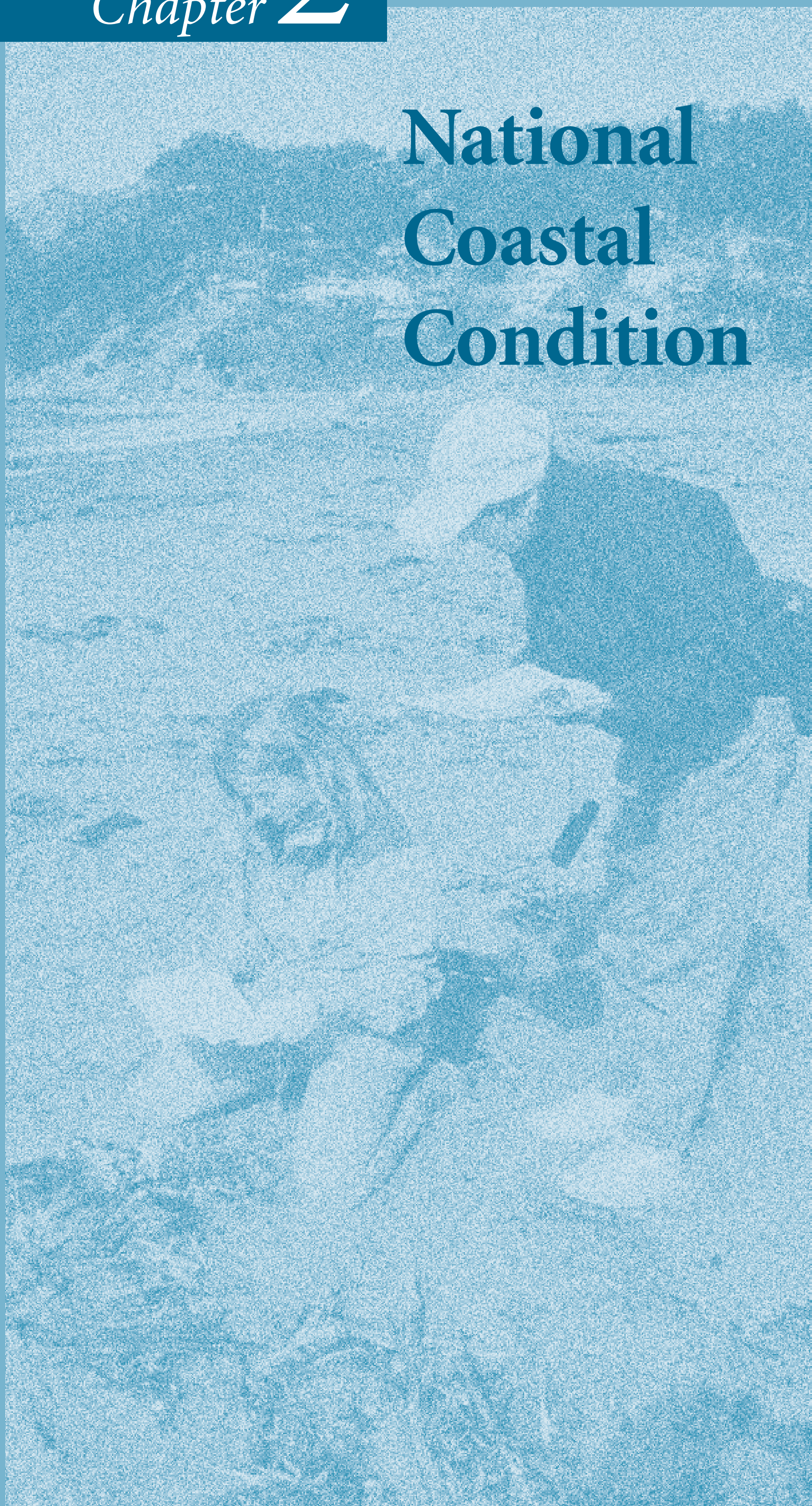
Chapter 2

National Coastal Condition



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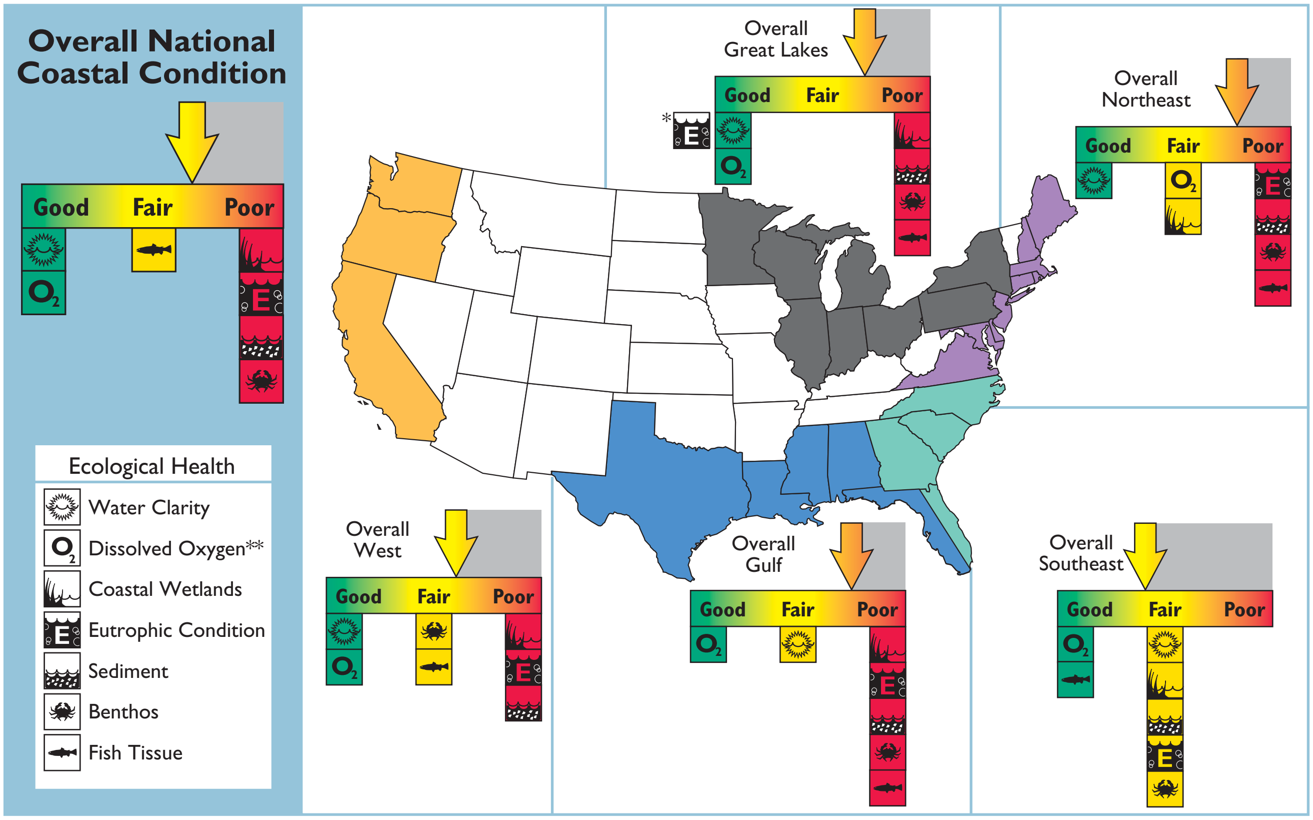
Overall, the condition of estuaries in the United States (Atlantic, Pacific, Gulf of Mexico, and the Great Lakes, excluding Alaska and Hawaii) is fair, with four of the seven indicators receiving a "poor" rating, one receiving a "fair" rating, and two with a "good" rating. Figure 2-1 summarizes U.S. estuarine conditions.

Water clarity is good in western and northeastern estuaries and the Great Lakes but fair in Gulf of Mexico and southeastern estuaries. Dissolved oxygen conditions are generally good throughout the estuaries of the United States. Eutrophic condition, sediment contaminant conditions, and benthic community conditions are generally poor throughout U.S. estuaries. Condition as measured by fish tissue contaminant concentrations is poor in northeastern, Gulf of Mexico estuaries and in the Great Lakes. The fish tissue contaminants indicator is good in southeastern estuaries and fair in western estuaries.

More specifically, about 56% of assessed estuarine area is in good condition for supporting plants, animals, and human uses (Figure 2-2). About 34% of the area of the nation's estuarine resources have poor conditions for aquatic life while 33% have unacceptable levels for human-related uses based on the available

BEACH Watch volunteers document the live and dead animals of the Gulf of the Farallones Sanctuary (Photo: Gulf of the Farallones NMS).



* No indicator data available.
** Does not include the hypoxic zone in offshore Gulf of Mexico waters.

Figure 2-1. Overall national coastal condition.

indicators. Most of the aquatic life in poor condition are benthic communities (bottom-dwelling organisms). Aquatic life is categorized as poor based on measures of biodiversity, increased abundances of pollution-tolerant species, and decreased abundances of pollution-sensitive species. These impaired communities occur in areas exhibiting low dissolved oxygen, eutrophic conditions, sediment contamination, and habitat degradation.

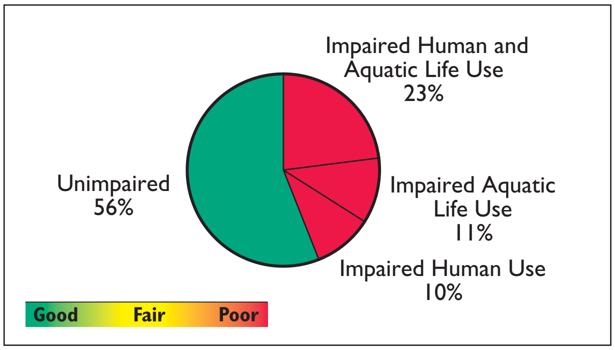


Figure 2-2. National estuarine condition (U.S. EPA/EMAP).

Coastal Monitoring Data

Note: The data presented in this section exclude the Great Lakes because of sampling design differences in the data sets. No areal estimates for the Great Lakes can be determined. The Great Lakes data are presented in Chapter 7.

Water Clarity

The overall water clarity of the nation's estuaries is rated as good. EMAP 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. Water visibility of only 10% (10% of surface light reaches 1 meter) is used to represent poor conditions. This is equivalent to being unable to see your hand in front of your face at a depth of 1 meter. As shown in Figure 2-3, poor light penetration is a problem in only about 4% of estuarine waters.

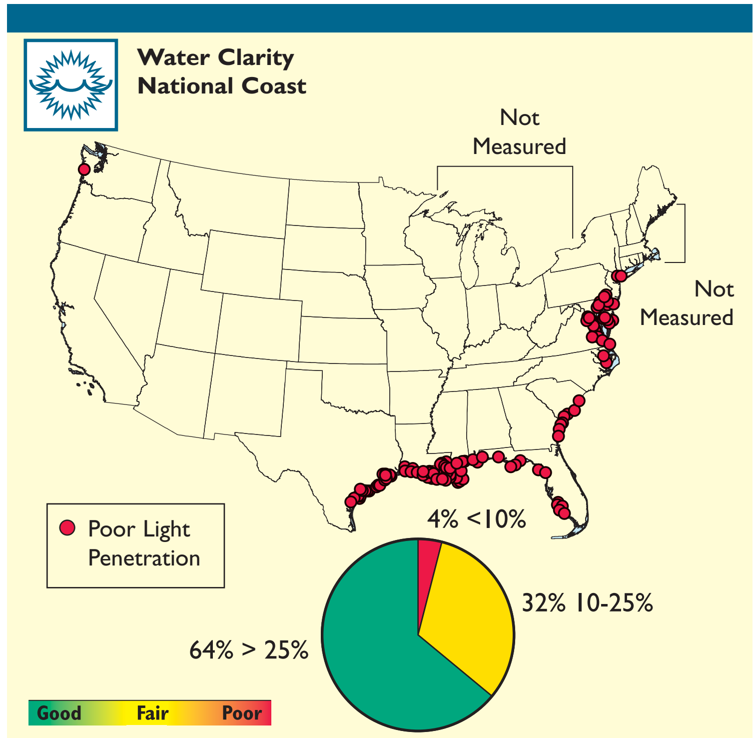


Figure 2-3. Light penetration data and locations for sites with <10% light penetration (U.S. EPA/EMAP).

