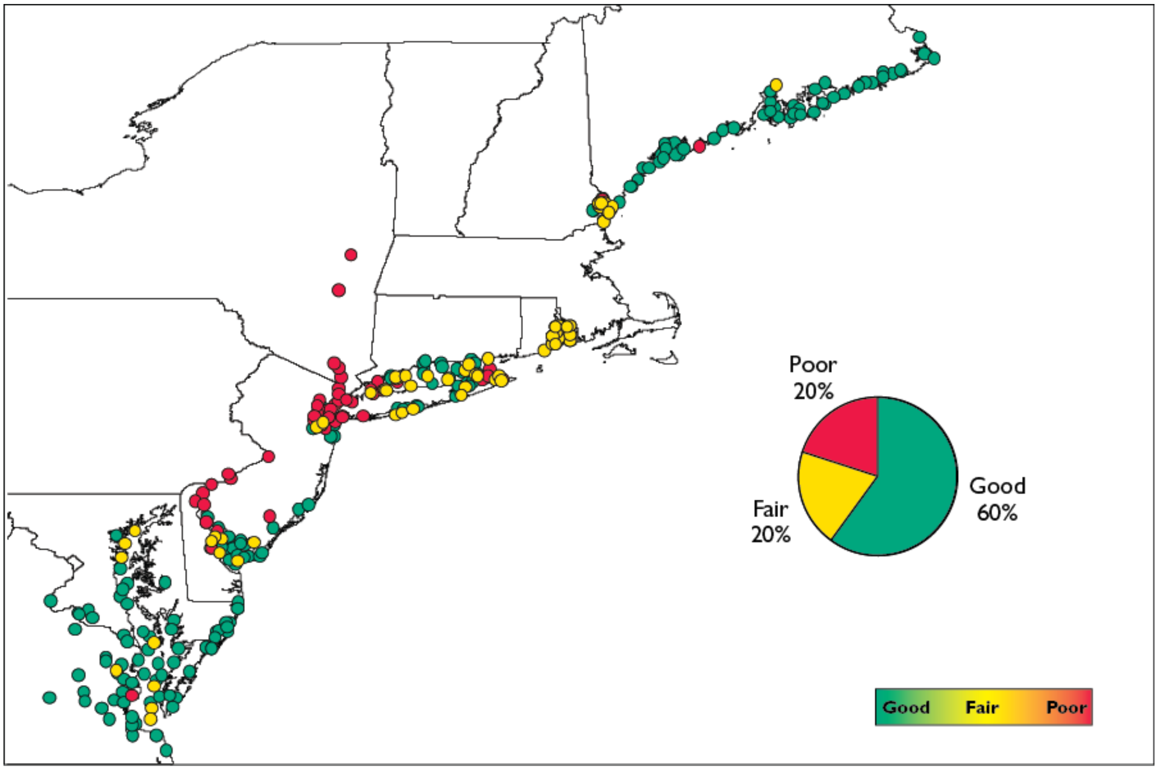


Figure 3-8. Fish tissue contaminants index data for Northeast Coast coastal waters (U.S. EPA/NCA).

Trends of Coastal Monitoring Data—Northeast Coast (excluding Chesapeake Bay)

Temporal Change in Ecological Condition

The NCA data were collected each summer from 2000 to 2006 using consistent sampling and measurement methods. This section examines the variability of the results along the Northeast Coast and looks for possible trends over the 7-year period. Chesapeake Bay is not included in this analysis because the NCA only assessed this estuary during 2005 and 2006. For additional information about conditions in Chesapeake Bay, please refer to the extensive assessment activity conducted and reported on by the Chesapeake Bay Program (http://www.chesapeakebay.net).

The 7-year NCA program is divided into three phases for the Northeast Coast region. Phase 1 covers the initial 2 years (2000–2001) of the program, when the entire coastline north of Chesapeake Bay was evaluated based on a single 2-year sampling design. Phase 2 refers to the intermediate next 3 years (2002–2004), when individual states employed separate sampling designs and several states did not participate for a year. The entire region was sampled in Phase 2, and results for this period were weighted to provide equal representation with the other phases. Phase 3 covers the final 2 years (2005–2006), when the region was assessed under another 2-year sampling design. This trend analysis includes all the measures of water, sediment, and benthic condition highlighted in this report. However, the fish tissue contaminant index was excluded from the analysis because high variability in several factors (species, tissue type, and sampling location) precluded simple comparison among the phases.

In large part, the water quality index and its component indicators showed consistency over the 7-year period (Figure 3-9). On average, approximately 7% of the Northeast Coast region displayed poor water quality index conditions and another 34% showed fair conditions in each phase. DIP was the most consistently impaired component in the Northeast Coast region, with about two-thirds of the coastal area rated fair and poor, combined, for each phase. The chlorophyll *a* component indicator was consistently rated fair and poor, combined, in about a quarter of the region's coastal area. Less than 15% of the study area reported fair or poor conditions for the DIN, water clarity, or dissolved oxygen component indicators. The small improving trend for DIN was statistically significant (i.e., the 95% confidence intervals for combined fair and poor categories did not overlap when comparing phases). The improvement in DIN concentrations was evident primarily in Delaware Bay and individual estuaries north of Long Island Sound, but absent elsewhere in the Virginian Province. No other apparent trends (DIP, water clarity, or dissolved oxygen) were statistically valid.

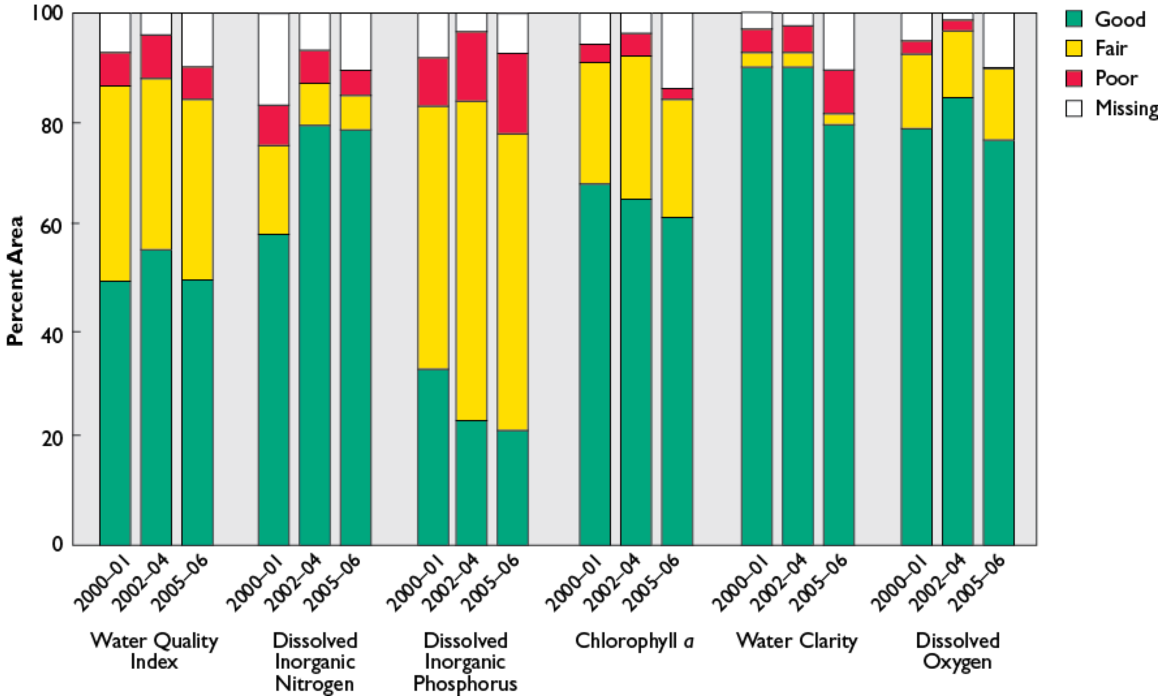


Figure 3-9. Percent area of Northeast Coast coastal area in good, fair, or poor categories for the water quality index and its component indicators over three time periods, 2000–2001, 2002–2004, and 2005–2006 (U.S. EPA/NCA).

Likewise, the sediment quality index and its component indicators showed relative constancy over the three phases (Figure 3-10). On average, about 20% to 25% of the Northeast Coast coastal area reported fair or poor condition for the sediment contaminants and sediment TOC component indicators, and about 8% of the coastal area was rated poor for sediment toxicity during each phase. Only the sediment contaminants component indicator displayed a statistically significant trend over time; specifically, an improving trend in the extent of area rated poor between the first and later phases. This improving trend for sediment contaminants was most evident from Narragansett Bay through Delaware Bay.

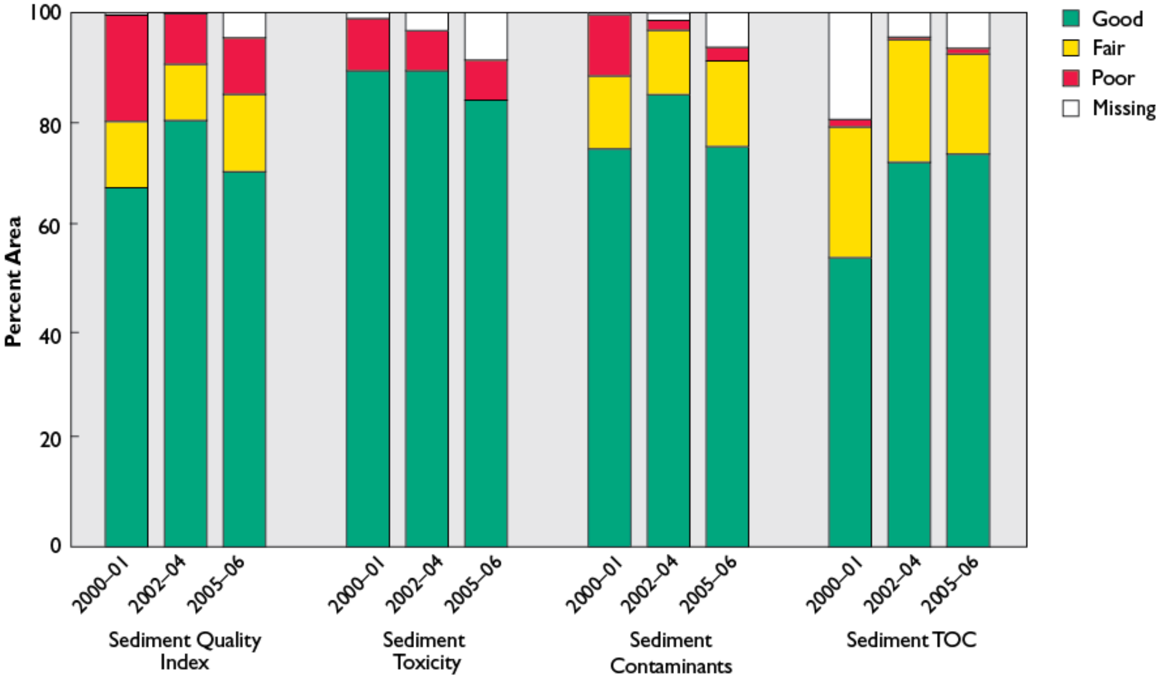


Figure 3-10. Percent area of Northeast Coast coastal area in good, fair, or poor categories for the sediment quality index and its component indicators over three time periods, 2000–2001, 2002–2004, and 2005–2006 (U.S. EPA/NCA).

The benthic index was consistently rated fair and poor, combined, in about 20% of the region's coastal area (Figure 3-11). The variation among the phases was not statistically significant.

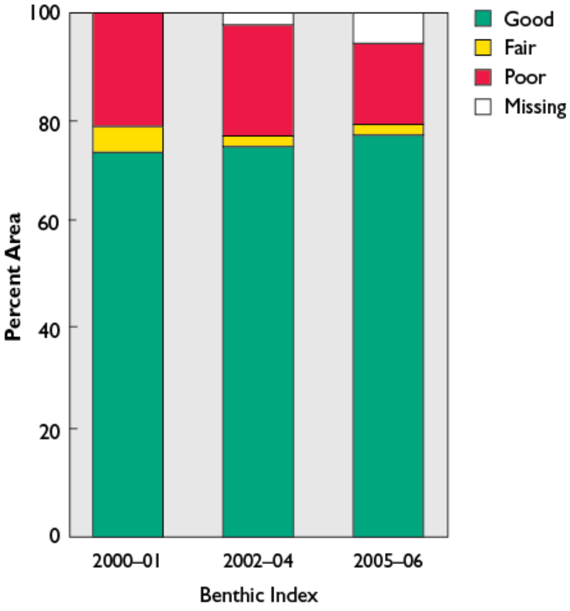


Figure 3-11. Percent area of Northeast Coast coastal area in good, fair, or poor categories for the benthic index over three time periods, 2000–2001, 2002–2004, and 2005–2006 (U.S. EPA/NCA).

It is difficult to draw conclusions regarding trends in a region as large and diverse as the Northeast Coast. As noted above, there were modest signs of overall improvement in a few indicators in the Northeast Coast region. Greater variation over the 7-year period was evident in the records of individual estuaries in some cases suggesting steady improvement, in other cases documenting steady degradation. However, 7 years is still a short time to sort out the complex year-to-year variations in climate, estuarine dynamics, and responses to remediation efforts. Periodic reassessments of the nation's coastal conditions using comparable assessment methods are planned for the future. Our ability to identify and interpret trends will improve as the data accumulate and the assessment period lengthens.

Coastal Ocean Condition—Mid-Atlantic Bight

The Mid-Atlantic Bight lies between Cape Cod and Nantucket Shoals to the northeast and Cape Hatteras to the south (Allen, 1983) and is a sub-region of the Northeast U.S. Continental Shelf LME (U.S. Commission on Ocean Policy, 2004). In May 2006, NOAA and the EPA conducted a study to assess the current status of ecological condition and stressor impacts throughout coastal-ocean (shelf) waters of the Mid-Atlantic Bight and to provide this information as a framework for evaluating future changes due to natural or human-induced disturbances (Figure 3-12). To address these objectives, the study incorporated standard methods and indicators applied in previous coastal EMAP/NCA projects and the NCCRs (U.S. EPA, 2001b, 2004a, 2008c), including multiple measures of water quality, sediment quality, benthic condition, and fish tissue contamination. Although the results of this study were used to assess ocean condition in these offshore waters, ratings of good, fair, and poor for several of the indicators were not assigned because corresponding cutpoints for such ratings have not been developed. The ocean condition developed from these sampling efforts was compared to estuarine condition assessed by NCA surveys conducted in the Virginian Province in 2003–2006. A more detailed report on results of the Mid-Atlantic Bight offshore assessment is provided by Balthis et al. (2009).

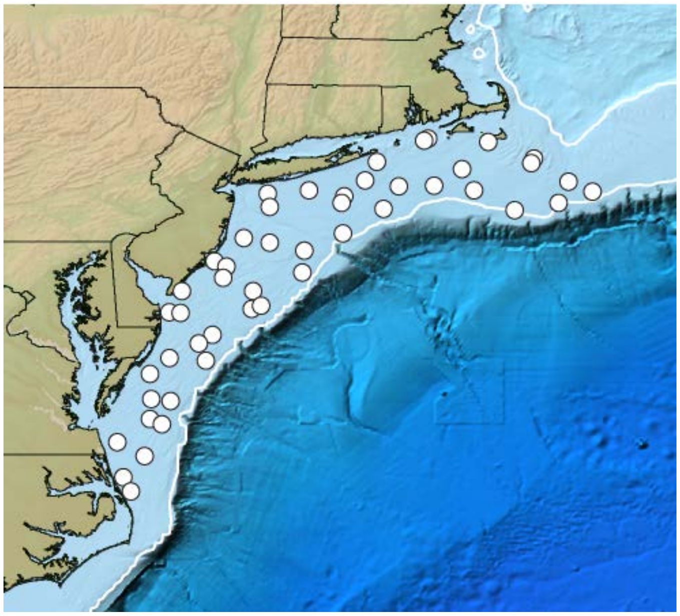


Figure 3-12. Map of the Mid-Atlantic Bight and locations of sampling stations (Balthis et al., 2009).

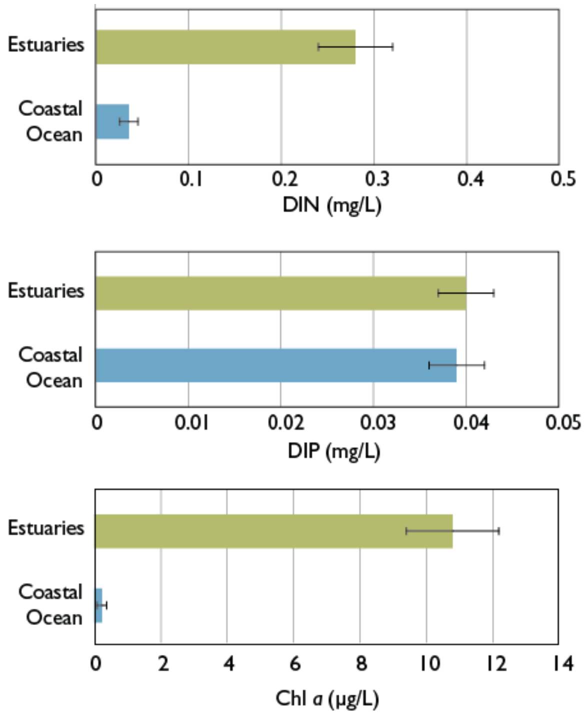


Figure 3-13. Mean concentrations ± 95% C.I.s of (a) DIN, (b) DIP, and (c) chlorophyll *a* in coastal ocean vs. estuarine surface waters (Balthis et al., 2009).

Water Quality

Nutrients: Nitrogen and Phosphorus

The average concentration of DIN (i.e., nitrogen as nitrate + nitrite + ammonium) in ocean surface waters was 0.04 mg/L, which was lower compared to estuarine waters (0.28 mg/L), although the range in values was much greater for estuaries. This pattern is illustrated in Figure 3-13, which compares mean concentrations of DIN and 95% confidence intervals in offshore versus estuarine waters. Although cutpoints are not available to assign ratings for ocean condition, about 94% of offshore surface waters had DIN concentrations below the estuarine cutpoint of 0.1 mg/L and would be rated good.

Near-bottom concentrations of DIN were higher than in surface waters, averaging 0.13 mg/L. Figure 3-14 shows the spatial distribution of DIN in bottom waters and that concentrations are highest near the shelf break. This pattern is consistent with prior studies that have found that concentrations of nutrients, particularly nitrate, in bottom shelf waters generally increase seaward and tend to remain high year round (Matte and Waldhauer, 1984). It is suggested that slope waters rich in nutrients represent a reservoir of nitrogen available to replace amounts utilized from inshore waters.

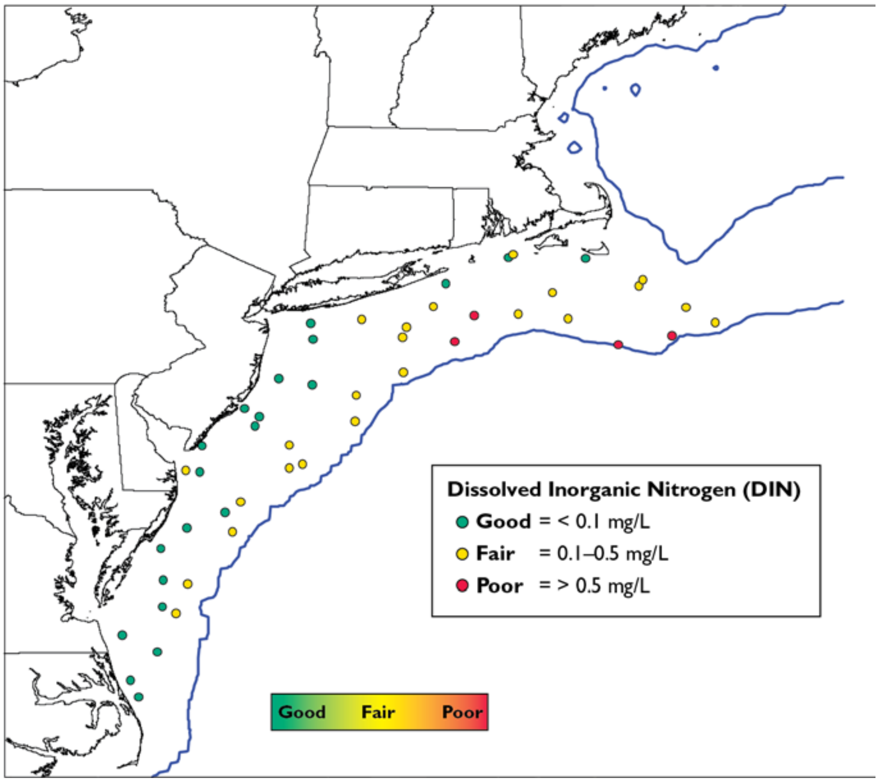


Figure 3-14. DIN component indicator data from the Mid-Atlantic Bight study area (Balthis et al., 2009).

Concentrations of DIP in coastal-ocean surface waters averaged 0.04 mg/L. These levels are similar to (though less variable than) concentrations measured in estuaries of the region, which also averaged 0.04 mg/L (see Figure 3-13). Although applicable cutpoints are not available to assign ratings for ocean condition, 10% of the ocean area had DIP concentrations greater than 0.05 mg/L and would have been rated poor had this estuarine cutpoint been applied. However, the percentage of ocean area with DIP in this upper range is probably more of a reflection of naturally higher phosphorus levels from nutrient-rich slope waters than an indication of poor water quality.

Ratios of DIN/DIP were calculated as an indicator of which nutrient may be controlling primary production. A ratio above 16 is indicative of phosphorus limitation, while a ratio below 16 is indicative of nitrogen limitation (Geider and La Roche, 2002). DIN to DIP ratios in offshore surface waters ranged from 0.43–6.25, which indicates that nitrogen is the limiting nutrient.

DIP concentrations in near-bottom ocean waters were slightly higher than in surface waters, averaging 0.05 mg/L. Near-bottom DIP concentrations did not show the same seaward increase that DIN concentrations showed.

Chlorophyll *a*

Concentrations of chlorophyll *a* in offshore surface waters, averaging 0.23 µg/L, tended to be much lower than in estuaries of the region, which averaged 10.8 µg/L (see Figure 3-13). As a further comparison, all offshore stations had chlorophyll *a* concentrations in surface waters below the cutpoint of 5 µg/L used to designate good water quality with respect to estuaries of the region. Near-bottom concentrations of chlorophyll *a* were also at low levels, averaging 0.30 µg/L.

Water Clarity

For offshore waters, concentrations of TSS were used as a surrogate indicator of water clarity. TSS in surface waters averaged 5.6 mg/L; these values are much lower than those in estuaries of the region, which averaged 27.4 mg/L. While most offshore surface waters had TSS concentrations under 10 mg/L, which is the 90th percentile of all measured values, most estuarine surface waters (65.7 % of the area) had TSS concentrations above this level.

Near-bottom TSS concentrations were similar to those in surface waters, averaging 6.9 mg/L. With the exception of the station with the highest value of 36.4 mg/L, located near the entrance to Delaware Bay, all other offshore stations had near-bottom levels of TSS less than or equal to 16.3 mg/L.

Dissolved Oxygen

Near-bottom concentrations of dissolved oxygen in offshore waters averaged 9.1 mg/L, and all sites in the offshore sampling area were greater than 5 mg/L, the NCA cutpoint for good water quality (Figure 3-15). In comparison, 9% of the estuarine area had bottom-water dissolved oxygen concentrations rated poor, with 17% and 71% rated fair and good, respectively. Dissolved oxygen levels in offshore surface waters (average of 8.9 mg/L) were similar to those in near-bottom waters.

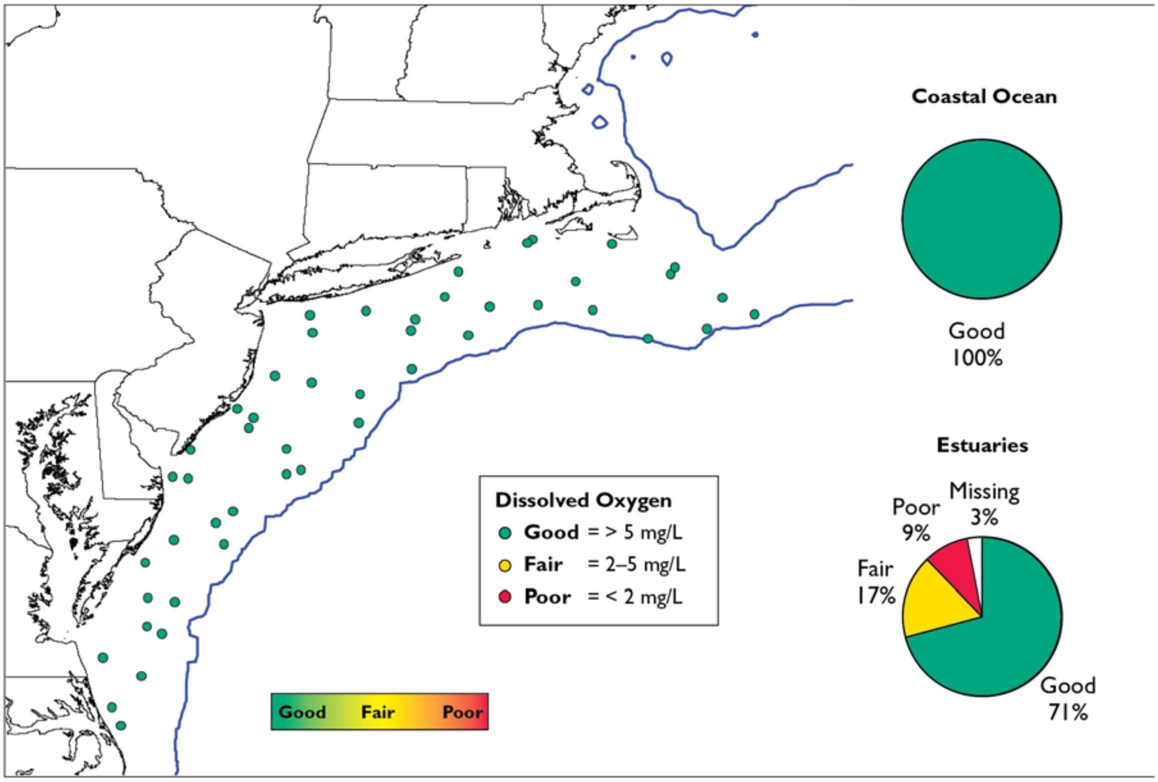


Figure 3-15. Dissolved oxygen data from the Mid-Atlantic Bight (Balthis et al., 2009).

Note: Pie charts compare coastal-ocean and estuarine dissolved oxygen levels using NCA cutpoints for rating categories.

Sediment Quality

Sediment Contaminants

Continental shelf sediments of the Mid-Atlantic Bight appeared to be relatively uncontaminated. No contaminants were found in excess of their corresponding ERM sediment quality guideline values (Long et al., 1995). Only three chemicals (arsenic, nickel, and total DDT) exceeded their corresponding ERL guidelines, and these lower-threshold exceedances occurred at only a few sites. Based on the cutpoints used by NCA to assess estuarine condition, 100% of the ocean area surveyed was rated good for the sediment contaminants component indicator. In comparison, about 3% of estuarine area was rated poor and 14% was rated fair (Figure 3-16).

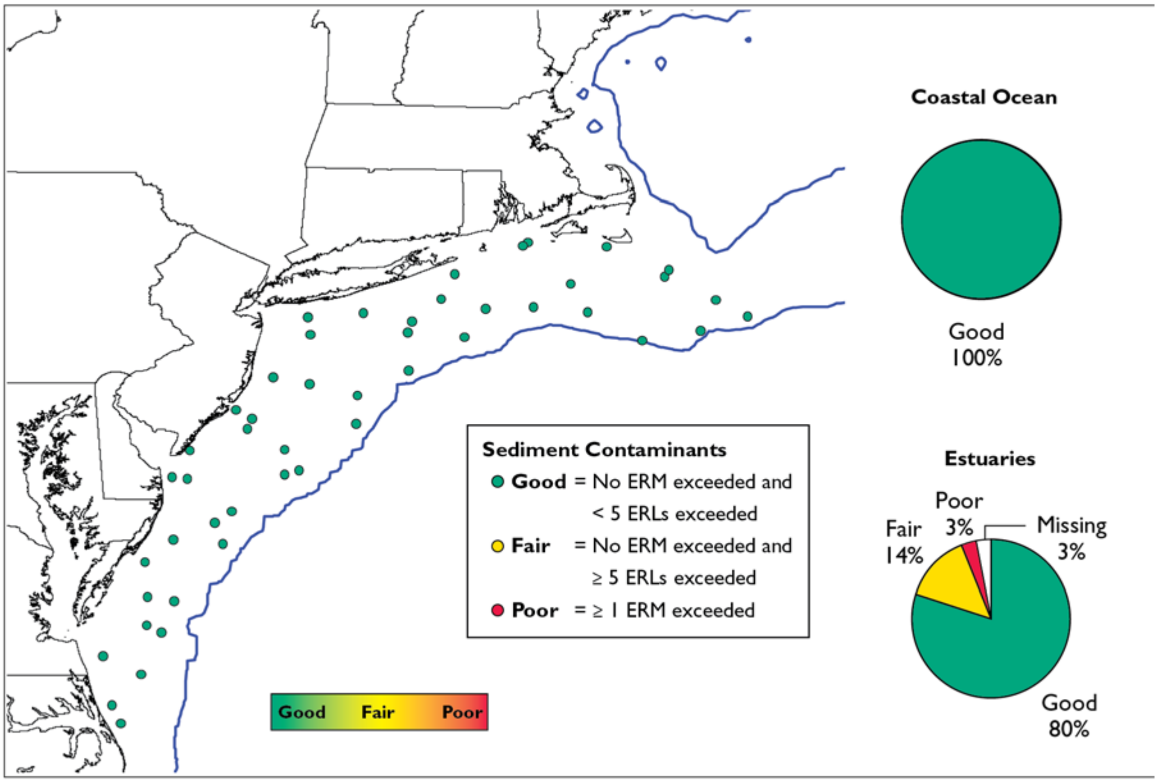


Figure 3-16. Sediment contaminants data from the Mid-Atlantic Bight (Balthis et al., 2009).

Note: Pie charts compare coastal-ocean and estuarine conditions.

Sediment TOC

High levels of TOC in sediments can serve as an indicator of adverse conditions and are often associated with increasing proportions of finer-grained sediment particles (i.e., silt-clay fraction) that tend to provide greater surface area for sorption of both organic matter and the chemical pollutants that tend to bind to organic matter. Given such an association, it is useful to note that about 92% of the ocean area had sediments composed of sands (< 20% silt-clay), 6% of the area was composed of intermediate muddy sands (20–80% silt-clay), and 2% consisted of mud (greater than 80% silt-clay).

These predominantly sandy sediments were found to have very low levels of TOC (Figure 3-17). With concentrations ranging from only 0.03–1.6% and averaging 0.19%, the entire offshore sampling area was rated good based on the NCA estuarine cutpoints for TOC. In addition, none of the sites exceeded the cutpoint of 3.5% provided by Hyland et al. (2005) as a more conservative bioeffect threshold. Because of their closer proximity to both natural and anthropogenic sources of organic materials, estuaries of the region had higher levels of TOC, with 20% of the estuarine area rated fair and 2% rated poor.

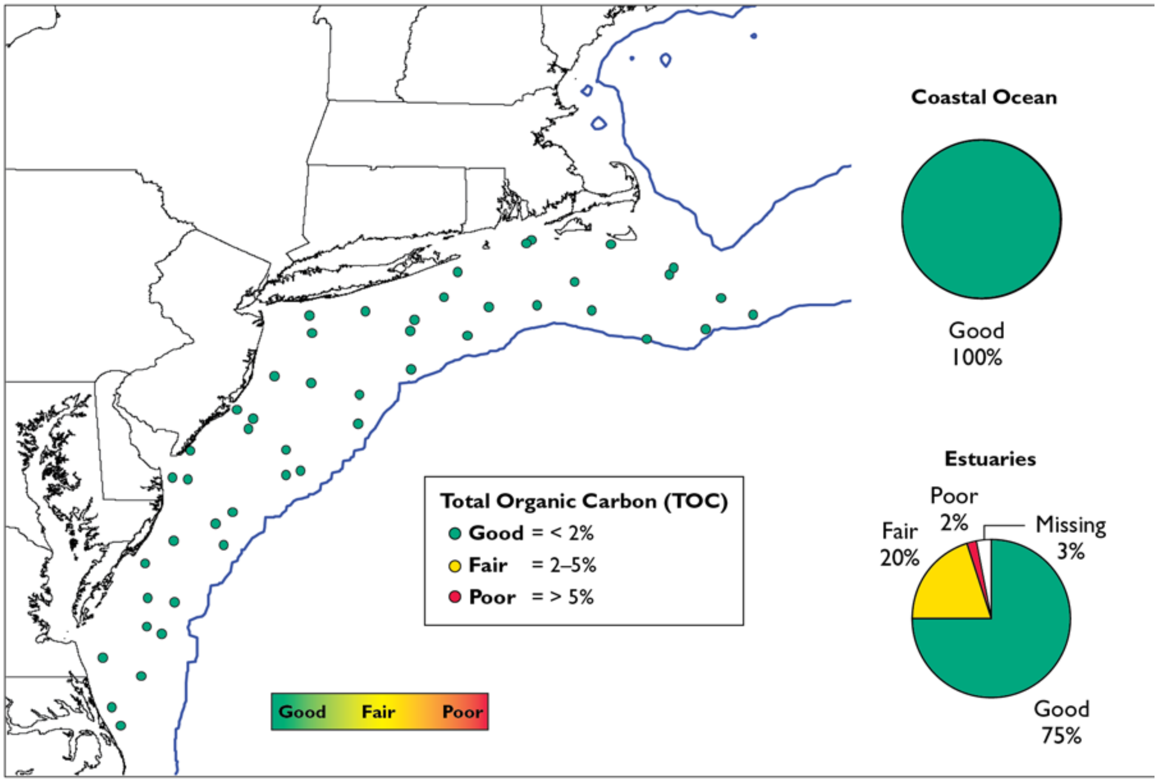


Figure 3-17. Sediment TOC data from the Mid-Atlantic Bight (Balthis et al., 2009).

Pie charts compare coastal-ocean and estuarine conditions.

Benthic Condition

The Mid-Atlantic Bight coastal ocean supports a moderately diverse assemblage of macrobenthic infauna, with values that are lower than some other offshore regions (e.g., see South Atlantic Bight, Chapter 4) and higher than corresponding estuaries of the region. A total of 23,044 individuals representing 381 taxa (215 distinct species) were identified in 95 samples collected throughout the study area. Polychaete worms were the dominant taxonomic group, followed by crustaceans, mollusks, and echinoderms. Crustaceans and echinoderms were more abundant at outer-shelf depths than on the inner shelf. Diversity and number of taxa also tended to be higher at outer-shelf sites than inner-shelf sites.

Although densities of benthic infauna were lower offshore than in estuaries, the mean number of taxa and mean diversity were both higher in the offshore sediments (Figure 3-18). Mean density, mean number of taxa, and mean diversity were much lower in Chesapeake Bay than in the remaining Virginian Province estuaries. Thus, if Chesapeake Bay samples were excluded, mean densities in estuaries would be equivalent to those offshore, although mean diversity and the number of taxa would still be lower. Moreover, only 95 samples were collected throughout the offshore area compared to 353 in estuaries. Because one can expect to find more taxa with increasing sample size, the difference in the number (and diversity) of taxa between offshore and estuarine waters is likely to be even greater than presently described if the sampling efforts were more equivalent.

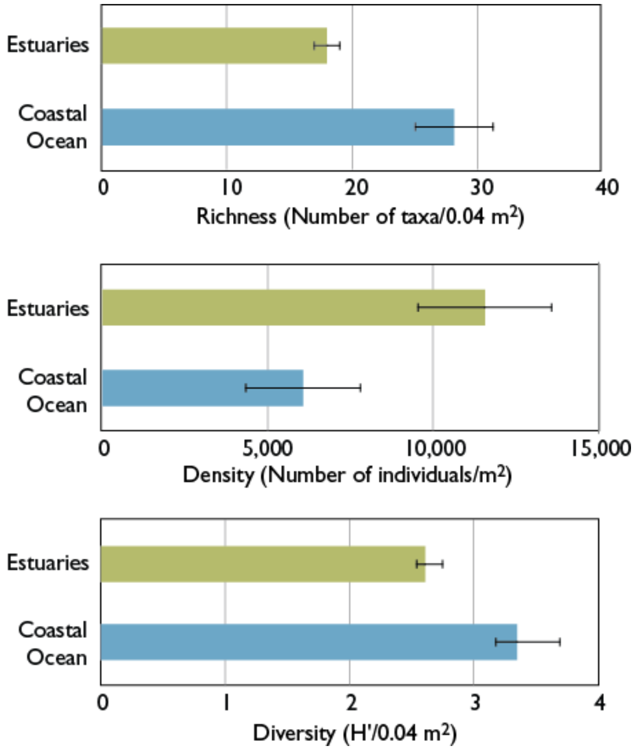


Figure 3-18. Mean richness (# of taxa/0.04 m^2), density (#/m^2), and diversity (Shannon H′/0.04 m^2 using base-2 logarithms) of macrobenthic infauna in Mid-Atlantic Bight coastal ocean and estuarine sediments (Balthis et al., 2009).

Error bars are 95% confidence limits for the mean.

The 10 most abundant offshore taxa, in decreasing order of abundance, included the amphipod crustacean *Ampelisca agassizi*; the polychaete worms *Polygordius* spp. and *Acmira catherinae*; tubuficid oligochaetes (family Tubificidae); the amphipod *Unciola irrorata*; the polychaete *Spiophanes bombyx*; the tanaid crustacean *Tanaissus psammophilus*; the polychaetes *Exogone hebes* and *Goniadella gracilis*; and the maldanid polychaetes (family Maldanidae). The composition of offshore assemblages was markedly different from estuaries, with 6 of the 10 offshore dominants either under-represented (found in < 10% of samples) or completely absent from estuaries. The reverse also was true, with 7 of the 10 most abundant estuarine species being found either in low numbers (occurring in < 10% of samples) or not at all offshore.

Non-Indigenous Species

No non-indigenous species were identified in samples from offshore sites, although some (worms *Harmothoe imbricata* and *Spiophanes. bombyx*) are considered to be of unknown origin. By comparison, a few species of unknown origin (worm *Boccardiella ligerica*, crustacean *Monocorophium acherusicum*) or non-indigenous status (oligochaete *Branchiura sowerbyi*, clam *Corbicula fluminea*) were identified in benthic collections from mid-Atlantic estuaries sampled as part of NCA efforts in 2003–2006. However, the estuarine non-indigenous species would not be expected to occur offshore because the ocean shelf environment would be outside their normal (lower) salinity ranges. Although not observed in the 2006 benthic survey, offshore occurrences of non-indigenous species off the Northeast coastal region have been documented in the literature. For example, the non-indigenous tunicate *Didemnum sp.* has been reported to be colonizing portions of the shelf off of New England and northern mid-Atlantic Bight (Cohen, 2005; Kott, 2004).

Fish Tissue Contaminants

Because none of the species of fish targeted for chemical contaminant analysis was collected during the core survey in May 2006, samples of summer flounder (*Paralichthys dentatus*) were obtained from a subsequent winter bottom-trawl survey conducted February 6–March 2, 2007, by the NOAA NMFS Northeast Fisheries Science Center and used for this report. Fish samples were taken from 30 bottom-trawl locations in shelf waters between Sandy Hook, NJ, and Cape Hatteras, NC. Although these samples were not part of the core probabilistic sampling design and, thus, could not be used to generate spatial estimates of condition, they do provide a good indication of the range of chemical contaminant levels likely to be encountered in edible tissues from bottom fish in the Mid-Atlantic Bight study area.

Concentrations of a suite of metals, pesticides, and PCBs were measured in edible tissues (fillets) of 30 individual summer flounder, one each from the 30 trawl sites, and compared to risk-based EPA Advisory Guideline values for recreational fishers (U.S. EPA, 2000c). None of the 30 stations where fish were measured had chemical contaminants in tissues above the corresponding upper human-health endpoints. Three stations had total PCB concentrations in tissues that were between the corresponding lower and upper endpoints, and two stations (one of which was also one of the stations with PCB exceedances) had total mercury concentrations between these endpoints. These stations would be rated fair based on the NCA cutpoints (see Table 1-21). All other stations had concentrations of contaminants below corresponding lower endpoints and thus were rated good.

Ocean Condition Summary—Mid Atlantic Bight

No major indications of poor sediment or water quality were observed in this assessment of Mid-Atlantic Bight coastal-ocean condition. The highest observed TOC concentration was 1.6%, well below the 5% cutpoint used in the NCA evaluations. Dissolved oxygen concentrations in bottom waters were at least 8.1 mg/L (well above the 5 mg/L cutpoint for a good rating), and all sampling sites were rated good for the sediment contamination component indicator, with no chemicals above corresponding ERM values and less than 5 chemicals above corresponding ERL values. Some indications of human impacts were observed in fish tissue contaminant analyses, where concentrations of methylmercury and PCBs were between corresponding lower and upper human-health guideline endpoints; these stations would be rated fair. However, no tissue concentrations exceeded the upper guidance endpoint for any contaminant. In addition, whereas some non-indigenous species were observed in estuarine waters, none were found in any of the offshore benthic samples.

Benthic indices have been developed for estuaries of the mid-Atlantic states, New York-New Jersey Harbor, and Chesapeake Bay (Weisberg et al., 1997; Adams et al., 1998; Llansó et al., 2002a, 2002b), and an index is being developed for near-coastal New Jersey (to 3 km; Strobel et al., 2008). However, no such index exists for coastal ocean shelf waters of the mid-Atlantic region. In the absence of a benthic index, Balthis et al. (2009) attempted to assess potential stressor impacts in the Mid-Atlantic Bight offshore study by evaluating linkages between reduced values of biological attributes (numbers of taxa, diversity, and abundance) and corresponding measured indicators of poor sediment or water quality. Using the lower 10th percentile as a basis for defining “low” values, they looked for co-occurrences of low values of biological attributes with indications of poor sediment or water quality based on NCA cutpoints.

An analysis of potential biological impacts (see text box) revealed no major evidence of impaired benthic condition linked to measured stressors. In fact, no indications of poor sediment or water quality were observed based on the cutpoints for poor ratings for the sediment contaminants, sediment TOC, and dissolved oxygen component indicators. These results suggest that coastal shelf waters and sediments of the Mid-Atlantic Bight are in good condition, with lower-end values of biological attributes representing parts of a normal reference range controlled by natural factors.

Alternatively, it is possible that, for some of these sites, the lower values of benthic variables reflect symptoms of disturbance induced by other unmeasured stressors. In efforts to be consistent with the underlying concepts and protocols of earlier EMAP and NCA efforts, the indicators in this study included measures of stressors, such as chemical contaminants and symptoms of eutrophication, which often are associated with adverse biological impacts in shallower estuarine and inland ecosystems. However, there may be other sources of human-induced stress in these offshore systems, particularly those causing physical disruption of the seafloor (e.g., commercial bottom trawling, cable placement, minerals extraction) that pose greater risks to living resources and that have not been captured adequately. Future monitoring efforts in these offshore areas should include indicators of such alternative sources of disturbance.

Large Marine Ecosystem Fisheries—Northeast U.S. Continental Shelf LME

The Northeast U.S. Continental Shelf LME extends from the Bay of Fundy, Canada, to Cape Hatteras, NC, along the Atlantic Ocean (Figure 3-19) and is structurally very complex, with marked temperature and climate changes, winds, river runoff, estuarine exchanges, tides, and complex circulation regimes. In this temperate ecosystem, intensive fishing is the primary driving force for changes in the pounds of fish harvested, with climate as the secondary driving force. This LME has an oceanographic regime marked by a recurring pattern of inter-annual variability, but showing no evidence of temperature shifts of the magnitude described for other North Atlantic LMEs, such as the Scotian Shelf LME to the north (Zwanenburg et al., 2002). The Northeast U.S. Continental Shelf LME is one of the world's most productive ecosystems and has been characterized by robust average annual primary productivity (phytoplankton) and relatively stable zooplankton biomass (measure of the quantity, usually in weight, of a stock at a given point in time) for the past 30 years (Sherman et al., 2002). The most visible natural resource capital of the Northeast U.S. Continental Shelf LME is its rich biodiversity of fish, plankton, crustacean, mollusk, bird, and mammal species.

Figure 3-19. Northeast U.S. Continental Shelf LME (NOAA, 2010b).

This LME provides the greatest commercial fishery revenue for the United States, generating over $5 billion from 2003 to 2006. As a group, invertebrates (e.g., American lobster, Atlantic sea scallop, blue crab, quahog, Atlantic surf clam) comprise the most valuable set of commercial fisheries in the Northeast U.S. Continental Shelf LME, with the lobster and scallop fisheries generating the largest portions of that revenue (see Figure 3-19). The other top-grossing commercial fisheries are goosefish (a bottom-dwelling species) and menhaden (a water-column dwelling species described in Chapter 5) (Figure 3-20).

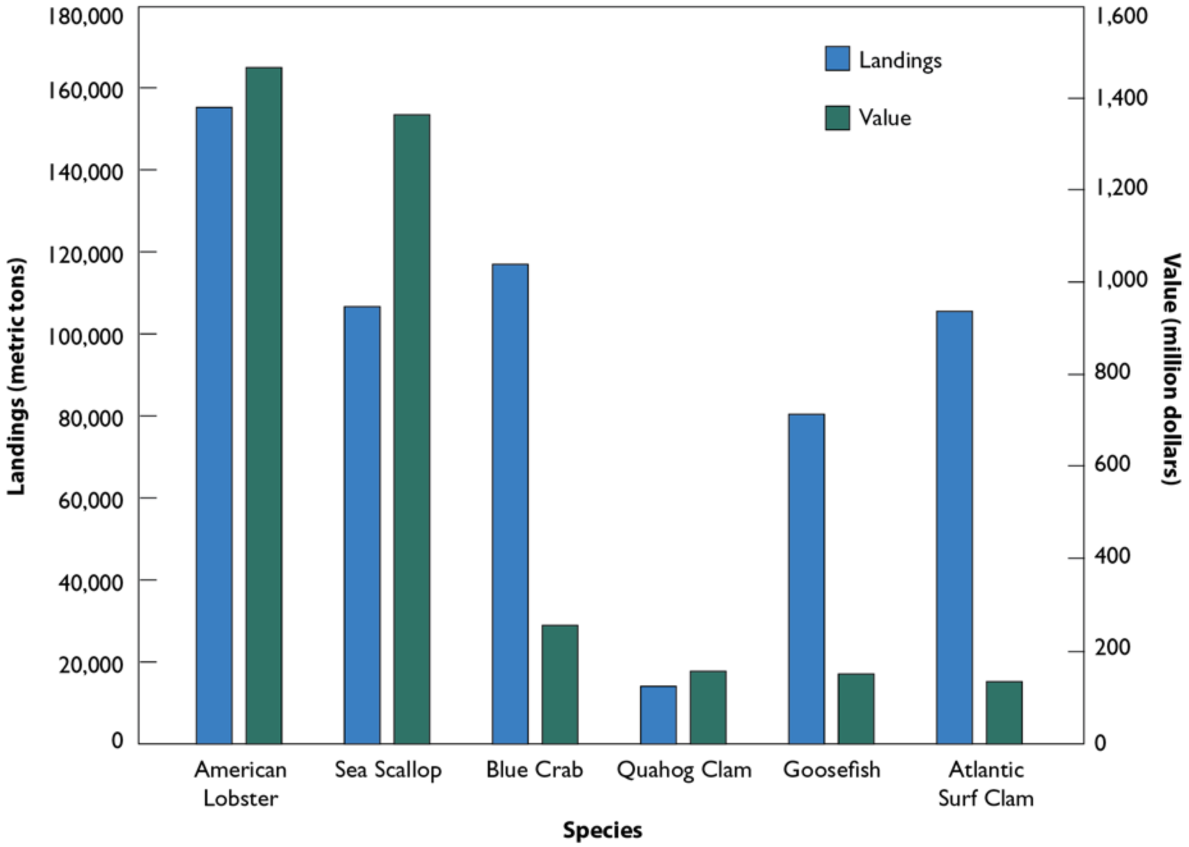


Figure 3-20. Top commercial fisheries for the Northeast U.S. Continental Shelf LME: landings (metric tons) and value (million dollars) from 2003–2006 (NMFS, 2010).

Invertebrate Fisheries

The commercial fisheries for crustaceans (lobster and crab) and mollusks (scallops and clams) are the most valuable fisheries in the Northeast U.S. Continental Shelf LME, with annual U.S. landings averaging 126,600 metric tons and ex-vessel revenues (the value before processing) averaging $884 million per year during 2004–2006. In 2003–2006, the American lobster fishery ranked first in value, with total ex-vessel revenues over $1.4 billion, and the sea scallop fishery ranked second, with total revenues of $1.3 billion (see Figure 3-20). The blue crab and quahog clam fisheries ranked third and fourth, respectively, generating $214 million and $148 million from 2003 to 2006 (see Figure 3-20; NMFS, 2010).

The American lobster (*Homarus americanus),* which is found in the waters of the Northwest Atlantic from Labrador to Cape Hatteras, is an iconic species for much of New England. It feeds on fish and small crustaceans, and its principal natural predators are bottom-dwelling fish (mainly cod and haddock). American lobsters are harvested with baited traps (called pots), which are set on the sea floor, allowing the specimens to be caught alive.

The American lobster fishery is managed under the Interstate Fisheries Management Plan of the Atlantic States Marine Fisheries Commission within state waters and under the Atlantic Coastal Fisheries Cooperative Management Act in offshore federal waters. The primary management controls for this fishery are size limits, release of egg-bearing females, and release of v-notched (breeding) females in some areas. The lobster fishery has become increasingly dependent on small and young lobsters that reach a legal size just prior to capture. Commercial catch rates have markedly declined in nearshore areas, particularly in areas south of Cape Cod and into Long Island Sound, where fishing is heaviest. Lobster abundance in the Gulf of Maine subsystem (Figure 3-21) has remained high despite heavy fishing pressure due to favorable environmental conditions for lobster reproduction and recruitment.

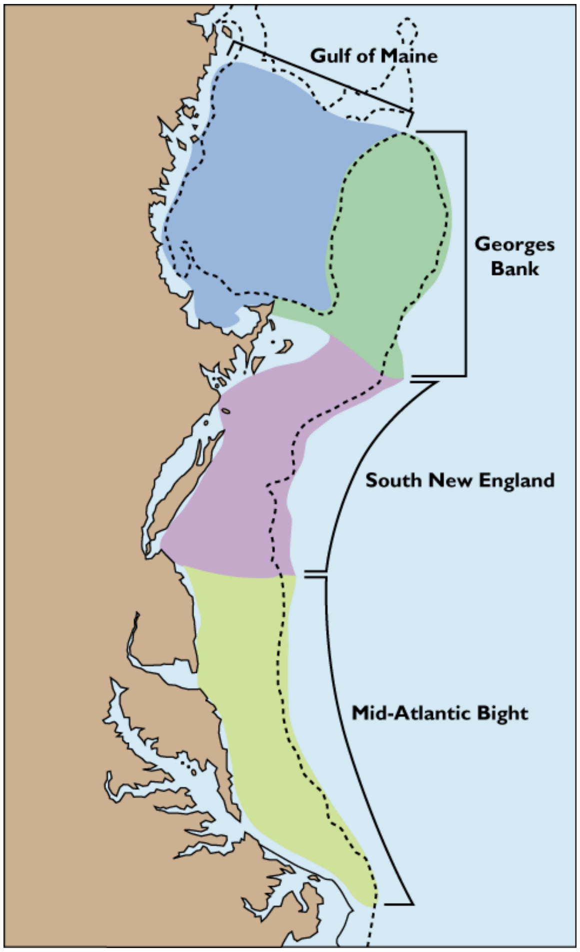


Figure 3-21. Northeast U.S. Continental Shelf LME subareas (Sherman et al., 2002).

The second-largest commercial fishery in the Northeast U.S. Continental Shelf LME is the Atlantic sea scallop (*Placopecten magellanicus),* which generated over $1.3 billion in total ex-vessel revenues from 2003 to 2006, despite significantly lower harvests than the American lobster (see Figure 3-20). Sea scallops are a mollusk, or shellfish, found from Newfoundland, Canada, to Cape Hatteras, NC. They are filter feeders, eating plankton that is siphoned through their mouths. Scallops are primarily harvested with bottom trawls or dredges, which are dragged by fishing vessels along the sea bottom, shoveling specimens into a steel scoop. At $13,198 per ton, the Atlantic sea scallop fishery is one of the most valuable fisheries in the United States, as well as the most valuable wild scallop fishery in the world (NMFS, 2009b).

The Atlantic sea scallop fishery is managed under the *Atlantic Sea Scallops Fishery Management Plan* (NEFMC, 2011b), in cooperation between the New England Fishery Management Council and the Mid-Atlantic Fishery Management Council. Since the 1990s, this FMP has instituted limited access and effort control provisions. Area closures implemented to protect demersal fish in two areas of the Georges Bank subsystem and one on Nantucket Shoals (see Figure 3-21) have also benefited the scallop stock and fishery. In the Mid-Atlantic Bight subsystem, rotational closures over the past decade for a period of 2–3 years have allowed small scallops to grow to a larger size. The combination of effort controls and area closures has rapidly rebuilt the sea scallop fishery so that the biomass is now well above its target and landings are at record levels (Hart and Rago, 2006).

The other major invertebrate fisheries in the Northeast U.S. Continental Shelf LME are blue crabs (*Callinectes sapidus*) and clams (quahog and Atlantic surf). The blue crab, a crustacean prized for its delicate meat, is harvested extensively in the Chesapeake Bay, the Southeast, and the Gulf of Mexico. Within the Northeast U.S. Continental Shelf LME, the blue crab fishery generated over $214 million in total ex-vessel revenues from 2003 to 2006. For more information on the blue crab, see Chapter 4.

The quahog, or hard clam (*Mercenaria mercenaria)*, is a mollusk that is present throughout the waters of the eastern border, but is most abundant from Cape Cod, MA, to New Jersey. From 2003 to 2006, the commercial quahog fishery had total ex-vessel revenues of $148 million, with the largest harvests in Connecticut, New York, and New Jersey. This clam is especially popular in Rhode Island, where it is the state shellfish. It is served in raw bars throughout the Northeast, open-shelled and with cocktail sauce.

Unlike the pervasive quahog, the habitat of the Atlantic surf clam (*Spisula solidissima*) is restricted to the coastal waters off New Jersey, New York, and Massachusetts, with these three states generating most of the $130 million total ex-vessel revenues from the 2003 to 2006 harvest. Although the revenues for these two clam fisheries are similar, the per-ton value of the quahog fishery is much greater than that of the Atlantic surf clam, which had landings nearly 10 times larger than the former (see Figure 3-20). This may be attributed to the fact that whereas quahog clams are often served raw, the Atlantic surf clam is often processed for chowder, broths, breaded strips, and other products. Both clam fisheries are managed under the same FMP (MAFMC, 2011) by the Mid-Atlantic Fishery Management Council, which utilizes a quota (catch allocated to individual fishermen) system.

Demersal Fish Fisheries

Of the demersal (bottom-dwelling) group, only goosefish ranks within the top-grossing commercial fisheries for the Northeast Continental Shelf LME; however, other demersal species, such as Atlantic cod, summer flounder, and haddock, once formed the basis of community life in this area or are prized by recreational fishermen. Demersal fisheries in the Northeast U.S. Continental Shelf LME include 35 stocks. The principal demersal fish group includes important species in the cod family (e.g., Atlantic cod, haddock, silver hake, red hake, white hake, pollock), flounders (e.g., yellowtail flounder, winter flounder, witch flounder, windowpane flounder, Atlantic halibut, American plaice), ocean pout, and Acadian redfish. In the Gulf of Maine and Georges Bank subsystems (see Figure 3-21), demersal fisheries are dominated by members of the cod family (e.g., Atlantic cod, haddock, hakes, pollock), flounders, and goosefish (also known as monkfish). In the Mid-Atlantic subsystem, demersal fisheries are primarily for summer flounder, scup, goosefish, and black sea bass. Demersal fish fishermen use various fishing gears including otter trawls, gillnets, traps, and set lines.

Recent (2004–2006) yields of the top 14 demersal species (representing 23 stocks) have averaged about 65,000 metric tons (78% U.S. and 22% Canadian). Many of these stocks are considered overfished and are currently rebuilding, though management efforts since the early 1990s have led to a doubling in overall abundance. Total ex-vessel revenue from the principal U.S. demersal fish commercial landings has dropped in recent years ($107 million in 2003, $83 million in 2006). The Northeast U.S. Continental Shelf LME demersal fish complex also supports important recreational fisheries for summer flounder, Atlantic cod, winter flounder, and pollock.

Currently, the most economically valuable demersal fishery is goosefish (*Lophius americanus).* From 2003 to 2006, the goosefish commercial fishery generated $147 million in total ex-vessel revenue in the Northeast. Goosefish, also known as monkfish, inhabit the bottom waters of the Northwest Atlantic from the Gulf of St. Lawrence down to Cape Hatteras. Their feeding habits are largely determined by availability, and only juveniles are targeted by larger prey species, including sharks, swordfish, and skates.

The goosefish is distinguished by its broad head and wide mouth, which allow this species to consume prey as large or larger than itself. This unique physical characteristic makes goosefish less profitable per landed ton than other fisheries (see Figure 3-20), because often, only the tail is sold to processors. Fishermen use trawls and gillnets to harvest goosefish, which is regulated by the New England Fishery Management Council under the Monkfish FMP (NEFMC, 2011a). This FMP prescribes total allowable catches, gear, time, and area restrictions, as well as a limited access program.

Fishery Trends and Summary

Figure 3-22 shows the trends in commercial landings for the top six fisheries in the Northeast U.S. Continental Shelf LME from 1950 to 2006. These fisheries do not necessarily have the greatest landings in terms of metric tons for the LME, but they generate the greatest ex-vessel revenues. The discrepancy can be attributed to market values. Since 1950, landings of the top commercial fisheries have had considerable annual fluctuations, though only the blue crab and quahog clam have had net decreases. The greatest increase in landings occurred in the American lobster fishery, catches of which rose from 10,000 metric tons in 1950 to just over 40,000 metric tons in 2006. Sea scallop landings have nearly tripled since 1950, while Atlantic surf clam catches increased by 20,000 metric tons (or 500%). Commercial harvests of goosefish began in the mid-1970s, peaked around 27,000 metric tons in the mid-1990s, and have been in decline since 2002 (NMFS, 2010).

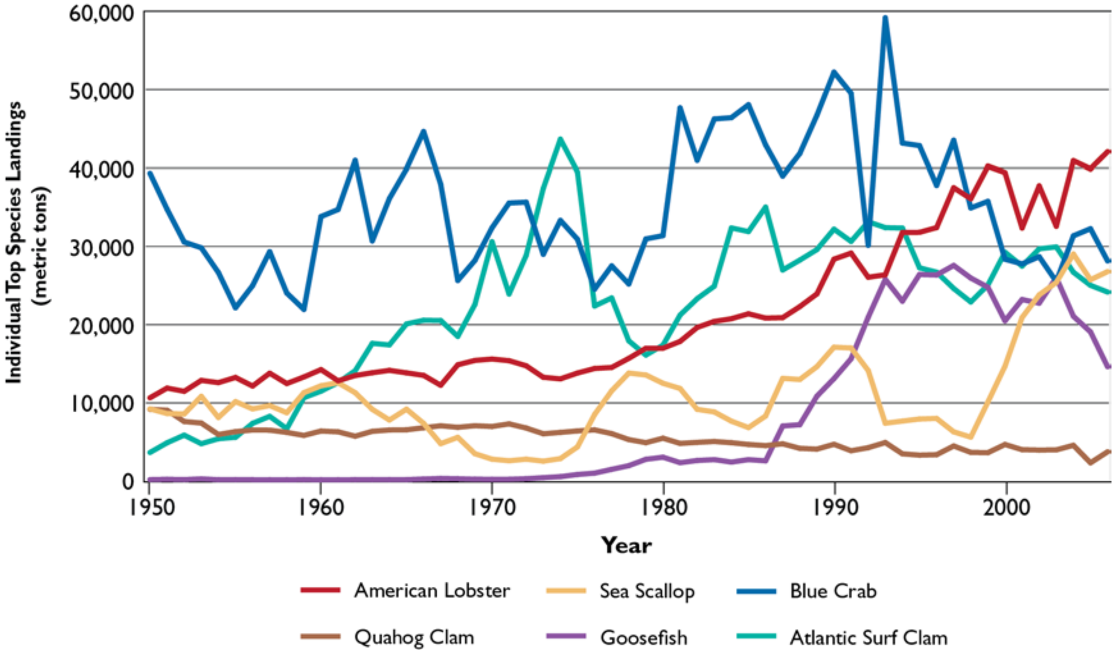


Figure 3-22. Landings of top commercial fisheries in the Northeast U.S. Continental Shelf LME from 1950 to 2006, metric tons (NMFS, 2010).

LMEs provide commercial and recreational fisheries opportunities. Invertebrate species (lobster, crab, scallops, and clams) provided commercial fisheries revenues averaging $884 million per year for 2003–2006. Commercial demersal fisheries averaged about $100 million each year. In addition to the substantial market value of these commercial fisheries, they support other related industries, such as boat building; fuel for vessels; fishing gear and nets; shipboard navigation and electronics; and ship repair and maintenance. Similarly, recreational fish such as striped bass, shad, and salmon, and the demersal fish summer flounder, drive an economic engine that supports tourism, bait and tackle shops, recreational boating, and much more, all of which contributes significantly to the value derived from the ecosystem service of fishery production.

Certainly, the Northeast U.S. Continental Shelf LME provides fish and shellfish for food, but there are additional ecosystem services and functions provided by this LME. Fish and shellfish are part of complex ecosystems that rely on various species interactions for the maintenance of necessary ecosystem functions. For instance, invertebrates and pelagic species provide sustenance for larger fish, like the goosefish, which themselves are prey for marine mammals and seabirds. These seabirds and marine mammals help support the ecotourism industry. Many functions performed by species in the LME indirectly benefit humans, including water purification by bivalves such as scallops, clams, and oysters. While feeding, these bivalves filter the water constantly, which helps to clean the water of algae, detritus, and toxics, resulting in a more enjoyable beach or boating experience for humans.

Advisory Data

Fish Consumption Advisories

In 2006, 7 of the 11 Northeast Coast states had statewide consumption advisories for fish in coastal waters, placing nearly all of their coastal and estuarine areas under advisory. The states were Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, and Rhode Island. Due in large part to these statewide advisories, an estimated 84% of the coastal miles of the Northeast Coast and 82% of the region's estuarine area was under fish consumption advisories (Figure 3-23) in 2006, with a total of 49 different advisories active for the estuarine and coastal waters of the Northeast Coast during that year. These advisories were in effect for eight different pollutants (Figure 3-24).

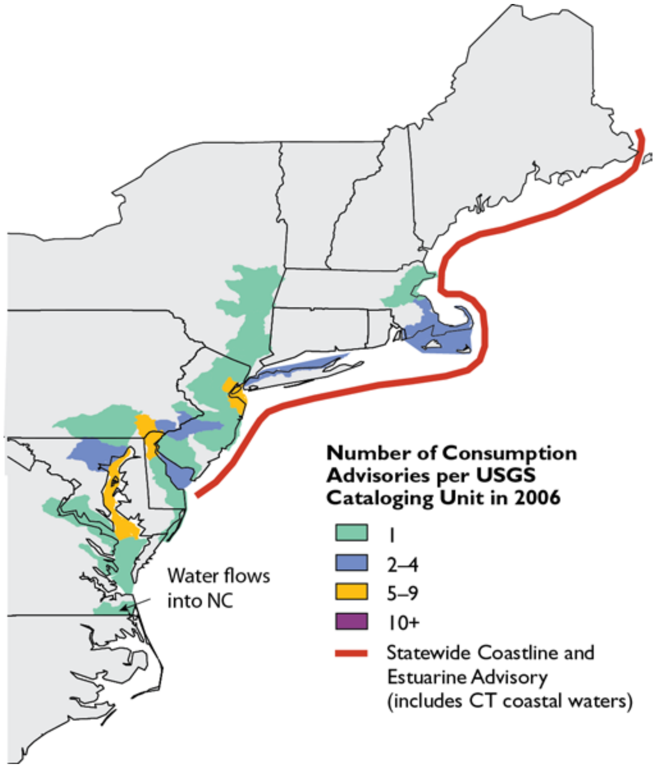


Figure 3-23. The number of fish consumption advisories active in 2006 for the Northeast Coast coastal waters (U.S. EPA, 2007c).

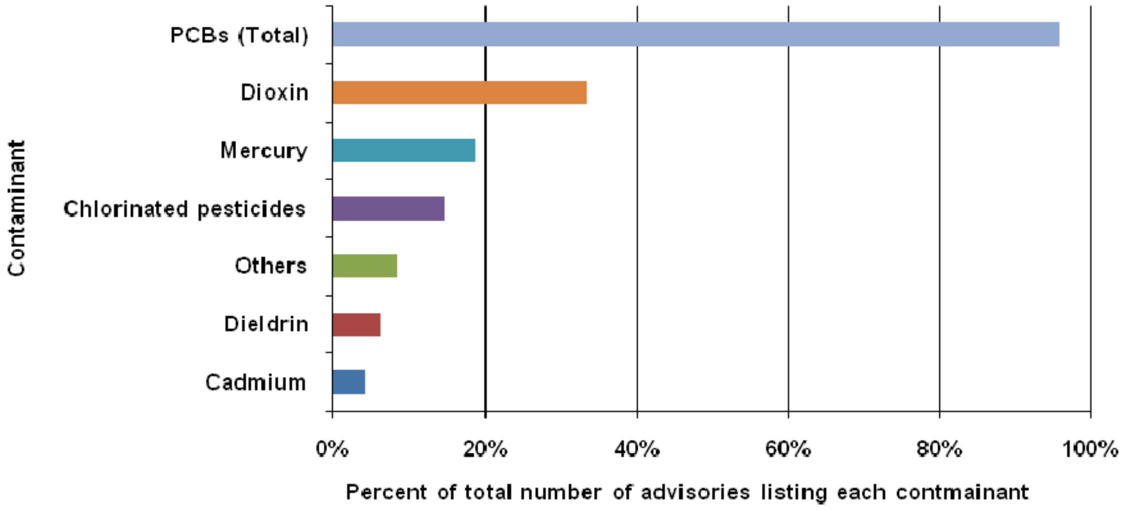


Figure 3-24. Pollutants responsible for fish consumption advisories in Northeast Coast coastal waters.

An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2007c).

Most of the fish advisory listings (96%) were, at least in part, caused by PCBs. Boston Harbor was listed for multiple pollutants (U.S. EPA, 2007c). Table 3-2 lists the species and/or groups under fish consumption advisory in 2006 for at least some part of the coastal waters of the Northeast Coast region.

Table 3-2. Species and/or Groups under Fish Consumption Advisory in 2006 for at Least Some Part of the Coastal Waters of the Northeast Coast Region

Species and/or Groups under Fish Consumption Advisory	
American eel	Atlantic needlefish
Bivalves	Bluefish
Bluegill sunfish	Blue crab (whole and hepatopancreas)
Brown bullhead	Common carp
Channel catfish	Flounder
Gizzard shad	Goldfish
King mackerel	Largemouth bass
Lobster (whole and tomalley)	Rainbow smelt
Scup Shark	Shellfish
Smallmouth bass	Striped bass
Swordfish	Tautog
Tilefish	Trout
Tuna	Walleye
White catfish	White perch

Source: U.S. EPA, 2007c

Beach Advisories and Closures

How many notification actions were reported for the Northeast Coast between 2004 and 2008?

Table 3-3 presents the number of total beaches and monitored beaches, as well as the number and percentage of monitored beaches, affected by notification actions from 2004 to 2008 for the Northeast Coast (i.e., New York's coastal beaches, Connecticut, Maine, Massachusetts, New Hampshire, Rhode

Island, New Jersey, Delaware, Maryland, and Virginia). Despite a slight increase in the number of monitored beaches for the Northeast Coast region from 2004 to 2005, the percentage of beaches affected by notification actions did not change for these years. Between 2006 and 2008, there were large fluctuations in the total number of identified and monitored beaches in this region, although little increase in the percentage of monitored beaches with advisories (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's BEACH Program Monitoring site: http://www.epa.gov/waterscience/beaches/seasons/.

Table 3-3. Beach Notification Actions, Northeast Coast, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004[a]	2005[a]	2006	2007	2008
Total number of beaches	1,740	1,607	1,782	1,685	1,713
Number of monitored beaches	1,440	1,445	1,611	1,508	1,534
Number of beaches affected by notification actions	212	214	389	375	401
Percentage of monitored beaches affected by notification actions	15%	15%	24%	25%	26%

[a] Data from New York are not included for these years because the summaries under the EPA's BEACH Program did not differentiate between the State's Great Lakes and marine beaches.

What pollution sources impacted monitored beaches?

Table 3-4 presents the numbers and percentages of monitored Northeast Coast beaches affected by various pollution sources for 2007. Non-investigated, unknown, and unidentified pollution sources affected over 70% of beaches on the Northeast Coast in 2007. The other major reason for advisories was storm-related runoff, which contributed to over 30% of 2007 advisories. Other sources, including septic and sewer systems (i.e., leakage, break, and overflow), non-storm runoff, boat discharge, wildlife, and treatment works accounted for around 10% of the advisories (U.S. EPA, 2009d).

Table 3-4. Reasons for Beach Advisories, Northeast Coast, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Pollution sources not investigated	495	33%
Storm-related runoff	473	31%
No known pollution sources	399	26%
Other and/or unidentified sources	174	12%
Sanitary/combined sewer overflow	46	3%
Wildlife	19	1%
Non-storm related runoff	15	1%
Boat discharge	13	< 1%
Septic system leakage	12	< 1%
Publicly owned treatment works	5	< 1%
Sewer line leak or break	5	< 1%

Note: A single beach advisory may have multiple pollution sources.

How long were the 2007 beach notification actions?

Over 50% of beach notifications in the Northeast in 2007 lasted 1 day, whereas over 25% lasted for only 2 days. Although beach notification actions of the 3- to 7-day duration accounted for over 15% of all the notifications, those lasting 8 to 30 days comprised only 3% of the advisories. Notifications of the greatest duration (over 30 days) accounted for less than 1% of all the advisories for the Northeast Coast region in 2007 (U.S. EPA, 2009d). For more information on state beach closures, please visit EPA's Beaches website: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

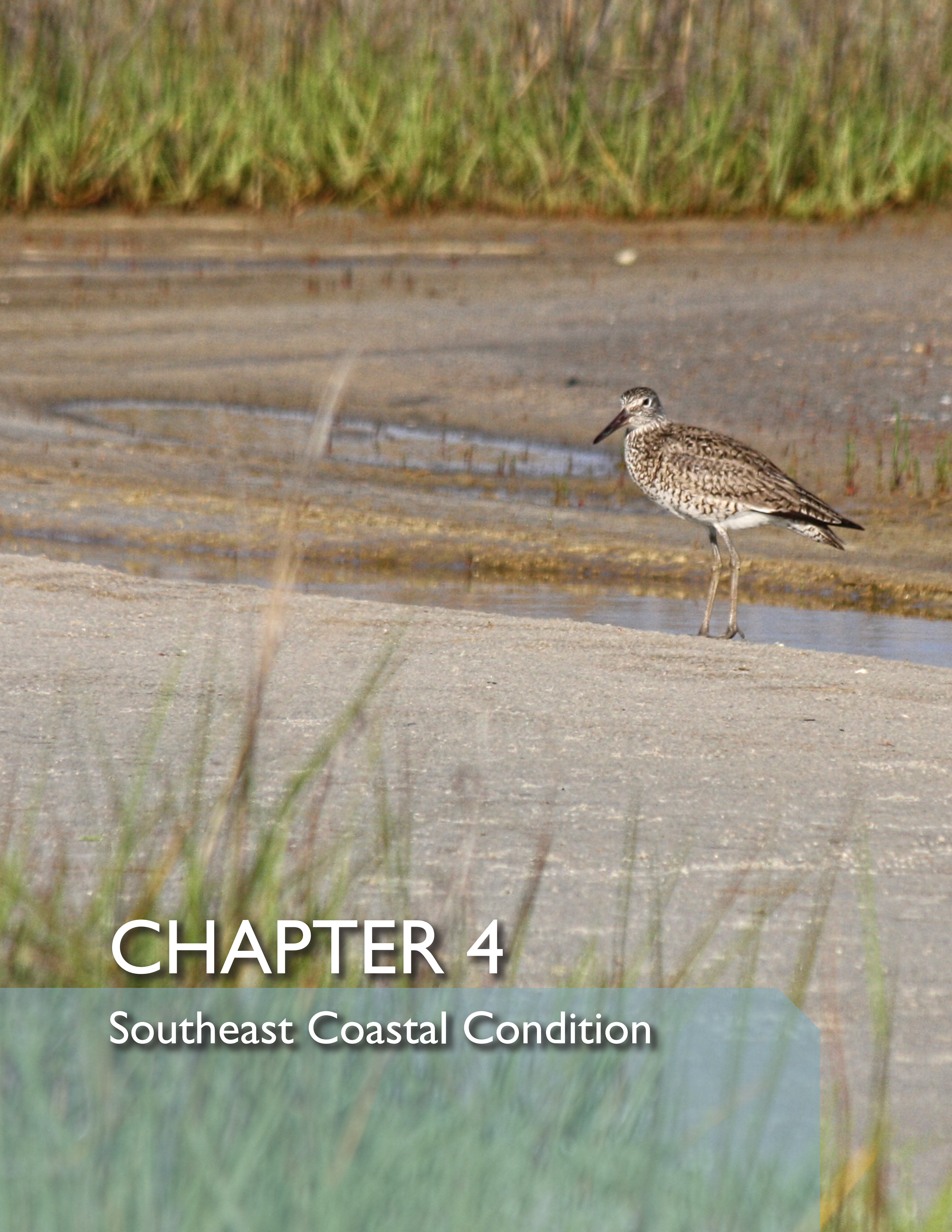
Summary

Based on data from NCA and NOAA, the overall condition of Northeast Coast coastal waters is rated fair. Good water quality conditions predominate in the well-mixed, open estuaries of the Gulf of Maine, whereas the poorly flushed and highly settled estuaries south of Cape Cod are more susceptible to eutrophication. 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 31% of the coastal area, often in the vicinity of high human population density. The coastal habitat index is rated good to fair. However, data more recent than 2000 area unavailable in the proper format, and the coastal habitat index score for the Northeast Coast region is the same as was reported in the NCCR III. Fish tissue contamination is also a concern in this region, with 20% of the samples rated poor and 20% rated fair.

The assessment of ocean condition in the Mid-Atlantic Bight found no major indications of poor sediment or water quality conditions. Some indications of poor condition were observed in fish tissue contaminant analyses of methylmercury and PCBs; however, no contaminants exceeded the upper guidance limits.

NOAA's NMFS manages several fisheries in the Northeast U.S. Continental Shelf LME, including invertebrates and demersal fish. Invertebrates, especially lobsters and scallops, are the most commercially valuable fishery in the Northeast Coast region. Lobster abundance in the Gulf of Maine has remained high in recent years due to favorable environmental conditions, despite heavy fishing pressure. The combination of effort controls and area closures has rapidly rebuilt the sea scallop fishery in the Mid-Atlantic Bight so that the landings are at record levels. Many stocks of principal demersal fish (such as cod and flounder) in this LME are considered overfished and currently rebuilding. However, after a decade of control measures, several of the demersal fish populations have begun to recover. Currently, goosefish are the most economically valuable demersal fishery, although they are less valuable per landed ton than other fish because, often, only the tail is sold. In addition to the substantial market value of these commercial fisheries, recreational fish such as striped bass, shad, salmon, and summer flounder drive an economic engine that supports tourism, bait and tackle shops, recreational boating, and other recreations, all of which contributes significantly to the value derived from the ecosystem service of fishery production.

Contamination in the coastal waters of the Northeast Coast region has affected human uses of these waters. In 2006, more than 80% of the region's coastal miles and estuarine areas were under fish consumption advisories. Most advisories (greater than 90%) were issued for PCB contamination, alone or in combination with one or more other contaminants. In addition, approximately 24% of the region's monitored beaches were closed or under advisory for some period of time during 2006. Elevated bacteria levels in the region's coastal waters were primarily responsible for the beach closures and advisories.



CHAPTER 4

Southeast Coastal Condition

4. Southeast Coast Coastal Condition

As shown in Figure 4-1, the overall coastal condition of the coastal waters of the Southeast Coast region is rated fair, with an overall condition score of 3.6. The benthic and fish tissue indices for the Southeast Coast region are rated good, the water quality and coastal habitat indices are rated fair; and the sediment quality index is rated fair to poor. Figure 4-2 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories 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 557 locations throughout Southeast Coast coastal waters using comparable methods and techniques.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

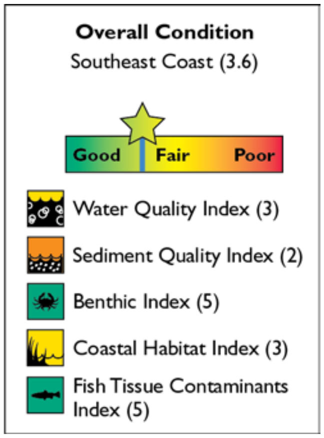


Figure 4-1. The overall condition of Southeast Coast coastal waters is rated fair (U.S. EPA/NCA).

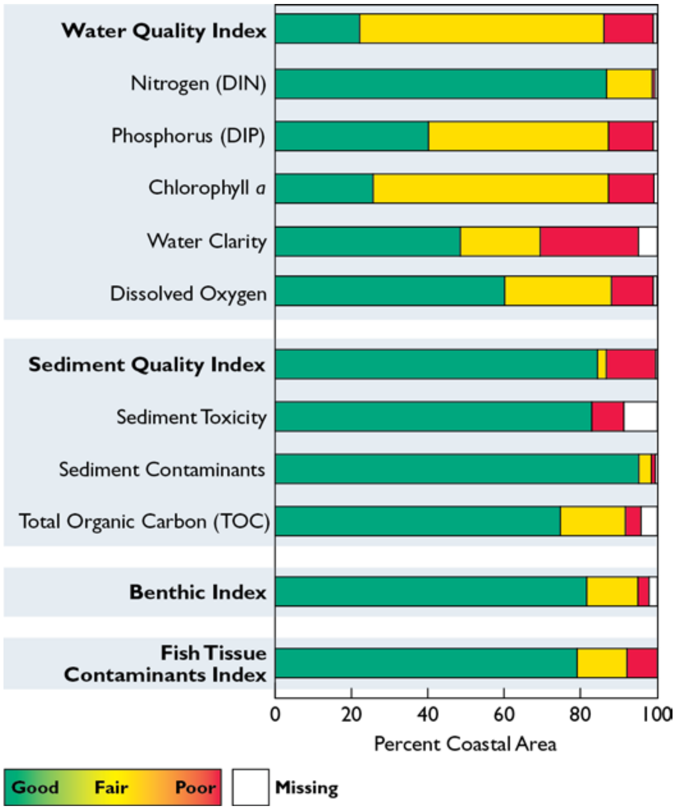


Figure 4-2. Percentage of coastal area achieving each ranking for all indices and component indicators—Southeast Coast region (U.S. EPA/NCA).

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 this region are diverse and extensive, covering an estimated 4,487 square miles. 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 part of the West Indian Province, which runs along the east coast of Florida from the Indian River Lagoon through Biscayne Bay. The borders of the Southeast Coast region roughly coincide with the borders of the Southeast U.S. Continental 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. The 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 2006, the coastal counties of the Southeast Coast region showed the largest rate of population increase (79%) of any coastal region in the conterminous United States from 7.15 million to 12.8 million people (Figure 4-3). The population density in Southeast Coast coastal counties (Figure 4-4) has also increased over this timeframe, from 186 to 332 persons/square mile (NOEP, 2010). There is evidence of human-induced stress in some areas of the Southeast Coast region. 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.

