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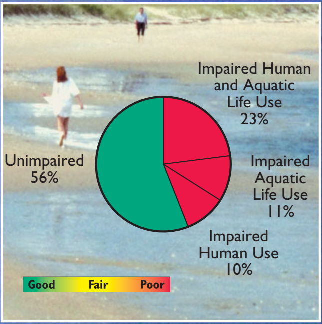
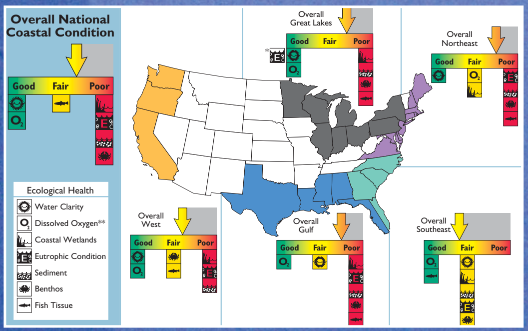
National Coastal Condition Report





Cover Photos: (Middle left) During the Hawaiian Islands Humpback Whale Sanctuary's dedication ceremony, the entire community was invited to participate in a Native Hawaiian fish gathering activity known as a "hukilau." The Maui Sanctuary office sits in front of one of the last remaining Native Hawaiian fishponds in South Maui. Prior to the Sanctuary's official approval, many people from the fishing community feared the imposition of additional Sanctuary regulations. On the contrary, however, fishing is not regulated in the Sanctuary but rather encouraged and welcomed throughout its waters (Photo: Jeff Alexander).

(Bottom) The seasonal catch of herring in Tomales Bay (Photo: Richard Allen).

Acknowledgments

This coastal report was prepared by the U.S. Environmental Protection Agency (EPA), Office of Water and Office of Research and Development (ORD). The EPA Project Manager for this document was Barry Burgan, who provided overall project coordination as well as technical direction. The principal author for this document was Kevin Summers, Technical Director of ORD's National Coastal Assessment Program. EPA was supported in the development of this document by RTI and Johnson Controls World Services. The content of this report was contributed by the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration (NOAA), and the Department of Interior in cooperation with several other local, state, and federal agencies. Special appreciation is extended to the following team, who provided technical information, reviews, and recommendations throughout the preparation of this document.

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Contents

Acronyms

ADEM	Alabama Department of Environmental Management
ALAMAP-C	Alabama's Monitoring and Assessment Program-Coastal
ANS	Aquatic Nuisance Species
AOC	Great Lakes Areas of Concern
AVHRR	advanced very high resolution radiometer
BEACH	EPA's Beaches Environmental Assessment, Closure, and Health Program
C2000	EPA's National Coastal Assessment
CAST	Council for Agricultural Science and Technology
CCMP	NEP Comprehensive Conservation and Management Plan
CENR	Committee on Environment and Natural Resources
CIIMMS	Cook Inlet Information Management and Monitoring System
CISnet	Coastal Intensive Site Network
CRTF	U.S. Coral Reef Task Force
CU	cataloging unit
CWAP	Clean Water Action Plan
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
CZM	Coastal Zone Management
DCE	1,2-dichloroethane
DDD	dichloro bis(p-chlorophenyl)ethane
DDE	dichlorodiphenyldichloroethane
DDT	dichlorodiphenyltrichloroethane
DIN	dissolved inorganic nitrogen
DO	dissolved oxygen
DOI	Department of the Interior
DRBC	Delaware River Basin Commission
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
EMAP	Environmental Monitoring and Assessment Program
EMAP-E	Environmental Monitoring and Assessment Program-Estuaries
ERL	Effects Range Low (concentration of a contaminant potentially having adverse effects)
ERM	Effects Range Medium (concentration of a contaminant associated with adverse effects on organisms)
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FDA	U.S. Food and Drug Administration
FWS	U.S. Fish and Wildlife Service
GIS	geographic information system
GLIFWC	Great Lakes Indian Fish and Wildlife Commission
GLNPO	Great Lakes National Program Office

GLWQA	Great Lakes Water Quality Agreement
GMP	Joint Gulf States Comprehensive Monitoring Program
GNP	Gross National Product
IJC	International Joint Commission
IWI	EPA's Index of Watershed Indicators
LaMP	Lakewide Management Plan
MODMON	Neuse Monitoring and Modeling Project
MPA	Marine Protected Area
MPN	most probable number
MWRA	Massachusetts Water Resources Authority
NAS	nonindigenous aquatic species
NASQAN	National Stream Water Quality Accounting Network
NAWQA	National Water Quality Assessment
NEP	National Estuary Program
NERRS	National Estuarine Research Reserve System
NLFWA	National Listing of Fish and Wildlife Advisories
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA's National Ocean Service
NO_x	nitrogen oxides
NRC	National Research Council
NS&T	National Status and Trends Program
NSTC	National Science and Technology Council
NWI	National Wetlands Inventory
NWIFC	Northwest Indian Fisheries Commission
OST	EPA's Office of Science and Technology
OWOW	EPA's Office of Wetlands, Oceans, and Watersheds
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyl congeners
POTW	publicly owned treatment works
PSAMP	Puget Sound Ambient Monitoring Program
RAP	Remedial Action Plan
RMP	Regional Monitoring Program
SAV	submerged aquatic vegetation
SCB	Southern California Bight
SCBPP	Southern California Bight Pilot Project
SCCWRP	Southern California Coastal Water Research Project
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources

SCECAP	South Carolina Estuarine and Coastal Assessment Program
SFEP	San Francisco Estuary Project
SJBEP	San Juan Bay Estuary Program
SOLEC	State of the Lakes Ecosystem Conference
SVOC	semivolatile organic compounds
SWMP	NERRS System-Wide Monitoring Program
TCE	tetrachloroethane
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UWA	Unified Watershed Assessments
VOC	volatile organic compounds
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WSRI	Wild Stock Restoration Initiative

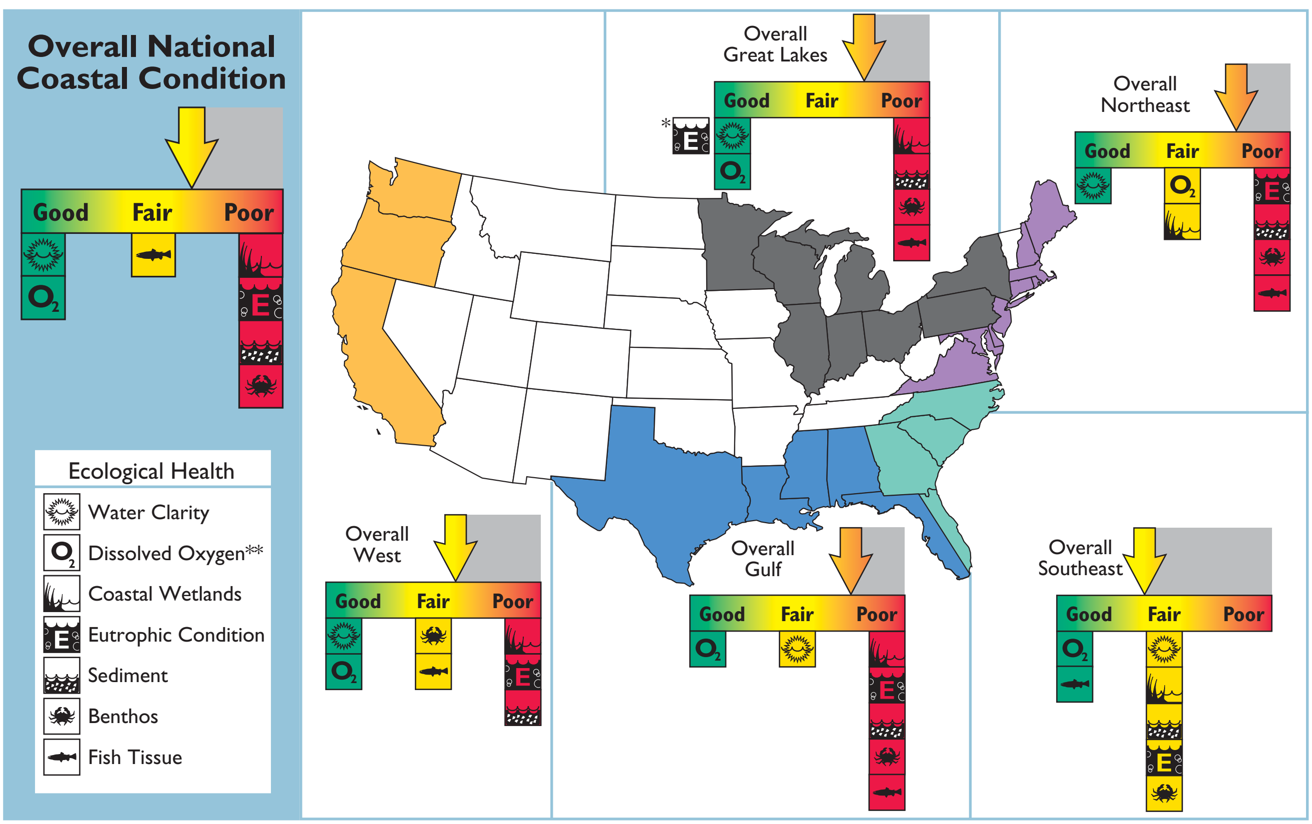
Executive Summary

The U.S. Department of Agriculture (USDA), the U.S. Environmental Protection Agency (EPA), and seven other federal agencies developed a Clean Water Action Plan to protect public health and restore our nation's waterways through 111 key actions. Included in those waterways are our coastal waters, and the Action Plan contains several key actions related to coastal waters. Key Action No. 60 calls for the development of a comprehensive report on the condition of the nation's coastal waters. This National Coastal Condition Report fulfills that key action of the Clean Water Action Plan and also serves as a foundation for the current administration's efforts to protect, manage, and restore coastal ecosystems. Four federal agencies and several state and regional/local organizations have come together to report on the current condition of the nation's coasts.

This National Coastal Condition report compiles several available data sets from different agencies and areas of the country and summarizes them to present a broad baseline picture of the condition of coastal waters. Although data sets presented in this report do not cover all coastal areas with respect to all ecological issues of concern, they do tell a story about coastal conditions from a multiregional perspective. For example, EPA's Environmental Monitoring and Assessment Program (EMAP) has monitoring data for the Virginian, Louisianian, and Carolinian provinces, which encompass 70% of continental U.S. estuarine acreage (or about 18% of U.S. estuarine acreage if Alaska is included). This report will serve as a useful benchmark for analyzing the progress of coastal programs in the future and will be followed in subsequent years by reports on more specialized coastal issues.