Dissolved Oxygen

Dissolved oxygen conditions in the nation's estuaries are good. Both EMAP and NOAA's National Eutrophication Assessment examined the extent of estuarine waters with low dissolved oxygen. Often low dissolved oxygen occurs as a result of large algal blooms that sink to the bottom and use oxygen during the process of decay. Dissolved oxygen is a fundamental requirement for all estuarine life. Low levels of oxygen often accompany the onset of severe bacterial degradation, sometimes resulting in algal scums, fish kills, and noxious odors, as well as loss of habitat and aesthetic values. This, in turn, results in decreased tourism and recreational water use. EMAP estimates that only about 4% of bottom waters have low dissolved oxygen (Figure 2-4). However, low dissolved oxygen is

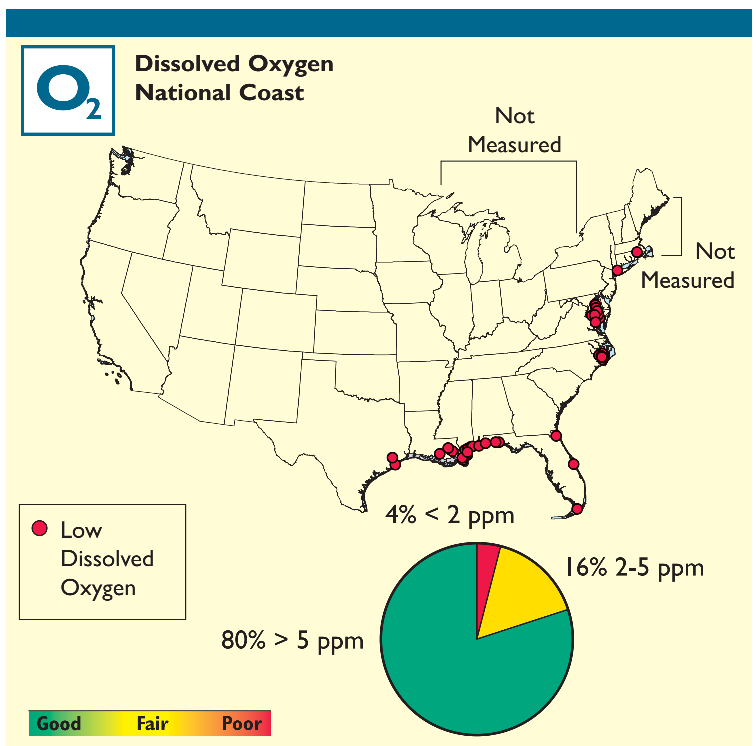


Figure 2-4. Estuarine sites with low dissolved oxygen and the distribution of dissolved oxygen data for all sampled sites (U.S. EPA/EMAP).

As the heavier materials from the mountains make their way through the plateau and piedmont in the streams, creeks, and rivers of the water transport system, silts and clay are picked up as well. By the time the heavier materials reach the coast, they have become sand and settle just offshore, while the lighter silts and clays settle in the calmer waters behind the barrier islands to become the black anaerobic mud of the marshes. These marshes are some of the most productive acres on earth. They supply an enormous amount of nutrients, which make our waters rich in marine life. At the same time, these nutrients make our water turbid. Frequently the visibility at Gray's Reef is poor due to the tremendous amounts of nutrients in the water and the huge volume of sediments that are being flushed from the mainland, especially during periods of heavy rain (Photo: Gray's Reef NMS).

a problem in some individual estuarine systems like the Neuse River Estuary, parts of Chesapeake Bay, and the Gulf of Mexico hypoxia zone.

Coastal Wetland Loss

The loss of wetland habitats in the United States is significant and, as a condition indicator, has received a poor rating. During the 200-year period from 1780 to 1980, nearly 50% of the existing wetlands of the conterminous United States were lost (Figure 2-5). Proportional losses along the West Coast have been the largest (68%), although the actual number of acres lost there is among the smallest. Absolute and proportional acreages lost in the Great Lakes and Gulf of Mexico coast are also high (about 50% of wetlands existing in 1780). Even in more recent years (mid- to late 1990s), wetland losses in southeastern and Gulf of Mexico states continue at a high rate (more than 1% per year). Currently, surveys are conducted only to estimate the amount of acreage of wetlands every 10 years. No surveys examine, at a national level, the ecological condition of these critical coastal habitats.

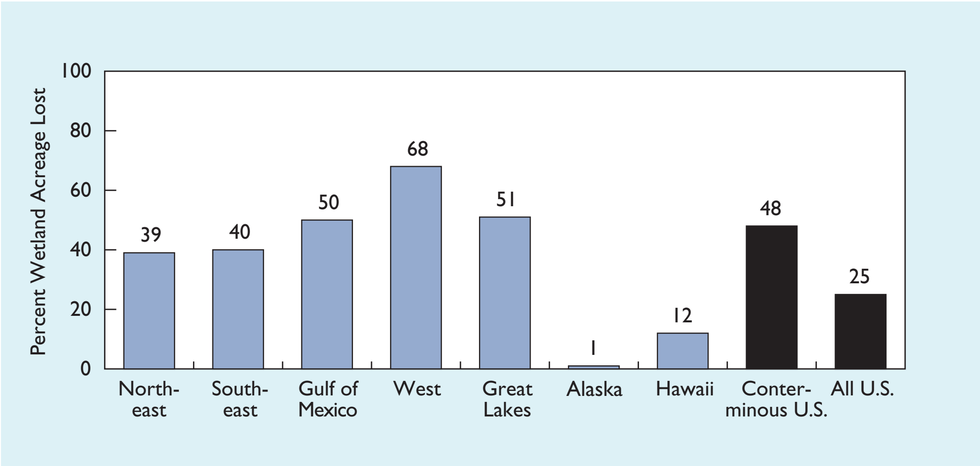
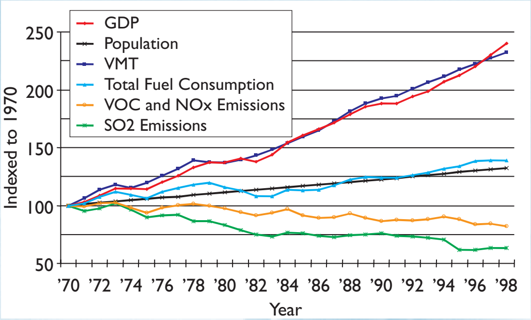


Figure 2-5. Proportion of total wetland acres existing in 1780 lost by 1980 in areas of the United States (Dahl, 1990; Turner and Boesch, 1988).

highlight

Atmospheric Deposition of Nitrogen

Atmospheric deposition occurs when pollutants fall out of the air (in the form of rain, snow, or microscopic particles, for example) onto the land or water. Pollutants can be released into the air from a variety of sources, including the burning of fossil fuels, industrial processes, cars and trucks, fertilizer, and the volatilization of animal wastes. Some may be carried by wind patterns for long distances away from their place of origin before they are deposited.



Trend in gross domestic product, population, vehicle miles traveled, total fuel consumption, combined volatile organic compound and nitrogen oxides emissions, and sulfur dioxide emissions, 1970 to 1998.

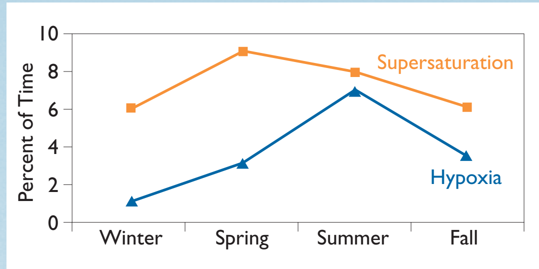
Many coastal waters have experienced eutrophication problems related to excess nitrogen in the water. Atmospheric deposition is a large contributor to the nitrogen load of many coastal waters. Depending on the waterbody and watershed being considered, it is estimated that roughly one-quarter of the nitrogen in an estuary comes from air deposition.

Nitrogen oxide (NO_x) is one of the prevalent forms of nitrogen emitted to the air from human activities. The majority of NO_x pollution comes from mobile sources such as cars and heavy-duty trucks and electric utilities, primarily coal-fired power plants. Combined emissions of several pollutants have decreased since 1970, even as the economy and population have grown (see graph). NO_x emissions specifically increased between 1970 and 1997, followed by a slight decline in 1998.

Numerous measures are planned or are already in place to help curb NO_x pollution, including a new EPA rule that will require most states in the eastern half of the country to submit plans to reduce NO_x emissions, which travel downwind and cross state borders, contributing to smog formation in the eastern United States. It is expected that many states will target electric utilities for reductions. Acid rain reduction measures, strengthened tailpipe emission standards, and more stringent emission standards for heavy-duty vehicles will also help reduce NO_x pollution.

More information about air quality is available in the EPA document National Air Pollution Emission Trends, available on the Internet at http://www.epa.gov/ttn/chief/trends/trends98/trends98.pdf.

Water Quality in the National Estuarine Research Reserves



Seasonal patterns of percent of time that dissolved oxygen is less than 28% saturation (hypoxia) or more than 120% saturation (supersaturation) across all NERRS sites during 1997 and 1998.

The NERRS System-Wide Monitoring Program (SWMP) has measured water quality (pH, conductivity, temperature, dissolved oxygen, turbidity, and water level) at 30-minute intervals in 22 Reserves since 1995. This program provides important information on habitat and water quality conditions at spatial and temporal scales not represented by other national, regional, or state monitoring programs. Standardized protocols and data management techniques developed for the Reserves ensure that data collection is comparable among sites so that the resulting data are of high quality.

Measurement of water quality parameters at short time intervals over extended periods provides a valuable way of characterizing the episodic nature and trends in environmental conditions that are not captured in point-in-time sampling techniques. These data are also used to evaluate key ecosystem processes like gross production and system metabolism. Examination of dissolved oxygen data collected by SWMP indicates that few sites have chronic problems with hypoxia (too little oxygen) or supersaturation (too much oxygen) (see graph). Considerable year-to-year variability exists in the frequency and severity of dissolved oxygen levels at several Reserves. Such large annual changes in hypoxia and supersaturation appear to be related to site-specific circulation patterns, land use, climatic conditions, pollution levels, and environmental conditions.

Reserve water quality data are used to evaluate key ecological processes such as system gross production, respiration, and net ecosystem metabolism. Production and respiration vary by a factor of 20 among reserves. In most of the reserves, more oxygen (and carbon) was consumed than was produced (i.e., were heterotrophic). Variability in metabolic rates may be affected by factors such as temperature regime, salinity fluctuations, nutrient concentration, and algal abundance. Not surprisingly, most of the sites showed a positive relationship between temperature and respiration and production (higher rates at higher temperatures).

Eutrophic Condition

Data from NOAA's National Estuarine Eutrophication Assessment (Bricker et al., 1999) indicate that the nation's estuaries exhibit strong symptoms of eutrophication, which result in a rating of poor. When data on the symptoms of eutrophication are combined, they suggest that 40% of the surface area of the nation's estuarine waters exhibit high expression of eutrophic condition (Figure 2-6). Many of these waters are in the Mid-Atlantic and Gulf regions of the United States. Moreover, based on expert opinion, eutrophic conditions are expected to worsen in 70% of U.S. estuaries by 2020 (Bricker et al., 1999).

One of the symptoms measured to determine the eutrophic condition in estuaries is the expression of chlorophyll *a* (as measured by concentration, spatial coverage, and duration). Chlorophyll *a* is a measure used to indicate the amount of microscopic algae, called phytoplankton, growing in a waterbody. High expressions of chlorophyll *a* indicate problems related to overproduction of algae. High expressions of chlorophyll *a* occurred in 39 estuaries throughout the United States, representing approximately 40% of estuarine area (Figure 2-7). Approximately 46% of estuarine area has moderate expressions of chlorophyll *a*, although many of these areas are expected to show worsening eutrophic conditions over the next 20 years (Bricker et al., 1999).

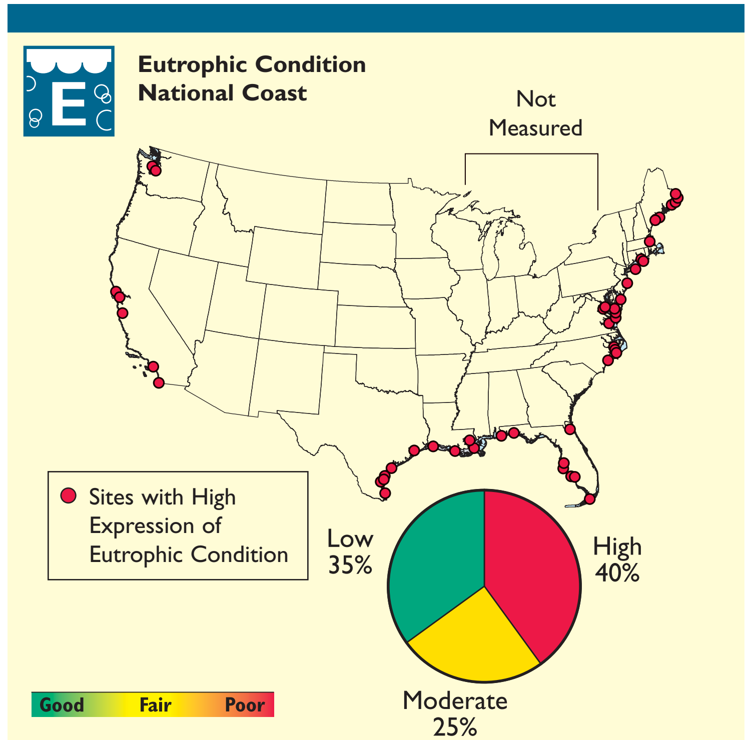


Figure 2-6. Eutrophic condition data and locations of estuaries with high expressions of eutrophic condition (NOAA/NOS).