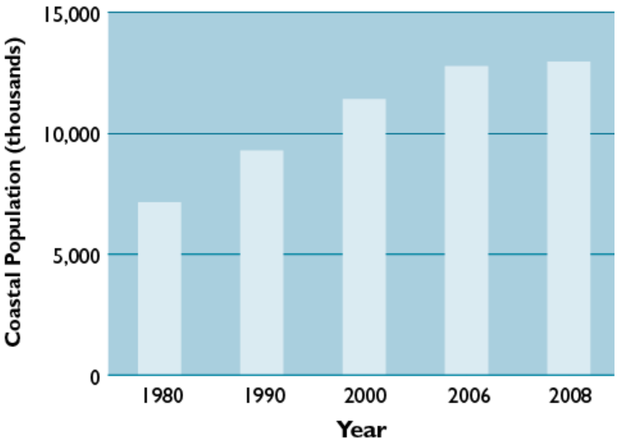


Figure 4-3. Population of coastal counties in Southeast Coast states, 1980–2008 (NOEP, 2010).

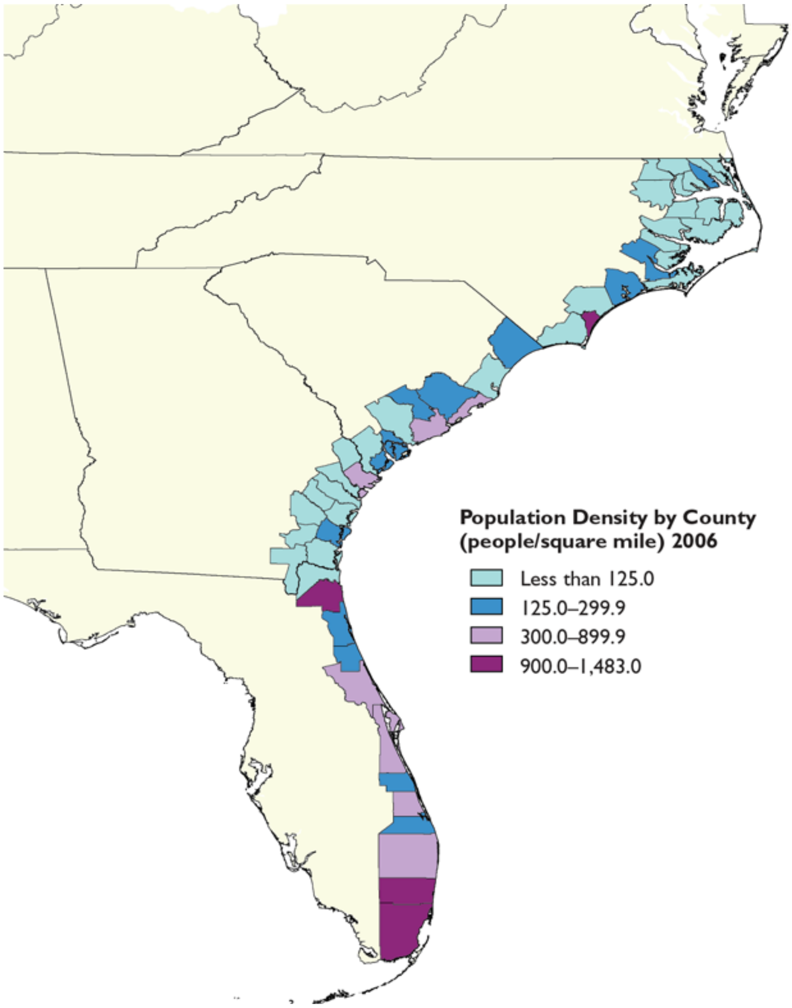


Figure 4-4. Population density in the Southeast Coast region's coastal counties in 2006 (NOEP, 2010).

Coastal Monitoring Data—Status of Coastal Condition

Several programs have monitored the coastal waters of the Southeast Coast region, including NOAA's NS&T Program and EPA's EMAP Carolinian Province. EPA's NCA program began partnerships with coastal states in this region in 1999 (South Carolina), 2000 (Georgia, Florida), and 2001 (North Carolina). Sampling sites were chosen randomly to represent larger spatial scales. Participating state partners sampled waters during the summer, when conditions were expected to be most stressful (i.e., experiencing low dissolved oxygen levels). This probabilistic sampling approach enabled comparison within and across state boundaries and allowed for the presentation of data in terms of percentages of coastal area rated good, fair, and poor.

Water Quality Index

The water quality index for the coastal waters of the Southeast Coast region is rated fair, with 13% of the coastal area rated poor and 64% of the area rated fair for water quality condition (Figure 4-5). The water quality index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen.

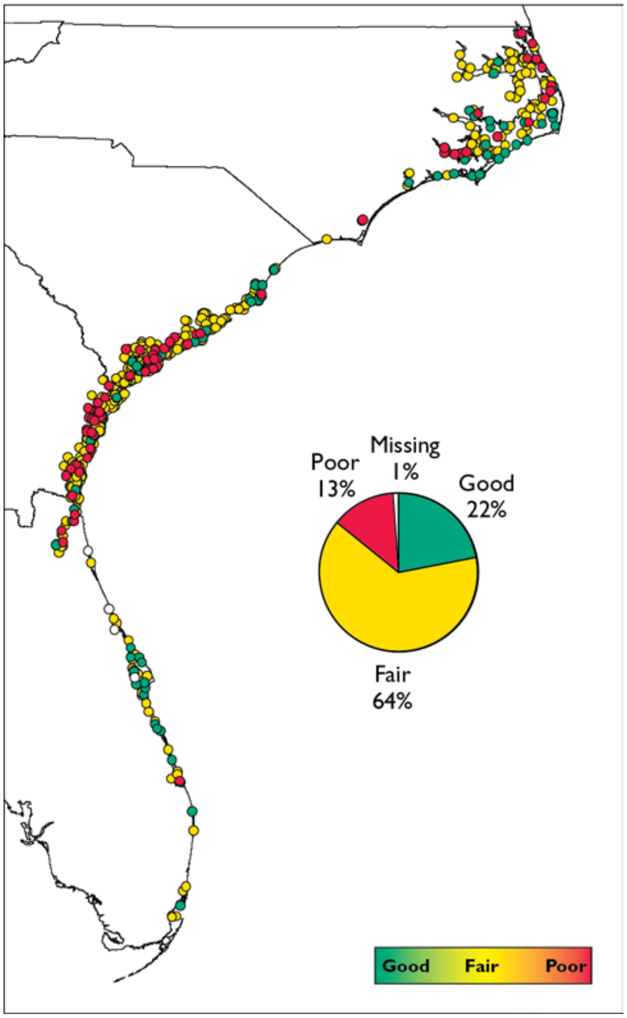


Figure 4-5. Water quality index data for Southeast Coast coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The Southeast Coast region is rated good for DIN concentrations because 1% of the region's coastal area was rated poor and 12% of the area was rated fair for this component indicator. The Southeast Coast region is rated fair for DIP concentrations, with 12% of the coastal area rated poor and 47% of the area rated fair for this component indicator.

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 would be required to define temporal variability and to confirm environmental condition at specific locations.

Chlorophyll a

The Southeast Coast region is rated fair for chlorophyll *a* because 73% 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 poor, with 21% of the coastal area rated fair and 26% of the area rated poor for this component indicator. The cutpoints 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 Chapter 1 for additional information). The box shows the cutpoints for rating a site in poor condition for water clarity in estuarine systems with differing levels of natural turbidity.

Coastal Areas	Cutpoints for a Poor Rating (Percentage of Ambient Light that Reaches 1 Meter in Depth)
Indian River Lagoon Estuarine System	< 20%
Albemarle-Pamlico and Biscayne Bay estuarine systems	< 10%
All remaining Southeast Coast estuarine systems	< 5%

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Data were not collected during other time periods.

Dissolved Oxygen

The Southeast Coast region is rated fair for dissolved oxygen concentrations, with 11% of the coastal area rated poor and 28% of the area rated fair for this component indicator.

Sediment Quality Index

The sediment quality index for the coastal waters of the Southeast Coast region is rated fair to poor, with 2% of the coastal area rated fair and 13% of the area rated poor for sediment quality condition (Figure 4-6). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

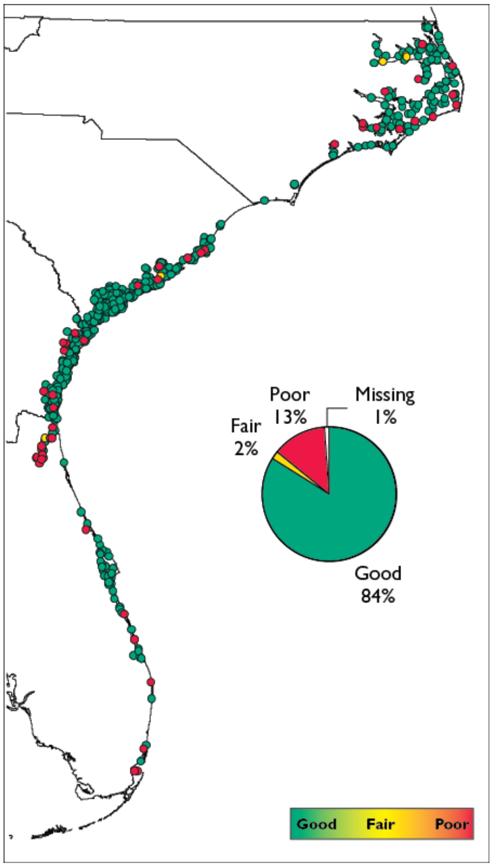


Figure 4-6. Sediment quality index data for Southeast Coast coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The Southeast Coast region is rated poor for sediment toxicity, with 83% of the area rated good and approximately 8% of the coastal area rated poor for this component indicator. The threshold for a good rating is less than or equal to 5% of the area being rated poor. Although the rating changed from good in previous surveys to poor, there was only a 3% change in the areal extent of sediments considered toxic. Sediment toxicity is commonly associated with high concentrations of metals or organic chemicals with known toxic effects on benthic organisms; however, most of the sites that were rated poor for sediment toxicity did not have high concentrations of sediment contaminants measured through the NCA. The toxicity at these sites may have been caused by naturally occurring conditions or persistent levels of contaminants that were not measured by the NCA.

Sediment Contaminants

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

Sediment TOC

The Southeast Coast region is rated good for sediment TOC concentrations, with 17% of the coastal area rated fair and 4% of the area rated poor for this component indicator.

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 82% of the Southeast Coast region's coastal area was rated good for benthic condition, 13% of the area was rated fair, and 3% of the area was rated poor (Figure 4-7). Stations rated poor were located in portions of the northern portion of Florida's St. Johns River; portions of the Savannah, Bear, Vernon, and Medway rivers in Georgia; the Neuse and New rivers in North Carolina; and the Coosaw River, Cape Romaine Refuge, and Winyah Bay in South Carolina.

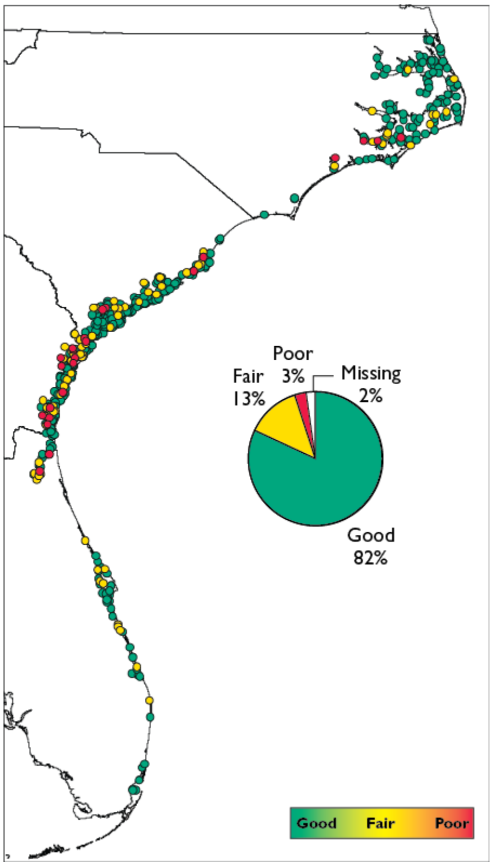


Figure 4-7. Benthic index data for Southeast Coast coastal waters (U.S. EPA/NCA).

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) and NCCR III (U.S. EPA, 2008c), coastal 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%. Human activities (e.g., land development, eutrophication, the introduction of toxic chemicals and exotic species) can directly impact wetlands. Sea-level rise, subsidence, and interference with normal erosional/depositional processes and water flow paths can also contribute to wetland losses.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of the Southeast Coast region is rated good. Fish tissue samples were collected at 368 of the 557 NCA sampling sites (64%) in the Southeast Coast region. Figure 4-8 shows that 8% of sites sampled where fish were caught were rated poor using whole-fish contaminant concentrations and EPA Advisory Guidance values. Contaminant concentrations exceeding EPA advisory guidance values in Southeast samples were observed primarily in Atlantic croaker, catfish, and spot (U.S. EPA, 2000c). Commonly observed contaminants included total PAHs, PCBs, DDT, mercury, and arsenic.

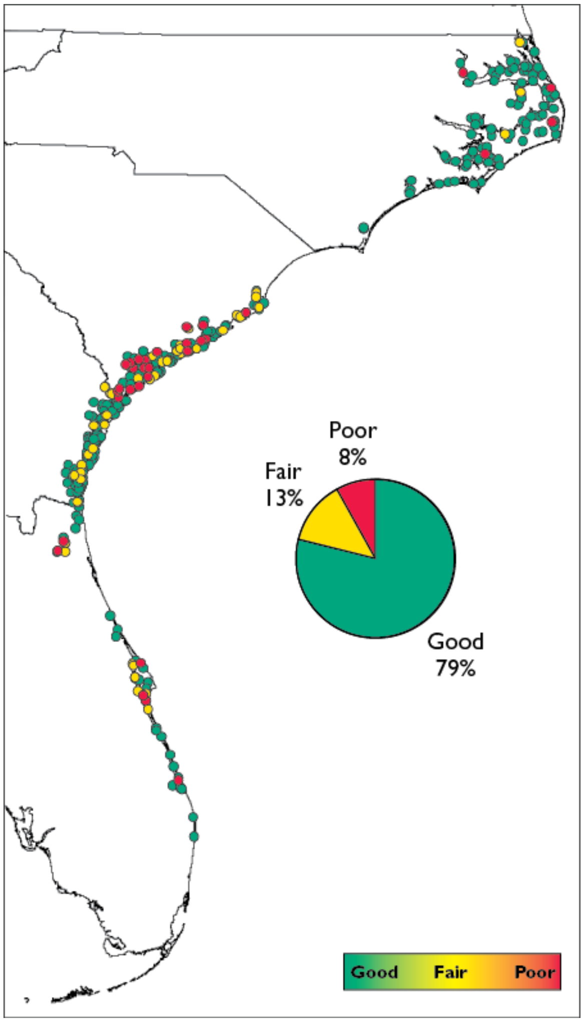


Figure 4-8. Fish tissue contaminants index data for Southeast Coast coastal waters (U.S. EPA/NCA).

Trends of Coastal Monitoring Data—Southeast Coast Region

Temporal Change in Ecological Condition

In 2000, EMAP-NCA initiated annual surveys of coastal condition in the Southeast. Results stemming from the 2000 and 2001–2002 surveys have been reported in the NCCR II and III, respectively. The NCCR IV represents the final installment of EMAP-NCA assessments and reports on data collected during a 3-year period, 2003–2006. The 7 years of accumulated monitoring data provide an ideal opportunity to investigate temporal changes in ecological condition assessment indicators. For the Southeast, these data can be analyzed to answer two basic types of assessment-related trend questions: what is the inter-annual variability in the proportions of area rated poor from 2000 to 2006; and has there been a significant change in the proportion of poor area from 2000 to 2006?

All of the condition indicators can be compared over time because data supporting these parameters were collected using similar protocols and QA/QC methods. NCA implemented probability-based surveys to estimate the percentage of coastal 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 cutpoints listed in Chapter 1 were used to determine good, fair, or poor condition for each index and component indicator. Inter-annual variation was evaluated by comparing annual estimates of the percent area in poor condition for each indicator and the associated standard error. A 2-year survey design was implemented for 2005–2006; therefore, this period was treated as a single "year." Trends in the percent area in poor condition for each indicator were evaluated using the Mann-Kendall statistical test. Although there were minor differences from year to year, there were no statistically significant trends in water quality, sediment quality, or benthic condition in the Southeast estuaries from 2000–2006.

Neither the water quality index nor any of the component indicators showed a significant linear trend over time in the percent area rated in poor condition (Figures 4-9 through 4-14).

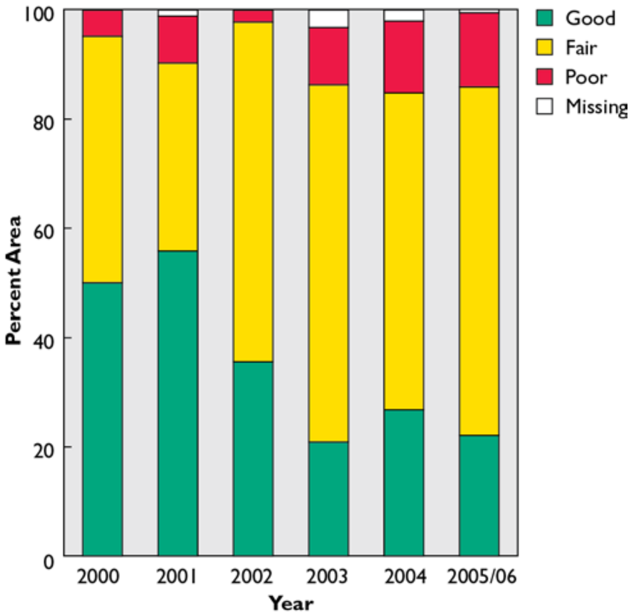


Figure 4-9. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for water quality index measured from 2000–2006 (U.S. EPA/NCA).

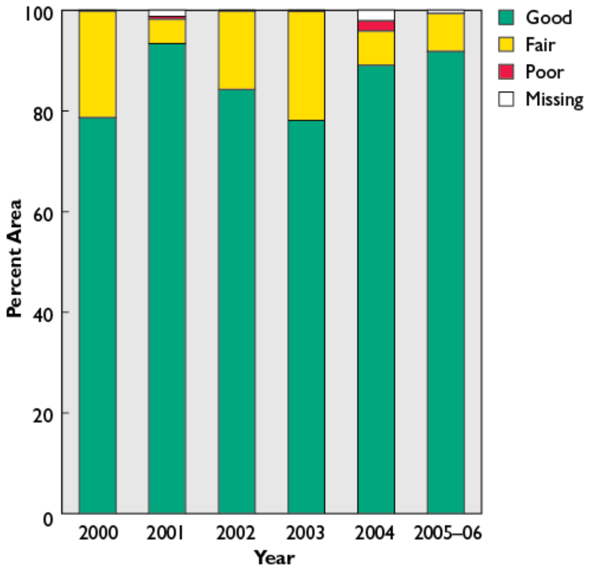


Figure 4-10. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for dissolved inorganic nitrogen measured from 2000–2006 (U.S. EPA/NCA).

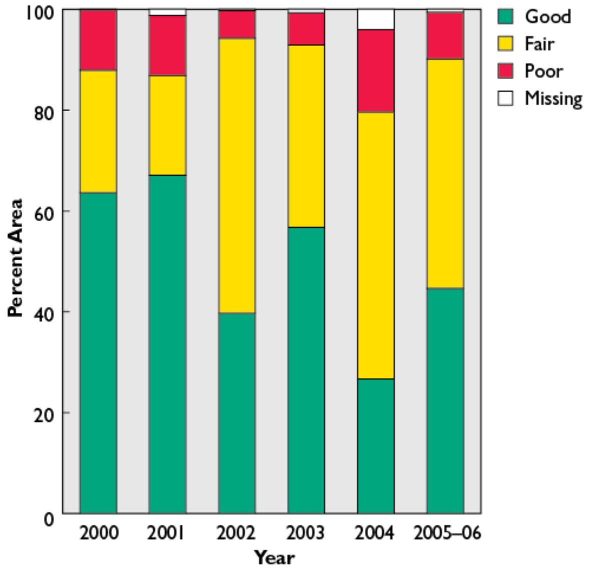


Figure 4-11. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for dissolved inorganic phosphorus measured from 2000–2006 (U.S. EPA/NCA).

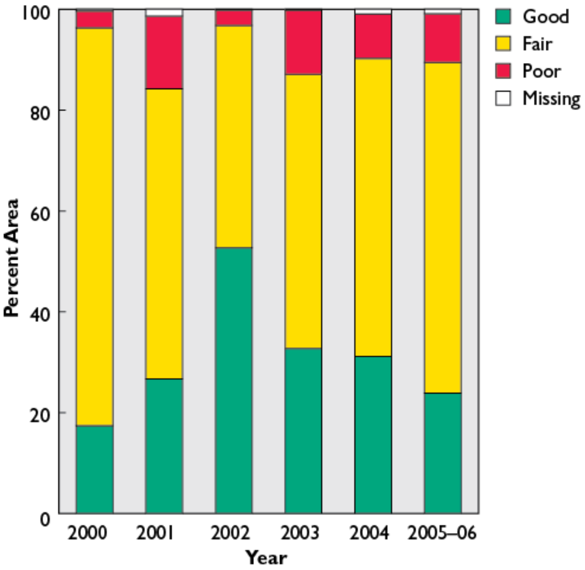


Figure 4-12. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for chlorophyll *a* measured from 2000–2006 (U.S. EPA/NCA).

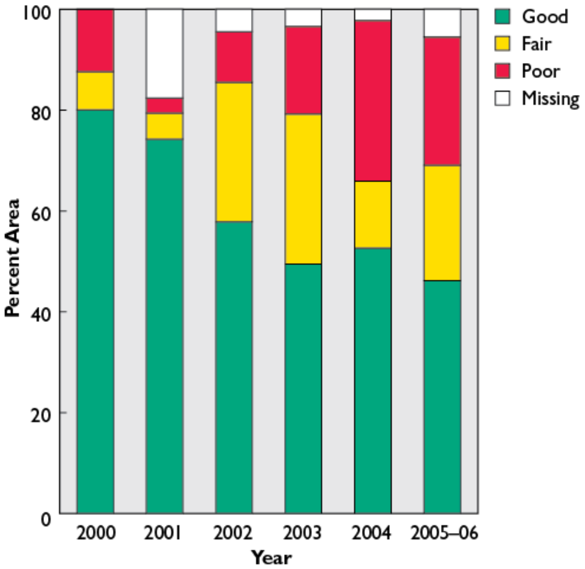


Figure 4-13. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for water clarity measured from 2000–2006 (U.S. EPA/NCA).

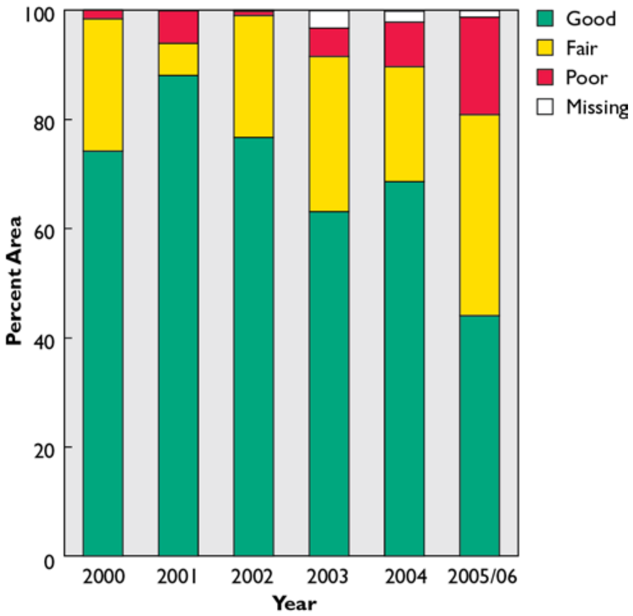


Figure 4-14. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for bottom-water dissolved oxygen concentrations measured from 2000–2006 (U.S. EPA/NCA).

The sediment quality index and component indicators (i.e., sediment toxicity, sediment contaminants, and sediment TOC) were also compared over time (Figures 4-15 through 4-18). Although there were no significant differences in the percent area rated poor for any of the indicators, the percent area rated poor for the sediment quality index in 2003 was higher than for other survey years. This was largely due to amount of area rated poor for sediment toxicity in 2003.

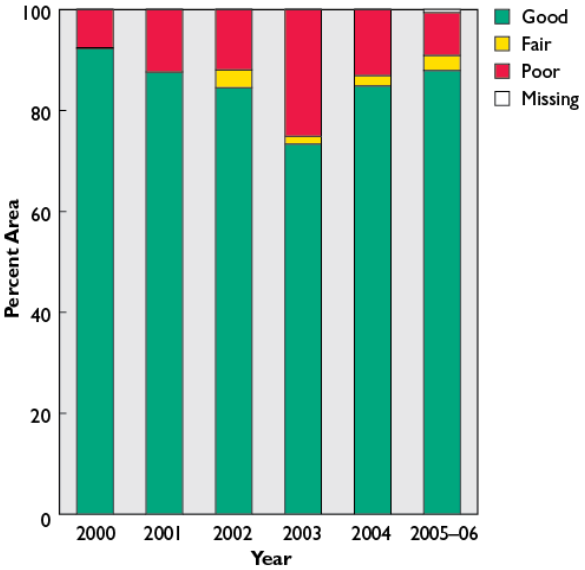


Figure 4-15. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for sediment quality

index measured from 2000–2006 (U.S. EPA/NCA).

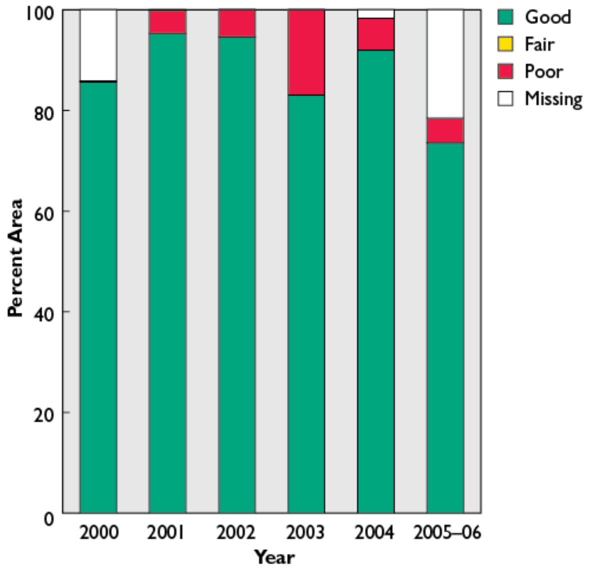


Figure 4-16. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for sediment toxicity measured from 2000–2006 (U.S. EPA/NCA).

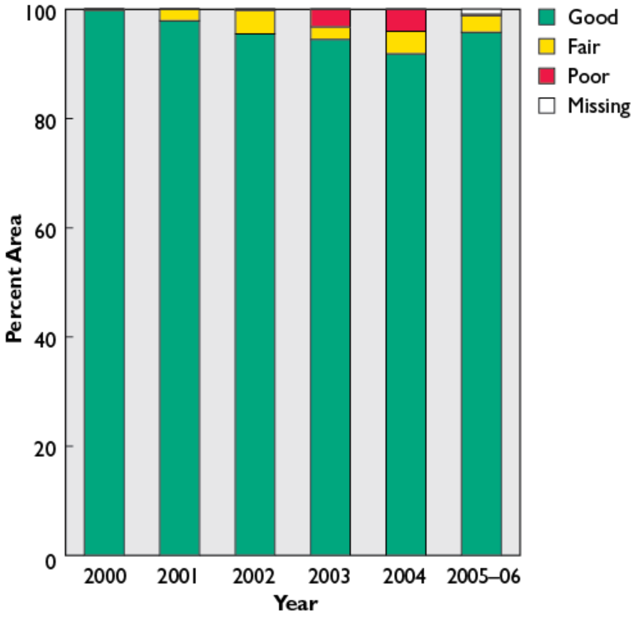


Figure 4-17. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for sediment contaminants measured from 2000–2006 (U.S. EPA/NCA).

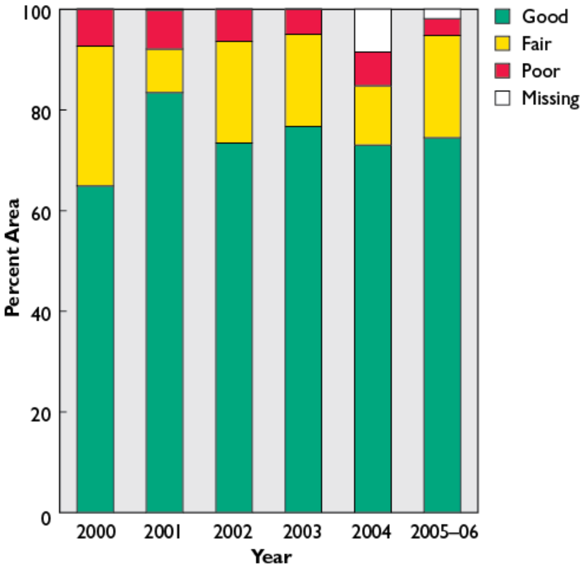


Figure 4-18. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for sediment TOC measured from 2000–2006 (U.S. EPA/NCA).

The benthic index for Southeast 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. There was no significant trend in the percent area with poor benthic condition from 2000–2006. However, the percent area with poor benthic condition decreased fairly steadily from 2000 to 2006 (Figure 4-19).

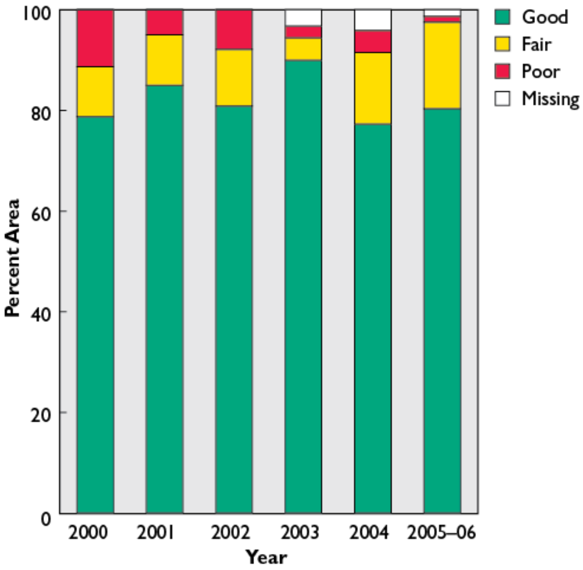


Figure 4-19. Percent area of Southeast Coast coastal waters in good, fair, poor, or missing categories for benthic index measured from 2000–2006 (U.S. EPA/NCA).

Coastal Ocean Condition—South Atlantic Bight

The South Atlantic Bight generally is defined as the coastal region extending from Cape Hatteras, NC, to West Palm Beach, FL (e.g., Alegria et al., 2000), although some authors have used Cape Canaveral as the southern boundary (e.g., Allen et al., 1983). This area encompasses aquatic habitats from estuaries seaward to the outer edge of the continental shelf (Figure 4-20). This region is also roughly equivalent to the Southeast U.S. Continental Shelf LME (U.S. Commission on Ocean Policy, 2004). In March–April 2004, NOAA and the EPA conducted a study to assess the current status of ecological condition and stressor impacts throughout coastal ocean waters of the South Atlantic Bight and to provide this information as a baseline for evaluating future changes due to natural or human-induced disturbances.

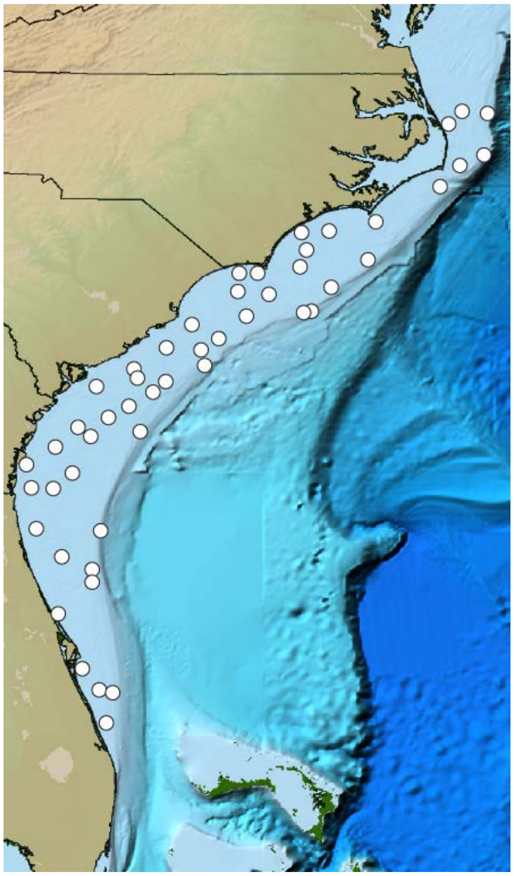


Figure 4-20. Map of Southeast coastal-ocean sampling stations (Cooksey et al., 2010).

To address these objectives, the study incorporated standard methods and indicators applied in previous coastal EMAP/NCA projects and NCCR series (U.S. EPA, 2001b, 2004a, 2008c), including multiple measures of water quality, sediment quality, and biological condition. A probabilistic sampling design, which included 50 stations distributed randomly throughout the region, was used to provide a basis for estimating the spatial extent of condition relative to the various measured indicators and corresponding cutpoints (where available). Conditions throughout these offshore waters are also compared to those of southeastern estuaries, based on data from NCA surveys conducted in 2003–2006 (featured in the previous section). A more detailed report on results of the South Atlantic Bight offshore assessment is provided by Cooksey et al. (2010).

Water Quality

Nutrients: Nitrogen and Phosphorus

The average concentration of DIN (i.e., nitrogen as nitrate + nitrite + ammonium) in ocean surface waters was 0.038 mg/L. Estuarine surface waters had much higher DIN concentrations, which averaged 0.079 mg/L (Figure 4-21). Although water-quality assessment cutpoints for DIN have not been established for ocean waters, reference to NCA cutpoints for estuaries (see Chapter 1) may be useful for comparative purposes. Accordingly, 98% of the survey area would be rated good for DIN and none of the area would be rated poor.

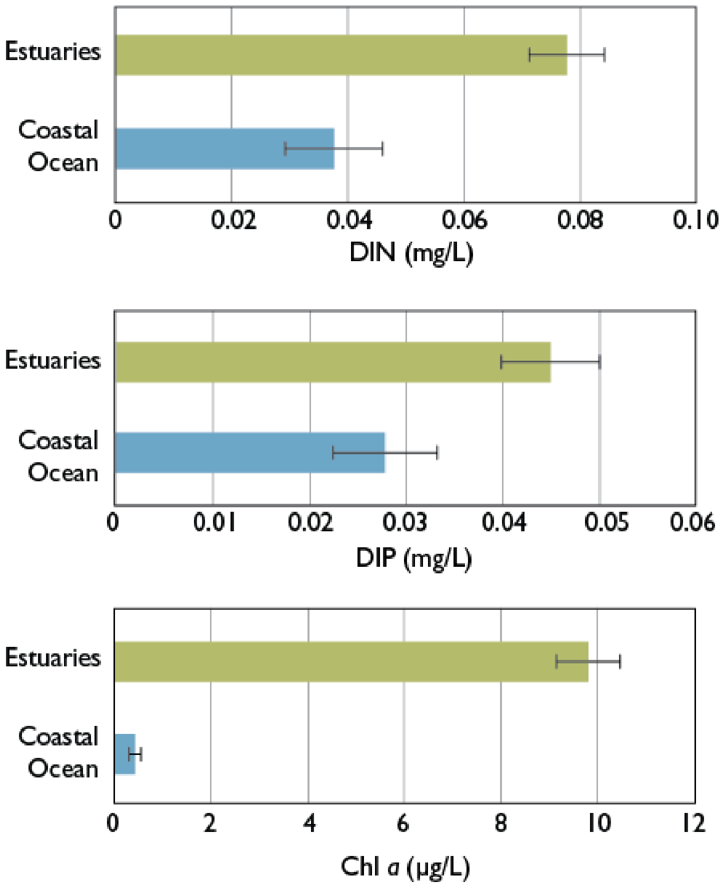


Figure 4-21. Mean concentrations ± 95% C.I.s of (a) DIN, (b) DIP, and (c) chlorophyll *a* in coastal ocean vs. estuarine surface waters (Cooksey et al., 2010; U.S. EPA/NCA).

Concentrations of DIP in offshore surface waters averaged 0.028 mg/L and were lower than those measured in estuaries of the region, which averaged 0.045 mg/L (Figure 4-21). Similar to DIN, there are no available water-quality assessment cutpoints for rating observed levels of DIP in coastal-ocean waters. However, for comparison, 92% of the survey area would be rated fair and 8% of the area would be rated poor using the NCA cutpoints. DIP levels in offshore surface waters of the South Atlantic Bight also appear to be lower than those observed to the north in the Mid-Atlantic Bight (see Chapter 3; also see Balthis et al., 2009). Near-bottom concentrations of DIP along the South Atlantic Bight, which averaged 0.024 mg/L, were similar to those measured in surface waters.

DIN/DIP ratios were calculated as an indicator of which nutrient may be controlling primary production. A ratio above 16 indicates that phosphorus is the limiting nutrient, whereas a ratio below 16 is indicative of nitrogen limitation (Geider and La Roche, 2002). Nitrogen to phosphorus ratios for offshore surface waters averaged 3.69, with 100% of the survey area indicating a nitrogen-limited environment.

Chlorophyll a

Concentrations of chlorophyll *a* in offshore surface waters, which averaged 0.44 µg/L, were considerably lower than those measured in estuaries (averaging 9.81 µg/L) (Figure 4-21). As a further comparison, 100% of the survey area would be rated good using the NCA cutpoints. Chlorophyll *a* levels in these coastal-ocean surface waters were also much lower than those observed along the west coast of the United States (e.g., average of 6.04 µg/L; see Chapter 6 and Nelson et al., 2008) and slightly higher than those measured in the Mid-Atlantic Bight (average of 0.23 µg/L; see Chapter 3 and Balthis et al., 2009). Near-bottom concentrations of chlorophyll *a* along the South Atlantic Bight, which averaged 0.67 µg/L, were slightly higher in comparison to the surface-water mean of 0.44 µg/L.

Water Clarity

Concentrations of TSS were used as a surrogate indicator of water clarity for offshore waters. TSS concentrations in coastal-ocean surface waters averaged 3.64 mg/L, which was considerably lower than levels typically observed in estuaries of the region (e.g., mean of 80.7 mg/L, 2003–2006 NCA data). While most offshore surface waters had TSS concentrations under 6.21 mg/L, the 90th percentile of all measured values, most estuarine surface waters (55% of the survey area) had TSS concentrations above this level. Near-bottom concentrations of TSS in the offshore waters, which averaged 3.30 mg/L, were similar to those measured in surface waters.

Dissolved Oxygen

Near-bottom concentrations of dissolved oxygen in coastal-ocean waters averaged 7.8 mg/L and would be rated good in 100% of the offshore survey area using the NCA cutpoints (Figure 4-22). In comparison, about 60% of the estuarine area was rated good for the dissolved oxygen component indicator, 28% was rated fair (dissolved oxygen 2.0 – 5.0 mg/L), and 11% was rated poor (dissolved oxygen < 2 mg/L). Dissolved oxygen levels in offshore surface waters (average of 7.7 mg/L) were similar to those in near-bottom waters.

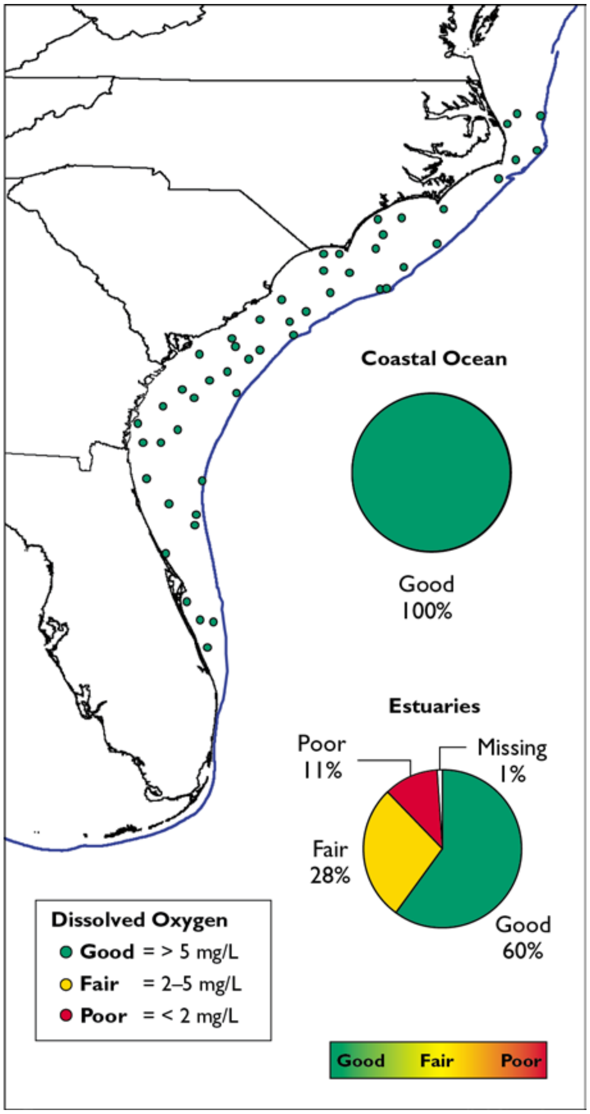


Figure 4-22. Dissolved oxygen data in near-bottom waters of the South Atlantic Bight (Cooksey et al., 2010; U.S. EPA/NCA).

Pie charts compare coastal ocean and estuarine dissolved oxygen levels.

Sediment Quality

Guidelines for Assessing Sediment Contamination (Long et al., 1995)

ERM (Effects Range Median)—Determined values 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 Contaminants

Shelf sediments of the South Atlantic Bight appeared to be relatively uncontaminated. No contaminants were found in excess of their corresponding ERM sediment quality guideline values (Long et al., 1995). Three metals (arsenic, cadmium, and silver) were found at moderate concentrations, between corresponding ERL and ERM values, at 9 of the 50 offshore sampling sites, and none of these sites had more than one ERL value exceeded. Based on the cutpoints used by NCA to assess estuarine condition, 100% of the offshore survey area would be rated good for the sediment contaminants component indicator. In comparison, 3% of estuarine area was rated fair and 1% was rated poor (Figure 4-23). While ratings of poor to fair with respect to sediment contamination were also fairly limited in estuaries of the region (4% of total estuarine area), at least one chemical contaminant exceeded corresponding ERL values at many of the sampling sites.

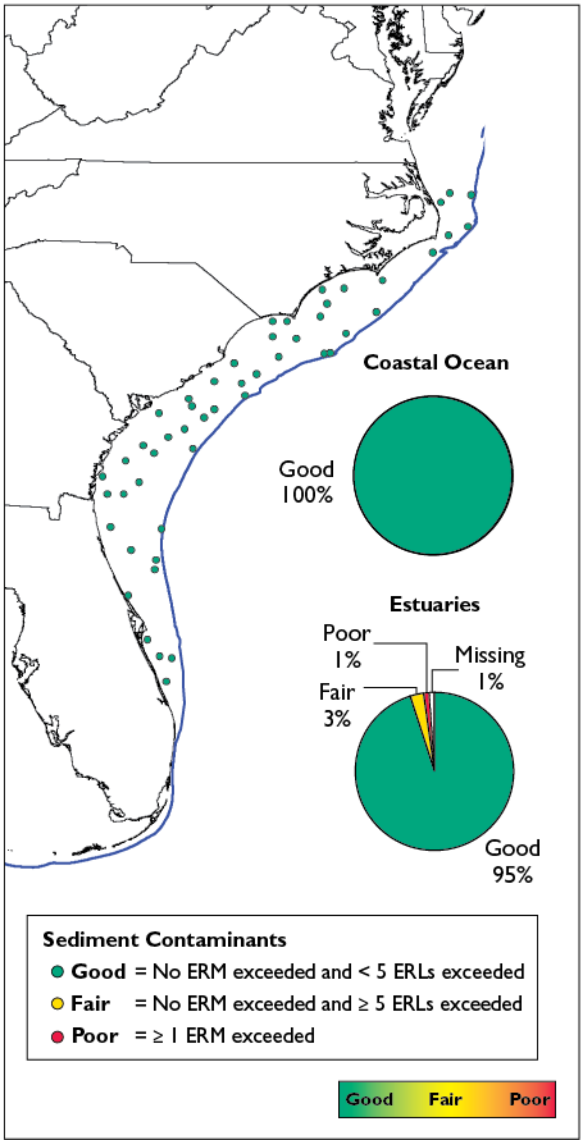


Figure 4-23. Sediment contaminants data in the South Atlantic Bight (Cooksey et al., 2010; U.S. EPA/NCA).

Pie charts compare offshore and estuarine conditions.

Sediment TOC

High levels of TOC in sediments can serve as an indicator of adverse conditions and are often associated with increasing proportions of finer-grained sediment particles (i.e., silt-clay fraction) that tend to provide greater surface area for sorption of both organic matter and the chemical pollutants that bind to organic matter. Given such an association, it is useful to note that 100% of the offshore survey area had sediments composed of sands (< 20% silt-clay). Such predominantly sandy sediments, with some exceptions, generally had low levels of TOC, with values ranging from 0.001–3.99% and averaging 0.35%. Ninety percent of the offshore survey area would be rated good for the sediment TOC component indicator, 10% would be rated fair, and none would be rated poor using NCA cutpoints (Figure 4-24). Estuaries of the region, which are often in closer proximity to both natural and anthropogenic sources of organic materials, generally had higher levels of TOC, with values averaging 1.21%. Seventy-five percent of the estuarine area had was rated good for the sediment TOC component indicator, 17% was rated fair, and 4% was rated poor.

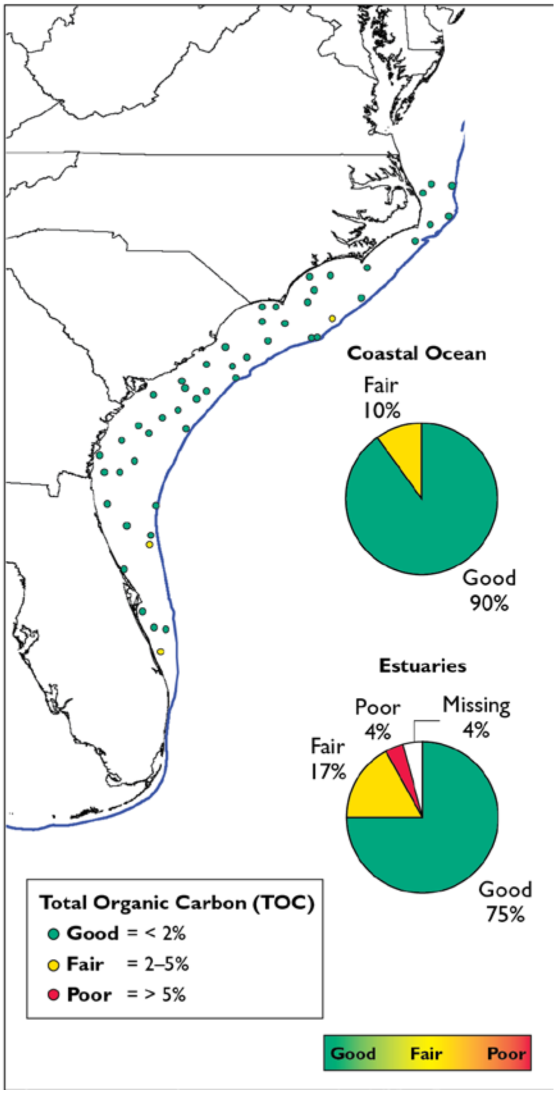


Figure 4-24. Sediment TOC data in the South Atlantic Bight (Cooksey et al., 2010; U.S. EPA/NCA).

Pie charts compare offshore and estuarine conditions.

Benthic Condition

The South Atlantic Bight coastal ocean supports a diverse assemblage of macro-benthic infauna (sediment-dwelling animals larger than 0.5 mm). A total of 6,236 individual specimens representing 462 taxa (313 distinct species) were identified in 50 grab samples collected throughout the assessment area. Polychaete worms were the dominant taxa, both by percent abundance and percent taxa, followed by crustaceans. Collectively, these two groups represented 75% of total faunal abundance and 77% of taxa throughout these offshore waters.

Although densities of benthic infauna were similar between coastal-ocean and estuarine habitats, mean diversity and mean number of taxa were both higher in the offshore sediments (Figure 4-25). Diversity and numbers of species in these offshore sediments were also higher in comparison to values observed in more northern waters of the Mid-Atlantic Bight (see Chapter 3). Within the South Atlantic Bight coastal-ocean assessment area, numbers of species tended to decrease with increasing latitude and were generally highest in the outer shelf areas (Cooksey et al., 2010).

The 10 dominant (i.e., most abundant) offshore taxa were the polychaete worms *Spiophanes bombyx*, *Protodorvillea kefersteini*, *Mediomastus* spp., *Synelmis ewingi*, and *Exogone lourei*; amphipod crustaceans *Ampelisca abdita* and *Protohaustorius wigleyi*; oligochaete worms (family Tubificidae); chordate *Branchiostoma* spp.; and unidentified ribbon worms (Nemertea). Three of these taxa — Nemertea, Tubificidae, and *Spiophanes bombyx* — were widely distributed throughout the region, occurring at greater than 50% of the stations.

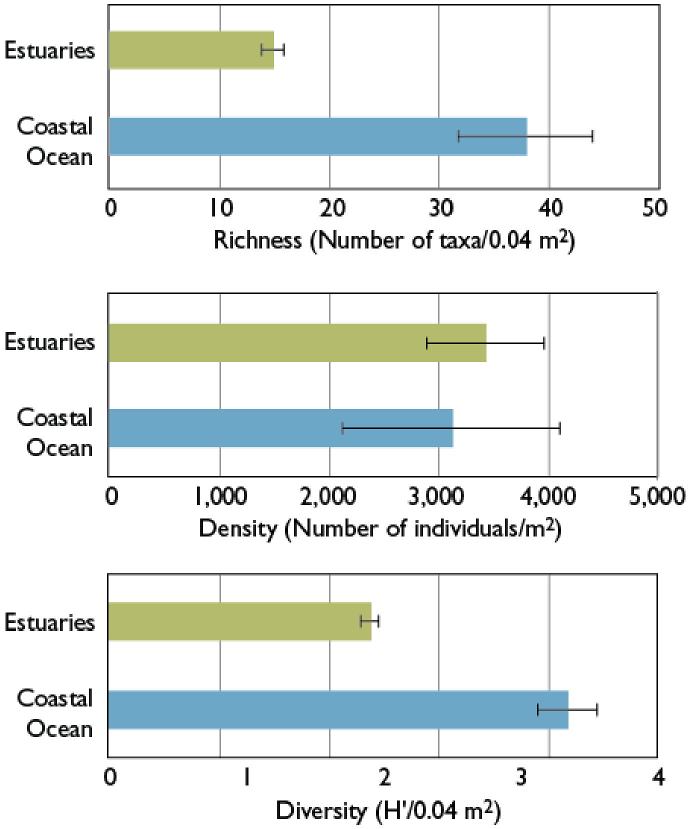


Figure 4-25. Comparison of benthic species richness (number of taxa/0.04 m^2), density (individuals/m^2), and diversity (H'/0.04 m^2, base 2 logs) in coastal ocean vs. estuarine sediments (Cooksey et al., 2010; U.S. EPA/NCA).

The composition of coastal-ocean assemblages was markedly different from estuaries of the region (Cooksey et al., 2010). Only five taxa were common to both the coastal-ocean and estuarine lists of 50 most abundant taxa. They were the amphipod *Ampelisca abdita*, polychaete genus *Mediomastus* spp., Actiniaria (sea anemones), Nemertea, and Tubificidae. Although *A. abdita* was among the 10 most abundant taxa offshore, it occurred at only 1 of the 50 offshore stations (at a very high density). Also, individual species within the Nemertea and Tubificidea taxanomic groups are most likely different between the estuarine and offshore environments. No taxa identified to the species level, other than *A. abdita*, were among the 50 most abundant taxa in both the estuarine and coastal-ocean environments.

Non-Indigenous Species

No non-indigenous species were found in benthic samples from any of the 50 coastal-ocean sampling stations. Three non-indigenous species—*Corbicula fluminea* (Asian clam), *Petrolisthes armatus* (green porcelain crab), and *Rangia cuneata* (Atlantic rangia)—were identified in benthic samples from the coastal waters of the Southeast Coast region sampled as part of the NCA efforts in 2000–2004 (Cooksey et al., 2010). Still, these three species represented a relatively small proportion (< 0.01%) of the total 408 taxa that were identified to species level from the analysis of 1,039 estuarine grab samples (0.04-square meters each). The South Atlantic Bight benthos appears to be less invaded than some other coastal regions, such as the Pacific Coast benthos, where non-indigenous species are common in estuaries and occur offshore as well, though in more limited numbers (e.g., 1.2% of the identified species in the offshore study by Nelson et al., 2008; also see Chapter 6 of this NCCR). Although no non-indigenous benthic species were observed in the 2004 offshore survey, it is important to note that there have been increasing reports in the literature of other non-indigenous species, such as the lionfish *Pterois sp.*, invading offshore waters along the southeastern United States (Hare and Whitfield, 2003).

Fish Tissue Contaminants

Analysis of chemical contaminants in fish tissues was performed on homogenized filets (including skin) from 20 samples of 7 fish species collected from 17 of the 50 coastal-ocean stations. The species were sand perch (*Diplectrum formosum*), black seabass (*Centropristis striata*), dusky flounder (*Syacium papillosum*), whitebone porgy (*Calamus leucosteus*), red porgy (*Pagrus pagrus*), lizardfish (*Synodus foetens*), and snake fish (*Trachinocephalus myops*). Concentrations of a suite of metals, pesticides, and PCBs were compared to risk-based EPA advisory guidance values for recreational fishers (U.S. EPA, 2000c). None of the 17 stations where fish were caught would be rated poor, 12% would be rated fair, and 88% would be rated good based on the NCA cutpoints.

Ocean Condition Summary—Southeast Atlantic Bight

The 2004 South Atlantic Bight coastal-ocean assessment showed no major evidence of poor sediment or water quality. Dissolved oxygen concentrations in near-bottom waters were at least 6.8 mg/L, all rated good based on NCA cutpoints. All of the survey area was rated as good for the sediment contaminants component indicator. The majority (90%) of the offshore survey area was rated good for the sediment TOC component indicator, and the remaining 10% was rated fair.

There was a slight indication of human-health risks based on chemical contaminant levels in fish tissues. For example, concentrations of methylmercury were found between corresponding lower and upper human-health endpoints at 2 of 17 sites where fish were measured, resulting in a fair rating for 12% of the stations where fish were caught. In addition, no non-indigenous species were found in any of the offshore benthic samples.

The analysis of potential biological impacts (see text box) found no association of low values of biological attributes with indicators of poor sediment or water quality. In fact, no indications of poor sediment or water quality were observed based on the NCA cutpoints. These results suggest that the offshore sediments and overlying waters of the South Atlantic Bight are in generally good condition, with lower-end values of biological attributes representing parts of a normal reference range controlled by natural factors.

Evaluating Offshore Benthic Condition

Multi-metric benthic indices are often used as indicators of pollution-induced degradation of the benthos (see review by Diaz et al., 2004). An important feature is the ability to combine multiple biological attributes into a single measure that maximizes the ability to distinguish between degraded vs. non-degraded benthic condition, while accounting for the influence of natural controlling factors. Although a related benthic index of biotic integrity (B-IBI) has been developed for southeastern estuaries (Van Dolah et al., 1999), there is currently no such index available for coastal ocean applications. In the absence of a benthic index, Cooksey et al. (2010) assessed potential stressor impacts in the South Atlantic Bight coastal ocean study by looking for obvious linkages between reduced values of key biological attributes (numbers of taxa, diversity, and abundance) and synoptically measured indicators of poor sediment or water quality. Low values of species richness, H′, and density were defined for the purpose of this analysis as the lower 10th percentile of observed values. Evidence of poor sediment or water quality was defined as poor ratings for the sediment contaminants, sediment TOC, and dissolved oxygen component indicators based on NCA cutpoints.

Alternatively, it is possible that for some of these sites, the lower values of benthic variables reflect symptoms of disturbance induced by other unmeasured stressors. In an effort to be consistent with the underlying concepts and protocols of earlier EMAP/NCA programs, the indicators in the coastal ocean assessment included measures of stressors, such as chemical contaminants and symptoms of eutrophication, which are often associated with adverse biological impacts in shallower estuarine and inland ecosystems. However, there may be other sources of human-induced stress in these coastal ocean systems, particularly those causing physical disruption of the seafloor (e.g., commercial bottom trawling, cable placement, minerals extraction) that pose greater risks to living resources and that have not been adequately captured. Future monitoring efforts in these coastal ocean areas should include indicators of such alternative sources of disturbance.

Large Marine Ecosystem Fisheries—Southeast U.S. Continental Shelf LME

The Southeast U.S. Continental Shelf LME extends from Cape Hatteras, NC, to the Straits of Florida (Figure 4-26) and is characterized by its temperate climate. This LME is considered to be moderately productive, based on primary production (phytoplankton) estimates, and upwelling along the Gulf Stream front and intrusions from the Gulf Stream can cause short-lived plankton blooms. The flow of fresh water from watersheds that drain the lower Appalachian Mountains, Piedmont, and Coastal Plains mixes along the coast with prevailing oceanic waters to create diverse wetlands, marsh, and mangrove habitats that transition gradually from freshwater to brackish-water to saltwater areas. The thin fringe of estuaries in this LME is dynamic, varying constantly with tidal fluctuations and levels of runoff, and serves as important habitat for invertebrates, fish, reptiles, waterfowl, mammals, and a diverse array of plants. These estuaries also act as a natural filter to remove pollutants and trap sediments from upland regions.

Figure 4-26. Southeast U.S. Continental Shelf (NOAA, 2010b).

The Southeast U.S. Continental Shelf LME coastal area supports diverse aquatic organisms and complex food webs. From 2003 to 2006, the fisheries in this LME generated $577 in total ex-vessel revenues (the value of landings before processing). The Southeast fisheries are dominated by blue crab and white shrimp, which generated approximately $140 million and $96 million in revenues from 2003 to 2006, respectively. The dominance of these fisheries is significant; the next highest grossing fishery, brown shrimp, generated $35 million from 2003 to 2006. The other top commercial fisheries in this LME are cero and king mackerel and summer flounder (NMFS, 2010). See Figure 4-27 for total 2003 to 2006 ex-vessel revenues and landings (in metric tons) for the top commercial fisheries in this LME. The fisheries in this LME are largely managed by the NMFS and the South Atlantic Fishery Management Council (NOAA, 2007b), although some of the fisheries are also managed by the Gulf of Mexico Fishery Management Council.

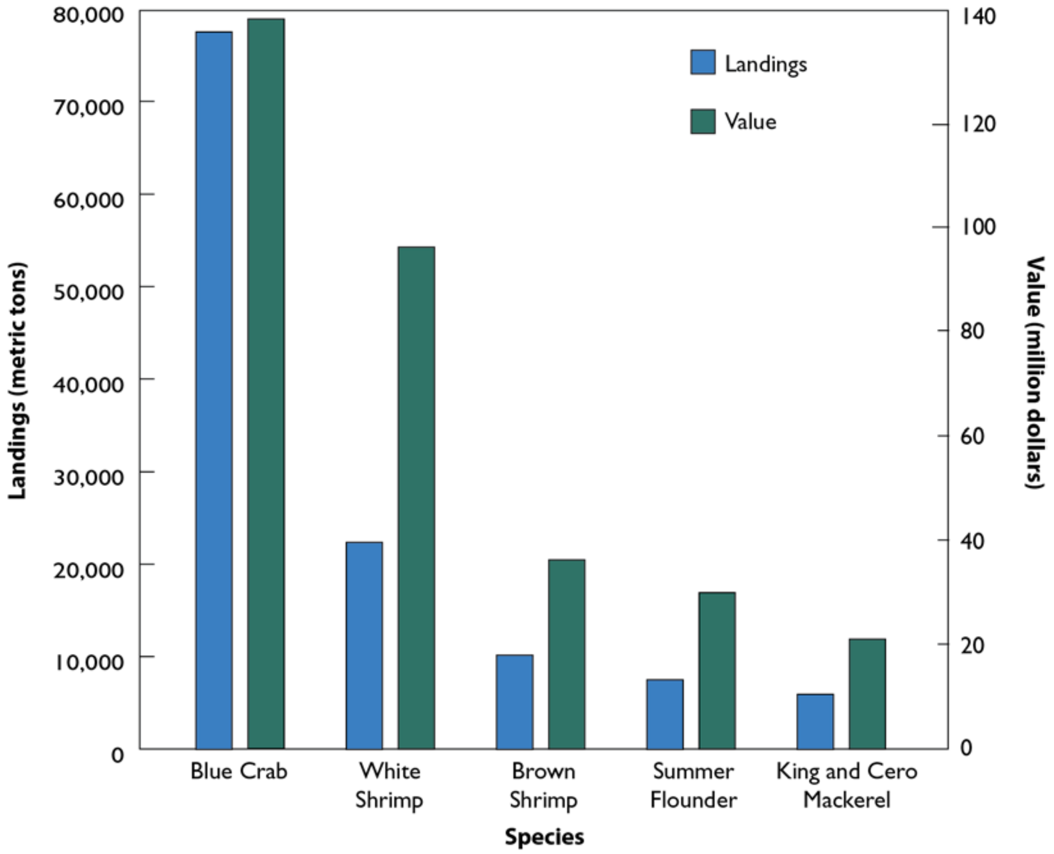


Figure 4-27. Top commercial fisheries for the Southeast U.S. Continental Shelf LME: landings (metric tons) and value (million dollars) from 2003–2006 (NMFS, 2010).

Southeast Shelf Invertebrate Fisheries

Recreational and commercial marine invertebrates in the Southeast U.S. Continental Shelf LME include blue crab, shrimp, spiny lobster, quahog clam, stone crab, and conch. The commercial blue crab (*Callinectes sapidus)* fishery yields the highest revenues in this region, totaling nearly $140 million from 2003 through 2006 for landings of nearly 80,000 metric tons (Figure 4-27) (NMFS, 2010). Although the Chesapeake Bay is famous for its blue crabs, which are the pride of Maryland, many of its local restaurants and markets actually import this delicacy from the Southeast fishermen. Crab fishermen separate the catch by sex and molting stage (crabs repeatedly shed and rebuild their shells throughout their lives), selling hard-shelled crabs, "peelers" (those getting ready to shed), and soft shell crabs (those that have recently shed their shells). Blue crabs are an integral part of the marine food web; they feed on detritus and numerous benthic organisms and serve as a food source for many bird and fish species. In addition to fishing pressure, this species is heavily impacted by habitat degradation, especially to underwater seagrasses that it uses for forage, mating, and nurseries. Crabs are harvested with the use of pots or traps, mesh wire cages with two entrances just large enough for the crab to squeeze in, while prohibiting exit.

The Southeast Coast white (*Litopenaeus setiferus)* and brown (*Farfantepenaeus aztecus*) shrimp fisheries, though smaller than their counterparts in the Gulf of Mexico, are two of the most valuable fisheries in the United States. Together, their total U.S. landings were worth $1.3 billion in ex-vessel revenues from 2003 to 2006 (NMFS, 2010). These fisheries have high values per metric ton. With landings of one-quarter of the weight of those of blue crab, the white shrimp fisheries generated three-quarters of the crab fishery revenues (Figure 4-27). In the Southeast Coast region along the Atlantic Ocean, white shrimp stocks are centered off the Georgia and South Carolina coasts, and brown shrimp are centered off the North and South Carolina coasts. In general, shrimp reside in shallow waters (90 feet or less), feeding on various benthic organisms, and migrate out of inshore spawning areas to offshore commercial fishing grounds in early autumn. Other valuable shrimp fisheries in this area include rock, prawn, and pink species. The Southeast U.S. Continental Shelf LME, the shrimp fishery is currently managed under a federal FMP (SAFMC, 2011b). The FMP provides for compatible state and federal closures, if needed, to protect over-wintering shrimp stocks and includes overfishing definitions for all species. The Southeast Coast shrimp fisheries face the same by-catch issues associated with usage of small-mesh trawl nets in the Gulf of Mexico fisheries.

Habitat concerns impact many of the Southeast U.S. Continental Shelf LME invertebrate fishery resources. Estuarine and marsh loss removes critical habitat used by young shrimp (Minello et al., 2003). Florida spiny lobsters depend on reef habitat and shallow water algal flats for feeding and reproduction, but these habitat requirements may conflict with expanding coastal development. The productivity of stone crabs in Florida Bay is related to water quality and flow through the Everglades. Specific water requirements need to be identified and maintained through comprehensive water management of the Everglades. A unified program to integrate and study the combined effects of environmental alterations, fishing technology improvements, regulations, habitat restoration, and economic factors on shrimp, lobster, and crab production is needed, particularly in the reef habitats of South Florida. Steps also need to be taken to mitigate or restore lost estuarine habitats.

Demersal Fisheries

Although there is great variation in habitat, feeding, and reproduction, demersal species are classified as those that inhabit bottom waters. Many of the demersal species that exist in the Northeast U.S. Continental Shelf LME migrate to the Southeast U.S. Continental Shelf LME, although their preference for colder waters limits their southern expansion mostly to North Carolina. Within the Southeast U.S. Continental Shelf LME, the greatest commercial value in the demersal group is generated within the summer flounder (*Paralichthys dentatus*) fishery, which was the fourth in terms of revenue for this LME. From 2003 to 2006, total ex-vessel revenues from the commercial summer flounder fishery were $29 million for landings of approximately 7,000 metric tons, mostly within the state of North Carolina (Figure 4-27) (NMFS, 2010). This species is also an important target for recreational fishermen.

Summer flounder, also known as “fluke,” is a type of flatfish, with a body that is laterally flattened and both eyes on one side. As flounder larvae mature into juveniles, their right eye migrates across the top of their head to the left. The placement of the eyes on top of the head is critical for this fish, which lies on the ocean floor disguised by sand and its own coloration, awaiting a passing meal of fish or crustacean. Summer flounder is harvested mostly with trawl gear and is managed under a cooperative FMP (MAFMC, 2011) established by the New England Fisheries Management Council, Southern Atlantic Fisheries Management Council, and the Mid-Atlantic Fisheries Management Council. Annual total allowable catches are established, divided amongst commercial (60%) and recreational (40%) fishermen. Other provisions include minimum mesh sizes and size and catch limits.

Coastal Pelagic Fisheries

Coastal pelagic (water column-dwelling) species in the Southeast U.S. Continental Shelf LME include king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), dolphinfish (*Coryphaena hippurus*), cobia (*Rachycentron canadum*), and cero mackerel (*S. regalis*). Coastal pelagic species are generally fast-swimming predatory fishes that school, feed voraciously, grow rapidly, mature early, and spawn over an extended period of several months. Most coastal pelagic species are highly valued and sought after gamefish. During 1984–2006, annual commercial landings of coastal pelagic fish were between 4,200 and 6,400 metric tons, while recreational fishermen landed between 7,200 and 19,000 metric tons. The value of commercial landings was highest for the king and cero mackerel fisheries, which generated nearly $21 million in revenue from 2003 to 2006, for landings around 6,000 metric tons (Figure 4-27) (NMFS, 2010). Most pelagic species are harvested for the processing market and, therefore, have a low market value. However, mackerel is harvested for direct consumption as fillets and steaks.

The commercial king mackerel fisheries utilize troll lines, hand lines, otter trawls, and pound nets in three major production areas off the coast of North Carolina, the east coast of Florida, and the Florida Keys. Recreational fisheries for king mackerel have been very popular in this LME, with several tournaments targeting these fish since the 1960s. The Atlantic king mackerel stock is thought to be at or near its maximum sustainable yield, although overfishing is not occurring for either king or Spanish mackerel. Because the Southeast U.S. Continental Shelf LME and Gulf of Mexico LME king mackerel stocks overlap during the winter months in the southeast Florida and the Florida Keys region, allowing considerable mixing, they are managed under a joint FMP (SAFMC, 2011a) coordinated by the South Atlantic and Gulf of Mexico Management councils. The plan includes provisions for the commercial fishery, such as total allowable catch, seasonal closures, and size and trip limits, and for the recreational fishery, with possession and size limits.

Fishery Trends and Summary

Catches of blue crab have demonstrably dwarfed the other top commercial species in the Southeast U.S. Continental Shelf LME since 1950 (Figure 4-28). Nevertheless, this fishery has declined by nearly 20,000 metric tons since peaking at nearly 40,000 metric tons in the mid 1990s. Since 1950, catches in the king and cero mackerel fishery rose only slightly, up to approximately 1,700 metric tons in 2006. Data for the summer flounder and white and brown shrimp fisheries were not available prior to the late 1970s. Landings in all three of these fisheries have remained well below 10,000 metric tons since then. Despite annual fluctuations, white shrimp landings remain above 5,000 metric tons. Recent brown shrimp and summer flounder catches have been about 3,000 metric tons (NMFS, 2010).

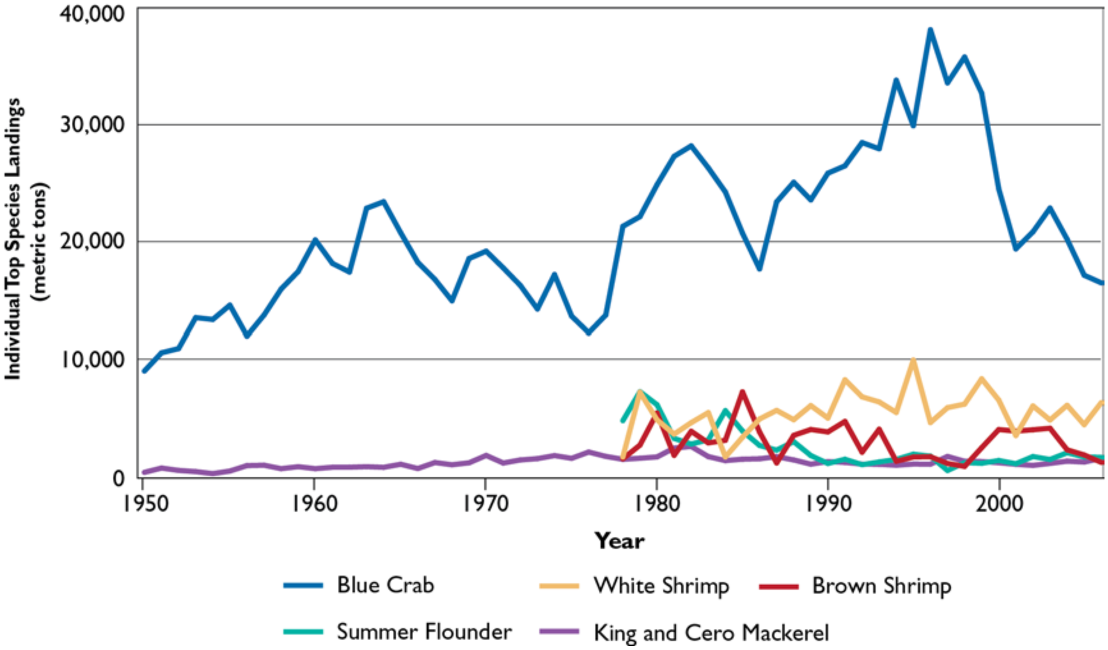


Figure 4-28. Landings of top commercial fisheries in the Southeast U.S. Continental Shelf LME from 1950 to 2006, metric tons (NMFS, 2010).

The Southeast U.S. Continental Shelf LME top commercial fisheries are dominated by blue crab, white and brown shrimp, summer flounder, and king and cero mackerel due to their high ex-vessel revenues, even though other fisheries may have been important in the past. Also, pelagic (king mackerel, cobia, dolphinfish) and highly migratory (swordfish, yellowfin and bluefin tuna, white and blue marlin, and sailfish) species comprise the majority of recreational fisheries. Interestingly, other species, especially pelagics, may actually have greater associated landings in terms of metric tons, but yield lower revenues than the species mentioned above because of lower market prices. Although these commercial and recreational fisheries are important ecosystem services because they provide food, all species have important roles in their ecosystems. For example, filter feeders such as clams, oysters, and scallops are not as highly prized as the recreational and commercial species above; however, they do provide a valuable service by filtering nearshore waters, which improves water quality. Smaller pelagic fish species and invertebrates are prey for larger demersal species, which themselves are prey for marine mammals, birds, and larger fish. As in other LMEs, commercial and recreational fisheries support related industries such as boat building, fuel for vessels, fishing gear and nets, ship repair and maintenance, tourism, bait and tackle shops, recreational boating and much more, all contributing significantly to the value derived from the ecosystem service of fishery production.

Advisory Data

Fish Consumption Advisories

Eleven fish consumption advisories were active in the coastal waters of the Southeast Coast region in 2006 (Figure 4-29). 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, North Carolina, 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 2006. Most (82%) fish consumption advisories for the Southeast Coast region were issued, at least in part, because of mercury contamination (Figure 4-30), with separate advisories issued for only two other specific pollutants, PCBs and dioxins. A Florida advisory added details of unspecified pollutant in 2006. All of the fish advisories for PCBs covered parts of Georgia, and the one fish advisory for dioxin was in North Carolina's Albemarle- Pamlico Estuarine System (U.S. EPA, 2007c). Table 4-1 lists the species and/or groups under fish consumption advisory in 2006 for at least some part of the coastal waters of the Southeast Coast region.

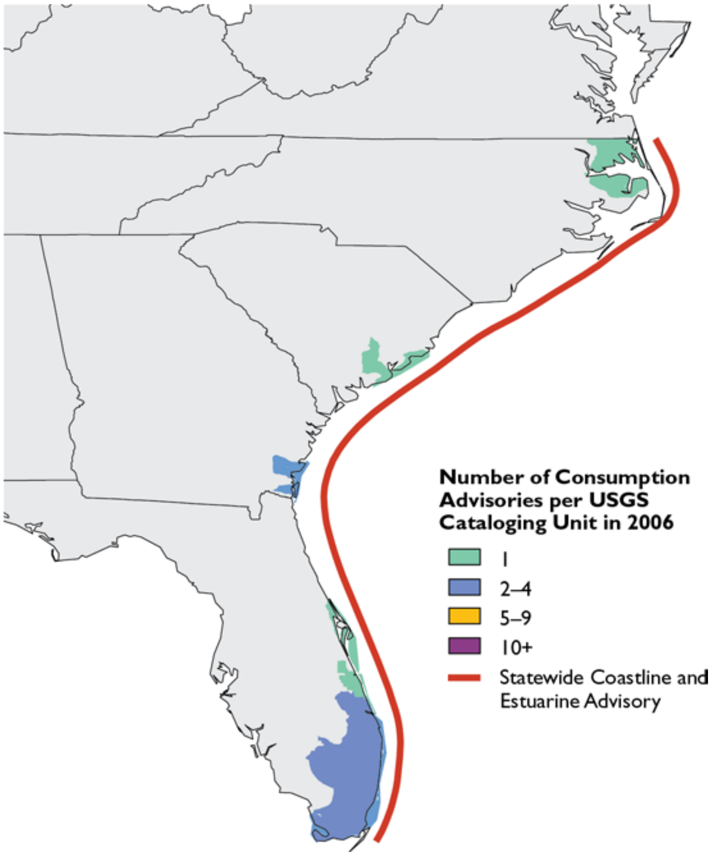


Figure 4-29. The number of fish consumption advisories in effect in 2006 for the Southeast Coast coastal waters (U.S. EPA, 2007c).

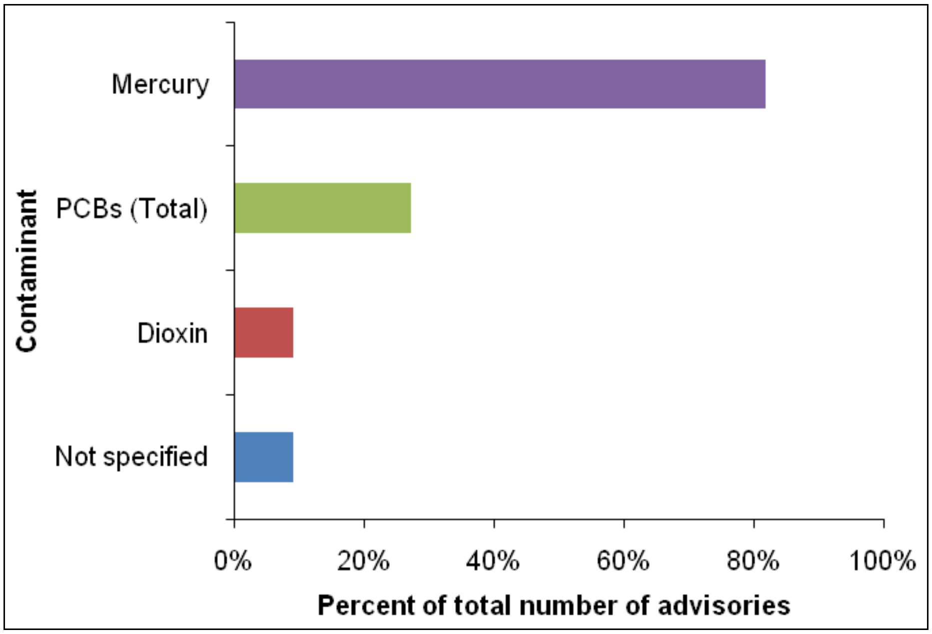


Figure 4-30. Pollutants responsible for fish consumption advisories in Southeast Coast coastal waters. An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2007c).

Table 4-1. Species and/or Groups under Fish Consumption Advisory in 2006 for at Least Some Part of the Coastal Waters of the Southeast Coast Region

Species and/or Groups under Fish Consumption Advisory		
Albacore tuna	Almaco jack	Atlantic croaker
Atlantic spadefish	Atlantic stingray	Atlantic thread herring
Banded rudderfish	Barracuda	Black drum
Black grouper	Blackfin tuna	Blue marlin
Bluefish	Bluntnose stingray	Bonefish
Bowfin	Carp	Catfish
Clam	Cobia	Crab-blue
Crab-dungeness	Crevalle jack	Croaker
Dolphin	Fantail mullet	Florida pompano
Flounder	Gafftopsail catfish	Gag grouper
Gray snapper	Greater amberjack	Grouper
Gulf flounder	Halibut	Hardhead catfish
Herring	Hogfish	Jacksmelt
King mackerel	Ladyfish	Lane snapper
Largemouth bass	Little tunny	Lobster
Lookdown	Mussels	Mutton snapper
Orange roughy	Oysters	Pacific cod
Perch	Pigfish	Pinfish
Pollock	Pompano	Puffer
Red drum	Red grouper	Red snapper
Salmon	Sand seatrout	Scallops
Scamp	Shark	Sheepshead
Shrimp	Silver perch	Skipjack tuna
Snook	Snowy grouper	Southern flounder
Southern kingfish	Spanish mackerel	Spot
Spotted seatrout	Striped mojarra	Striped mullet
Swordfish	Tarpon	Tilefish
Tripletail	Tuna	Vermillion snapper
Wahoo	Weakfish	White grunt
White mullet	Whitefish	Yellowedge grouper
Yellowfin tuna	Yellowtail snapper	

Source: U.S. EPA, 2007c

Beach Advisories and Closures

How many notification actions were reported for the Southeast Coast between 2004 and 2008?

Table 4-2 presents the number of total and monitored beaches, as well as the number and percentage of monitored beaches affected by notification actions from 2004 to 2008 for the Southeast Coast (i.e., North and South Carolina, Georgia, and Florida's southeast beaches). Between 2004 and 2005, the number of monitored beaches dropped slightly and the percentage of beaches with notification actions increased by 2%; however, the total number of beaches decreased dramatically, only to increase again the 2006. Between 2006 and 2008, the total number of beaches dropped significantly again, although the numbers of monitored beaches and those affected by notifications remained largely constant (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring site: http://www.epa.gov/waterscience/beaches/seasons/.

Table 4-2. Beach Notification Actions, Southeast Coast, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004[a]	2005[a]	2006	2007	2008
Total number of beaches	582	310	806	533	530
Number of monitored beaches	302	297	416	416	413
Number of beaches affected by notification actions	31	36	54	53	54
Percentage of monitored beaches affected by notification actions	10%	12%	13%	13%	13%

[a] Data from Florida are not included for 2004 and 2005 because the state did not differentiate between Southeast and Gulf Coast beaches within their state summaries for these years.

What pollution sources impacted monitored beaches?