Currently, comprehensive and nationally consistent data on the condition of coastal waters are not available for all coastal regions of the United States. However, we can begin to describe the condition of our nation's coasts using data for some variables that have been measured consistently across a number of regions. These data are derived largely from a combination of ongoing federal and state coastal monitoring programs. In this report, the condition of coastal waters is described based primarily on data from estuaries, which are the productive transition areas between freshwater rivers and the ocean.

Although the objective of this report is to evaluate the condition of coastal resources (in this case, primarily estuaries) on a national level, there is sufficient information to assess completely only northeastern, southeastern, and Gulf of Mexico estuaries. Partial assessments are possible for West Coast estuaries and the Great Lakes, and no assessment is currently possible for the estuarine systems of Alaska, Hawaii, and island territories (Figure ES-1). In order to do a complete assessment of coastal resources for a region of the country, data that are representative of the entire resource are required. Obtaining the data needed for estuarine assessment generally requires a particular type of monitoring that is now used in all 24 coastal states, but not yet in the Great Lakes region.



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

Figure ES-1. Overall national coastal condition.

Summary of the Findings

Thousands of pieces of information on the condition of the estuarine and Great Lakes resources of the United States were collected from 1990 to 1997. Many of these data were analyzed to develop the assessment described in this report. Statistically and ecologically consistent and representative data were collected representing all of the estuarine resources in the Northeast, Southeast, and Gulf of Mexico, and data representing selected locations were collected throughout the remainder of the country. The resulting ecological assessment of the nation's estuaries using these mixed data sets shows estuaries to be in fair to poor condition, varying from poor conditions in the Northeast to fair conditions in the Southeast. No overall assessments were completed for Alaska, Hawaii, or the island territories. New ecological monitoring programs, both proposed and in place, will permit a comprehensive and consistent overall assessment of all the nation's coastal resources by 2005.

The major findings of the 1990 to 1997 study period are as follows:

- Overall condition of the nation's estuaries was fair based on seven basic indicators of ecological condition—water clarity, dissolved oxygen, loss of coastal wetlands, eutrophic condition, sediment contamination, benthic condition, and accumulation of contaminants in fish tissue.

- Fifty-six percent of assessed estuarine resources were in good condition while 44% were characterized by impaired human use or impaired aquatic life use.

- Generally, the nation's coastal areas were rated as poor if the mean conditions for these seven indicators showed that greater than 20% of the estuarine area in that region was degraded.

- Indicators that showed the poorest condition throughout the United States were coastal wetland loss, eutrophic condition, and benthic condition. Indicators that showed the best condition generally were water clarity and dissolved oxygen concentrations.

- These areal estimates represent over 70% of the estuarine area of the conterminous United States (all areas except New England and the West Coast). Consistent and comprehensive surveys are currently being conducted throughout all coastal states (including Alaska, Hawaii, and Puerto Rico), and the results of these surveys will be available in 2004. Consistent and comprehensive surveys of the nation's offshore waters (0-12 miles) are being planned for 2002, and the results will be available (assuming survey completion) in 2005.

Tables ES-1 and ES-2 summarize the estimates of areal degradation by region and nationally and the rating scores, respectively, for each indicator.

Table ES-1. Percent Area of Degradation[a] by Indicator and Region

Indicator	Northeast	Southeast	Gulf of Mexico	West	Great Lakes	United States
Water Clarity	6	12	22	<1	—	4
Dissolved Oxygen	5	2	4[b]	0	—	4
Coastal Wetland Loss	39	40	50	68	51	48
Contaminated Sediments	41	13	43	—	—	35
Benthos	23	17	23	—	—	21
Fish Tissue Contaminants[c]	30	9	20	—	—	26
Eutrophic Condition	60	13	38	20	—	40
Overall[d]	43	46	49	—	—	44

[a] Percent area of degradation is the percentage of total estuarine surface area in a region or the nation.
[b] Area of degradation does not include hypoxic zone in offshore Gulf of Mexico waters.
[c] Represents the percentage of target fish populations.
[d] Overall percentage includes areas of impaired human use.

Table ES-2. Rating Scores[a] by Indicator and Region

Indicator	Northeast	Southeast	Gulf of Mexico	West	Great Lakes	United States[b]
Water Clarity	5	4	3	5	5	4.3
Dissolved Oxygen	4	5	5[c]	5	4	4.5
Coastal Wetland Loss	2	2	1	1	1	1.4
Contaminated Sediments	1	3	1	1	1	1.3
Benthos	1	2	1	3	1	1.4
Fish Tissue Contaminants	1	5	1	3	1	1.9
Eutrophic Condition	1	4	1	1	—[d]	1.7
Overall	2.1	3.6	1.9	2.7	2.2	2.4

[a] Rating scores are based on a 5-point system where 1 is poor and 5 is good.
[b] U.S. score is based on an areally weighted mean of regional scores.
[c] Rating score does not include the impact of the hypoxic zone in offshore Gulf of Mexico waters.
[d] No eutrophication survey results are available for the Great Lakes.

Describing Coastal Condition

This report presents two types of data: (1) coastal monitoring data from programs like EMAP and the National Oceanic and Atmospheric Administration (NOAA) National Status & Trends Program (NS&T) that have been analyzed for this report and used to develop indicators of condition and (2) assessment and advisory data provided by states or other regulatory agencies and compiled in nationally maintained databases. Because the assessment and advisory data are contributed by different agencies that use different methodologies and criteria for assessment, they cannot be used for a broad-based comparison between different coastal areas. The data are presented in this report because they provide information about designated use support (e.g., is it safe to swim in an estuary), which affects public perception of coastal condition. These data also present coastal condition as it relates to public health.