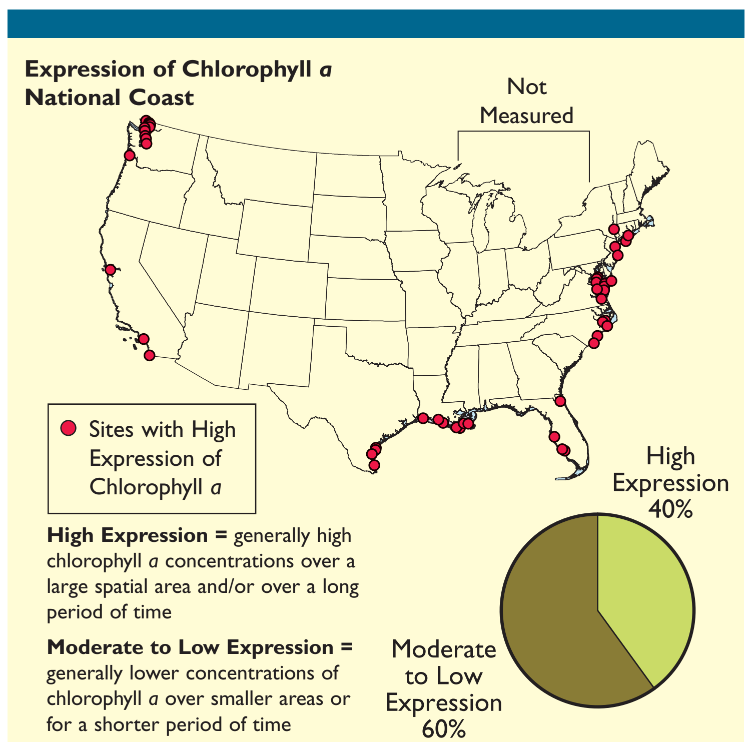


Figure 2-7. Chlorophyll *a* data and locations of estuaries with high expressions of chlorophyll *a* (NOAA/NOS).

Sediment Contaminants

National estuarine conditions, as measured by sediment contamination, are poor. Figure 2-8 shows the enrichment of sediments due to human sources. These measurements show that 40%, 45%, and 75% of U.S. estuarine sediments are enriched with metals, PCBs, and pesticides from human sources. One of the challenges of assessing the magnitude of sediment contamination is differentiating between contaminants such as organics and metals that may occur naturally in the earth's crust from those that are added from human activities. Pesticides and PCBs are relatively easy to evaluate, as they can only come from human activities. However, polycyclic aromatic hydrocarbons (PAHs) and metals can and do naturally occur in estuarine sediments. The approach used to determine these percentages is based on the methods described in Windom et al. (1989). This approach uses regression relationships between natural sources of aluminum in sediments and concentrations of other heavy metals to determine the expected levels of metals naturally occurring in estuarine sediments. The extent of the difference between the observed concentration of heavy metals and the expected concentrations (derived from the regressions) is the basis for the determination of whether the "contamination" is due to human sources. Concentrations of heavy metals exceeding the 95% confidence level of the regression are deemed affected by human sources.

National and regional monitoring programs conducted by EPA and NOAA provide baseline information on the concentrations of contaminants found in estuarine sediments throughout the United States. Surface sediments have been or are being examined

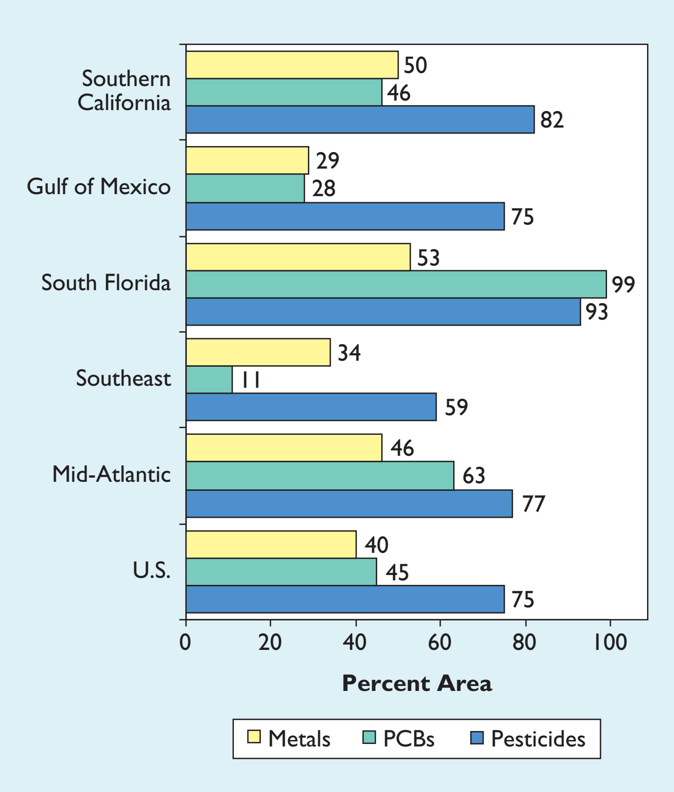


Figure 2-8. Regional sediment enrichment due to human sources.

Bottom samples from the Olympic Coast Sanctuary help researchers map communities of bottom-dwelling organisms (Photo: Olympic Coast NMS).

in over 2,000 locations throughout the estuaries of the United States. Measurements of over 100 contaminants have been taken at each site including over 25 PAHs, 22 PCBs, total PCBs, over 25 pesticides, and 15 metals. One to two percent of estuarine sediments in the United States show concentrations of contaminants (PAHs, PCBs, pesticides, and metals) that are above ERM guidelines (mid-range concentrations of contaminants above which adverse effects on marine organisms are likely to occur), while 10% to 29% of sediments have contaminant concentrations between the ERM and lower-level ERL guidelines (concentrations below which adverse effects on marine organisms are not likely to occur) (Figure 2-9).

Figure 2-10 shows that most of the locations exceeding the ERM guidelines are in the Northeast coastal area, while the Gulf of Mexico Coast contains many locations with exceedances of the ERL for five or more contaminants.

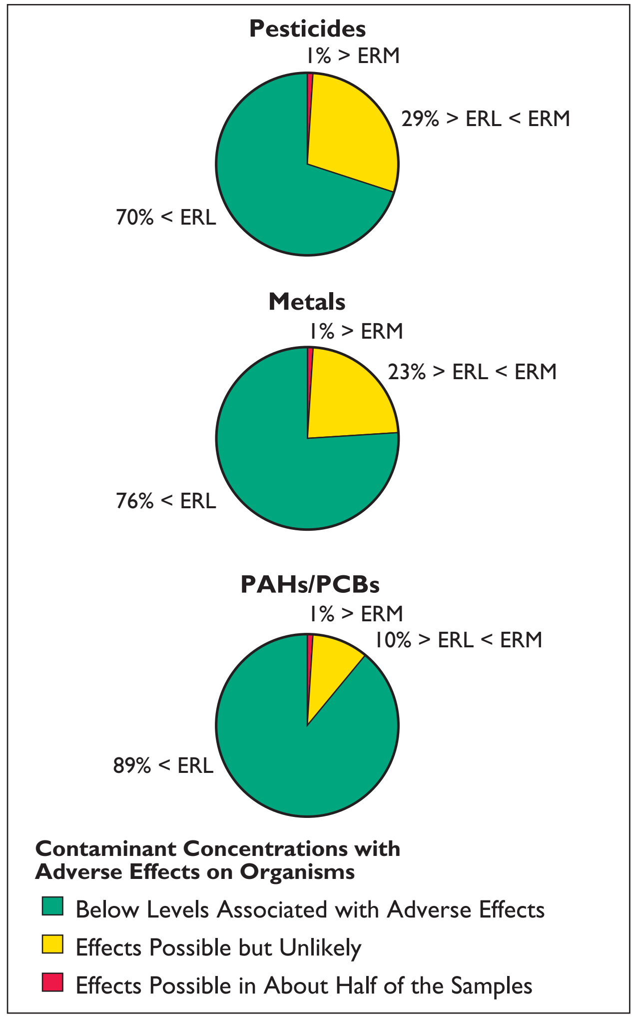


Figure 2-9. Distribution of sediment contaminants in sampled estuarine sites (NOAA and U.S. EPA).

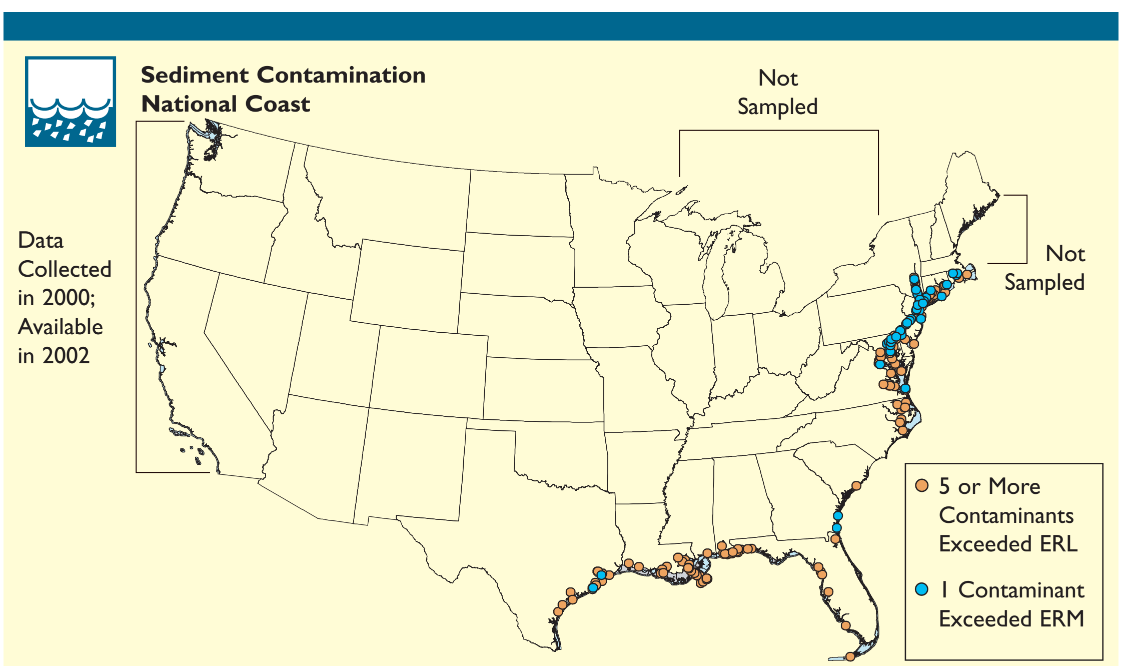


Figure 2-10. Sampled estuarine sites that exceed ERL or ERM criteria (U.S. EPA/EMAP).

NOAA's NS&T program has collected samples of shellfish tissue (mussels and oysters) from over 200 locations since 1986 to assess the bioavailability of sediment and waterborne contaminants. Information from selected sites throughout the United States shows that little change has occurred in the bioavailability of contaminants to shellfish since 1986 (83% of contaminants have not changed in bioavailability). Of contaminants measured, 14% showed decreases in availability and only 3% showed increases (Figure 2-11).

Chemical analyses of sediments can provide information on the concentrations and mixtures of potentially toxic substances in sediment samples. However, information gained from these analyses alone provides no direct measure of the toxicological significance of the chemicals. It is now possible to do an analysis of tissue residues based on the critical body residue concept. This could be used in the future as an indicator of the toxicological condition of bioaccumulated residues.