Table 4-3 presents the numbers and percentages of monitored Southeast Coast beaches affected by various pollution sources for 2007. The most frequent reasons for beach advisories were storm-related runoff, which contributed to almost 60% of closures, and wildlife, affecting over 40% of beaches. Although boat discharge contributed to 10% of advisories, unidentified and unknown pollution sources together affected over 35% of beaches. Other reasons, including septic and sewer systems (leaks, overflows, and breaks), other runoff, and treatment works together affected less than 10% of Southeast Coast beaches (U.S. EPA, 2009d).

Table 4-3. Reasons for Beach Advisories, Southeast Coast, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Storm-related runoff	186	58%
Wildlife	137	42%
No known pollution sources	63	20%
Other and/or unidentified sources	51	16%
Boat discharge	31	10%
Sanitary/combined sewer overflow	8	2%
Non-storm related runoff	7	2%
Septic system leakage	3	1%
Publicly owned treatment works	2	1%
Sewer line leak or break	1	< 1%

Note: A single beach advisory may have multiple pollution sources.

How long were the 2007 beach notification actions?

In 2007, nearly 60% of beach notifications in the Southeast lasted either 1 day (37%) or 2 days (21%). Another 30% of the notifications lasted from 3 to 7 days, and 10% were of the 8- to 30-day duration. The remaining 2% was attributed to notifications of over 30 days (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

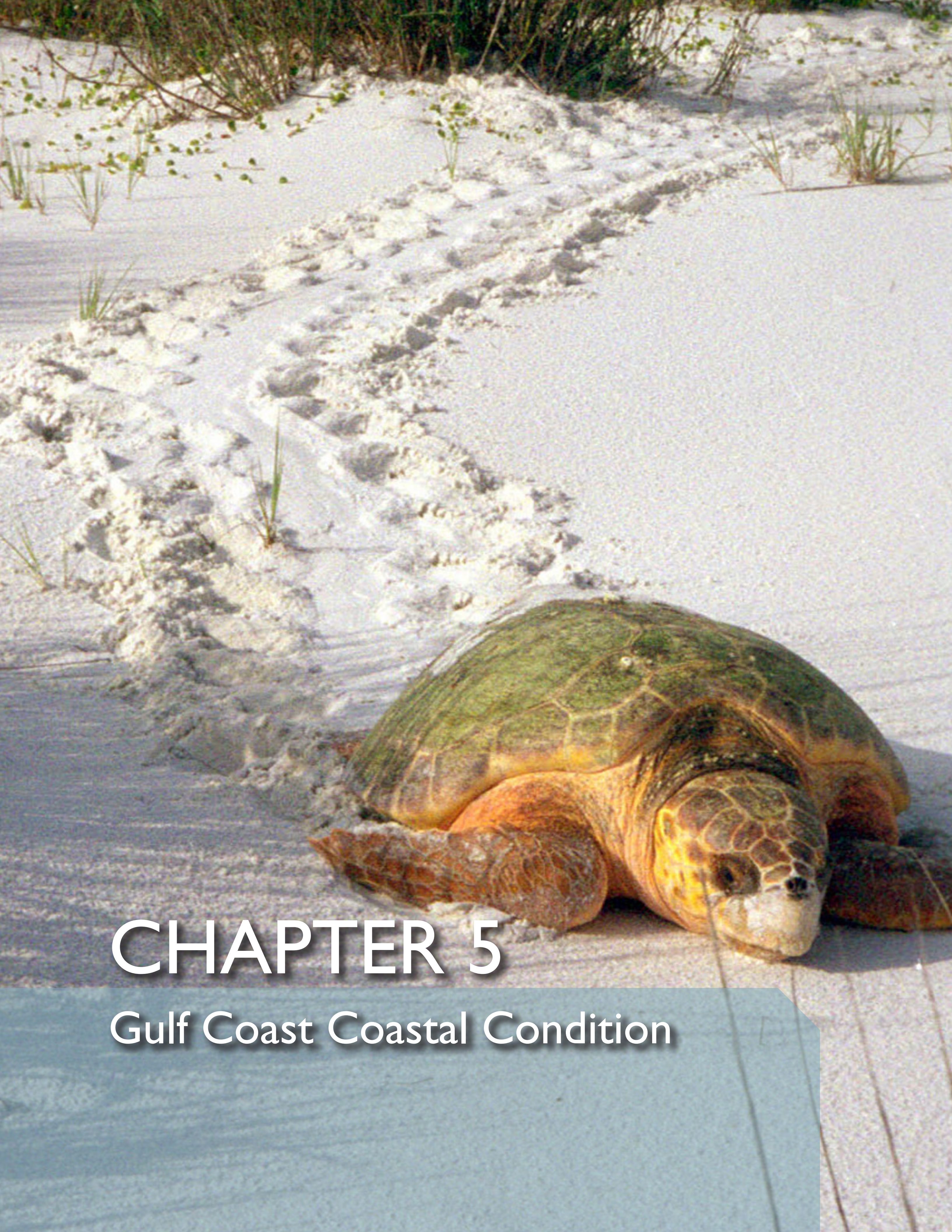
Summary

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 from 2003 to 2006 showed that the Southeast Coast region sediment quality index is rated fair to poor, the water quality and coastal habitat indices are rated fair, and the benthic and fish tissue indices are rated good. The 7 years of accumulated EMAP-NCA monitoring data, collected from 2000–2006, have provided an ideal opportunity to investigate temporal changes in ecological condition assessment indicators. Although there were no significant trends in water quality, sediment quality, or benthic condition in the Southeast estuaries from 2000–2006, increasing population growth in this region could contribute to increased susceptibility for water quality degradation in the future.

In 2004, NOAA and EPA assessed the status of ecological condition throughout coastal ocean waters of the South Atlantic Bight. The analysis found no indications of poor sediment or water quality, and no non-indigenous species were found in any of the coastal ocean benthic samples. These results suggest that coastal ocean waters and sediments of the South Atlantic Bight are in good condition. There was a slight indication of human-health risks based on mercury levels in fish tissues; however, none of the sites were rated poor based on the NCA cutpoints. Future monitoring efforts should include additional indicators of other types of disturbance, such as commercial bottom trawling, cable placement, and minerals extraction, which may pose greater risks to living resources and which have not been adequately studied.

The Southeast U.S. Continental Shelf LME coastal area supports diverse aquatic organisms and complex food webs. From 2003 to 2006, the fisheries in this LME generated $577 in total ex-vessel revenues, and top commercial fisheries are dominated by blue crab, white and brown shrimp, summer flounder, and king and cero mackerel. Landings of blue crab have dwarfed the other top commercial species in the Southeast U.S. Continental Shelf LME since 1950. With landings of one-quarter of the weight of those of blue crab, the white shrimp fisheries generated three-quarters of the crab fishery revenues. The summer flounder (*Paralichthys dentatus*) fishery was the fourth in terms of revenue for this LME, with total ex-vessel revenues from the commercial summer flounder fishery were $29 million from 2003 to 2006. During 1984–2006, annual commercial landings of coastal pelagic fish were between 4,200 and 6,400 metric tons, while recreational fishermen landed between 7,200 and 19,000 metric tons.

Contamination in Southeast Coast coastal waters has affected human uses of these waters. In 2006, 100% of the Southeast Coast shoreline miles were under fish consumption advisories. Most fish advisories were issued, at least in part because of mercury contamination. In addition, 13% of the region’s monitored beaches were closed or under advisory for some period of time during 2006. Elevated bacteria levels in the region’s coastal waters were primarily responsible for the beach closures and advisories.



CHAPTER 5

Gulf Coast Coastal Condition

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, with an overall condition score of 2.4. The water quality index for the region's coastal waters is rated fair; the benthic index is rated fair to poor; the sediment quality 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 the 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 879 locations, ranging from Florida Bay, FL, to Laguna Madre, TX, from 2003 to 2006. The hurricanes of 2005 (Katrina and Rita) significantly affected the data collected; Alabama, Mississippi, and Louisiana did not collect data in 2005 (except for water quality indicators in Mississippi).

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

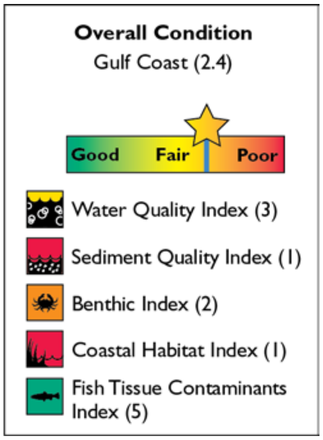


Figure 5-1. The overall condition of Gulf Coast coastal waters is rated fair (U.S. EPA/NCA).

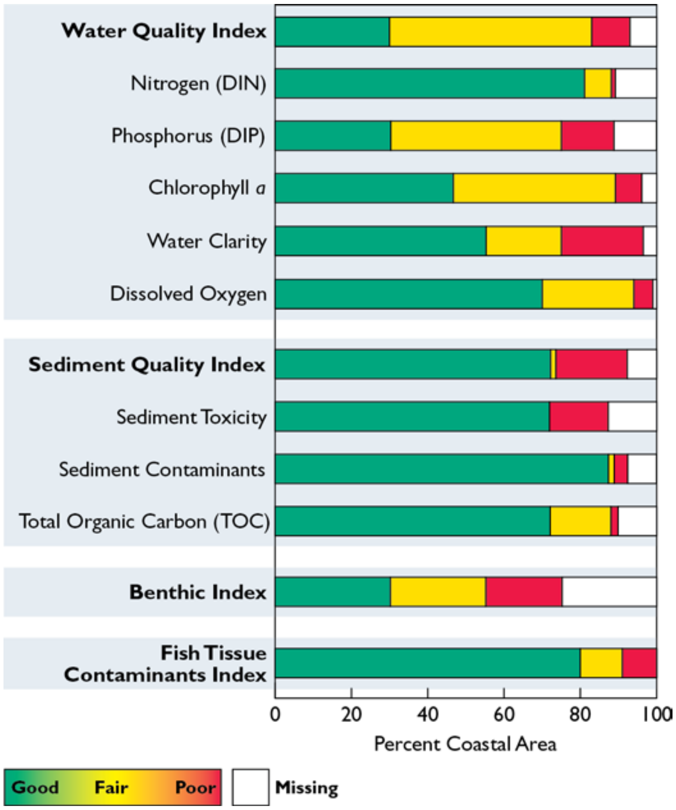


Figure 5-2. Percentage of coastal area achieving each ranking for all indices and component indicators—Gulf Coast region (U.S. EPA/NCA).

Uses of the National Coastal Condition Reports

This report is designed to help us understand the questions, "What is the condition of the nation's coastal waters, is that condition getting better or worse, and how do different regions compare?" This report, however, cannot represent all individual coastal and estuarine systems of the United States and is based on a limited number of ecological indices and component indicators for which nationally consistent data sets are available to support estimates of ecological condition. The assessments provided in this report, and more importantly, the underlying data used to develop the assessments, can provide a picture of historical coastal conditions at state, regional, or national scales. For example, the National Coastal Assessment (NCA) data have been used to provide insight into the conditions in the estuaries of Louisiana and Mississippi prior to Hurricane Katrina. These data may also be used to help us understand conditions in Gulf of Mexico estuaries prior to the Deepwater Horizon incident and subsequent BP Oil Spill. However, the methodology and data used in this report were not designed to asses impacts directly related to the BP Oil Spill. This report does not include, for example, indicators such as water chemistry, oil-related contaminants (i.e., oil, grease, alkylated PAHs, or volatile organic compounds), dispersant compounds, or other indicators of exposure that might be required in an environmental assessment. Any comparisons to environmental data collected to assess the impact of the BP Oil Spill on Gulf of Mexico estuaries should be limited to the indicators and methods presented in this report and to broad generalizations about coastal condition at state, regional, or national scales.

The Gulf Coast coastal area 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 10,538 square miles. 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 or threatened species such as the Kemp's ridley sea turtle, Gulf sturgeon, Perdido Key beach mouse, West Indian manatee, telephus spurge, and piping plover. This region's coastal waters also support vegetated habitats that stabilize shorelines from erosion, reduce nonpoint-source loadings, and improve water clarity.

Gulf Coast coastal waters 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 borders of the Gulf Coast region roughly coincide with the borders of the Gulf of Mexico LME.

The Gulf Coast is home to approximately 13% of the nation's coastal residents. Between 1980 and 2006, the population of coastal counties in the Gulf Coast region increased by 53% from 10.7 million to 16.3 million people (Figure 5-3). Population density also increased by 53% from 158 to 241 persons/square mile. Figure 5-4 presents population density data for Gulf Coast coastal counties in 2006 (NOEP, 2010).

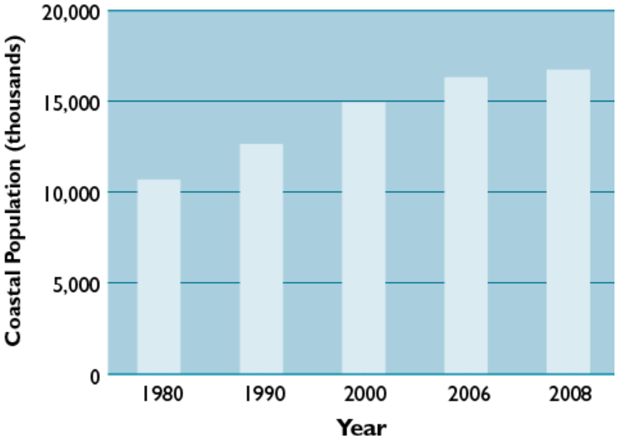


Figure 5-3. Population of coastal counties in Gulf Coast states from 1980 to 2008 (NOEP, 2010).

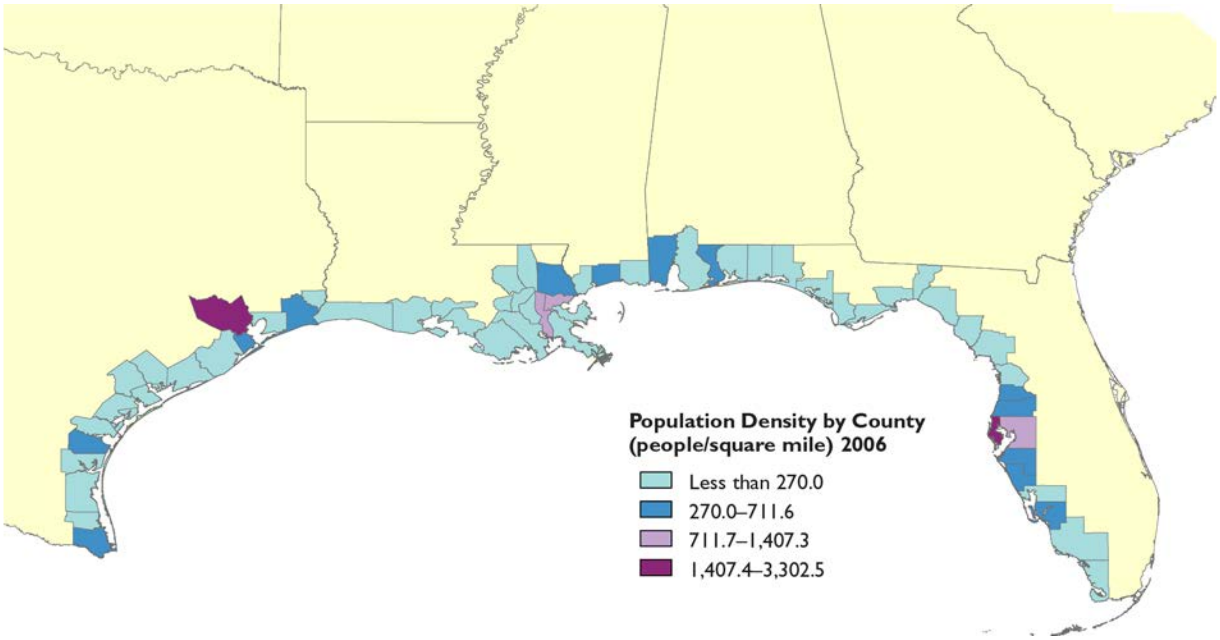


Figure 5-4. Population density in coastal counties in Gulf Coast states in 2006 (NOEP, 2010; U.S. Census Bureau, 2010).

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Data were not collected during other time periods.

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) began an assessment in 2000, in conjunction with EPA's Coastal 2000 Program (U.S. EPA, 2000). This partnership has continued as part of the NCA, with coastal monitoring being conducted by the five Gulf Coast states through 2006. 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). Data from the NS&T Program Bioeffects Project are available at http://ccma.nos.noaa.gov/about/coast/nsandt/download.aspx.

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The sampling conducted in the EPA NCA survey has been designed to estimate the percent of coastal area (nationally or in a region) 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 would be required to define temporal variability and to confirm environmental condition at specific locations.

Water Quality Index

Based on the 2003 to 2006 NCA survey results, the water quality index for the coastal waters of the Gulf Coast region is rated fair, with 10% of the coastal area rated poor and 53% of the area rated fair for water quality condition (Figure 5-5). 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. Poor water clarity, high DIP concentrations, and high chlorophyll *a* concentrations contributed to poor water quality ratings. Only three sites in Louisiana had high concentrations of both DIN and DIP. Poor or fair conditions for the component indicators did not necessarily co-occur at the same station, resulting in a lower percentage of Gulf Coast coastal area rated good for the water quality index than for any of its component indicators (see Chapter 1 for more information). This water quality index can be compared to the results of NOAA's Estuarine Eutrophication Survey (Bricker et al., 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.

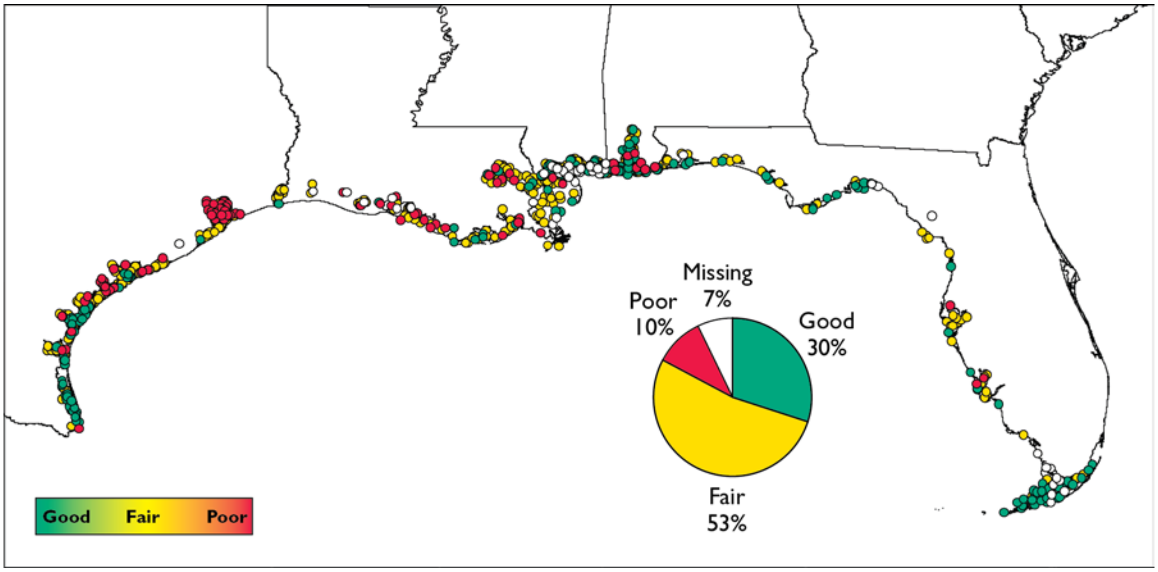


Figure 5-5. Water quality index data for Gulf Coast coastal waters (U.S. EPA/NCA).

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 several sites in Louisiana and Texas, primarily from 2003 and 2004. 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 are rated poor in 14% 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 50 locations that were sampled each year in the NCA 2003–2006 survey; however, because of the high density of these sites and the small area of 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 because more of the coastal area is rated fair and poor, combined, than is rated good 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 Florida 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 21% of the coastal area rated poor for this component indicator. Lower-than-expected water clarity occurred throughout the Gulf Coast region, with poor conditions observed most frequently in Texas and Louisiana. The cutpoints used to assign water clarity ratings varied across Gulf Coast coastal waters (Figure 5-6) based on natural variations in turbidity levels, regional expectations for light penetration related to SAV distribution, and local waterbody management goals (see text box).

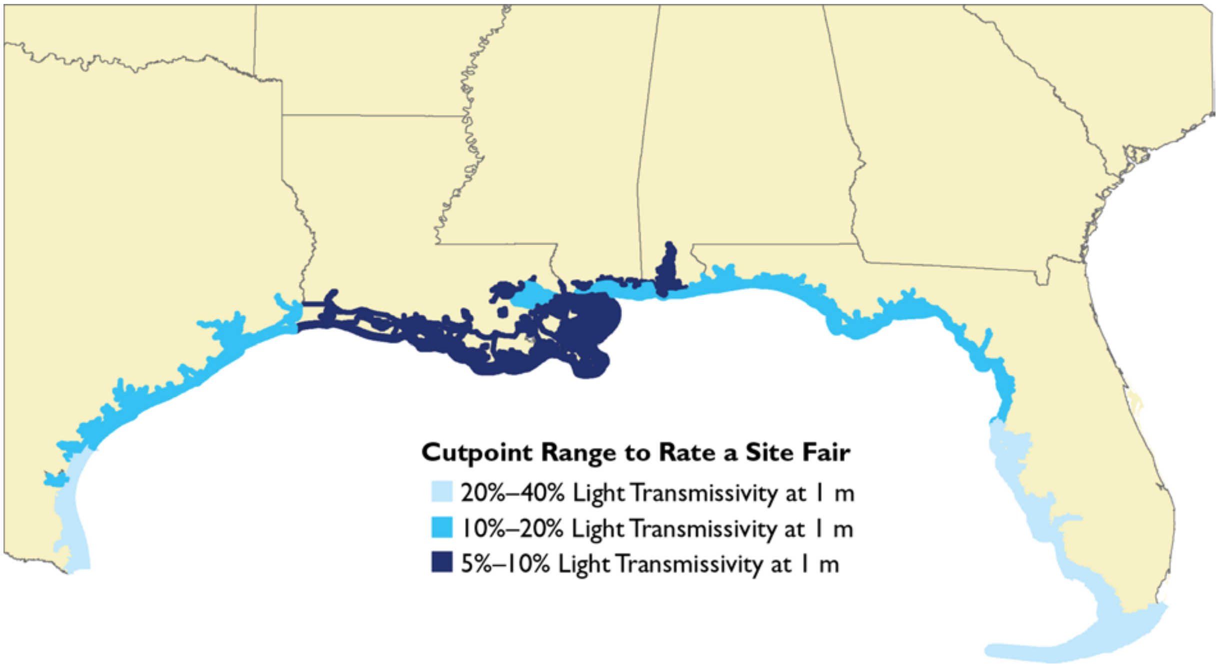


Figure 5-6. Map of water clarity cutpoints used in Gulf Coast coastal waters to rate a site fair (U.S. EPA/NCA).

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 region. 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 decreasing the "expected" water clarity levels to lower levels for much of the Gulf Coast region. 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.

Dissolved Oxygen

The Gulf Coast region is rated good for dissolved oxygen concentrations, with less than 5% (4.8%) 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).

Although hypoxia is a relatively local occurrence in Gulf Coast estuaries, 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., 2002a). 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. The area of the Gulf of Mexico hypoxic zone varied from 3,305 square miles in 2003 to 6,670 square miles in 2006 (Figure 5-7) (LUMCON, 2003, 2006). In 2004 and 2006, the hypoxic zone area was greater than the long-term average of 5,000 square miles (LUMCON, 2006). 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., 2002a). River-borne organic matter, along with nutrients that fuel phytoplankton growth in the Gulf waters, enters the Gulf of Mexico from the Mississippi River. Annual variability in the area of the hypoxic zone has been related to the flows of the Mississippi and Atchafalaya rivers and, by extension, to the precipitation levels that influence these flows. 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). Estimates of hypoxia for the Gulf of Mexico shelf have not been included in the NCA estimates of hypoxia for Gulf Coast estuaries; consequently, the good rating for dissolved oxygen concentrations in the Gulf Coast region provided in this report should not be considered indicative of offshore conditions.

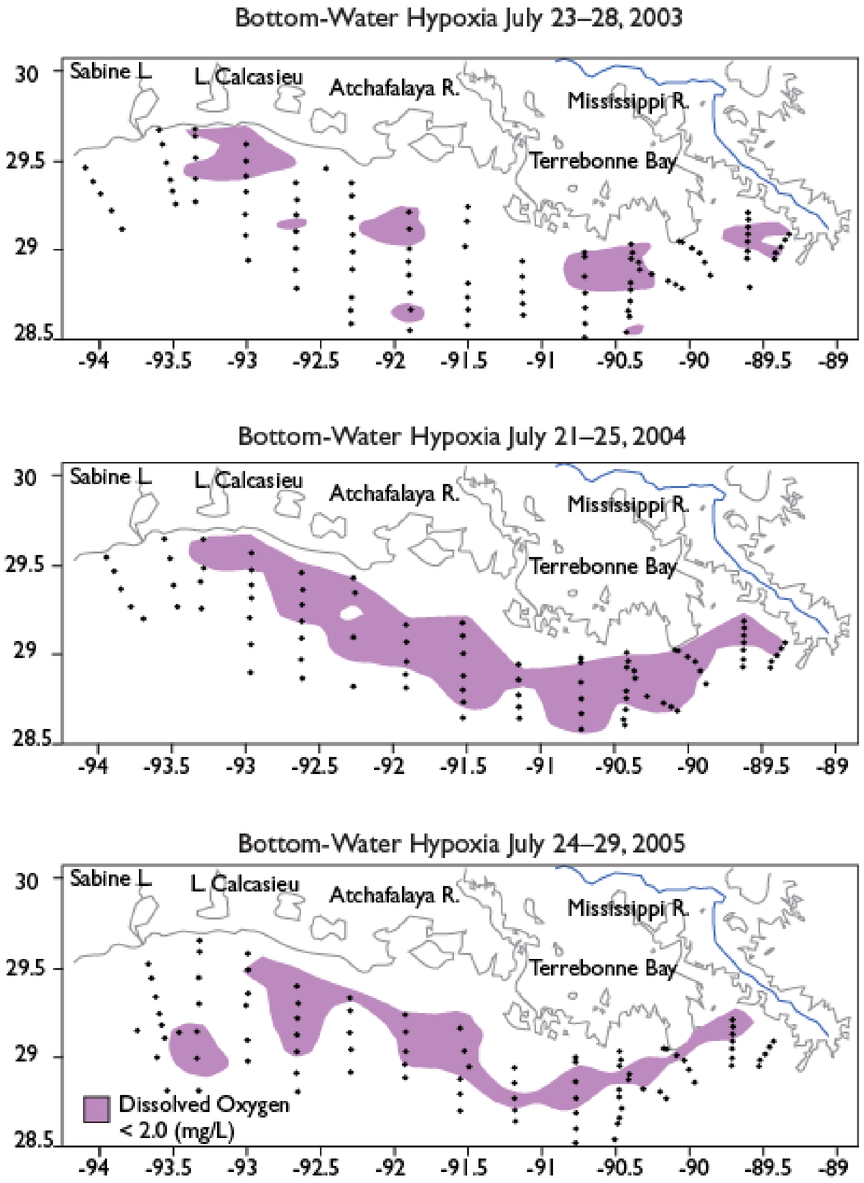


Figure 5-7. Spatial extent of the Gulf Coast hypoxic zone during July, 2003–2005 (U.S. EPA/NCA, based on data provided by NOAA, 2010a).

The cutpoint 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 between 5 and 2 mg/L in bottom waters as being in fair condition (i.e., threatened).

Sediment Quality Index

The sediment quality index is based on the rating scores for the sediment toxicity, sediment contaminants, and sediment TOC component indicators. In the Gulf Coast, the sediment quality index is rated poor because 19% of the coastal area was rated poor for at least one of the component indicators. However, these conditions rarely co-occurred in Gulf Coast sediments from the same sampling station, and the poor rating for the sediment quality index resulted primarily from the high percentage of coastal area rated poor for the sediment toxicity component indicator. Poor ratings for the sediment toxicity and sediment contaminants component indicators co-occurred at only three stations in Florida Bay, which had high concentrations of silver. The remaining stations with poor ratings for the sediment toxicity component indicator did not have high concentrations of sediment contaminants. The sediment toxicity at these sites may have been caused by naturally high levels of hydrogen sulfide (e.g., Florida Bay), high salinity (greater than 55 practical salinity units [psu]; e.g., Laguna Madre), sediment grain-size, or persistent levels of contaminants that were not measured by the NCA.

Sediment toxicity results do not always reflect sediment contaminant concentrations because toxicity also depends on contaminant bioavailability, which is controlled by pH, sediment grain-size, and organic content. Although sediment contaminant concentrations and sediment toxicity tests can be useful screening tools, it is not unusual to find a lack of correlation between the results of these component indicators because some toxic contaminants may not be bioavailable, some contaminants are not lethal to test organisms, and not all potentially toxic contaminants are analyzed. These points underscore the utility of a combined approach to assess the condition of sediment quality in coastal waters.

In 2010, the NCCA changed the sediment toxicity test protocols to conduct estuarine assays with the amphipod, *Leptocheirus plumulosus*, instead of *A. abdita*. The advantages of using *L. plumulosus* include the organism's tolerance to a wider range of salinities and sediment grain-size (*A. abdita* is sensitive to low salinity [< 10 psu] and to coarse-grained sediments). The use of *L. plumulosus* is hoped to reduce the occurrence of poor ratings for the sediment toxicity component indicator as a result of naturally occurring conditions. The NCCA is also reviewing the current NCA sediment quality index to determine the best approach to evaluate the component indicators and the cutpoints used to rate them. The next report, *National Coastal Condition Report V*, will reflect these modifications to the sediment quality index.

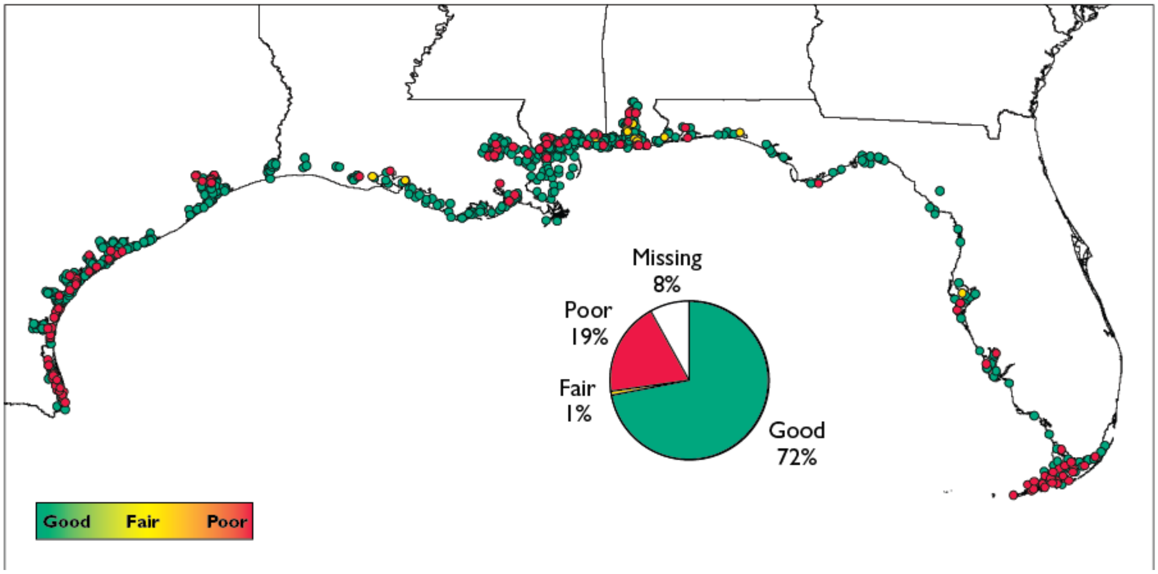


Figure 5-8. Sediment quality index data for Gulf Coast coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The Gulf Coast region is rated poor for sediment toxicity, with 15% 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; however, most of the sites sampled during this survey that were rated poor for sediment toxicity did not have high sediment contaminant concentrations. The toxicity at these sites may have been caused by naturally high levels of hydrogen sulfide (e.g., Florida Bay), high salinity (greater than 55 psu; e.g., Laguna Madre), or persistent levels of contaminants that were not measured by the NCA.

Guidelines for Assessing Sediment Contamination (Long et al., 1996)

ERM (Effects Range Median)—Determined values 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 Contaminants

The sediment contaminants component indicator for the Gulf Coast region is rated good, with 3% of the coastal area rated poor for this component indicator. Most of these sites were located in Florida Bay, with sediment concentrations of silver that exceeded the ERM guideline. In addition, 2% of the coastal area was rated fair, primarily due to sites located in Mobile Bay, AL. The sediment contaminants measured in Gulf Coast waters included elevated levels of metals, pesticides, PCBs, and, occasionally, PAHs.

Sediment TOC

The Gulf Coast region is rated good for sediment TOC, with 16% of the coastal area rated fair for this component indicator and only 2% of the area rated poor.

Benthic Index

The condition of benthic communities in Gulf Coast coastal waters is rated fair to poor, with 20% of the coastal area rated poor for benthic condition (Figure 5-9). Benthic community data were not collected (missing) in 25% of the estuarine area in the Gulf Coast. This was primarily due to the impacts of Hurricanes Katrina and Rita, which prevented Louisiana, Mississippi, and Alabama from conducting the NCA survey in 2005. This rating is borderline, as the criterion for a poor rating is more than 20% of the coastal area in poor condition. 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.

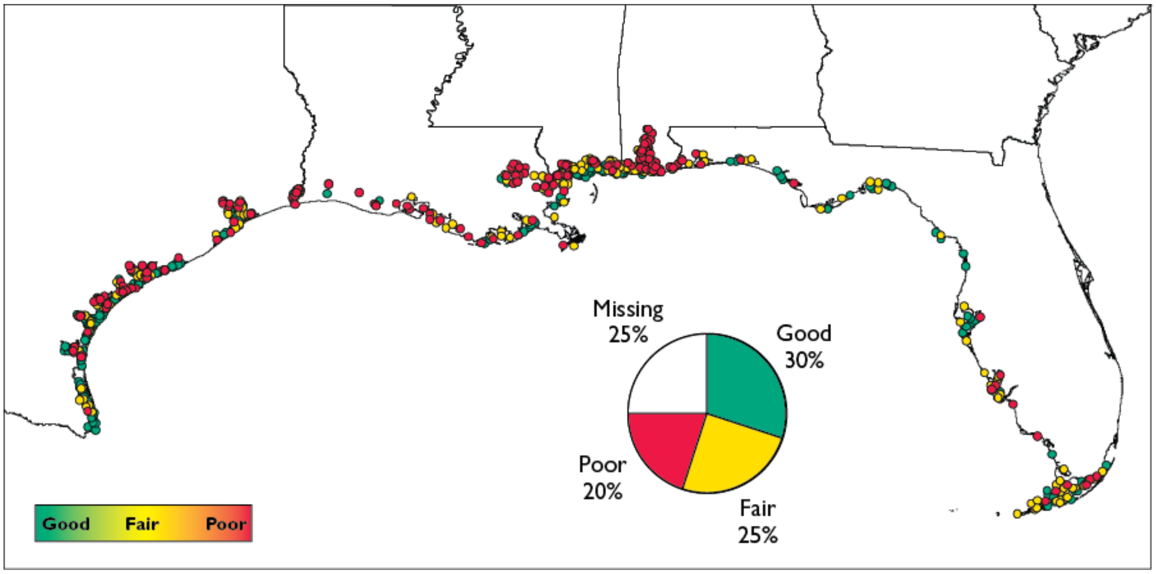


Figure 5-9. Benthic index data for Gulf Coast coastal waters (U.S. EPA/NCA).

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 41,800 acres (1.2%) of coastal wetlands from 1998 to 2004 (Stedman and Dahl, 2008), and the long-term, average decadal wetland loss in coastal states is 2.4%. This estimate does not include the substantial losses of coastal wetlands in the Gulf Coast that occurred as a result of Hurricanes Katrina, Rita, and Wilma in 2005. In Louisiana alone, Hurricanes Katrina and Rita impacted more than 64,000 acres of coastal forested wetlands and more than 135,000 acres of coastal marshes (NMFS, 2007b). In Mississippi, 1,890 acres of coastal wetlands were impacted by Hurricane Katrina, while in Florida, mangrove wetlands were extensively damaged by Hurricane Wilma (NMFS, 2007b). Coastal wetlands in the Gulf Coast region constitute 66% of the total coastal wetland acreage in the conterminous 48 states (Dahl, 2003). Although the Gulf Coast region sustained the largest net loss of coastal wetland acreage during the past decade compared with other regions of the country, the region also had the greatest total acreage of coastal wetlands in 2004 (3,508,600 acres). While coastal development and interference with normal erosional/depositional processes contributes to wetland losses along the Gulf Coast, significant losses also result from climatic changes that affect sea-level rise, subsidence, and the frequency and severity of hurricanes.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of the Gulf Coast region is rated good, with 9% of all sites where fish were sampled rated poor for fish tissue contaminant concentrations (Figure 5-10). Contaminant concentrations exceeding EPA advisory guidance values in Gulf Coast samples were observed primarily in Atlantic croaker and hardhead catfish. Commonly observed contaminants included total PAHs, PCBs, DDT, mercury, and arsenic. Although many of the Gulf Coast estuarine and coastal areas do have fish consumption advisories in effect, that advice primarily concerns recreational game fish such as king mackerel, which are not sampled by the NCA program.

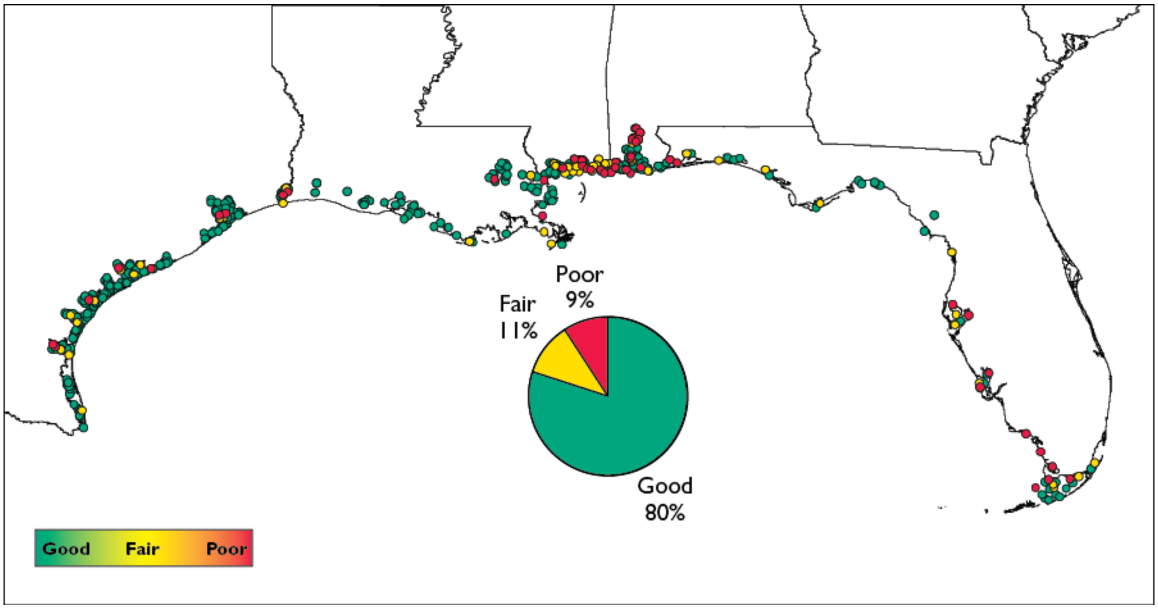


Figure 5-10. Fish tissue contaminants index data for Gulf Coast coastal waters (U.S. EPA/NCA).

Trends of Coastal Monitoring Data—Gulf Coast Region

Temporal Change in Ecological Condition

EMAP/NCA initiated annual surveys of coastal condition in the Gulf of Mexico in 2000, and these data were reported in the NCCR II. Data from 2001 and 2002 were assessed in the NCCR III, and data from 2003–2006 are assessed in this current report (NCCR IV). Seven years of monitoring data from Gulf Coast coastal waters provide an ideal opportunity to investigate temporal changes in ecological condition indices and component 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 area rated good, fair, or poor, and has there been a significant change in the proportion of poor area from 2000 to 2006?

With the exception of the fish tissue contaminants index, all of the condition indices and component indicators can be compared over time (2000–2006) because data supporting these parameters were collected using similar protocols and QA/QC methods. NCA implemented probability-based surveys that support estimations of the percent of coastal area in good, fair, or poor condition based on the indices and component 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 cutpoints listed in Chapter 1 were used to determine good, fair, or poor condition for each index and component indicators. Inter-annual variation was evaluated by comparing annual estimates of percent area in poor condition for each indicator and the associated standard error. A 2-year survey design was implemented for 2005–2006; therefore, this was treated as a single "year." Trends in the percent area in poor condition for each indicator were evaluated using the Mann-Kendall test.

Neither the water quality index nor any of its component indicators showed a significant linear trend over time in the percent area rated in poor condition (Figures 5-11 through 5-16). The percent area in poor condition for the water quality index increased from 2000 to 2004 and then decreased (Figure 5-11), although there were no statistically significant differences between any of the years. The change in percent area in poor condition for DIP, chlorophyll *a*, and dissolved oxygen showed a similar pattern (Figures 5-13, 5-14, 5-16). The percent area with poor DIN ratings did not change over time (Figure 5-

12), while there was a slight, but not statistically significant, decrease in the percent area with poor water clarity over time (Figure 5-15).

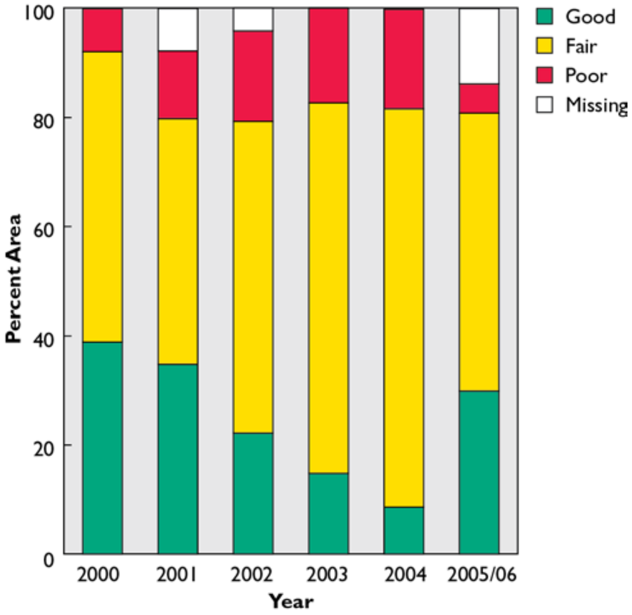


Figure 5-11. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for the water quality index measured from 2000–2006 (U.S. EPA/NCA).

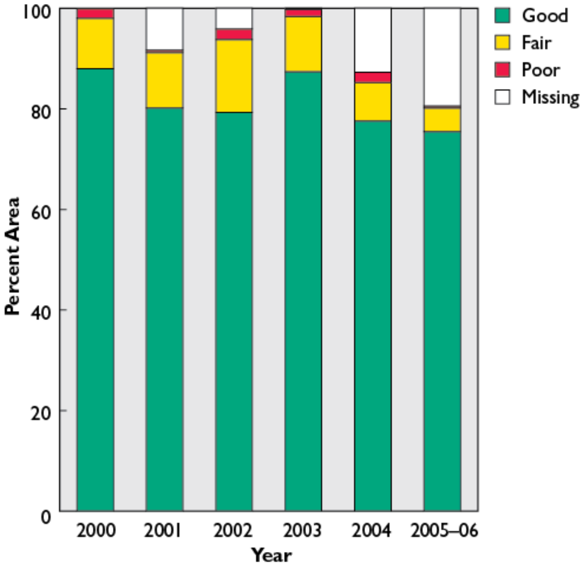


Figure 5-12. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for DIN measured from 2000–2006 (U.S. EPA/NCA).

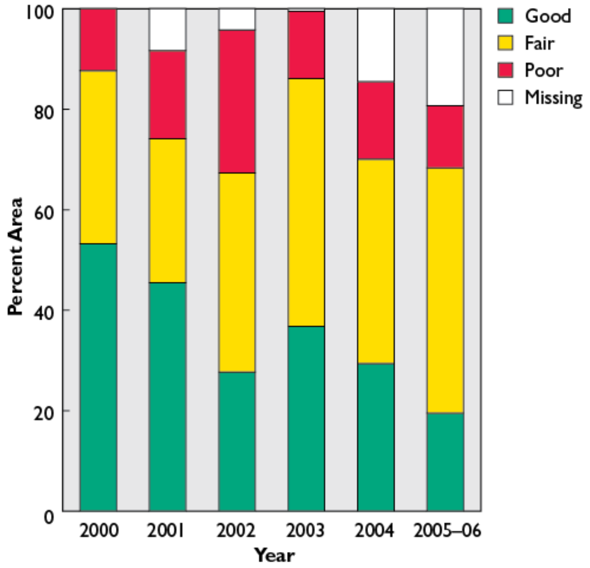


Figure 5-13. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for DIP measured from 2000–2006 (U.S. EPA/NCA).

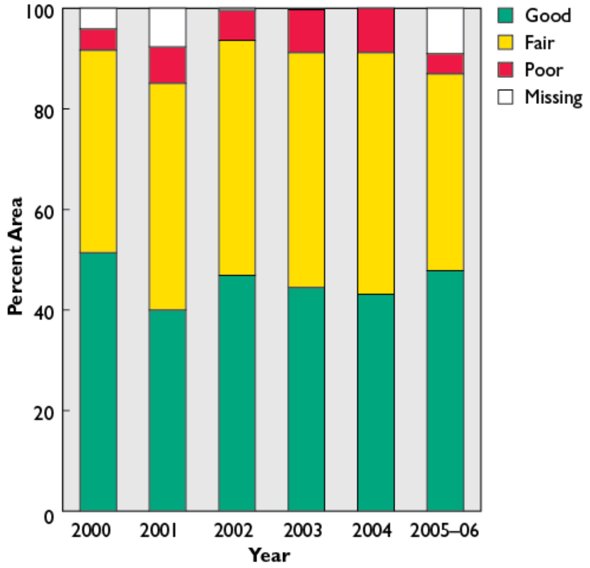


Figure 5-14. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for chlorophyll *a* measured from 2000–2006 (U.S. EPA/NCA).

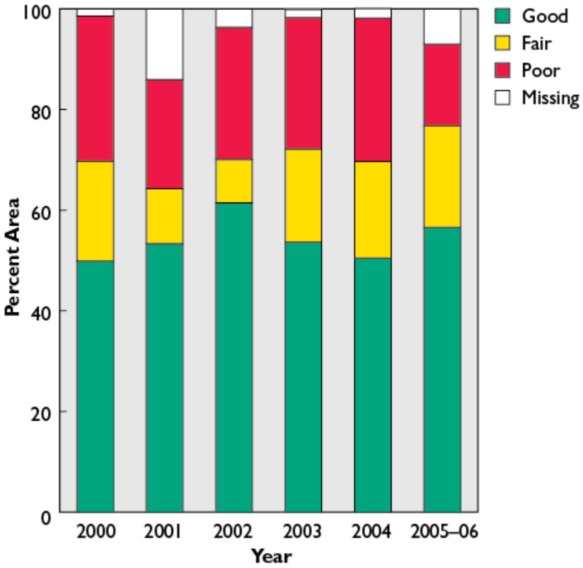


Figure 5-15. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for water clarity measured from 2000–2006 (U.S. EPA/NCA).

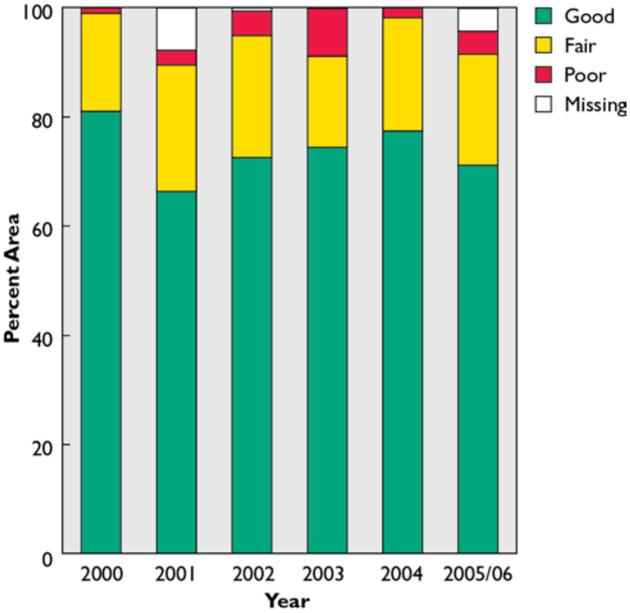


Figure 5-16. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for bottom-water dissolved oxygen measured from 2000–2006 (U.S. EPA/NCA).

The sediment quality index and its component indicators (i.e., sediment toxicity, sediment contaminants, and sediment TOC) were compared over time. Only the percent area with poor ratings for the sediment toxicity component indicator showed a significant positive trend from 2000–2006 ($p < 0.10$; Figure 5-18). Although there were no statistically significant differences in the percent area rated poor for sediment contaminants, TOC, or the sediment quality index from 2000–2002 (Figures 5-17 through 5-20), the percent area rated poor for the sediment contaminants component indicator decreased from 13% in 2000 to 0% in 2004–2006 (Figure 5-19).

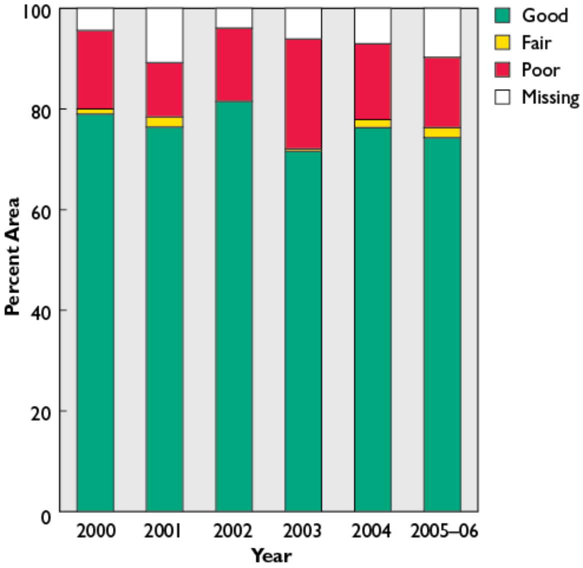


Figure 5-17. Percent area of Gulf Coast coastal waters in good, poor, or missing categories for the sediment quality index measured from 2000–2006 (U.S. EPA/NCA).

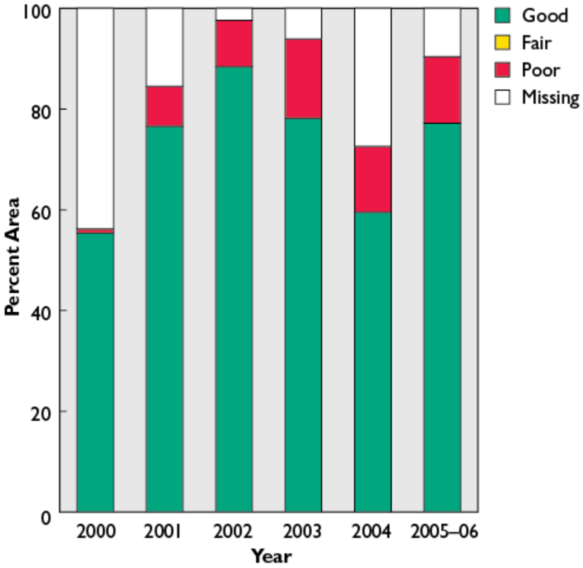


Figure 5-18. Percent area of Gulf Coast coastal waters in good, poor, or missing categories for sediment toxicity measured from 2000–2006 (U.S. EPA/NCA).

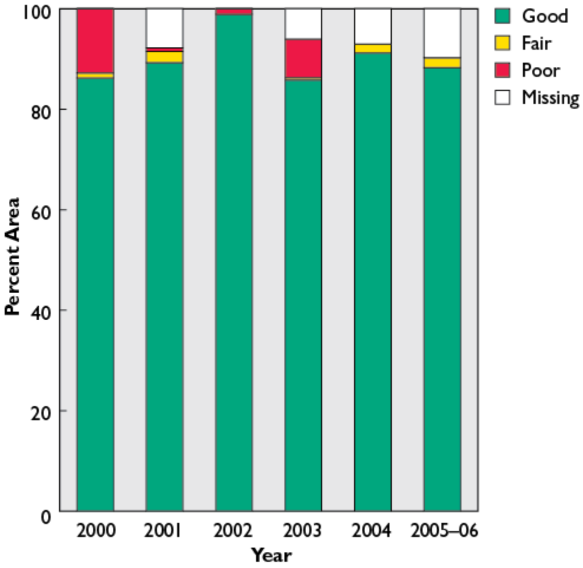


Figure 5-19. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for sediment contaminants measured from 2000–2006 (U.S. EPA/NCA).

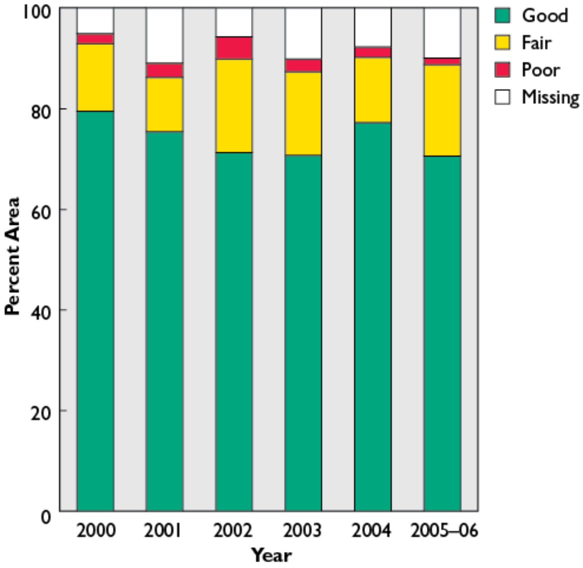


Figure 5-20. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for sediment TOC measured from 2000–2006 (U.S. EPA/NCA).

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. There was no statistically significant trend in the percent area with poor benthic condition from 2000–2006. The percent area with poor benthic condition increased from 2000 to 2002 and then decreased (Figure 5-21). More than 50% of the area had missing benthic data in 2005–2006; this was, in part, due to difficulties in obtaining samples after the hurricanes of 2005 (e.g., Katrina and Rita).

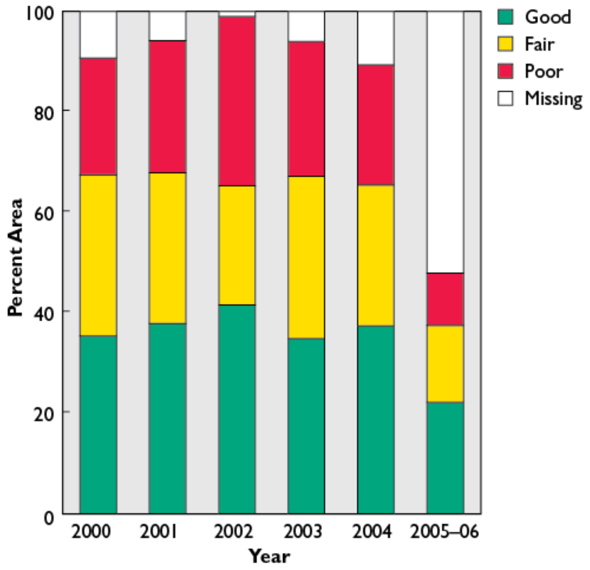


Figure 5-21. Percent area of Gulf Coast coastal waters in good, fair, poor, or missing categories for the benthic index measured from 2000–2006 (U.S. EPA/NCA).

In summary, there were no statistically significant trends in water quality, sediment quality, or benthic condition in the Gulf Coast estuaries from 2000–2006.

Large Marine Ecosystem Fisheries—Gulf of Mexico LME

The Gulf of Mexico LME extends from the Yucatan Peninsula, Mexico, to the Straits of Florida, and is bordered by the United States and Mexico (Figure 5-22). In this LME, intensive fishing is the primary driving force of biomass change, with climate as the secondary driving force. The Gulf of Mexico LME is considered a moderately productive LME based on global estimates of primary production (phytoplankton) (NOAA, 2007a). The LME is partially isolated from the Atlantic Ocean, and the portion 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 high 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.

Figure 5-22. The Gulf of Mexico Large Marine Ecosystem (NOAA, 2010a).

From 2003 to 2006, commercial fisheries in the Gulf of Mexico LME generated over $2.6 billion in revenue, dominated by the white and brown shrimp fisheries, which generated over $677 million and $650 million during this period, respectively. The next-highest grossing fishery, the Eastern oyster (*Crassostrea virginica*), yielded over $240 million (NMFS, 2010). The other top-grossing fisheries include menhaden, blue crab, and pink shrimp. Most of the commercial fishery revenue within this LME is generated by Louisiana and Texas. See Figure 5-23 for revenues and landings of the top Gulf of Mexico LME commercial fisheries. As in other LMEs, the fisheries are managed through a combination of federal and state regulatory regimes, the latter playing an especially large role because invertebrates tend to occur within state waters. Recreational fishers target red drum and spotted seatrout, as well as pelagic (water-column dwelling) species such as mackerel, dolphinfish, and cobia.

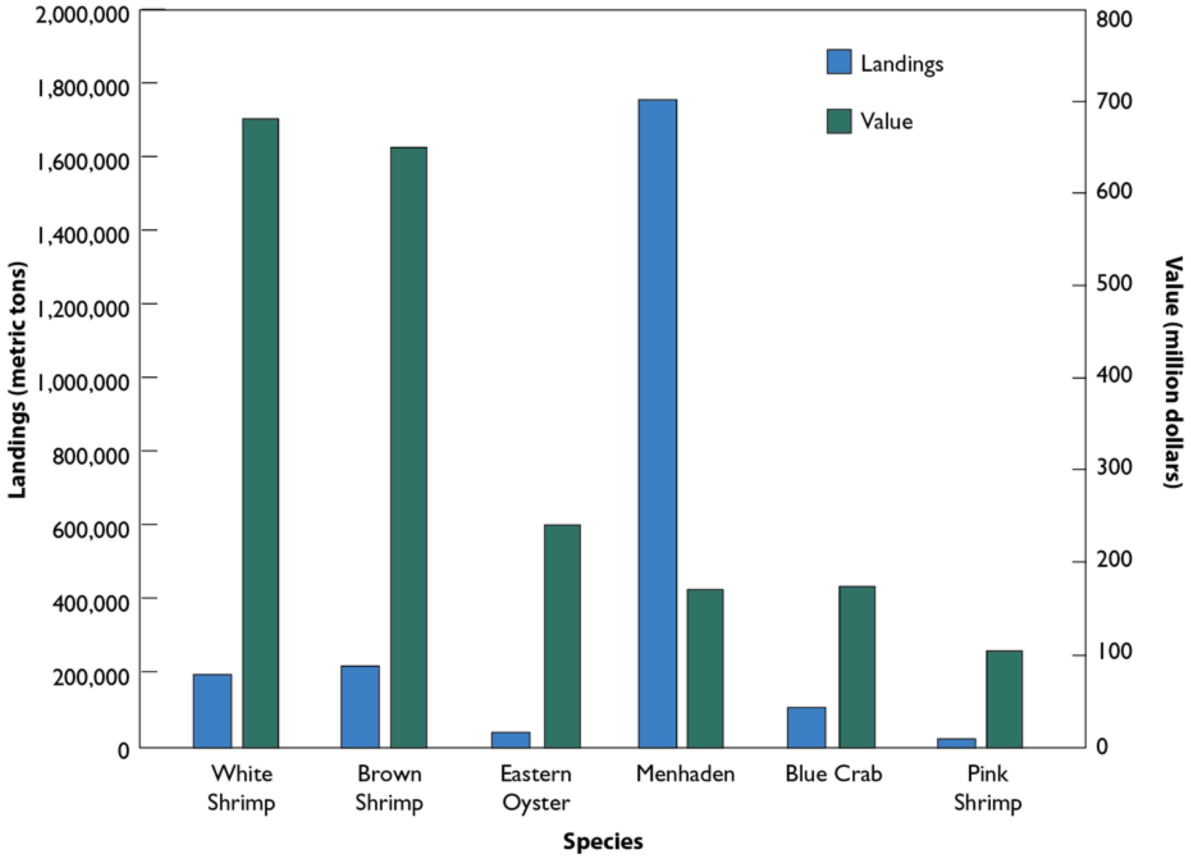


Figure 5-23. Top commercial fisheries for the Gulf of Mexico LME: landings (metric tons) and value (million dollars) from 2003–2006 (NMFS, 2010).

Invertebrate Fisheries

In the Gulf of Mexico LME, the most important commercial fisheries are invertebrates (shrimp, oysters, and crab), which represent five of the six top-grossing fisheries. Shrimp fisheries in this LME are some of the most valuable U.S. fisheries based on ex-vessel revenues (pre-processing value) and are fished using a twin-trawl system that allows the towing of four trawls simultaneously. Brown, white, and pink shrimp account for over 99% of the total Gulf of Mexico LME shrimp catch. In 2006 alone, these three important species produced approximately 129 metric tons valued at more than $388 million in ex-vessel revenues. They are typically found in all U.S. Gulf of Mexico LME waters shallower than 395 feet. Most of the offshore brown shrimp catch is taken at 130- to 260-foot depths; white shrimp are caught in waters 66 feet deep or less; and pink shrimp in waters of 130–200 feet. Brown shrimp are most abundant off the Texas–Louisiana coast, and the greatest concentration of pink shrimp is in waters off southwestern Florida. Between 2004 and 2006, the average annual yield for brown shrimp (53,500 metric tons), pink shrimp (6,500 metric tons), and white shrimp (52,000 metric tons) was below maximum sustainable yield levels (NMFS, 2009b).

Catch levels in 2006 were excellent for brown and white shrimp, with white shrimp reaching an all time high at approximately 59,500 metric tons, while pink shrimp have shown a moderate declining trend in recent years (Hart and Nance, 2007). For each species, the number of young shrimp entering the fisheries has generally reflected the level of catch, with harvesting occurring at maximum levels. The number of young brown shrimp produced per parent increased significantly until about 1991—most likely in relation to marsh habitat alterations—and has remained near or slightly below that level during most years.

Coastal sinking and sea-level rise in the northwestern Gulf of Mexico LME inundate intertidal marshes, 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. However, continued coastal sinking will lead to marsh deterioration and an ultimate loss of supporting wetlands, and current high fishery yields may not be indefinitely sustainable.

In the Gulf of Mexico LME, harvesting is regulated under the Gulf of Mexico Fishery Management Council's Shrimp FMP (GMFMC, 2011), which restricts shrimping by closing two shrimping grounds—a seasonal closure of fishing grounds off Texas for brown shrimp and a closure off Florida for pink shrimp. The harvesting of small shrimp is sacrificing the yield and value of the catch by cutting short future population growth (Caillouet et al., 2008); therefore, size limits also exist for white shrimp caught in federal waters and landed in Louisiana. Because shrimp are a short-lived species (with life spans only up to 1.5 years), they can quickly benefit from management practices.

Until very recently, the shrimp fisheries were overcapitalized, with more fishing effort being expended than was needed to sustainably harvest the resource (Nance et al., 2006). Lower-than-average ex-vessel prices for shrimp and higher-than-average fuel prices over the past few years have stemmed this trend. As in the Southeast U.S. Continental Shelf LME, another management concern is the use by shrimp fisheries of small-mesh trawl nets that catch non-target species, including species at low stock levels; commercially fished species such as red snappers, croakers, and seatrouts; and protected resources such as sea turtles. All sea turtle species are listed as endangered or threatened under the Endangered Species Act, and shrimp vessels have been required to use turtle-excluder devices in their nets since 1988 to avoid capturing sea turtles. The NMFS and the fishing industry are working together to continue development of bycatch-reduction gear to address the problems of finfish by-catch in shrimp fisheries of the Gulf of Mexico and Southeast U.S. Continental Shelf LMEs.

The other major invertebrate fisheries in the Gulf of Mexico LME are the blue crab and Eastern oyster. The Eastern oyster is a mollusk native to the U.S. eastern seaboard and the Gulf of Mexico. As a filter feeder, this oyster provides a critical ecosystem function by cleaning the water of plankton and detritus. Oysters build reef-like structures and are harvested using dredges, which scrape sea bottoms and haul the specimens into a basket. From 2003 to 2006, the Eastern oyster fishery in the Gulf of Mexico LME provided over $241 million in total ex-vessel revenues (see Figure 5-23) (NMFS, 2010). This species is also heavily harvested in the Chesapeake Bay. Both areas now supplement natural production by farming oysters, a process that induces oyster reproduction in controlled environmental conditions.

The crab fisheries include blue and stone crab, which provide differing economic values for Gulf states. The biology and harvesting specifications for the blue crab are described within the Southeast U.S. Continental Shelf LME section (Chapter 4), where this is the top-grossing fishery and an iconic species. Although less well known in the Gulf, the blue crab fishery generated over $165 million in total ex-vessel revenues from 2003 to 2006 for this area, providing many of the crabs served on the East Coast market (NMFS, 2010).

Menhaden Fishery

Menhaden, a herring-like fish, are found in coastal and estuarine waters of the Gulf of Mexico, Southeast U.S. Continental Shelf, and Northeast U.S. Continental Shelf LMEs. They form large schools at the surface, which are located by aircraft and harvested by purse seines to produce baitfish; fishmeal; fish oil; flavoring for pet food; protein in animal feed; and fertilizer. Menhaden are prey for many fish, marine mammals, and sea birds, and, as filter feeders, minimize algal blooms, all of which are important functions within coastal ecosystems. Gulf menhaden (*Brevoortia patronus*) play a greater role in U.S. commercial fisheries than their Atlantic relative, Atlantic menhaden (*Brevoortia tyrannus),* generating

$168.6 million in total ex-vessel revenues from 2003 to 2006 within the Gulf (mostly by Louisiana) (see Figure 5-23) (NMFS, 2010). In both the Gulf and the Atlantic, menhaden are largely harvested by one company, Omega Protein of Houston, which owns reduction factories along the Gulf Coast and one in Virginia.

Gulf menhaden are most abundant in the north-central portion of the Gulf of Mexico, though they are present throughout the Gulf. They form large surface schools that appear in nearshore Gulf 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. In 2005, Hurricanes Katrina and Rita did considerable damage to the four Gulf menhaden reduction factories (which process the fish into fertilizer, feed stock, and fish oil); two closed for the remainder of the fishing season after the storms and faced major difficulties re-opening in 2006. Because Gulf of Mexico LME menhaden have a short life cycle and a high natural mortality, overfishing has not been a management concern. Management is coordinated through the Gulf States Marine Fisheries Commission and consists of an approximate 28-week fishing season from April to October. Menhaden in the Atlantic are largely managed by the Atlantic States Marine Fisheries Commission and the states.

Fishery Trends and Summary

Figure 5-24 shows landings of the menhaden fishery in the Gulf of Mexico LME since 1950. The menhaden and the other top fisheries in this LME are displayed on separate graphs because catches of menhaden are too large to demonstrate on the same scale as the rest of the Gulf of Mexico fisheries. Landings in the menhaden fishery increased steadily from 1950, peaked at nearly 1 million metric tons in the mid-1980s and declined to present-day levels of 400,000 metric tons. In addition to changes in fishing effort, the variations in landings are largely attributable to altered environmental conditions that affect recruitment of gulf menhaden, including adverse meteorological events such as hurricanes. Increased tropical activity also leads to decreased fishing effort and, coupled with lower recruitment level, results in a negative impact on fishery landings.

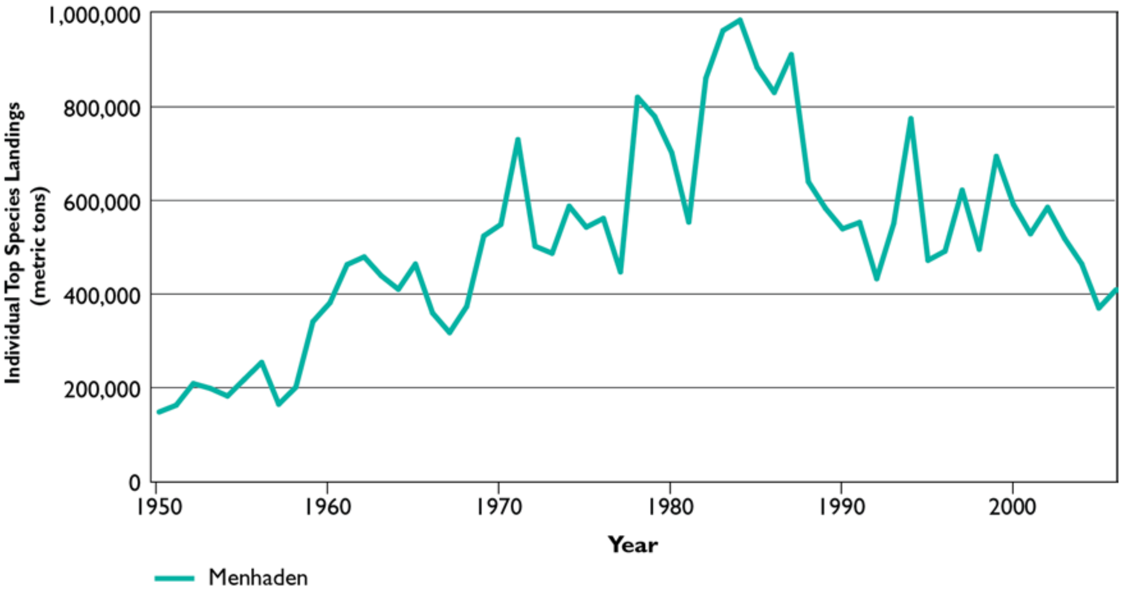


Figure 5-24. Landings of the menhaden fishery in the Gulf of Mexico LME from 1950 to 2006, metric tons (NMFS, 2010).

Landings in the invertebrate fisheries, which generate the largest revenues for the Gulf of Mexico LME, are presented in Figure 5-25. Since 1950, the blue crab has steadily increased from 10,000 metric tons to present-day landings of 30,000 metric tons. Landings in the Eastern oyster fishery have consistently fluctuated around 10,000 metric tons over the past five decades. Data for the shrimp fisheries was not available prior to 1961, and landings from 1972 to 1977 were reported as combined totals rather than as separate species. Nevertheless, with the data that are available, there is evidence of considerable fluctuation in landings over the past several decades for all three shrimp species. During this time, both the white and brown shrimp fisheries landings have increased to just over 60,000 metric tons, with catches in the white shrimp fishery steadily increasing since the late 1990s. Landings in the brown shrimp fishery had been declining since 2000, though a recent spike brought catches up to average levels. The pink shrimp fishery, which yields much lower catches than the other two shrimp species, declined from a peak of 25,000 metric tons in the mid-1960s to less than 5,000 metric tons in 2006 (NMFS, 2010).

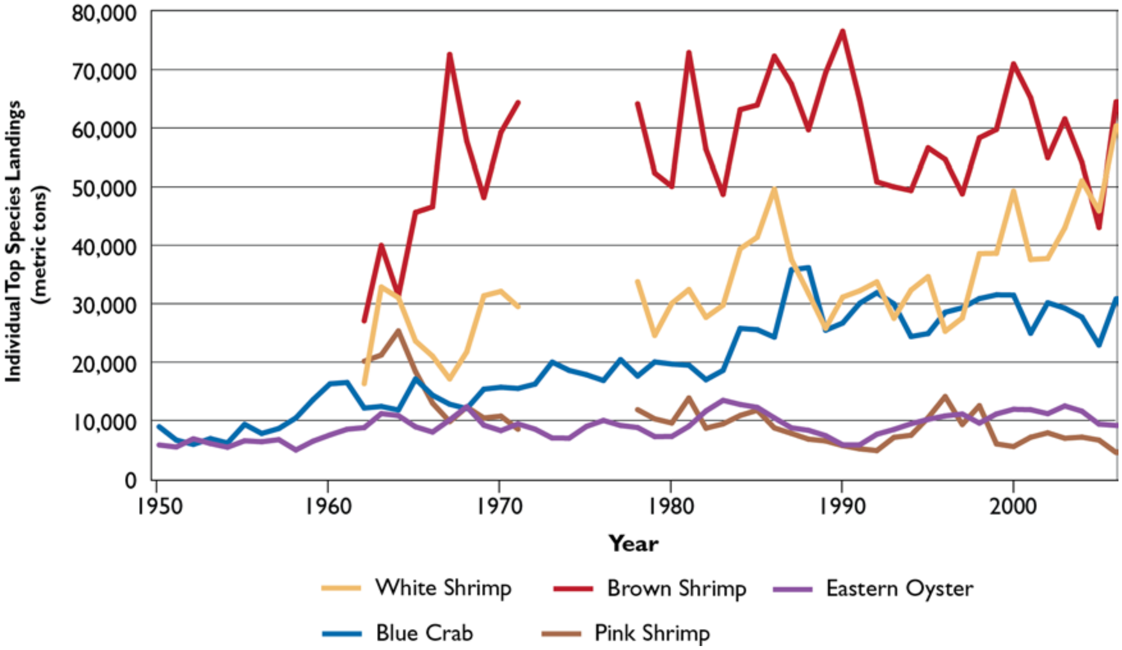


Figure 5-25. Landings of the top commercial fisheries in the Gulf of Mexico LME from 1950 to 2006, metric tons (NMFS, 2010).

The Gulf of Mexico LME provides significant commercial and recreational fisheries opportunities. The top commercial species are invertebrate species of white, brown, and pink shrimp. These species accounted for over $350 million in 2006 alone. From 2003 to 2006, Eastern oyster catches provided over $240 million, and blue crab generated $165 million for commercial fisheries. The menhaden fishery generated $165 million from 2003–2006 from approximately 400,000 metric tons per year (NMFS, 2010). Interestingly, and unlike most other Gulf fisheries, the menhaden catch far exceeded its market value. Menhaden are used in a variety of industries such as fertilizer production, protein in animal feed, and flavoring in pet foods.

In addition to the substantial market value of these commercial fisheries, they support other related industries, such as boat construction, fuel for vessels, fishing gear and nets, shipboard navigation and electronics, and ship repair and maintenance. Similarly, recreational fish such as grouper, snapper, and amberjack drive an economic engine that supports tourism, bait and tackle shops, recreational boating and much more, all contributing significantly to the value derived from the ecosystem service of fishery production. This "coastal economy" (Yoskowitz, 2009) of the Gulf of Mexico LME provides fish and shellfish for food, but that is not the only ecosystem service or function it offers. Fish and shellfish are part of complex ecosystems that rely on various species interactions for the maintenance of necessary ecosystem functions. For instance, invertebrates and pelagic (water-column dwelling) species provide sustenance for larger fish, which themselves are prey for marine mammals and seabirds, which can also support tourism and coastal development. Many functions performed by species in the LME also indirectly benefit humans, such as water purification by bivalves such as scallops, clams, and oysters that filter the water constantly while feeding, helping to clean the water of algae, detritus, and toxics, which results in a more enjoyable beach or boating experience for humans.

Advisory Data

Fish Consumption Advisories

In 2006, 11 fish consumption advisories were in effect for the estuarine and marine waters of the Gulf Coast region. Most of the advisories (9) were issued for mercury, and each of the five Gulf Coast states had one state-wide coastal advisory in effect for mercury levels in king mackerel. The statewide king mackerel advisories covered all coastal and estuarine waters in Florida, Mississippi, Louisiana, and Alabama, but covered only the coastal shoreline waters in Texas. As a result of the statewide advisories, 100% of the coastal miles of the Gulf Coast and 76% of the estuarine square miles were under advisory in 2006 (Figure 5-26) (U.S. EPA, 2007c). Table 5-1 lists the species and/or groups under fish consumption advisory in 2006 for at least some part of the coastal waters of the Gulf Coast region.

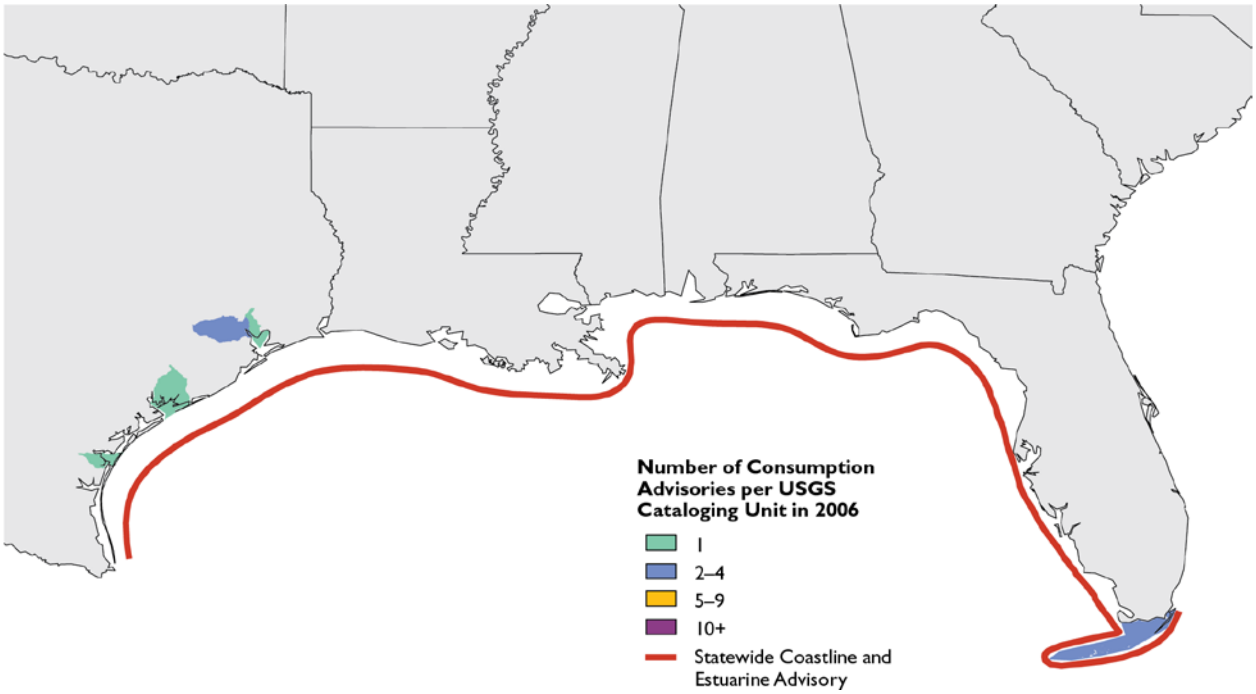


Figure 5-26. The number of fish consumption advisories active in 2006 for the Gulf Coast coastal waters (U.S. EPA, 2007c).

Table 5-1. Species and/or Groups under Fish Consumption Advisory in 2006 for at Least Some Part of the Coastal Waters of the Gulf Coast Region

Species and/or Groups under Fish Consumption Advisory		
Almaco jack	Atlantic croaker	Atlantic spadefish
Atlantic stingray	Atlantic thread herring	Barracuda
Black drum	Black grouper	Blackfin tuna
Blue crab	Bluefish	Bluntnose stingray
Bonefish	Catfish	Cobia
Crab	Crevalle jack	Dolphin
Fantail mullet	Florida pompano	Gafftopsail catfish
Gag grouper	Gray snapper	Greater amberjack
Gulf flounder	Hardhead catfish	Hogfish
Lane snapper	King mackerel	Ladyfish
Little tunny	Lookdown	Mutton snapper
Oysters	Pigfish	Pinfish
Red drum	Red grouper	Red snapper
Sand seatrout	Scamp	Shark
Sheepshead	Silver perch	Skipjack tuna
Common Snook	Snowy grouper	Southern flounder
Southern kingfish	Spanish mackerel	Spot
Spotted seatrout	Tarpon	Striped mojarra
Striped mullet	Wahoo	Tripletail
Vermillion snapper	White mullet	Weakfish
White grunt	Yellowtail snapper	Yellowedge grouper
Yellowfin tuna		

Source: U.S. EPA, 2007c

In addition to the statewide coastal advisory, Florida had two mercury advisories in effect for a variety of fish. In Texas, the Houston Ship Channel continued an advisory for all fish species because of the risk of contamination by chlorinated pesticides and PCBs. In addition, the advisory was expanded to include potential dioxin contamination for all fish in the Houston Ship Channel. Figure 5-27 shows the number of advisories issued along the Gulf Coast for each contaminant (U.S. EPA, 2007c).