The overall condition of the nation's coasts based on available data is fair (Figure ES-2). This assessment was made based on (1) EMAP sampling of environmental variables over 8 years (1990-1997) at more than 1,000 random probability-based sites representing 70% of all estuarine areas in the continental United States and (2) other monitoring and advisory data from EPA, NOAA, the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (FWS), and state and tribal programs.

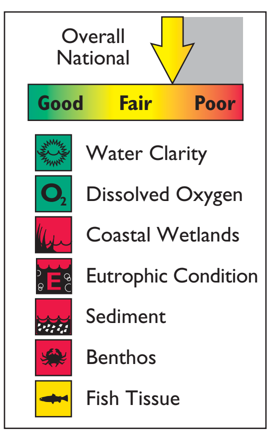


Figure ES-2. The overall estuarine condition for the nation is fair.

Seven primary indicators are used to rate coastal condition in this report: water clarity, dissolved oxygen, coastal wetland loss, eutrophic condition, sediment contamination, benthic index, and fish tissue contaminants (Table ES-3). Supplemental information (e.g., algae concentrations, sediment toxicity, fish pathology data) are also presented throughout the report where available. The seven indicators were assigned a score of good, fair, or poor for each coastal area of the United States (Northeast, Southeast, Gulf of Mexico, West Coast, and Great Lakes areas) (Figure ES-2). The indicator scores were then averaged to create an indicator score for overall condition of each coastal area. The assessments for each coastal area were combined to form national scores by calculating an average weighted by the amount of estuarine area in each coastal region (excluding Alaska).

Caution about Indicator Data

Using indicators to compare estuarine conditions throughout the nation can be misleading because the natural state of estuaries varies throughout the nation. For example, estuaries in the Southeast tend to have poor water clarity due to high turbidity that results from naturally high productivity and strong sediment transport and resuspension processes. So the "fair" water clarity rating in southeastern estuaries does not necessarily mean that water quality is poor or degraded.

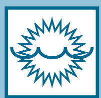
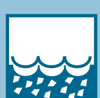
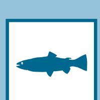
The use of indicators to describe coastal condition is experimental in nature. In this report, the overall condition for each coastal area is assessed using a straightforward combination of the seven indicator scores. Continued research is necessary to establish the most appropriate indicators to use in describing coastal condition and the appropriate weighting factors for combining them for an overall assessment.

Sediment Contaminant Criteria

ERM (Effects Range Medium)—The concentration of a contaminant that will result in ecological effects approximately 50% of the time based on literature studies.

ERL (Effects Range Low)—The concentration of a contaminant that will result in ecological effects about 10% of the time.

Table ES-3. Indicators Used To Assess Coastal Condition

Icon	Poor Condition	Ranking
 Water Clarity	Water clarity is considered poor if less than 10% of surface light reaches a depth of 1 meter.	**Good**: Less than 10% of the coastal waters have poor light penetration. **Fair**: 10% to 25% of the coastal waters have poor light penetration. **Poor**: More than 25% of the coastal waters have poor light penetration.
 Dissolved Oxygen	Dissolved oxygen levels are considered poor when concentrations are less than 2 ppm.	**Good**: Less than 5% of the coastal waters have poor dissolved oxygen. **Fair**: 5% to 15% of the coastal waters have poor dissolved oxygen. **Poor**: More than 15% of the coastal waters have poor dissolved oxygen.
 Coastal Wetland Loss	Areas with a greater than 40% decline in wetland acreage from 1780 to 1980 and/or a greater than 10% decline from the mid-1970s to the mid-1980s are considered to be in poor condition.	**Good**: Less than 25% decline in wetland acreage from 1780 to 1980 and/or less than 5% decline from the mid-1970s to the mid-1980s. **Fair**: Between 25% and 40% decline from 1780 to 1980 and/or between 5% and 10% decline from the mid-1970s to the mid-1980s. **Poor**: Greater than 40% decline from 1780 to 1980 and/or greater than 10% decline from the mid-1970s to the mid-1980s.
 Eutrophic Condition	Eutrophic condition is a measure developed by NOAA that examines six different eutrophication symptoms and assigns a value of low, moderate, or high. High eutrophic condition is equivalent to poor condition for this indicator.	**Good**: Less than 10% of the coastal waters have high eutrophic condition. **Fair**: 10% to 20% of the coastal waters have high eutrophic condition. **Poor**: More than 20% of the coastal waters have high eutrophic condition.
 Sediment Contamination	Sediment contamination is evaluated using ERM and ERL criteria. ERM is the concentration of contaminant that will result in ecological effects 50% of the time. ERL is the concentration of contaminant that will result in ecological effects 10% of the time. An estuary is in poor condition if it exceeds one ERM criterion or five ERL criteria.	**Good**: Less than 5% of the coastal waters exceed one ERM criterion or five ERL criteria. **Fair**: 5% to 15% of the coastal waters exceed one ERM criterion or five ERL criteria. **Poor**: More than 15% of the coastal waters exceed one ERM criterion or five ERL criteria.
 Benthic Index	A poor benthic index score indicates that benthic communities are less diverse than expected, populated by greater than expected pollution-tolerant species, and contain fewer than expected pollution-sensitive species.	**Good**: Less than 10% of the coastal waters have a low benthic index score. **Fair**: 10% to 20% of the coastal waters have a low benthic index score. **Poor**: More than 20% of the coastal waters have a low benthic index score.
 Fish Tissue Contaminants	An estuary is in poor condition for fish tissue contaminants if more than 10% of fish sampled have tissue residues greater than FDA and international criteria or more than 20% of fish sampled have tissue residues greater than EPA Guidance Values.	**Good**: Less than 2% of the coastal waters have poor fish tissue condition. **Fair**: 2% to 10% of the coastal waters have poor fish tissue condition. **Poor**: More than 10% of the coastal waters have poor fish tissue condition.