National Status and Trends Program: Bioaccumulation in Shellfish

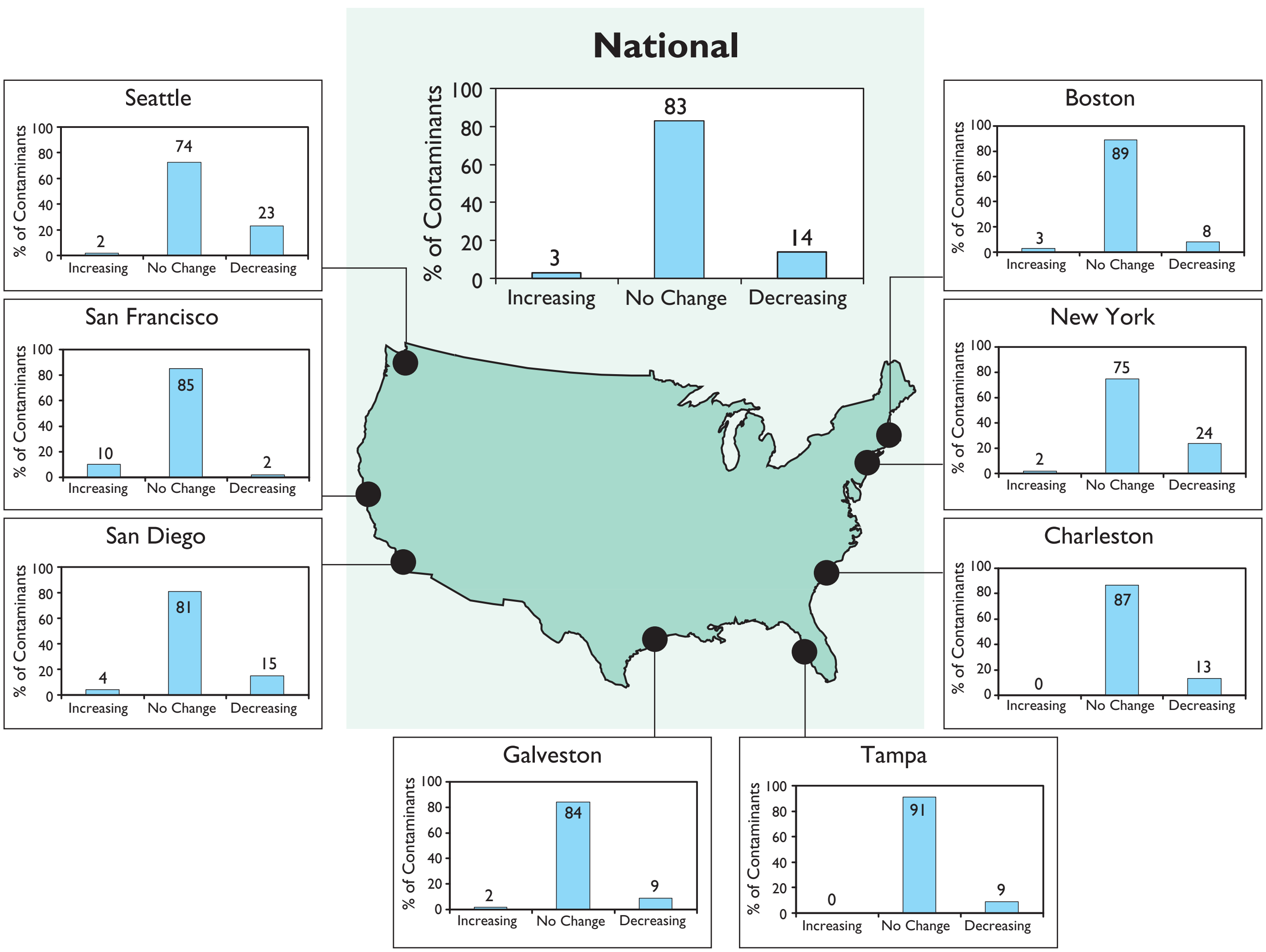
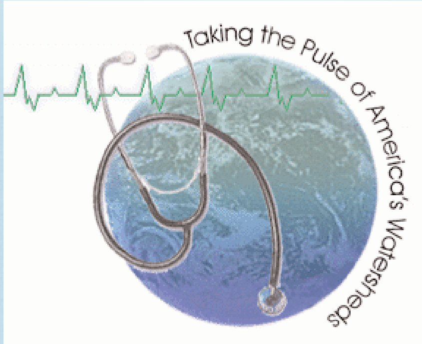


Figure 2-11. Trends in the bioaccumulation of contaminants in shellfish (NOAA/NOS).

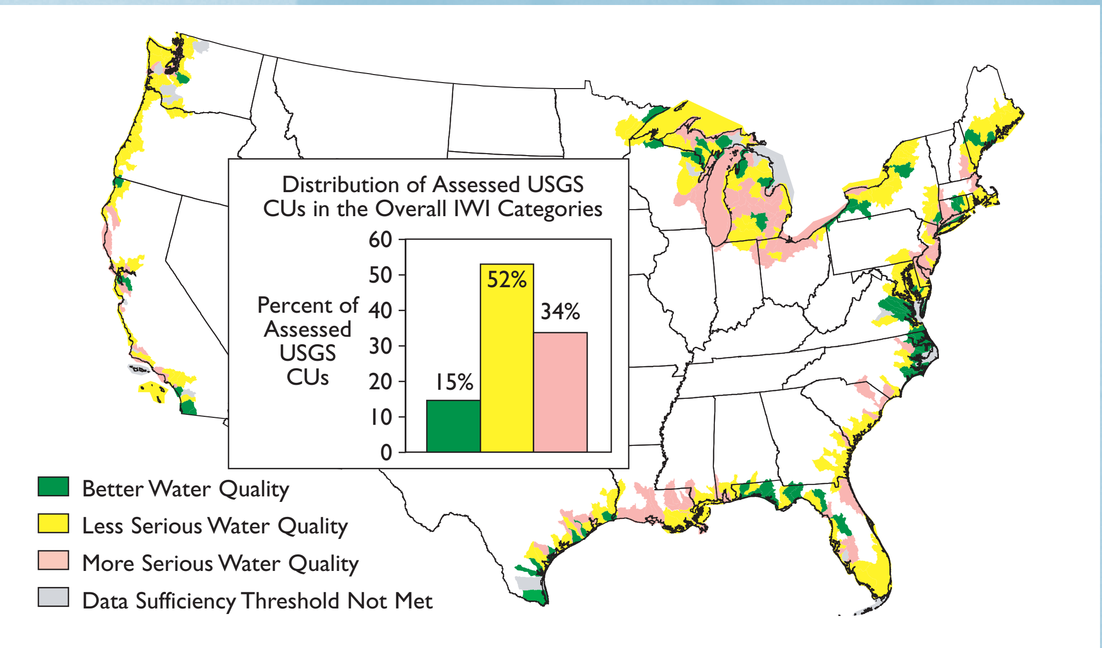
Index of Watershed Indicators



http://www.epa.gov/iwi

EPA's Index of Watershed Indicators (IWI) combines 16 different indicators of the health of the nation's water resources. Seven indicators draw on monitoring data or other information sources that document the condition of the aquatic resources in USGS Cataloging Unit (CU) watersheds. The other nine indicators are viewed as documenting a watershed's vulnerability and susceptibility to pollution. These vulnerability indicators are not based directly on water quality monitoring data or assessments, but instead draw on whether watersheds have shown major shifts in population, the intensity of agricultural land uses, or the results of screening models. The indicator shows that 34% of the nation's coastal watersheds suffer from more serious water quality problems, while only 15% are categorized as having "better water quality." Few coastal watersheds have insufficient data.

EPA's IWI national and watershed-level indicators are found on the Internet: http://www.epa.gov/iwi.



The overall watershed characterization is a compilation of condition and vulnerability indicators.

Unified Watershed Assessments

Of coastal watersheds, 81% were classified as needing restoration.

The Clean Water Action Plan in February 1998 announced the opportunity for states and tribes to provide Unified Watershed Assessments (UWAs). The current process of water quality assessment for federal agencies, states, and tribes is the use of multiple reporting mechanisms focused on various water program areas. UWAs bring together the different water quality assessment processes to better identify priorities for watershed restoration and protection. The primary focus is to identify and assemble background data on watersheds where nonpoint source pollution issues are major factors contributing to water quality problems. The aim was to characterize watersheds, where suitable data were available, into four categories:

- Watersheds Needing Restoration
- Watersheds Meeting Water Quality Standards or Goals
- Watersheds with Exceptionally High Quality Needing Protection Measures
- Watersheds Where Data Are Not Presently Available To Assign UWA Categories.

More information on Unified Watershed Assessments is available on the Internet: http://www.epa.gov/owow/uwa.

Coastal Habitat Losses and Gains – Developing a National Strategy

Habitat loss and degradation remain serious concerns for the health of the nation's coastal areas. Scientists estimate that we lost more than 50% of the nation's original wetland area between 1790 and 1980 (Dahl, 1990; Turner and Boesch, 1988). Passage of the Estuaries and Clean Water Act of 2000 enhances the strong federal commitment to estuarine habitat restoration. Many federal programs are already working to reverse the centuries-old trend of habitat decline in the United States. Federal agencies are involved in activities ranging from habitat protection and restoration to tracking acreage losses and gains. However, we lack a national system to monitor and evaluate the condition of coastal habitats, which prevents using habitat quality as an indicator of the status of our coastal wetlands.

U.S. Department of Interior
- U.S. Fish and Wildlife Service
- Coastal Habitat Conservation Program
- National Park Service
- Bureau of Land Management

National Oceanic and Atmospheric Administration
- Office of Ocean and Coastal Resource Management
- Damage Assessment and Restoration Program
- National Habitat Plan
- National Marine Fisheries Service
- National Estuarine Research Reserves
- National Marine Sanctuary Program

U.S. Environmental Protection Agency
- Office of Wetlands, Oceans, and Watersheds
- Great Waters Program
- National Estuary Program
- Chesapeake Bay Program Office

U.S. Department of Agriculture
- Natural Resource Conservation Service
- Wetland Reserve Program
- Water Bank Program
- U.S. Forest Service

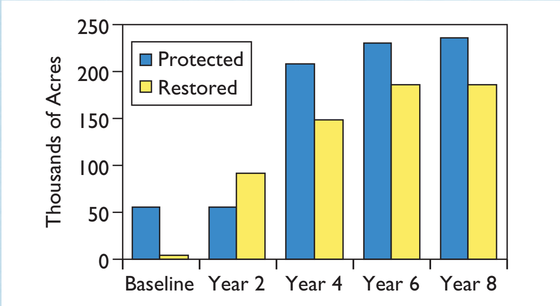
U.S. Department of Defense
- U.S. Army Corps of Engineers
- Defense Environmental Restoration Program

The Estuaries and Clean Water Act of 2000 promotes local conservation efforts and aims to restore 1 million acres of estuarine habitat by 2010. The legislation authorizes $275 million in federal matching funds over the next 5 years to support local restoration efforts. The measure also creates a council that will review project proposals for funding and develop a national strategy for estuarine habitat restoration.

The Clean Water Action Plan of 1998 makes wetland restoration a high priority and sets a national goal of increasing wetland area by 100,000 acres per year by 2005. At least 20 federal offices and programs play a role in achieving this goal by protecting, restoring, and tracking the status of coastal habitats (see sidebar). Although these programs have been successful in restoring thousands of acres of wetlands, the quality of these restored habitats remains largely unknown.

Several large-scale programs focus on protecting and restoring coastal habitat. For example, the Coastal Habitat Conservation Program, which is administered by the U.S. Fish and Wildlife Service, has succeeded in restoring over 63,000 acres and protecting over 166,000 acres of habitat in 14 high-priority sites around the country. Also, the USDA administers a program to encourage voluntary wetland preservation and rehabilitation on agricultural land. Although no data are available to determine the amount of coastal habitat protected under this program, over 5,000 contracts have been enrolled in this nationwide effort.

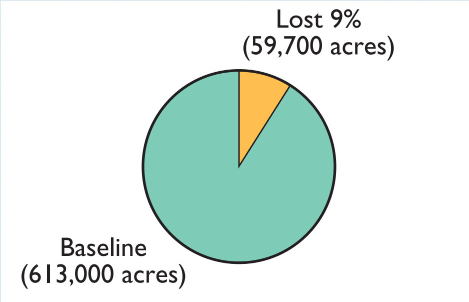
The National Oceanic and Atmospheric Administration Damage Assessment Restoration Program rehabilitates coastal habitat damaged by oil or other hazardous material spills. This program has rehabilitated 26 sites nationwide, including Prince William Sound in Alaska. The EPA's National Estuary Program has protected or restored over 400,000 acres of coastal habitat in 28 estuaries around the country (see bar chart).



Combined total of habitat acres restored or protected in connection with the National Estuary Program. Because the 28 programs began in 5 separate years, the time period refers to years since a program's inception.

Tracking the change in wetland acreage is critical to assessing whether we are achieving our restoration goals. The U.S. Fish and Wildlife Service administers a program known as the National Wetlands Inventory (NWI), which determines the location and extent of our nation's wetlands. While this effort has produced extensive data on the types and locations of wetland resources, it does not provide the information necessary to assess the status, trends, or condition of wetlands on a national basis. Another program, the NWI Status and Trends Program, reports on wetland gains and losses nationally every 10 years. Detailed regional level information is available for a few areas, including the Texas coastal wetlands (see pie chart), Great Lakes wetlands, the Mid-Atlantic region, Florida, and Alaska.

While these efforts have helped us track wetland acreage, they do not provide information on the health or condition of the nation's wetlands. EPA has established monitoring of wetland condition as a national priority and is working with states and tribes to help develop and implement monitoring programs to assess the effectiveness of wetland protection programs. This information will tell us about the condition of our wetlands and will help us understand whether coastal wetland protection and restoration efforts are producing high-quality habitats.



Loss of Texas coastal wetlands from the mid-1950s to early 1990s. While NWI has mapped a large percentage of the lower 48 states, this level of detail is available in only a few areas around the country.

Benthic Condition

The condition of benthic communities in the nation's estuaries is poor. Figure 2-12 shows that 22% of estuarine sediments are characterized by benthic communities that are in poor condition (i.e., the communities are less diverse or abundant than expected, populated by greater than expected pollution-tolerant species, or contain fewer than expected pollution-sensitive species as measured by multimetric benthic indices). Largely these differences appear to result from contaminated sediments, hypoxic conditions, habitat degradation, and eutrophication.

Benthic organisms are also used in tests of sediment toxicity. The NS&T Program and EMAP have been conducting surveys of sediment toxicity throughout the United States since 1981. Over 2,500 locations have been tested using a benthic organism as a test animal (*Ampelisca abdita*, an amphipod that naturally occurs in estuarine sediments). EMAP test results show that 10% of the sediments in the estuaries of the United States are toxic (resulting in significant mortalities) to amphipods exposed to the sediments for 10 days (Figure 2-13). NS&T bioeffects surveys of 22 major estuaries throughout the United States show a similar figure of 11% of the sediments in these estuaries are toxic to the amphipod. The NS&T surveys also examined two alternative toxicity tests using sea urchin fertilization and microbial organisms as indicators of chronic effects on estuarine organisms (nonlethal effects). The results showed that 43% to 62% of sediments in these estuaries showed some toxic effects on estuarine organisms (Table 2-1).