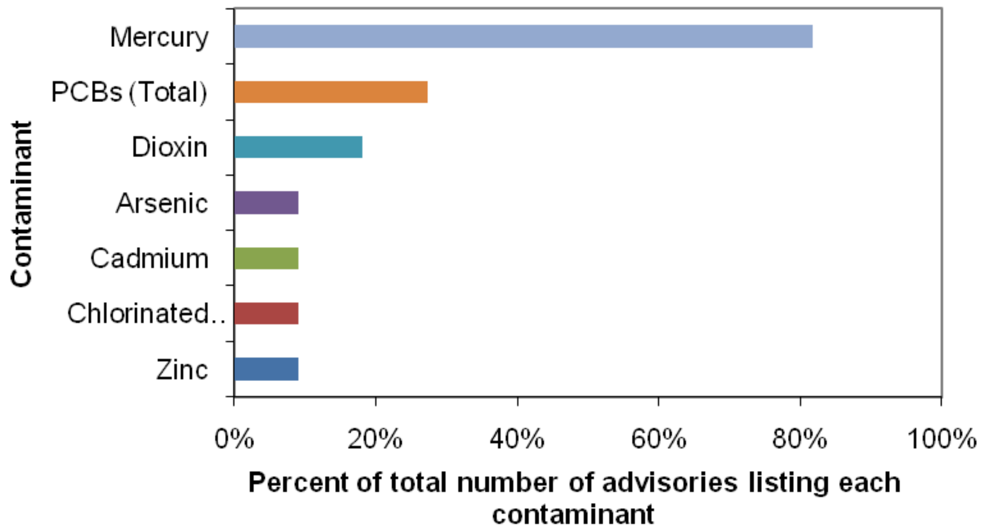


Figure 5-27. Pollutants responsible for fish consumption advisories in Gulf Coast coastal waters. An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for the Gulf Coast between 2004 and 2008?

Table 5-2 presents the number of total and monitored beaches, as well as the number and percentage of monitored beaches affected by notification actions from 2004 to 2008 for the Gulf Coast (i.e., Florida's Gulf Coast beaches, Texas, Louisiana, Mississippi, and Alabama). Data from Florida were not included in 2004 and 2005, nullifying comparison with the 2006 to 2008 information. Nevertheless, there is an increase of 32 monitored beaches for those years amongst the other three states. From 2006 to 2008, the percentage of monitored beaches affected by notifications increased demonstrably from 48% to 54% (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring site: http://www.epa.gov/waterscience/beaches/seasons/.

Table 5-2. Beach Notification Actions, Gulf Coast, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004[a]	2005[a]	2006	2007	2008
Total number of beaches	241	242	651	649	650
Number of monitored beaches	100	132	316	323	323
Number of beaches affected by notification actions	65	67	152	164	176
Percentage of monitored beaches affected by notification actions	65%	51%	48%	51%	54%

[a] Data for Florida's Gulf Coast beaches is not included for 2004 and 2005 because the state did not differentiate between its Southeast and Gulf coast beaches in its state summary.

What pollution sources impacted monitored beaches?

Table 5-3 presents the numbers and percentages of monitored Gulf Coast beaches affected by various pollution sources for 2007. Unknown, unidentified, and uninvestigated pollution sources contributed to over 85% of beach notifications on the Gulf Coast. The other major pollution sources affecting Gulf Coast beaches in 2007 were boat discharges (22%), storm-related runoff (28%), and wildlife (22%) (U.S. EPA, 2009d).

Table 5-3. Reasons for Beach Advisories, Gulf Coast, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Other and/or unidentified sources	92	41%
Pollution sources not investigated	73	33%
Storm-related runoff	62	28%
Wildlife	50	22%
Boat discharge	49	22%
No known pollution sources	30	13%
Agricultural runoff	19	9%
Septic system leakage	19	9%
Sanitary/combined sewer overflow	15	7%
Sewer line leak or break	11	5%
Publicly owned treatment works	1	< 1%

Note: A single beach advisory may have multiple pollution sources.

How long were the 2007 beach notification actions?

In 2007, nearly 90% of beach notifications on the Gulf Coast lasted up to a week, with most (70%) in the 3- to 7-day duration period. Another 19% were either 1 day (4%) or 2 days (15%), and the remaining 11% were of the 8- to 30-day duration (9%) and over 30-day duration (2%) (U.S. EPA, 2009d). For more information on state beach closures, please visit EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

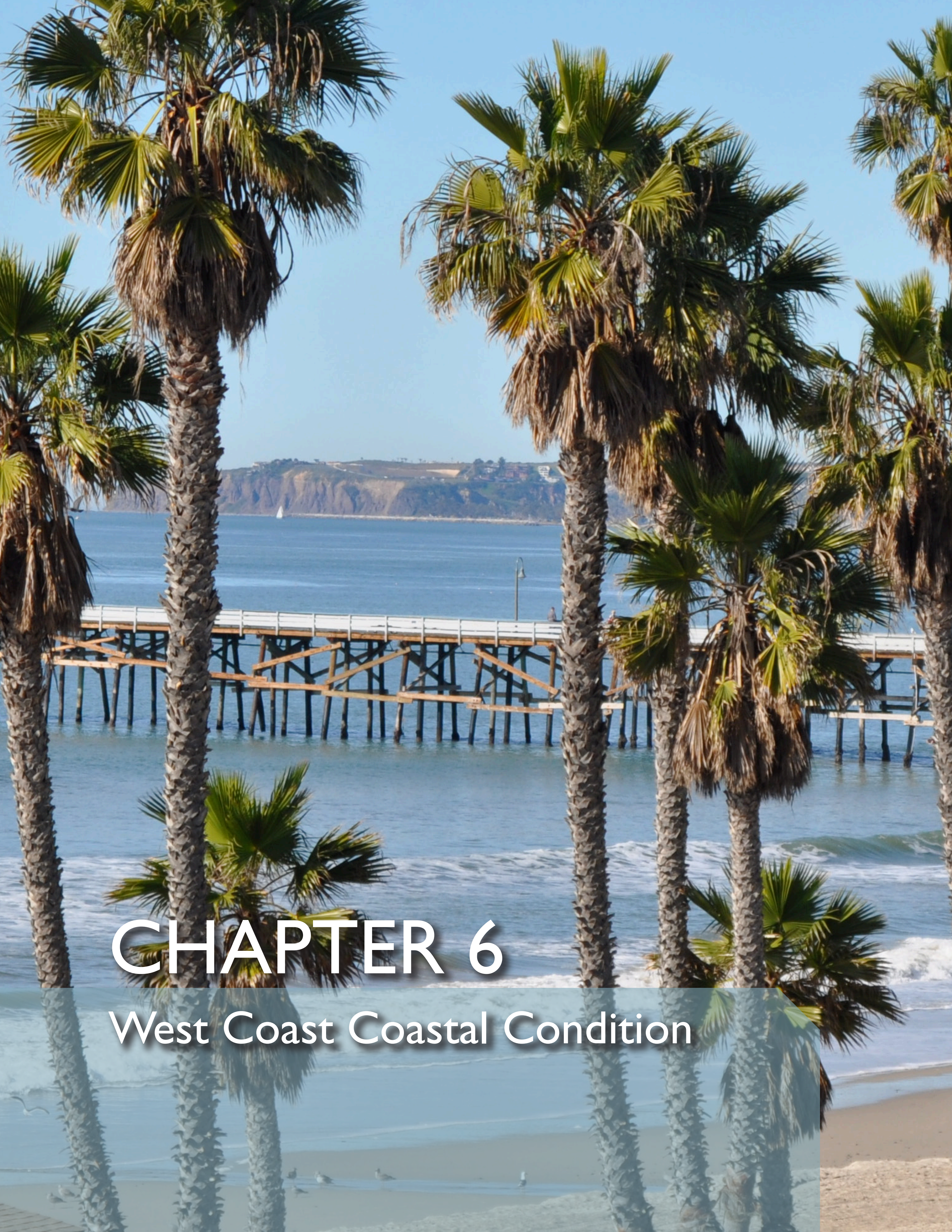
Summary

Based on the indices used in this report, the overall condition of Gulf Coast coastal waters is rated fair. The coastal wetland and sediment quality indices are rated poor in Gulf Coast coastal waters for 2003–2006, while water quality and benthic condition were also of concern (rated fair and fair to poor, respectively). Benthic index values were lower than expected in 20% of the Gulf Coast estuaries. Although elevated sediment contaminant concentrations were found in only 3% of the coastal area, sediments were toxic in 15% of the coastal area. Poor water clarity was observed in 21% of the coastal area, elevated levels of DIP were observed in 14% of the area, and dissolved oxygen concentrations were rated poor in less than 5% (4.8%) of the area. DIN concentrations rarely exceeded guidelines. The overall condition rating of 2.4 in this report represents no significant change from the ratings of 2.4 and 2.2 observed in the previous reports (NCCR II and III), but still represents an improvement in overall condition since the early 1990s.

NOAA's NMFS manages several fisheries in the Gulf of Mexico LME, including reef fishes, mackerel, and shrimp. The top commercial species are invertebrate species of white, brown, and pink shrimp; oysters; and blue crabs. The menhaden stock in this LME is healthy, but in 2005, Hurricanes Katrina and Rita did considerable damage to the four Gulf menhaden reduction factories. Continued coastal sinking and sea-level rise in the northwestern Gulf of Mexico LME may lead to shrimp habitat deterioration, and current high fishery yields may not be indefinitely sustainable.

Contamination in Gulf Coast coastal waters has affected human uses of these waters. In 2006, 100% of the coastal miles of the Gulf Coast and 76% of the estuarine square miles were under fish consumption advisories, primarily due to mercury contamination. In addition, approximately 48% of the region's monitored beaches were closed or under advisory for some period of time during 2006.

Increasing population pressures in the Gulf Coast region warrant additional monitoring programs and increased environmental awareness to correct existing problems and to ensure that indicators that appear to be in fair condition do not worsen.



CHAPTER 6

West Coast Coastal Condition

6. West Coast Coastal Condition

As shown in Figure 6-1, the overall condition of the coastal waters of the West Coast region based on the 2004–2006 assessment period is rated good to fair, with an overall score of 3.8. The water quality, benthic, and fish tissue contaminants indices are rated good, the sediment quality index is rated fair; and the coastal habitat index is rated poor. Figure 6-2 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on environmental stressor and response data collected by NCA from 139 sites in 2004 and 165 sites in 2005 through 2006 throughout West Coast coastal waters using comparable methods and techniques.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

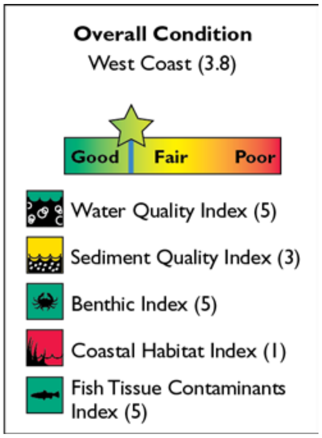


Figure 6-1. The overall condition of West Coast coastal waters is rated good to fair (U.S. EPA/NCA).

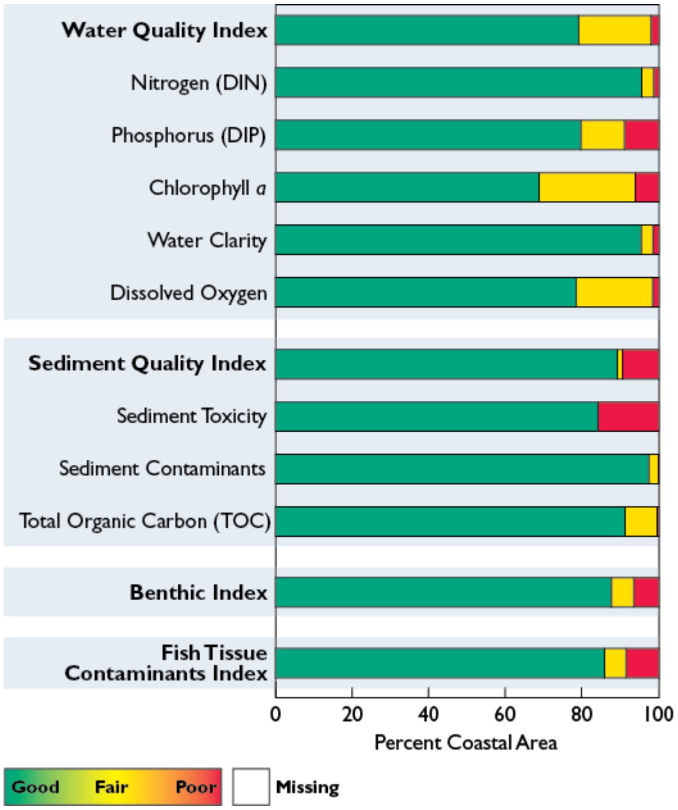


Figure 6-2. Percentage of coastal area achieving each ranking for all indices and component indicators—West Coast region (U.S. EPA/NCA).

The West Coast coastal area comprises more than 410 estuaries and bays, including the sub-estuary systems that are associated with larger estuaries. The size range of these West Coast coastal waterbodies is illustrated by five order-of-magnitude size classes of the systems sampled by EMAP/NCA—from less than 1 square mile (Yachats River, OR) to 2,551 square miles (Puget Sound and the Strait of Juan de Fuca, WA). The total coastal area of the West Coast estuaries, bays, and sub-estuaries is 3,940 square miles, 61.5% of which consists 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 San Francisco Bay, and generally around most of the coastal waters of southern California. In contrast, the section of coastline north of the San Francisco Bay through northern Puget Sound has a much lower population density.

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the United States during a 9- to 12-week period during the summer. Data were not collected during other time periods.

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 in, live in, and visit these areas. In the West Coast states of California, Oregon, and Washington, the majority of the population lives in coastal counties. Between 1980 and 2006, the coastal population of the West Coast region increased by 44%, from 23.1 million to 33.3 million people (Figure 6-3). This was the largest increase in the number of individuals for any coastal region in the United States over this time period. Population density in these coastal counties has also increased over this time period, from 299 to 431 persons/square mile (NOEP, 2010). Figure 6-4 maps the population density by county for the West Coast region in 2006. These population growth rates suggest that human pressures on West Coast coastal resources will increase substantially in future years.

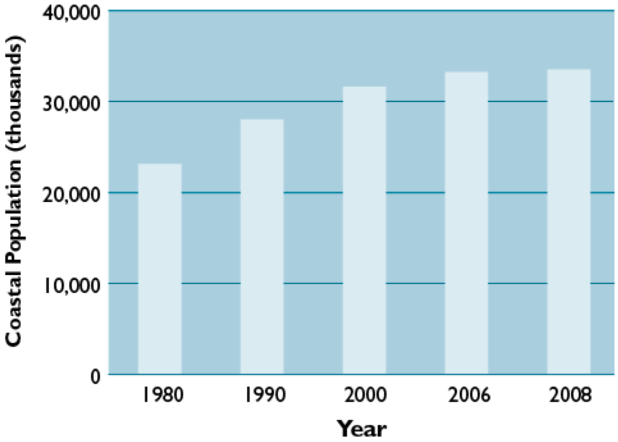


Figure 6-3. Population of coastal counties in the West Coast region from 1980 to 2008 (NOEP, 2010).

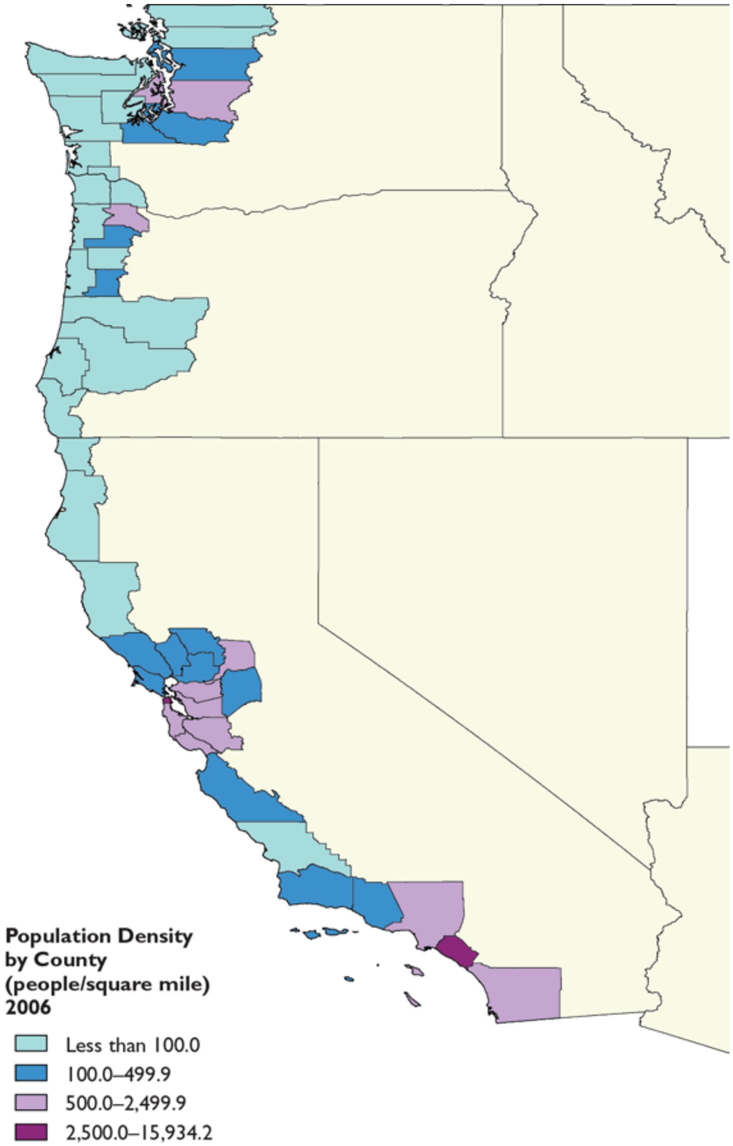


Figure 6-4. Population density in the West Coast region's coastal counties in 2006 (NOEP, 2010).

Coastal Monitoring Data—Status of Coastal Condition

The sampling program for the West Coast under NCA differed somewhat from other regions of the country. As a part of the EMAP Western Pilot Project, a variety of new initiatives were conducted. 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 waters of the continental shelf in 2003. Results of these surveys have been published in a series of reports (Nelson et al., 2004, 2005, 2007a, 2008; Hayslip et al., 2006, 2007; Partridge, 2007; Sigmon et al., 2006; Wilson and Partridge, 2007). The assessment results from 1999–2000 were previously reported in the NCCR III (U.S. EPA, 2008c).

All estuarine waters of the West Coast region were included in the sampling framework for the 2004 survey, and this framework also was used in a sampling effort spread out over 2 years in 2005–2006. This sampling framework differed from the previous 1999–2000 survey by excluding several open water marine areas (e.g., Bodega Bay, Strait of Juan de Fuca), the riverine portion of the Columbia River

Estuary, several harbors in northern California (e.g., Monterey Harbor, Santa Barbara Harbor), and intertidal areas in Washington. Both surveys were conducted using probability-based sampling designs, with sampling conducted during the summer. In 2004, 34 sites were sampled in Washington, 50 in Oregon, and 49 in California. In 2005–2006, 50 sites were sampled each in Washington and Oregon, and 100 sites were sampled in California, equally divided between northern and southern California. Sampling categories for the randomized designs differed somewhat between the 2004 and 2005–2006 time periods, so all sample locations were post-stratified into 10 categories by area (e.g., Puget Sound, WA; remaining coastal waters, WA; San Francisco Bay, northern CA; remaining coastal waters, northern CA). These areas were used in the areal weightings for the final statistical analyses. Actual sample numbers obtained or analyzed varied due to various factors, including equipment failure. For example, benthic samples were obtained from 136 of 144 stations in 2004 and from all 200 stations in 2005–2006.

The West Coast regional ratings for the sediment contaminants component indicator and the fish tissue contaminants index were principally driven by results for the harbor areas of southern California. Compared to the results from the 1999–2000 survey, contamination indicators showed fewer poor stations from Puget Sound and San Francisco Bay. In the 1999–2000 survey, most of the stations in the riverine portion of the Columbia River were rated poor for contaminants; however, this area was not sampled in the 2004–2006 survey. Sites from the majority of smaller estuarine systems along the West Coast were estimated to be in generally good condition.

The sampling conducted in the EPA NCA survey is designed to estimate the percent of coastal area (nationally or in a region or state) in varying conditions, and the results are displayed as pie diagrams. Many of the figures in this report illustrate environmental measurements made at specific locations (colored dots on maps); however, these dots (color) represent the value of the indicator specifically at the time of sampling. Additional sampling would be required to define temporal variability and to confirm environmental condition at specific locations.

Water Quality Index

The water quality index for the coastal waters of the West Coast region is rated good, with 19% of the coastal area rated fair and 2% rated poor for water quality condition (Figure 6-5). The water quality index is based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. In the NCCR III report (U.S. EPA, 2008c), a large percentage of West Coast survey area was rated in fair or poor condition for the DIP indicator, and it was suggested that re-evaluation of this indicator's cutpoints was required to better reflect natural background conditions. For this report, the rating cutpoints for DIN and DIP have been revised and computational approaches for the water clarity indicator have been changed to better reflect the attenuation of light through the water column rather than just in the shallow surface layer.

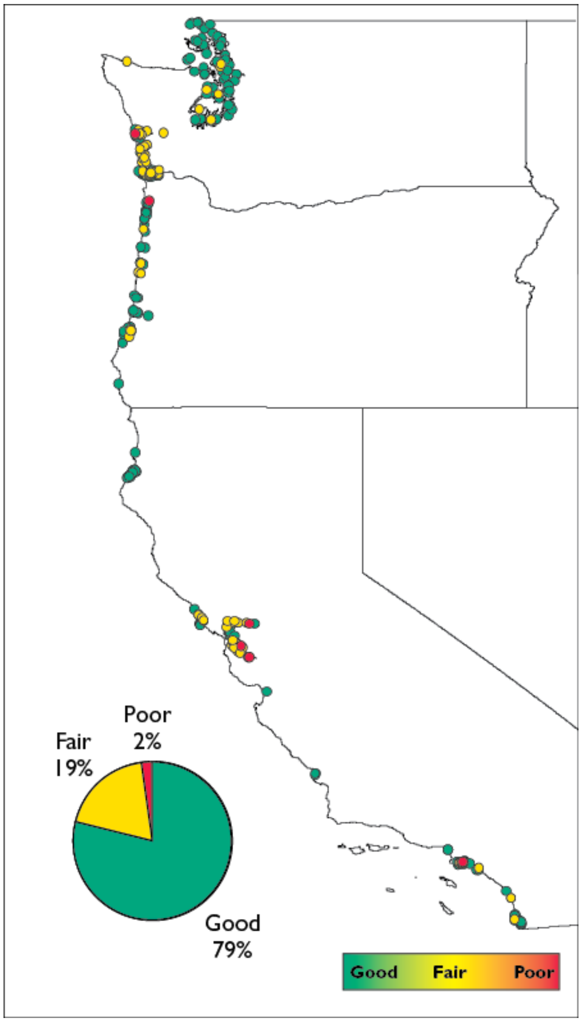


Figure 6-5. Water quality index data for West Coast coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The West Coast region is rated good for DIN concentrations, with 3% of the coastal area rated fair and 1% of the area rated poor. The West Coast region is rated good for DIP concentrations, with 11% of the coastal area rated fair and 9% rated poor.

Chlorophyll a

The West Coast region is rated good for the chlorophyll *a* component indicator, with 25% of the coastal area rated fair and 6% of the area rated poor. The majority of sites rated poor were located in the outer coast estuaries of Washington and Oregon, particularly Willapa Bay and Gray's Harbor in Washington. It is questionable whether these poor conditions result from anthropogenic impacts since this portion of the coast has low population densities and limited anthropogenic sources for nitrogen inputs. Percentiles for chlorophyll *a* data were also computed from the GLOBEC data set (Wetz et al., 2004), and the measured concentrations at NCA sites rated poor are in considerable excess of the 95th percentiles calculated from the GLOBEC study. The extremely high values measured by NCA may reflect upwelling-related nutrient sources for phytoplankton blooms. It appears that phytoplankton blooms may take place even closer to the coastline than the locations where the GLOBEC data were recorded, potentially in the surf zone. Menge et al. (2009) report similarly high values of chlorophyll *a* from very nearshore sites along the Oregon coast. Although long-term mean chlorophyll *a* concentrations at these Oregon sites were often above the NCA rating cutpoints for poor water quality, these concentrations are the result of natural upwelling processes. Menge et al. (2009) also document significant interdecadal variation in chlorophyll *a* levels. Further assessment of the chlorophyll *a* rating cutpoints is warranted.

How were the new DIN and DIP rating cutpoints assigned?

Research has shown that coastal waters in the West Coast region may be strongly influenced by upwelled water entering the estuaries on flood tides, especially during the summer months when NCA sampling occurs (Hickey and Banas, 2003; Brown and Ozretich, 2009). Upwelling activity is an important contributing factor determining the DIN and DIP concentrations measured in the coastal waters of the West Coast region during the summer. Thus, the highest values of nitrogen and phosphorus observed in summer months tend to be associated with the upwelled water moving into the estuary. The concentration values for assigning condition ratings for DIN and DIP used for the West Coast in the NCCR II and NCCR III were based on literature from the East Coast, and it was recognized that a reassessment of West Coast rating cutpoints in light of new research was warranted. Based on the DIP cutpoints used in the NCCR III, much of the West Coast was rated either fair or poor for phosphorus, in spite of the fact there was no source of anthropogenic inputs of phosphorus in much of the region assessed. The DIP cutpoints were too low to be appropriate for reference conditions in the West Coast region. The DIN cutpoints also appeared to be somewhat high and did not appear to be particularly sensitive.

Upwelling activity along the West Coast is at a maximum during the summer months. Between 1997 and 2004, nutrient data were collected in waters at seven locations from Newport, OR, to near Pt. Arenas, CA, from the Global Ocean Ecosystems Dynamics (GLOBEC) Northeast Pacific Long Term Observation Program (Wetz et al., 2004). Data for DIN and DIP from April through September were extracted for the most inshore station for depths below 66 feet, and percentiles were computed for the pooled data from the seven stations. For DIN and DIP, the 75th percentile values appear to be reasonable to use as a basis for a rating cutpoint for good condition based on comparison to estuarine nutrient data sets in the region (Brown et al., 2007; Nelson and Brown, 2008). Because the NCCR series has used units of mg/L for rating cutpoints, values were converted from µM to mg/L. The revised rating cutpoints for DIN and DIP used for the West Coast region in the NCCR IV are given in Tables 1-2 and 1-3 of Chapter 1.

Water Clarity

The West Coast region is rated good for water clarity, with 2% of coastal area rated poor and 3% rated fair. The same rating cutpoints 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.

Dissolved Oxygen

The West Coast region is rated good for dissolved oxygen concentrations, with 20% of the coastal area rated fair and 2% of the coastal area rated poor. The sites with the lowest measured values of dissolved oxygen were located in Dabob Bay, and the southern arm of Hood Canal, both in Washington. Three stations sampled in the Los Angeles – Long Beach Harbor area were also rated poor for this component indicator.

Sediment Quality Index

The sediment quality index for the coastal waters of the West Coast region was rated fair, with 10% of the coastal area rated poor and 1% rated fair (Figure 6-6). The sediment quality index used is based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC; however, there was some variation in the areas assessed and the methods used to assess the sediment toxicity component indicator. Sediment toxicity testing was not conducted by Oregon in 2005–2006 because of the cost involved; however, the 2004 sampling included samples across all estuaries, such that an adequate coverage for Oregon was available, although data density was lower than for Washington and California. Also, California used *Eohaustorius estuarius* as a test organism in 2005–2006 instead of the NCA standard organism, *Ampelisca abdita*, since *A. abdita* was viewed by the state as insufficiently sensitive. In spite of this difference, the results of the sediment toxicity indicator were virtually the same from the two sample periods.

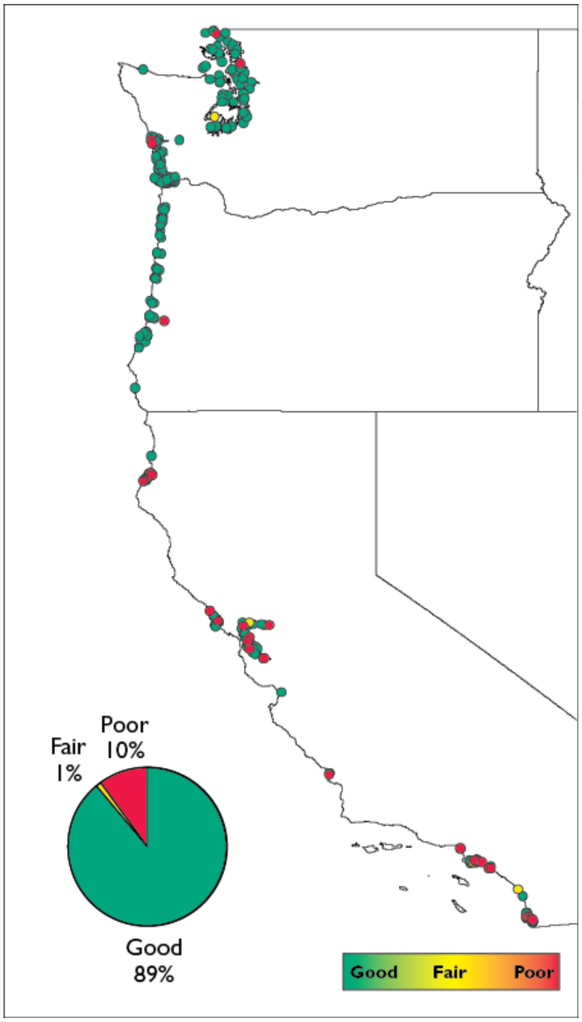


Figure 6-6. Sediment quality index data for West Coast coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The West Coast region is rated poor for sediment toxicity, with 16% of the coastal area rated poor. This rating should be considered provisional for several reasons. There were only a total of 238 stations with sediment toxicity data. Many of the 2004 sediment samples exceeded the holding times specified by the NCA quality assurance project plan (U.S. EPA, 2001a) due to a hurricane that damaged the testing laboratory, and this may have potentially increased the rate of false positives. The toxicity testing involved use of two species with distinctly different sensitivities; *Eohaustorius estuarius* is more sensitive than *Ampelisca adita*. Interpretation of the toxicity results is unclear because of the low association (30%) of poor sediment toxicity ratings and a poor sediment contaminant rating at a station. There was no association of the toxicity results with percent TOC at a station. There was a significant, but weak ($r^2 = 0.1$), negative association of survivorship of *E. estuarius* with percent fines in the sediment.

Sediment Contaminants

The West Coast region is rated good for the sediment contaminants component indicator, with 3% of the coastal area rated fair and less than 1% rated poor. With the exception of one ERM exceedance for zinc in Grays Harbor, WA, all other ERM exceedances were in harbors in southern California (e.g., Newport Bay, San Diego Bay, Marina del Rey, Long Beach Harbor). ERMs for copper, mercury, zinc, total DDT, and 4,4’-DDE were exceeded in California. There were few ERL exceedances for total PCBs, and no exceedances for total PAHs.

Guidelines for Assessing Sediment Contamination (Long et al., 1995)

ERM (Effects Range Median)—Determined values 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 West Coast region is rated good for the sediment TOC component indicator, with 8% of the coastal area rated fair and 1% of the area rated poor.

Benthic Index

Benthic condition in West Coast coastal waters is rated good, with 6% of the coastal area rated fair and 7% rated poor (Figure 6-7). In lieu of a formal 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. Log species richness was regressed on salinity, to establish expected species richness across varying salinity levels. A highly significant ($p < 0.0001$) linear regression between log species richness and salinity was found for the region, although variability was high ($R^2 = 0.33$).

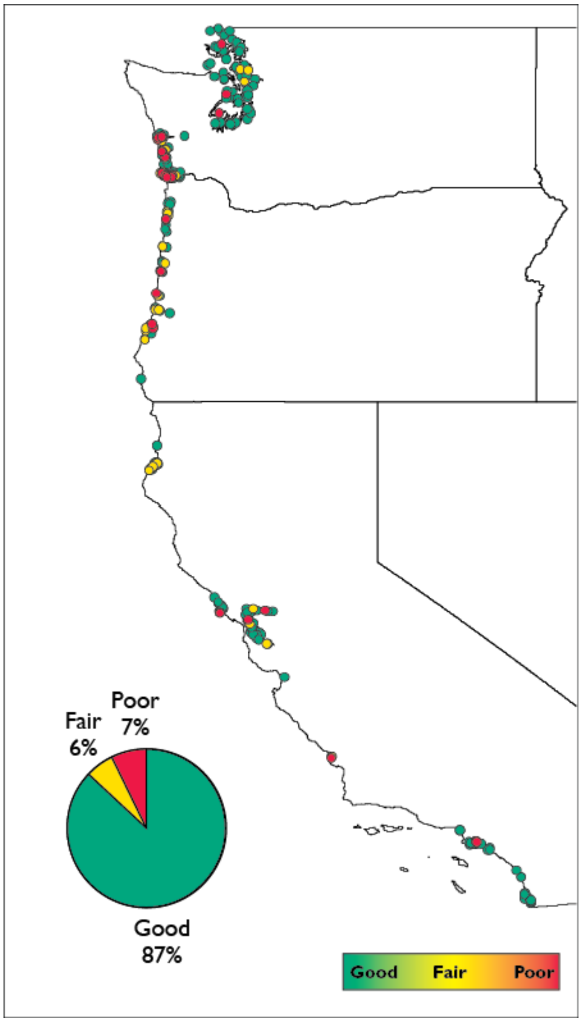


Figure 6-7. Benthic index data for West Coast coastal waters (U.S. EPA/NCA).

Coastal Habitat Index

The coastal habitat index for the coastal waters of the West Coast region is based on the same information as that prepared for the NCCR III. The coastal habitat index is rated poor. From 1990 to 2000, the West Coast region experienced a loss of 1,720 acres (0.53%) of coastal wetlands (Dahl, 2010). The long-term, average decadal loss rate of West Coast wetlands is 3.4%. Although the number of coastal wetland acres lost for the West Coast region was less than the losses noted in other regions of the United States, the relative percentage of existing coastal wetlands lost in the West Coast region was the highest nationally. West Coast wetlands constitute only 6% of the total coastal 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 is rated good. Based on EPA advisory guidance values, 5% of the stations where fish were caught rated fair and 9% of stations rated poor (Figure 6-8). Fish for contaminant analysis were collected at 197 stations, and with multiple species collected at some stations; this yielded a total of 272 tissue analyses. The available data represent a mixture of tissue analysis types. Depending on state, year, and size of fish collected, the data available may be for filets or for whole fish. Stations with poor or fair ratings for the fish tissue contaminants index were found principally in the harbors in southern California (e.g., Newport Bay, San Diego Bay, Los Angeles – Long Beach Harbor), a few locations in Puget Sound in Washington, and two locations in the Columbia River Estuary. The contaminants found most often in fish tissue samples included total PCBs and DDTs.

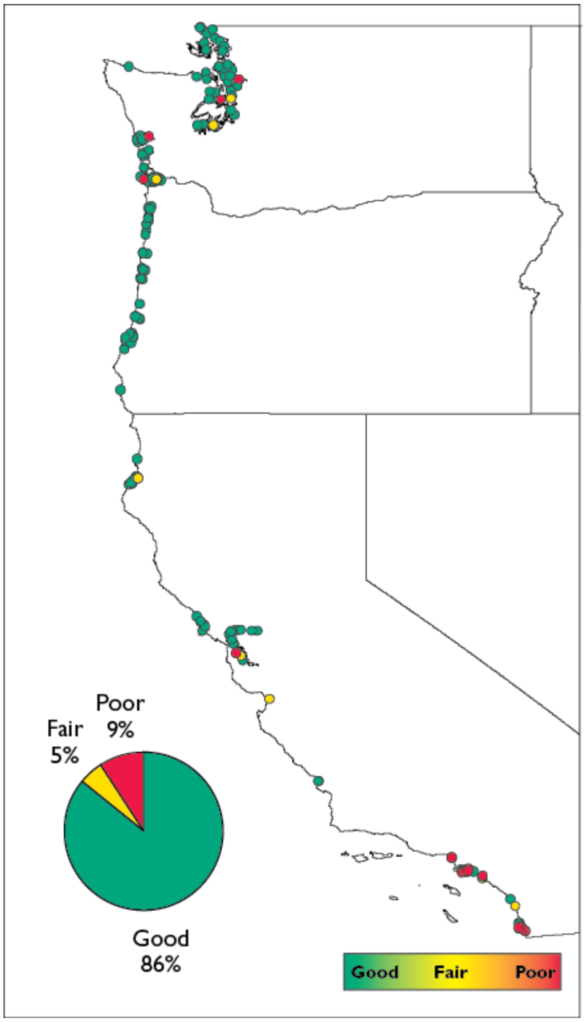


Figure 6-8. Fish tissue contaminants index data for West Coast coastal waters (U.S. EPA/NCA).

Trends of Coastal Monitoring Data—West Coast Region

A temporal trends analysis for the West Coast region was not conducted in previous NCCRs due to lack of appropriate comparison data sets. The sampling efforts in 2001, 2002, and 2003 are not directly comparable to the other sampling efforts, so the most reasonable temporal comparison for the West Coast region is the aggregated sample data from 1999–2000 (U.S. EPA, 2008c) compared to the aggregated sample data from 2004 through 2006. The coastal waters included in the two surveys, however, represent different geographic areas. All small and large estuaries were included in the 1999–2000 survey, while several areas were excluded from the 2004–2006 survey. Several open water marine areas (e.g., Bodega Bay, Strait of Juan de Fuca), the riverine portion of the Columbia River Estuary, several harbors in northern California (e.g., Monterey Harbor, Santa Barbara Harbor), and intertidal areas in Washington were not part of the 2004–2006 survey. The 1999–2000 assessment is based on data collected by NCA from 210 sites in 1999 and 171 sites in 2000, for a total of 381 stations. Data on sediment contaminants for 41 of the 71 sites within Puget Sound were collected by NOAA's NS&T Program in 1997–1999. NOAA NS&T also provided sediment and infauna data for 33 of the 50 sites in San Francisco Bay in 2000.

For this report, the rating cutpoints for DIN and DIP were revised, and the 1999–2000 data were reanalyzed using the modified rating cutpoints. Rating cutpoints for the chlorophyll *a*, water clarity, and dissolved oxygen component indicators were not changed; however, computational approaches for the water clarity indicator were changed to better reflect the attenuation of light through the water column rather than just in the shallow surface layer. The 1999–2000 water clarity indicator data were reanalyzed to reflect this change. Based on this reanalysis of the DIN, DIP, and water clarity indicators, the water quality index for 1999–2000 received a revised rating of good, with 18% of the coastal area rated fair and 7% rated poor. In the NCCR III, the water quality index received a rating of fair, with the lower ratings driven primarily by the DIP and water clarity indicators. The revised rating resulted from the application of more appropriate rating cutpoints for the DIN and DIP indicators and from the more appropriate computation methods used for the water clarity component indicator.

Figure 6-9 presents a comparison of the percent of coastal waters rated good, fair, and poor for the water quality index and its component indicators between the data collected in the 1999–2000 and the 2004–2006 surveys. In both time periods, the water quality index was rated good, although the area rated poor decreased slightly in 2004–2006. DIN and DIP were rated good in both time periods, with a slightly greater area rated fair for DIP in 2004–2006. The West Coast region was rated good for the chlorophyll *a* component indicator in both time periods. More area was rated poor and less area was rated fair in 2004–2006. The water clarity component indicator was rated good in both time periods, with slightly less area rated poor in 2004–2006. The West Coast region was rated good for dissolved oxygen concentrations during both time periods, with less of the area rated fair in 2004–2006. Low dissolved oxygen levels were measured in sub-estuaries of Puget Sound (Dabob Bay and southern Hood Canal) during both periods. These areas of Puget Sound are known to often have low dissolved oxygen concentrations in the bottom waters, due to restriction on flushing in these fjord-like embayments. The relative contribution of anthropogenic nutrient inputs versus climatic alterations in water replacement is still under scientific assessment. Additional information is available online at: http://www.hoodcanal.washington.edu/index.jsp.

How was the water clarity component indicator recalculated?

The computation of percent light at 1 meter used in the NCCR II and NCCR III reports calculated a light extinction coefficient (k_d) using the shallowest in-water readings only. To make the 1999–2000 water clarity index comparable to that from the 2004–2006 analysis, raw data for the photosynthetically active radiation (i.e., PAR) were reexamined, new analysis routines were applied, and additional QA inspection was used. This resulted in exclusion of data from some stations that were included in the NCCR III analysis. A number of stations in Puget Sound were rejected because the in-water readings were taken only at the surface, mid-depth, and bottom locations. At deep water stations, the mid-depth reading was often zero, so there was no way to estimate the depth interval at which light went to zero in order to be able to calculate a meaningful k_d. After reanalysis, the percentage area in the three rating categories was very similar between sample periods.

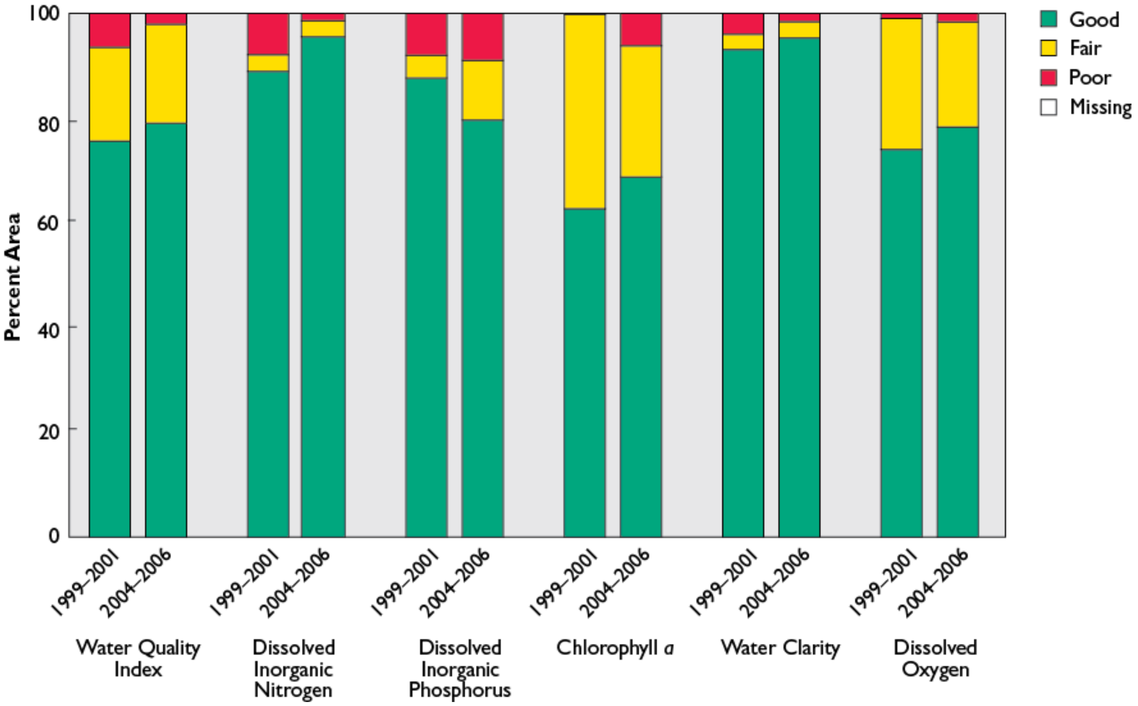


Figure 6-9. Comparison of percentage of coastal area of the West Coast in good, fair, and poor condition for the water quality index and its component indicators between data collected in 1999–2000 and data collected in 2004–2006 (U.S. EPA/NCA).

The percentages of coastal area in the West Coast region rated in good, fair, and poor condition for the sediment quality index and its component indicators are compared in Figure 6-10 for data collected in 1999–2000 and 2004–2006 sampling periods. The rating for the sediment quality index improved from fair to poor in the 1999–2000 sampling period to fair in 2004–2006. Although the species used to measure sediment toxicity varied in the 2004–2006 time period, the West Coast region was rated poor for the sediment toxicity component indicator during both time periods and the percentage of coastal area rated poor was comparable. Although the West Coast region was rated good for the sediment contaminants component indicator during both time periods, much less of the coastal area was rated fair and poor in 2004–2006. The West Coast region was also rated good for the sediment TOC component indicator for both time periods, with similar percentages of the coastal area rated fair and poor in both 1999-2000 and 2004–2006. The apparent improvement in the sediment quality index should be interpreted cautiously because the trend comparison includes only two points in time.

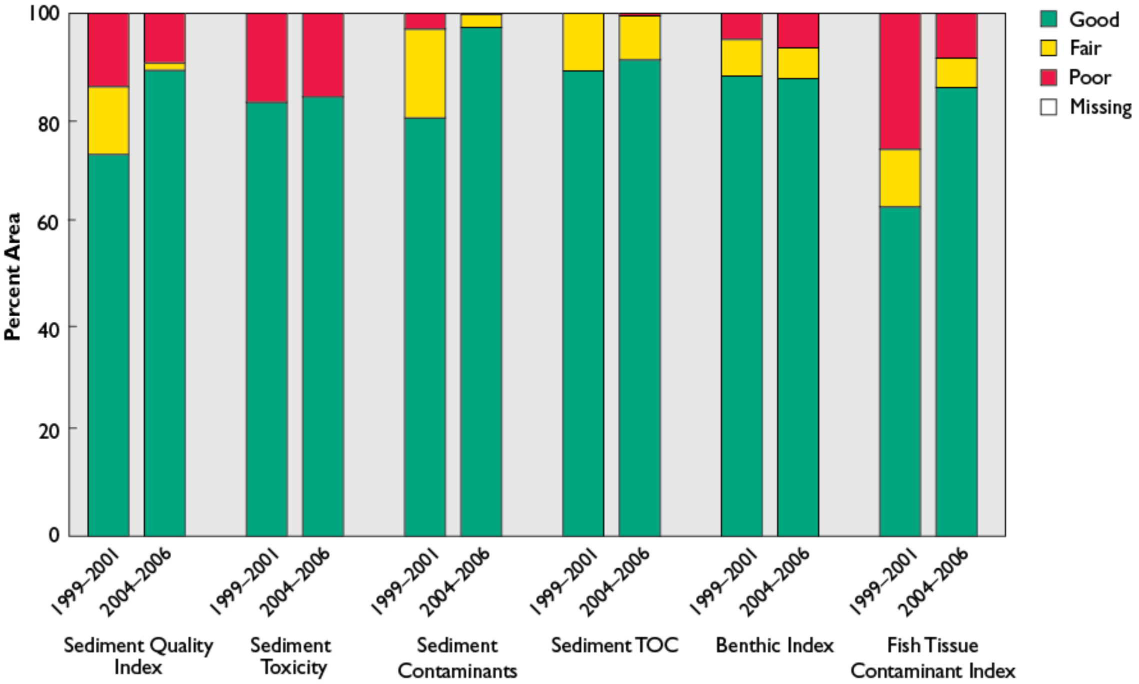


Figure 6-10. Comparison of percentage of coastal area of the West Coast in good, fair, and poor condition for the sediment quality index and its component indicators, the benthic index, and the fish tissue contaminants index* between data collected in 1999–2000 and 2004–2006.

*The fish tissue contaminants index is measured as a percentage of stations where fish were caught rather than as percentage of coastal area (U.S. EPA/NCA).

Benthic condition in West Coast coastal waters was rated good in 1999–2000 and in 2004–2006, with similar percentages of the area rated fair and poor (see Figure 6-10). During both time periods, a significant ($p < 0.01$ for 1999–2000 and $p < 0.0001$ for 2004–2006) linear regression between log species richness and salinity was found for the region, although variance was high ($R^2 = 0.43$ in 1999–2000 and $R^2 = 0.33$ in 2004–2006) in both cases.

Based on EPA Advisory Guidance values, the fish tissue contaminants index was rated poor for 1999–2000 and good for 2004–2006. As shown in Figure 6-10, the percentage of stations that were rated poor decreased from 26% to 9% in the latter time period. Much of this difference is due to the exclusion of the riverine portion of the Columbia River Estuary in the later survey. Thirty sites in the Columbia River were rated poor for fish tissue contaminants in the 1999–2000 survey; if these sites were omitted from the 1999–2000 survey, only 17% of the stations would have been rated poor, and the West Coast rating for fish tissue contaminants would have been fair instead of poor. It should also be noted that the 1999–2000 assessment data were based on analysis of whole-fish contaminant concentrations while the 2004–2006 data included both fillet and whole-fish concentrations. Although the inclusion of fillet samples might be expected to result in the observation of lower concentrations than whole fish, the total number of analyzed fish composites that were scored either fair or poor in 2004–2006 was virtually the same for fillet and whole fish samples. However, a possible impact of inclusion of fillet samples on the overall fish tissue result cannot be excluded. The contaminants found most often in fish tissue samples included total PCBs and DDTs.

Coastal Ocean Condition—West Coast

This assessment area covers coastal ocean waters along the western U.S. continental shelf, from the Strait of Juan de Fuca in Washington to the U.S./Mexican border, which coincides roughly with the U.S.

portion of the California Current LME (U.S. Commission on Ocean Policy, 2004). In summer 2003, the western NCA, NOAA's NOS and NMFS, western states (Washington, Oregon, and California), and the Southern California Coastal Water Research Project (Bight '03 program) coordinated various monitoring efforts to assess status of ecological condition and stressor impacts throughout this offshore coastal ocean area and to provide information as a baseline for evaluating future changes due to natural or human-induced disturbances.

To address these objectives, the study incorporated standard methods and indicators applied in previous coastal EMAP/NCA projects and NCCRs (U.S. EPA, 2001b; 2004a; 2008c), including multiple measures of water quality, sediment quality, and biological condition. A total of 257 stations were sampled (Figure 6-11) at target depths of 98–393 feet.

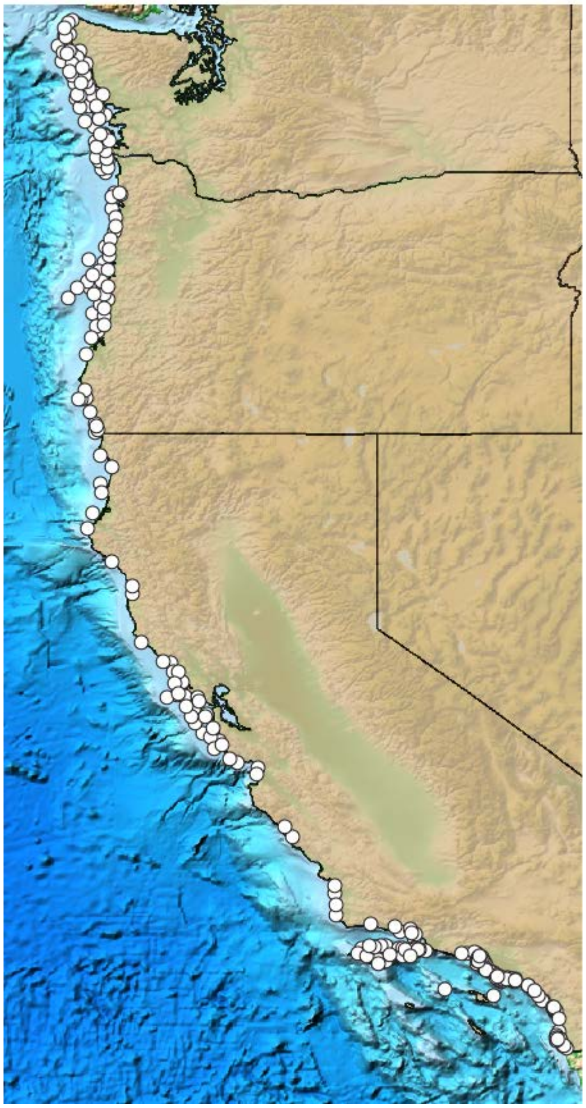


Figure 6-11. Map of West Coast coastal ocean sampling stations (Nelson et al., 2008).

Another key feature was the incorporation of a stratified-random sampling design with stations stratified by state and by NMS status. Each of the three states was represented by at least 50 random stations. In addition, a total of 84 random stations were located within NOAA's NMS sites along the west coast, including the Olympic Coast, Cordell Bank, Gulf of Farallones, Monterey Bay, and Channel Islands sanctuaries. Collection of flatfish via hook-and-line for fish-tissue contaminant analysis was successful at 50 of the offshore stations distributed along the entire coast.

Condition of these offshore coastal ocean waters is presented here on a region-wide basis and compared to West Coast estuaries, based on data from related NCA surveys conducted in 2004–2006 (featured in the previous section). A detailed report on results of the West Coast coastal-ocean assessment, including more in-depth comparisons of condition by state and by NMS vs. non-sanctuary status, is provided by Nelson et al. (2008).

Water Quality

Nutrients: Nitrogen and Phosphorus

The average concentration of DIN (nitrogen as nitrate + nitrite + ammonium) in coastal-ocean surface waters, exclusive of the Southern California Bight stations wherein ammonium was not measured, was 0.106 mg/L (Figure 6-12). Concentrations were much higher at sites in California than in Washington or Oregon, reflecting the influence of upwelling events in the central California area at the time of sampling.

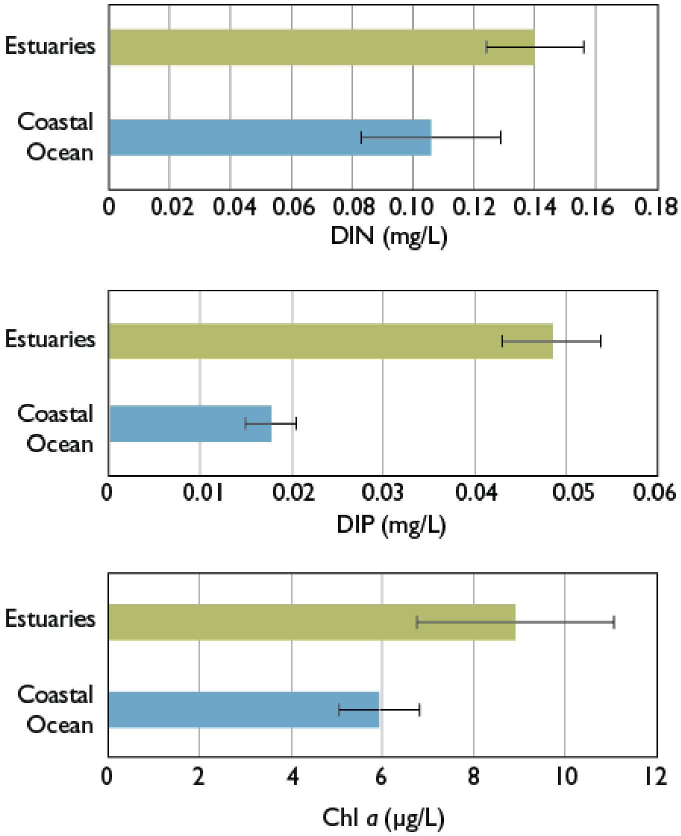


Figure 6-12. Mean concentrations ± 95% C.I.s of (a) DIN, (b) DIP, and (c) chlorophyll *a* in coastal ocean vs. estuarine surface waters (Nelson et al., 2008; U.S. EPA/NCA).

Estuarine surface waters had higher DIN concentrations, which averaged 0.140 mg/L (see Figure 6-12). Although water quality assessment endpoints for DIN have been defined for estuaries, none are available for coastal ocean waters to use as a basis for evaluating whether observed levels reflect good vs. poor conditions. However, for comparison, less than 1% of offshore coastal-ocean area would be rated poor for the DIN component indicator using the NCA cutpoints. Near-bottom concentrations of DIN in offshore waters, which averaged 0.421 mg/L, were slightly higher in comparison to the offshore surface-water mean of 0.106 mg/L.

Concentrations of DIP in offshore surface waters averaged 0.018 mg/L for the 188 stations with DIP data (see Figure 6-12). These levels are lower than those measured in estuaries of the region, which averaged 0.048 mg/L. Similar to DIN, there are no available water-quality assessment cutpoints for rating observed levels of DIP in offshore coastal ocean-waters of the region. However, for comparison, none of the coastal ocean area would be rated poor for the DIP component indicator based on the NCA cutpoints. DIP levels in offshore surface waters in the West Coast region also appear to be lower than those observed along the Atlantic coast of the United States (e.g., average of 0.04 mg/L for Mid-Atlantic Bight, Chapter 3; Balthis et al., 2009). Coastal-ocean, Nnar-bottom concentrations of DIP collected in the West Coast region, which averaged 0.061, were slightly higher in comparison to the surface water mean of 0.018 mg/L.

DIN/DIP ratios were calculated as an indicator of which nutrient may be controlling primary production (phytoplankton growth). A ratio above 16 indicates that phosphorus limits growth, while a ratio below 16 indicates that nitrogen is limiting (Geider and La Roche, 2002). DIN/DIP ratios for offshore coastal ocean waters averaged 12.7, with the vast majority of the survey area (about 93%) having values ≤ 16, indicating that nitrogen levels are limiting primary production in these areas.

Chlorophyll a

Concentrations of chlorophyll *a* in offshore surface waters averaged 6.04 µg/L (see Figure 6-12). In general, these levels were lower than those measured in estuaries of the region, which averaged 9.07 µg/L. As a further comparison, relative to the NCA rating cutpoints for chlorophyll *a* concentrations, 4% of the offshore survey area would be rated poor. In contrast, chlorophyll *a* levels in offshore surface waters along the West Coast were much higher than those observed along the Atlantic coast of the United States (e.g., average of 0.23 µg/L for the Mid-Atlantic Bight, see Chapter 3; Balthis et al., 2009). Near-bottom concentrations of chlorophyll *a* along the West Coast, which averaged 0.36 µg/L, were much lower in comparison to the surface-water mean of 6.04 µg/L.

Water Clarity

Concentrations of TSS were used as a surrogate indicator of water clarity for offshore waters. TSS in coastal ocean surface waters averaged 4 mg/L, considerably lower than averages for estuaries in the region (11.5 mg/L). While most offshore surface waters had TSS concentrations under 7.4 mg/L, the 90th percentile of all measured values, 38% of the estuarine survey area surface waters had TSS above this level, which is not surprising given the proximity of these sites to land. Near-bottom concentrations of TSS in the offshore waters, averaging 3 mg/L, were slightly lower in comparison to surface waters.

Dissolved Oxygen

Near-bottom concentrations of dissolved oxygen in offshore waters averaged 3.7 mg/L. Although none of the coastal-ocean area would be rated poor for the dissolved oxygen component indicator based on NCA cutpoints, 92% of the survey area would be rated fair and 8% of the area would be rated good (Figure 6-13). The stations rated as good tended to be grouped at the extreme southern and northern ends of the survey region.

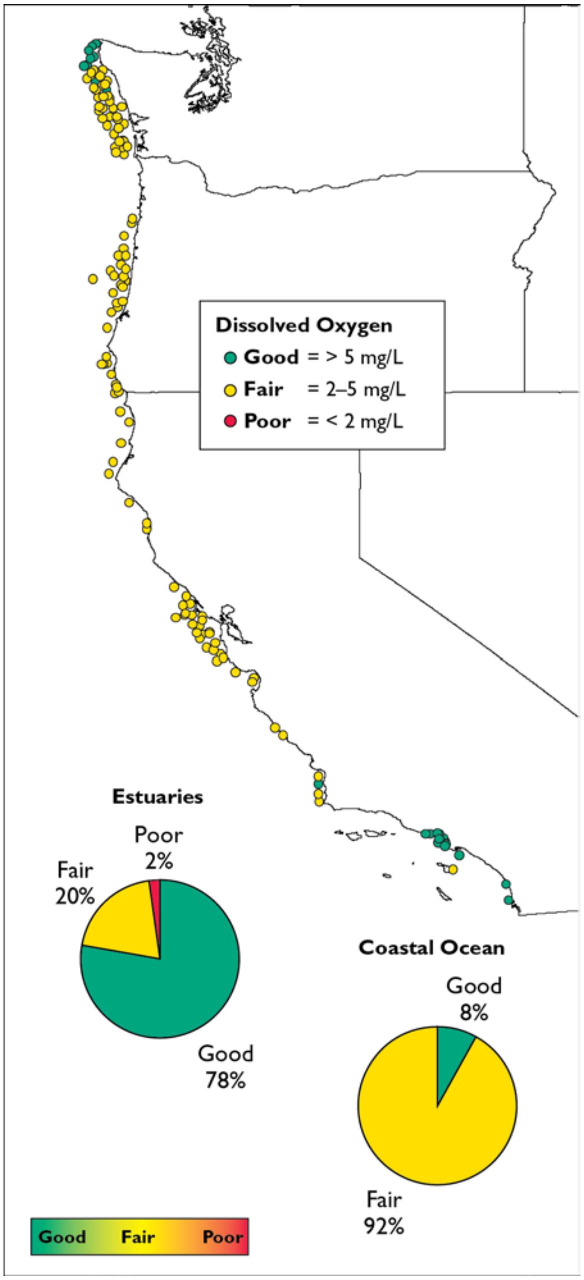


Figure 6-13. Dissolved oxygen data in near-bottom coastal-ocean waters of the West Coast region (Nelson et al., 2008; U.S. EPA/NCA).

Pie charts compare offshore and estuarine dissolved oxygen levels.

In comparison to these offshore waters, only 20% of the estuarine area was rated fair and a much larger portion (78%) was rated good (see Figure 6-13). Near-bottom dissolved oxygen levels in coastal ocean waters in the West Coast region also tended to be lower than levels observed in other coastal ocean regions, for example, in comparison to the Mid-Atlantic Bight, where 100% of the survey area would be rated good (Chapter 3, Balthis et al., 2009) based on NCA cutpoints. Hypoxia along the continental shelf appears to be associated with upwelling conditions in the region, while severe hypoxic events in inshore shelf areas (< 70 meters) may be associated with changes in cross-shelf current patterns (Grantham et al., 2004).

Dissolved oxygen levels in coastal-ocean surface waters along the west coast, averaging 9.4 mg/L, were generally higher than those in near-bottom waters. The vast majority of surface waters (about 98% of the area) was rated good using the NCA rating cutpoints for dissolved oxygen (Nelson et al., 2008).

Sediment Quality

Sediment Contaminants

Sediments throughout the region were relatively uncontaminated except for a group of stations in the Southern California Bight (Figure 6-14). Based on the cutpoints used by NCA, about 99% of the offshore survey area would be rated good, less than 1% would be rated fair, and less than 1% would be rated poor for the sediment contaminants component indicator.

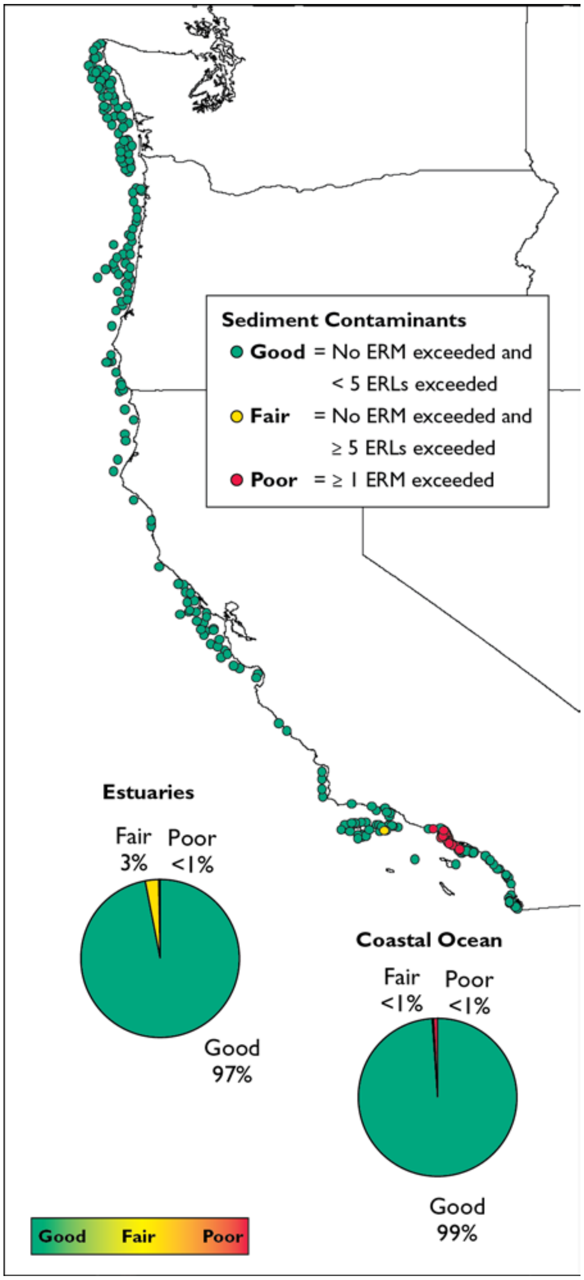


Figure 6-14. Sediment contaminants data in coastal ocean sediments of the West Coast region (Nelson et al., 2008; U.S. EPA/NCA).

Pie charts compare offshore and estuarine conditions.

All stations rated poor for the sediment contaminants component indicator were located in the coastal ocean waters near Los Angeles. The poor designation is based primarily on 4,4'-DDE and total DDT concentrations exceeding their corresponding ERM vales. No other locations outside of the Los Angeles area had ERM exceedances. Ten other contaminants, including seven metals (i.e., arsenic, cadmium, chromium, copper, mercury, silver, zinc), 2-methylnaphthalene, low-molecular-weight PAHs, and total PCBs exceeded corresponding ERLs. The most prevalent chemicals exceeding ERLs in terms of coastal area were chromium (31%), arsenic (8%), 2-methylnaphthalene (6%), cadmium (5%), and mercury (4%). The chromium contamination may be related to natural background sources common to the region. The 2-

methylnaphthalene exceedances were conspicuously grouped around the Channel Islands NMS. The mercury exceedances were all at non-sanctuary sites in California, particularly in the Los Angeles area.

In comparison, estuarine habitats in the West Coast region show a relatively higher incidence of sediment contamination (see Figure 6-14), with many contaminants above ERM values (including mercury, copper, zinc, DDT, and 4,4′-DDE). Based on the 2004–2006 NCA data, 97% of survey area is rated good, 3% is rated fair, and >1% is rated poor.

Sediment TOC

High levels of TOC in sediments can serve as an indicator of adverse conditions and is often associated with increasing proportions of finer-grained sediment particles (i.e., silt-clay fraction) that tend to provide greater surface area for sorption of both organic matter and the chemical pollutants that bind to organic matter. Given the association between TOC levels and finer-grain sediment particles, it is useful to note that about 44% of the offshore survey area had sediments composed of sands (< 20% silt-clay), 47% consisted of intermediate muddy sands (20–80% silt-clay), and 9% consisted of mud (> 80% silt-clay). Washington and Oregon sites were dominated by sands, while the majority of California sites had intermediate muddy sands; all sites classified as muds were in California (Nelson et al., 2008).

TOC levels (% total sediment weight) throughout the region exhibited a wide range (0.0% to 7.6%, with an overall mean of 0.7%), consistent with the broad range of sediment types. Based on the NCA rating cutpoints, the majority of the survey area (97%) would be rated good; about 3% would be rated fair; and less than 1% of the area, represented by two sites in California, would be rated poor (Figure 6-15). The cause of the elevated TOC at these latter two sites, both in the Channel Islands NMS, is unknown at this time.

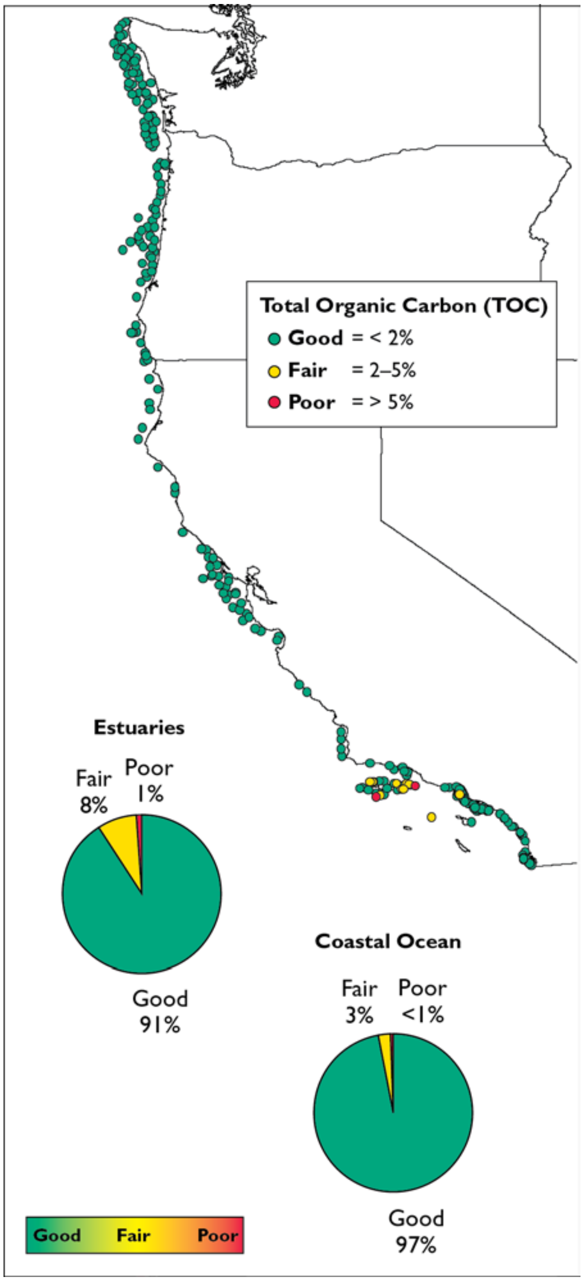


Figure 6-15. Sediment TOC data in coastal-ocean sediments in the West Coast region (Nelson et al., 2008; U.S. EPA/NCA).

Pie charts compare offshore coastal ocean and estuarine conditions.

Estuaries of the region, which are often in closer proximity to both natural and anthropogenic sources of organic materials, had slightly higher levels of TOC. While 91% of estuarine area was rated good, 8% was rated fair, and 1% was rated poor.

Benthic Condition

Coastal ocean waters along the West Coast support a diverse assemblage of macrobenthic infauna (those retained on a 1-millimeter sieve). A total of 99,135 individual specimens representing 1,482 taxa (1,108 distinct species) were identified in 259 0.1-m^2 grab samples collected throughout the 2003 coastal-ocean survey area. Polychaetes were the dominant taxa, both by percent abundance (59%) and percent taxa (44%). Crustaceans and molluscs were the second and third most-dominant taxa, respectively, both by percent abundance (17% crustaceans, 12% molluscs) and percent taxa (25% crustaceans, 17% molluscs). Collectively, these three groups represented 88% of total faunal abundance and 86% of the species throughout these offshore waters.

Density, mean diversity and mean number of taxa were all higher offshore than in NCA estuarine habitats (Figure 6-16). Approximately 50% of the coastal-ocean survey area had less than or equal to 67 taxa per grab sample, while only about 29% of the estuarine sediments had 67 or more taxa per grab. The diversity and number of taxa in the offshore sediments tended to be higher at California sites than at Washington and Oregon sites and were similar between NMS and non-sanctuary sites (Nelson et al., 2008).

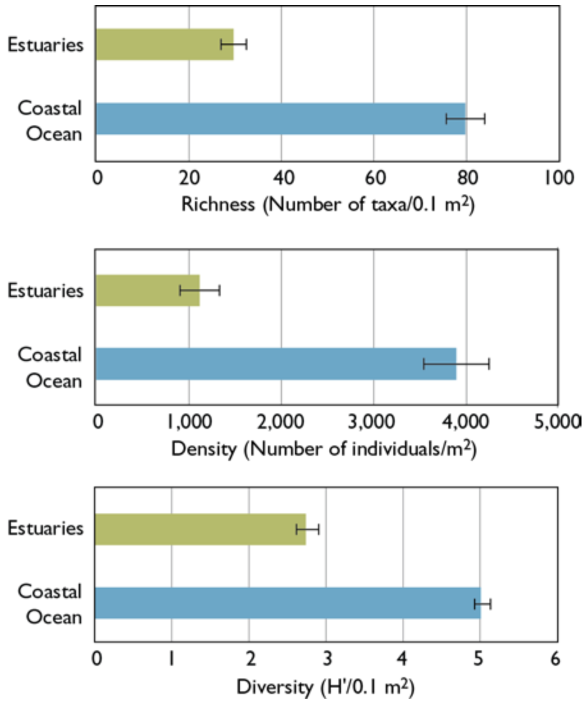


Figure 6-16. Comparison of benthic species richness (# of taxa/0.1 m^2), density (#/m^2), and diversity (H′/0.1 m^2, base 2 logs) in coastal ocean vs. estuarine sediments along the U.S. West Coast (Nelson et al., 2008; U.S. EPA/NCA).

The 10 most abundant taxa were the polychaete worms *Mediomastus* spp., *Magelona longicornis*, *Spiophanes berkeleyorum*, *Spiophanes bombyx*, *Spiophanes duplex*, and *Prionospio jubata*; the bivalve *Axinopsida serricata*; the brittle star *Amphiodia urtica*; the decapod crustacean *Pinnixa occidentalis*; and the ostracod crustacean *Euphilomedes carcharodonta*. *Mediomastus* spp. and *A. serricata* were the two most abundant taxa overall. Although many of these dominant taxa have broad geographic distributions throughout the region, the same species were not ranked among the 10 most abundant taxa consistently across states. The closest similarities among states were between Oregon and Washington. At least half of the 10 most abundant taxa in NMSs were also dominant in corresponding non-sanctuary waters.

Multi-metric benthic indices are often used as indicators of pollution-induced degradation of the benthos (see review by Diaz et al., 2004). An important feature is the ability to combine multiple biological attributes into a single measure that maximizes the ability to distinguish between degraded vs. non-degraded benthic condition, while accounting for the influence of natural controlling factors. Although a related index has been developed for the southern California mainland shelf (Smith et al., 2001), there is currently no such index available for offshore applications across the West Coast.

In the absence of a benthic index, Nelson et al. (2008) assessed potential stressor impacts in the West Coast offshore study by looking for obvious linkages between reduced values of key biological attributes (numbers of taxa, diversity, and abundance) and synoptically measured indicators of poor sediment or water quality. Low values of species richness, H′, and density were defined for the purpose of this analysis as the lower 10th percentile of values within each individual state. Evidence of poor sediment or water quality was defined as less than or equal to 1 chemical in excess of ERMs, TOC greater than 5%, or dissolved oxygen in near-bottom water less than 2 mg/L.

Many of the abundant benthic species have wide latitudinal distributions in the coastal-ocean waters of the West Coast region, with some species ranging from southern California into the Gulf of Alaska and Aleutians. Of the 39 taxa on the list of 50 most abundant taxa that could be identified to species level, 85% have been reported at least once from estuaries of California, Oregon, or Washington, exclusive of Puget Sound. Such broad latitudinal and estuarine distributions are suggestive of wide habitat tolerances.

Non-Indigenous Species

Benthic species lists were examined for presence of non-indigenous species in the offshore shelf environment by comparison to the PCEIS classification scheme, a geo-referenced database of native and non-indigenous species of the Northeast Pacific (Lee et al., 2008). Of the 1,108 taxa identified to species level, 13 were classified as non-indigenous, 121 as cryptogenic (of uncertain origin), and 208 as undetermined with respect to potential invasiveness. Spionid polychaetes and the ampharetid polychaete *Anobothrus gracilis* were a major component of the non-indigenous species collected on the shelf. A more detailed analysis of the occurrence of non-indigenous species in this region is available in Nelson et al. (2008).

Despite uncertainties of classification, the number and densities of non-indigenous species appear to be much lower in the coastal ocean than in estuaries of the West Coast region. For example, 42 non-indigenous species were noted in a survey of tidal wetlands of the West Coast (Nelson et al., 2007a) and over 200 non-indigenous species have been reported from San Francisco Bay (Cohen and Carlton, 1995).

Fish Tissue Contaminants

Analysis of chemical contaminants in fish tissues was performed on whole-fish composites from 55 samples of four fish species collected from 50 West Coast coastal-ocean stations. Fish were collected from 21 stations in Washington, 20 in Oregon, and 9 in California. The fish species selected for analysis were Pacific sanddab (*Citharichthys sordidus*), speckled sanddab (*Citharichthys stigmaeus*), butter sole (*Isopsetta isolepis*), and Dover sole (*Microstomus pacificus*). Concentrations of a suite of metals, pesticides, and PCBs were compared to risk-based EPA advisory guidelines for recreational fishers (U.S. EPA, 2000c).

None of the 50 stations where fish were caught would have been rated poor based on NCA cutpoints. Nine stations had cadmium concentrations between the corresponding lower and upper endpoints, and one station had total PCB concentrations between these endpoints. Therefore, these10 stations would be rated fair based on the NCA cutpoints (see Table 1-21). The remaining 40 stations had concentrations of contaminants below corresponding lower endpoints and would be rated good based on the NCA cutpoints. Based on the NCA Fish Tissue Contaminants Index (see Table 1-22) the overall offshore region would receive the same rating, good, as the West Coast coastal waters.

West Coast Sanctuaries

NOAA's five NMS areas in the West Coast region appeared to be in good ecological condition, based on the measured indices and component indicators, with no evidence of major anthropogenic impacts or unusual environmental qualities compared to nearby non-sanctuary waters (Nelson et al., 2008). Benthic communities in sanctuaries resembled those in corresponding non-sanctuary waters, with similarly high levels of species richness and diversity and low incidence of non-indigenous species. Most oceanographic features were also similar between sanctuary and non-sanctuary locations. Exceptions (e.g., higher concentrations of some nutrients in sanctuaries along the California coast) appeared to be attributable to natural upwelling events in the area at the time of sampling.

In addition, sediments within the sanctuaries were relatively uncontaminated, with none of the samples having any measured chemical in excess of ERM values. The ERL value for chromium was exceeded in sediments at the Olympic Coast NMS, but at a much lower percentage of stations (4 of 30) compared to Washington and Oregon non-sanctuary areas (31 of 70 stations). ERL values were exceeded for arsenic, cadmium, chromium, 2-methylnaphthalene, low-molecular-weight PAHs, total DDT, and 4,4′-DDE at multiple sites within the Channel Islands NMS. However, cases where total DDT, 4,4′-DDE, and chromium exceeded the ERL values were notably less prevalent than in non-sanctuary waters of California. In contrast, 2-methylnaphthalene above the ERL was much more prevalent in sediments at the Channel Islands NMS compared to non-sanctuary waters off the coast of California. While there are natural background sources of PAHs from oil seeps throughout the Southern California Bight, we cannot, at present, either confirm or exclude this as a possible cause of the higher incidence of 2-methylnaphthalene contamination around the Channel Islands NMS.

Ocean Condition Summary—West Coast

The 2003 West Coast offshore assessment showed no major evidence of poor water quality, and there were indications of poor sediment quality only in limited areas. Based on NCA cutpoints, the majority (97%) of sediments had TOC levels in the good range, 3% was rated fair, and less than 1% was rated poor. Relative to chemical contamination of sediments, 99% of the survey area was rated as good, less than 1% was rated fair, and less than 1% was rated poor. None of the offshore sampling area was rated poor for the dissolved oxygen component indicator.

An analysis of potential biological impacts (see text box) revealed no major evidence of impaired benthic condition linked to measured stressors. There was only one station, representing 0.02% of the survey area, where low values of any of the targeted benthic attributes co-occurred with poor sediment or water quality. This one station (off Los Angeles) had low benthic species richness and abundance accompanied by high sediment contamination, with eight chemicals in excess of corresponding ERL values and two in excess of ERM values. There were two stations located in California waters (Channel Islands NMS) that had TOC levels in a range (> 5%) potentially harmful to benthic fauna, but low values of benthic community attributes were not observed at either of these sites. High sediment contamination from chemicals was a more prevalent stressor, occurring at 22 stations (all in California), but only at one of the sites where low values of benthic attributes were observed. In fact, most of these latter stations with high sediment contamination had more than 100 species per grab.