Coastal Monitoring Data

About 56% of the estuarine area in the continental United States is in good condition for supporting aquatic life use (animal and plant communities) and human uses (such as drinking water, agriculture, swimming, and boating) (Figure ES-3). About 34% of the estuarine area shows evidence of impaired aquatic life use, and 33% of the area shows evidence of impaired human use. In fact, 23% of estuarine area in the continental United States is degraded for both aquatic life and human uses.

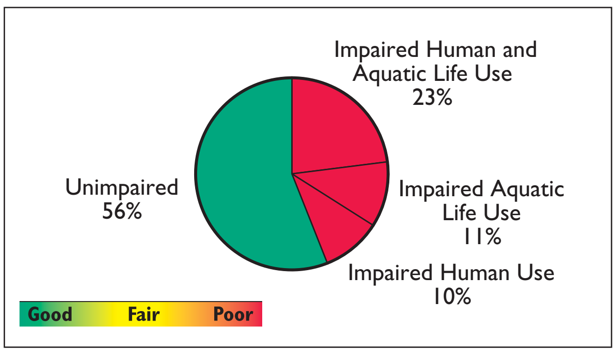


Figure ES-3. National estuarine condition (U.S. EPA/EMAP).

The overall water clarity of the nation's estuaries is rated as good. Water clarity is good in West Coast and northeastern estuaries as well as the Great Lakes, but fair in the Gulf of Mexico and southeastern estuaries. Dissolved oxygen condition (using occurrence of hypoxia as a standard) in the nation's estuaries is generally good.

Coastal wetland losses throughout the United States have been significant, and this indicator receives a poor rating. During the 200-year period from 1780 to 1980, nearly 50% of the existing wetlands in the conterminous United States were lost.

The overall score for eutrophic condition of estuarine waters for the nation is poor. Eutrophication in estuarine waters is increasing throughout much of the United States. All coastal areas are in poor condition as rated by eutrophic condition, except for the Southeast, which is in fair condition, and Alaska and Hawaii, which were not evaluated.

Sediment contaminant concentrations are generally poor throughout the estuaries and Great Lakes of the United States. Eleven to thirty percent of estuarine sediments in the United States show concentrations of contaminants (polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], pesticides, and metals) that are above guidance levels (concentrations that are likely to result in biological effects). Most of the sample sites that displayed the greatest exceedances are in the Northeast. Measurements of sediment enrichment due to human sources show that 40% of U.S. estuarine sediments are enriched with metals, 45% are enriched with PCBs, and 75% are enriched with pesticides (note that these percentages exclude Alaska, Hawaii, and the Great Lakes).

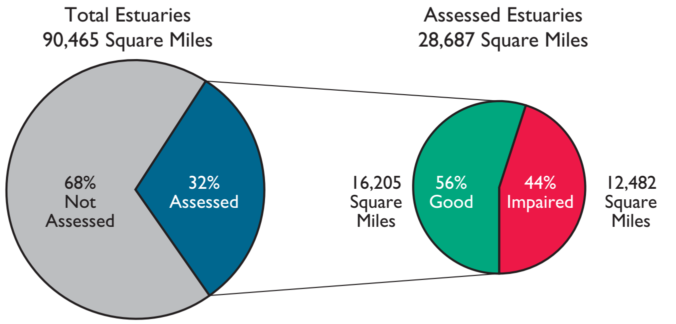
Benthic condition is poor in estuaries throughout the United States, largely due to contaminated sediments, low dissolved oxygen conditions, habitat degradation, and eutrophication. Benthic condition in the Great Lakes is also poor.

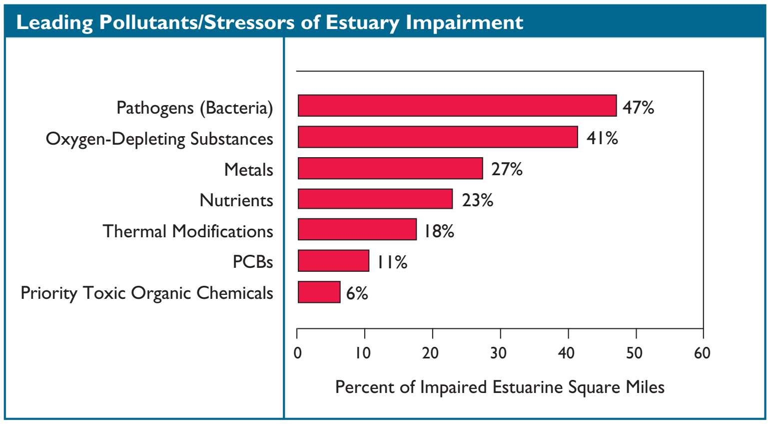
The overall rating for fish tissue contaminants for the nation is fair. Fish tissue contaminant concentrations are generally low throughout the estuarine waters of the United States with the exceptions of the northeastern estuaries, the Gulf of Mexico, and the Great Lakes.