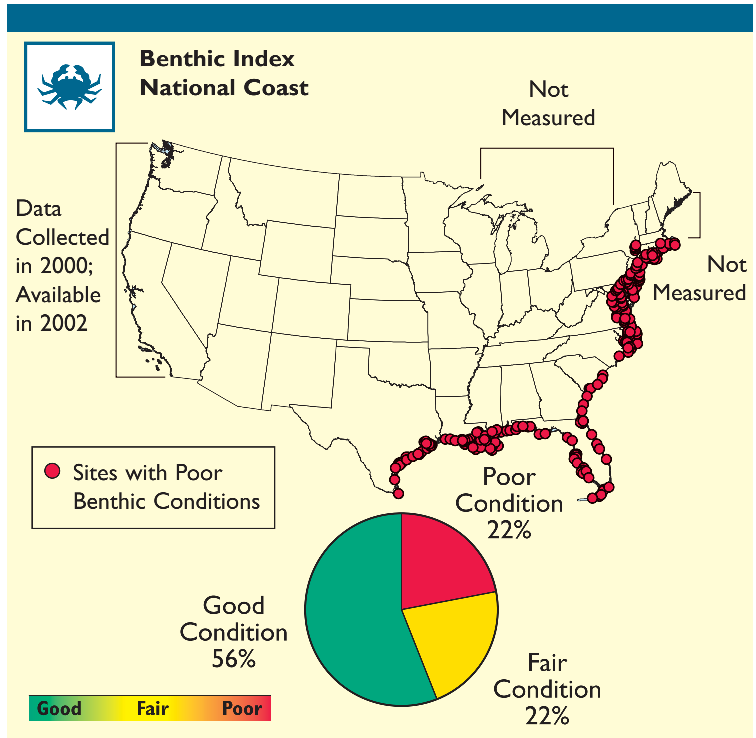


Figure 2-12. Benthic index condition data and locations with poor benthos (U.S. EPA/EMAP).

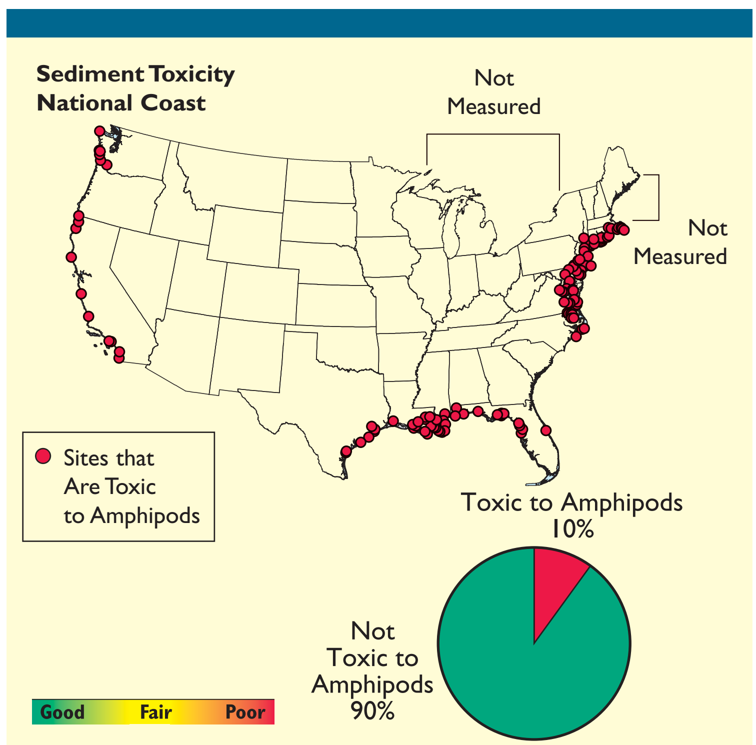


Figure 2-13. Amphipod data and locations of sites with toxic sediments (U.S. EPA/EMAP).

Table 2-1. Spatial Extent of Sediment Toxicity in Each of 22 Estuaries Using Three Toxicity Tests (Long et al., 1996)

Estuary	Percent of Area Toxic: *Ampelisca*	Sea Urchin Fertilization	Microbial
Boston Harbor	10	7	45
Long Island Sound	51	ND	68
Hudson-Raritan Estuary	38	ND	39
Newark Bay	85	ND	ND
Winyah Bay	0	42	70
Charleston Harbor	0	30	43
Leadenwah Creek	0	0	20
Savannah River	1	18	57
St. Simons Sound	<1	3	46
Biscayne Bay	25	52	96
Tampa Bay	<1	84	<1
Apalachicola Bay	0	34	100
St. Andrews Bay	0	2	100
Choctawhatchee Bay	0	44	100
Pensacola Bay	<1	5	97
Sabine Lake	0	6	79
Southern California Estuaries	58	43	ND
San Pedro Bay	14	98	ND
Mission Bay	0	66	ND
San Diego River	0	52	ND
San Diego Bay	66	76	ND
Tijuana River	56	56	ND
U.S. Estimate	11	43	62

ND = No data available.

For the locations that showed poor benthic community quality, the co-occurrence of poor environmental quality (exposure) is shown in Figure 2-14. Of the 22% of the nation's estuarine area that had poor benthos, 62% also showed contaminated sediments, 2% showed sediment toxicity, 11% showed low levels of dissolved oxygen, and 7% showed poor light conditions (high levels of total suspended solids). From this comparison, we can see that generally impaired benthic condition was linked more closely to sediment contamination than to these other stressors. About 18% of the locations that showed poor benthic community conditions (3% of the total estuarine area) had no sediment or water-quality degradation. These locations were spread throughout the regions sampled.

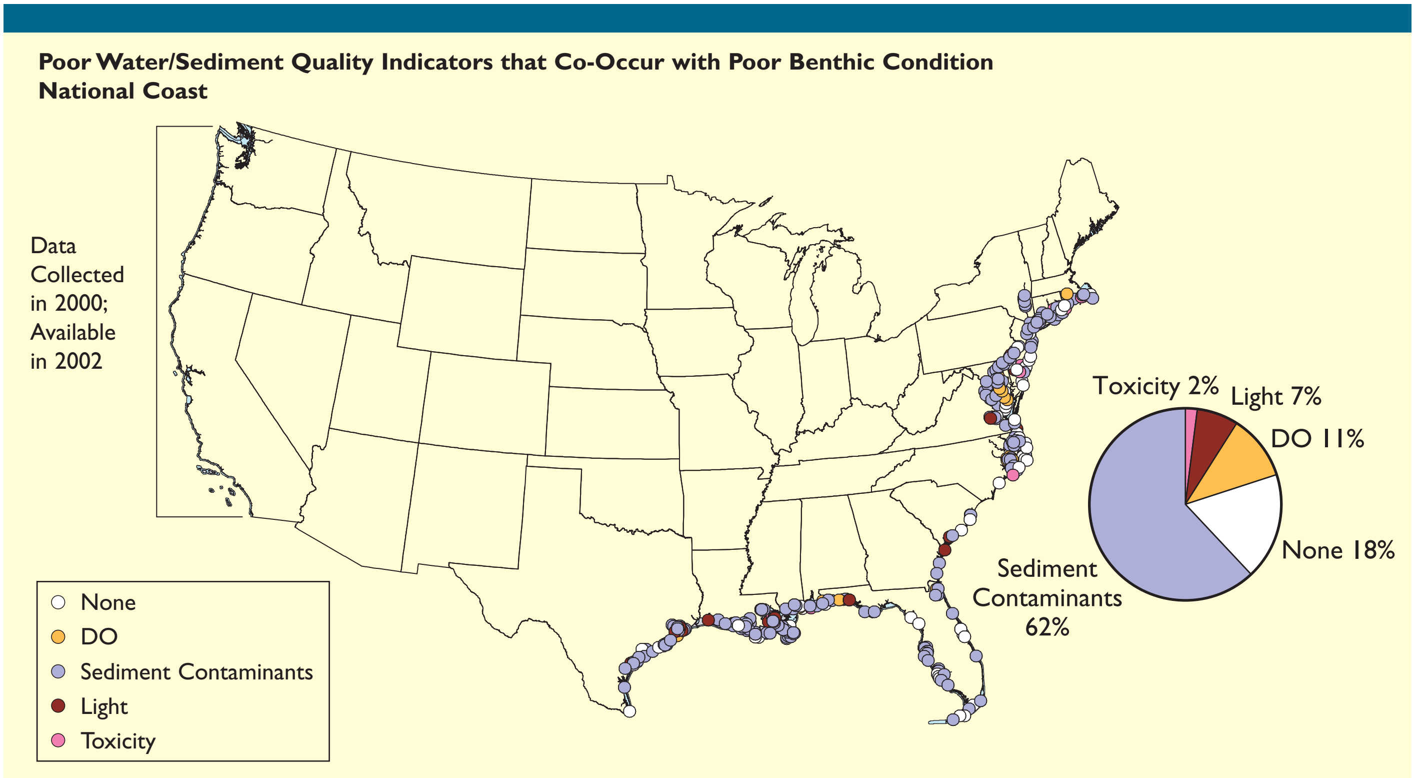
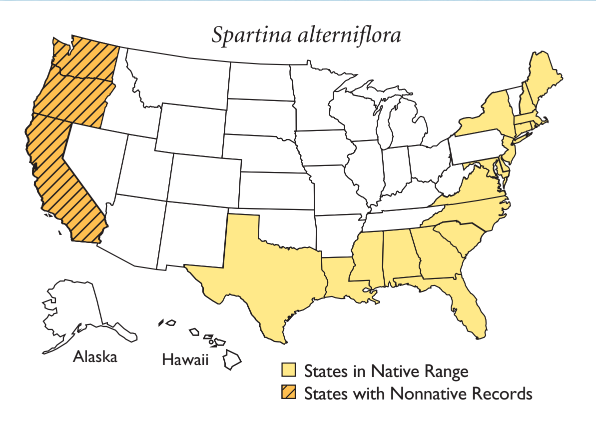


Figure 2-14. Indicators of poor water/sediment quality that co-occur with poor benthic condition in U.S. estuaries (U.S. EPA/EMAP).

highlight

Exotic Species in Coastal Environments

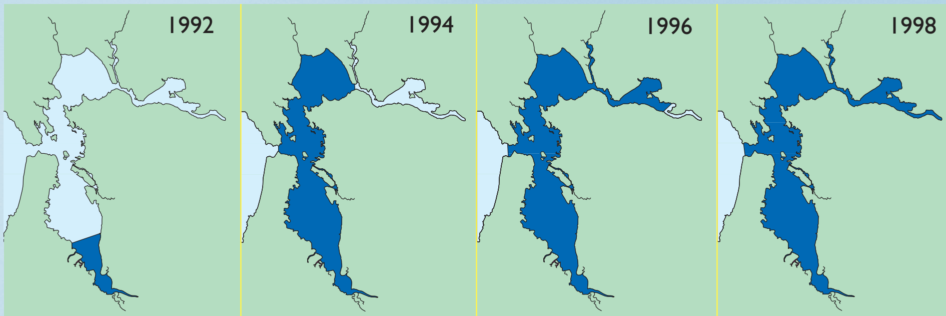
Scientists believe the spread of exotic species is one of the five most critical issues facing marine environments (Wilcove et al., 1998). Exotic species, also called nonindigenous, nuisance, or invasive species, or biotic invaders, are "species that establish a new range in which they proliferate, spread, and persist to the detriment of the environment" (Ecological Society of America, 1999).



The spread of *Spartina alterniflora* to West Coast estuaries threatens native habitats in California, Oregon, and Washington.

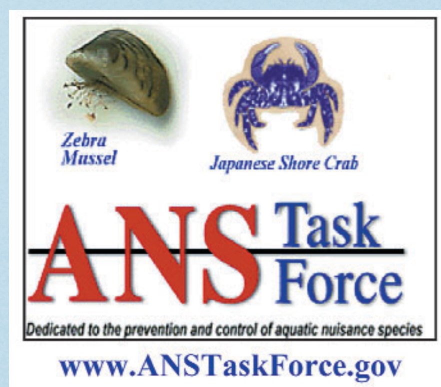
Over the past decade, an increasing number of nonindigenous aquatic fauna like the zebra mussel, Asian clam, Japanese shore crab, Chinese mitten crab, European green crab, and Asian green mussel; plant species such as *Spartina alterniflora*, purple loosestrife, Brazilian pepper, and Australian paperbark tree (*Melaleuca quinquenervia*); and pathogens like cholera have been unintentionally introduced into nonnative coastal environments with consequent harmful, sometimes devastating, ecological, public health, and socioeconomic effects.

These species can upset the balance of coastal ecosystems through predation or displacement of native species, as in the case of *Spartina alterniflora*, an East Coast native that has spread rapidly and displaced native wetland species in northern California, Oregon, and Washington state estuaries (see map). Exotic species can also cause major disruption to power plants as well as to municipal and industrial water treatment and distribution systems by clogging those systems' intake pipes. For instance, water users in the Great Lakes region now must bear the cost of tens of millions of dollars spent each year to remove zebra mussels from the Great Lakes and their tributaries.



Distribution of the Chinese mitten crab in the San Francisco Estuary and its watershed. Solid blue area or lines indicates presence of the crab (California Department of Fish & Game).