Such lack of concordance suggests that these offshore waters are currently in good condition, with the lower-end values of the various biological attributes representing parts of a normal reference range controlled by natural factors (e.g., latitude, depth, sediment type). Alternatively, it is possible that for some of these sites the lower values of benthic variables reflect symptoms of disturbance induced by other unmeasured stressors, including human activities causing physical disruptions of the seafloor (e.g., commercial bottom trawling, cable placement, minerals extraction). Future monitoring efforts in these offshore areas should include indicators of such alternative sources of disturbance.

Large Marine Ecosystem Fisheries—California Current LME

The California Current LME extends along the Pacific Coast of North America from the northwestern corner of Washington to the southern end of the Baja California Peninsula in Mexico (Figure 6-17). The California Current LME is temperate and represents a transition zone between subtropical and subarctic water masses. Major driving forces in this LME are the effects of shifting oceanic climate regimes and intensive commercial fishing. The LME is considered to have moderately high productivity based on primary productivity (phytoplankton) estimates. The major commercial fisheries are salmon (e.g., Chinook, coho, sockeye, pink, chum), pelagic (water-column dwelling) species (e.g., Pacific hake, Pacific sardine, northern anchovy, jack mackerel, chub, Pacific mackerel, Pacific herring), groundfish (bottom-dwelling) species (e.g., Pacific halibut, Dover sole, shortspine thornyhead, longspine thornyhead, sablefish), tuna, and invertebrates (e.g., Pacific oyster, Dungeness crab, California market squid).Coastal upwelling, El Niño, and the El Niño-Southern Oscillation result in strong inter-annual variability in California Current LME productivity. There is evidence of a decline in zooplankton abundance in the 1980s, a possible indication of a major oceanic regime shift. There is speculation about the causes of these fluctuations and the role of climate on seasonal change in the regulation of community structure, energy flow, and population dynamics (NOAA, 2010b).

Figure 6-17. California Current LME (NOAA, 2010b).

From 2003 to 2006, commercial fisheries in the California Current LME generated over $1.6 billion for Washington, Oregon, and California. These fisheries are dominated by invertebrates, particularly crab, oysters, and squid. Other important fisheries in this LME include salmon, which are harvested for recreational and subsistence purposes, pelagics (mostly hake and sardines), salmon, tuna, and groundfish (particularly sablefish and sole). See Figure 6-18 for revenues and landings of the top commercial fisheries in the California Current LME. Resources in this LME are shared by the United States, Canada, Mexico, and numerous tribes, and are harvested by a mixture of commercial, recreational, and subsistence fishermen. Consequently fisheries management is a mix of regulations from several international organizations, federal agencies, state governments, and tribes.

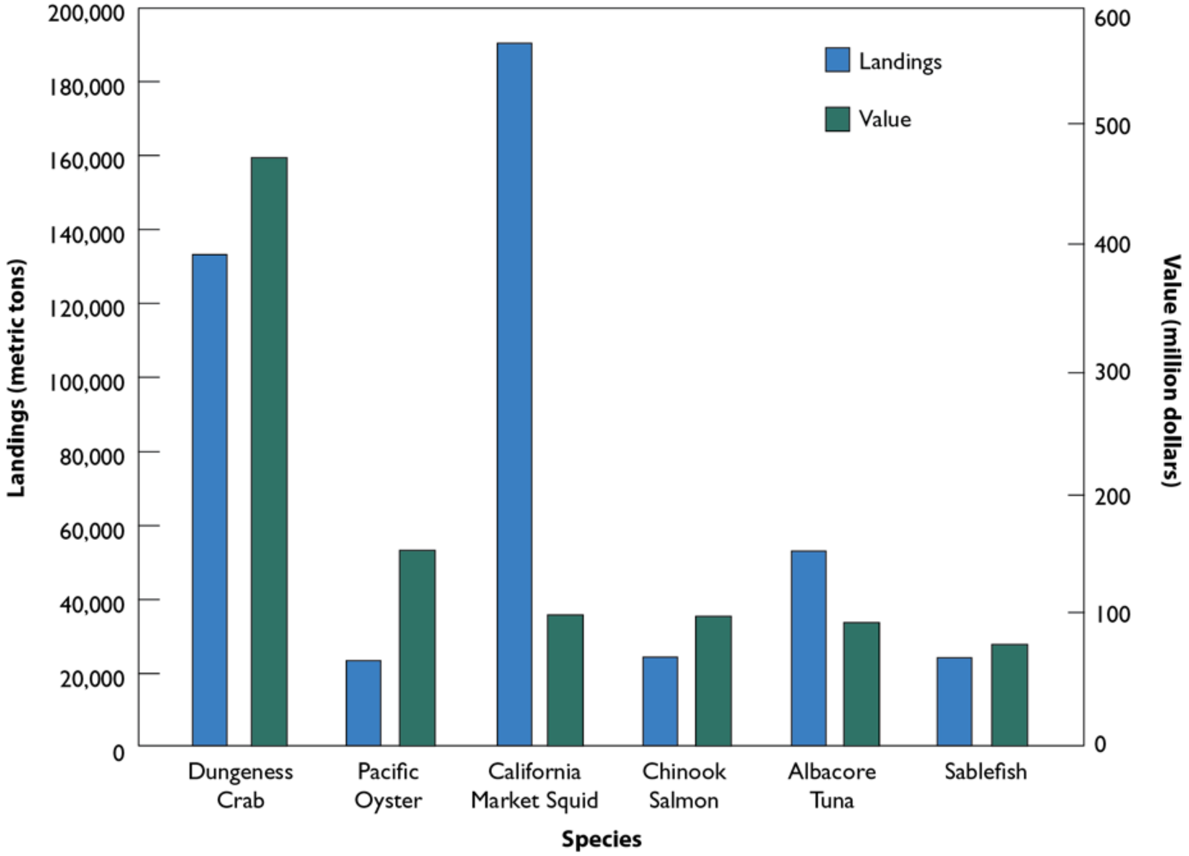


Figure 6-18. Top commercial fisheries for the California Current LME: landings (metric tons) and value (million dollars) from 2003–2006 (NMFS, 2010).

Invertebrate Fisheries

In the California Current LME, the greatest revenue is generated by the invertebrate fisheries, dominated by the Dungeness crab (*Metacarcinus magister)*. Indeed, this fishery yielded over $480 million in total ex-vessel (preprocessing) revenues from 2003 to 2006, over three times the value of the next highest commercial fishery, the Pacific oyster (Figure 6-18). The Dungeness crab, named after Dungeness, WA, has a range that spans from the Aleutian Islands of Alaska to Point Conception, CA. Although landings of this crab species (130,000 metric tons) are only about a third of those for pelagic fisheries, the higher market value for crab generates greater total revenues. Other crab species harvested in this LME are Red Rock crab and Southern Tanner crab, which have much lower revenues. Crabs are harvested with the use of traps or pots and, because they are largely caught in state waters, are regulated by the relevant state agencies. State agencies consult on issues affecting this crab fishery under the Pacific States Marine Fisheries Commission.

In terms of revenue, the Pacific oyster (*Crassostrea gigas)* comprises the second largest fishery, with commercial landings between 2003 and 2006 totaling only 23,000 metric tons, but worth over $156 million in total ex-vessel revenues (see Figure 6-18) (NMFS, 2010). The Pacific oyster is an introduced species from Japan, cultivated primarily in aquaculture farms throughout estuaries. Farmed mostly in state waters, these oysters are regulated by state agencies.

California market squid (*Loligo opalescens*), the third largest commercial fishery in this LME, is mostly harvested in northern and southern California. Between 2003 and 2006, this fishery generated approximately $103 million in total ex-vessel revenues for the California Current LME (see Figure 6-18) (NMFS, 2010). The California market squid fishery fluctuates in response to environmental conditions, coupled with rapid changes in the export market. California landings plummet during the cyclical El Niño oceanographic regimes, but increase considerably when these relatively warm water oceanic events are displaced by cool-water processes (i.e., La Niña). Volume increased during the 1990s because of new Asian and European markets and higher prices paid for squid from California Current LME waters. Despite the increased demand, the market value of squid remains low. Of the top commercial species in this LME, squid had the largest landings (60,000 metric tons greater than the next highest), but the third-largest revenues. Squid are fished at night with powerful lights that attract them to the surface, where they are either directly vacuumed into a boat's hold or are caught with an encircling net. This fishery is regulated under the Pacific Fishery Management Council's Coastal Pelagic Species FMP (PFMC, 2011a), which also includes northern anchovy, market squid, Pacific sardine, Pacific mackerel, and jack mackerel. This FMP regulates coastal pelagic fisheries largely by limiting entry and restricting allowable harvests.

Pacific Salmon Fisheries

Pacific salmon include five species: Chinook, coho, sockeye, pink, and chum salmon. Commercially, the most valuable species is Chinook salmon (*Oncorhynchus tshawytscha)*, with combined catches from 2003 to 2006 worth over $103 million in total ex-vessel revenues (see Figure 6-18) (NMFS, 2010). All species are harvested for commercial, recreational, and subsistence uses. All are anadromous (migratory); they are born in freshwater and swim to the ocean, where they may undergo extensive migrations. At maturity, they return to their home stream to spawn and complete their life cycles. The abundance of individual stocks of Pacific salmon and the mixture of stocks contributing to fisheries fluctuates considerably. Consequently, annual landings also fluctuate. During 2004–2006, the annual commercial salmon catch in the California Current LME averaged 16,300 metric tons and provided revenues averaging approximately $40 million at dockside. During the same period, recreational catches averaged about 4,700 metric tons (NMFS, 2010). Since 2003, stocks originating south of the Columbia River have declined sharply, culminating in the 2008 closure of all commercial salmon fisheries in California and most of the Oregon coast.

Chinook salmon has an average yield of 8,919 metric tons and is harvested recreationally and commercially throughout the LME. Chinook salmon production tends to fluctuate considerably, depending on hatchery production, freshwater habitat conditions, and ocean productivity. Since a warming of the waters in the California Current LME in the late 1970s, abundance of Chinook salmon has declined. Nevertheless, Chinook salmon are still the fourth-largest fishery for the California Current LME, with landings generating over $103 million in total ex-vessel revenues from 2003 to 2006. Recreational landings of Chinook salmon have averaged about 480,000 fish annually for the period 2004–2006 (NMFS, 2010). In recent years, freshwater habitat loss and degradation have been exacerbated by drought in many areas in the western United States, resulting in historically low abundance for a number of stocks and reduced commercial and recreational catches in many areas.

Pacific salmon depend on freshwater habitat for spawning and juvenile rearing and are particularly vulnerable to habitat degradation. 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 competes with salmon for the fresh water on which they depend. In recent years, freshwater habitat loss and degradation have been exacerbated by drought in many areas in the west, resulting in historically low abundance for a number of stocks and reduced commercial and recreational catches in many areas.

Declines in Chinook salmon abundance have forced reductions and closures of ocean fisheries in recent years. These reductions, in some cases, follow earlier, legally mandated salmon allocations to interior-water fisheries for harvest by Native American tribes. The proportion of Chinook salmon production originating from hatcheries (fish breeding and raising centers) has been increasing, though hatcheries still play a larger role in coho salmon production. The number of salmon farms is also on the rise. The key difference is that farmed salmon are raised entirely in pens until they are adults, whereas hatcheries release raised young. The increasing role of aquaculture in salmon fisheries is raising concerns about the interactions of these fish with wild stocks. Another problem faced by commercial salmon fisheries in the California Current LME is price declines driven by market competition from record landings of Alaskan salmon and steadily increasing aquaculture production. Since 2003, prices have somewhat rebounded as greater niche markets for local ocean-caught fish have developed.

The management of the salmon resource is complex, involving many stocks originating from various rivers and the interactions of various jurisdictions, including international commissions and federal, state, and tribal agencies. The Pacific Salmon Commission oversees the allocation of salmon between the United States and Canada, based on aggregate stock abundance. The Pacific Fishery Management Council (PFMC), in cooperation with the States and tribal fishery agencies, manages ocean fisheries for Chinook and coho salmon under a framework FMP (PFMC, 2011c). Fisheries within state waters are managed by state agencies or tribal governments.

Groundfish Fisheries

The PFMC’s Groundfish FMP (PFMC, 2011b) contains 89 species that are organized into several sub-fisheries, including the Dover sole, thornyheads, and sablefish complex; nearshore, shelf, and slope rockfishes; and Pacific hake (whiting). Most vessels targeting groundfish deliver to shore-side processors. From 2004–2006, the recent average yield of California Current LME groundfish in the United States was 288,604 metric tons. In 2006, U.S. commercial landings of California Current LME groundfish totaled 288,990 metric tons, generating $81 million in ex-vessel revenues. Pacific hake accounted for 91% of the 2006 landed catch and 44% of the associated ex-vessel value. Other important species in 2006 were Petrale sole ($6 million), Dover sole ($5 million), and thornyhead rockfish ($3 million; PSMFC, 2008). The trawl fleet is the largest sector of the commercial fishery, generating 75% of the ex-vessel revenues (PSMFC, 2008).

Although Pacific hake (*Merluccius productus)* accounts for a majority of the landing tonnage, sablefish (also known as black cod) (*Anoplopoma fimbria)* is the highest grossing groundfish fishery in the California Current LME, generating over $79 million in total ex-vessel revenues from 2003 to 2006 with landings of nearly 30,000 metric tons (see Figure 6-18). This species is considered highly valuable, making up only 2% of groundfish catch, but generating 28% of total groundfish revenues in 2006 (Hastie and Bellman, 2007). Sablefish is a long-lived groundfish species that resides on muddy bottoms between 1,000 and 9,000 feet in the North Pacific. Adult sablefish are opportunistic feeders, consuming various invertebrates and other fish. Sablefish larvae are prey for many invertebrate and vertebrates, while adults are generally targets for seabirds, sharks, killer whales, and other fish. Because the sablefish is highly mobile, with migration up to 2,000 miles, it is also managed under the Gulf of Alaska and the Bering Sea/Aleutian Islands FMPs (NPFMC, 2011; 2010a).

The PFMC, which manages the groundfish fishery stocks in the California Current LME, has recently brought sweeping managerial changes. The Council implemented a catch-share program for the groundfish fisheries in January of 2011. The use of these types of fisheries management schemes is increasing in popularity throughout the Regional Councils. In essence, the annual allowable harvest or quota is divided by sectors, with allocations based on catch history. For the Pacific Coast groundfish fishery, there are currently three participating sectors—Shoreside Trawl, Mothership Trawl, and Catcher-Processor. For more information on this new regulatory regime within the Pacific Fishery Management Council, see http://www.pcouncil.org/groundfish/fishery-management-plan/fmp-amendment-20/.

Highly Migratory Fisheries

The other major class of revenue-generating fisheries in the California Current LME is comprised of highly migratory species, the most commercially important of which is Albacore tuna (*Thunnus alalunga)*. From 2003 to 2006, the Albacore tuna fishery generated nearly $96 million in total ex-vessel revenues, with landings over 50,000 metric tons, ranking it the fifth-largest commercial fishery for this region (NMFS, 2010). This tuna resides throughout the world's temperate waters, migrating thousands of miles annually. In the Pacific Northwest, its diet largely consists of pelagic species and squid.

Due to its migratory nature, this tuna is regulated by the Inter-American Tropical Tuna Commission, developing policies implemented by NMFS and respective state agencies. The regulations are largely based on a permit system (for both commercial and recreational fisheries), logbooks, and seasonal restrictions on certain gear types. Because this species is heavily targeted by sports fishermen, managers have recently implemented bag limits on sport-caught albacore. Other tuna fisheries in this LME include yellowfin, bigeye, skipjack, and Pacific bluefin.

Fishery Trends and Summary

Figure 6-19 shows landings of the top commercial fisheries in the California Current LME since 1950. Until 1980, landings in the squid fisheries were reported as a group, rather than on a single species–specific basis. Catches of California market squid have dropped precipitously (by 70,000 metric tons) since peaking in 2000 at 120,000 metric tons. Dramatic fluctuations in this fishery are a regular occurrence, as the Californian market squid is highly vulnerable to alterations in the El Nino cycle. Landings of the other top species have remained below 40,000 metric tons since 1950, with considerable fluctuations in the Albacore tuna and Dungeness crab fisheries, though both have been trending upwards since 1990. Recent landings of Pacific oyster, Chinook salmon, and sablefish have been under 10,000 metric tons. The Chinook salmon and sablefish fisheries have both had decreasing landings since the 1980s, while harvests of the Pacific oyster have remained consistent.

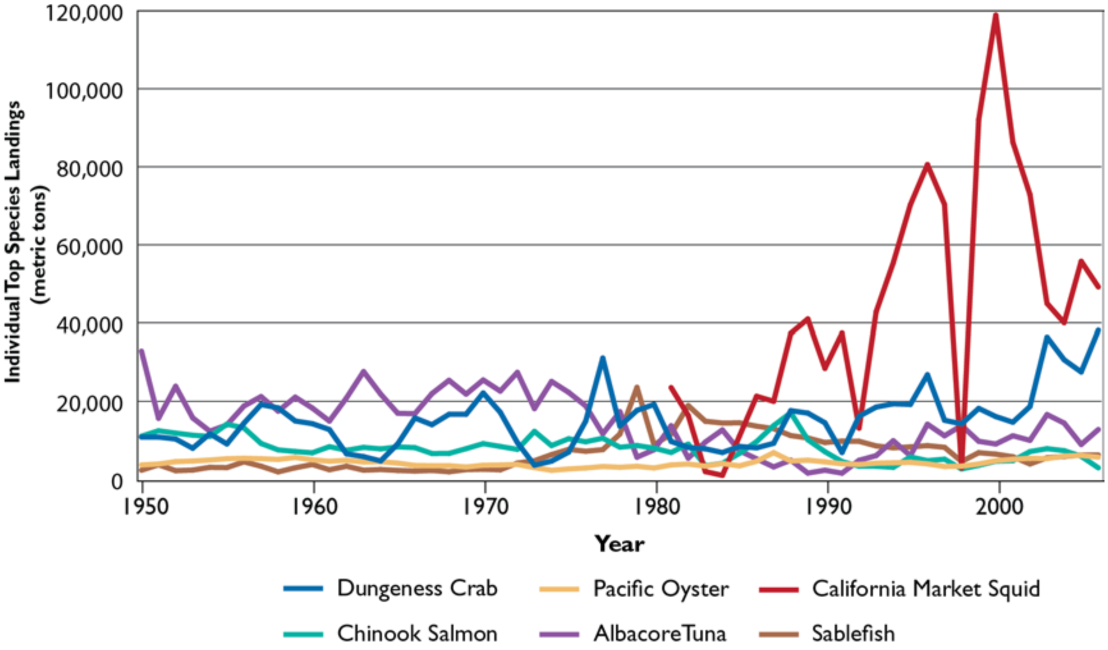


Figure 6-19. Landings of top commercial fisheries in the California Current LME from 1950 to 2006, metric tons (NMFS, 2010).

Currently, Dungeness crab, Pacific oyster, California market squid, Chinook salmon, Albacore tuna, and sablefish comprise the top commercial fisheries for the California Current LME because they generate the highest ex-vessel revenues. This LME generated over $1.6 billion from 2003–2006, $480 million of which was from Dungeness crab alone. Currently, the most important recreational fisheries are for various species of salmon, flatfish, and tuna, which support tourism, bait and tackle shops, and recreational boating and other activities, all of which contribute significantly to the value derived from the ecosystem service of fishery production. In terms of landed tonnage, this LME is dominated by hake and squid; however, the hake fishery is not one of the top six commercial fisheries due to lower market prices. Aside from their commercial and recreational values, all fish species have important roles in their ecosystems. Smaller species serve as prey for larger predators, which themselves may be food for seabirds or marine mammals. When fishermen over-harvest specific species, this can undermine a critical balance in ecosystem function, and through a cascade of events, can inadvertently eliminate both predator and prey species. Interestingly, in this LME, there seems to be a pronounced effect on fishery production from El Niño, causing seasonal changes in fishery community structure and population dynamics.

Advisory Data

Fish Consumption Advisories

In 2006, 42 fish consumption advisories were in effect for the estuarine and coastal waters of the West Coast region (Figure 6-20). A total of 39% of the estuarine square miles on the West Coast were under advisory in 2006, and most of the estuarine area under advisory was located within the San Francisco Bay/Delta region or within Puget Sound. Only 13% of the region's 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 2006 (U.S. EPA, 2007c).

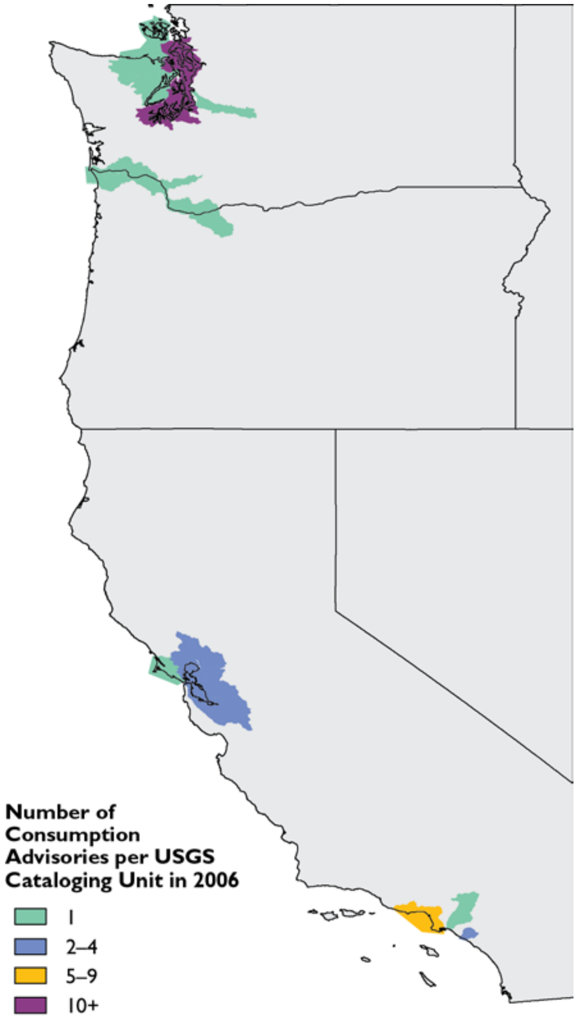


Figure 6-20. The number of fish consumption advisories active in 2006 for the West Coast coastal waters (U.S. EPA, 2007c).

Seventeen different contaminants or groups of contaminants were responsible for West Coast fish advisories in 2006, and 10 of those contaminants were listed only in the waters of Puget Sound and the bays emptying into the Sound. These contaminants were arsenic, creosote, diethylphthalates, industrial and municipal discharge, metals, multiple contaminants, PAHs, pentachlorophenol, tetrachloroethene, and volatile organic compounds. In California, Oregon, and Washington, PCBs used to be the major pollutant, accounting for 71% of advisories in 2003, but they are now responsible for only 38% of advisories (Figure 6-21). DDT was partly responsible for 12 advisories issued in California. Although only three advisories were issued for mercury on the West Coast, the entire San Francisco Bay was covered by one of these advisories. Among the other pollutants, the chemicals with most advisories were inexplicit pollutants, such as not-specified pollutants, which were issued under the advisories in Puget Sound (U.S. EPA, 2007c). Table 6-1 lists the species and/or groups under fish consumption advisory in 2006 for at least some part of the coastal waters of the West Coast region is provided below.

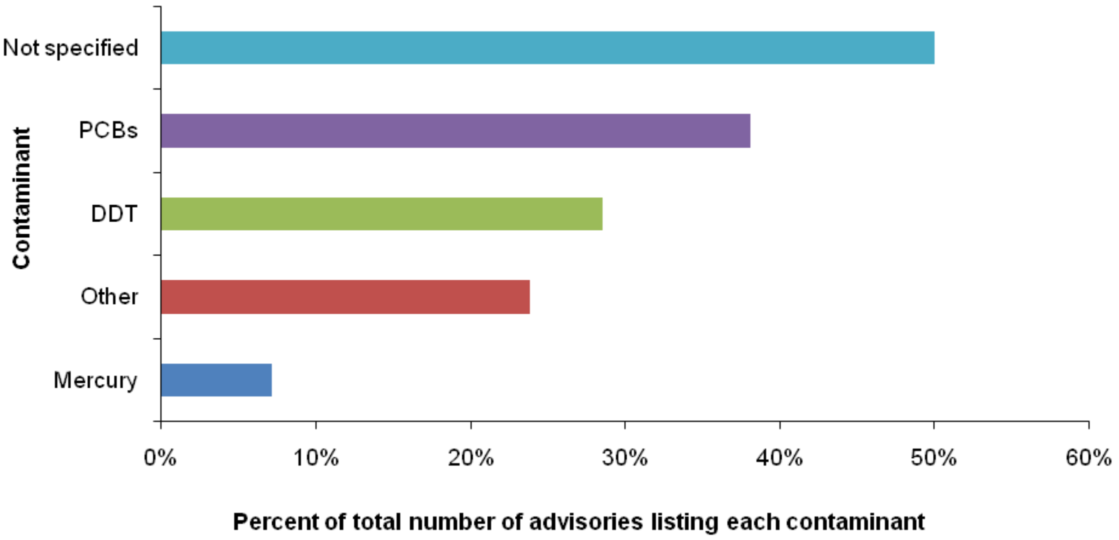


Figure 6-21. Pollutants responsible for fish consumption advisories in West Coast coastal waters.

An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2007c).

Table 6-1. Species and/or Groups under Fish Consumption Advisory in 2006 for at Least Some Part of the Coastal Waters of the West Coast Region

Species and/or Groups under Fish Consumption Advisory		
Bat ray	Bivalves	Black croaker
Brown smooth hound shark	Bullhead	California halibut
Chinook salmon	Clams	Corbina
Crabs (whole, shell, and hepatopancreas)	English sole	Gobies
Jacksmelt	Kelp bass	Leopard shark
Pacific angel shark	Pile surfperch	Queenfish
Red rock crabs	Redtail surfperch	Rockfish
Salmon	Sculpin	Shark
Shellfish	Shiner perch	Starry flounder
Striped bass	Sturgeon	Surfperch
White croaker	Yelloweye rockfish	

Source: U.S. EPA, 2007c

Beach Advisories and Closures

How many notification actions were reported for the West Coast between 2004 and 2008?

Table 6-2 presents the number of total and monitored beaches, as well as the number and percentage of beaches affected by notification actions from 2004 to 2008 for the West Coast region. Over the past several years, the total number of beaches identified by the West Coast states increased substantially, from 501 in 2004 to 1,829 in 2008, largely resulting from changes in State delineations of beaches rather than increasing acreage. During this same period, the number of monitored beaches increased from 501 to 516. Of these monitored beaches, the percentage of beaches that were closed or under advisory for some period of time during the year has consistently hovered between 31% and 33% (or 160 beaches) (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring site: http://www.epa.gov/waterscience/beaches/seasons/.

Table 6-2. Beach Notification Actions, West Coast, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	501	1227	1227	1226	1829
Number of monitored beaches	501	519	525	509	516
Number of beaches affected by notification actions	160	170	167	160	160
Percentage of monitored beaches affected by notification actions	32%	33%	32%	31%	31%

What pollution sources impacted monitored beaches?

Table 6-3 presents the numbers and percentages of monitored West Coast beaches affected by various pollution sources for 2007. Nearly all beach advisories on the West Coast were attributed to unidentified and/or other sources (85%) and non-investigated sources (about 15%). With septic system leakage and “no known pollution source,” together contributing less than 1% of all beach advisories (U.S. EPA, 2009d).

Table 6-3. Reasons for Beach Advisories, West Coast, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Other and/or unidentified sources	425	84%
Pollution sources not investigated	75	15%
No know pollution sources	5	< 1%
Septic system leakage	4	< 1%

Note: A single beach advisory may have multiple pollution sources. Additional reasons for beach advisories exist, but were not documented for the West Coast states for 2007.

How long were the 2007 beach notification actions?

Over three-quarters of beach notification actions on the West Coast in 2007 lasted a week or less, with the highest frequency (40%) ranging from 3 to 7 days. While actions lasting 8 to 30 days accounted for nearly 20% of all the notifications, those of the greatest duration (above 30 days) only comprised 5% of all beach actions (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA’s Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Summary

Based on data from the NCA assessment of 2004–2006, the overall condition of West Coast coastal waters is rated good to fair. Indicators for overall water quality, tissue contaminants, and benthic condition were all rated good for the West Coast region; however, coastal habitat and sediment quality were rated poor and fair, respectively, and driven primarily by the harbor areas of southern California. Although assessments from 2001–2003 are not directly comparable to the 2004–2006 sampling efforts, the current contamination indicators showed fewer poor stations from Puget Sound and San Francisco Bay compared to the results from the 1999–2000 survey. Sites from the majority of smaller estuarine systems along the West Coast were estimated to be in generally good condition.

The 2003 West Coast region offshore assessment showed that these waters are in generally good condition, with no major evidence of poor water quality. Poor sediment quality was indicated only in limited areas. While some areas of impaired benthic condition were found, they did not appear to be linked to sediment quality indicators. High sediment contamination from chemicals was found at 23 stations (all in California), but not at any of the sites where low values of benthic attributes were observed. This indicates that the areas of biological impairment may just be within the normal range, or it is possible that there are some other types of disturbances that have not yet been measured, including human activities such as commercial bottom trawling, cable placement, and minerals extraction. Future monitoring efforts in these offshore areas should include indicators of other sources of disturbance.

In the California Current LME, the greatest revenue is generated by the invertebrate fisheries, dominated by the Dungeness crab, Pacific oyster, and California market squid. The California market squid fishery fluctuates in response to environmental conditions, coupled with rapid changes in the export market. Since 2003, stocks originating south of the Columbia River have declined sharply, culminating in the 2008 closure of all commercial salmon fisheries in California and most of the Oregon coast. In recent years, freshwater habitat loss and degradation have been exacerbated by drought in many areas in the west, resulting in historically low abundance for a number of salmon stocks. The Albacore tuna fishery is the fifth-largest commercial fishery for this region. Although Pacific hake accounts for a majority of the landing tonnage, sablefish is the highest grossing groundfish fishery in the California Current LME. Recent years have brought sweeping changes to the management of Pacific Coast groundfish fishery and the research necessary to support the fishery's management. Harvest rates for most assessed groundfish stocks have been reduced in recent years, and new permitting and observation programs have been implemented to help stocks recover. The states of California, Oregon, and Washington are developing and implementing protected areas within their waters to guard sensitive habitats of particular concern for groundfish fish production.

Contamination in West Coast coastal waters has affected human uses of these waters. In 2006, 39% of the estuarine square miles on the West Coast and 13% of the region's coastal miles were under fish consumption advisory. Advisories were issued for a number of contaminants, including PCBs and mercury. In addition, 32% of the region's monitored beaches were closed or under advisory for some period of time during 2006. Elevated bacteria levels in the region's coastal waters were primarily responsible for the beach closures and advisories.

Chapter 7

Great Lakes Coastal Condition

7. Great Lakes Coastal Condition

As shown in Figure 7-1, the overall condition of the U.S. coastal waters of the Great Lakes region between 2003 and 2006 is 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 coastal habitat and benthic indices are rated fair to poor, and the sediment quality index is rated 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 2009* (Environment Canada and U.S. EPA, 2009b). This report is the sixth biennial report issued jointly by the governments of Canada and the United States. NCA survey strategies are being implemented in the Great Lakes region during the 2010 sampling season, and future assessments will be more similar to those for other regions. This assessment will allow for a more direct comparison of coastal conditions found in the Great Lakes to those of the marine coastal environment.

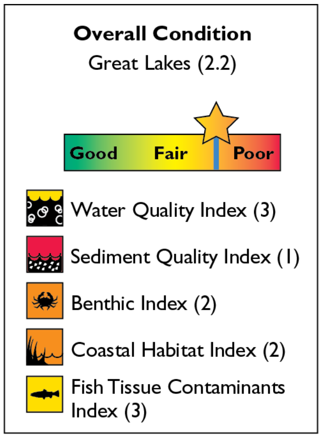


Figure 7-1. The overall condition of Great Lakes coastal waters is rated fair to poor (based on data from Environment Canada and U.S. EPA, 2009a, b).

The Great Lakes ecosystem covers 295,000 square miles, with nearly 11,000 miles of shoreline, and holds 5,500 cubic miles of water. This watershed includes a broad range of habitats, from the coniferous forests and rocky shorelines of Lake Superior to the fertile soils and sandy shores of Lake Michigan and Lake Erie. The coastal ecosystems of the Great Lakes include about 30,000 islands, wetlands, coastal marshes, sand dunes, savannas, prairies, and alvars.

The coastal counties of the U.S. Great Lakes region represent the third-largest coastal population in the nation. The population of Great Lakes coastal counties increased by 1% between 1980 and 2006, from 19.4 million to 19.7 million people (Figure 7-2). Over the same time period, the region's coastal population density increased slightly from 271 to 275 persons per square mile (NOEP, 2010). Figure 7-3 presents a map of the U.S. Great Lakes region population density in 2006.

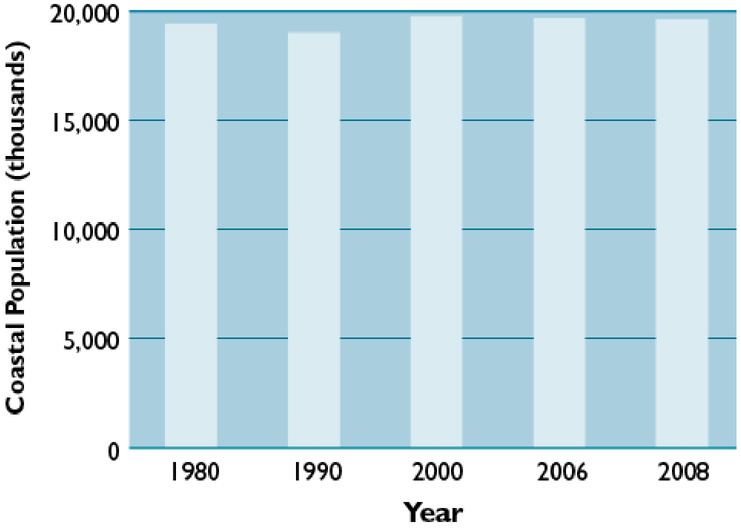


Figure 7-2. Population of U.S. coastal counties in the Great Lakes region from 1980 to 2008 (NOEP, 2010).

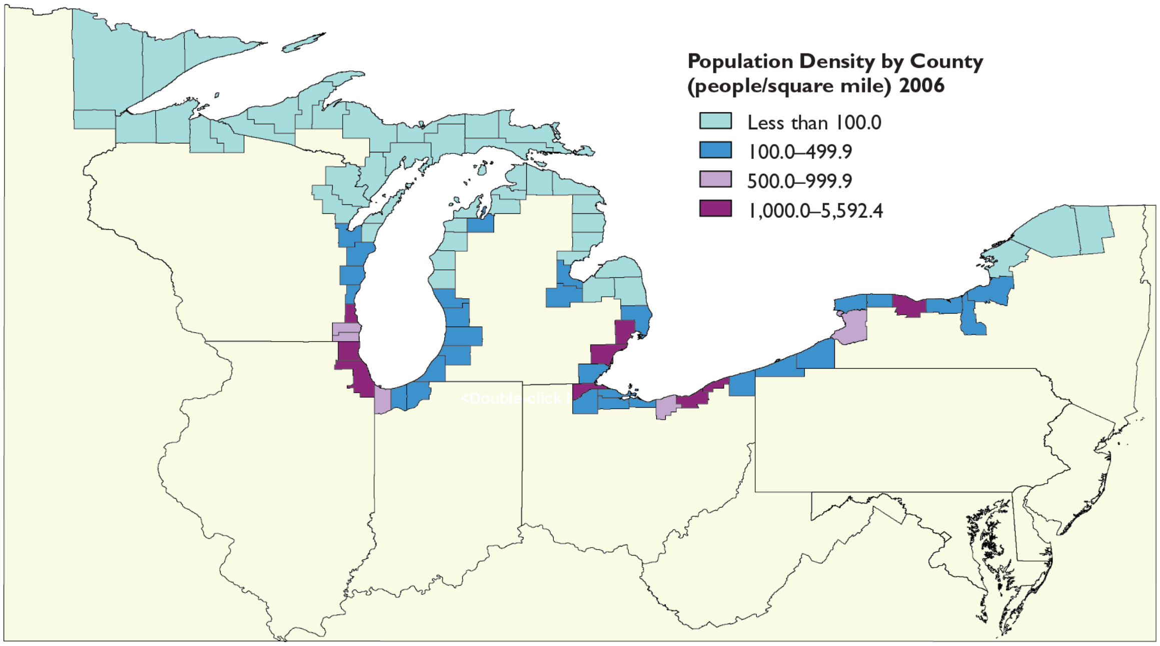


Figure 7-3. Population density in the Great Lakes region's coastal counties in 2006 (NOEP, 2010).

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 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 three Web sites: the State of the Lakes Ecosystem Conferences (SOLEC) site, available at http://www.epa.gov/grtlakes/solec; the GLNPO site, available at http://www.epa.gov/glnpo; and a binational site, available at http://binational.net/home_e.html. These results are used to quantify and categorize NCA indices and component indicators for the Great Lakes in the NCCR IV 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. NCCA sampling was being implemented during 2010 through coordination with EPA and multiple state agencies. Information on binational programs contributing to overall assessment of the Great Lakes from both Environment Canada and the EPA is available at http://www.binational.net.

Water Quality Index

The NCCR IV assessment combines several SOLEC indicators and GLNPO Water Quality Survey results (e.g., eutrophic condition, water clarity, dissolved oxygen levels, phosphorus concentrations) into a water quality index to allow comparison of water quality condition estimates for the Great Lakes with the NCA water quality index for U.S. marine coastal waters. Based on these component indicators, the Great Lakes water quality index is rated fair to poor. Starting with this report, the SOLEC indicators used for the water quality index include nearshore waters and open waters. Nearshore waters are defined as having a depth of 66 feet or less. Of the four SOLEC indicators used to develop the water quality index, eutrophic condition is rated fair to poor, phosphorus concentrations are rated poor, water clarity is rated good to fair, and dissolved oxygen concentrations are 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 due to seasonal stratification in areas greater than 66 feet deep.

Eutrophic Condition

Eutrophic conditions for the nearshore areas of the Great Lakes are rated fair to poor. Eutrophic conditions were determined using a surface water quality index developed by Chapra and Dobson (1981), and summarized data of nearshore water quality parameters of total phosphorus and chlorophyll *a* concentrations from *Nearshore Areas of the Great Lakes 2009* (Environment Canada and U.S. EPA, 2009a). The upper lakes (Lake Superior and Lake Huron) and Lake Ontario coastal waters were described as oligiotrophic waters, whereas Lake Erie coastal waters were described as having eutrophic conditions. Data suggest that *Cladophora* algal blooms have become more problematic by fouling beaches in the lower lakes during the past decade. This may be due in part to consumption of plankton by dreissenid mussels (the zebra and quagga mussels), which promotes *Cladophora* growth by increasing water clarity (Environment Canada and U.S. EPA, 2009a).

Nutrients: Phosphorus

Phosphorus concentrations and loadings for the nearshore areas of the Great Lakes region were rated poor. After strong efforts to reduce phosphorus concentrations were implemented during the 1970s, phosphorus concentrations declined steadily. Recent evidence suggests that although total phosphorus concentrations have remained relatively constant, the proportion of phosphorus present in an available dissolved form has increased dramatically. Point-source controls have been effective in decreasing phosphorus levels in the past; however, the primary driver of phosphorus loadings is now related to nonpoint sources such as stormwater runoff (Environment Canada and U.S. EPA, 2009a). This finding has strong implications for nearshore areas and embayments. Elevated levels of phosphorus in these regions are likely to contribute to nuisance algae growths, such as the attached green algae *Cladophora,* and toxic cyanophytes, such as *Microcystis*.

Water Clarity

Water clarity, measured by Secchi disk, was rated as good to fair for the Great Lakes region. In general, the upper lakes exhibited good water clarity, and the lower lakes, especially Lake Erie and Lake Michigan, had fair water clarity due in part to harmful algal blooms along the coastline during the latter part of the summer. Increasing water clarity is an indicator of declining algal populations, which form the base of the aquatic food chain in the Great Lakes. This is not necessarily an indication of improving conditions.

Dissolved Oxygen

Dissolved oxygen concentrations are rated good for the Great Lakes region, with levels that are capable of supporting life in most coastal regions of the Great Lakes. However, portions of the offshore central basin of Lake Erie are still experiencing anoxic (< 2 mg/L) conditions during summer stratification periods, and at times, these conditions may persist until late summer turnover. This condition is variously hypothesized to be a result of regional climate effects or of invasive species, particularly dreissenid mussels, improving water clarity, or altering the cycling of nutrients. Some of these alterations lead to algal blooms that die and sink to the bottom and consume dissolved oxygen during the decay process, resulting in summer anoxia in the bottom waters.

Sediment Quality Index

The NCCR II and III assessments 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 continues to be rated as poor for the NCCR IV, with sediment contamination contributing to the poor condition assessed in many harbors and tributaries and affecting the beneficial uses at all 30 of the U.S. Great Lakes Areas of Concern (AOCs) throughout the region (Figure 7-4). Contaminated sediments are also the leading cause of fish consumption advisories for this region and serve as a source of contaminants to open water as a result of sediment re-suspension processes (Environment Canada and U.S. EPA, 2009b). In addition, sediment contamination continues to be a problem affecting the sediment quality in this region.

Figure 7-4. Great Lakes Areas of Concern (U.S. EPA, 2009a).

Benthic Index

The benthic condition of the Great Lakes, as measured by benthic community health, is rated fair to poor, although conditions in individual lakes vary. This rating was based on results of the GLNPO's benthic invertebrate monitoring and surveillance monitoring programs. Populations of the benthic invertebrates *Diporeia* (in cold, deepwater habitats) and *Hexagenia* (in mesotrophic habitats) were used for evaluating benthic health because of their importance at the base of the Great Lakes food web. Benthic conditions for 2003–2006 have an unchanging trend: some Great Lakes have good benthic conditions while areas of other lakes have fair or poor conditions. Further explanation of this evaluation states that a good status indicates oligotrophic conditions, while a fair or poor status indicates mesotrophic to eutrophic conditions at locations that have historically been oligotrophic. This rating is based on the Milbrink's index of oligochaete worm densities, which was used as a component of the Benthos Diversity and Abundance SOLEC indicator.

The status and trend of the benthic invertebrate *Diporeia* are mixed and deteriorating (Environment Canada and U.S. EPA, 2009b). Although the cause of declines is unknown, populations are dramatically declining in Lakes Michigan, Huron, and Ontario, and they are extremely rare and even absent in some areas of Lake Erie. However, *Diporeia* populations in Lake Superior remain good and stable despite what is occurring in the other lakes. The decline of *Diporeia* populations began to occur 2 to 3 years after the invasion of the dreissenid mussels. Figure 7-5 illustrates the decline of *Diporeia* populations in Lake Huron. One initial hypothesis is that mussels are outcompeting *Diporeia* for food. Yet, *Diporeia* seem to be persisting in the presence of mussels in the New York Finger Lakes, and they have also disappeared in some areas where food is available and mussels are absent. Therefore, it appears that a more complex situation responsible for the decline of *Diporeia*.

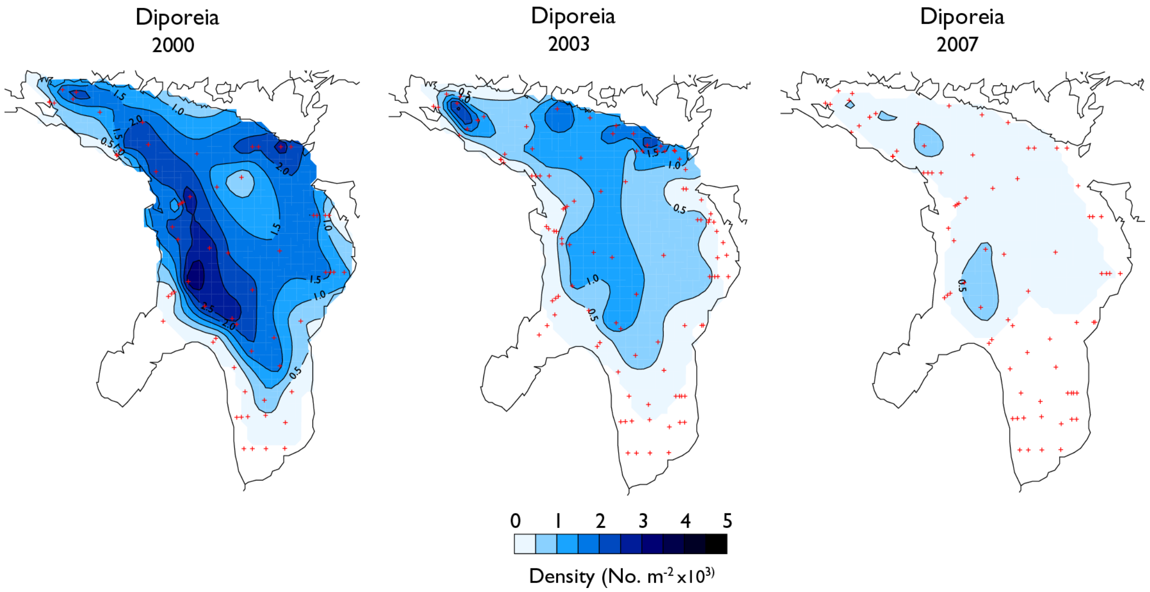


Figure 7-5. Distribution and abundance (number per square meter) of the amphipod *Diporeia* spp. in Lake Huron in 2000, 2003, and 2007.

Small crosses indicate location of sampling stations (Environment Canada and U.S. EPA, 2009b).

Currently, the status of *Hexagenia* is mixed, with a mixed-to-improving trend. *Hexagenia* is used as a mestrophic indicator to the Great Lakes because it is important to many species of fish and because it is sensitive to pollution and changes in habitat. *Hexageni*a was very abundant in the 1930s–1940s; however, in the 1950s, anoxic conditions caused populations to collapse in many of the embayments and coastal areas where they were formerly abundant. Anecdotal reports of *Hexagenia* recovery in the Great Lakes started to occur in the 1990s, which led to the investigation of its distribution in western Lake Erie. In 2002, nymph density drastically increased; however, that was followed by a steady decrease from 2002–2006 (Environment Canada and U.S. EPA, 2009b).

Coastal Habitat Index

The coastal habitat index for the Great Lakes region is rated fair to poor and has a deteriorating trend. This index is based on amphibian abundance and diversity, wetland-dependent bird diversity and abundance, the areal extent of coastal wetlands by type, and the effects of water level fluctuations.

The Great Lakes support a diversity of coastal wetlands types despite significant losses. More than one-half of the Great Lakes coastal wetlands was lost between 1780 and 1980 (Turner and Boesch, 1988; Dahl, 1990). The extent of coastal wetlands in the Great Lakes has a mixed status with a deteriorating trend. This assessment was made based on the Great Lakes Coastal Wetland Consortium coordination of a binational coastal wetland database (Albert et al., 2005). This database identified that approximately 535,584 acres of coastal wetlands exist within the Great Lakes basin.

Amphibian communities are often used to assess wetlands because amphibians are very sensitive to wetland contamination and degradation. The Marsh Monitoring Program (MMP) has been collecting amphibian data since 1995 across the Great Lakes basin. During this time, the MMP has recorded 13 different species of amphibians, with the spring peeper being the mostly frequently detected. Currently, the coastal wetland amphibian communities of the Great Lakes have a mixed status and deteriorating trend. The MMP has detected significantly declining trends in the American toad, chorus frog, green frog, and northern leopard frog. There has also been no significantly increasing trend in any common species of amphibian (Environment Canada and U.S. EPA, 2009b). However, it should be noted that there is high among-year variability in amphibian populations and that they are very sensitive to changes in water level. Further monitoring would determine if the declines observed reflected environmental fluctuations that caused water level changes, or if other factors influenced individual amphibian species.

The status of coastal wetland bird communities is mixed with a deteriorating trend. The MMP has been collecting data on coastal wetland birds since 1995, with 610 routes around the Great Lakes basin. The MMP recorded that the most common nonaerial foraging bird species was the red-winged blackbird, followed by the swamp sparrow, yellow warbler, and the marsh wren. Another common species that exclusively nests in marshes are the undifferentiated common moorhen and American coot, Virginia rail, black tern, common moorhen, pied-bille grebe, American bittern, American coot, sora, and least bittern. Lastly, the most common bird species that typically forage above the marsh are the tree swallow and bank swallow. Overall, 17 species of wetland birds exhibit significant declines across the Great Lakes basin while only 6 species of birds exhibit a significantly positive trend (Environment Canada and U.S. EPA, 2009b). One stressor to waterfowl populations in some areas of the lower Great Lakes is avian botulism. It is thought that recurring outbreaks of botulism are due to the effects of dreissenid mussels and round gobies, because the mussels create environmental conditions that promote the pathogen, and the gobies transfer it from the mussels to higher levels of the food web (Environment Canada and U.S. EPA, 2009b). Additionally, further monitoring would determine the degree to which changes in wetland bird species occurrences reflect changing marsh conditions as a consequence of changing water levels.

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of the Great Lakes region is rated fair, with an improving trend for the NCCR IV based on SOLEC indicator 121. 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. Concentrations of these contaminants are generally declining in fish tissues, as shown in Figure 7-6, but are still present at levels that support continuation of existing fish advisories for all five Great Lakes. Whole-fish composite samples of top-predatory fish are analyzed for contaminants in the United States, and fillets are analyzed in Canada; however, the guidelines are similar in both countries. The represented top-predatory fish used are walleye for Lake Erie and lake trout for the other four Great Lakes. Each lake is rated individually based on the concentrations of PCBs and DDT and the corresponding fish advisory category; the final overall rating is an average of all five individual ratings (Environment Canada and U.S. EPA, 2009b).

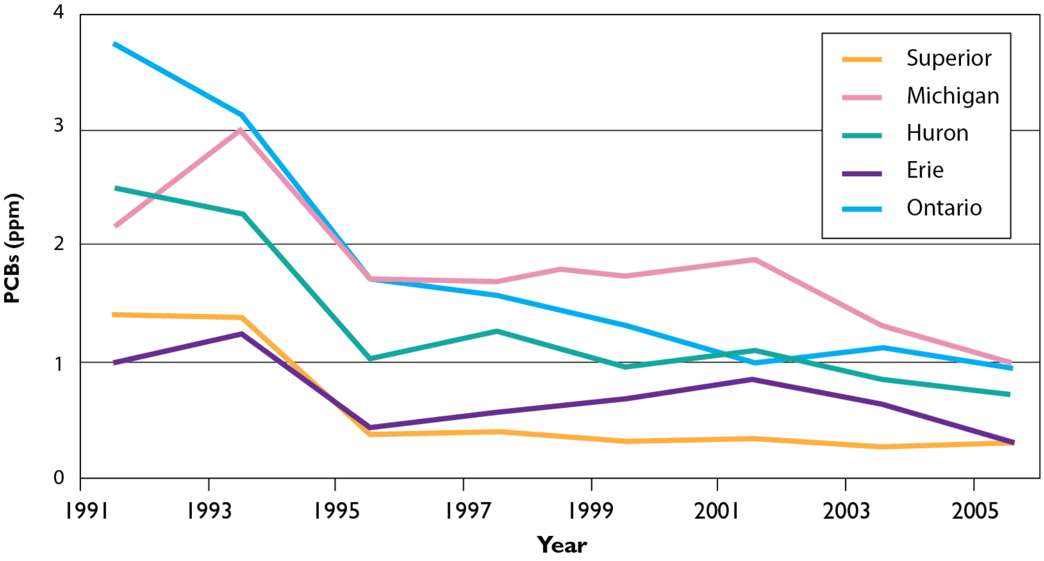


Figure 7-6. Total PCBs in composites of lake trout (walleye in Lake Erie), 1991–2005 (Environment Canada and U.S. EPA, 2009b).

Lake Trout = 600–700 mm size range. Walleye = 450–550 mm size range.

Trends of Coastal Monitoring 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 NCCR III), and ratings in this report for 2003–2006 remain the same as in 1998 through 2000. Therefore, the analysis of trends in environmental condition estimates for the Great Lakes cannot be made at this time. Comparisons of previously reported conditions with current conditions are briefly discussed in the previous sections.

Fisheries—Great Lakes

Once home to over 150 unique fish species, fishery production in the Great Lakes continues to decrease due to the combined effects of overfishing, invasive species, and habitat destruction (Ontario Ministry of Natural Resources, 2009; Environment Canada and U.S. EPA, 2007). By the 1950s, stocks of many of the most commercially valuable species (lake trout, lake sturgeon, blue pike, Atlantic salmon, and lake herring) had nearly collapsed, having been replaced by their less valuable native counterparts (whitefish and yellow perch) and introduced species (Pacific, Chinook, and Coho salmon; smelt; and alewife) (GLFC, 2008). From 1970 to 2007, commercial landings declined again from 65 to 20 million pounds (Figure 7-7).

Fisheries of the Great Lakes are shared by the United States and Canada and mostly occur in offshore waters. Presently, the U.S. commercial fishery is dominated by lake whitefish, yellow perch, smelt, and bloater chubs, with Lake Michigan representing the largest portion of these catches (Kinnunen, 2003). From 2003 to 2006, the commercial fisheries in the Great Lakes generated over $52.7 million in total ex-vessel revenues (preprocessing value) (NMFS, 2009a). The annual Canadian commercial harvest, which is estimated at 28 million pounds, primarily consists of walleye and yellow perch catches from Lake Erie (Kinnunen, 2003). Both U.S. and Canadian fisheries are managed at the regional level, by state, provincial, and intertribal agencies.

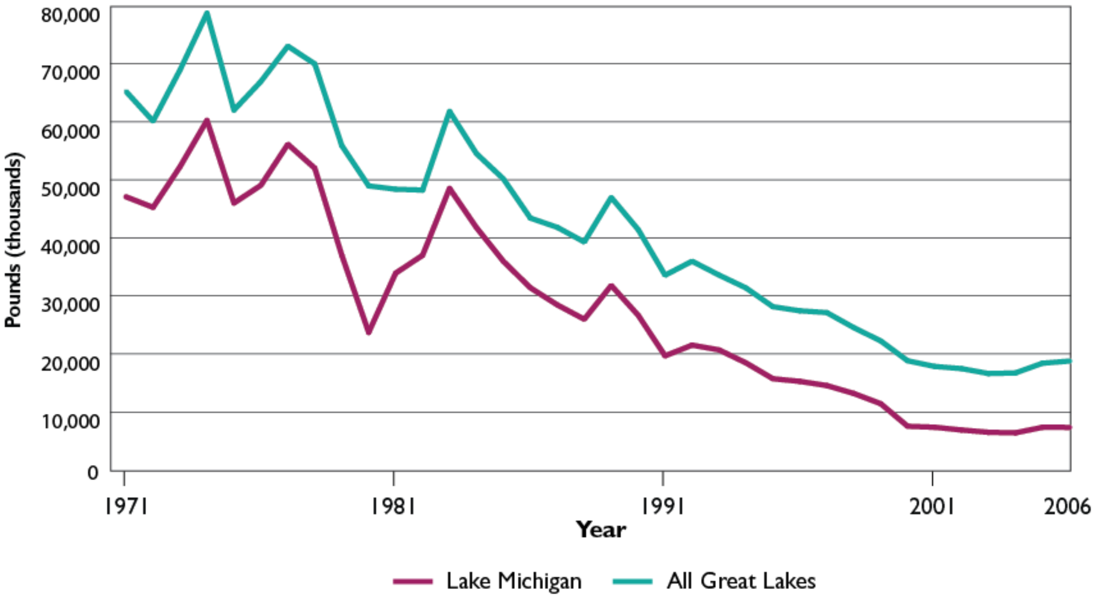


Figure 7-7. U.S. Great Lakes commercial fish landings totals in pounds, 1971–2007 (NMFS, 2009a).

Lake Whitefish and Yellow Perch Fisheries

Lake whitefish (*Coregonus clupeaformis)*, a member of the salmon family, dominates U.S. commercial fishery landings in the Great Lakes. From 2003 to 2006, the total ex-vessel revenues generated by the U.S. commercial harvests of lake whitefish were over $28 million (NMFS, 2009a). Lake whitefish averages one to three pounds at harvest and is valued for its meat as well as its roe, which is made into caviar (Fisheries and Oceans Canada, 2009). The small mouth of this fish limits its diet to small fish, fish eggs, insect larvae, clams, and zooplankton (primarily *Diporeia,* a small shrimp-like crustacean). This fishery increased markedly beginning in the early 1980s, and despite declines in landings in the late 1990s, seems to be increasing again (Figure 7-8).

Yellow perch (*Perca flavescens*) is another valuable commercial fishery species because of its favorable taste and texture, yielding over $11 million in total U.S. ex-vessel revenues from 2003 to 2006 (NMFS, 2009a). This species has a vast geographic range spanning from Nova Scotia to South Carolina along the Atlantic Coast and west to Kansas and the Montana border, reaching the southern portions of the Northwest Territories of Canada. Small fish and minnows are the favored diet of adult yellow perch, which are themselves an important prey for many predatory fish, including walleye, bass, northern pike, and muskellunge (University of Wisconsin Sea Grant Institute, 2010). Populations of yellow perch have considerable interlake variability, although recently commercial harvests throughout the Great Lakes stabilized at around 2 million pounds (Figure 7-8) (NMFS, 2009a).

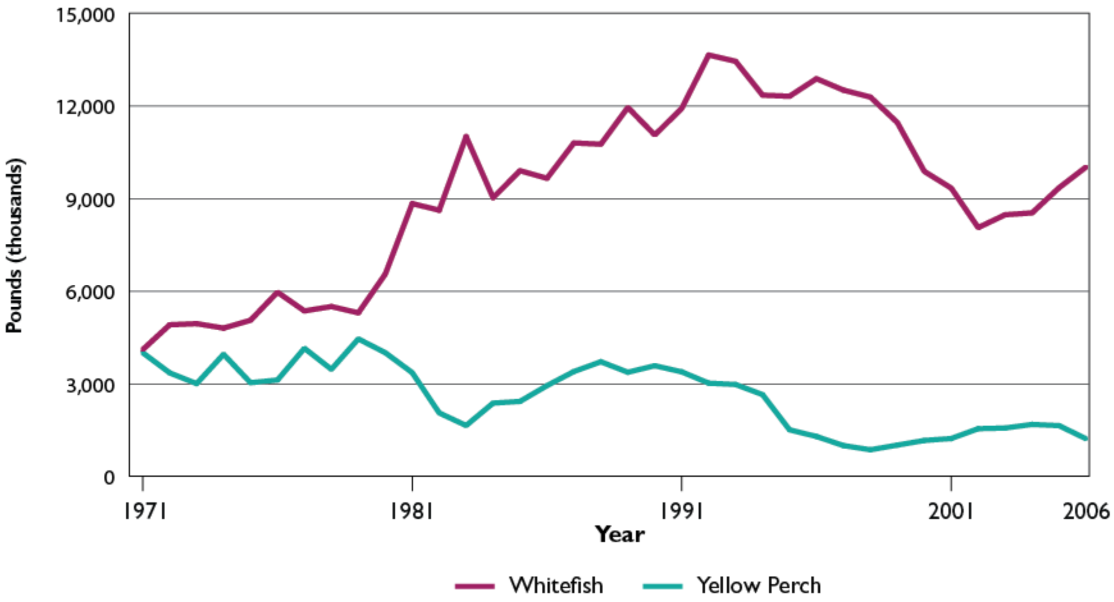


Figure 7-8. U.S. Great Lakes whitefish and yellow perch commercial landings totals in pounds, 1971–2006 (NMFS, 2009a).

Note: Yellow perch is often considered a prey species.

Lake Trout and Walleye Fisheries

Lake trout and walleye were once dominant predatory fish in the Great Lakes, but current populations only allow for a limited commercial fishery (Figure 7-9). From 2003 to 2006, the total U.S. ex-vessel revenues from this fishery were $683,000 (NMFS, 2009a). Lake trout (*Salvelinus namaycush*) inhabits all five Great Lakes and has a geographical range that extends to the northernmost reaches of North America. On average, lake trout weighs around 7 pounds, though some trophy specimens have weighed in at 25 pounds. The diet of lake trout consists of several prey species, including native chubs and sculpins and introduced alewives and smelt (University of Wisconsin Sea Grant Institute, 2010). Before nearing complete extinction in the 1950s, lake trout was a valuable commercial species in the Great Lakes. It now survives in sufficient numbers to allow commercial harvesting only in Lake Superior. Stocking programs, which raise fish in controlled conditions, continue in the other lakes.

After peak harvests from the mid-1980s to early 1990s, the walleye (*Stizostedion vitreum*) landings declined from the mid-1990s through 2000, possibly due to shifts in environmental states, variable reproductive success, influences from invasive species, and changing fisheries (Environment Canada and U.S. EPA, 2007). Since 2000, harvests have increased primarily due to improvements in environmental conditions around spawning and nursery habitats (Environment Canada and U.S. EPA, 2007).The commercial harvests in this fishery remain small, generating just over $173,000 from 2003 to 2006, with the vast majority occurring in Lake Erie (NMFS, 2009a). However, walleye is a very important recreational fishery in all the Great Lakes with the exception of Lake Superior, where harvests are mostly tribal (Environment Canada and U.S. EPA, 2007).Walleye remain in the darkness of bottom waters during the day, emerging at night to feed on bullheads, freshwater drum, yellow perch, and other small fish. Walleye and yellow perch have a special relationship that allows effective population control of both species. While adult walleye feed on the smaller yellow perch, adult perch feed on the young of walleye (Mecozzi, 1989). This fish averages only one to three pounds in size, but is a popular commercial and recreational fishing target because it is considered one of the best-tasting freshwater species (University of Wisconsin Sea Grant Institute, 2010). Walleye reproduction is largely driven by uncontrollable environmental events (i.e., spring weather patterns and alewife abundance); however, degraded spawning and nursery habitats in some areas due increased human use of nearshore and watershed environments also impede reproduction (Environment Canada and U.S. EPA, 2007).

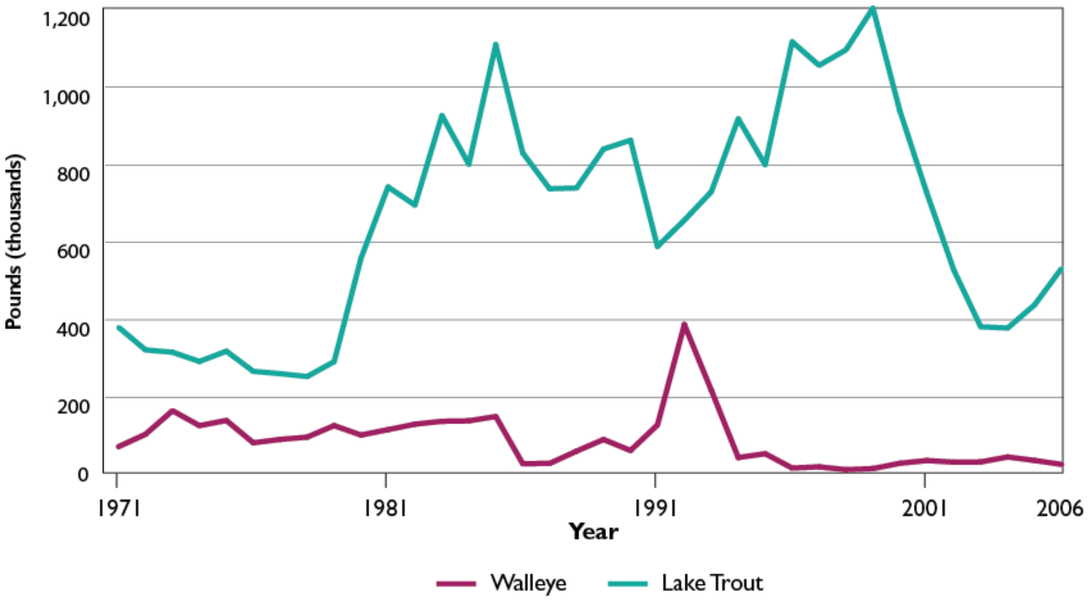


Figure 7-9. U.S. Great Lakes walleye and lake trout commercial landings totals in pounds, 1971–2006 (NMFS, 2009a).

Preyfish Fisheries

Predator-prey relationships are important to the maintenance of healthy fisheries, but these relations have been changing for several decades throughout the Great Lakes. Preyfish are characterized as both pelagic (water-column dwelling) and demersal (bottom-dwelling) species that prey on invertebrates their entire lives. Invasive prey species such as alewives and smelt were first found in the Great Lakes in the 1920s, but were widespread by the 1940s, causing vast changes in ecosystem dynamics. In the 1990s, the invasive round goby was introduced, likely via ballast water, and its populations have been increasing in several of the Great Lakes (Walsh et al., 2006). Alewives, smelt, and gobies outcompete native preyfish species (e.g., lake herring, chubs, sculpins) for food and spawning habitat. In fact, fishery managers introduced non-native salmon species to the lakes in the 1950s in order to curtail the growing populations of invasive preyfish (Environment Canada and U.S. EPA, 2007).

Despite the negative impacts of non-native preyfish species, they have become an important component of the Great Lakes ecosystem and even the commercial fishing industry. From 2003 to 2006, the preyfish commercial fishery in the Great Lakes (i.e., chubs, cisco-herring, and rainbow smelt) generated over $7.3 million in ex-vessel revenues. The alewife supported a fishery of 50 million pounds in the late 1970s, and the bloater chubs fishery is currently the second-largest in the Great Lakes (NMFS, 2009a). Over the past several years landings of non-native preyfish has decreased throughout all the lakes (Figure 7-10), with the exception of Lake Superior (Environment Canada and U.S. EPA, 2007). Preyfish populations are under pressure from predation by salmon and lake trout and other preyfish and from the population collapse of a major food source, the deepwater amphipod *Diporeia*. The collapse of *Diporeia* is hypothesized to be the result of successful colonization of the Great Lakes by invasive dreissenid mussels, which also consume pelagic plankton (Environment Canada and U.S. EPA, 2007). These mussels outcompete native species for food and attach to the shells of native mussels, interfering with their feeding, respiration, and locomotion (Environment Canada and U.S. EPA, 2007). The effects on the alewife population have been particularly significant, resulting in the near elimination of the commercial harvest of this species by the early 1990s. As a result of these declines in preyfish populations, fishery managers have implemented a variety of harvest restrictions.

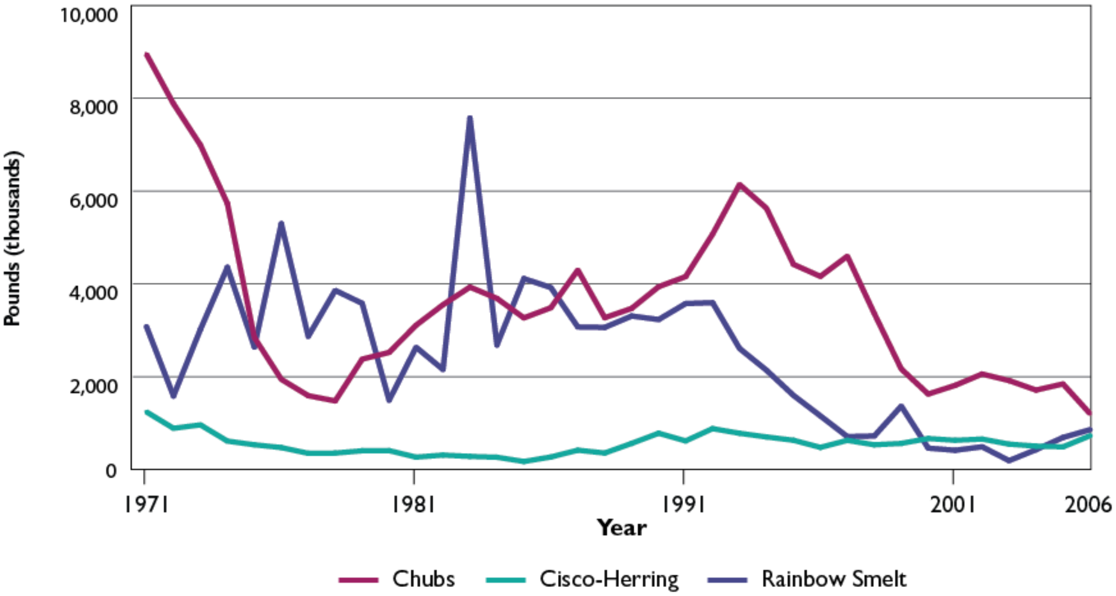


Figure 7-10. U.S. Great Lakes preyfish commercial landings totals in pounds, 1971–2006 (NMFS, 2009a).

Stresses

To varying degrees, fishery resources in the Great Lakes have been impacted by three major disturbances: non-native species introductions, overfishing, and habitat degradation (GLFC, 2008). Non-native species introductions are extensive throughout the Great Lakes via shipping activities (e.g., ballast waters, ship hulls), unintentional releases from aquaculture and aquariums, and stocking efforts by fishery managers. Impacts associated with non-native species introductions are varied; this differentiation is also reflected in the terminology used for non-native species. According to the 1999 Executive Order 13112 (64 FR 6183), invasive species are those that cause harm to ecosystems, economies, or human health; other terms applied to this class of species that do not cause harm include “non-native,” “alien,” or “introduced” (NISC, 2008). Whereas some invasives have had severe negative impacts on the Great Lakes ecosystem, as in the case of zebra and quagga mussels, non-native species have also played beneficial roles. Stocked salmon have curtailed the growth of alewife populations (a non-native prey species that competes with its native counterpart) and reinstituted important predator-prey relationships while creating new recreational fishing opportunities (Environment Canada and U.S. EPA, 2007). Another invasive species, the parasitic sea lamprey, greatly contributed to the decimation of lake trout populations in the Great Lakes. The lamprey has a suction-cup like mouth and sharp teeth that are used to feed on the tissue and blood of the host fish, resulting in death from either direct blood loss or secondary infections.

Decades of overfishing, which also contributed to the sharp decline in lake trout populations, have undermined the health of fish stocks throughout the Great Lakes. Commercial fishing in the Great Lakes began in the 1820s and increased by about 20% annually until peaking in the late 1800s (Environment Canada and U.S. EPA, 1995). Serious efforts at harvest controls were not instituted until the creation of the Great Lakes Fishery Commission (GLFC) in the mid 1950s; however, inadequate stock assessments, poor monitoring, and overall incompliance limited the efficacy of regulatory measures implemented by the GLFC.

Since the arrival of the Europeans, vital fish habitats, such as wetlands and streams, have been degraded by agriculture, damming, urbanization, shoreline development, and invasive species (especially the common carp and purple loosestrife) (Environment Canada and U.S. EPA, 2007). Two-thirds of Great Lakes coastal wetlands have been lost since colonialization; a particularly extensive loss in Hamilton Harbor is just one example. Wetlands have been filled or drained for agriculture and development, polluted by excess nutrient deposition and urban runoff, and degraded by dredging for commercial and recreational water traffic. Common carp damage habitat by uprooting coastal vegetation and reducing water clarity during feeding. Purple loosestrife, a tall aquatic plant from Eurasia, can cause wetlands to dry out and thereby impede the survival of species that thrived there (Environment Canada, 1995).

Fisheries Management

Governance of fisheries in the Great Lakes is complicated by the multiple and often overlapping jurisdictions in this area. For example, fisheries in Lake Superior are subject to the regulatory authority of Michigan, Minnesota, Wisconsin, Ontario province, the Chippewa Ottawa Resources Authority, and the Great Lakes Indian Fish and Wildlife Commission (Read, 2003). In recognition of the potentially negative impact of multiple authorities regulating single fisheries, the GLFC was formed under the jurisdiction of the International Joint Commission to manage and promote the health of Great Lakes fisheries.

The five Great Lakes Committees within the GLFC set annual harvest limits for each lake. Great Lakes fishery managers largely rely on harvest limits, fishing licenses, area and time restrictions, and gear restrictions. Particularly unique to fishery management in the Great Lakes are the numerous fish stocking programs, including trout, salmon, sturgeon, herring, muskellunge, walleye, and yellow perch. Fishery stocking is under the jurisdiction of the States and ministries of the Great Lakes, as well as the Province of Ontario.

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, six of the eight states bordering the Great Lakes had advisories, for a total of 29 fish consumption advisories in effect during 2006 for the waters and connecting waters of the Great Lakes. During 2006, every Great Lake had at least one advisory, and advisories covered 100% of the Great Lakes shoreline that year (Figure 7-11). Michigan, which borders four of the five Great Lakes and encompasses four of the six connecting waterbodies, issued the largest number (13) of fish consumption advisories (U.S. EPA, 2007c).

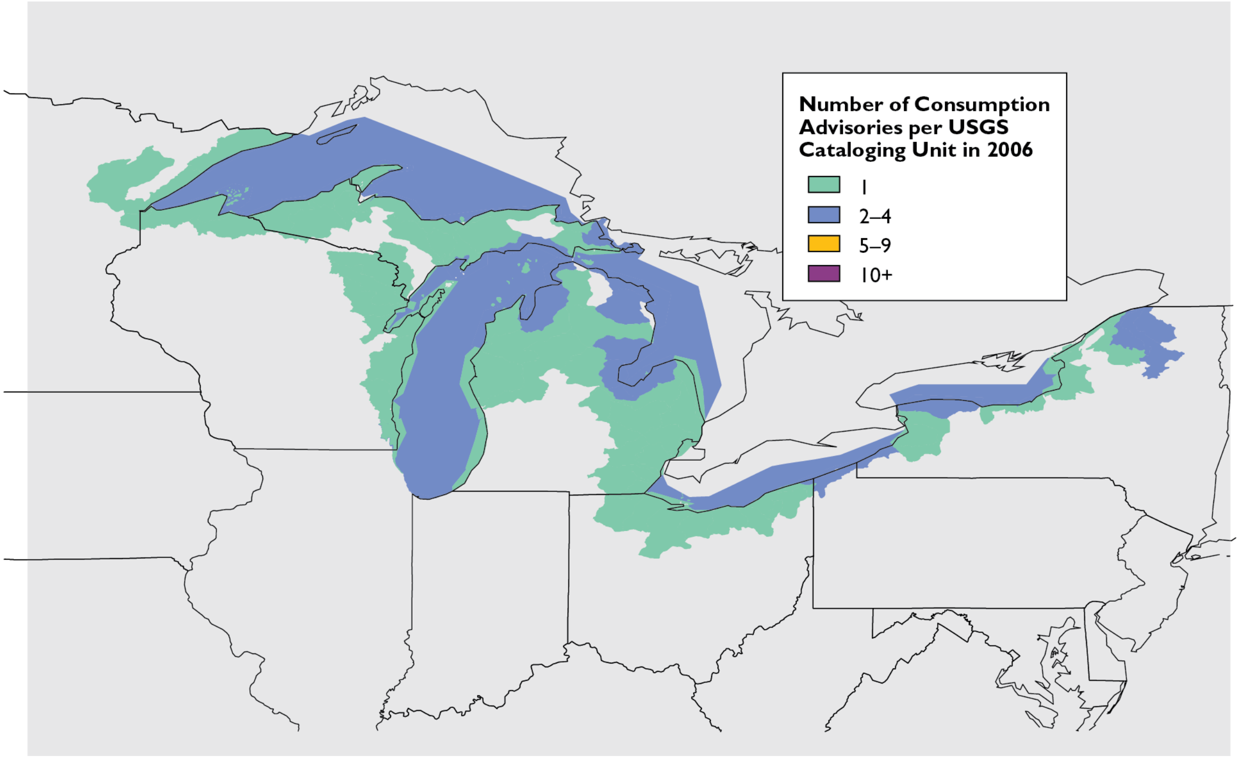


Figure 7-11. The number of fish consumption advisories in effect in 2006 for the U.S. Great Lakes waters (U.S. EPA, 2007c).

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 (52%) also listed dioxins (Figure 7-12). Lake Superior, Lake Michigan, and Lake Huron were under advisory for at least four pollutants each in 2006 (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 web (U.S. EPA, 2007c).

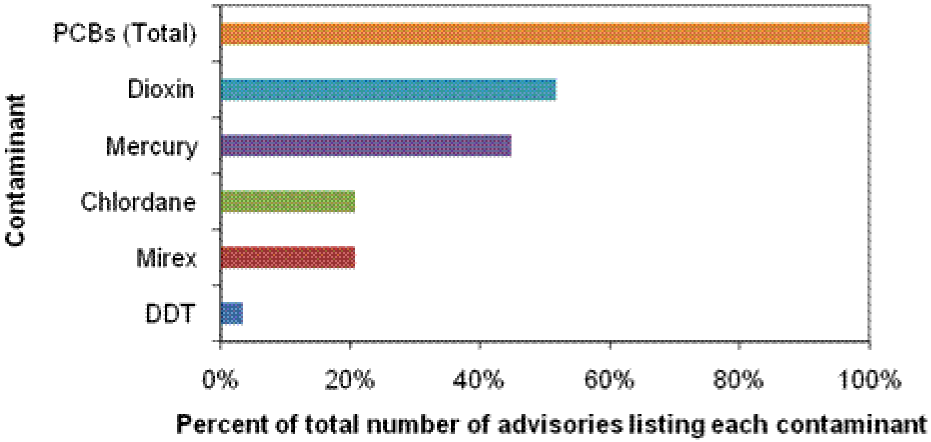


Figure 7-12. Pollutants responsible for fish consumption advisories in Great Lakes waters. An advisory can be issued for more than one contaminant, so percentages may add up to more than 100 (U.S. EPA, 2007c).

Table 7-1. Fish Advisories Issued for Contaminants in Each of the Great Lakes (U.S. EPA, 2007c)

Great Lakes	PCBs	Dioxins	Mercury	Chlordane	DDT	Mirex
Lake Superior	Yes	Yes	Yes	Yes	—	—
Lake Michigan	Yes	Yes	Yes	Yes	Yes	—
Lake Huron	Yes	Yes	Yes	Yes	—	—
Lake Erie	Yes	Yes	Yes	—	—	—
Lake Ontario	Yes	Yes	—	—	—	Yes

Species and/or groups under fish consumption advisory in 2006 for at least one of the Great Lakes or their connecting waters:

American eel
Bluegill sunfish
Bowfin
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 pike
Rainbow trout
Redhorse
Rock bass
Sheepshead Siscowet trout
Smallmouth bass
Smelt
Splake trout
Steelhead trout
Sturgeon
Walleye
White bass
White perch
White sucker
Whitefish
Yellow perch

Source: U.S. EPA, 2007c.

Beach Advisories and Closures

How many notification actions were reported for the Great Lakes between 2004 and 2008?

Table 7-2 presents the number of total and monitored beaches, as well as the number and percentage of monitored beaches affected by notification actions from 2004 to 2008, for the U.S. Great Lakes (summed for New York's Great Lakes beaches, Minnesota, Indiana, Illinois, Pennsylvania, Ohio, Wisconsin, and Michigan). Data from New York are not included for 2004 and 2005, nullifying comparison with the 2006 to 2008 information. Nevertheless, the percentage of beaches with notifications remained nearly constant between 2004 and 2005. The number of total and monitored beaches decreased for the whole region between 2006 and 2008, but the percentage of beaches affected by notification actions remained constant (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring site: http://www.epa.gov/waterscience/beaches/seasons/.

Table 7-2. Beach Notification Actions, Great Lakes, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004[a]	2005[b]	2006	2007	2008
Total number of beaches	766	852	1,441	1,446	1,379
Number of monitored beaches	514	525	566	551	542
Number of beaches affected by notification actions	207	203	276	276	269
Percentage of monitored beaches affected by notification actions	40%	39%	49%	50%	50%

[a] Data from Pennsylvania and New York are not included for this year. New York data are available for the entire state; however, the data do not differentiate between Great Lakes and coastal beaches for 2004 and 2005.

[b] Data from New York are not included for this year because coastal and Great Lakes beaches were not differentiated.

What pollution sources impacted monitored beaches?

Table 7-3 presents the numbers and percentages of monitored Great Lakes beaches affected by various pollution sources for 2007. Unidentified and unknown pollution sources together affected over 90% of Great Lakes beaches. Other significant contributors to notification actions included storm-related runoff (19%), wildlife (14%), and non-storm related runoff (8%) (U.S. EPA, 2009d).

Table 7-3. Reasons for Beach Advisories, Great Lakes, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Other and/or unidentified sources	306	57
No known pollution sources	186	35
Storm-related runoff	102	19
Wildlife	73	14
Non-storm related runoff	44	8
Septic system leakage	27	5
Sanitary/combined sewer overflow	23	4
Sewer line leak or break	10	2
Agricultural runoff	9	2
Concentrated animal feeding operations	9	2
Boat discharge	6	1
Publicly owned treatment works	6	1
Pollution sources not investigated	1	< 1

Note: A single beach advisory may have multiple pollution sources.