Assessment and Advisory Data

The nation's Clean Water Act Section 305(b) reporting process largely agrees with the assessment based on coastal monitoring data. States and tribes rate water quality for Clean Water Act reporting by comparing available water quality data to their water quality standards (water quality standards include narrative and numeric criteria that support specific designated uses, such as swimming and aquatic life use). Each state has different monitoring resources and uses a different methodology for assessment, so this information is not nationally consistent and is often incomplete. State 1998 water quality reports suggest that 44% of assessed estuaries and 12% of assessed coastal shoreline in the United States (excluding Alaska) was impaired by some form of pollution or habitat degradation. The most frequent use impairments were for aquatic life support, primary contact recreation (swimming), and fish consumption. The leading stressors resulting in these impairments were pathogens, oxygen-depleting substances (oxygen is consumed during the degradation of organic matter and the oxidation of some inorganic matter), metals, and nutrients (Figure ES-4). The primary sources of impairing pollutants reported by states were municipal point sources, urban runoff or storm sewers, atmospheric deposition, industrial discharges, and agriculture.

The number of coastal and estuarine waters under fish consumption advisories represents an estimated 71% of the coastline miles of the contiguous 48 states, including 92% of the Atlantic Coast, 100% of the





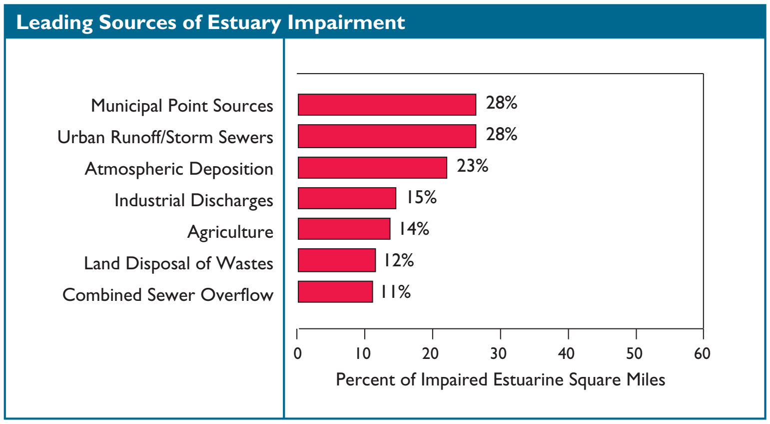


Figure ES-4. 1998 305(b) water quality assessment data for estuaries.

Gulf Coast, and 10% of the Pacific Coast. An estimated 82% of the estuarine square miles also were under advisory, including 81% of Atlantic Coast estuaries, 64% of Gulf Coast estuaries, and 30% of Pacific Coast estuaries (Figure ES-5).

In 1995, 4,230 individual shellfish-growing areas containing 24.8 million acres of estuarine and nonestuarine growing waters were classified in 21 coastal states. Sixty percent of waters were classified as approved (Figure ES-6). The top five pollution sources reported as contributing to harvest limitations were urban runoff, upstream sources, precipitation-related runoff of animal wastes from high-wildlife-concentration areas (e.g., water fowl), individual wastewater treatment systems, and wastewater treatment plants.

EPA's review of coastal beaches (U.S. coastal areas, estuaries, and the Great Lakes) showed that, of the 1,444 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 ES-7). 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.