Unintentionally introduced pathogens can be deadly, especially when these introductions go unnoticed. An introduced strain of cholera bacteria, possibly released in the bilge water of a Chinese freighter, caused the deaths of 10,000 people in Latin America in 1991. This cholera strain was then transported to the United States from Latin America in the ballast tanks of ships that anchored in the port of Mobile, Alabama. Fortunately, cholera bacteria were detected in oyster and finfish samples in Mobile Bay. A public health advisory was issued, and no additional deaths occurred from exposure to this pathogen.



In the United States, the Aquatic Nuisance Species (ANS) Task Force (Task Force), an intergovernmental organization co-chaired by the Fish and Wildlife Service and NOAA, is the main federal body dedicated to coordinating efforts nationwide that target prevention, research, outreach/education, and management of coastal and estuarine exotic species. Information about Task Force activities can be found on the Internet at http://www.ANSTaskForce.gov. Together with the Task Force, the U.S. Geological Survey has organized a National Nonindigenous Aquatic Species (NAS) Information Center that maintains updated information on nonindigenous aquatic species found throughout the United States. Through the Center, lists of nonindigenous aquatic species are available by state and by watershed for each of the major animal groups. Those lists can be accessed on the Internet at http://nas.er.usgs.gov. In addition, Sea Grant's National Aquatic Nuisance Species Clearinghouse maintains a library that includes a searchable electronic database of published research and other documentation on aquatic nuisance species. Sea Grant's Clearinghouse can be accessed on the Internet at http://www.cce.cornell.edu/programs/nansc/nan_1d.cfm.

Fish Tissue Contaminants

National estuarine conditions as measured by fish tissue contamination are fair. Figure 2-15 shows that 26% of estuarine fish populations sampled show elevated levels of contaminants in their edible tissues. Moreover, of this 26%, 22% were fish with elevated levels of arsenic represented by organic arsenobetaines that are not considered toxic to humans. Thus, only 4% of examined fish have nonarsenical toxic compounds at significant concentrations in their edible flesh to be of concern to humans.

The frequency and type of gross pathologies on fish taken in trawls in estuarine waters are indicators of overall condition of fish populations. All fish collected by EMAP were examined for evidence of disease, parasitism, tumors, and lesions on the skin; malformations of the eyes; gill abnormalities; and skeletal curvatures. Nearly 100,000 fish were examined from U.S. estuaries; only 454 of the fish (0.5%) had external abnormalities (Table 2-2). Of the fish examined, bottom-feeding fish (e.g., catfish) had the highest frequency of disease. The number of fish with multiple gross pathologies increased in areas where the sediments contained high levels of multiple contaminants.

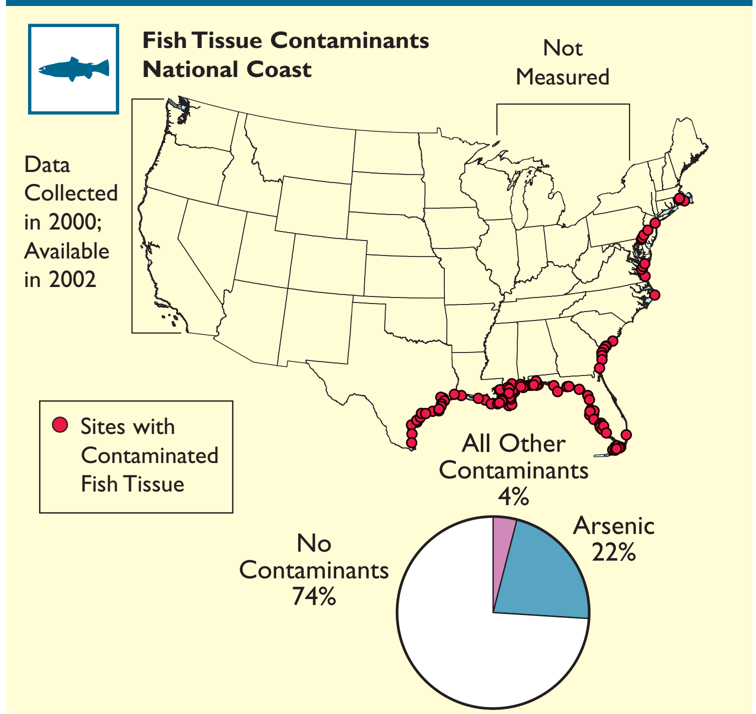


Figure 2-15. Contaminants in edible fish tissue (U.S. EPA/EMAP).

Table 2-2. Fish Pathologies by Province (U.S. EPA/EMAP)

Province	Number of Fish	Percent of Pathologies
Virginian	13,421	0.4
Carolinian	13,304	0.3
Louisianian and West Indian	64,100	0.7
United States	90,825	0.5

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

Assessments and Advisories

Photo© John Theilgard

Clean Water Act Section 305(b) and 303(d) Assessments

Note: Great Lakes data are not included here. The Great Lakes 305(b) assessment is presented in Chapter 7.

Of the 27 coastal states and territories, 22 rated general water quality conditions in some of their estuarine waters. Information was also submitted by the District of Columbia, the Delaware River Basin Commission, and the Interstate Sanitation Commission. Together, these states assessed 28,687 square miles of estuarine waters, which equals 32% of the 90,465 square miles of estuarine waters in the nation. Of these 27 coastal states, 15 rated general water quality conditions for ocean shoreline. They assessed 3,130 miles, representing 5% of the nation's coastline including 44,000 miles of coastline in Alaska, or 14% of the 22,419 miles of national coastline excluding Alaska.

States reported that 46% of the assessed estuarine waters have good water quality that fully supports designated uses (Figure 2-16). Of these waters, 10% are threatened for one or more uses. Some form of pollution or habitat degradation impairs the remaining 44% of assessed estuarine waters. Most of the assessed ocean shoreline miles (2,753 miles, or 88%) have good water quality that supports a healthy aquatic community and public activities (Figure 2-17).

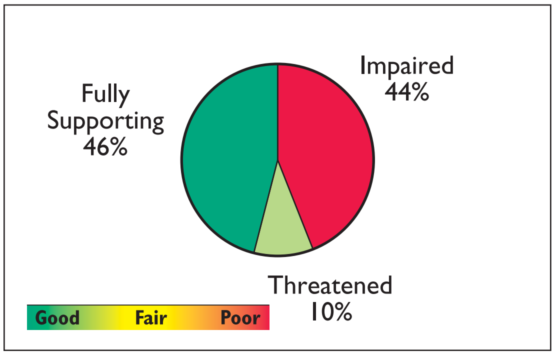


Figure 2-16. Water quality in assessed estuaries (U.S. EPA).

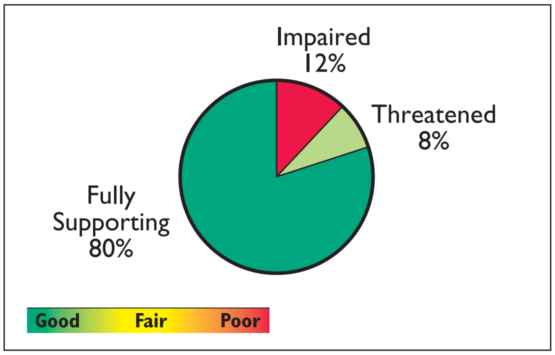


Figure 2-17. Water quality in assessed shoreline waters (U.S. EPA).

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

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

For the purposes of this report, waters classified as partially supporting or not supporting their uses are categorized as impaired. Twenty-five states reported the individual use support of their estuarine waters (Figure 2-18). States provided limited information on individual use support in ocean shoreline waters (Figure 2-19). General conclusions cannot be drawn from such a small fraction of the nation's ocean shoreline waters. Significantly, 11 states have adopted statewide coastal fish consumption advisories for mercury, PCBs, and other pollutants. These advisories are not represented in the use support numbers.

Included in the 1998 303(d) list of impaired waters are 1,402 waters located on the coast of the conterminous United States (Figure 2-20). These coastal waters represent 6% of the nation's total number of 303(d) listed waters (22,010). The major stressors that impair 303(d) listed waters are sedimentation, nutrients, pathogens, toxics/metals/inorganics, toxics/organics, mercury, and pesticides.

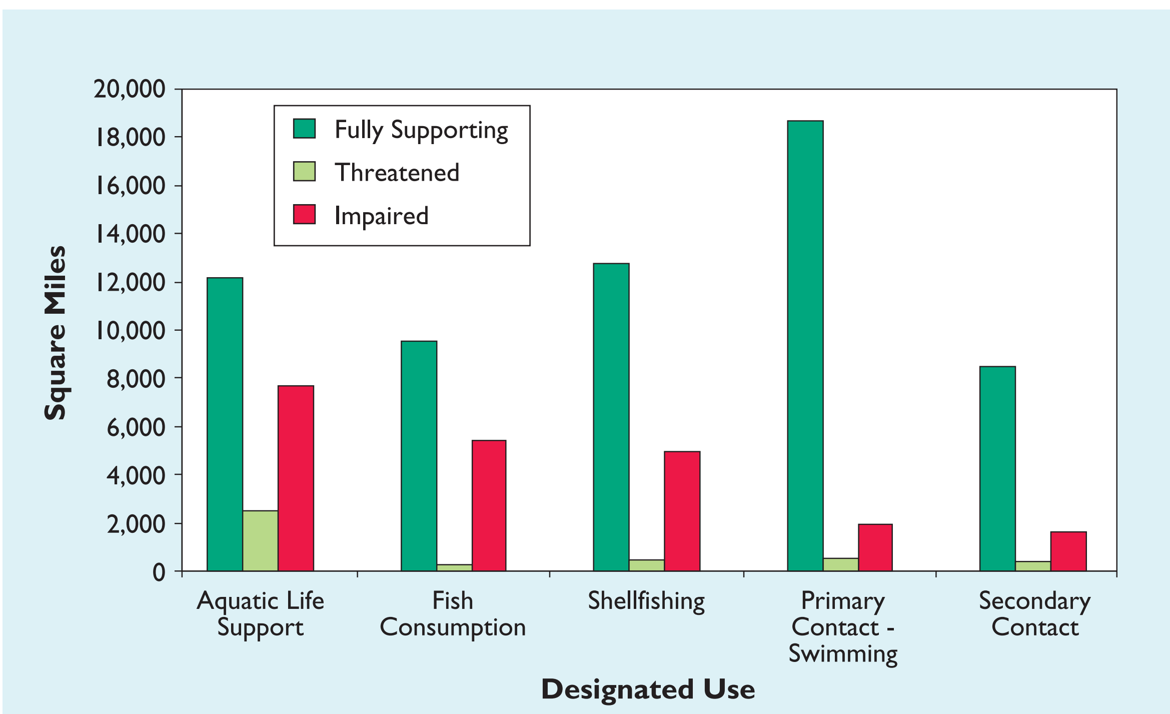


Figure 2-18. Individual use support for assessed estuarine waters (U.S. EPA).

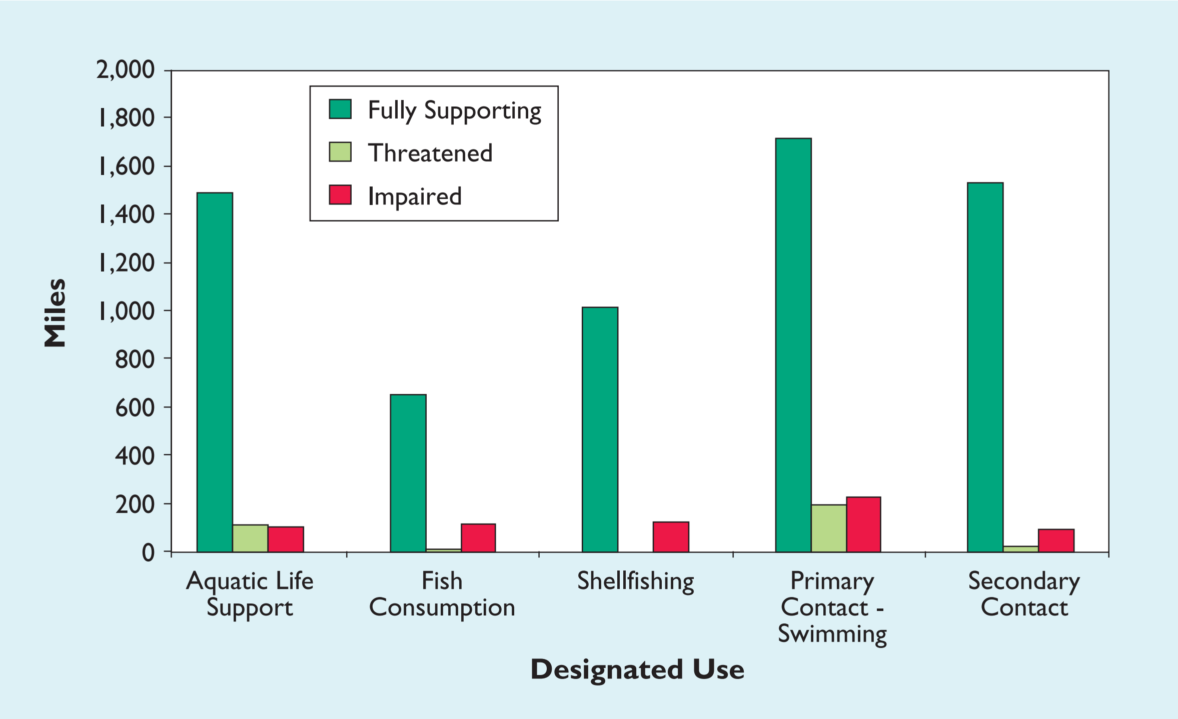


Figure 2-19. Individual use support for assessed coastal shoreline waters (U.S. EPA).