How long were the 2007 beach notification actions?

Most (80%) of beach advisories for the Great Lakes in 2007 lasted either 1 day (65%) or 2 days (15%). Notifications lasting 3 to 7 days comprised 17% of all advisories, and the other 3% of notifications were of the 8- to 30-day duration (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

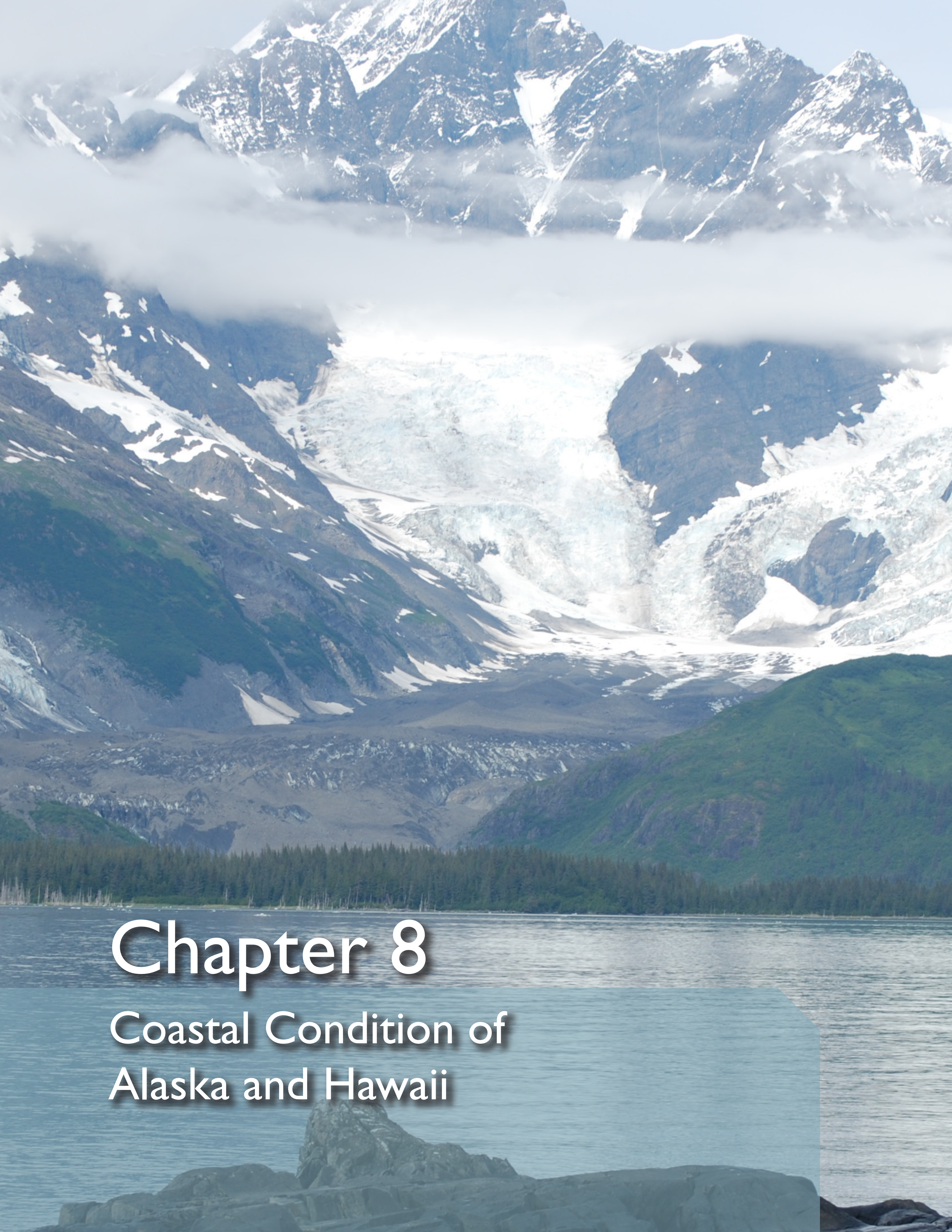
Summary

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, the assessments conducted by SOLEC apply in most cases to the whole of the Great Lakes, rather than only nearshore or coastal conditions. Although a nearshore framework and suite of indicators have been evolving, this is a relatively recent development. Additionally, 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, the 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 assessments of coastal condition will use the NCCR series 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. NCA strategies and monitoring of nearshore areas of the Great Lakes is currently being implemented by U.S. EPA Region 5, which will allow for the next NCCA reporting on the Great Lakes to be comparable to the findings and trends assessed for the marine coastal areas.

The vastness of the Great Lakes watershed and the consequent diversity of its ecosystems allowed this area to be home to numerous unique fish species. However, non-native species invasions, habitat degradation, and overfishing have led to the collapse and diminution of many commercially valuable fishery species. Lake trout have recovered after nearing extinction in the 1950s, although commercial fishing for this species is now sustainable only in Lake Superior. Walleye stocks have also shown signs of recovery after a population collapse in the mid-1990s. Despite improvements in fisheries management, commercial landings have continued to decline.

Contamination in the Great Lakes has affected human uses of these waters. The data indicate that fish tissue contamination is decreasing over time, although mercury contamination is still a problem in many areas. In 2006, every Great Lake had at least one fish consumption advisory, and advisories covered 100% of the Great Lakes shoreline that year. All of these advisories were issued for PCB contamination (alone or in conjunction with other contaminants). In addition, 49% of the region’s monitored beaches were closed or under advisory for some period of time during 2006. Elevated bacteria levels in the region’s coastal waters were primarily responsible for the beach closures and advisories.



Chapter 8

Coastal Condition of Alaska and Hawaii

8. Coastal Condition of Alaska and Hawaii

Southeastern Alaska

As shown in Figure 8-1, the overall condition of Southeastern Alaska's coastal waters is rated good, with an overall condition score of 5.0. The water quality, sediment quality, coastal habitat, and fish tissue contaminants indices are rated good, and the benthic index for this region could not be evaluated. Figure 8-2 provides a summary of the percentage of Southeastern Alaska coastal area in good, fair, poor, or missing categories for each index and component indicator. This assessment is based on environmental stressor and response data collected from 42 locations (three samples for water quality and sediments were lost, resulting in only 39 sample sets used to assess water quality and sediment condition) along Southeastern Alaska's coastline in 2004. The NCCR III presented an assessment of coastal waters in Southcentral Alaska; therefore, the results of the two surveys cannot be compared for changes in condition.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and limitations of the available data.

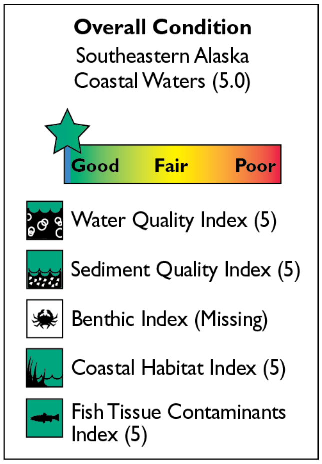


Figure 8-1. The overall status of Southeastern Alaska's coastal waters is rated good (U.S. EPA/NCA).

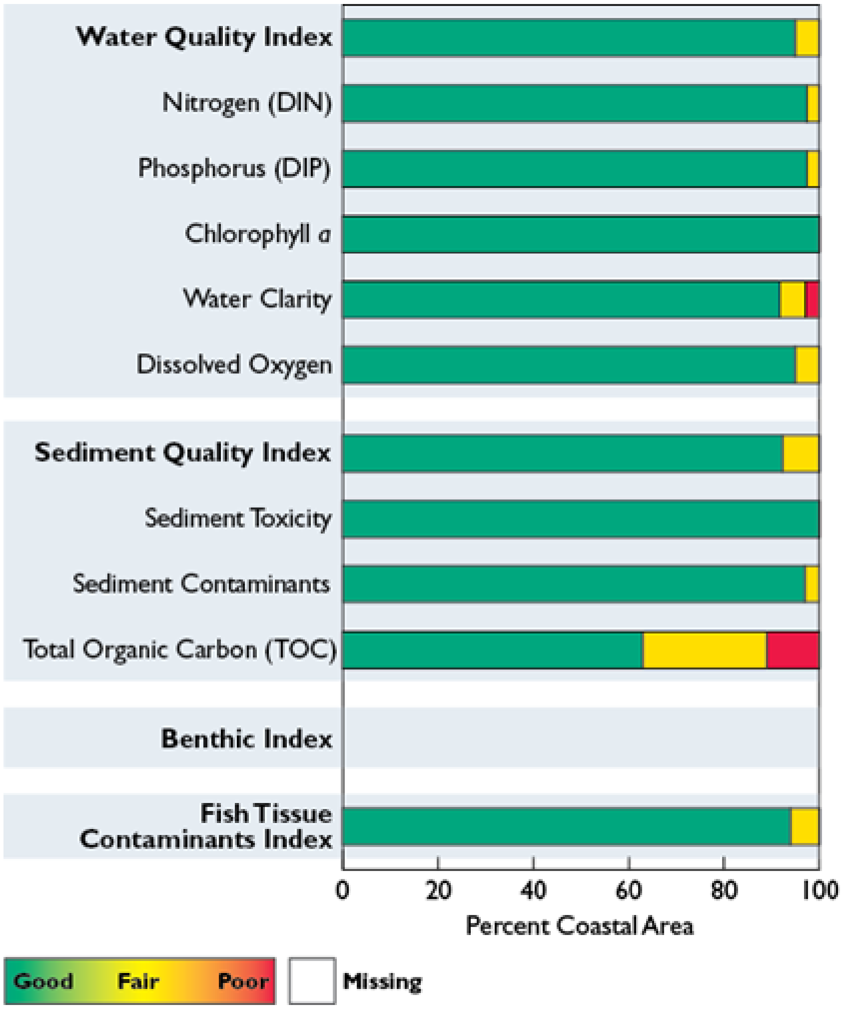


Figure 8-2. Percentage of coastal area achieving each ranking for all indices and component indicators – Southeastern Alaska region (U.S. EPA/NCA).

The sheer scale and geographic complexity of Alaska's shoreline dictate that comprehensive assessments of its coastal resources are inherently difficult. Alaska's marine shoreline of approximately 34,000 miles constitutes more than 50% of total U.S. coastline miles, and the state's coastal bays and estuaries have a total surface area of 33,211 square miles. Much of the southeastern coast of Alaska is very convoluted, containing hundreds of bays, estuaries, coves, fjords, and other coastal features; it is estimated to contain approximately 63% of the total Alaskan coastline (Sharma, 1979). The Gulf of Alaska LME is located offshore of this region. Southeastern Alaska, also known as the Alaskan panhandle, encompasses several national parks and monuments, as well as the largest national forest in the United States, the Tongass National Forest. The region is ecologically unique: a lush temperate rain forest with a coastline that is buffered from the open ocean by an extensive chain of islands. It is home to a vast array of terrestrial and marine wildlife, including black and brown bears, mink, waterfowl, several salmon species, and various marine mammal species.

Alaska's coastal resources are not subject to population and development pressures to the same extent as the rest of the U.S. coastline because of the state's low population density, the distance between most of its coastline and major urban or industrial areas, the lack of road access to most coastal areas, and its limited agriculture activities. Consequently, some contaminant concentrations have been measured as having levels significantly lower than those in the rest of the coastal United States, although localized sources of trace metal and organic contaminants such as PCBs and mercury exist in Alaska (AMAP, 2010; Landers et al., 2010). Indeed, the principal input of organic contaminants is from global sources; however, concentrations of trace metals and organic contaminants in marine fish from Alaska are low and not a public health concern according to studies conducted by Alaskan authorities (Alaska H&SS, 2010). Nevertheless, Southeastern Alaska includes several population centers, the state's capital city of Juneau, and the port city of Ketchikan, which is a popular destination for cruise ships. Large-scale timber and fishery industries also inflict pressures on the coastal resources of this area.

Between 1980 and 2006, the population of coastal counties along the Alaskan Coast increased 72% from 331,000 to 569,000 people (Figure 8-3), and the area experienced the second-largest rate of population increase of any coastal region in the entire United States. However, Alaska has a relatively small population and a large coastal area, so the population density is low, and Alaska is home to less than 1% of the total U.S. coastal population. Population density has increased from approximately 0.9 persons per square mile in 1980 to 1.5 persons per square mile in 2006 (Figure 8-4) (NOEP, 2010).

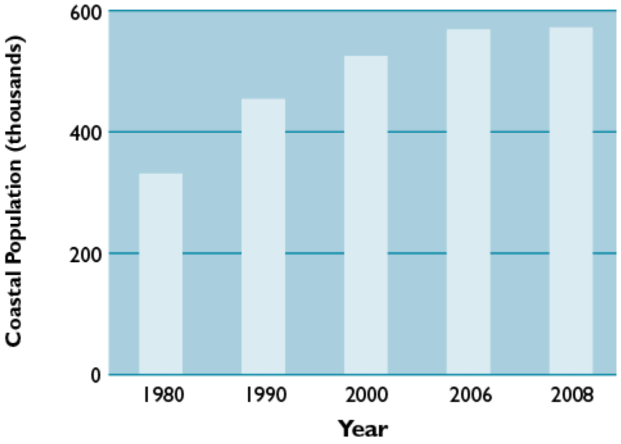


Figure 8-3. Population of coastal counties in Alaska, 1980–2008 (NOEP, 2010).

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

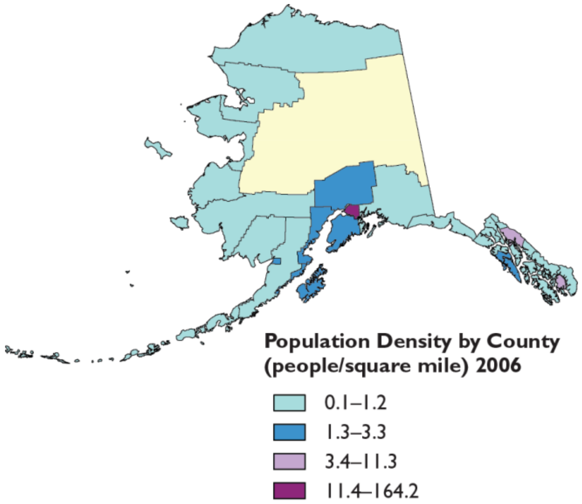


Figure 8-4. Population density in Alaska's coastal counties in 2006 (NOEP, 2010).

The scenario for Alaska's coastal aquatic resources is not one of existing degradation from agricultural, industrialization, and urbanization pollution drivers, but one of possible large-scale changes due to climate change and future resource development (AMAP, 2009, 2010; State of Alaska, 2010). Ocean acidification refers to the decrease in ocean pH due to the uptake of excess carbon dioxide, which results primarily from burning of fossil fuels and other human activities, such as cement production and deforestation. Human carbon dioxide emissions contributed 34 tons to the atmosphere in 2009 (Global Carbon Project, 2010; Friedlingstein et al., 2010). Monitoring for ocean acidification has not been a component of the NCA in Alaska's coastal oceans, where the effects of ocean acidification may be occurring more rapidly than in other regions (Bates et al., 2009; Fabry et al., 2009; Feely et al., 2010).

The sampling conducted in the EPA NCA survey has been designed to estimate the percent of coastal area (nationally or in a region) 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 would be required to define temporal variability and to confirm environmental condition at specific locations.

Large-scale resource development of Alaska's oil, gas, and mineral reserves is likely to occur in the future as world resources grow more scarce. A recent USGS report (Bird et al., 2008) placed Arctic Alaska as the second-ranked province likely to contain major deposits of undiscovered oil, gas, and natural gas liquids. Alaska's coastal regions also contain potentially significant mineral resources, such as chromium, coal, copper, "oil-shale," silver, and zinc (Alaska DNR, 2010).

It is crucial that future Alaska NCCA designs take into account the overall focus for Alaska waters. This focus includes developing a current status for much of Alaska's "pristine" aquatic resources for future reference. The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling found the scientific understanding of environmental conditions in the Arctic to be inadequate (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011). Understanding the primary drivers for the region's potential aquatic resource degradation, which differ from the contiguous populated United States, is also important in order to apply the correct indicators to assess condition and trends resulting from climate change and future large-scale resource development. An important consideration is that a rapidly evolving climate may be presenting us with an ecosystem already in a state of flux (Wang et al., 2010).

Coastal Monitoring Data—Status of Coastal Condition

The geographic expanse of Alaska, the reduced sampling window in the Arctic regions, and the unique fiscal and logistical challenges of sampling the state's coastal resources (which are mostly inaccessible by road) necessitated a comprehensive federal−state sampling design. In 2001, under the NCA program, the Alaska DEC and EPA Region 10 developed a design to assess all of the state's coastal resources by monitoring 250 sites throughout the state during five phases—Southcentral Alaska, Southeastern Alaska, the Aleutian Islands, the Bering Sea, and the Beaufort Sea. In 2005, the Alaska DEC established the Alaska Monitoring and Assessment Program to conduct these marine surveys. As of 2010, the Southcentral Alaska, Southeastern Alaska, and the Aleutian Islands phases have been surveyed, and the plan has been modified to split the Arctic coastal phase into lower and upper Chukchi Sea and Beaufort Sea (Figure 8-5). The ability to complete the remaining phases and begin a repeat sampling for long-term trend analysis remains uncertain due to funding constraints. Before this collaboration between Alaska's resource agencies and the EPA, the Alaska DEC routinely assessed only about 1% of the state's coastal resources, focusing its efforts on water bodies known or suspected to be impaired (Alaska DEC, 1999). In June 2005, the Alaska DEC 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 (Alaska DEC, 2005a, 2005b).

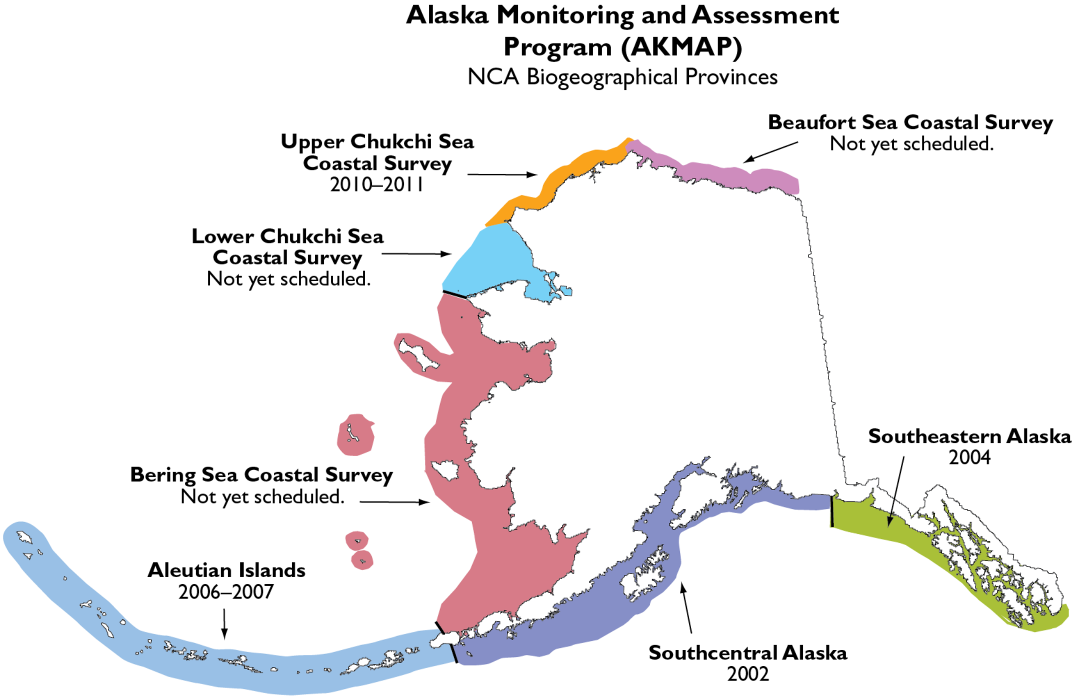


Figure 8-5. Alaska Monitoring and Assessment Program survey status (Alaska DEC, Division of Water).

In 2004, Alaska's southeastern coast (Alaskan Province) was the second portion of the state to be assessed by the NCA because of the importance of this area's major estuarine resources, high cruise-ship use, and importance to local and state economies. Because of the long distances between sites and the area that needed to be assessed, the surveys were conducted using a large (100-foot), oceangoing research vessel equipped with a powered skiff for shallow-water work. Depths ranged from approximately 60 to 1,500 feet for the 39 sites used to calculate this report's water quality and sediment indices.

Water Quality Index

The water quality index for the coastal waters of Southeastern Alaska is rated good. This index was developed based on measurement of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Most (95%) of the coastal area was rated good, with the remainder of the area rated fair (Figure 8-6). Fair conditions were largely due to low water clarity measurements or low dissolved oxygen concentrations, which are most likely the result of naturally occurring conditions, and not human influences. Low water clarity measurements are associated with glacial silt input by nearby glaciers or river systems draining glaciated watersheds, and low dissolved oxygen levels are associated with deeper waters of fjords in this region.

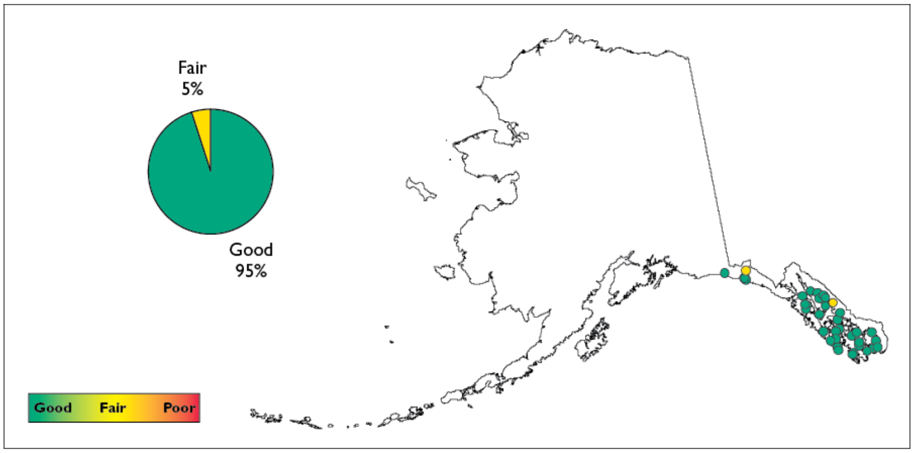


Figure 8-6. Water quality index data for Southeastern Alaska coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

Southeastern Alaska’s coastal waters are rated good for DIN and DIP concentrations, with 97% of the coastal area rated good and 3% rated fair for both indicators. These rating were based on the NCA DIN and DIP cutpoints for the western United States (see Chapter 1). Although these cutpoints have been adjusted to reflect the effects of West Coast regional upwelling events, further work is needed to determine if these or alternate cutpoint values are the best to apply to Southeastern Alaska’s coastal waters. The 3% of the area rated fair should be considered a provisional assessment. Given the low human population density in Southeastern Alaska, the fair values may reflect an upper range of natural conditions, rather than human influences.

Chlorophyll *a*

Chlorophyll *a* concentrations in Southeastern Alaska’s coastal waters are rated good, with 100% of the coastal area rated good for this component indicator.

Water Clarity

Water clarity in the coastal waters of the Southeastern Alaska region is rated good, with 5% and 3% of the coastal area, respectively, rated fair and poor for this component indicator. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 10% of surface illumination.

Dissolved Oxygen

Dissolved oxygen conditions in the coastal waters of Southeastern Alaska are rated good, with 95% of the coastal area rated good and 5% rated fair for this component indicator. Although conditions in the

Southeastern Alaska region appear to be generally good for dissolved oxygen, the measured values reflect surface conditions and do not include natural hypoxic conditions in the deep fjords sampled.

Sediment Quality Index

The sediment quality index for the coastal waters of Southeastern Alaska is rated good, with 8% of the coastal area rated fair (Figure 8-7). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

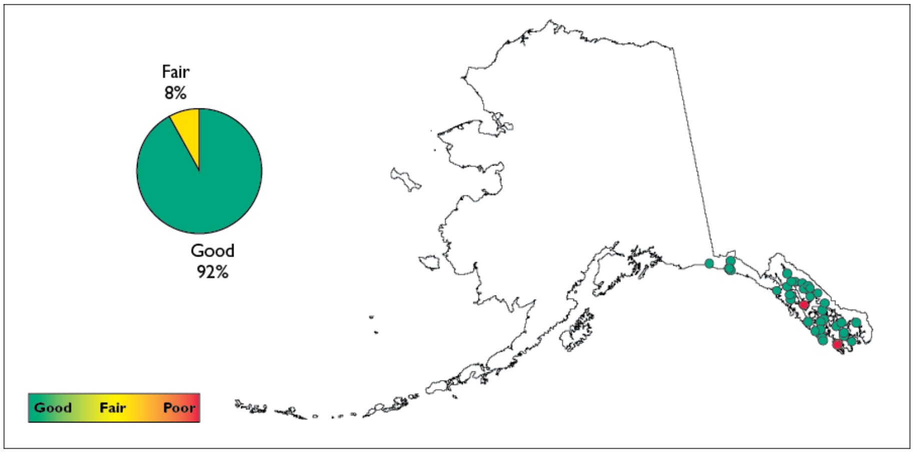


Figure 8-7. Sediment quality index data for Southeastern Alaska coastal waters (U.S. EPA/NCA).

Sediment Toxicity

Sediment toxicity for Southeastern Alaska's coastal waters is rated good, with none 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 Southeastern Alaska. The State of Alaska has yet to select specific benthic species for use in sediment toxicity studies, but it considers the NCA work important in supporting future efforts to develop a sediment toxicity test for Alaska.

Guidelines for Assessing Sediment Contamination (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 Contaminants

The coastal waters of Southeastern Alaska are rated good for the sediment contaminants component indicator, with approximately 2% of the coastal area rated poor and approximately 3% of the area rated fair. 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 Southeastern Alaska'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.

Sediment TOC

The coastal waters of Southeastern Alaska are rated good for the sediment TOC component indicator, with 11% of the area rated poor, 26% rated fair, and 63% rated good.

Benthic Index

The benthic index for the coastal waters of Southeastern Alaska could not be evaluated. Although several efforts are underway and indices of benthic community condition have been developed for some regions of the West Coast (e.g., Smith et al., 1998), there is currently no benthic community index applicable for Southeastern Alaska. In lieu of a benthic index for Southeastern 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 be predicted from salinity, and, in the case of the Southeastern Alaska survey data, the regression was not significant.

Coastal Habitat Index

The coastal habitat index for Alaska is rated good. Although estimates of habitat loss are available for Alaska as a whole, data were not available to correspond with the geographic region sampled by the NCA survey (i.e., Southeastern Alaska); therefore, overall trends for the whole state are presented. The Alaska coast region experienced a loss of 900 acres (0.04%) of coastal wetlands from 1990 to 2000 (Dahl, 2010), and the statewide, long-term, average decadal wetlands loss rate is 0.01%. Arctic coastal wetlands may be especially vulnerable to climate change. Average annual erosion rates in some coastal areas of northern Alaska have increased from 20 feet per year in the 1950s to 45 feet per year in the mid-2000s (Jones et al., 2009).

Fish Tissue Contaminants Index

The fish tissue contaminants index for the coastal waters of Southeastern Alaska is rated good, with 6% of the stations where fish were caught rated fair and none of the stations rated poor (Figure 8-8).

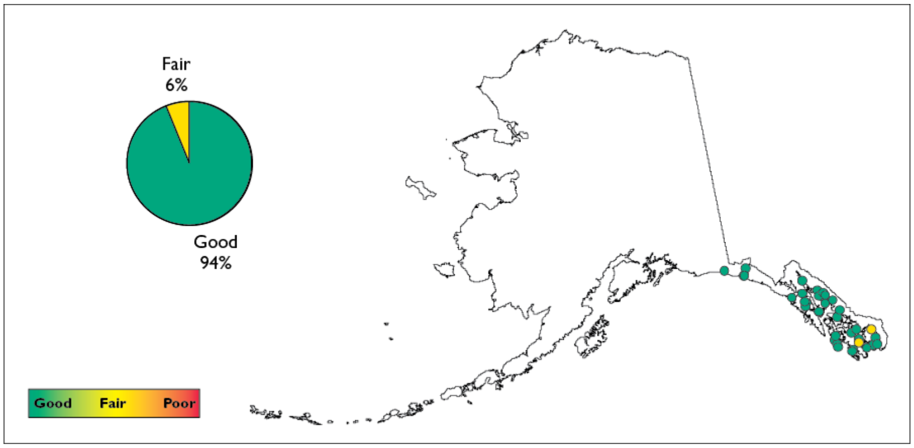


Figure 8-8. Fish tissue contaminants index data for Southeastern Alaska coastal waters (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries—Gulf of Alaska and East Bering Sea LMEs

Alaska is surrounded by five sub-arctic LMEs: Gulf of Alaska, East Bering Sea, West Bering Sea, Chukchi Sea, and Beaufort Sea (Figure 8-9). The total commercial fishery landings in all five of Alaska's LMEs generated over $4.8 billion in total ex-vessel revenues (preprocessing value) from 2003 to 2006 (NMFS, 2010). This summary focuses on two of these LMEs, the East Bering Sea LME and the Gulf of Alaska LME, in order to provide an update of the information presented in the NCCR III. The East Bering Sea LME is considered to have moderately high productivity based on estimates of primary production (photoplankton). The ability of many East Bering Sea LME juvenile fish and crabs to reach harvest size is linked to decadal-scale patterns of climate variability (Minobe and Mantua, 1999). Like the East Bering Sea, the Gulf of Alaska LME is sensitive to climate variations on time scales ranging from years to decades. These variations and large-scale atmospheric and oceanographic conditions have an effect on the overall productivity of the LME, including plankton production and plankton species composition. The Gulf of Alaska LME is considered a moderately productive ecosystem with nutrient-rich waters that support rich biological diversity.

Figure 8-9. Alaska is surrounded by five LMEs (NOAA, 2010b).

The groundfish (bottom-dwelling fish) complex (mostly pollock, halibut, cod, and sablefish) is the most important fishery in terms of both landings and revenue for Alaskan commercial fishermen, generating nearly $2.9 billion in total ex-vessel revenues from 2003 through 2006. Walleye pollock dominates this group, with harvests worth over $1.1 billion during the same period. The other top fisheries are for salmon, with total commercial ex-vessel revenues of nearly $1 billion from 2003 through 2006, and for crab, with revenues over $500 million for this same period (NMFS, 2010). See Figure 8-10 for landing and revenues of the top commercial fisheries for Alaska. Fisheries within Alaskan LMEs are managed through a combination of international commissions, federal councils, and state and tribal agencies.

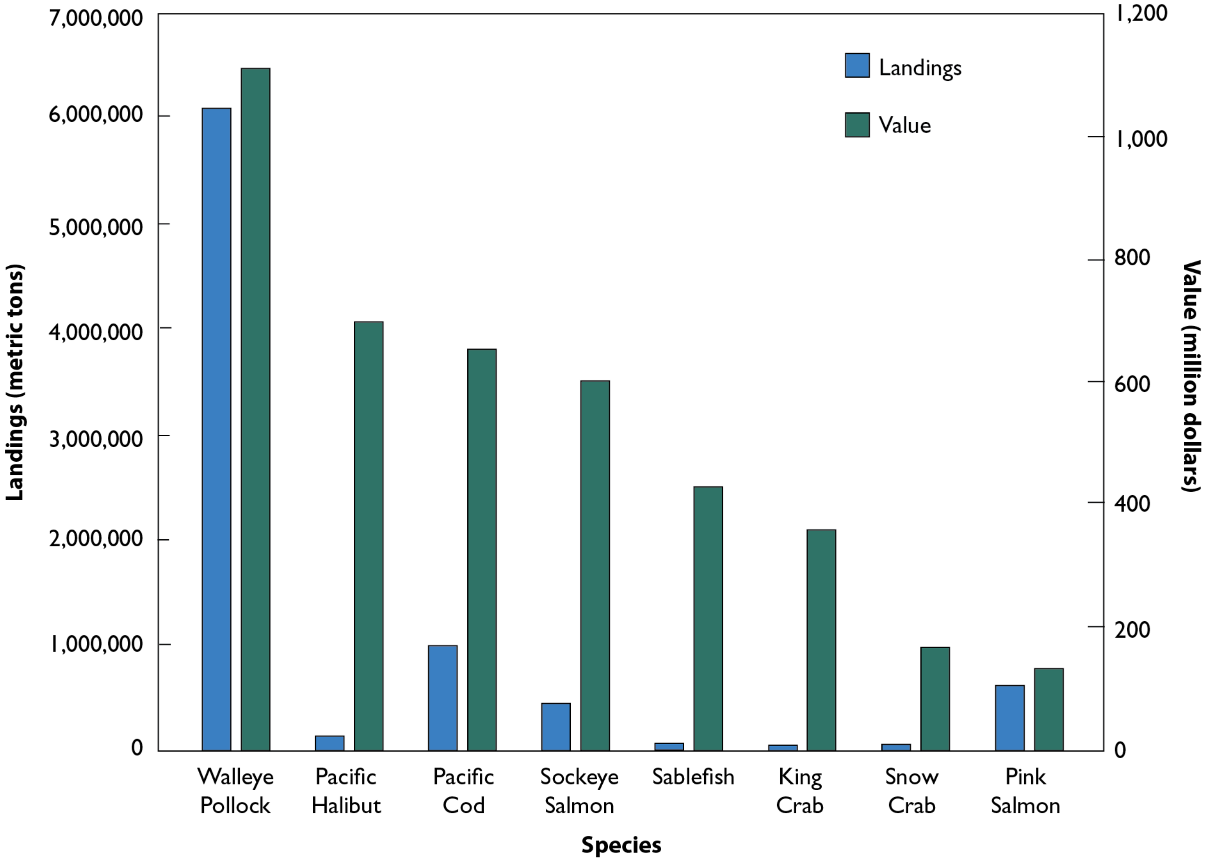


Figure 8-10. Top commercial fisheries for Alaska's LMEs: landings (metric tons) and value (million dollars) from 2003 to 2006 (NMFS, 2010).

Alaska Groundfish Fisheries

The groundfish complex is the most abundant fisheries resource off Alaskan LMEs, with a combined biomass of more than 21.8 million metric tons. About 76% of the biomass is found in the East Bering Sea LME, with the remainder in the Gulf of Alaska LME. From 2004 to 2006, groundfish catches averaged nearly 2.2 million metric tons, or about 10% of the total groundfish biomass. The dominant species harvested were walleye pollock (75%), Pacific cod (11%), yellowfin sole (4%), Atka mackerel (3%), and rock sole (2%) (NMFS, 2009b). In terms of commercial fishing revenue, the top groundfish species are walleye Pollock (*Theragra chalcogramma*), Pacific halibut (*Hippoglossus stenolepis*), Pacific cod (*Gadus macrocephalus*), and sablefish (*Anoplopoma fimbria*); the discrepancy resulting from higher market prices for these species. Walleye pollock catches are the largest of any single species within the U.S. EEZ, with average landings of over 1.5 million metric tons and total revenues of $1.1 billion from 2003 through 2006 (see Figure 8-10). During this same period, revenues from other top groundfish fisheries, including Pacific halibut, Pacific cod, and sablefish, were $697 million, $652 million, and $424 million, respectively (see Figure 8-10) (NMFS, 2010).

As a species group, groundfish inhabit near-bottom waters, with diets that include all sorts of species of invertebrates and vertebrates, depending on their role within the water column. These fish are generally harvested for direct human consumption, with various gear types. The North Pacific Fisheries Management Council manages Alaska groundfish fisheries within the U.S. EEZ, beyond state waters (0–3 miles), which are managed by the Alaska Department of Fish and Game. Pacific halibut is managed by a bilateral treaty between the United States and Canada, and through the recommendations of the International Pacific Halibut Commission.

East Bering Sea LME Groundfish

The groundfish FMP (NPFMC, 2010a) for the East Bering Sea LME caps catch quotas for this group at 2 million metric tons. Current landings for walleye pollock are 1.4 million metric tons in the East Bering Sea and 44,500 metric tons in the Aleutian Islands. Recent trends indicate that the stock has declined since 2003 due to poor survival rates of juveniles from 2001 through 2005 (NMFS, 2009b). However, surveys conducted in 2010 show positive changes. The 2010 bottom trawl survey biomass estimate for pollock was 3.75 million metric tons, up 64% from the 2009 estimate, but still below average for the 1987–2010 time series. The estimate from the acoustic-trawl survey was 2.32 million metric tons, up 151% from the 2009 estimate, but still below average for the 1979–2010 time series (NPFMC, 2010b). Management of this fishery has produced differing results throughout Alaskan waters, with some areas, including the Bogoslof Island region and the Aleutian Islands, experiencing long-term fishery closures. On the other hand, the East Bering Sea stock is considered fully utilized and is well managed for bycatch and other issues, such as minimizing impacts on Steller sea lion populations and benthic habitats (NMFS, 2009b).

Another management issue in this LME is the pollock fishery occurring in the “Donut Hole” area of the Bering Sea. This fishery has come under regulation with the implementation of the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea in 1997. Under this Convention, signed by the Russian Federation, Japan, Poland, China, the Republic of Korea, and the United States, a central Bering Sea pollock fishery has not been authorized because of low biomass of the Aleutian Basin pollock stock.

Pollock, Atka mackerel, and Pacific cod are carefully managed and regulated due to concerns about the impact of fisheries on endangered and threatened Steller sea lions, which feed on pollock. The impact of fish removals on Steller sea lions has been implicated as an important factor in the decline of sea lion populations. NMFS has proposed some alternatives to disperse the intensity of pollock, Atka mackerel, and Pacific cod fisheries in the critical habitat of sea lions and has enacted additional prohibitions, including 10–20 nautical mile no-trawl zones around sea lion rookeries and haul-out areas.

Gulf of Alaska LME Groundfish

Groundfish abundance in the Gulf of Alaska LME in 2007 was 5.3 million metric tons, primarily due to increasing arrowtooth flounder biomass. From 2004 to 2006, the recent average yield was just over 188,000 metric tons, with catches dominated by walleye pollock, flatfish, Pacific cod, and rockfish. The Pacific cod stock is considered healthy but declining and is fully utilized. Flatfishes in the LME are in general very abundant and underutilized due to halibut by-catch considerations, while rockfish stocks in general appear to be in good condition due to precautionary management practices. Current landings for walleye pollock from the Gulf of Alaska are approximately 68,000 metric tons. Pollock abundance in the Gulf of Alaska LME is at a low level and may be negatively impacted by increases in predatory fish species in this LME.

Alaska Salmon

Pacific salmon have played an important role in the Gulf of Alaska and East Bering Sea LMEs. For Alaska native peoples, salmon is an economic, cultural, and subsistence necessity (Betts and Wolf, 1992). Subsistence use accounts for around one million fish per year (Alaska DFG, 2005; NPAFC, 2005).

Commercial salmon harvests have increased over the past three decades, reaching an all time high in 2005 at 22 million metric tons of salmon (NMFS, 2009b). Sockeye (*Oncorhynchus nerka*) is the most lucrative salmon species for Alaska's LMEs, yielding over $604 million in total commercial fishery revenues from 2003 to 2006 (see Figure 8-10). Sockeye salmon provide a greater dollar value than all other commercially caught salmon in Alaskan LMEs combined, usually yielding between 60% and 70% of the ex-vessel value of the annual harvest. Bristol Bay sockeye salmon in the East Bering Sea LME is the most valuable wild-capture fishery for salmon in the world. The second-largest commercial salmon fishery is for pink salmon (*Oncorhynchus gorbuscha)*, which generated about $130 million in total ex-vessel revenues from 2003 to 2006 and has the greatest landings in tons of all the salmon species (see Figure 8-10), accounting for 40% to 70% of the total harvest each year, mostly harvested by purse seines.

All five species of Alaskan salmon (pink, sockeye, chum, coho, and Chinook) are fully utilized, and stocks in the Gulf of Alaska and East Bering Sea LMEs have rebuilt to near or beyond previous high levels. The factors contributing to the current high abundance of Alaska salmon in the two LMEs are the following:

- Pristine habitats with minimal impacts from extensive development;
- Generally favorable oceanic conditions that allow high survival of juveniles;
- Improved fisheries management by state and federal agencies;
- Elimination of high-seas drift-net fisheries by foreign nations;
- A well-managed hatchery program.

Although commercial harvests of salmon have been at high levels in recent years, the value of the catch has declined significantly. Along with this general decline is a rising trend in total worldwide salmon production due to a rapid growth of the worldwide production of farmed salmon, in addition to the record catches of wild salmon (including fish produced from hatcheries and ocean ranching programs) in Alaskan, Japanese, and Russian waters. Total world production from capture and farmed fisheries in 2002 was about 1.8 million metric tons, including 983,000 metric tons of farmed salmon. Over 70% of the farmed production of salmon comes from Norway, Chile, and the United Kingdom (Knapp, 2003).

Since salmon are highly mobile species that traverse international boundaries, management of these fisheries is best conducted on a multilateral basis. For example, management of some Gulf of Alaska LME salmon fisheries has been negotiated with Canada under the 1985 Pacific Salmon Treaty, though some issues regarding transboundary catches remain. On a broader international scale, the need to manage the salmon harvest in the high seas led to the establishment of the North Pacific Anadromous Fish Commission in 1993. Because salmon are anadromous (migratory) and spend a portion of their lives in freshwater streams, rivers, and lakes, the health of salmon populations in Alaskan LMEs is directly influenced by land management practices. The quality of freshwater habitats determines the success of both reproduction and initial rearing of juveniles.

Alaska Shellfish Fisheries

Shellfish landings in 2006 generated an estimated ex-vessel value of over $153 million, with king and snow crab accounting for a majority of this value, about $127 million (NMFS, 2010). Three king crab species (red, blue, and golden or brown), snow crab (*C. opilio*), and southern Tanner crab have traditionally been harvested commercially in Alaskan LMEs. Alaska crab resources are considered to be fully utilized. The recent average yields for king (10,537 metric tons) and snow (14,711 metric tons) crabs were below their respective sustainable yields (NMFS, 2009b). The harvest of snow crab has been lower than the sustainable yield since 2000 due to low abundance and lower harvest rates established under a rebuilding plan. Almost all recent crab production came from the East Bering Sea LME, because almost all Gulf of Alaska king crab fisheries have been closed since 1983.

Because shellfish are generally landed within the three-mile boundary of state waters, the Alaska Department of Fish and Game is the primary management authority for a majority of Alaska shellfish resources. Seasonal closures are set to avoid fishing during times when crabs are molting or mating, and during soft-shell periods. These regulations are in place both to protect the crab resource and to maintain product quality.

Fishery Trends and Summary

Figure 8-11 shows landings of the walleye pollock commercial fishery in Alaska from 1950 to 2006 in metric tons. The walleye pollock fishery is displayed on a separate graph because catches of this species are too large to display on the same scale as the rest of Alaska's fisheries. Until 1975, harvests in the walleye pollock fishery were not reported on the individual species level. This fishery witnessed tremendous growth in catches from the mid 1980s to 1990. Despite net declines in the 1990s, landings in the walleye pollock fishery rebounded in 2000, with recent harvests above 1.5 million metric tons (NMFS, 2010).

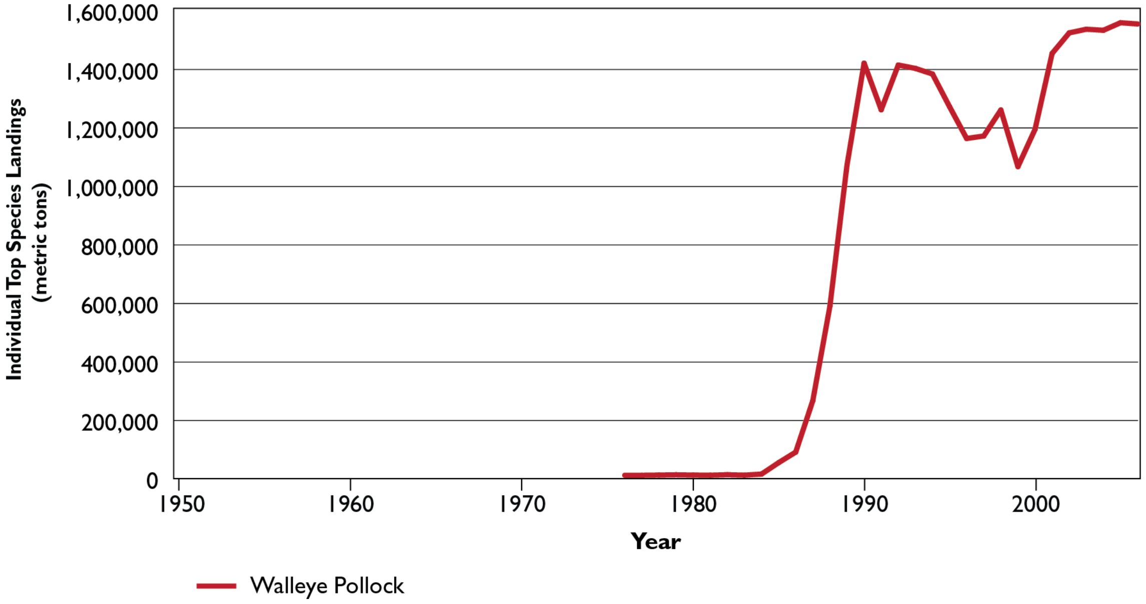


Figure 8-11. Landings of walleye pollock commercial fishery in Alaska from 1950 to 2006, metric tons (NMFS, 2010).

Figure 8-12 displays landings of the other top commercial fisheries in Alaska from 1950 to 2006. In terms of landed tons, the Pacific cod fishery ranks second amongst the top commercial species in Alaska. Harvests in this fishery peaked in the mid 1990s at just over 300,000 metric tons, declined for several years, and despite increasing again from 2000 to 2003, have been in general decrease for the past several years, with 2006 landings at about 240,000 metric tons. Both of the top commercial salmon species (sockeye and pink) currently have landings of about 100,000 metric tons. This represents a significant decline for pink salmon, which peaked at 225,000 metric tons in 2004. Landings of Pacific halibut remain around 35,000 metric tons, where they have hovered for the past two decades. Both crab fisheries (snow and king) have had stabilized landings around 25,000 metric tons since 2000. Although no species-specific data were available for the snow crab fishery until 1980, this fishery has witnessed a severe decline since peaking in the early 1990s at about 150,000 metric tons. Landings in the sablefish fishery have remained under 50,000 metric tons since species-specific data became available in the mid-1980s.

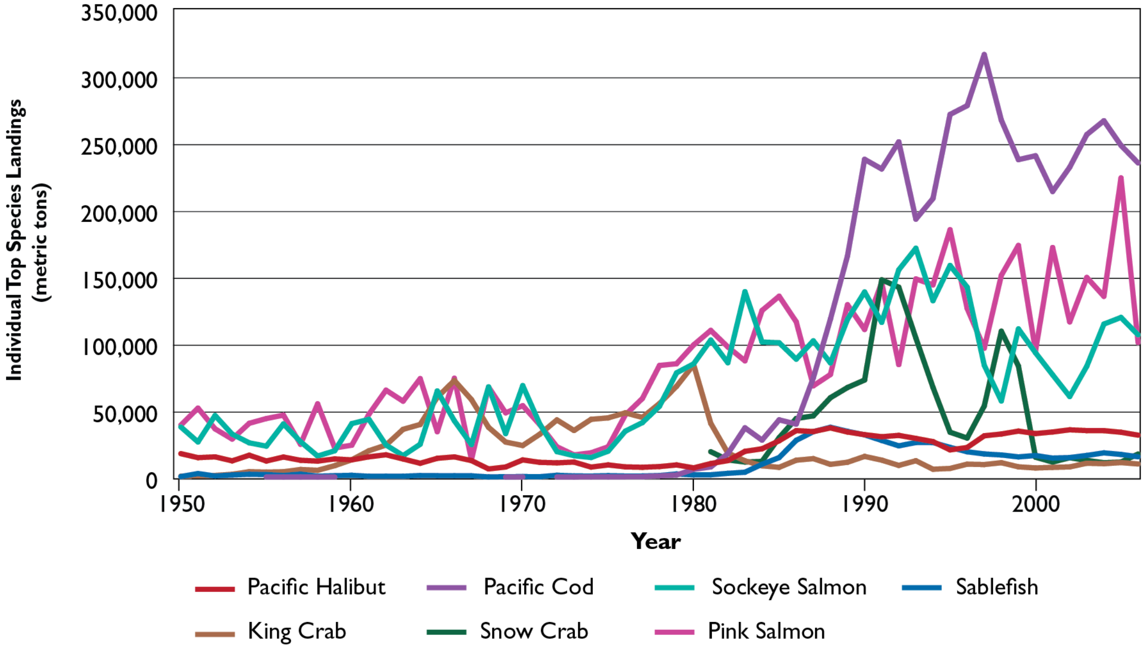


Figure 8-12. Landings of the top commercial fisheries in Alaska from 1950 to 2006, metric tons (NMFS, 2010).

Like other LMEs, Alaska's five LMEs are economically important, generating over $4.8 billion from 2003 to 2006 (NMFS, 2010). In addition to the large commercial and recreational fisheries that also contribute to the Alaskan economy, there are subsistence fisheries that are important to native Alaskans. This cultural ecosystem service is difficult to quantify in terms of money, but is very important to the health, well being, and cultural identity of native Alaskans. Tourism and recreational fisheries are also important contributors to the Alaskan economy.

Advisory Data

Fish Consumption Advisories

In 2006, no consumption advisories were in effect for chemical contaminants in fish and shellfish species harvested in Alaskan waters (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for Alaska between 2004 and 2008?

Table 8-1 presents the number of total beaches and monitored beaches, as well as the number and percentage of monitored beaches affected by notification actions from 2005 to 2008 for Alaska. Alaska's beach monitoring program remains limited. The total number of beaches identified and the number monitored has increased from 2 to 3 between 2005 and 2008. Of these monitored beaches, the percentage closed or under advisory for some period of time during the year has decreased from 100% to 0% (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring site: http://www.epa.gov/waterscience/beaches/seasons/.

Table 8-1. Beach Notification Actions, Alaska, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	No data	2	3	3	3
Number of monitored beaches	No data	2	3	3	3
Number of beaches affected by notification actions	No data	2	0	0	0
Percentage of monitored beaches affected by notification actions	No data	100%	0%	0%	0%

What pollution sources impacted monitored beaches in Alaska?

Table 8-2 presents the numbers and percentages of monitored beaches in Alaska that were affected by various pollution sources in 2007. States can identify potential reasons for beach advisories even if they do not issue any notification actions. Alaska reported that both publicly owned treatment works and sanitary/combined sewer overflow affected 33%, or one, of its beaches. For two of the beaches, “no known pollution sources” caused concern (U.S. EPA, 2009d).

Table 8-2. Reasons for Beach Advisories, Alaska, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
No known pollution sources	2	67%
Publicly owned treatment works	1	33%
Sanitary/combined sewer overflow	1	33%

Note: A single beach may have multiple sources.

Since Alaska did not report any advisories or closure notifications for 2007, there is no information on beach advisory duration (U.S. EPA, 2009d). For more information on state beach closures, please visit EPA’s Beaches website: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Hawaii

The overall condition of Hawaii’s coastal waters is rated fair based on assessment of two of the indices assessed by NCA (Figure 8-13). The water quality index is rated good, and the sediment quality index is rated poor. The overall rating of fair represents a change from a rating of good from the 2002 NCA survey of Hawaii. The NCA was unable to evaluate the benthic, coastal habitat, or fish tissue contaminant indices for Hawaii’s coastal waters in the 2006 survey, and this limitation should be considered when interpreting the overall condition score for the state. Figure 8-14 provides a summary of the percentage of coastal area in good, fair, and poor categories for each index and component indicator. This assessment is based on environment stressor and response data collected under the NCA program, in conjunction with the Hawaii Department of Health and the University of Hawaii, from 50 locations along the main islands of the Hawaiian chain in 2006.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and limitations of the available data.

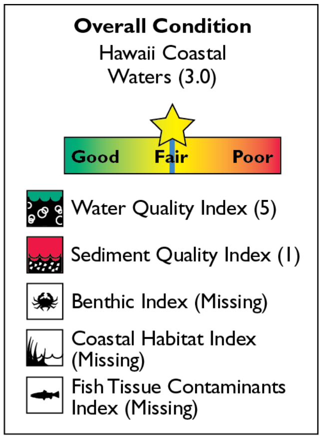


Figure 8-13. The overall condition of Hawaii coastal waters is rated fair (U.S. EPA/NCA).

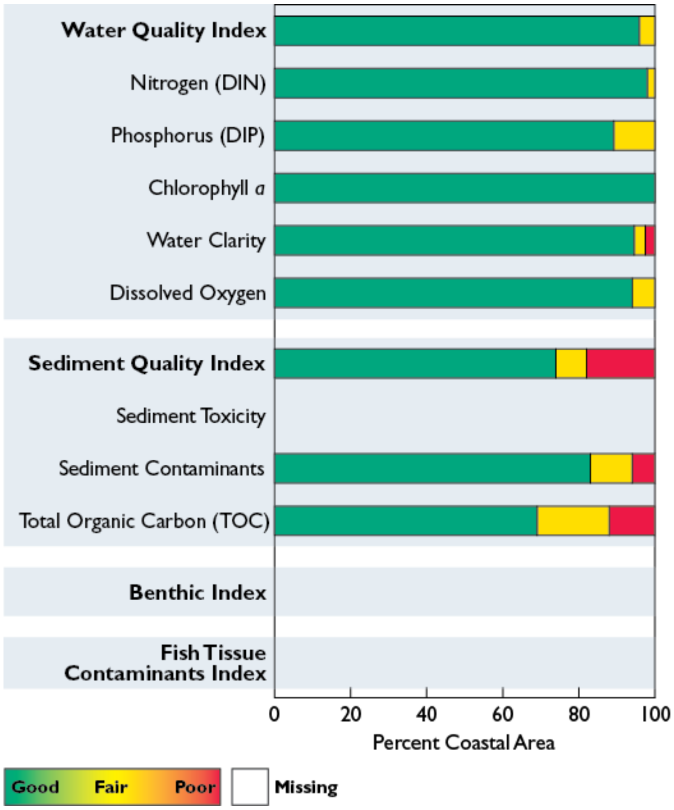


Figure 8-14. Percentage of coastal area achieving each ranking for all indices and component indicators—Hawaii (U.S. EPA/NCA).

Compared to other regions considered in the NCCR IV, estuaries are a small, but ecologically significant, component of Hawaii's coastal resources. These coastal waters represent less than 1% of the coastal ocean area around the Hawaiian Islands and are best developed on the older islands (Kauai and Oahu). Pearl Harbor, with a surface area of approximately 22 square miles, is one of the country's largest naval ports, and is also the largest remaining Hawaiian estuary. Most of Hawaii's estuaries are small, occupying less than 0.5 square miles. Historically, these coastal waters were more significant than they are today.

For example, 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 (Cox and Gordon, 1970; Meier et al., 1993).

Corals covered with sediment in Maunalua Bay, Oahu.

(Source http://hawaii.gov/dlnr/dar/coral/coral_las_lbsp.html, Hawaii Division of Aquatic Resources)

Estuaries serve as important nursery habitat for a number of commercial and recreational Hawaiian fishery resources. Several species that are estuarine-dependent are important to the economy of Hawaii, including mullet, milkfish, shrimp, and the nehu, a tropical anchovy used as live bait in the pole-and-line skipjack tuna fishery. In the Hawaii NCA, the coastal area assessed included semi-enclosed coastal embayments, in addition to the more spatially limited true estuaries. These embayments often include nearshore coral reef habitats, which are highly important to Hawaii, both ecologically and economically. The direct economic benefits of Hawaii's coral reefs have been estimated as $360 million per year (Friedlander et al., 2008).

Continued increases in population and economic growth will tend to exacerbate the impacts to native ecosystems because of the relatively small land area of the Hawaiian Islands. Changing land uses, such as reduction of agriculture and increased residential and commercial development, may alter the magnitude and types of stressors that impact the coastal waters of Hawaii. Problems associated with runoff (e.g., sediments, nutrients, bacteria, toxics) may be especially acute in the coastal areas of Hawaii because of the combination of steeply sloped coastal watersheds and high seasonal rainfall (Cox and Gordon, 1970; Meier et al., 1993). Sediment run off is probably the most important stressor on coral reef habitats in the coastal embayments (Friedlander et al., 2008).

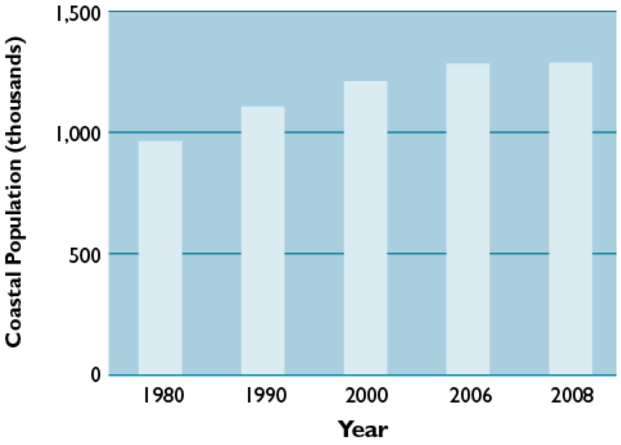


Figure 8-15. Population of Hawaiian counties, all of which are coastal, from 1980 to 2008 (NOEP, 2010).

Between 1980 and 2006, the Hawaiian population increased by 33%, from 0.96 million to 1.11 million people (Figure 8-15) (NOEP, 2010). Figure 8-16 shows a map of population density in 2006 for Hawaiian counties. The principal population and commercial center for the Hawaiian Islands is located on the south shore of Oahu in an area encompassing Pearl Harbor, the Port of Honolulu, and several other estuaries or embayments. Some 70% of the population of Hawaii lives on Oahu (Crossett et al., 2008). The coastal systems on the south shore of Oahu are often highly altered and surrounded by a high-density, urban setting. The rest of the Hawaiian Islands have a much lower population density. Honolulu County has a population density of 1,551 persons per square mile, while the second-most populous county is Maui, with a density of 126 persons per square mile (Crossett et al., 2008). The average population density for Hawaii's counties, all of which are coastal, has increased from 150 persons per square mile in 1980 to 200 persons per square mile in 2006 (NOEP, 2010). Although one might presume that the magnitude of anthropogenic impacts would be highest in the urbanized estuaries of Oahu, there are also potential areas of anthropogenic impacts in other areas of the Hawaiian Islands.

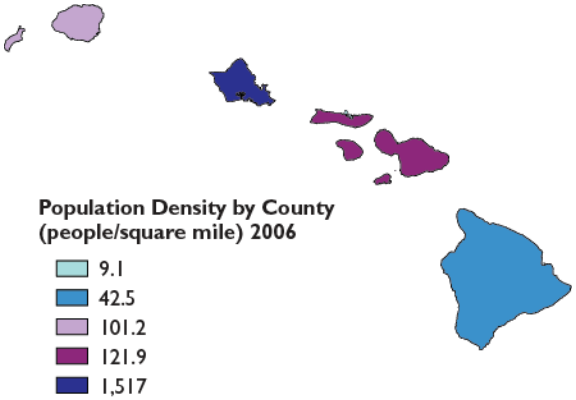


Figure 8-16. Population density of Hawaii's counties in 2006 (NOEP, 2010).

Coastal Monitoring Data—Status of Coastal Condition

Hawaii does not yet have a comprehensive coastal monitoring program. Coral reef monitoring activities are probably the most spatially and temporally extensive and are summarized in Friedlander et al. (2008). Most coastal resource monitoring is targeted to address specific bays and/or issues, such as nonpoint-source runoff and offshore discharges. For example, Mamala Bay has been sampled intensively since 1983 to examine the effects of wastewater treatment plant (WWTP) outfalls from Oahu into the Bay (Ambrose et al., 2009). The NCA conducted the first comprehensive, probability-based survey of the coastal condition of Hawaii in 2002, sampling 50 stations across the main islands and 29 stations within the urbanized estuaries of Oahu (Nelson et al., 2007b). The 2006 assessment of coastal waters of Hawaii was restricted to the main Hawaiian Islands and did not include the waters of the Northwestern Hawaiian Islands. The coastal waters assessed for the main Hawaiian Islands included estuaries, lagoons, and harbors, as well as more open coastal embayments.

Water Quality Index

The water quality index for Hawaii's coastal waters is rated as good in the 2006 survey. This index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a,* water clarity, and dissolved oxygen. Most (96%) of the coastal area was rated good for water quality condition, with 4% of the area was rated fair and no area rating poor (Figure 8-17). The two instances of fair condition ratings were driven by a poor rating for the water clarity component indicator at a station in Pearl Harbor and a poor rating for the DIN component indicator at a station in Hilo Bay.

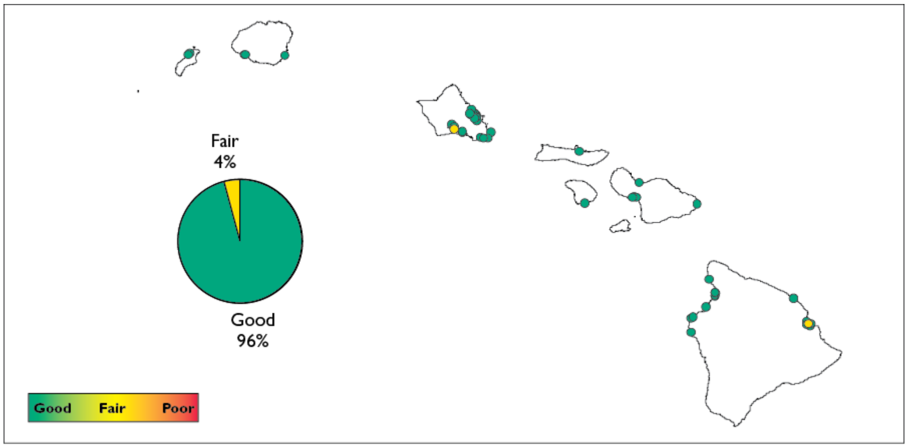


Figure 8-17. Water quality index data for Hawaii's coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

Hawaii's coastal waters are rated good for DIN concentrations, with only 2% of the coastal area rated fair for this component indicator. Hawaii's coastal waters are also rated good for DIP concentrations, with 11% of the coastal area rated fair for this component indicator.

Chlorophyll *a*

Hawaii's coastal waters are rated good for chlorophyll *a* concentrations, with 100% of the coastal area rated good.

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 and 3% of area was rated fair for this component indicator. The single site rated poor for water clarity was in Pearl Harbor, and the single site rated fair was in Keehi Lagoon, a boat basin near downtown Honolulu.

Dissolved Oxygen

Dissolved oxygen conditions in Hawaii's coastal waters are provisionally rated good, with only 6% of the area rated fair and none of the coastal area rated poor for this component indicator. An equipment malfunction with the dissolved oxygen probe occurred during the sampling of several of the Hawaiian Islands, in particular the island of Hawaii. Data were collected for dissolved oxygen at only 26 stations, and thus the magnitude of confidence limits is larger than the NCA target. The sites rated fair were located in Pearl Harbor (1 site) and Kaneohe Bay (1 site), with the dissolved oxygen concentration at the latter location 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 poor, with 8% of the coastal area rated fair and 18% of the area rated poor for sediment quality condition (Figure 8-18). The sediment quality index in 2006 was calculated based on measurements of only two component indicators: sediment contaminants and sediment TOC. The sediment toxicity bioassay organism used by NCA in 2006 was not deemed appropriate for the sediments found in Hawaii. High levels of TOC contributed more stations rated as poor (5) than did sediment contaminants (2), and this was also the case for stations rated fair (8 versus 5).

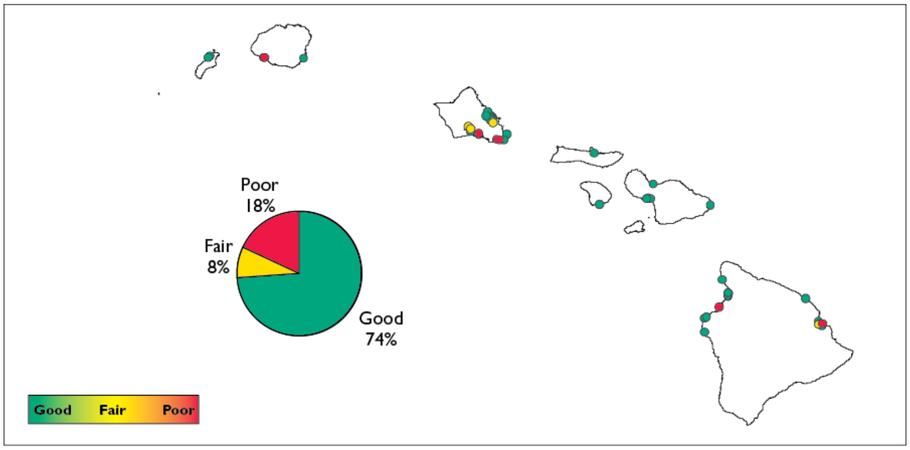


Figure 8-18. Sediment quality index data for Hawaii's coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The sediment toxicity component indicator was not measured in 2006 because the sediment toxicity bioassay organism used by NCA in 2006 was not deemed appropriate for the sediments found in Hawaii.

Sediment Contaminants

Hawaii's coastal waters are rated fair for sediment contaminant concentrations, with 11% of the coastal area rated fair and 6% of the area rated poor for this component indicator. The two sites rated poor were located in Waimea Bay, Kauai, where the ERM for chromium was exceeded. The sites rated fair were primarily in Pearl Harbor and other harbor areas, such as Keehi Lagoon on Oahu and Hilo Bay on Hawaii, resulting from exceedances of the ERL for metals and some individual PAHs. Nickel was excluded as a component of the sediment contamination index because the ERM value for this metal has a low reliability for areas where high natural crustal concentrations of nickel exist (Long et al., 1995). A study of metal concentrations in cores collected along the U.S. 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).

Sediment TOC

The coastal waters of Hawaii are rated good for the sediment TOC component indicator. A total of 12% of the coastal area was rated poor, and 19% of the area was rated fair. Sites rated poor for sediment TOC were located in waters off the suburban development of Hawaii Kai east of Honolulu, Keehi Lagoon, and Hilo Bay. The majority of sites rated fair were located in Kaneohe Bay on Oahu.

Benthic Index

A benthic index for Hawaii is not currently available.

Coastal Habitat Index

As was the case in the 2002 survey, the quantitative estimates of coastal habitat loss from two time periods are still not available for Hawaii; therefore, a coastal habitat index could not be calculated. The best available estimate of total wetland loss in Hawaii is 12% over the period 1780–1980 (Dahl, 1990), and no separate estimate for coastal wetlands was provided.

Fish Tissue Contaminants Index

The fish tissue contaminant index was not assessed in the 2006 survey. In the 2002 survey, a feasibility study was conducted to determine whether sea cucumbers could be utilized to assess tissue body burdens. Results had a high degree of uncertainty because of small sample size, and analytical issues were present with the tissue matrix. Fish and shellfish contaminant studies have been limited in Hawaii (Friedlander et al., 2008). Evidence of elevated levels of some metals was observed in outplanted oysters near stream mouths in the southern portion of Kaneohe Bay, Oahu (Hunter et al., 1995).

Trends of Coastal Monitoring Data—Hawaii

The NCA and its partners conducted probabilistic sampling in 2002 and again in 2006. A comparison of the results of these assessments is discussed below.

Figure 8-19 compares the percentage of Hawaii's coastal area rated good, fair, or poor for the water quality index and its component indicators in the 2002 and 2006 surveys. The water quality index for Hawaii's coastal waters was rated good for both surveys, with a higher percentage of the coastal area rated fair and poor in the 2002 survey. The higher percentage area estimated as fair and poor is most likely associated with the focused sampling on the urbanized estuaries of Honolulu, which was a part of the design in the 2002 survey. Both the DIN and DIP component indicators were rated as good in both surveys, and less of the coastal area was rated fair and poor in the 2006 survey. The chlorophyll *a* component indicator was also rated fair in the 2002 survey and good in the 2006 survey, with significantly more area rated fair and poor in the 2002 survey. This difference is due to the much greater sampling focus in 2002 on the urbanized estuaries of Honolulu, where approximately two-thirds of sites rated poor for chlorophyll *a* concentrations were found. The water clarity component indicator was also provisionally rated good in both timeframes. Although the water clarity rating in 2002 was provisional because a valid reading of Secchi depth for estimating water clarity could not be obtained, this provisional rating was confirmed by the use of a PAR meter in the 2006 survey. The dissolved oxygen component indicator was also rated good in both surveys, with similar amounts of the coastal area rated fair and none of the area rated poor.

The NCA monitoring data used in this assessment were based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

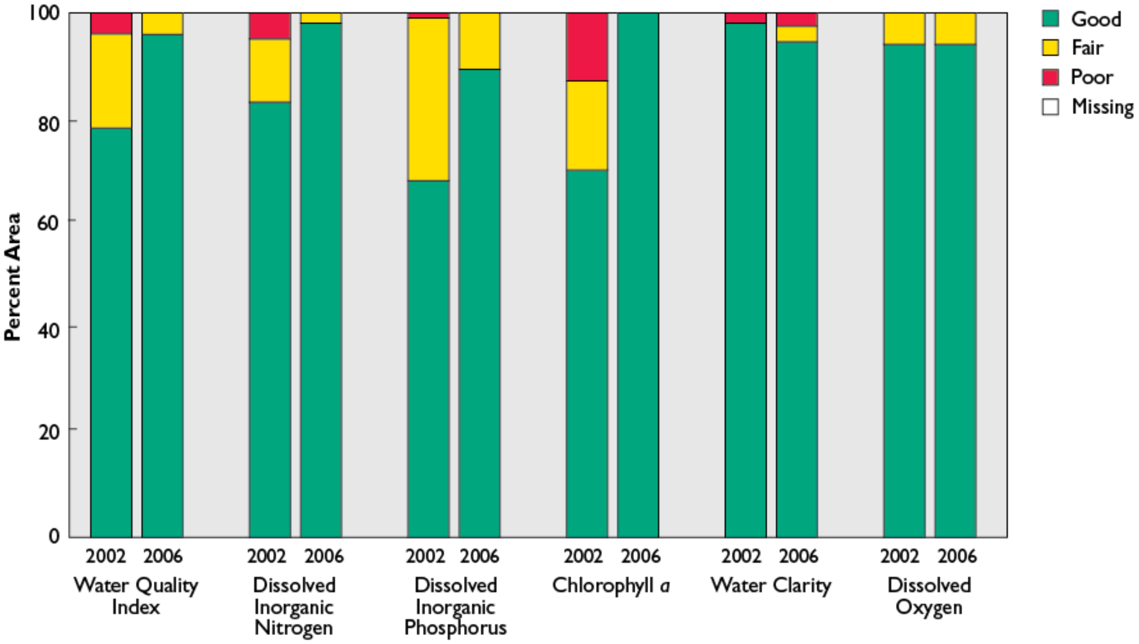


Figure 8-19. Percentage of Hawaii's coastal area achieving each ranking for the water quality index and its component indicators compared between the 2002 and 2006 surveys (U.S. EPA/NCA).

Figure 8-20 compares the percentage of Hawaii's coastal area rated good, fair, or poor for the sediment quality index and its component indicators in the 2002 and 2006 surveys. The sediment quality index was rated good to fair in the 2002 survey and poor in the 2006 survey, with significantly less of the coastal area rated poor during the 2002 survey. It should be noted that the 2002 sediment quality index was calculated based on measurements of three component indicators (i.e., sediment toxicity, sediment contaminants, and sediment TOC), and the 2006 sediment quality index rating was based on two component indicators (i.e., sediment contaminants and sediment TOC). More of the coastal area was rated fair and poor for the sediment contaminants component indicator in 2006, and the rating decreased from good to fair. The sediment TOC component indicator was rated good in both surveys; however, the total area estimated as being in either fair or poor condition increased from 8% in 2002 to 30% in 2006. The range of values of TOC recorded in the 2006 data set was also much greater than in 2002. Given the high carbonate content of sediments in Hawaii, it is possible that laboratory analytical differences in the degree to which inorganic carbon was removed from sediments may have contributed to this difference.

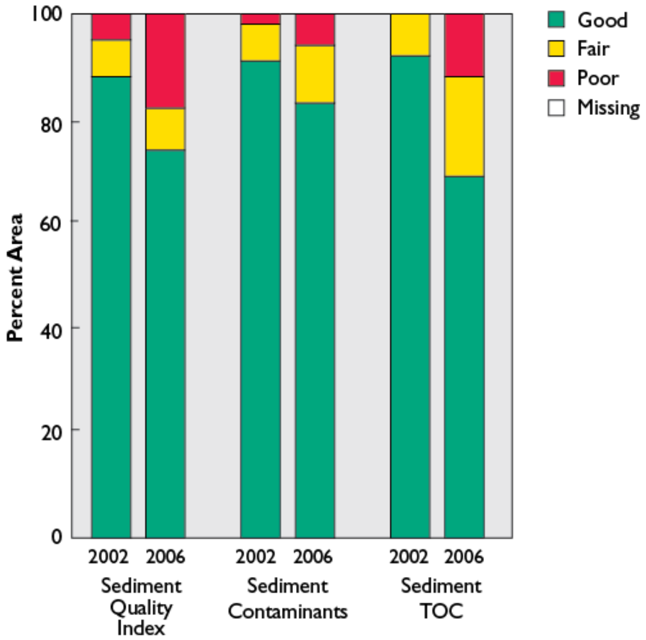


Figure 8-20. Percentage of Hawaii's coastal area achieving each ranking for the sediment quality index and component indicators compared between the 2002 and 2006 surveys (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries—Insular Pacific-Hawaiian LME

The Insular Pacific-Hawaiian LME comprises a range of islands, atolls, islets, reefs, and banks that extends 1,500 nautical miles on a west−northwest axis (Figure 8-21), and their surrounding waters. In 2000, President Clinton, through Executive Orders 13178 and 13196, established the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, in which fishing activities are prohibited. To continue protection of the Northwestern Hawaiian Islands, President George Bush in 2006 established the Papahānaumokuākea Marine National Monument, which is cooperatively managed by the FWS and NOAA/NMFS, in close coordination with the State of Hawaii. This monument encompasses 105,564 square nautical miles (139,797 square miles) of emergent and submerged lands and waters of the Northwestern Hawaiian Islands, providing protection to 4,500 square miles of coral reefs, 14 million seabirds, and over 7,000 marine species. For more information, visit http://www.papahanaumokuakea.gov/.

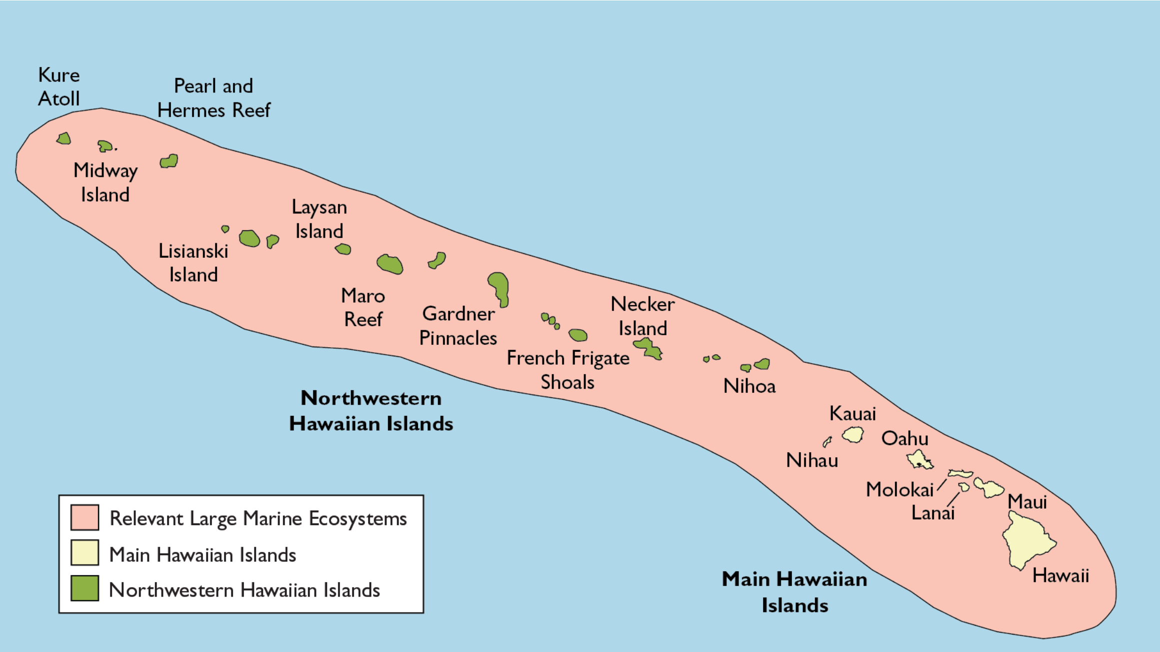


Figure 8-21. The Main Hawaiian Islands (MHI) and the Northwestern Hawaiian Islands (NWHI) of in the Insular Pacific-Hawaiian LME.

From 2003 to 2006, Hawaii generated over $247 in commercial fisheries total ex-vessel revenues within this LME. In terms of both landings and revenues, Hawaiian fisheries are dominated by the tuna group, including bigeye, yellowfin, albacore, skipjack, and kawakawa. The bigeye and yellowfin commercial tuna fisheries are the most important, generating over $124 million and $30 million in total ex-vessel revenues from 2003 to 2006, respectively (NMFS, 2010). Other important commercial species include dolphinfish, swordfish, wahoo, opah, and striped marlin. Yellowfin tuna and dolphinfish are the most important recreational species as well. See Figure 8-22 for revenues and landings of the top Hawaiian commercial fisheries harvested within the Insular Pacific-Hawaiian LME. Fisheries in this LME are managed jointly by the Western Pacific Fishery Management Council and the State of Hawaii, in accordance with terms determined under international agreements for transboundary species.

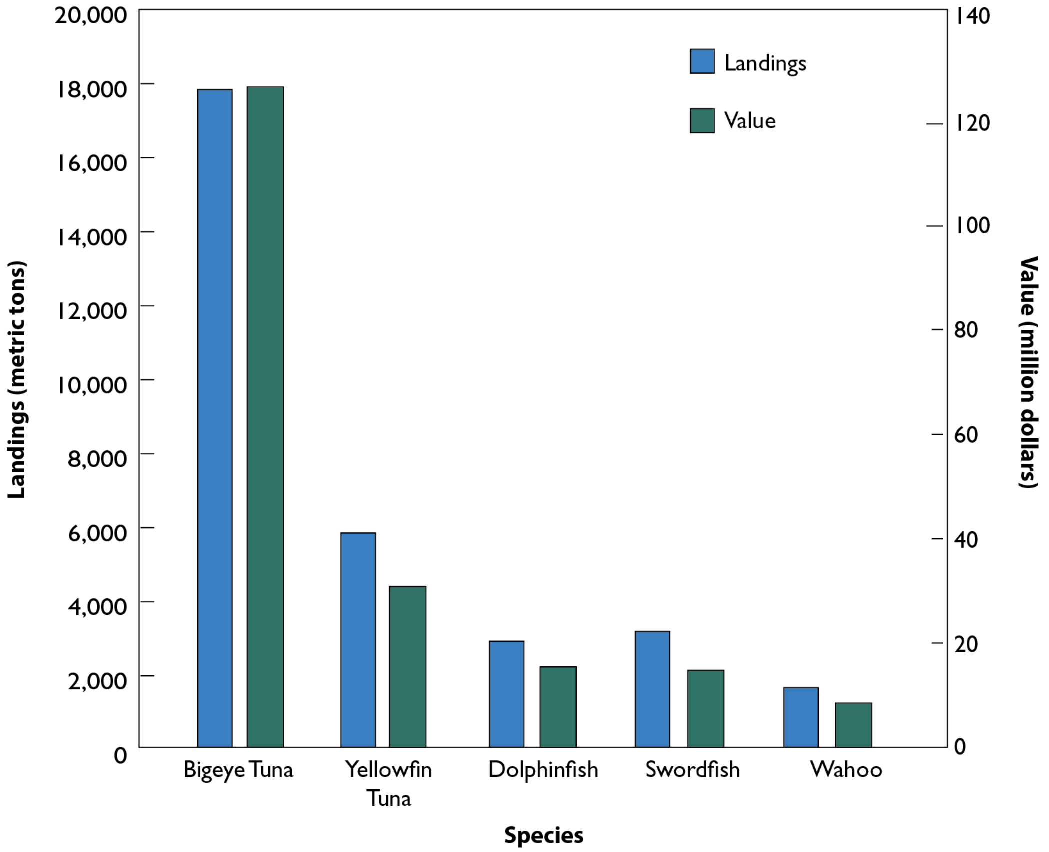


Figure 8-22. Top commercial fisheries for Hawaii from the Insular-Pacific LME: landings (metric tons) and value (million dollars) from 2003 to 2006 (NMFS, 2010).