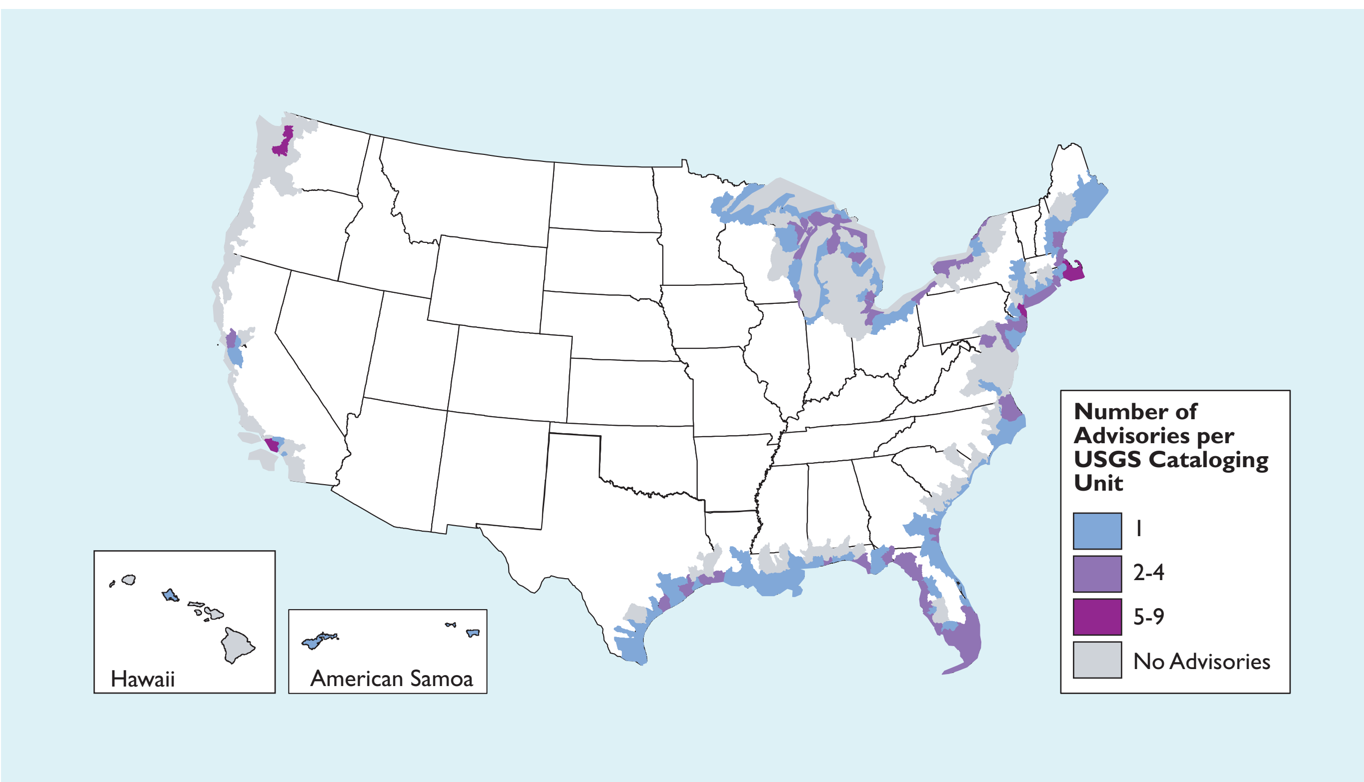


Figure ES-5. The number of coastal and estuarine fish consumption advisories per USGS cataloging unit. This count does not include advisories that may exist for noncoastal or nonestuarine waters. Alaska did not report advisories (U.S. EPA NLFWA, 2000c).

Shortcomings of Available Data

Very little information to support the kind of analysis used in this report (i.e., spatial estimates of condition based on indicators measured consistently across broad regions) exists for estuarine conditions in Alaska. Nearly 75% of the area of all the bays, sounds, and estuarine areas in the United States is located in Alaska, and no national report on estuarine condition can be truly complete without information on the condition of living resources and use attainment of these waters. Similarly, little information to support estimates of conditions based on the indicators

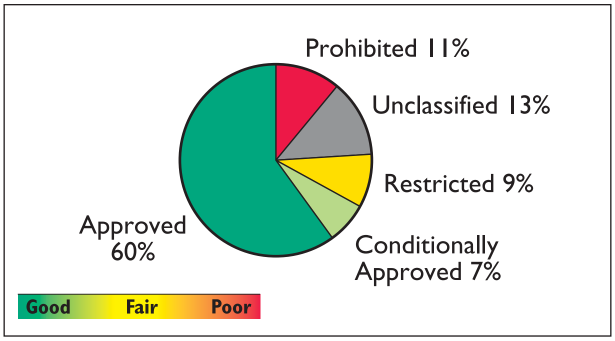


Figure ES-6. 1995 classification of shellfish-growing waters (NOAA).