Total Maximum Daily Load (TMDL) Program

You can view maps of the nation's 303(d) listed waters and associated impairments at EPA's Total Maximum Daily Load website. You can view local information and download GIS and database files from this site as well:

http://www.epa.gov/owow/tmdl

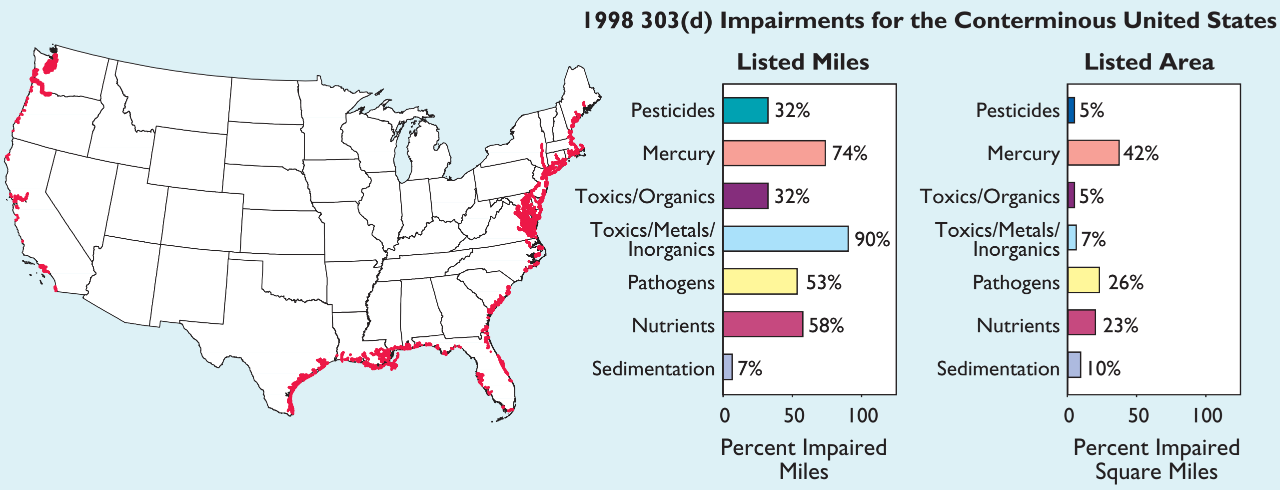
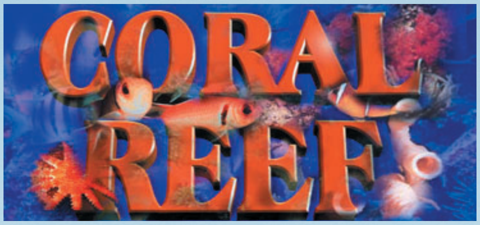


Figure 2-20. 1998 coastal 303(d) listed waters and the distance/area impaired by the top pollutants (U.S. EPA).



Coral Reefs in the United States

Coral reefs are among the most diverse and biologically complex ecosystems on earth. Now under threat from multiple stresses, coral reefs are deteriorating worldwide at alarming rates. It is difficult to generalize about the condition of coral reefs in the United States because of their broad geographic distribution and the lack of long-term monitoring programs that document environmental and biological baselines. However, it is clear that coral reefs are threatened wherever they are close to large concentrations of people. Data are available to evaluate the status and trends of coral reefs at only a few sites.

The only emergent coral reefs found off the continental United States are located in the Florida Keys and the Gulf of Mexico. Coral reefs are also found in the Hawaiian Islands, the U.S. Virgin Islands, Puerto Rico, and U.S. territories in the Pacific including American Samoa, the Northern Mariana Islands, and Guam. A number of small U.S. territorial islands in the Pacific also have significant reef habitats in their waters, including the islands of Howland, Baker, Jarvis, Johnston Atoll, Palmyra Atoll, Kingman Reef, and Wake. Few surveys of these reefs exist. All are within the 200 nautical mile U.S. Exclusive Economic Zone.

The United States is one of many nations around the world working to halt the coral reef crisis and protect, restore, and sustainably use coral reef ecosystems for current and future generations. The U.S. Coral Reef Task Force (CRTF) was established in June 1998 to lead the U.S. response to this growing global environmental crisis. The CRTF is responsible for developing and implementing coordinated efforts to

- Map and monitor U.S. coral reefs
- Research the causes and solutions to coral reef degradation
- Reduce and mitigate coral reef degradation from pollution, overfishing, and other causes
- Implement strategies to promote conservation and sustainable use of coral reefs internationally.

Members of the CRTF include the heads of 11 federal agencies (including EPA and NOAA) and the governors of 7 states, territories, or commonwealths with responsibilities for coral reefs. The CRTF has produced a National Action Plan (available on the Internet at http://coralreef.gov) that outlines its approach to conserve coral reefs within the United States. More information on federal programs to study and conserve coral reefs is also available on the Internet at http://www.coralreef. noaa.gov.

A Brief Introduction to Coral Reefs of the United States

Florida—The coral reefs immediately off the Florida Keys are part of the world's third largest barrier reef ecosystem, stretching 139 mi^2 from south of Miami to the Dry Tortugas. A major monitoring program is in place to collect information about the condition of coral reef resources in the Florida Keys National Marine Sanctuary and the effectiveness of various management strategies.

Hawaii—The main Hawaiian Islands contain a large area of coral reefs (340 mi^2) located in both federal and state waters. In general, coral reefs in state waters are overfished and some reefs are degraded due to coastal development.

Texas/Louisiana—In the Gulf of Mexico, well-developed coral reefs are found 110 miles south of the Texas/Louisiana border. These reefs, designated as the Flower Garden Banks National Marine Sanctuary in 1992, are less impacted by most fishing and diving pressures due to their remote location.

Puerto Rico—Well-developed shallow reefs are located around the islands of Puerto Rico, Mona, Culebra, and Vieques, where coral cover is up to 20%, and along the southwest coast near LaParquera with about 20% coverage. Reefs in parts of Puerto Rico such as the Jobos Bay National Estuarine Research Reserve, however, are in poor condition due to sewage disposal and coastal erosion, and coral cover averages less than 5%.

U.S. Virgin Islands—In general, the amount of living coral on these reefs has declined and the amount of algae has increased in the last two decades. Hurricanes in 1989 and 1995 and white band disease produced the most damage to reefs; however, sedimentation from runoff and overfishing through the use of fish traps are also problems.

Guam—Nearly all coral reefs surrounding Guam are located within territorial waters and are generally overfished and degraded as a result of various human activities, especially coastal development leading to sedimentation. The commercial fish catch has declined over 70% in the past 15 years.

Northern Mariana Islands—A chain of 16 volcanic islands starting about 100 miles northeast of Guam and extending over 900 miles north, the Northern Mariana Islands includes fringing reefs along most islands. The condition of the coral reefs varies due to physical disturbances from storms and outbreaks of crown-of-thorns starfish, but because the region is sparsely populated, human-caused disturbances such as overfishing and pollution are most evident on the southernmost islands. Several marine reserves were established in 1997.

American Samoa—This U.S. territory includes five volcanic islands and two coral atolls. The more remote islands are in good condition, with far more live coral cover and species richness than the main island (Tutuila Island). Rose Atoll, located over 149 miles east of Tutuila, is one of the world's most isolated and least disturbed atolls and is protected as a National Wildlife Refuge.

Source: NOAA State of the Coast Report, 1998.

State Fish Consumption Advisories

A total of 79 fish consumption advisories were in effect for estuarine and coastal marine waters of the United States in 2000, including 71% of the coastal waters of the contiguous 48 states (Figure 2-21). There are also 32 fish consumption advisories in the Great Lakes and their connecting waters. An advisory may represent one waterbody or one type of waterbody within a state's jurisdiction. Some of the advisories are issued as single statewide advisories for all coastal estuarine and/or marine waters within the state (Table 2-3). While the statewide coastal advisories have placed a large proportion of the nation's coastal waters under advisory, these advisories are often issued for the larger size classes of predatory species (such as bluefish and king mackerel) because larger, older individuals have had more time to be exposed to and accumulate one or more chemical contaminants in their tissues than younger individuals.

The number and geographic extent of advisories can serve as indicators of the level

Table 2-3. Summary of Statewide Advisories for Coastal/Estuarine Waters

State	Pollutants	Species Under Advisory
Alabama	Mercury	King mackerel
Connecticut	PCBs	Striped bass Bluefish
Florida	Mercury	Shark King mackerel
Georgia	Mercury	King mackerel
Louisiana	Mercury	King mackerel
Maine	Dioxins	Striped bass Bluefish Lobster (tomalley)
Massachusetts	PCBs	Lobster (tomalley)
Mississippi	Mercury	King mackerel
New Hampshire	PCBs	Bluefish Lobster (tomalley)
New Jersey	PCBs, cadmium, dioxins	American eel Striped bass Bluefish Lobster (tomalley)
New York	Cadmium, dioxins	Lobster (tomalley) Blue crab (hepatopancreas)
North Carolina	Mercury	King mackerel
Rhode Island	PCBs	Striped bass Bluefish
South Carolina	Mercury	King mackerel
Texas	Mercury	King mackerel

Figure 2-21. The number of coastal and estuarine fish consumption advisories per USGS cataloging unit. The count does not include advisories that may exist for noncoastal or nonestuarine waters. Alaska did not report advisories (U.S. EPA NLFWA, 2000c).

of contamination of estuarine and marine fish and shellfish, but a number of other factors 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 estuarine waters and many hundreds of miles of coastal waters.

Although advisories in U.S. estuarine and coastal waters have been issued for a total of 20 individual chemical contaminants, most advisories issued have resulted from four primary contaminants. These four chemical contaminants—PCBs, mercury, DDT and its degradation products DDE and DDD, and dioxins/furans—were responsible for 77% of all fish consumption advisories in effect in estuarine and coastal marine waters in 2000 (Figure 2-22, Table 2-4). These chemical contaminants are biologically accumulated (bioaccumulated) in the tissues of aquatic organisms to concentrations many times higher than concentrations in seawater (Figure 2-23). Concentrations of these contaminants in the tissues of aquatic organisms may be increased at each successive level of the food chain. As a result, top predators in a food chain 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

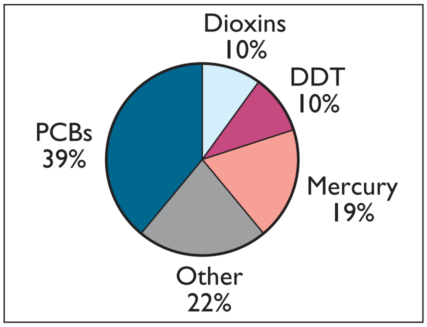


Figure 2-22. Percentage of estuarine and coastal marine advisories issued for each contaminant (U.S. EPA NLFWA, 2000c).

Table 2-4. Four Bioaccumulative Contaminants Were Responsible for 77% of Fish Consumption Advisories in Estuarine and Coastal Marine Waters in 2000.

Contaminant	Number of Advisories	Comments
PCBs	48	Five northeastern states (CT, MA, NH, NJ, and RI) had statewide advisories.
Mercury	24	Eight states (AL, FL, GA, LA, MS, NC, SC, TX) had statewide advisories in their coastal marine waters; 6 of these states also had statewide advisories for estuarine waters.
DDT, DDE, and DDD	13	All DDT advisories were in effect in California (12) or the Territory of American Samoa (1).
Dioxins and Furans	12	Statewide dioxin advisories were in effect in ME, NJ, and NY. Historically, dioxin/furan advisories have been associated with pulp and paper mill effluents as the source of contamination.

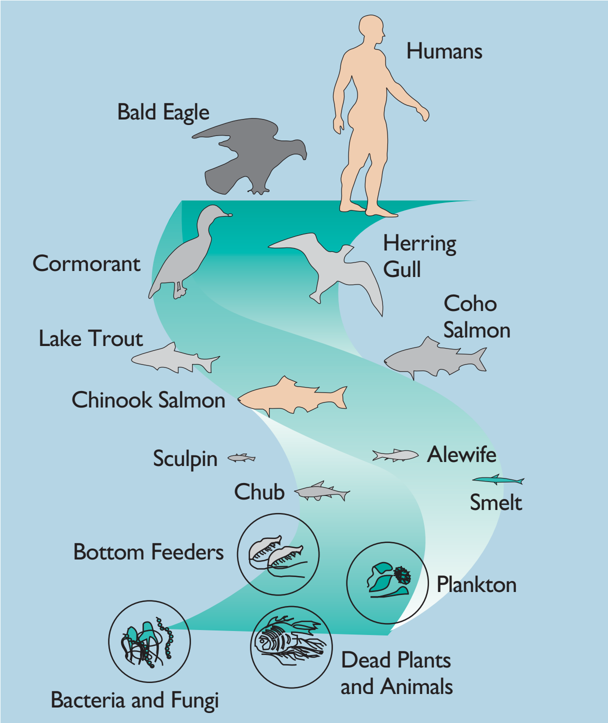


Figure 2-23. Bioaccumulation (U.S. EPA).

sediment contaminants is not possible because states often issue advisories for groups of chemicals. However, five of the top six contaminants associated with fish advisories (PCBs, DDT, dieldrin, chlordane, and dioxins) are among the contaminants most often responsible for a Tier 1 National Sediment Inventory classification (associated adverse effects to aquatic life or human health are probable) of waterbodies based on potential human health effects (U.S. EPA, 1997).