Pacific Highly Migratory Pelagic Fisheries

Large pelagic (water-column dwelling) predators routinely travel great distances across the Pacific Ocean, crossing the waters of several nations and the high seas in their pursuit of forage and ideal habitat for reproduction. Highly migratory pelagic species include tropical tunas (yellowfin, bigeye, and skipjack), temperate tunas (Pacific bluefin and albacore), billfishes (marlins and swordfish), oceanic sharks (thresher, blue, and mako), dolphinfish, and wahoo. In Hawaii, pelagic species are caught mostly by trollers (65%) and longline fishermen (28%). These fish are also caught for recreational and subsistence purposes.

For Hawaii, tuna landings are dominated by bigeye (*Thunnus obesus*), with total landings from 2003 to 2006 of 18,000 metric tons generating over $120 million in total ex-vessel revenues (see Figure 8-22). Yellowfin tuna (*Thunnus albacares)* is another prized species used principally for canning, with landings of 6,000 metric tons worth around $30 million from 2003 to 2006 (NMFS, 2010). Both yellowfin and bigeye tuna are known as ahi in Hawaii and are used in raw fish dishes, such as sashimi. Tuna mostly inhabit the upper 300 feet of the water column, are capable of high speeds, travel long distances, and can reach up to 400 pounds due to their relatively long life spans. Although bigeye and yellowfin dominate Hawaii's tuna landings, skipjack is the volume leader throughout the Pacific Ocean.

Billfishes, including swordfish, marlins, and spearfish, are more abundant near islands, continental slopes, seamounts, and oceanic fronts, and many are important to the local economy. They are categorized by their long length and sword-like bills. Commercial fisheries in this group generated nearly $26 million in total ex-vessel revenues for Hawaii from 2003 to 2006. Swordfish (*Xiphias gladius)* dominates this group, with landings of over 3,000 metric tons generating over $10 million in total ex-vessel revenues from 2003 to 2006 (see Figure 8-22) (NMFS, 2010). This species, named after its spear-like bill, can reach over 14 feet in length and weigh over 1,400 pounds. It is a popular fish for cooking and is most often sold for steaks.

Other Pacific highly migratory species are wahoo (*Acanthocybium solandri)* and dolphinfish (*Coryphaena hippurus*), which are primarily caught commercially using longline, troll, and handline gears. The U.S. landings of dolphinfish and wahoo are worth about $4,200 per ton. From 2003 to 2006, the total ex-vessel revenues for dolphinfish were over $15 million, and over $8 million for wahoo (see Figure 8-22) (NMFS, 2010). Dolphinfish, also known as mahi-mahi, can reach up to 30 pounds in weight and live about 4 to 5 years. The wahoo is a much bigger fish, reaching up to 8 feet in length and weighing as much as 180 pounds. Both fish are targeted by recreational and sports fishermen.

In the Pacific waters of the United States, pelagic species are managed by the Western Pacific Regional Fishery Management Council under the *Pacific Pelagics Fishery Ecosystem Plan* (WPRFMC, 2009b), in accordance with international conventions. In 2000, after 5 years of negotiations involving 24 nations, 19 Pacific nations adopted the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (WCPFC) in Hawaii, which was entered into force in 2004. The WCPFC has authority to manage catch, by-catch, fishing capacity, and effort in order to conserve and manage the stocks of tuna and tuna-like species west of 150°W longitude. A management issue closely aligned with fishing capacity is the problem of illegal, unreported, and unregulated fishing by vessels that operate outside the control of regional management regimes. This is particularly problematic with the highly migratory species that are of such commercial importance to Hawaii. Another issue in the Pacific is the high fishing mortality (and subsequent reduction in future spawning biomass) on juvenile bigeye and yellowfin tuna with increasing use of fish aggregating devices by purse seiners and domestic fisheries of the Philippines and Indonesia.

Other Important Fisheries

Other fisheries off Hawaii include coral reef, bottomfish (fish that dwell on the bottom), and crustaceans. The coral reef fisheries (i.e., coastal pelagic scad, soldierfish, parrotfish, surgeonfish, and goatfish) and the crustacean fisheries (i.e., lobsters and crabs) are primarily conducted in nearshore waters under Hawaiian management. Harvests of bottomfish (i.e., snappers, jacks, and grouper) take place both in state and federal waters. Management of these fisheries in federal waters is conducted by the Western Pacific Regional Fishery Management Council under the *Fishery Ecosystem Plan for the Hawaii Archipelago* (WPRFMC, 2009a), which utilizes an ecosystem-based management approach that emphasizes habitat, ecosystem, protected species, and community participation. See http://www.wpcouncil.org/HawaiiArchipelago.htm for more details.

A unique characteristic of this LME is the harvest of various coral species, which do not generate enough monetary value to rank within the top commercial fisheries, but are important locally. Gold, bamboo, and pink deepwater corals and shallower black corals represent a precious resource in the Hawaiian Islands. Black coral is harvested mostly in state waters from a bed located in the Auau Channel. This coral was sustainably harvested for over 40 years, beginning in the late 1950s. Unfortunately, increased fishing pressure and the introduction of an invasive species are threatening the stability of this fishery. There is a biannual quota of 11,000 pounds for the Auau coral bed.

Fishery Trends and Summary

Figure 8-23 shows landings of the top commercial fisheries for Hawaii within the Insular-Pacific LME since 1980, when consistent data collection began. No species-specific data for the dolphinfish and wahoo fisheries were available until 2002. Landings of bigeye tuna, which have increased continuously since the mid-1980s, currently dominate this LME at just over 4,500 metric tons. Landings of the other top commercial tuna species, yellowfin, seem to have stabilized around 1,500 metric tons, after considerable annual variability beginning in the mid-1980s, when the fishery peaked at 5,000 metric tons. The swordfish fishery, which yielded the largest landings for Hawaii in the early 1990s at 6,000 metric tons, now hovers over 1,000 metric tons. Current catches of both dolphinfish and wahoo are about 500 metric tons.

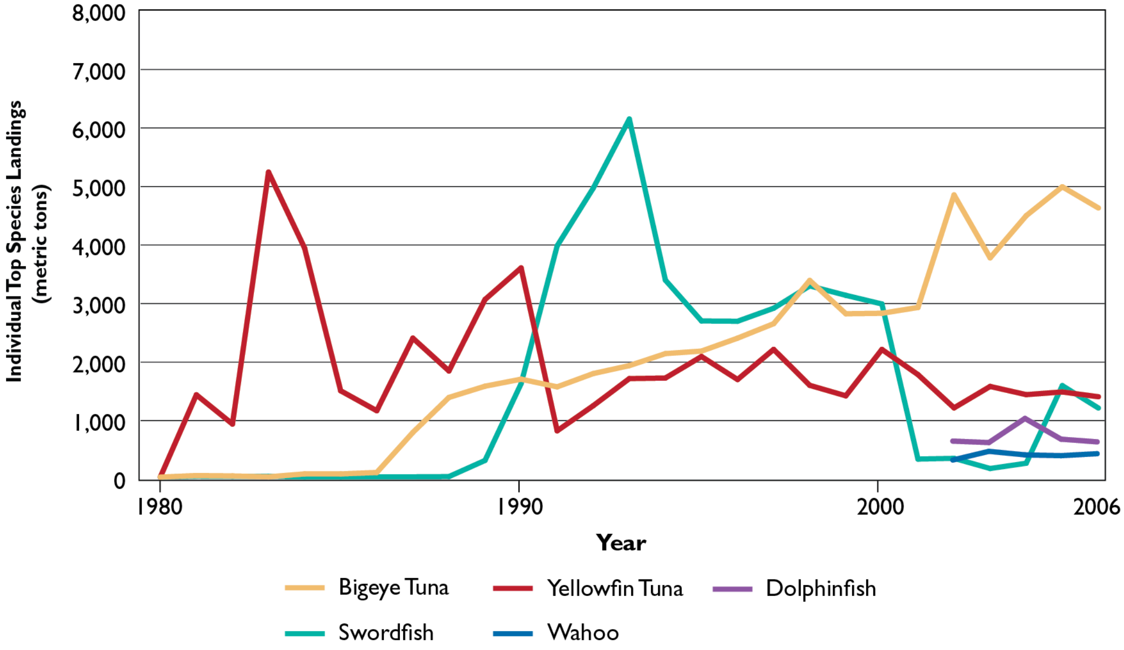


Figure 8-23. Landings of top commercial fisheries in the Insular-Pacific LME for Hawaii from 1980 to 2006, metric tons (NMFS, 2010).

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 8-24). In addition to the estuarine advisory, a statewide advisory took effect in 2003. The statewide advisory targets sensitive populations (e.g., pregnant women, nursing mothers, children) and provides data on mercury contamination for several species of marine fish (U.S. EPA, 2007c).

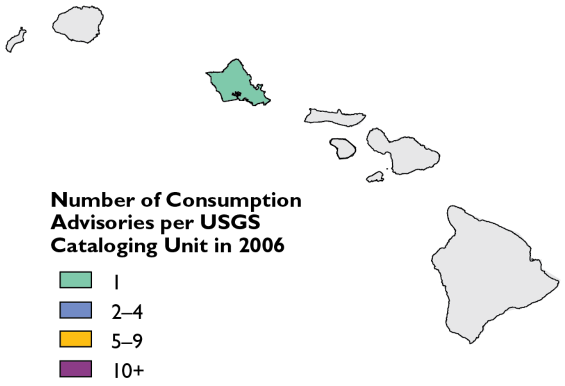


Figure 8-24. Fish consumption advisory for Hawaii, location approximate.

Hawaii also has a statewide advisory for marine fish consumption by sensitive populations, although this is not mapped (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for Hawaii between 2004 and 2008?

Table 8-3 presents the number of total and monitored beaches, as well as the number and percentage of beaches affected by notification actions from 2004 to 2008 for Hawaii. Over the past several years, the total number of beaches identified by Hawaii increased from 376 in 2004 to 444 in 2008. During this same period, monitoring efforts also increased significantly, from 50 to 248 beaches between 2004 and 2008. Of these monitored beaches, the percentage closed or under advisory during the year has also decreased substantially, from 52% in 2004 to 3% (or 7 beaches) in 2008 (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring site at http://www.epa.gov/waterscience/beaches/seasons/.

Table 8-3. Beach Notification Actions, Hawaii, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	376	483	438	444	444
Number of monitored beaches	50	134	112	115	248
Number of beaches affected by notification actions	26	13	16	8	7
Percentage of monitored beaches affected by notification actions	52%	10%	14%	7%	3%

What pollution sources impacted monitored beaches?

Table 8-4 presents the numbers and percentages of monitored Hawaii beaches affected by various pollution sources for 2007. Storm-related runoff was a pollution source for all of Hawaii's beaches in 2007, while combined sewer overflow contributed to 10% of beach advisories that year. Other identified pollution sources included septic system leakage and publicly owned treatment works (U.S. EPA, 2009d).

Table 8-4. Reasons for Beach Advisories, Hawaii, 2007 (U.S. EPA, 2009d)

Reason for Advisories	Total Number of Monitored Beaches Affected	Percent of Total Monitored Beaches Affected
Storm-related runoff	444	100%
Sanitary/combined sewer overflow	44	10%
No known pollution sources	13	3%
Other and/or unidentified sources	13	3%
Publicly owned treatment works	13	3%
Septic system leakage	4	1%

Note: A single beach may have multiple sources.

How long were the 2007 beach notification actions?

Of the 2007 beach advisories, half lasted 3 to 7 days. Actions lasting only a day accounted for one-fifth of the total advisories, as did those of the 8- to 30-day duration. Only 10% of actions lasted more than 30 days (U.S. EPA, 2009d).

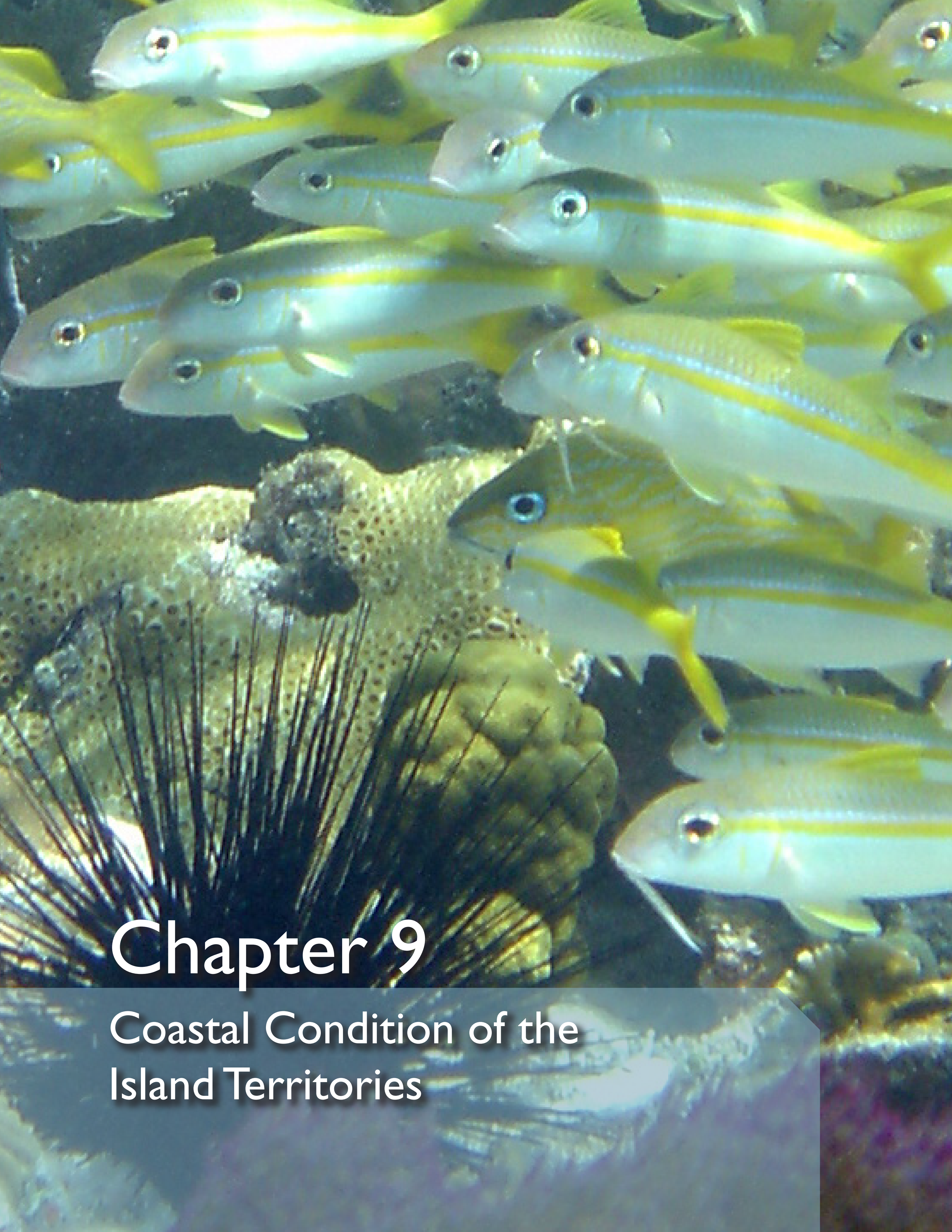
Summary

NCA conducted sampling in the coastal waters of Southeastern Alaska in 2004 and in Hawaii in 2006. These assessments resulted in an overall condition rating of good for Southeastern Alaska's coastal waters, where water quality, sediment quality, coastal habitat, and fish tissue contaminants are all rated good. The benthic index for Southeastern Alaska could not be evaluated. Hawaii received an overall coastal condition rating of fair. Hawaii's coastal water quality index is rated good, and the sediment quality index is rated poor. The NCA was unable to evaluate the benthic, coastal habitat, or fish tissue contaminants indices for Hawaii's coastal waters in the 2006 survey.

NOAA's NMFS manages several fisheries in the LMEs bordering Alaska and Hawaii. The East Bering Sea LME and the Gulf of Alaska LME are two of the LMEs that surround Alaska, and NMFS manages the salmon, groundfish, and shellfish fisheries in these waters. The groundfish group, dominated by walleye pollock, is the most important in terms of both landings and revenue for Alaskan commercial fishermen. The other top fisheries are for salmon and crab. Recent trends indicate that the walleye pollock stock in the East Bering Sea LME has declined since 2003 due to poor survival rates of juveniles from 2001 through 2005. Pollock abundance in the Gulf of Alaska LME also is at a low level, and this stock is carefully managed to help protect the endangered and threatened Steller sea lions, which feed on pollock. All five species of Alaskan salmon are fully utilized, and stocks in the Gulf of Alaska and East Bering Sea LMEs have rebuilt to near or beyond previous high levels. In addition to the large commercial and recreational fisheries that contribute to the Alaska economy, there are subsistence fisheries that are important to the health, well being, and cultural identity of native Alaskans.

The Insular Pacific-Hawaiian LME consists of the waters around Hawaii. In terms of both landings and revenues, Hawaiian fisheries are dominated by the tunas, especially bigeye and yellowfin. Catches of bigeye tuna have increased continuously since the mid-1980s. Other highly migratory species (i.e., dolphinfish, swordfish, and wahoo) are the next most valuable fisheries in this LME. The coral fishery is open, but only shallow-water black coral is being harvested.

Contamination in the coastal waters of Hawaii has affected human uses of its waters. In 2006, there was one fish consumption advisory in effect for Pearl Harbor, Hawaii, for PCBs. Alaska did not have any fish consumption advisories in effect in 2006. Alaska monitored three beaches in 2006, but none of them were closed or under advisory for any part of the year due to contamination.



Chapter 9

Coastal Condition of the Island Territories

9. Coastal Condition of the Island Territories

In 2004, NCA efforts were expanded to include the coastal areas of the U.S. territories of American Samoa, Guam, and the U.S. Virgin Islands. A second survey of the Commonwealth of Puerto Rico was also completed in 2004. This chapter briefly describes assessment findings for each of these 2004 NCA surveys and represents baseline ecological assessments for the island territories. The Commonwealth of the Northern Mariana Islands was not included in the baseline ecological assessments for the island territories.

> Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

American Samoa

The overall condition presented for American Samoa coastal waters is good based on two of the five indices of ecological condition (Figure 9-1). The water quality and fish tissue contaminants indices are rated good. A sediment quality index was not calculated for American Samoa because sediment samples were not collected for the majority of sites. In addition, no information was collected to calculate the benthic or coastal habitat indices. Figure 9-2 provides a summary of the percentage of coastal area in good, fair, or poor categories for each index and component indicator.

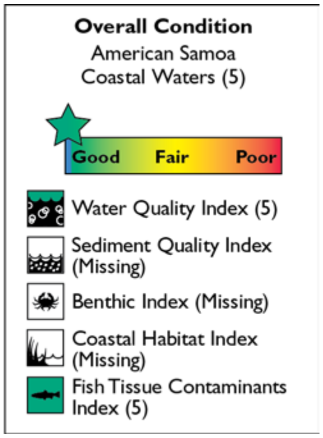


Figure 9-1. The overall condition of American Samoa coastal waters is rated good (U.S. EPA/NCA).

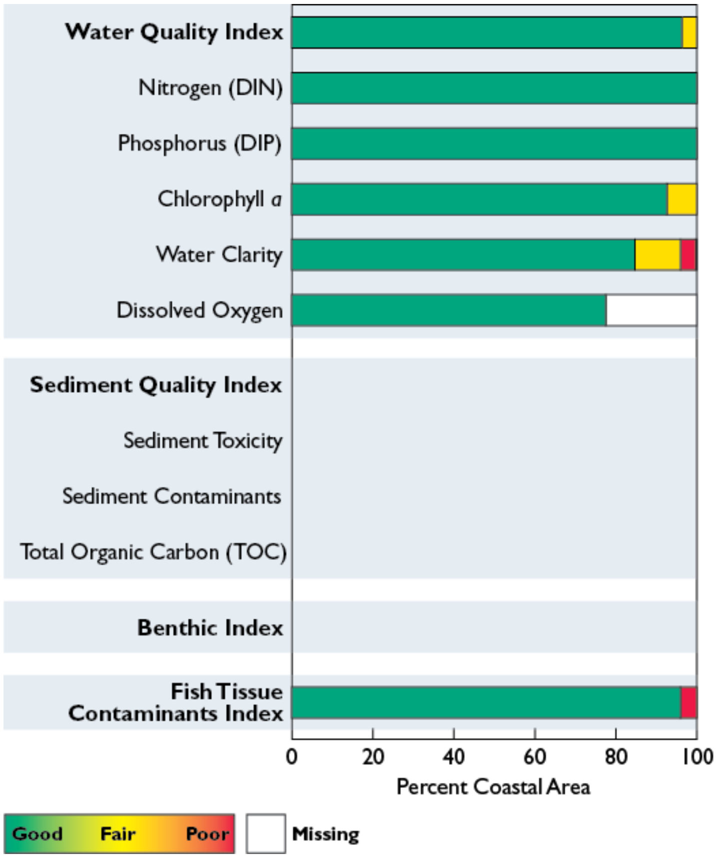


Figure 9-2. Percentage of area receiving each ranking for all indices and component indicators – American Samoa (U.S. EPA/NCA).

American Samoa is part of the Central Polynesian Province and is the southern-most U.S. territory. The territory consists of five volcanic high islands (Tutuila, Aunu'u, Ofu, Olosega, and Ta'u) and two atolls (Rose and Swains). The combined land area of American Samoa is approximately 77 square miles. The surveyed resources include estuaries, embayments, and nearshore waters within approximately 0.22 nautical miles of the shoreline. Forty-nine sites were sampled in 2004, with 50% of the sites falling within National Park boundaries.

Although American Samoa represents far less than half a percent of the U.S. population, the population of this island territory has grown by 95% between 1980 and 2006, from 32,000 to 63,000 people (Figure 9-3). Over the same period, the territory's population density has increased from 416 persons per square mile to 818 persons per square mile (U.S. Census Bureau, 2010).

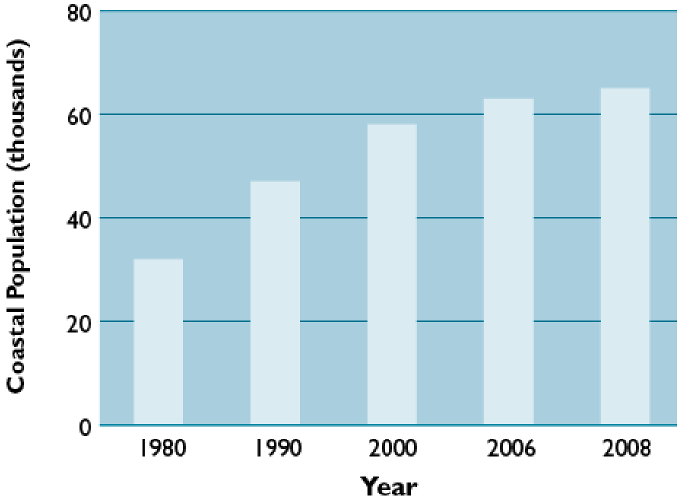


Figure 9-3. Population of coastal counties in American Samoa from 1980 to 2008 (U.S. Census Bureau, 2010).

Coastal Monitoring Data—Status of Coastal Condition

> The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

Water Quality Index

The water quality index for American Samoa is rated good, with 96% of the coastal area rated good and 4% of the area rated fair (Figure 9-4). The water quality index was developed based on measurements of five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Reduced water clarity contributed to the fair water quality ratings.

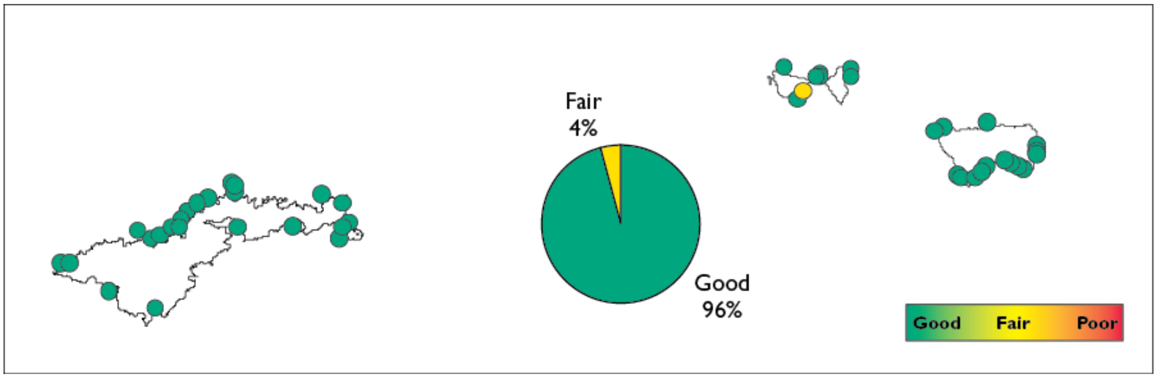


Figure 9-4. Water quality index data for American Samoa coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

American Samoa is rated good for DIN, with all of the coastal area rated good for this component indicator. Similarly, the DIP component indicator is rated good for 100% of the coastal area.

Chlorophyll *a*

The chlorophyll *a* component indicator is rated good for American Samoa, with 7% of the coastal area rated fair.

Water Clarity

American Samoa is rated good for water clarity, with 11% of the coastal area rated fair and 4% rated poor for this component indicator.

Dissolved Oxygen

American Samoa is rated good for the dissolved oxygen component indicator, with 77% of the coastal area rated good. Dissolved oxygen data were missing for the remainder of the coastal area.

Sediment Quality Index

Guidelines for Assessing Sediment Contamination (Long et al., 1995)

ERM (Effects Range Median)—Determined values 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.

A sediment quality index was not calculated for American Samoa because only 25% and 16% of the area were sampled for sediment contaminants and TOC, respectively (Figure 9-5). Scores for these two component indicators are presented in Figure 9-6 for the sites sampled. Two sites, representing 15% of the sites sampled, exceeded ERM concentrations for nickel and were rated poor. ERL concentrations were also exceeded for arsenic, nickel, and chromium in sediments from 6 of the 13 sites sampled. No TOC concentrations were observed greater than 5%. No sediment toxicity data were collected.

Figure 9-5. Sediment quality index data for American Samoa coastal waters (U.S. EPA/NCA).

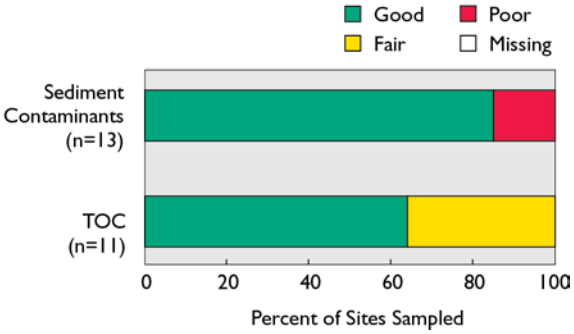


Figure 9-6. Results of the limited data collected for the sediment contaminants and sediment TOC component indicators (U.S. EPA/NCA).

Benthic Index

Benthic data are not available for American Samoa; therefore, the benthic index could not be calculated.

Coastal Habitat Index

Estimates of coastal habitat loss are not available for American Samoa; therefore, the coastal habitat index could not be calculated.

Fish Tissue Contaminants Index

The fish tissue contaminants index for American Samoa is rated good based on fish tissue samples collected at 47 sites. The fish tissue contaminants index is rated poor at 4% of the sites at which fish were caught due to concentrations of PAHs and mercury in fish tissue (Figure 9-7).

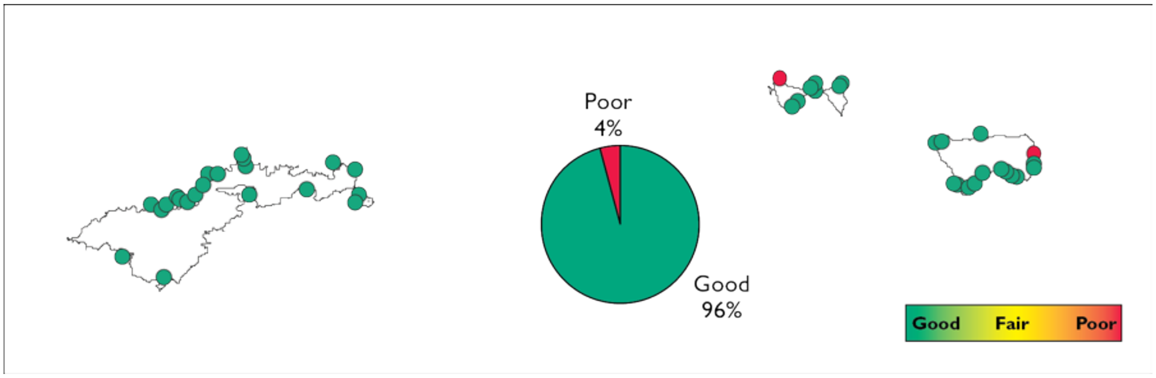


Figure 9-7. Fish tissue contaminants index data for American Samoa (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries—American Samoa

American Samoa is not located within an LME, as designated by NOAA. Landings from American Samoan waters are dominated by pelagic (water-column dwelling) species (mostly albacore tuna), with about 30 longline vessels harvesting 11 million pounds annually (WPRFMC, 2011b). Annually, commercial vessels also land about 6,000 to 30,000 pounds of bottomfish (bottom-dwelling fish), 20,000 pounds of coral reef fish, and 1,200 pounds of spiny lobster (WPRFMC, 2011a). Coral reef species and crustaceans are also harvested by subsistence fishermen. Within 3 miles of shore, American Samoa's fisheries are managed by the Territorial government. Between the 3-mile mark and the boundary of the U.S. EEZ, the fisheries are managed by the NMFS Western Pacific Regional Fishery Management Council, which regulates all fisheries by archipelago except for the pelagic fisheries, which are managed under a fishery ecosystem plan for pacific pelagics (WPRFMC, 2009b). *The American Samoa Fishery Ecosystem Plan* (WPRFMC, 2009a) utilizes an ecosystem-based management approach that emphasizes habitat, ecosystem, protected species, and community participation.

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 9-8). In 2006, arsenic was added to the list of potential contaminants to this estuary. The advisory recommends that all members of the general population (including sensitive populations of pregnant women, nursing mothers, and children) not consume any fish, fish liver, or shellfish from the Inner Pago Pago Harbor. 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 (U.S. EPA, 2007c).

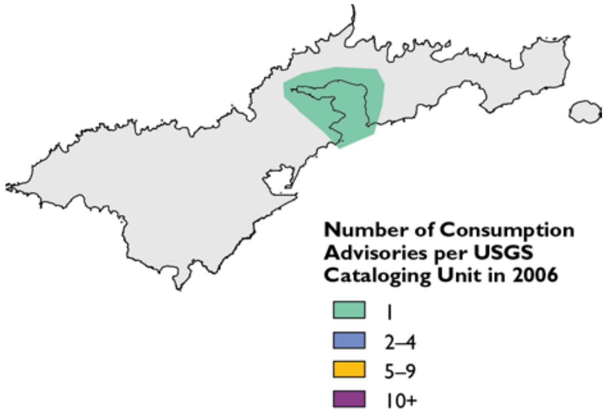


Figure 9-8. Fish consumption advisory for American Samoa, location approximate (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for American Samoa between 2004 and 2008?

Table 9-1 presents the number of total beaches and monitored beaches for the U.S. Pacific island territory of American Samoa, as well as the number and percentage of beaches affected by notification actions from 2005 to 2008. Since 2005, the total number of beaches and the number of monitored beaches decreased from 77 to 42. Of these monitored beaches, the percentage closed or under advisory for some period of time during the year increased from 43% in 2005 to 100% in 2008 (or 42 beaches) (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm

Table 9-1. Beach Notification Actions, American Samoa, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	No data	77	74	74	42
Number of monitored beaches	No data	77	45	45	42
Number of beaches affected by notification actions	No data	33	42	42	42
Percentage of monitored beaches affected by notification actions	No data	43%	93%	93%	100%

Data on pollution sources for American Samoan beaches were not available under the EPA Beaches program at the time of publication.

How long were the 2007 beach notification actions for American Samoa?

Over 99% of beach notification actions in American Samoa lasted between 3 to 7 days in 2007. Less than 1% of the actions lasted longer than 30 days (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Guam

The overall condition of Guam's coastal waters is rated good based on four of the indices assessed by the NCA (Figure 9-9). The water quality index is rated good, the sediment quality index is rated good, the benthic community index is rated good to fair, and the fish tissue contaminants index is rated good. The NCA was unable to evaluate the coastal habitat index for Guam. Figure 9-10 provides a summary of the percentage of coastal area in good, fair, or poor categories for each index and component indicator. This assessment is based on environment stressor and response data collected by the Guam Environmental Protection Agency, through collaboration with NCA, from 50 locations within coastal waters of the island of Guam.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

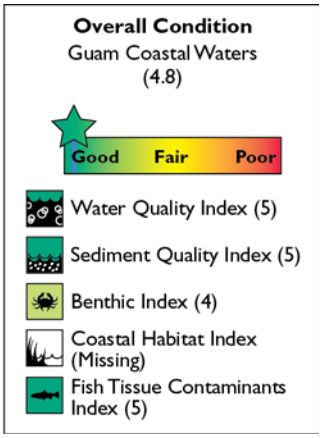


Figure 9-9. The overall condition of Guam's coastal waters is rated good (U.S. EPA/ NCA).

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

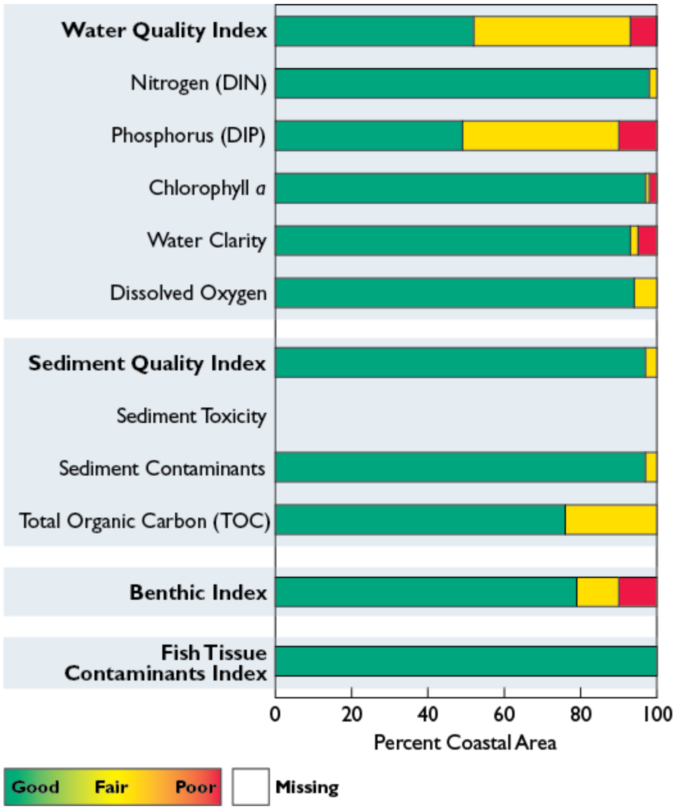


Figure 9-10. Percentage of coastal area achieving each ranking for all indices and component indicators—Guam (U.S. EPA/NCA).

The Island of Guam is a territory of the United States with an estimated population of about 171,000 in 2006, an area of 210 square miles, and a population density of 815 persons per square mile (Crossett et al., 2008; U.S. Census Bureau, 2010). Between 1980 and 2006, the island's population increased by 60%, from 107,000 to 171,000 people (Figure 9-11; U.S. Census Bureau, 2010), and the population is projected to continue to increase by an additional 13% between 2008 and 2015 (Crossett et al., 2008). However, this estimated additional increase does not account for the planned immigration of some 26,000 military personnel and dependents, in part due to transfer of a U.S. Marine Corps base from Okinawa to Guam by 2014. With associated economic immigrants, the population may increase by up to 38% in less than 10 years, to over 230,000 (Burdick et al., 2008).

Guam is the westernmost point of the United States (latitude 13° 28' N, longitude 144°45' E), and approximately 1.1 million tourists visit Guam annually, largely drawn by its tropical climate, coral reefs, and recreational waters. Guam's 117 miles of shoreline consist of an estimated 62% rocky coastline and 31% sandy beaches, with the remainder consisting of mangrove mud flats. There is also an estimated 1.2 square miles of seagrass beds (Guam Coastal Atlas, 2010). Compared to other regions considered in the NCCR IV, estuaries and coastal embayments are a small, but ecologically significant, component of Guam's coastal resources. Within the definition of the sampling area for the NCA assessment in Guam, estuarine systems make up only about 1.4 square miles along the coast, although there are an additional 10 square miles of marine bays, including the deepwater lagoon of Apra Harbor, the principle commercial and military anchorage and harbor on the island (Guam Coastal Atlas, 2010).

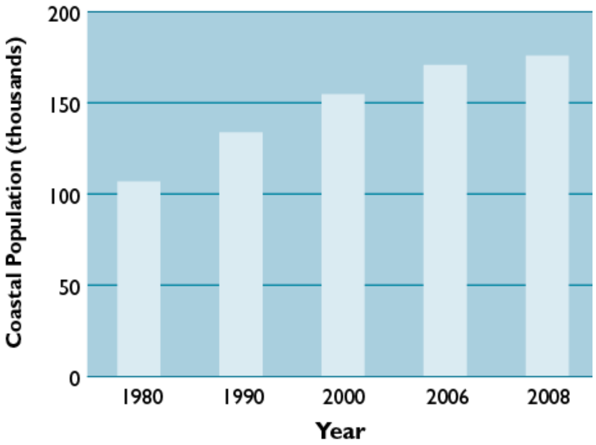


Figure 9-11. Population of counties in Guam from 1980 to 2008 (U.S. Census Bureau, 2010).
All counties in Guam are coastal.

Assigned designated uses for the marine waters of Guam are aquatic life preservation, protection, support, and propagation; primary recreation/whole body contact recreation and secondary recreation/limited body contact; and consumption. Likely stressors affecting these designated uses include sedimentation, point- and nonpoint-source inputs of nutrients and contaminants, thermal effluent, and impacts from shipping, boating, marinas, and tourist activities. Of particular concern with respect to coral habitats are sedimentation, freshwater runoff and associated pollutants, and heavy fishing pressure (Burdick et al., 2008).

The population of Guam is concentrated on the central and northern portions of the island (Crossett et al., 2008). Tumon Bay, the Waikiki of Guam, has high-density commercial development for the tourist industry along its shoreline. Apra Harbor houses both the commercial port for Guam, as well as a major naval base. The coastal systems in this area of Guam have shorelines that are, for the most part, highly altered, although Sasa Bay Marine Preserve, an area of mangrove habitat, is also located in Apra Harbor. The southern portion of Guam has a much lower population density (Crossett et al., 2008). Although one might presume that the magnitude of anthropogenic impacts would be highest in the waters bordering the most urbanized shorelines of Guam, geologic differences between the north and south sides of the island must also be taken into account. The northern karst terrain is highly porous and therefore has no rivers, so the northern coastal waters are relatively devoid of sedimentation due to the lack of discharge points. The southern portion of the island is volcanic with fine soils and small rivers. Due to challenges with land-based sources of pollution (e.g., fires, erosion, stormwater, aquaculture, farming), the southern watersheds tend to have poorer water quality.

Coastal Monitoring Data—Status of Coastal Condition

The Guam Environmental Protection Agency conducts monitoring of the physical and chemical condition of marine receiving waters, and there are a number of studies of point-source impacts or of marine water quality at localized scales (Bailey-Brock and Krause, 2007; Denton et al., 1999, 2005; Tsuda and Grosenbaugh, 1977). NOAA has conducted a series of rapid assessments of coral reef condition and is instituting a longer-term coral monitoring program on Guam (Burdick et al., 2008). However, there is a general lack of quantitative baseline information for water, sediment, and tissue pollutant concentrations for island marine waters as a whole. The NCA program, therefore, developed a collaborative project with the Guam Environmental Protection Agency to conduct a comprehensive assessment of Guam's coastal waters within the 60-foot depth contour. Field sampling commenced in Guam in 2004 and was completed in 2005.

Tumon Bay, Guam, with a view of coastal development.

Water Quality Index

The water quality index for Guam's coastal waters is rated good. The Guam water quality index was developed based on measurements of five component indicators: nitrate as nitrogen (NO_3-N), DIP, chlorophyll *a*, water clarity, and dissolved oxygen. This index differs from the standard NCA water quality index in substituting NO_3-N for DIN as the component indicator of nitrogen because the Guam Environmental Protection Agency has established a numeric water quality standard for NO_3-N in marine waters (Guam EPA, 2001); there is no such numeric standard for DIN. The cutpoints for assessing condition for the DIP and dissolved oxygen component indicators were also adopted from the water quality standards adopted by the Guam Environmental Protection Agency and thus differ from those used by NCA in other tropical locations.

Over half (52%) of the coastal area was rated good for the water quality index, 41% of the area was rated fair, and 7% of the coastal area was rated poor (Figure 9-12). Most cases of fair condition were driven by elevated concentrations of DIP. The finding that 41% of the area has fair water quality should be considered preliminary. As described below, water clarity measurements were not obtained at many stations. In addition to the five indicators incorporated into the water quality index, the Guam Environmental Protection Agency assessed concentration of *Enterococci* bacteria. All 50 sites sampled would rate good based on the Guam Environmental Protection Agency numeric cutpoints for a measurement at a single point in time.

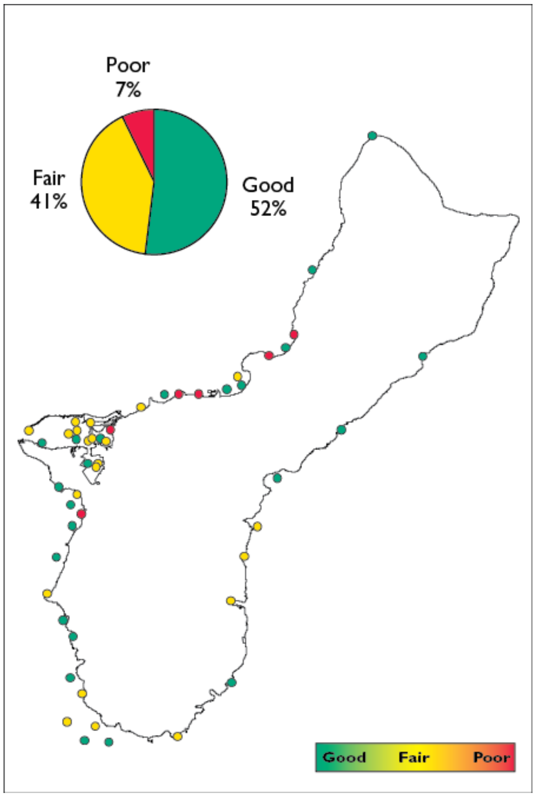


Figure 9-12. Water quality index data for Guam's coastal waters (U.S. EPA/NCA).

View of Talofofo Bay, Guam. Aquaculture ponds near the Talofofo River can be seen at the head of the Bay (photo – R. Calvo, Guam EPA).

Nutrients: Nitrogen and Phosphorus

Guam is rated good for NO_3-N concentrations, with only 2% of the coastal area rated fair for this component indicator. Sites with highest nitrate levels were located in Tumon Bay and near the mouth of the commercial port area within Apra Harbor. Blooms of green algae have been observed along the shoreline of Tumon Bay. The source of nutrients for these blooms has been identified as freshwater seepage, which was enriched by runoff from the urbanized developments in the region through the porous limestone substrate of this portion of the island (Denton et al., 2005).

Guam is rated fair for DIP concentrations based on the Guam Environmental Protection Agency water quality cutpoints for marine waters, with 10% of the coastal area rated poor and 41% rated fair for this component indicator. Stations rated poor for the DIP component indicator were located near the mouth of the commercial port area within Apra Harbor and within Talofofo and Ylig bays on the east coast of Guam. There is a considerable area of aquaculture ponds adjacent to Talofofo Bay, although it cannot be determined from this study if there is a relation of this land use to the water quality in the Bay.

Chlorophyll *a*

Guam is rated good for the chlorophyll *a* component indicator, with 2% of the coastal area rated poor and 1% rated fair. Sites rated poor or fair for chlorophyll *a* concentrations were located within Talofofo Bay and within the Sasa Bay mangrove area of Apra Harbor.

Water Clarity

Water clarity in Guam's coastal waters is rated good, based on an assessment of photosynthetically active radiation (PAR) in the water column. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 20% of surface illumination. Approximately 5% of the coastal area was rated poor for this component indicator, 2% of the area was rated fair, and 93% of the area was rated good. The evaluation of water clarity should be considered provisional. Due to equipment problems and implementation issues at very shallow water sites, data were collected at only 31 stations, which is minimal for attaining area estimates with the magnitude of error targeted by NCA. Poor water clarity was found at stations in Hagåtña and Agat bays, while fair water quality was found at Talofofo Bay. There is a WWTP outfall in the vicinity of the Hagåtña Bay stations.

Dissolved Oxygen

Dissolved oxygen condition in Guam's coastal waters is rated good based on the Guam Environmental Protection Agency marine waters standard, with only 6% of the area rated fair and none of the coastal area rated poor for this component indicator. The sites rated fair were widely distributed and included Talofofo Bay, the entrance to the commercial port, Sasa Bay at a shallow water mangrove site, and several locations in Agat Bay. At each of these stations, the dissolved oxygen concentrations were in the range of 4.3 to 4.8 mg/L. Although conditions in Guam appear to be generally good for dissolved oxygen, measured values reflect daytime conditions, some areas with restricted circulation may still experience hypoxic conditions at night.

Sediment Quality Index

The sediment quality index for Guam's coastal waters is rated good, with 3% of the coastal area rated fair and 97% of the area rated good for the sediment quality index (Figure 9-13). The sediment quality index was calculated based on measurements of three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Fair sediment quality ratings were driven by the fair ratings of the sediment contaminants component indicator.

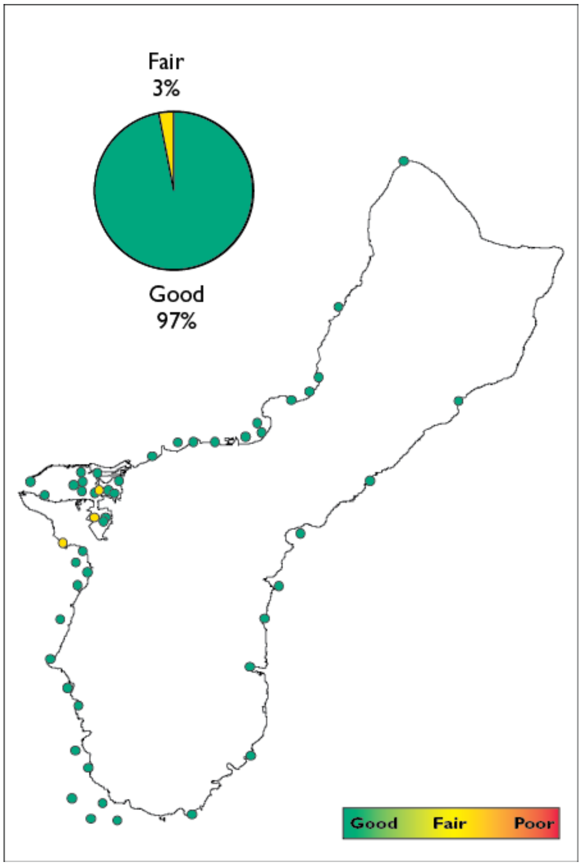


Figure 9-13. Sediment quality index data for Guam's coastal waters (U.S. EPA/NCA).

View of the commercial port area of Guam within Apra Harbor. Power plants are located at the head of the port area.

Sediment Toxicity

Guam's coastal waters received a highly qualified rating of good for sediment toxicity, with 71% of the coastal area rated good and 29% of the area rated fair for this component indicator. Guam sediments were tested for toxicity using sediment bioassays with the amphipod *Ampelica abdita*. Inspection of the sediment data showed no relationship between presence of sediment contaminants or sediment TOC and the survivorship of the bioassay species. The survival of this species may be negatively affected by sediments composed of more than 95% sandy sediments (U.S. EPA, 1996); approximately 72% of the Guam sediment samples contained greater than 95% sandy sediments. Thus, this bioassay may not be entirely suitable for Guam sediments. As a result of this issue, Guam toxicity results were determined differently from other NCA regions. For toxicity to be rated poor, survivorship of the test organism had to be less than 80% and the site also had to have a rating or poor for either the sediment contaminants index or the benthic community index. If survivorship was less than 80% and the sediment contaminants index or benthic community index was rated other than poor, the sediment toxicity index was rated fair. A fair rating in this context is considered as potentially toxic, but this status is not confirmed.

Sediment Contaminants

Guam's coastal waters are rated good for sediment contaminant concentrations, with 3% of the coastal area rated fair and 97% of the area rated good for this component indicator. Two of the three sites rated fair were located within Apra Harbor, where a high percentage of fine materials in the sediments indicated a depositional environment. The remaining site was located along the south shore of the Orote Peninsula, adjacent to the Apra Harbor Naval Reservation. These three sites were primarily rated fair due to elevated concentrations of metals (e.g., arsenic, chromium, copper, lead, mercury), although several sites also showed levels above the ERL for DDT and PCBs.

Nickel was excluded from the evaluation of sediment contamination in Guam's coastal waters. The ERM value for this metal has been shown to have a low reliability for areas of the U.S. Pacific 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).

Sediment TOC

The coastal waters of Guam are rated good for sediment TOC. A total of 24% of the coastal area was rated fair and 76% of the area was rated good. Sites that were rated fair for sediment TOC were widely distributed and showed no particular spatial pattern.

Benthic Index

The benthic community index for Guam's coastal waters is rated good to fair. A total of 11% of the coastal area was rated fair and 10% of the area was rated poor for benthic community condition (Figure 9-14). Insufficient data on benthic infaunal communities in the coastal waters of Guam were available to construct a fully validated benthic condition index; however, a provisional assignment of benthic community condition was made by inspection of benthic community indicators, such as soft sediment infaunal species richness and total abundance. A regression of species richness versus percent fines in the sediments indicated that a significant negative relationship was present. Sediments with more than 10% fines generally had decreased species richness and abundance, sometimes markedly so. Break points in the distribution of species richness and total abundance were used to assign condition scores. Stations with species richness greater than 20 per sample and abundance greater than 100 per sample were considered in good condition; stations with species richness less than 12 per sample and abundance less than 50 per sample were considered in poor condition; and stations with one of these two indicators in good range and neither indicator in the poor range were considered in fair condition.

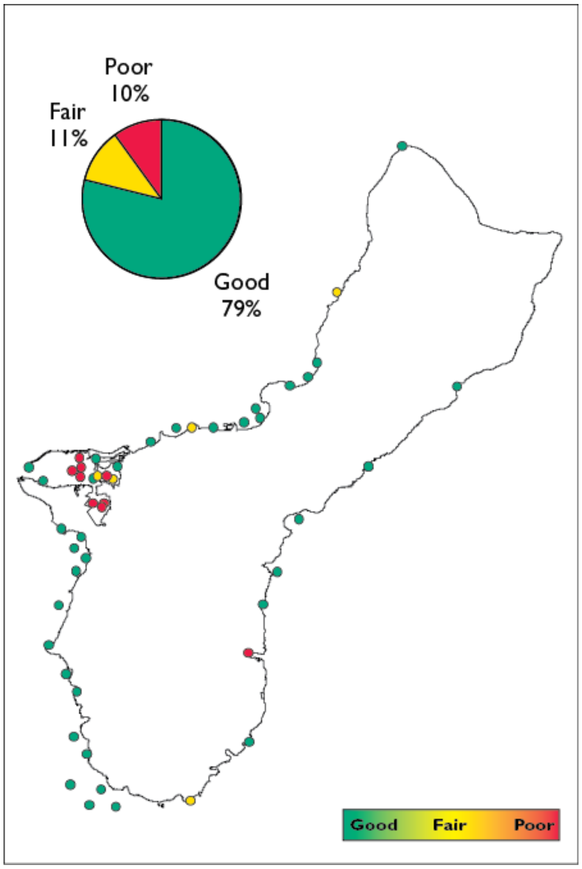


Figure 9-14. Benthic index data for Guam's coastal waters (U.S. EPA/NCA).

Coastal Habitat Index

Quantitative estimates of coastal habitat loss over time are not available for Guam; therefore, a coastal habitat index could not be calculated. It is clear that there have been major alterations and losses of coastal wetlands in Guam. Ellison (2009) lists a total present area of 173 acres for mangrove habitat on Guam. Modification of coastal wetlands prior to western contact was probably generally limited to the conversion of marshes into taro cultivation ponds. An estimated 1,236 acres of mangroves and freshwater marshes were destroyed between 1945 and 1950 (Wiles and Ritter, 1993), but the estimate does not separate the two habitat types.

Fish Tissue Contaminants Index

The fish tissue contaminants index for Guam is rated good, with 100% of the stations where fish were caught rated good (Figure 9-15). The fish tissue contaminant index rating is considered provisional because data are available for only 28 stations. Additionally, it is worth noting that only one sample was collected from some of the areas where contaminants have historically been present in Guam's waters (e.g., Apra Harbor and Cocos Lagoon).

The NCA survey of Guam conducted a feasibility study to determine whether sea cucumbers could be utilized to assess tissue body burdens of chemical contaminants. Various species of sea cucumbers were encountered (i.e., *Actinopyga mauritiana, Bohadschia argus, Bohadsia marmorata, Holothuria atra, Holothuria edulis, Holothuria nobulis, Holothuria* sp.), depending on station location, and generally one species per station was collected for analysis. Some heavy metals (e.g., arsenic, cadmium, zinc) were detected in sea cucumber tissue samples, but all metals were below levels of concern. Pesticides were almost never detected in the sea cucumber tissue samples, while PCBs were detected at low levels at only two stations.

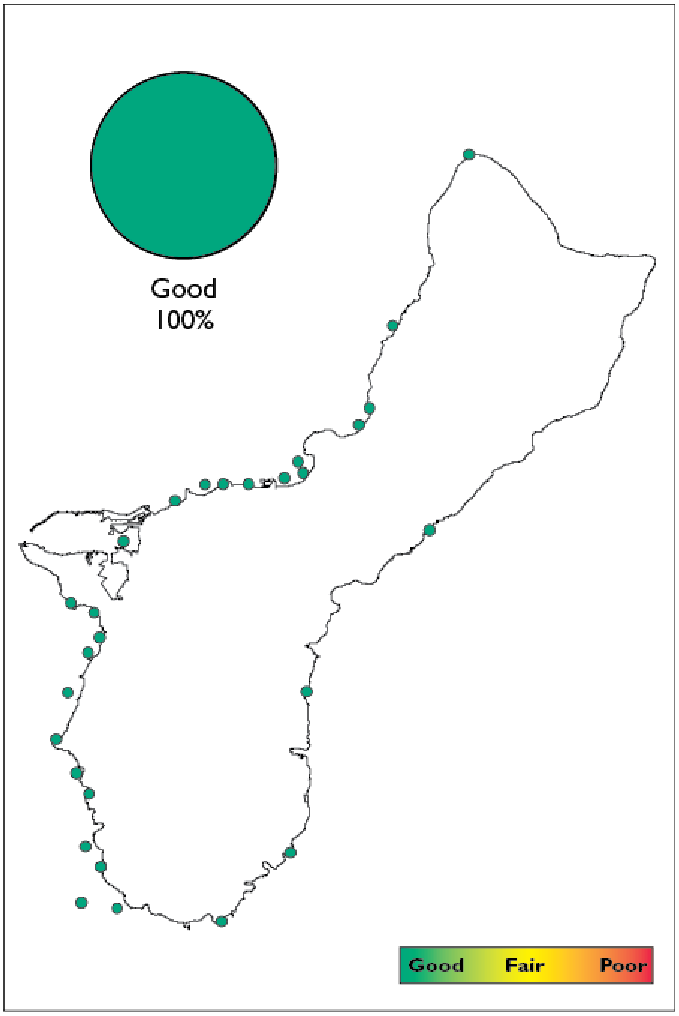


Figure 9-15. Fish tissue contaminants index data for Guam's coastal waters (U.S. EPA/NCA).

Large Marine Ecosystem Fisheries—Guam

Guam is not located within an LME, as designated by the NOAA. Fish landings in Guam are dominated by pelagic (water-column dwelling) species (about 510,000 pounds in 2006), primarily mahi mahi, wahoo, skipjack tuna, yellowfin tuna, and Pacific blue marlin (WPRFMC, 2011b). These fish are harvested using small trolling boats by fishermen who are generally employed in other industries, although most at some point sell portions of their catch. Fishermen also participate in the bottomfish (bottom-dwelling fish), crustacean, and coral reef fisheries, mostly for subsistence and cultural sharing purposes (e.g., fiestas, food exchanges). Within 3 miles of shore, Guam's fisheries are managed by the Territorial government. Between the 3-mile mark and the boundary of the U.S. EEZ, the fisheries are managed by the NMFS Western Pacific Regional Fishery Management Council, which regulates all fisheries by archipelago accept for the pelagic fisheries. Pelagic fisheries are managed under the *Pacific Pelagics Fishery Ecosystem Plan* (WPRFMC, 2009b). Guam's non-Territorial fisheries are managed under the *Mariana Archipelago Fishery Ecosystem Plan* (WPRFMC, 2009c), which utilizes an ecosystem-based management approach that emphasizes habitat, ecosystem, protected species, and community participation.

Advisory Data

Fish Consumption Advisories

Guam issued two coastal fish consumption advisories in 2001 (Figure 9-16) due to the presence of chlorinated pesticides, dioxins, and PCBs. Both advisories recommend that the general population not consume seafood from waters under advisory (U.S. EPA, 2007c).

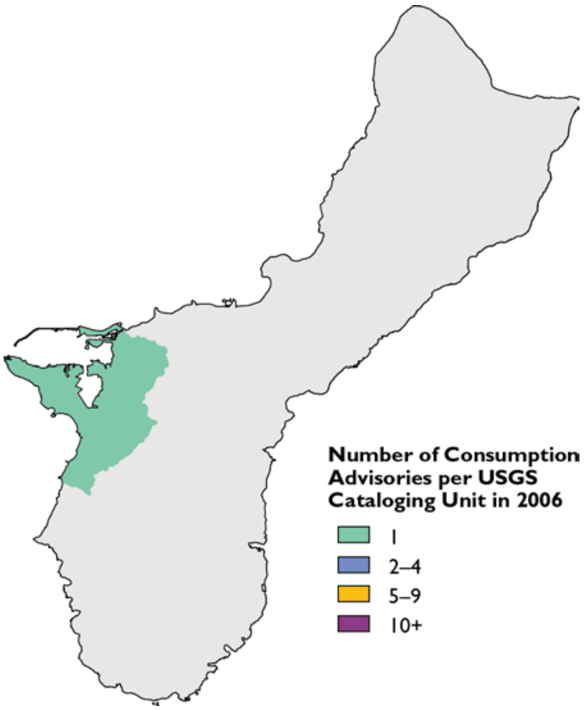


Figure 9-16. Fish consumption advisory for Guam, location approximate (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for Guam between 2004 and 2008?

Table 9-2 presents the number of total beaches and monitored beaches for the U.S. Pacific island territory of Guam, as well as the number and percentage of beaches affected by notification actions from 2005 to 2008. Since 2005, the total number of beaches and the number of monitored beaches decreased significantly, from 141 to 31 in 2008. Of these monitored beaches, the percentage closed or under advisory for some period of time during the year increased from 31% in 2005 to 100% in 2008 (or 31 beaches) (U.S. EPA, 2009d). Annual national and state summaries are available on EPA’s Beaches Monitoring Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Table 9-2. Beach Notification Actions, Guam, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	No data	141	33	33	31
Number of monitored beaches	No data	141	33	33	31
Number of beaches affected by notification actions	No data	43	33	29	31
Percentage of monitored beaches affected by notification actions	No data	31%	100%	88%	100%

Data on pollution sources for Guam's beaches were not available under the EPA BEACH Program at the time of publication.

How long were the 2007 beach notification actions for Guam?

In 2007, all of the beach notification actions in Guam lasted between 3 to 7 days (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Northern Mariana Islands

The Commonwealth of the Northern Mariana Islands consists of 14 islands in the North Pacific Ocean, formed by underwater volcanoes along the Marianas Trench about three-quarters of the way from Hawaii to the Philippines. The total land area of the Commonwealth is just 179 square miles, but the islands have a total coastline of 920 miles, which varies between the fringing coral reefs of the south and the volcanic northern islands. Between 1980 and 2006, the population of the Commonwealth grew by 259%, from 17,000 to 61,000 people (see Figure 9-17), with a population density of 453 persons per square mile in 2006.

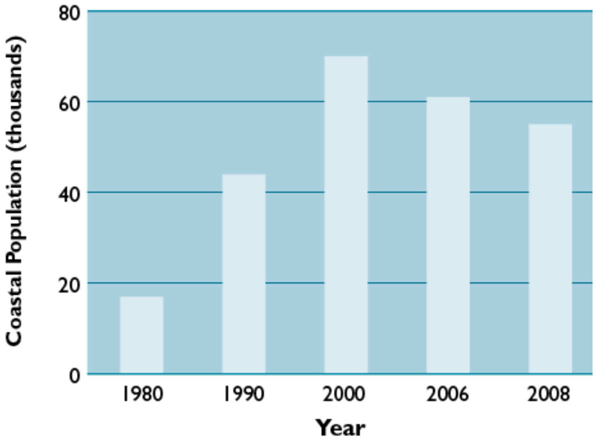


Figure 9-17. Population of counties in the Northern Mariana Islands from 1980 to 2008 (U.S. Census Bureau, 2010).

All counties are coastal.

Over 90% of the Commonwealth's 55,000 inhabitants (2008 estimate) reside on the island of Saipan, and the remaining 10% inhabit the Tinian and Rota islands. These three southern islands also encompass many of the Northern Mariana Islands' coral reefs. The island of Saipan offers diverse coral habitats, with both fringing and barrier coral reefs. Unfortunately, these reefs are also subject to pressures associated with coastal populations, including pollution from sewage outflows, wastewater disposal systems, sedimentation from rural runoff, and chemicals and nutrients from urban runoff. Since the economy of the Northern Mariana Islands is largely dependent on tourism, which centers on recreational marine activities, the maintenance of these reefs should be assessed in terms of their economic value.

Coastal Monitoring Data—Status of Coastal Condition

The Northern Mariana Islands have not been assessed by the NCA.

Large Marine Ecosystem Fisheries—Northern Mariana Islands

The Northern Mariana Islands are not located within an LME. Fish landings in the Northern Mariana Islands are dominated by pelagic (water-column dwelling) species, primarily skipjack tuna (about 250,000 pounds in 2007) harvested by small trolling boats for the local market (WPRFMC, 2011b) Fishermen also participate in the bottomfish (bottom-dwelling fish), crustacean, and coral reef fisheries, mostly for subsistence and cultural sharing purposes (fiestas and food exchanges). All waters around the Northern Mariana Islands are considered federal, and thereby under the jurisdiction of the Western Pacific Regional Fishery Management Council, which regulates all fisheries by archipelago, except for the pelagic fisheries. Pelagic fisheries are managed through the *Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region* (WPRFMC, 2009b). The fisheries of the Northern Mariana Islands are managed under the *Mariana Archipelago Fishery Ecosystem Plan* (WPRFMC, 2009c), which utilizes an ecosystem-based management approach that emphasizes habitat, ecosystem, protected species, and community participation. .

Advisory Data

Fish Consumption Advisories

The Northern Mariana Islands did not report fish consumption advisory information to EPA in 2006 (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for the Northern Mariana Islands between 2004 and 2008?

Table 9-3 presents the number of total beaches and monitored beaches for the Northern Mariana Islands, as well as the number and percentage of beaches affected by notification actions from 2005 to 2008. Since 2005, the total number of beaches, as well as the number of monitored beaches, decreased by one-third, from 75 to 50 in 2008. Of these monitored beaches, the percentage closed or under advisory for some period of time during the year remained fairly constant around 80% (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Table 9-3. Beach Notification Actions, Northern Mariana Islands, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	No data	75	76	76	50
Number of monitored beaches	No data	75	76	76	50
Number of beaches affected by notification actions	No data	61	56	61	39
Percentage of monitored beaches affected by notification actions	No data	81%	74%	80%	78%

Data on pollution sources for the beaches of the Northern Mariana Islands were not available under the EPA BEACH Program at the time of publication.

How long were the 2007 beach notification actions for the Northern Mariana Islands?

In 2007, all of the beach notification actions in the Northern Mariana Islands lasted between 3 to 7 days (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Puerto Rico

As shown in Figure 9-18, the overall coastal condition of Puerto Rico's coastal waters is rated fair, with an overall condition score of 2.7 based on three of the indices used by the NCA. Data to assess the water quality, sediment quality, and benthic indices were collected for the majority of the 50 sites sampled in 2004. The water quality index is rated good to fair, the benthic index is rated fair, and the sediment quality index is rated poor. NCA was unable to evaluate the coastal habitat or fish tissue contaminants indices for Puerto Rico. Figure 9-19 provides a summary of the percentage of coastal area in good, fair, poor, or missing categories for each index and component indicator for the Puerto Rico coastal resources survey in 2004.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

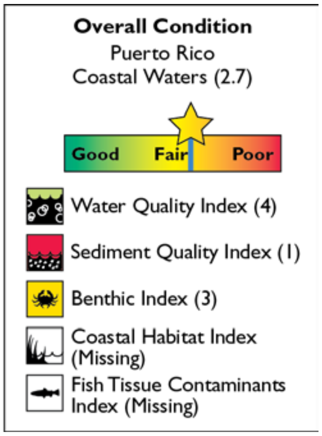


Figure 9-18. The overall condition of Puerto Rico's coastal waters is rated fair to poor (U.S. EPA/NCA).

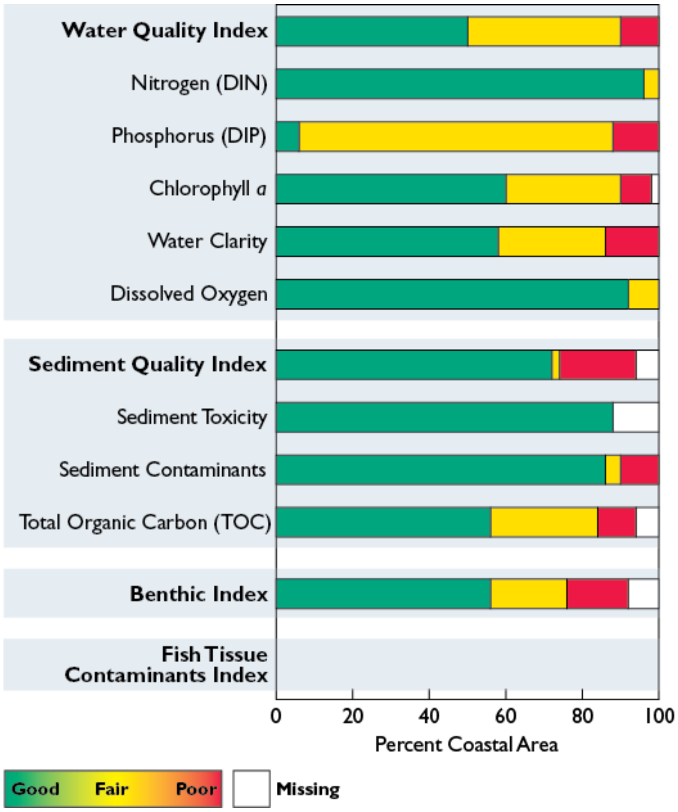


Figure 9-19. Percentage of coastal area achieving each ranking for all indices and component indicators—Puerto Rico (U.S. EPA/NCA).

The island of Puerto Rico is the smallest island of the Greater Antilles and part of the West Indian Province. The volcanic island's geography is mostly mountainous, with a coastal plain belt to the north consisting of sandy beaches along most of the coastal area. Puerto Rico is a densely populated Island Commonwealth of the United States, with approximately 1,146 people per square mile in 2006. Puerto Rico is home to 1.3% of the U.S. population, and the population has increased by 22% between 1980 and 2006, from 3.2 million to 3.9 million people (Figure 9-20) (U.S. Census Bureau, 2010). The majority of the population is concentrated in and around the coastal areas. The estuarine areas are heavily developed, with the island's industries focused in the vicinity of San Juan Bay.

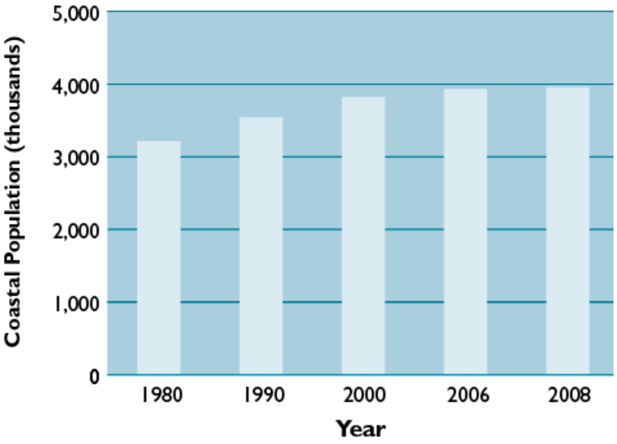


Figure 9-20. Population of Puerto Rico, 1980–2008 (U.S. Census Bureau, 2010).

Coastal Monitoring Data—Status of Coastal Condition

The 2004 assessment of Puerto Rico's coastal resources indicated that, for the indices and component indicators measured, the primary problems in Puerto Rico's coastal waters are degraded sediment quality, degraded benthos (low diversity), and some areas of poor water quality. Sampling stations with consistently low scores for the water quality, sediment quality, and benthic indices were located in San Juan Bay, Guanica Bay, Puerto Yabucoa, and Laguna San José.

Water Quality Index

The water quality index for Puerto Rico's coastal waters is rated good to fair. This water quality index was developed using five water quality indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Although only 10% of the coastal area was rated poor, 50% of the area was rated poor and fair, combined (Figure 9-21). Poor water clarity ratings paired with elevated DIP or chlorophyll *a* concentrations at individual sites resulted in poor water quality index scores.

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

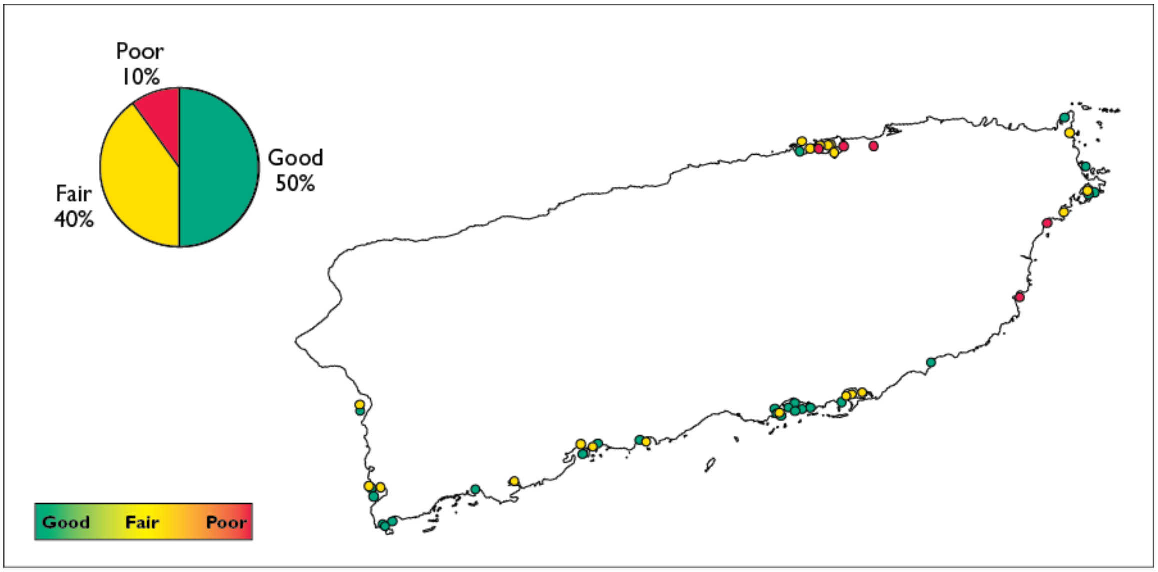


Figure 9-21. Water quality index data for Puerto Rico coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

DIN concentrations were rated good in Puerto Rico's coastal waters, and DIP concentrations were rated fair. For DIN, 4% of the coastal area was rated fair and none of the area was rated poor. The DIP component indicator was rated fair in 82% of the coastal area and poor in 12% of the area.

Chlorophyll *a*

Puerto Rico's coastal waters are rated good for the chlorophyll *a* component indicator, with 30% of the area rated fair and 8% rated poor.

Water Clarity

Water clarity for Puerto Rico is rated fair, with 28% of the coastal area rated fair and 14% of the area rated poor.

Dissolved Oxygen

The dissolved oxygen component indicator is rated good for Puerto Rico because only 8% of the coastal area is rated fair and the rest of the area is rated good.

Sediment Quality Index

Overall, sediment quality in Puerto Rico's coastal waters is rated poor. A sediment quality index was developed for Puerto Rico's coastal waters using three sediment quality component indicators: sediment toxicity, sediment contaminants, and sediment TOC. An estimated 20% of Puerto Rico's coastal area is rated poor for this index, and 2% of the area is rated fair (Figure 9-22). No overlap was identified for areas with elevated TOC concentrations and contaminated sediments.

Sediment Toxicity

Puerto Rico's sediment toxicity was rated good, with none of the coastal area rated poor. Sediment toxicity was not tested for 12% of the area.

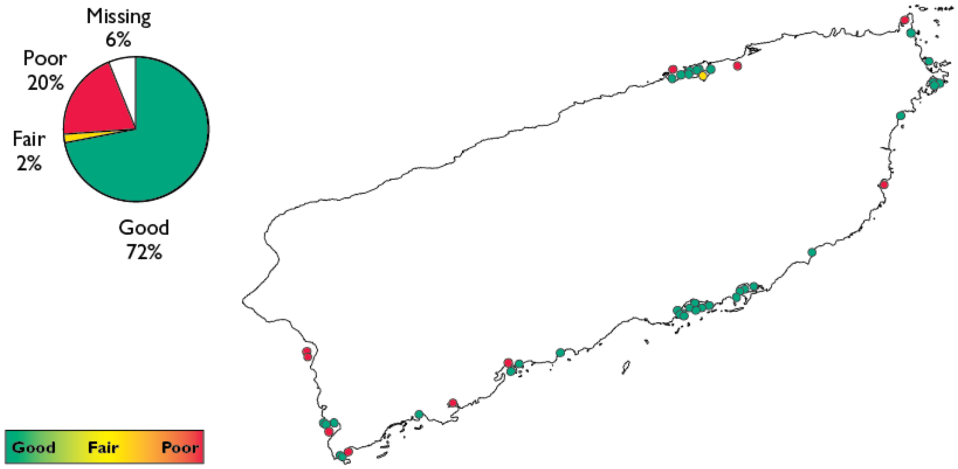


Figure 9-22. Sediment quality index data for Puerto Rico's coastal waters (U.S. EPA/NCA).

Sediment Contaminants

The sediment contaminants component indicator was rated poor for 10% of the coastal area and fair for 4% of the area, resulting in a fair rating for this indicator.

Sediment TOC

The sediment TOC component indicator is rated good for Puerto Rico, with 10% of the coastal area rated poor and 28% rated fair.

Benthic Index

The benthic index for Puerto Rico's coastal waters is rated fair based on deviation from the mean benthic diversity. Approximately 16% of the coastal area is rated poor and 20% is rated fair for this index (Figure 9-23). An additional 8% of the area had missing values.

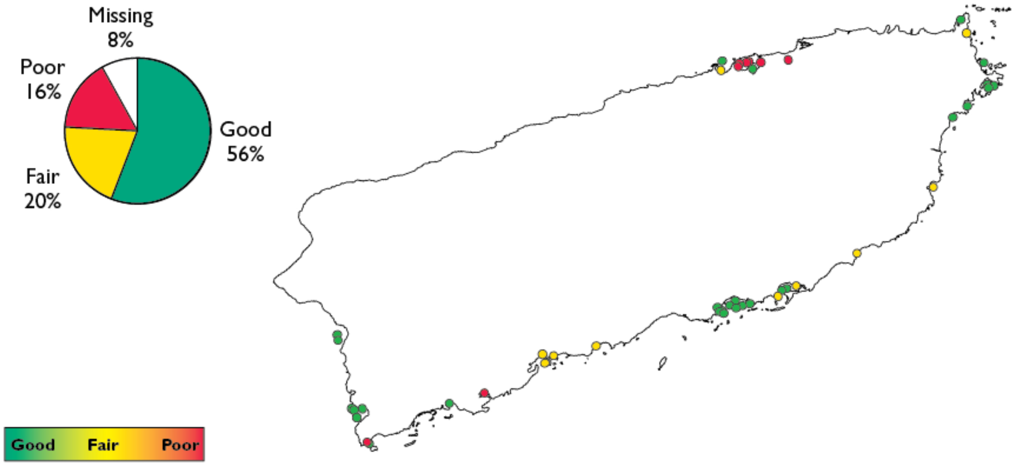


Figure 9-23. Benthic index data for Puerto Rico's coastal waters (U.S. EPA/NCA).

Coastal Habitat Index

Table 9-4 presents the types of wetlands in Puerto Rico between 1990 and 2005. Estimates of coastal habitat loss are not available for Puerto Rico; therefore, the coastal habitat index could not be calculated.

Table 9-4. Marine and Estuarine Wetlands of Puerto Rico (Dahl, 2010)

Type of Wetland	1990–2005 Era Status (acres)
Marine Intertidal	2,174
Estuarine Non-Vegetated	3,685
Estuarine Emergent	13,885
Estuarine Shrub/Forested	23,964
Estuarine Vegetated (subtotal)	37,849
All Intertidal Wetlands	43,708

Fish Tissue Contaminants Index

Fish tissue samples were not collected for 2004 NCA survey of Puerto Rico; therefore, a fish tissue contaminants index could not be calculated. A fish tissue index was calculated from samples collected from San Jose Lagoon and reported for the San Juan Bay Estuary in the 2006 *National Estuary Program Coastal Condition Report* (U.S. EPA, 2006). Based on concentrations of contaminants found in fish and crustacean tissues during the San Jose Lagoon survey, 40% of the sites sampled exceeded EPA Advisory Guidance values for consumption, rendering the calculated fish tissue contaminant index poor for this National Estuary Program waterbody (U.S. EPA, 2006).

Trends of Coastal Monitoring Data—Puerto Rico

In 2000, the first NCA survey conducted in Puerto Rico indicated that the ecological condition of the estuarine resources were in fair to poor condition. Poor condition was mainly attributed to consistently low scores for water quality, sediment quality, and benthic diversity within the areas of San Juan Harbor, the Caño Boquerón, Laguna del Condado, and Laguna San José (U.S. EPA, 2004a). In 2000, the sampling efforts were intensified in San Juan Bay. Differences in results from the 2000 survey and the 2004 assessment presented here may be due to the changes in sample design. However, in areas with recurring degraded ecological conditions, further investigation of potential causes is warranted.

In both surveys, the water quality index was rated fair. In the NCCR II for the 2000 Puerto Rico survey, the water quality scores were attributed to poor chlorophyll *a* scores and fair water clarity. The percent of the coastal area in poor condition for the sediment quality index decreased from over 60% in the 2000 survey to 20% in the 2004 survey. Puerto Rico's rating for the benthic index improved from poor for the 2000 survey to fair for the 2004 survey. With two surveys completed (2000 and 2004) for Puerto Rico, there is sufficient information to develop a benthic index for the island commonwealth. Such an index is needed to examine the relationship between benthic diversity and benthic community structure and habitat to determine whether or not benthic communities are considered degraded for Puerto Rico coastal areas.