Classified Shellfish-Growing Waters

In 1995, 4,230 individual shellfish-growing areas containing 24.8 million acres of estuarine and nonestuarine waters were classified in 21 coastal states. This represents an increase of 2.1 million acres and 1,058 shellfish-growing areas compared to the 1990 Register. The increase is due primarily to the rise in the number of states classifying nonestuarine waters—in the 1995 Register, every state except Alabama reported classified areas in nonestuarine waters. Sixty percent of waters were classified as approved (Figure 2-24).

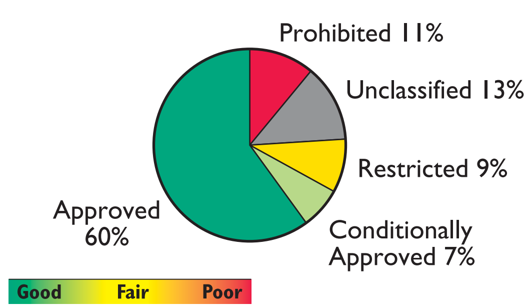


Figure 2-24. Classification of shellfish-growing waters (1995 Shellfish Register, NOAA, 1997).

The top five pollution sources reported as contributing to harvest limitations were urban runoff, upstream sources, wildlife, individual wastewater treatment systems, and wastewater treatment plants. Compared to the 1990 Register, there is a significant decrease in the acreage that is harvest-limited due to contributions from industry, wastewater treatment plants, and direct discharges. There is an increase in the acreage limited by boating and marinas, urban runoff, and agricultural runoff.

State shellfish management personnel reported almost 500 shellfish restoration activities taking place in harvest-limited waters in 1995. Nineteen of the 21 coastal states were engaged in at least one restoration activity. Restoration of shellfish-growing areas includes activities that improve water quality, restore habitat, or enhance shellfish stocks. Examples of restoration projects include connecting residences with malfunctioning or failing septic systems to a sewage collection system to improve water quality, planting cultch to increase suitable habitat, and releasing hatchery-raised, disease-resistant spat to increase production.

Beach Closures

EPA gathered information on 2,051 beaches nationwide (both coastal and inland) through the use of a voluntary survey. The survey respondents were almost exclusively local government agencies from coastal counties, cities, or towns bordering the Atlantic Ocean, Gulf of Mexico, Pacific Ocean, or the Great Lakes, although a few respondents were state or regional (multiple-county) districts. Data are available only for those beaches for which officials participated in the survey. EPA will conduct the survey each year and display the results on the BEACH Watch website.

EPA's review of coastal beaches (U.S. coastal areas, estuaries, and the Great Lakes) showed that, of the 1,444 coastal beaches responding to the survey, more than 370 beaches or 26%

had an advisory and/or closing in effect at least once during 1999 (Figure 2-25). Approximately 13% of the coastal beaches experienced at least one closure. Beach closures were issued for a number of different reasons, including sewage, elevated bacterial levels, and preemptive reasons. The major causes of beach closures included stormwater runoff, pipeline breaks, combined sewer overflows, and unknown causes.

The majority of beach closings in the United States are due to indications of the presence of high levels of harmful micro-organisms found in untreated or partially treated sewage. Most of this sewage enters the water from combined sewer overflows, sanitary sewer overflows, and malfunctioning sewage treatment plants. Untreated storm water runoff from cities and rural areas can be another significant source of beach water pollution. In some areas, boating wastes and malfunctioning septic systems can also be important local sources of beach water pollution. People who swim in water near storm drains can be at increased risk of becoming ill. A recent epidemiological study in Santa Monica Bay, California, revealed that individuals who swam in areas adjacent to flowing storm drains were 50% more likely to develop a variety of symptoms than those who swam farther away from the same drain. Swimmers who did not avoid the drains experienced an increased risk for a broad range of adverse health effects.

Discovering treasures in the tidepools at Fitzgerald Marine Reserve in Moss Beach (Photo: Joe Heath).

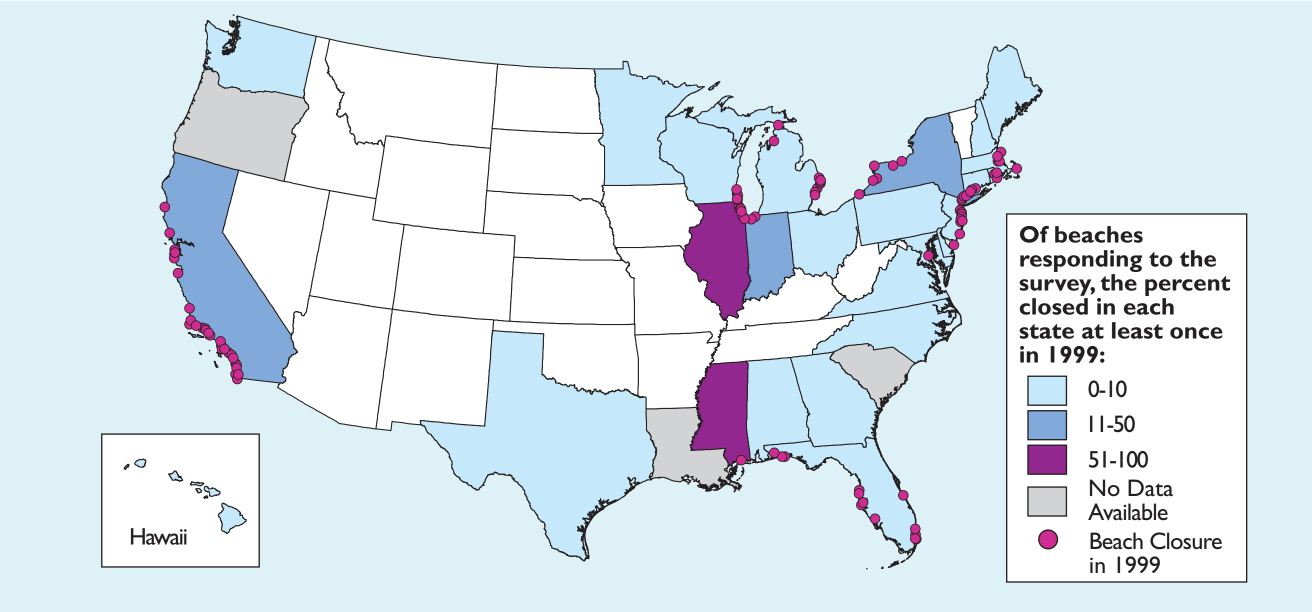


Figure 2-25. The percentage of beaches responding to the survey that closed at least once in 1999. Percentages are based on the number of beaches in each state that reported information, not the total number of beaches. There were no BEACH Watch Survey responses from Alaska (U.S. EPA).

Freshwater Inflow to Estuaries—How Much Is Enough?

The productive habitat of an estuary relies on a balance between freshwater coming from inland sources and saltwater coming from coastal bays and the ocean. Seasonal flooding flushes marsh wetlands, transports food materials from the marshes into the estuaries, and removes or limits pollutants, parasites, bacteria, and viruses in the marshes. However, increasing demand is being placed on freshwater resources in the United States as a result of population growth, agriculture, and industrial needs, and it is not unusual for one river to be diverted in several locations to supply water to different communities. This can have consequences on the amount of freshwater that flows into an estuary and can cause alterations to the water quality (e.g., salinity) as well as to the quality of the area's habitat. A decrease in freshwater inflow can result in a decrease in the quantity of low-salinity wetlands, changes in tidal-flow patterns, and losses of vital estuary habitats. The timing of the arrival of freshwater to estuarine areas is important to plants and animals. Their life cycles are often triggered by or conditional to the salinity of the water. A few estuary programs, such as the Albemarle-Pamlico Sounds National Estuary Program, have problems with increased freshwater inflow due to hurricanes, large rain storms, or the draining of areas previously not connected to the estuarine system. Where too much freshwater inflow occurs, diversion of streams may be used to mitigate the problem.

The issue of freshwater inflow is so important that several federal programs, including EPA's National Estuary Program (NEP), consider freshwater inflow a priority problem that must be addressed. According to a survey of directors from the 28 NEPs conducted in the fall of 1999, the Albemarle-Pamlico Sounds National Estuary Program, Charlotte Harbor, and the San Francisco Estuary Project are the only NEPs that list freshwater inflow as a high-priority action item. Several other estuaries list freshwater inflow as a concern but not as a top priority.

In Florida, Rookery Bay National Estuarine Research Reserve (NERR), part of the national program run by NOAA, is leading efforts to restore natural freshwater inflows to estuaries in south Florida. Rookery Bay staff received support from the Florida Coastal Management Program to develop a watershed restoration and management plan for local, state, and federal agencies. The plan identifies historic and current surface water inflows in the reserve and makes specific recommendations for restoring surface water flow.

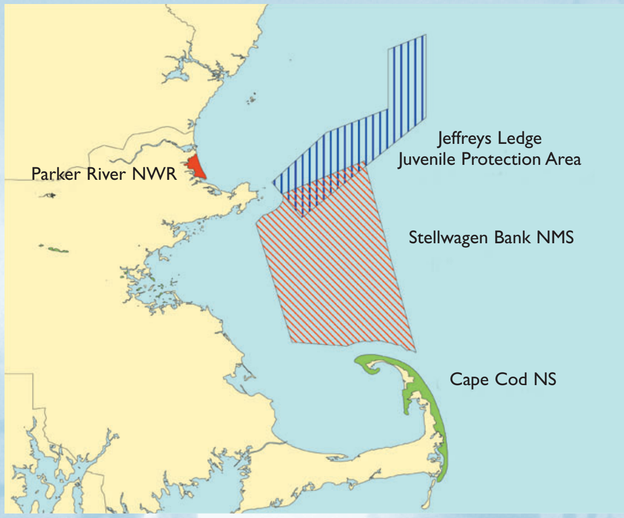
Rookery Bay NERR is also working to understand the effects of freshwater inflows on fish species. Research by the Florida Department of Environmental Protection indicates that alterations in freshwater inflows during Hurricane Andrew and other major storm events damaged estuarine habitats within the reserve. Human impacts, such as the construction of weirs (or dams), alter the flow of freshwater and nutrients flowing into estuaries. The reserve recently received funding from the National Marine Fisheries Service to restore natural freshwater inflow patterns. The reserve proposes to computerize a weir on Henderson Creek, which would allow for more natural flow of freshwater into the estuary. It is hoped that the studies associated with this project will enable water management districts to facilitate more natural water flow impact on downstream salinity and aquatic communities in southwest Florida. The computerization of the weir will provide for a more natural habitat for fish populations.

Source: NOAA State of the Coast Report, 1998.

highlight

Developing a Nationwide Strategy for Marine Protected Areas

Since the 1950s, a combination of legislation, voter initiatives, and regulations has created a complex collection of Marine Protected Areas (MPAs). Federal agencies alone manage over 300 areas that may meet the MPA definition. On May 26, 2000, President Clinton signed Executive Order 13158, intended to protect significant natural and cultural resources within the marine and Great Lakes environments. The Order establishes a national system and inventory of MPAs consisting of a coordinated network of local, state, tribal, and federal sites.



Marine Protected Areas near Cape Cod, MA. This map shows examples of several types of MPAs including a National Seashore, National Wildlife Refuge, National Marine Sanctuary, and a Juvenile Protection Area managed by the National Marine Fisheries Service.

The Order defines MPAs as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Under this definition, MPAs could include a wide variety of sites established for different purposes in areas of coastal and ocean waters, the Great Lakes and their connecting waters, and submerged lands in areas of U.S. jurisdiction. Areas fitting this description include national marine sanctuaries, some national parks and national wildlife refuges, national estuarine research reserves, national estuary programs, some state and local marine parks, and some fishery management areas (see the figure). Federal agencies will use this definition to create an inventory of all U.S. MPAs, one of the steps needed to help build a nationally consistent system.

The order outlines actions to be taken by federal agencies to improve the management of MPAs (see sidebar). Federal agencies will work with an Advisory Committee composed of nonfederal scientists, resource managers, and other interested persons and organizations and will establish a National MPA Center to meet these goals.

- Strengthen the management, protection, and conservation of existing MPAs
- Establish new or expanded MPAs
- Develop a science-based national system of MPAs representing diverse U.S. marine ecosystems and the nation's natural and cultural resources
- Avoid causing harm to MPAs through federal activities
- Provide state, territorial, tribal, and local governments with MPA information, technology, and management strategies to establish and manage MPAs

Goals outlined by Executive Order 13158 to improve the management of Marine Protected Areas.