Large Marine Ecosystem Fisheries—Caribbean Sea LME

The semi-enclosed Caribbean Sea LME, bounded by the Southeast U.S. Continental Shelf and Gulf of Mexico LMEs, Central America, South America, and the Atlantic Ocean, is considered a moderate-productivity ecosystem with localized areas of higher productivity along the coast of South America (Figure 9-24). This LME is bordered by 38 countries and dependencies (NOAA, 2007a). Commercial fishermen in the Caribbean Sea LME focus mostly on the reef and invertebrate groups. Recreational fishers mainly target dolphinfish, barracuda, snappers, tuna, and wahoo.

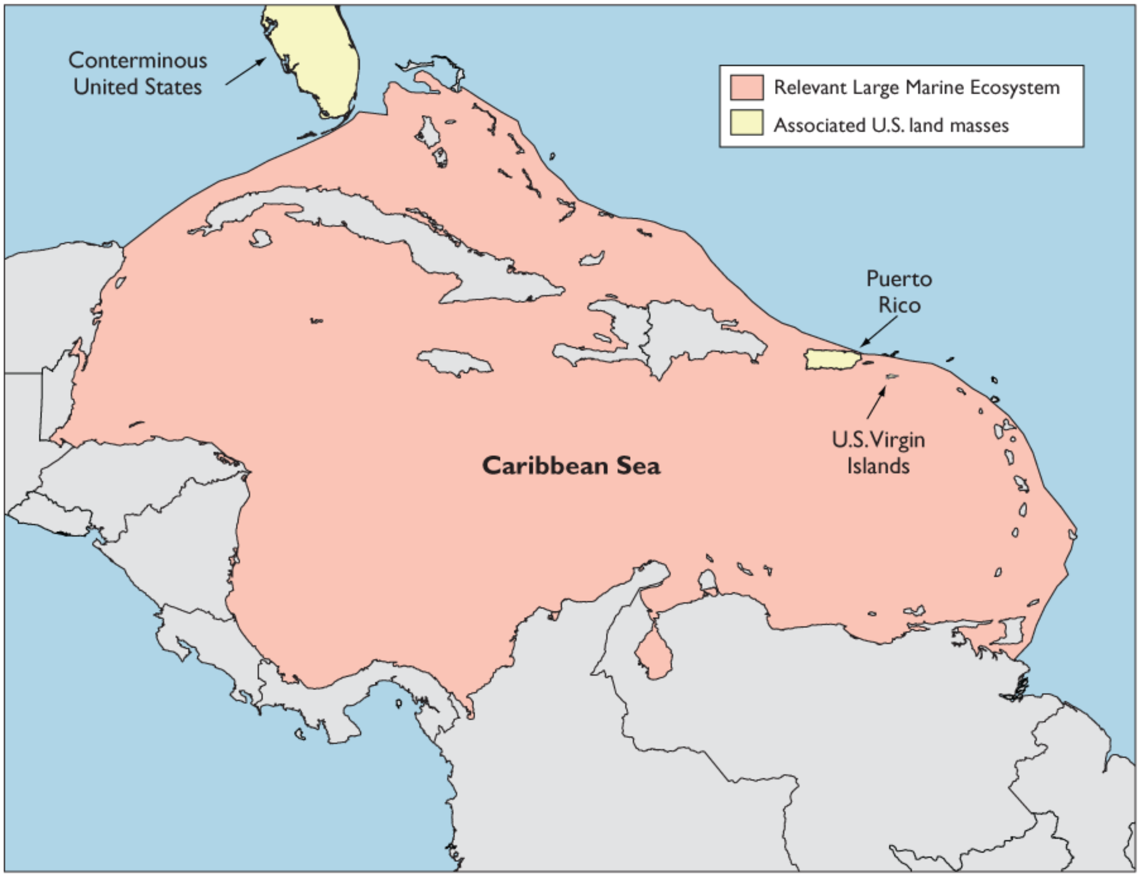


Figure 9-24. Caribbean Sea LME (NOAA, 2010b).

Reef Fisheries

Reef fish of the Caribbean Sea LME include a variety of structure-associated species that reside on coral reefs, artificial structures, or other hard-bottom areas, as well as tilefish that live in muddy-bottom and continental shelf areas. These fish, which include red snapper and grouper, occur at depths ranging from 6 to over 650 feet. Reef -fish fisheries are extremely diverse; vary greatly by location and species; and are utilized by commercial, subsistence, and recreational fisheries for food, commerce, sport, and trophies. These fisheries operate from charter boats, head boats, private boats, and the shore and utilize a range of gear such as fish traps, hook and line, longlines, spears, trammel nets, bang sticks, and barrier nets. Reef fish are associated closely with fisheries for other reef animals, including spiny lobster, conch, stone crab, corals, and live rock and ornamental aquarium species. Non-consumptive uses of reef resources (e.g., ecotourism, sport diving, education, scientific research) also are economically important and may conflict with traditional commercial and recreational fisheries.

Many reef fishes are vulnerable to overfishing due to life-history characteristics, such as slow growth, late maturity, ease of capture, and large body size. Consequently, many stocks are currently considered overfished, including red snapper and gray triggerfish. Fishing may have direct and indirect effects on reef fish ecosystem structure and production. Removals of apex predators from the reef complex may result in shifts of species composition (i.e., trophic and ecological cascades), increased variability in population dynamics of targeted species, and potential evolutionary effects on targeted species. Bycatch is also an area of concern, increasing mortality rates for non-targeted species. Information on species interactions (e.g., predator-prey dynamics) is necessary to guide multi-species assessments and facilitate the movement towards ecosystem management.

Total U.S. reef fish landings in the Caribbean Sea LME have decreased since 1980 (Figure 9-25). At the same time, international pressure on these fishery resources has increased due to growing human populations, greater demands for fishery products, and technological improvements. The Caribbean Fishery Management Council (CFMC) manages reef-fish fisheries within the U.S. EEZ off of the Commonwealth of Puerto Rico and the U.S. Virgin Islands. The Council has developed a FMP for reef fisheries that includes a combined total of 117 reef fish species harvested for human consumption or for the aquarium trade (CFMC, 1996b).

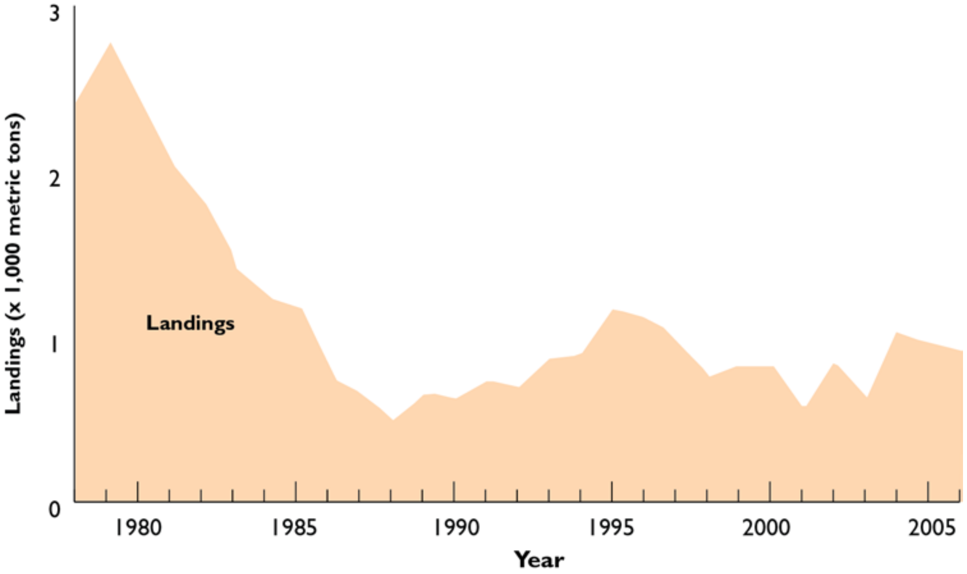


Figure 9-25. U.S. Caribbean Sea LME reef fish landings in metric tons, 1978–2006 (NMFS, 2009b).

Invertebrate Fisheries

Invertebrate fisheries in the Caribbean Sea LME harvest shrimp, spiny lobster, stone crab, and conch. The fishery for spiny lobster in the U.S. Caribbean territories is small. Annual spiny lobster landings for Puerto Rico have averaged 104 metric tons since 1990. U.S. Virgin Islands landings for 1980–2006 were fairly stable, averaging 28 metric tons. In the U.S. Caribbean, spiny lobster is caught primarily by fish traps, lobster traps, and divers (NMFS, 2009b). The CFMC's *Spiny Lobster Fishery Management Plan* (CFMC et al., 2008) is based on a 3.5-inch minimum carapace length and protection of egg-bearing female lobsters (Bolden, 2001).

The conch fishery targets the queen conch (*Strombus gigas)*, most of which are taken by divers. Queen conch is a mollusk with a spiral-shaped shell and a pink or orange interior. It can reach a weight of 5 pounds and a length of 12 inches. Conch are mostly harvested for direct human consumption, though their meat may also be used for bait, and their shells are often used for jewelry. The resource can be easily depleted, and the queen conch is covered by an FMP (CFMC, 1996a). For the 2004−2006 time period, the recent conch average yield is 110 metric tons (NMFS, 2009b). Queen conch is considered overfished, largely due to trap fishing and bycatch associated with the reef fisheries (NMFS, 2009b).

Habitat concerns impact many of the Caribbean invertebrate fishery resources. Estuarine and marsh loss removes critical habitat used by young shrimp (Minello et al., 2003). Spiny lobsters depend on reef habitat and shallow water algal flats for feeding and reproduction, but these habitat requirements may conflict with expanding coastal development.

Advisory Data

Fish Consumption Advisories

Puerto Rico did not report fish consumption advisory information to the EPA in 2006 (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for Puerto Rico between 2004 and 2008?

Table 9-5 presents the number of total and monitored beaches for Puerto Rico from 2004 to 2008, as well as the number and percentage of beaches affected by notification actions over this same time period. Over the past several years, the total number of identified and monitored beaches in Puerto Rico has fluctuated between 22 and 23. Of these monitored beaches, the percentage closed or under advisory for some period of time during the year increased from 5% in 2004 to 50% in 2008 (or 11 beaches) (U.S. EPA, 2009d). Annual national and state summaries are available on EPA's Beaches Monitoring Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Table 9-5. Beach Notification Actions, Puerto Rico, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	22	23	23	23	22
Number of monitored beaches	22	23	23	23	22
Number of beaches affected by notification actions	1	5	8	14	11
Percentage of monitored beaches affected by notification actions	5%	22%	35%	61%	50%

Data on pollution sources is not available under the EPA BEACH Program for Puerto Rico.

How long were the 2007 beach notification actions?

Just over half of beach notification actions in Puerto Rico in 2007 lasted from 3 to 7 days. The other half of the notification actions was comprised of those lasting from 8 to 30 days (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

U.S. Virgin Islands

As shown in Figure 9-26, the overall coastal condition of the U.S. Virgin Islands' coastal waters is rated good to fair based on three of the indices used by NCA. Both the water quality and benthic diversity indices are rated good, and the sediment quality index is rated fair to poor. NCA was unable to evaluate the coastal habitat or fish tissue contaminant indices for the U.S. Virgin Islands. Figure 9-27 provides a summary of the percentage of coastal area in good, fair, or poor categories for each index and component indicator. This assessment for the U.S. Virgin Islands is based on results from 47 sites sampled in 2004.

Please refer to Chapter 1 for information about how these assessments were made, the cutpoints used to develop the rating for each index and component indicator, and the limitations of the available data.

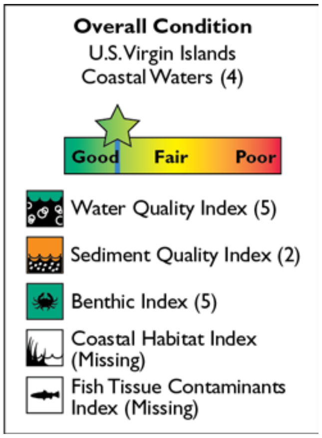


Figure 9-26. The overall condition of the U.S. Virgin Islands' coastal waters is rated good to fair (U.S. EPA/NCA).

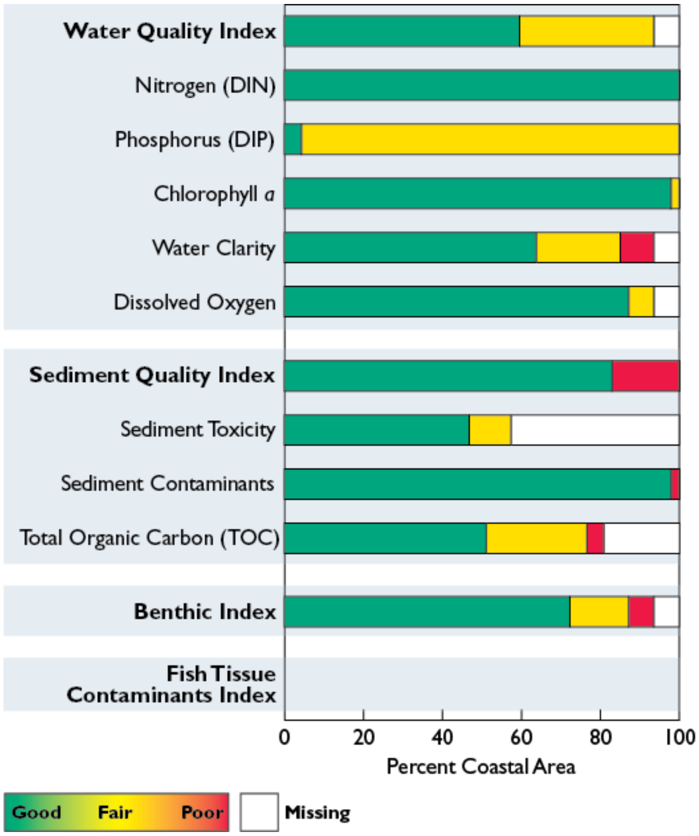


Figure 9-27. Percentage of coastal area achieving each ranking for all indices and component indicators—U.S. Virgin Islands (U.S. EPA/NCA).

The U.S. Virgin Islands are part of the West Indian Province. The combined coastline of the islands is approximately 117 miles. The islands of St. John and St. Thomas are of volcanic origin, with hilly terrains, while St. Croix has a gentle sloping topography and is built of coral reefs. Between 1980 and 2006, the population of the U.S. Virgin Islands increased by approximately 12%, from 98,000 people to

110,000 people (Figure 9-28). In 2006, the population density was 613 persons per square mile (U.S. Census Bureau, 2010). Charlotte Amalie, the capital city of the U.S. Virgin Islands, is a popular port of call for cruise ships in St. Thomas, with more than a million passengers passing through each year. The islands are characterized by natural deep-water harbors, beautiful beaches, and National Park areas, all of which draw industry, trade, and tourism to these U.S. island territories.

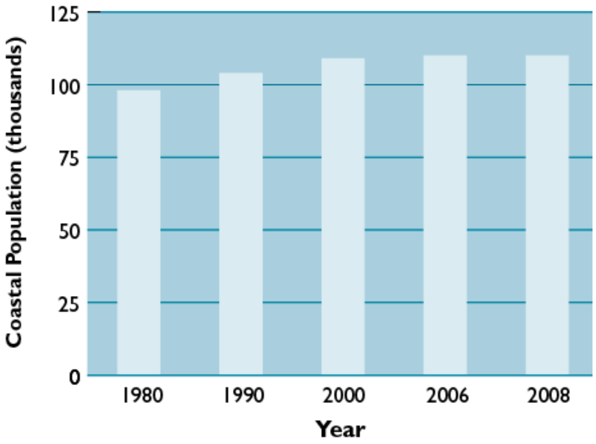


Figure 9-28. Population of the U.S. Virgin Islands, 1980–2008 (U.S. Census Bureau, 2010).

Coastal Monitoring Data—Status of Coastal Condition

Water Quality Index

The water quality index for the U.S. Virgin Islands coastal waters is rated good, with 34% of the coastal area rated fair and none rated poor (Figure 9-29). This water quality index was developed using five water quality indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Decreased water clarity and elevated DIP concentrations (fair) contributed to fair water quality scores.

The NCA monitoring data used in this assessment are based on single-day measurements collected at sites throughout the U.S. coastal waters (excluding the Great Lakes) during a 9- to 12-week period during the summer. Each site was sampled once during the collection period of 2003 through 2006. Data were not collected during other time periods.

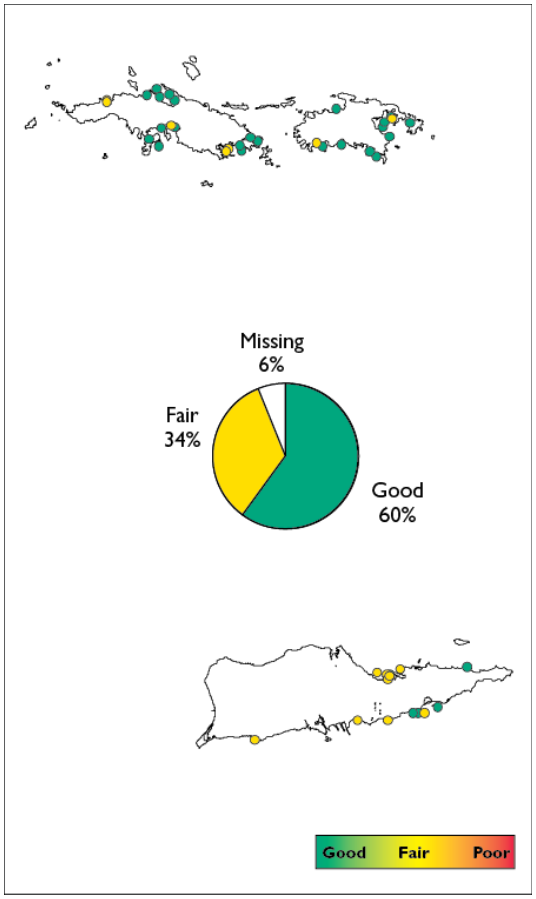


Figure 9-29. Water quality index data for the U.S. Virgin Islands coastal waters (U.S. EPA/NCA).

Nutrients: Nitrogen and Phosphorus

The U.S. Virgin Islands are rated good for DIN, with 100% of the coastal area rated good for this component indicator. The DIP component indicator is rated fair because 96% of the U.S. Virgin Islands coastal area is rated fair.

Chlorophyll *a*

The chlorophyll *a* component indicator is rated good for the U.S. Virgin Islands, with 98% of the coastal area rated good and 2% rated fair.

Water Clarity

Water clarity is rated good in the U.S. Virgin Islands. Approximately 21% of the coastal area is rated fair and 9% is rated poor.

Dissolved Oxygen

The U.S. Virgin Islands are rated good for dissolved oxygen, with 7% of the coastal area rated fair and none rated poor for this component indicator.

Sediment Quality Index

The sediment quality index is rated fair to poor for the U.S. Virgin Islands. The sediment quality index was calculated for the U.S. Virgin Islands using component indicators for sediment toxicity, sediment contaminants, and sediment TOC. Approximately 17% of the survey area exhibited poor sediment quality (Figure 9-30). Elevated TOC and sediment toxicity were found at various sites across the islands of St. Croix, St. Thomas, and St. Johns.

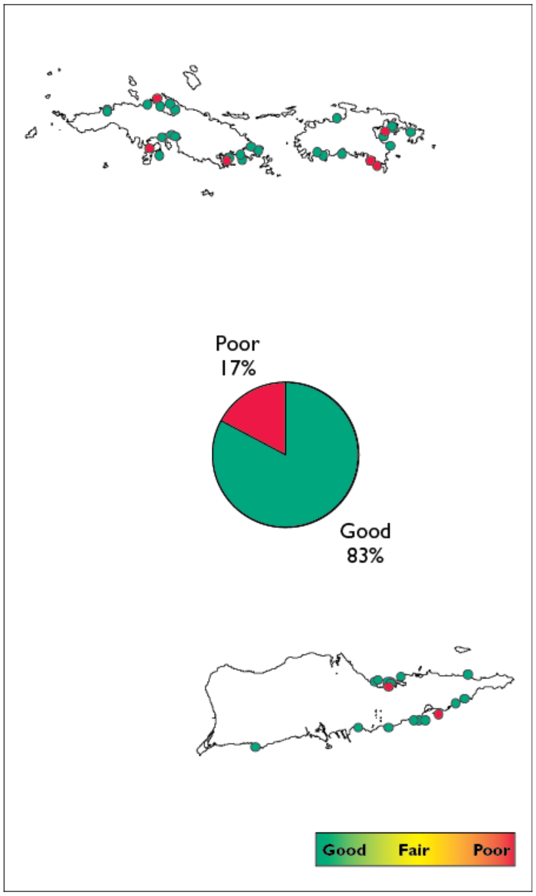


Figure 9-30. Sediment quality index data for U.S. Virgin Islands' coastal waters (U.S. EPA/NCA).

Sediment Toxicity

The sediment toxicity component indicator is rated poor for the U.S. Virgin Islands. Although only 11% of the coastal area is rated poor for this indicator, results are missing for 42% of the area.

Sediment Contaminants

The U.S. Virgin Islands are rated good for the sediment contaminants component indicator, with 2% of the coastal are rated poor and 98% rated good. The sites rated poor were located in Christenstead Harbour, a capital city port of the island of St. Croix, and demonstrated elevated levels of chromium, copper, and lead.

Sediment TOC

The sediment TOC component indicator is rated good for the U.S. Virgin Islands, with 26% of the area rated fair and 4% rated poor. Results were missing for 19% of the coastal area.

Benthic Index

The benthic index for the U.S. Virgin Islands is rated good based on deviation from the mean benthic diversity. Approximately 6% of the coastal area is rated poor and 15% is rated fair for this index (Figure 9-31). An additional 7% had missing values.

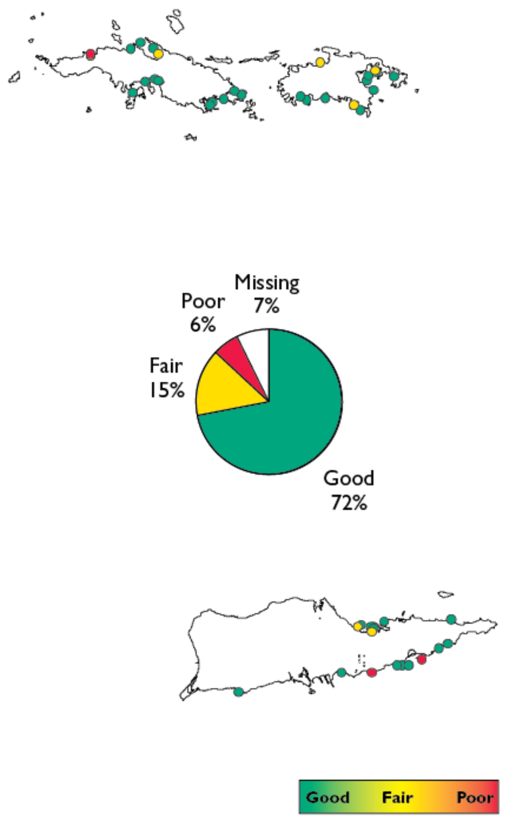


Figure 9-31. Benthic index data for U.S. Virgin Islands' coastal waters (U.S. EPA/NCA).

Coastal Habitat Index

Table 9-6 presents the types and extents of wetlands in U.S. Virgin Islands between 1990 and 2005, as well as the change in the wetlands' extents over this timeframe. These estimates of coastal habitat loss do not cover the time period necessary to calculate the coastal habitat index (see Chapter 1 for more information); therefore, the coastal habitat index could not be calculated.

Table 9-6. Marine and Estuarine Wetlands of U.S. Virgin Islands (Dahl, 2010)

Type of Wetland	1990 Era (acres)	2005 Era (acres)	Change (acres)
Marine intertidal	18	112	94
Estuarine non-vegetated	467	405	-62
Estuarine emergent	1	8	7
Estuarine shrub/forested	663	617	-46
Estuarine vegetated (subtotal)	664	625	-39
All intertidal wetlands	1149	1142	-7

Fish Tissue Contaminants Index

Estimates of fish tissue contaminants were not available for U.S. Virgin Islands; therefore, the fish tissue contaminants index could not be calculated.

Large Marine Ecosystem Fisheries—Caribbean Sea LME

The U.S. Virgin Islands are located within the Caribbean Sea LME, which is discussed in the Puerto Rico section of this chapter.

Advisory Data

Fish Consumption Advisories

The U.S. Virgin Islands did not report fish consumption advisory information to the EPA in 2006 (U.S. EPA, 2007c).

Beach Advisories and Closures

How many notification actions were reported for the U.S. Virgin Islands between 2004 and 2008?

Table 9-7 presents the total number of beaches, the number of monitored beaches, the number of beaches affected by notification actions, and the percentage of monitored beaches affected by notification actions from 2005 to 2008 for the U.S. Virgin Islands. Over the past several years, the total number of beaches and the number of monitored beaches has decreased from 45 in 2005 to 43 in 2008. Of these monitored beaches, the percentage closed or under advisory for some period of time during the year has decreased markedly from 71% in 2005 to 19% in 2008 (or 8 beaches) (U.S. EPA, 2009d). Individual state summaries are available on EPA's Beaches Monitoring Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

Table 9-7. Beach Notification Actions, Virgin Islands, 2004–2008 (U.S. EPA, 2009d)

Numbers and Percentages	2004	2005	2006	2007	2008
Total number of beaches	No data	45	45	45	43
Number of monitored beaches	No data	45	45	45	43
Number of beaches affected by notification actions	No data	32	8	3	8
Percentage of monitored beaches affected by notification actions	No data	71%	18%	7%	19%

Data on pollution sources is not available under the EPA BEACH Program for the U.S. Virgin Islands.

How long were the 2007 beach notification actions?

For 2007, all of the beach notification actions lasted between 3 to 7 days (U.S. EPA, 2009d). For more information on state beach closures, please visit the EPA's Beaches Web site: http://water.epa.gov/type/oceb/beaches/beaches_index.cfm.

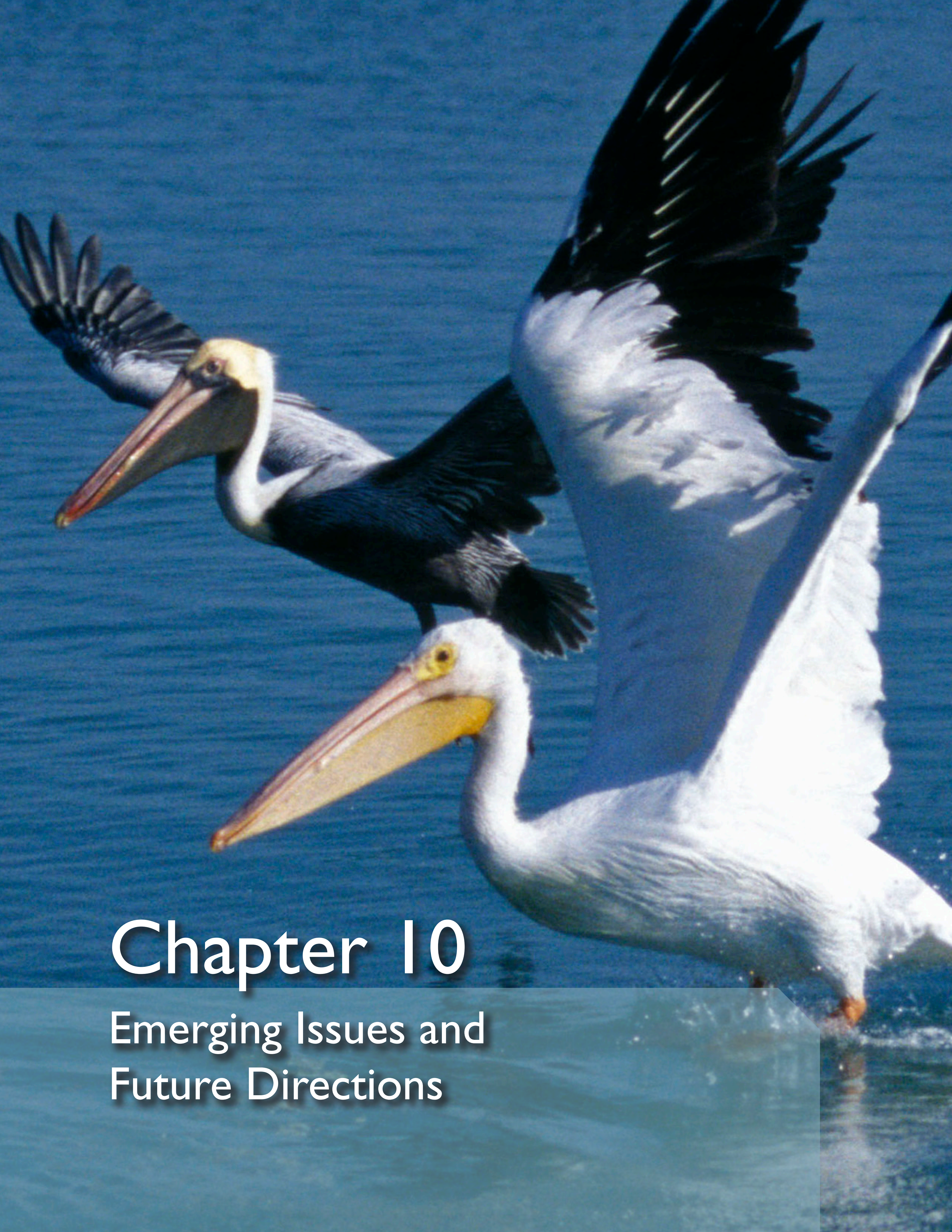
Summary

In 2004, NCA assessed the coastal areas of the U.S. territories of American Samoa, Guam, and the U.S. Virgin Islands, and the Commonwealth of Puerto Rico. The overall condition of American Samoa coastal waters is good based on ratings for water quality and fish tissue contaminants. Guam's coastal waters are also rated good, with all indices measured rated good except benthic condition, which was rated good to fair. NCA did not perform assessments for the Northern Mariana Islands. The overall coastal condition of Puerto Rico's coastal waters is rated fair, with the water quality index rated good to fair, the benthic index rated fair, and the sediment quality index rated poor. The U.S. Virgin Islands' coastal waters are rated good to fair, with both water quality and benthic diversity indices rated good, and the sediment quality index rated fair to poor.

Guam and American Samoa are not located within LMEs. The NMFS Western Pacific Region manages the fisheries in these waters in conjunction with those of the Insular Pacific-Hawaiian LME. Landings from the waters surrounding American Samoa, Guam, and the Northern Mariana Islands are dominated by highly migratory pelagic species. Puerto Rico and the U.S. Virgin Islands are located in the Caribbean Sea LME, and the reef fish stocks in their coastal waters are managed by the CFMC. Fishing pressure in these areas has increased over time, along with growing human populations, greater demands for fishery products, and technological improvements. Many stocks with a known status are currently considered overfished.

Contamination in the coastal waters of American Samoa and Guam has affected human uses of these waters. American Samoa had one advisory in effect in 2006 for Inner Pago Pago Harbor due to arsenic, chromium, copper, DDT, lead, mercury, zinc, and PCBs. Two advisories were in effect for Guam's Orote Point and Apra Harbor for chlorinated pesticides, dioxins, and PCBs. Puerto Rico, the Northern Mariana Islands, and the U.S. Virgin Islands did not report fish consumption advisory information to EPA in 2006.

Ninety-three percent of American Samoa's monitored beaches were closed or under advisory for some period of time during 2006 due to contamination. Guam monitored 33 beaches in 2006, all of which were closed or under advisory at some time during the year due to contamination. The Northern Mariana Islands issued beach advisories or closures for 74% of monitored beaches in 2006. In Puerto Rico and the U.S. Virgin Islands, 35% and 18% of beaches, respectively, were affected by advisories or closures in 2006.



Chapter 10

Emerging Issues and Future Directions

10. Emerging Issues and Future Directions

Over the past decade, national coastal monitoring programs have consistently adapted to changing national priorities and emerging issues. As demand for coastal and marine resources increases due to growing populations and development, ecosystems are affected by the resulting environmental stress. The combination of multiple coastal stressors (e.g., invasive species, hypoxia, emerging contaminants, climate change) will impact ecosystem function, likely undermining the provision of ecosystem services to human well-being. This chapter presents the complexities of these combinations and stresses the need for targeted coastal monitoring efforts.

Each consecutive report in the NCCR series has presented an expanded spatial extent of sampling, improved indices, and the current state of coastal monitoring science. Such improvements will continue as the NCA becomes the National Coastal Condition Assessment (NCCA), under the purview of the EPA's Office of Water (OW), for the next NCCR (*National Coastal Condition Report V*). The NCCA will be part of the National Aquatic Resource Survey program, an effort to assess the quality of various U.S. aquatic resources, including lakes, rivers and streams, and wetlands (see http://www.epa.gov/OWOW/monitoring/nationalsurveys.html). As part of this transformation, the NCCA will reflect changing priorities with greater focus on human health and evolving coastal issues. The NCCA will also include, for the first time, sampling in the Great Lakes and updated sampling for the non-conterminous U.S. states and territories (with the exception of Alaska). The latest addition to the NCCR list of indicators under the NCCA is bacterial contamination. This indicator reflects the evolution of the NCCA program towards prioritizing human health, as well as a general effort to expand estuarine monitoring efforts to assess other existing and emerging coastal issues. In addition, EPA has formed indicator workgroups to reassess the indices, component indicators, and cutpoints prior to the data analysis for the NCCR V.

Improvements in coastal programs are occurring on a much greater scale as well. Under a directive from President Obama, an Interagency Ocean Policy Task Force was formed in June of 2009 to streamline federal decision making and management of activities in our nation's coastal and ocean waters. The Task Force drafted a set of recommendations that highlighted nine priority areas, including regional ecosystem protection and the integration of ocean observing systems and data platforms (White House Council on Environmental Quality, 2009). The NCA program is particularly relevant to this effort because it provides geospatially referenced coastal environmental data that are based on regional ecosystem delineations and integrate information from other federal agencies. The Task Force also drafted the CMSP Framework (discussed in Chapter 2), which provides for a comprehensive and integrated approach to facilitating multiple uses and activities in the nation's coastal waters without undermining the services generated by coastal ecosystems.

Ecosystem Services

Our nation's ecosystems provide vast amounts of services that generate numerous social and economic benefits to individuals and society as a whole. These benefits range from energy production and nutrient cycling to education and recreational activities. For example, although estuaries comprise only 13% of the land area of the continental United States, they account for a large proportion of national ecosystem services, including the provision of seafood and pharmaceuticals, waste treatment, waste cycling, coastal protection, and income generation from tourism and recreational activities.

Despite the benefits to human health and social well-being ensured by these services, a lack of scientific and socioeconomic knowledge has prevented policy makers from fully considering ecosystem services in planning efforts. In order to minimize this gap, researchers in EPA's Office of Research and Development developed the Ecosystem Services Research Program (ESRP) to identify, map, model, and quantify ecosystem services. The decision support framework generated by this program will provide managers with the tools to make decisions with knowledge of the value ecosystem services provide and the potential costs of their alteration. For the ESRP, see http://www.epa.gov/ecology/.

Climate Change

The priority areas identified by the Interagency Ocean Policy Task Force included resiliency and adaptation to climate change and ocean acidification, issues that are being tackled by numerous federal agencies, including the EPA. There are three overarching impacts on coastal waters from climate change: sea-level rise, rising sea surface temperatures, and ocean acidification. These impacts interact in various ways. The impacts may correlate directly, as is the case with higher sea temperatures leading to sea-level rise, or the combination of these impacts may magnify individual impacts. For example, rising temperatures and ocean acidification could mutually and concurrently undermine the viability of coral reefs. Rising sea temperatures may cause coral bleaching events, while ocean acidification may directly undermine the skeletal structures of reefs. On the other hand, these three impacts may also counteract one another. For example, increased freshwater input from melting glaciers may actually counterbalance some of the saltwater intrusion (i.e., the movement of salt water into freshwater aquifers or waterbodies) caused by sea-level rise, although this effect would be regionally specific. Overall landward saltwater movement will depend on a combination of sea level rise, as well as changes in precipitation, runoff, and recharge in coastal watersheds (Barlow, 2003). Despite uncertain interactions, climate change effects will likely significantly alter the composition, productivity, and functioning of coastal ecosystems.

Despite overwhelming scientific consensus on the inevitability of climate change, significant uncertainty as to the degree of impact remains. Furthermore, regional differences in geomorphology (i.e., landscape elevation and shape), biogeochemistry, ecology, and even coastal communities will affect sensitivity to climate change around the United States (Field et al., 2000). This inherent complexity makes the science of climate change a dynamic field; therefore, the information presented below is meant as an introduction to current understanding, areas of research, and some relevant programs.

Sea Surface Temperature

Since the 1880s, the Earth's surface temperature has been rising. According to NASA estimates (NASA, 2010), the rate of temperature increase has accelerated over the past 30 years, and the previous decade (2000–2009) was the warmest on record (Figure 10-1). Sea surface temperatures rose by approximately 0.3 degree Celsius during the past 10 years.

Sea temperature directly affects oceanic biophysical and chemical processes, as well as ecosystem functions, such as the distribution, function, and reproduction of plant and animal species. Several severe consequences for coastal ecosystems are associated with rising sea surface temperatures, including changes in the frequency and extent of harmful algal blooms, altered or disrupted migrations of marine organisms, increased hurricane intensity, and sea-level rise (discussed below). The rate of sea surface temperature increase will not be uniform across the world. High latitudes will warm faster than low latitudes due to differences in the reflective qualities of ice and water. Sea water is less reflective than ice; therefore, the melting of ice near the poles would result in the oceans absorbing more solar radiation and energy, causing additional warming closer to the poles (GFDL, 2007). Between 1955 and 2003, the temperature of the North Atlantic Ocean increased by twice the global average rate (Smith et al., 2010).

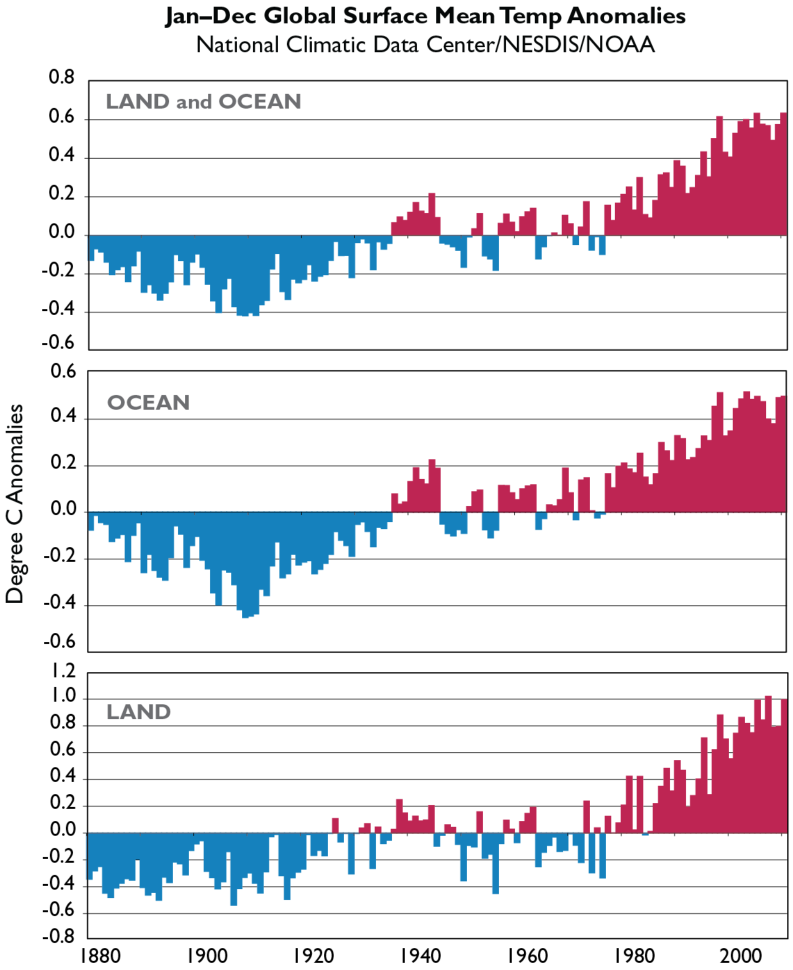


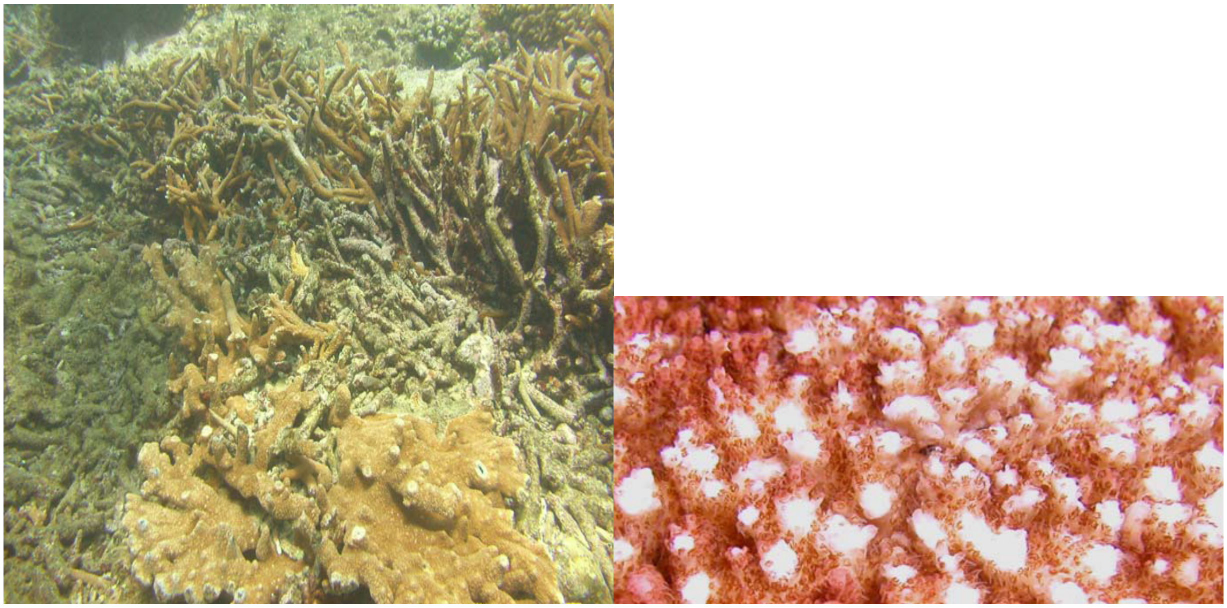
Figure 10-1. Global mean surface temperatures over time (NCDC, 2010).

Effects on marine species will also vary based on particular biological characteristics and local conditions. Generally, mobile organisms will be able to move to more hospitable habitats whereas stationary organisms (e.g., coral) will be more susceptible to any changes. However, increasing air, soil, and water temperatures may have positive effects for some flora (e.g., mangroves, salt marshes, forested wetlands) for which low temperatures and freezing events are the limiting factors for geographic distribution (Scavia et al., 2002). For example, demersal (bottom-dwelling) species (e.g., cod, plaice, haddock, redfish, flounder) that are found in the Atlantic Ocean are expected to migrate northward, with current mid-Atlantic species (e.g., butterfish, herring, mackerel, menhaden) expanding as far north as the Gulf of Maine (Scavia et al., 2002; Field et al., 2000). Population shifts for individual species may alter predator-prey relationships and community dynamics, ultimately impacting whole ecosystems (Field et al., 2000). Other mechanisms, including feeding, growth, and reproduction, will be impacted in diverse and complex ways by rising sea temperatures (Smith et al., 2010).

Warming waters favor algal blooms, some of which can produce toxins consumed by filter-feeders like mussels and clams. These toxins accumulate and can cause paralytic shellfish poisoning in humans who eat them. Harmful algae can also cause deterioration of water quality through the buildup of high biomass, which degrades aesthetic, ecological, and recreational values. Evidence indicates that climate warming may benefit some species of harmful blue-green algae (cyanobacteria) by providing more optimal conditions for their growth (Paerl and Huisman, 2008; 2009). Rising sea surface temperatures have also been associated with increases in dinoflagellates (many harmful algal bloom species are dinoflagellates) and with an earlier appearance of dinoflagellates in the seasonal cycle (Dale et al., 2006).

Living in above-optimal temperatures may increase stress on individual organisms, reducing growth, slowing metabolism, and weakening immune systems (Scavia et al., 2002). High-temperature variability leaves organisms stressed and vulnerable to marine diseases, which favor warmer waters. For example, when the El Niño Southern Oscillation cycle increased in frequency and severity in the mid-1970s, the Caribbean became a disease hot spot, with virtual eradication of staghorn and elkhorn corals and a sea urchin species (Harvell et al., 1999).

Rising sea surface temperatures are already altering tropical ecosystems via coral bleaching. Corals lose their symbiotic algae and/or their pigments under stressful conditions, most notably anomalously high sea surface temperatures (~1 degree C above average seasonal maxima), resulting in a whitening of corals known as bleaching (though bleaching events have also occurred with anomalously low sea surface temperatures). Major bleaching events have been noted throughout the world's oceans since the 1980s, with a particularly severe bleaching event affecting the Caribbean in late 2005 (Donner, 2009). This event resulted in a 51.5% decline in mean coral cover between 2005 and 2006, due to the bleaching effects coupled with a spread of marine diseases (Woody et al., 2008). The predicted rise in future sea surface temperatures will likely increase the occurrence of bleaching events and marine diseases, exacerbating existent coral stressors, including pollution, destructive fishing, diseases, and loss of key herbivores.



"A partially bleached Acropora coral. The white portions have lost the golden brown algae (zooxanthellae) that normally give the tissues their color"
(U.S. EPA, 2007b; photo by Eric Mielbrecht).

The socioeconomic consequences of rising sea surface temperatures could affect numerous coastal communities throughout the United States. Unsightly algal blooms will likely decrease swimming, boating, and tourism activities, while noxious algae may actually have detrimental impacts on human health (NSTC, 2003). Harmful algal blooms in coastal waters have been conservatively estimated to result in economic impacts in the United States of at least $82 million/year with the majority of impacts in the public health and commercial fisheries sectors (Hoagland and Scatasta, 2006). Impacts of a single bloom event on commercial fisheries can be very significant. In 2005, a major toxic algae bloom caused state agencies to close the shellfish beds from Maine to Martha's Vineyard, resulting in an estimated $20 million loss to the Massachusetts shellfish industry (NOAA, 2010).

The economies of the U.S. Virgin Islands, Puerto Rico, Hawaii, and Pacific island territories rely heavily upon their surrounding coral reefs for numerous ecosystem services, including fisheries, recreation, tourism, and coastal protection. Reefs are important habitat, spawning, and nursery grounds for numerous commercially viable fish species. In Hawaii, surrounding coral reefs are largely responsible for annual contributions of $60 million from the fishery industry and $800 million from the marine tourism industry (Friedlander et al., 2008). A 2001 study estimated the annual use value of Florida's southeastern coral reefs at over $250 million, with a capitalized value of $8.5 billion (Johns et al., 2001). Therefore, the long-term survival of coral reefs is crucial for coastal communities and economies. Coral reefs also serve as buffers against storm surges. With increasing hurricane strength, resulting from climate change, the role of reefs as protective buffers will likely be diminished. For more information on the potential impacts of rising sea surface temperatures on coastal and marine ecosystems, see NOAA's Ocean and Coastal Resource management Web site at http://coastalmanagement.noaa.gov/climate.html.

Sea-Level Rise

Rising sea surface temperatures may also impact our coasts by contributing to sea-level rise via a process known as thermal expansion (when water warms, it expands and thereby increases in volume). This volume increase along with freshwater input from melting ice sheets, glaciers, and ice caps will cause sea levels to rise. During the 20th century, the global average sea level rose between 4.8 and 8.8 inches (U.S. EPA, 2010a). Regional rates, known as relative sea-level rise, differ because they are measured as the sum of global sea-level rise and regional vertical land movements (resulting from regional tectonics, post-glacial isostatic adjustments, natural sediment compaction, or subsidence due to the withdrawal of subsurface fluids such as groundwater, oil, and natural gas) (Figure 10-2). Throughout the 20th century, sea-level rise in the mid-Atlantic and Gulf was 5 to 6 inches more than the global average. Rising sea levels may cause beach erosion, land submersion, wetland loss, coastal flooding, saltwater intrusion into estuaries and aquifers, and greater damages from hurricanes due to higher storm surge.

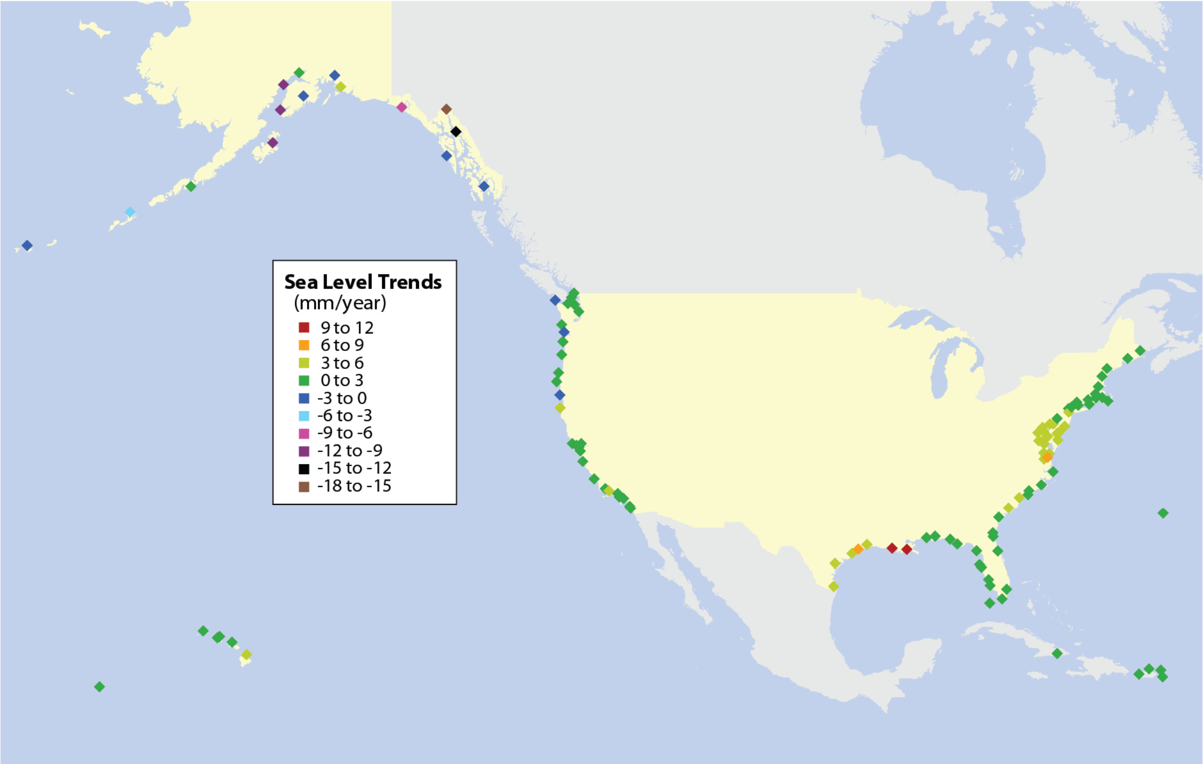


Figure 10-2. Trends in sea level (NOAA, 2008).

The impacts associated with sea-level changes will be varied based on relative sea-level rise and local geographic, biological, ecological, and socioeconomic conditions. Shallow coastal aquifers in places like the Everglades are susceptible to salinity increases (i.e., saltwater intrusion), which can potentially impact communities of plants and animals with limited tolerance to salinity fluctuations and complicating water intakes for coastal communities. The East and Gulf coasts are more susceptible to inundation because of their gently sloping coasts and developed barrier islands, which are prone to erosion (Scavia et al., 2002). In Florida, where 90% of state residents live on the coast, a rise of 23 inches by 2050 would cost the state $92 billion per year due to losses in tourism and real estate; a rise of 27 inches by 2060 would result in 70% of the city of Miami being under water (Schrope, 2010).

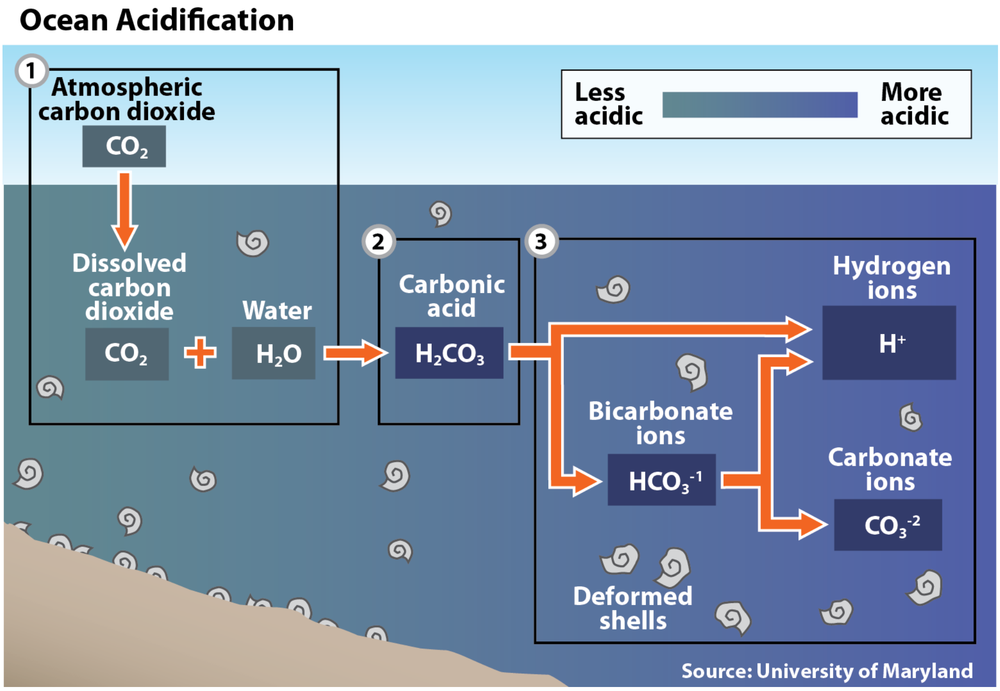
For several coastal communities throughout the United States, the effects of sea-level rise are already visible. On Alaska's Sarichef Island, reductions in protective sea ice, thawing permafrost, and alterations to natural hydrography resulting from armoring shorelines have caused massive storm surge erosion. Located on this island is the 400-year old village of Shishmaref, which is facing potential evacuation because of this erosion (NOAA, 2006). In Rhode Island, the relative sea level rose by over 10 inches during the 20th century, causing coastal freshwater wetlands to begin transitioning to salt marshes (Goss, 2002).

The combined impact of thermal expansion and ice loss from ice caps and small glaciers is likely to raise sea level by approximately 2 feet by the end of the century. Ice loss from the Greenland and Antarctic ice sheets could contribute an additional 1 foot of sea level rise (NRC, 2011). Migration of ecosystems like coastal marshes, mangroves, and wetlands will be hampered by coastal armoring infrastructure (e.g., dikes, bulkheads). This would result in a critical loss of the services, such as nursery, refuge, and forage habitats; nutrient cycling; and waste management. Sea-level rise would undermine other services as well, with saltwater intrusion affecting fishery productivity, beach erosion destroying crucial habitats, and flooding altering the infrastructure of coastal communities. For example, researchers estimate that

Delaware may lose the services generated by 21% of its wetlands by 2100 and become subject to 100-year floods three to four times more frequently (Najjar et al., 2000). For more information on potential impacts and current preparation strategies, see the EPA's Web site on coastal zones and sea-level rise: http://epa.gov/climatechange/effects/coastal/index.html.

Ocean Acidification

The third major impact of elevated CO_2 concentrations in the atmosphere on coastal ecosystems will be ocean acidification, which is a decrease in pH due to oceanic uptake of atmospheric carbon dioxide. When carbon dioxide dissolves in seawater, it acts as an acid, ultimately causing decreases in the amount of available calcium carbonate, a compound necessary for the growth and maintenance of calcifying marine organisms, such as corals, crustaceans, and mollusks (Figure 10-3). About one-third of the carbon dioxide released by human activity over the past 200 years has been taken up by the oceans (Fabry, 2008). In fact, without this sink for carbon dioxide, current atmospheric concentrations would be 55% higher than present levels (Fabry et al., 2009; Sabine et al., 2004). This uptake is reflected in changing ocean chemistry. Since the beginning of the Industrial Revolution, ocean pH has decreased by approximately 30%, a rate of change not witnessed in over 800,000 years (Ridgewell and Zeebe, 2005).



Source: University of Maryland

Figure 10-3. Process of ocean acidification.

Many important marine organisms like reef-building corals, mollusks (oysters), and echinoderms (sea urchins, starfish, sea cucumbers) use calcium carbonate to form their skeletons. Reductions in the availability of this compound may negatively impact various organism functions, including metabolism, reproduction, development, immunity, and skeletal density, potentially increasing vulnerability to physical damage, coral bleaching events, erosion, predation, and diseases, which often favor warmer temperatures (Scavia et al., 2002). Corals and other marine calcifiers near the poles will likely be impacted first. Because cold water can hold more gas than warm water, the oceans closest to the poles will absorb more carbon dioxide and be more acidic.

Although there is no decisive number for future carbon dioxide concentrations, current models and scenarios based on assumptions of future growth and development estimate that atmospheric carbon dioxide concentrations will likely exceed 500 ppm by mid-century. This would result in approximately a 0.4 decrease in surfacewater pH and a corresponding 50% decrease in calcification rates (Feely et al., 2008). Ocean acidification may have important long-term socioeconomic impacts on valuable commercial fisheries like shellfish. In 2007, mollusks contributed 19%, or $748 million, of the ex-vessel commercial harvest revenues in the United States (Cooley and Doney, 2009). Effects on lower-level organisms may also impact the food web, as larger predators effectively lose a food source.

Climate Change Effects Summary

The additive effects of increasing sea surface temperatures, sea-level rise, and ocean acidification will compound existing stresses from population growth and development (e.g., sediment, nutrient, and toxic pollution; habitat loss or degradation; resource consumption). These effects increase with climate change, doubling or tripling the impacts of existent stressors. For instance, northward migrations of commercially valuable fishery species such as cod, haddock, and halibut would have serious regional impacts on fishing communities in the Northeast Coast region, where fish stocks have already declined due to overfishing and pollution. Communities reliant upon tourism in the Southeast Coast region and island territories, which are already subject to pressures from development, would be adversely impacted by coral depletion resulting from the combination of higher sea surface temperatures and ocean acidification. Rising sea levels could also accelerate current wetland losses and damage from excessive sediment and nutrient runoff from coastal development.

Comprehensive monitoring programs of potential indicators, such as sea surface temperature, pH, and relative sea-level rise, are integral to effective initiatives addressing climate-change effects. Secondary effects such as species migration, reproduction, and juvenile survival rates; coral bleaching, skeleton density, and reef building; and changes in salinity, sediment, and nutrient concentrations may also need to be assessed. Current conditions can serve as reference points or benchmarks against which future changes can be measured.

Monitoring of climate change impacts on ecosystems is complicated by the aforementioned regional variations and complex interactions of rising sea surface temperature, ocean acidification, and sea-level rise. These interactions, along with cumulative effects of other coastal stressors, may complicate the evaluation of the impacts of separate factors, especially with regards to impacts on whole ecosystems. Furthermore, although physical parameters (e.g., sea-level rise) and chemical parameters (e.g., temperature, salinity, oxygen, nutrients, total alkalinity, pH) can be measured, monitoring of biological effects of climate change on our oceans cannot take place until appropriate parameters exist. More research is necessary to determine biological effects (on organism function) from the species, population, community, and ecosystem levels. Changes to these functions may not become apparent until there are severe impacts on populations.

Furthermore, trend analysis requires years of data to separate the influence of seasonal variations and anomalies (including those associated with the El Niño cycle and storm events) from climate change-related trends. For instance, researchers have shown that pH can vary with depth and time. Strong seasonal and interannual variability has been noted in surface pH in the central North Pacific. In addition, there is evidence of pH stratification that is influenced by physical and biogeochemical processes (Dore et al., 2009). Trend analysis of pH in coastal waters is also hampered by a general lack of data, complex nearshore circulation processes, and coarse model resolution in global ocean-atmosphere coupled models (Fabry et al., 2009). Although the presence of distinct strata is more relevant for ocean monitoring, vertical gradients in oxygen, pH, and sea surface temperature do occur in estuaries as well. Furthermore, these gradients are influenced by seasonal fluxes. These factors are important to consider when developing and interpreting ocean monitoring programs. It should be noted that the drawback to needing long-term trends to separate seasonal variability from trends in climate change indicators is that by the time the trends are identified, they may be irreversible.

Programs

The EPA and other federal, state, and local agencies are developing new means and expanding existing programs to address the unique challenges posed by the potential effects of climate change. Below is a list of an abbreviated list of some of these programs:

- U.S. Global Change and Research Program (GCRP)
  - Integrates research from 13 federal agencies
  - http://www.globalchange.gov/
- U.S. Global Ocean Ecosystem Dynamics (GLOBEC)
  - Examines the effects of climate change on marine ecosystems and fisheries
  - http://www.usglobec.org/features/overview.php
- Integrated Ocean Observing System (IOOS)
  - Network of coastal and ocean monitoring efforts
  - http://ioos.gov/about/basics.html
- EPA's Climate Change Program
  - Provides information on current science and research initiatives
  - http://www.epa.gov/climatechange/
- NOAA's Prototype Climate Service
  - Comprehensive source for all climate-related information generated by NOAA
  - http://www.noaa.gov/climate.html
- EPA's Climate Ready Estuaries (U.S. EPA, 2009f)
  - An initiative to assist the National Estuary Programs to assess climate change vulnerabilities and develop and implement adaptation strategies
  - http://www.epa.gov/climatereadyestuaries/

Invasive Species

Climate-change impacts on populations of marine organisms and community dynamics may increase ecosystem susceptibility to invasive species. As defined under a 1999 Executive Order, invasive species are "non-native species that cause or are likely to cause harm to the economy, environment, or human health" (NISC, 2008). As highlighted in the Great Lakes regional chapter (Chapter 7), invasive species are already an issue in our aquatic ecosystems. Negative impacts of invasive species include reduced biodiversity, altered habitats, changes in water chemistry and biogeochemical processes, hydrological modifications, and changes to food webs. Although the impact of invasive species is by definition negative, non-native species can have positive contributions to ecosystem sustainability. For example, some non-native species, which do not meet the definition as invasive species, have been introduced purposefully as a means of biological control for invasive species. For example, salmon have been introduced to the Great Lakes to control alewives. Even species that are invasive and harmful in one ecosystem may have a different effect in another ecosystem.

Invasive species are present in virtually all coastal waters of the United States. This fact can be attributed to the pathways of introduction, including ship-borne vectors, aquaculture escapes, and accidental or intentional releases. These pathways are prevalent throughout our coasts and have increased in both frequency and magnitude over the past several decades (NISC, 2008). Shipping activities account for over two-thirds of recent introductions, with ballast water as the most common method of introduction (U.S. EPA, 2010c).

Although the EPA and other agencies are working to control invasive species, interactions with climate change will likely complicate these efforts. Climate change may alter pathways of introduction; influence the establishment, spread, or distribution of species; or change resiliency of native habitats, which could change the impacts of non-native species so that they meet the definition of invasive species. For instance, rising sea surface temperatures will likely force some marine organisms to shift poleward, and species with limited capacity for migration will decline in their southern ranges or even become extinct, leaving niches open for invasive species. Even in instances where the native species remain viable in warmer habitats, altered food availability, reduced reproduction rates, and diminished protective habitat may undermine population health and resistance to invasive species.

Although many federal, state, and regional governing bodies have established programs to address invasive species, these efforts most often do not address potential impacts of climate change. In recognition of this informational and regulatory gap, the EPA hosted two workshops in 2006 to assess management needs and to specifically highlight potential considerations for aquatic invasive species. The latter workshop laid the groundwork for the report *Effects of Climate Change on Aquatic Invasive Species and Implications for Management and Research* (U.S. EPA, 2008b), which highlights both the potential interactions of climate change and invasive species and the role of expanding management.

Below is a list of other sources of information on invasive species:

- EPA's Invasive Species Program
  - General information on invasive species and control initiatives
  - http://www.epa.gov/owow/invasive_species/
- Aquatic Nuisance Species Task Force
  - Intergovernmental agency dedicated to preventing and controlling aquatic nuisance species
  - http://www.anstaskforce.gov/default.php
- USDA's National Invasive Species Information Center
  - Comprehensive source of information for aquatic and terrestrial invasive species
  - http://www.invasivespeciesinfo.gov/
- Smithsonian Environmental Research Center – Marine Invasions Research Laboratory
  - Research on biological invasions in coastal marine ecosystems
  - http://serc.si.edu/labs/marine_invasions/

Hypoxia

Climate change may also worsen hypoxic conditions (low oxygen availability in water), which are already undermining ecosystem health throughout coastal waters as outlined in Chapter 1 (Introduction) and Chapter 5 (Gulf Coast). Bays and estuaries that have limited water exchange and experience water column stratification resulting from massive freshwater input into a saltwater system are particularly susceptible to hypoxia, as evidenced in the Gulf of Mexico (Diaz and Rosenberg, 2008). In fact, eutrophication is affecting over half of all national estuaries (NSTC, 2003). Areas of heightened upwelling are also susceptible to hypoxia. Upwelling is the process by which coastal winds push surface waters offshore, allowing nutrient-rich, oxygen-poor waters from the deep to replace them. These nutrient-rich waters stimulate plankton growth, which ultimately depletes oxygen levels. Increased upwelling is hypothesized to be the cause of dead zones off the coast of Oregon that began to arise during the summer of 2002 (Juncosa, 2008).

The frequency and extent of hypoxic conditions are increasing in coastal and estuarine waters (Rabalais et al., 2002b), mostly as a result of increasing nitrogen from agricultural runoff (NSTC, 2003). Increased levels of nutrients (i.e., nitrogen and phosphorus) in coastal waters can lead to toxic or noxious algal blooms, decreased water clarity, hypoxic conditions, and habitat degradation, all of which will impact the provision of ecosystem services (NSTC, 2003). The lack of oxygen in deeper, cooler water during the summer decreases the availability of these waters to marine species and may undermine the reproductive capacity of many fish species that tend to spawn or nurse in these waters during this time of year (Diaz and Rosenberg, 2008), decreasing fishery productivity with subsequent impacts on the recreational and commercial fishing industries (NSTC, 2003). Effects on higher trophic levels may also result if demersal species are deprived of a valuable food source due to reductions in benthic populations caused by lower bottom-water oxygen levels or if predation in benthos is limited by predators' low tolerance to reduced oxygen concentrations (Diaz and Rosenberg, 2008).

Climate Change and Hypoxia

The future extent and severity of hypoxia in coastal ecosystems will depend on the success of efforts to limit nutrient input and the impacts of climate change, which may alter oxygen concentrations, precipitation, and mixing within the water column. Warmer waters may cause reduced oxygen concentrations due to decreased oxygen solubility and increased production of oxygen-consuming bacteria, while simultaneously increasing the metabolic rate, and thereby oxygen needs, of cold-blooded aquatic species.

Climate models also predict alterations to other processes affecting hypoxia, including precipitation and coastal winds. Precipitation variability predicted under some climate models could cause more dry years followed by extreme rain events, resulting in nutrient influxes to coastal waters from fertilizers that build up on soils during dry years (Scavia et al., 2002). Potential increases in precipitation and extreme rainfall events would lead to greater agricultural and urban runoff, ultimately increasing the amount of nutrients, sediment, and contaminants entering coastal waters. The timing of freshwater inflows may also be a factor as increased air temperatures may lead to earlier snowmelt and earlier inflows to coastal waters (Field et al., 2000). Reductions in summerflows due to earlier snowmelt may deprive estuaries of important freshwater input during times of greatest evapotranspiration, increasing estuarine salinities and stratification (Field et al., 2000), a process already occurring in San Francisco Bay. Climate change may also increase the upwelling process by creating stronger coastal winds and greater storm intensity, both of which can increase water-column mixing (Juncosa, 2008). On the other hand, because warmer waters are less efficient at absorbing oxygen, increased sea surface temperatures may strengthen stratification by preventing oxygen from reaching deeper ocean layers (Diaz and Rosenberg, 2008). Precise predictions of future effects are limited by the complicated interactions of these variables impacting coastal ecosystems.

Climate variability may already be influencing the size of the hypoxic zone (i.e., dead zone) in the Gulf of Mexico. By one estimate this variability may have contributed as much as 20% of variance to the size of the Gulf of Mexico hypoxic zone since the 1950s (Cronin and Walker, 2006). According to recent model simulations (Cronin and Walker, 2006), Gulf of Mexico hypoxia is highly sensitive to riverine nitrate influx, freshwater discharge, and ambient water temperatures. These modeling efforts indicated that although a 30% decrease in the nitrate flux of the Mississippi River would correspond to a 37% reduction in the size of the hypoxic zone, a 20% increase in Mississippi River discharge would produce an equal increase in size of the hypoxic zone (Cronin and Walker, 2006). According to climate projections, such an increase in Mississippi River discharge is possible, which would mean that reductions in nitrate flux would have to be greater to make up the difference (Justic et al., 2003).

Below is a list of other sources of information on hypoxia:

- Mississippi River/Gulf of Mexico Watershed Nutrient Task Force

  - Consists of 5 federal and 10 state agencies, established to reduce hypoxia in the Gulf
  - http://www.epa.gov/msbasin/
- NOAA's Gulf of Mexico Hypoxia Watch
  - Partnership between NOAA, NCDC, NMFS, and CoastWatch to develop real-time data of the Gulf hypoxic area
  - http://ecowatch.ncddc.noaa.gov/hypoxia

Emerging Contaminants

As monitoring efforts evolve to include indicators of climate change, invasive species, and hypoxia, research is also being directed toward indentifying contaminants of emerging concern (CECs). This term encompasses a broad range of contaminants, including pharmaceuticals and personal care products (PPCP); endocrine disruptors; pesticides; persistent organic pollutants such as perfluoronated compounds; and nanomaterials. Although the term "emerging" can refer to a completely new contaminant, such as nanoparticles, the term also refers to new byproducts of production, new metabolites of a parent compound, and newly detectable chemicals. Categorically, CECs often have certain similar characteristics, including low detectable levels, multiple sources, limited toxicological information, and the perception of being a long-term threat to human health, public safety, or the environment.

The sheer number and pathways of entry of potential CECs make monitoring and analysis of potential effects a formidable task. According to the American Chemical Society, less than 300,000 of the 39 million chemicals in use today are either inventoried or regulated, and the number of available chemicals increases every day. The pathways of entry into the environment for CECs are numerous and may include effluents from WWTPs, which do not for the most part treat sewage for pharmaceuticals; concentrated animal feeding operations; septic systems; aquaculture operations; and surface application of manure and biosolids.

Pharmaceuticals are a good example of the potential effects of CECs. These compounds are designed to have biological effects at low doses; therefore, even limited exposure may have subtle effects on non-target populations. The thousands of distinct compounds in pharmaceuticals can also have potential effects when combined with other pharmaceuticals or contaminants. These compounds may bioaccumulate in the food web or persist in the environment, affecting multiple generations. Of particular concern is the potential for pharmaceuticals to act as endocrine disruptors, mimicking, inhibiting, stimulating, or blocking the endocrine system that regulates hormones. For estuarine ecosystems, observed effects on fish and amphibians are particularly noteworthy. Endocrine-active contaminants have been identified as a potential cause of fish that have developed organs of both sexes downstream of a WWTP in Boulder Creek, CO (Woodling et al., 2006), and around high-density population and farming areas on the Potomac River (Blazer et al., 2007). Other CECs may also act as endocrine disruptors. Atrazine, the most commonly applied herbicide in the United States, has been in use for over 40 years and acts as an endocrine disruptor in amphibians. Feminization of male frogs exposed to atrazine has occurred in the laboratory and in the wild and has led to speculations that this pesticide may be associated with global amphibian declines (Hayes et al., 2002a,b).

Increased documentation of such ecological impacts and rising concerns about the effects of pharmaceuticals in our drinking waters have led to increased research and monitoring efforts. The EPA's Office of Science and Technology recently conducted a pilot study of PPCPs in fish tissue and found anti-depressants, anti-histamines, anti-hypertension, antilipemic, and anti-seizure drugs, along with personal care products, in the samples (Ramirez et al., 2009). In 2008 and 2009, this effort expanded under the National Rivers and Streams Assessment to include sampling for PPCPs in fish tissue at 150 sites (U.S. EPA, 2010b). The upcoming NCCA will include sampling for PFCs, PBDEs, and pharmaceuticals in fish tissue collected from the Great Lakes. The EPA is also assessing the capacity of existing regulatory tools to address CECs, see below.

In comparison to legacy pollutants, monitoring for CECs is relatively new. As understanding of which contaminants fit into this category expands, monitoring will become more comprehensive. This necessitates more research on all categories of CECs and the development of better detection methods for compounds that are present in complex ecosystems. Also, water quality standards/maximum concentrations for ambient water do not exist for most CECs; therefore, even detectable contaminants may not be included in managerial decisions. Monitoring for effects of CECs, such as alterations to reproductive organs in individuals or the gender balance of populations, would require establishing often questionable cause-and-effect relationships (changes to species or populations may be due to other environmental variables) and be overly reactive to have positive effects on management decisions.

Below is a list of other sources of information on CECs:

- EPA's Aquatic Life Criteria (U.S. EPA, 2008a)
  - White paper on Aquatic Life Criteria for CECs
  - http://www.epa.gov/waterscience/criteria/aqlife/cec.html
- EPA's Endocrine Disruptor Screening Program
  - Information on EPA's approach and progress for screening and testing chemicals for endocrine disrupting potential
  - http://www.epa.gov/endo/index.htm
- USGS: Emerging Contaminants Project
  - Information on chemicals about their threat to the environment and human health
  - http://toxics.usgs.gov/regional/emc/

Microbial Pathogens

While monitoring programs for CECs are in relative infancy or an early developmental phase, testing waters for pathogens (e.g., disease-causing bacteria, viruses, microorganisms) is more developed but still evolving. The upcoming NCCA will include an assessment of coastal water pathogen contamination, using *Enterococci* as an indicator of fecal bacteria contamination. As revealed in the Beach Advisory sections of this report, the majority of beach closings in the United States are due to the presence of harmful pathogens from untreated or under-treated sewage (including from combined sewer overflows, septic systems, and WWTPs). States establish their own guidance for bacterial contamination, although their criteria must be as minimally as protective of human health as EPA's 1986 bacteria criteria (U.S. EPA, 1986). Some states have adopted even more restrictive guidance. Beach closures present a non-uniform picture of coastal water contamination because the criteria used to trigger a beach closure vary from state to state. The inclusion of microbial pathogens as an NCCA indicator will allow more comparability between regions and across states.

Monitoring pathogens in recreational coastal waters is also indicative of the EPA OW's focus on human health. The chosen pathogen for monitoring, *Enterococci*, is recommended by the EPA as the best indicator of health risk in salt water used for recreation because of its ability to survive in saline environments. This recommendation was based on a series of studies conducted by the EPA to determine the correlation between different bacterial indicators and the occurrence of digestive system illnesses at swimming beaches (U.S. EPA, 2009e). Detection of *Enterococci* may indicate the possible presence of pathogenic bacteria and the potential health risk of swimming in and eating shellfish harvested from contaminated waters. Microbial contamination is addressed under the Safe Drinking Water Act, which regulates contamination of finished drinking water and source waters, and under the Clean Water Act, which enables regulation of certain sources for the protection of surface water for drinking water, recreational, and aquatic food source uses.

For more information on microbial pathogens:

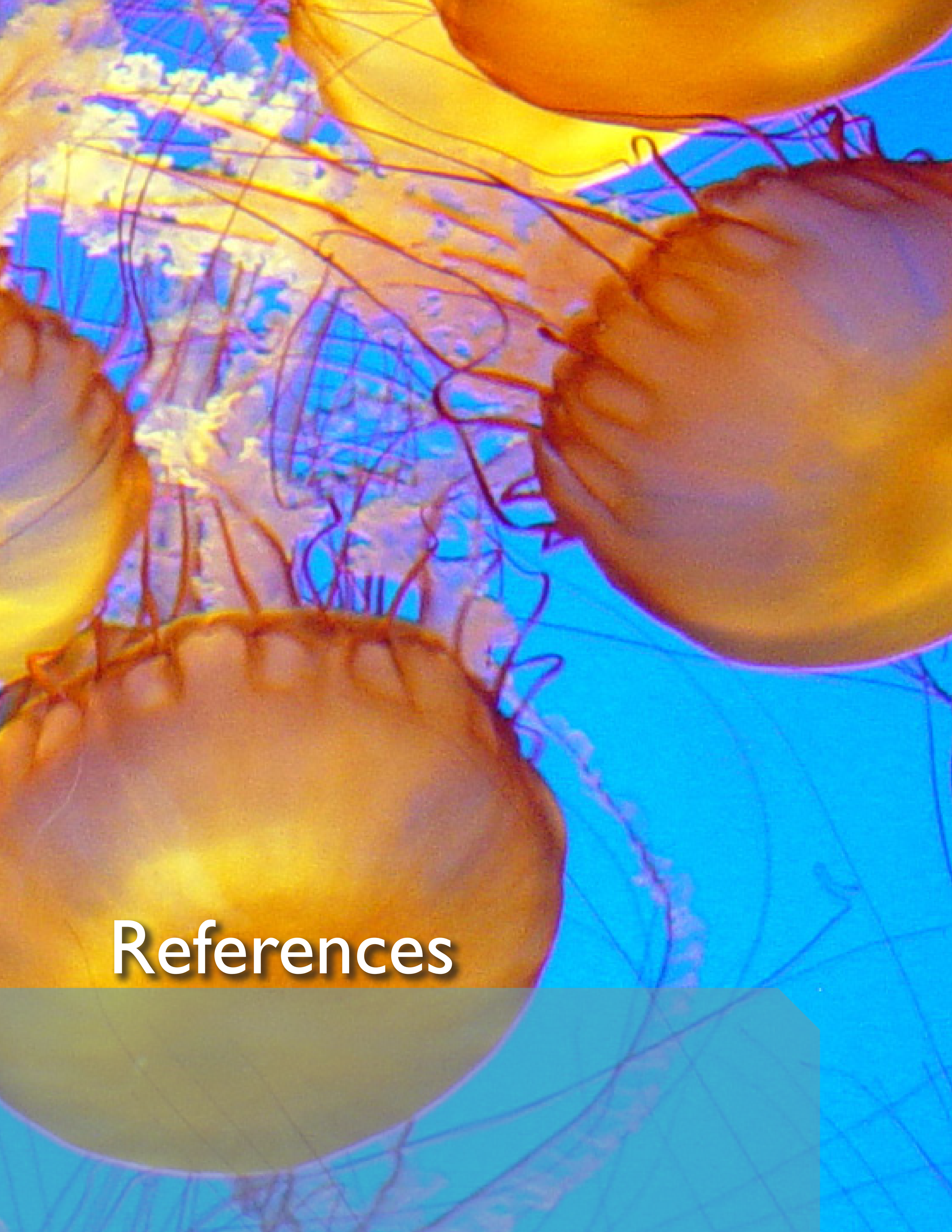
- EPA's Water Quality Criteria: microbial pathogens
  - Information on how existing regulations address microbial pathogens
  - http://www.epa.gov/waterscience/criteria/humanhealth/microbial/

Conclusion

The inclusion of *Enterococci* as an indicator of microbial pathogens is indicative of the evolving process of coastal monitoring and the NCA program. This chapter highlighted other emerging concerns for coastal waters and their invariable, although uncertain, interactions with the effects of climate change. Although monitoring of pathogens is a relatively straightforward process based on predetermined unhealthy concentrations of microbials and likely exposure scenarios, establishing indicators for CECs and the impacts of climate change is more complicated.

Where monitoring of direct climate change effects is limited or prohibitive in cost, secondary effects on marine organisms, populations, community dynamics, predator–prey relationships, and whole ecosystems may be observed. Identifying trends from monitoring is complicated by anomalies (e.g., El Niño/La Niña, storm events), interactions between effects, and data duration (analyses on time-series data require several years of regular recording).

Despite the intrinsic difficulty of incorporating these issues into the NCCA program, EPA and other federal agencies recognize the evolving nature of coastal issues, links with potential climate change effects, and the need to perpetually update monitoring programs. As shown throughout this chapter, many programs already exist to address these emerging issues, and the scientific community is researching new indicators to adopt in monitoring programs.



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