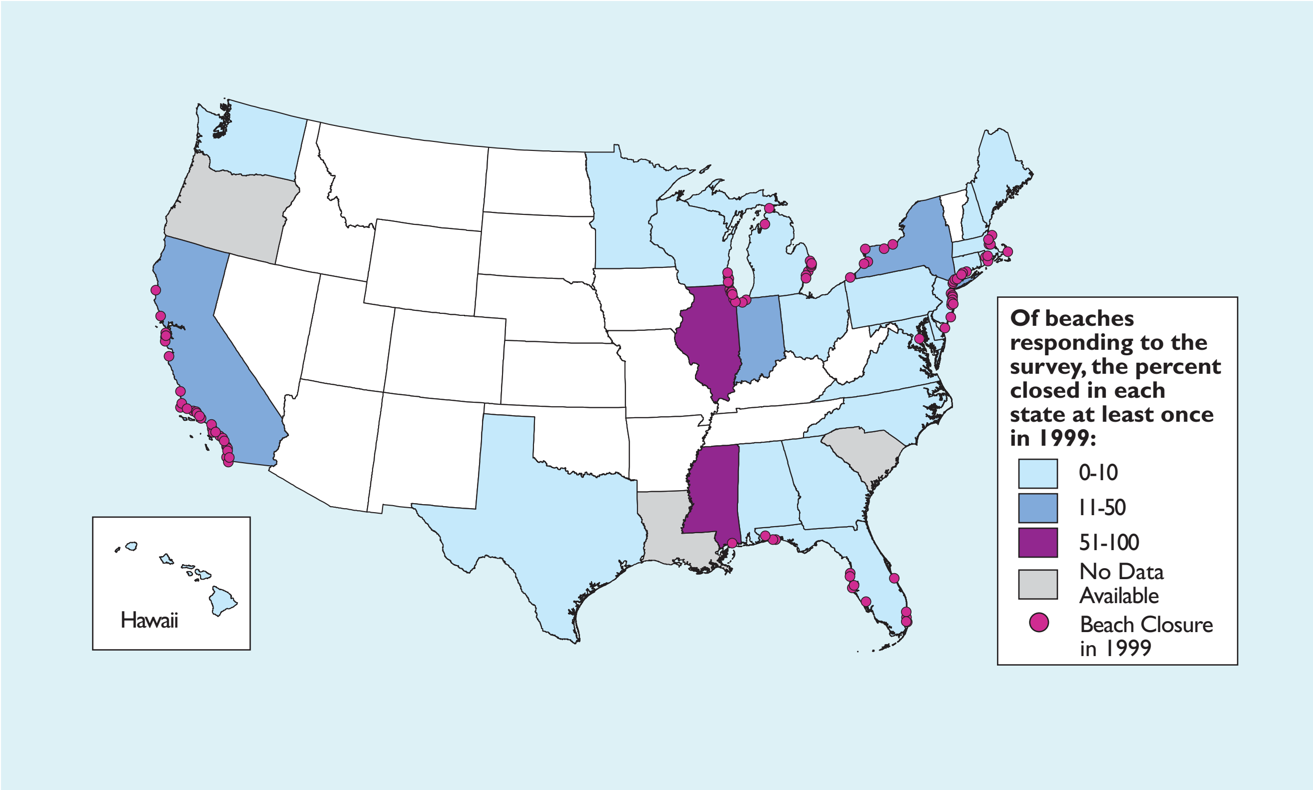


Figure ES-7. The percentage of beaches responding to the survey that closed at least once in 1999. There were no BEACH survey responses from Alaska (U.S. EPA).

used in this report is available for Hawaii and the Caribbean/Pacific commonwealths. Although these latter systems make up only a small portion of the nation's estuarine area, they do represent a unique set of estuarine subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States with the exception of the Florida Keys and the Flower Gardens. These unique systems should not be excluded from future national assessments, and plans are already under way for monitoring programs in Alaska, Hawaii, and Puerto Rico.

Attaining consistent reporting in all of the coastal ecosystem in the United States depends on our ability to focus fiscal and intellectual resources on the creation of a national coastal monitoring program. The conceptual framework for such a program is outlined in the National Coastal Research and Monitoring Strategy (www.cleanwater.gov). This Strategy calls for a national program organized at the state level and carried out by a partnership between federal agencies (EPA, NOAA, USGS, U.S. Department of the Interior [DOI], and USDA) and state natural resource agencies, as well as with academia and industry. This monitoring program would provide the capability to measure, understand, analyze, and forecast ecological change at national, regional, and local scales. A first step in the development of this type of program was the initiation of EPA's *Coastal 2000* program, a national estuarine monitoring program organized and executed at the state level. However, this program is merely a starting point for what is needed to achieve a comprehensive national coastal monitoring program that can offer a nationwide coastal assessment.

This report represents our current best effort to characterize and assess the condition of the nation's estuarine resources; however, the report is incomplete because it cannot represent all estuarine regions of the United States or all of the appropriate spatial scales (national, regional, and local) necessary to assess the condition of estuaries. This assessment is also based on a limited number of ecological indicators for which there are consistent data sets available to support estimates of ecological condition on regional and national scales. Through a multiagency and multistate effort over the next 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 our next effort to gauge the health of America's coastal ecosystem be successful.

Chapter 1

Introduction

The Clean Water Action Plan (U.S. EPA, 1998) is intended to "protect public health and restore our nation's waterways" by setting strong goals and providing states, tribes, communities, and individual land owners with the tools and resources to meet these goals.

Several coast-related action items are recommended in the Action Plan's 111 key actions. This report is designed to fulfill action No. 60, which calls for the development of a comprehensive report to the public on the condition of the nation's coastal waters to be prepared by the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the Department of the Interior (DOI), and the U.S. Department of Agriculture (USDA) in cooperation with other federal agencies, states, and tribes.

The current condition of our nation's coasts can be explored using data provided by several existing coastal programs. For example, EPA's Environmental Monitoring and Assessment Program (EMAP) and NOAA's Status and Trends Program (NS&T) provide data for many indicators of coastal condition for nearly 70% of the estuarine area of the conterminous United States.

Why Are Coastal Waters Important?

Our Nation's Coasts Are Valuable and Productive Natural Ecosystems

Coastal waters are productive and diverse, including estuaries, coastal wetlands, coral reefs, mangrove forests, and upwelling areas. Critical coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, birds, and other wildlife. Our coasts also provide essential nesting, resting, feeding, and breeding habitat for 85% of waterfowl and other migratory birds.

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

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

Female humpback whales and their calves are sometimes accompanied by a single adult male humpback whale, otherwise known as an "escort" whale. This escort protects the female and her calf from other whales and may sometimes attempt to mate with her (Photo: Joseph Mobely - NMFS Permit #810).

More Than Half of the U.S. Population Lives on the Coast

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

Photo: © John Theilgard

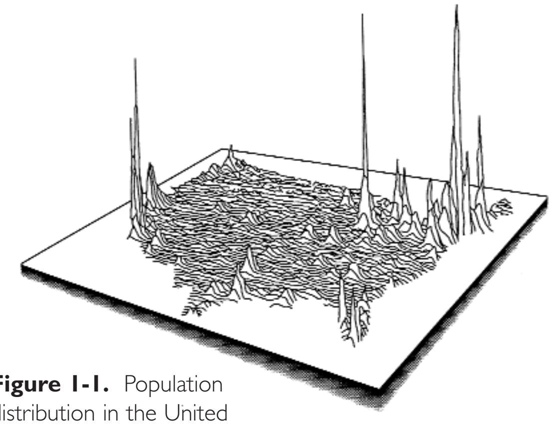


Figure 1-1. Population distribution in the United States (NRC, 1993).

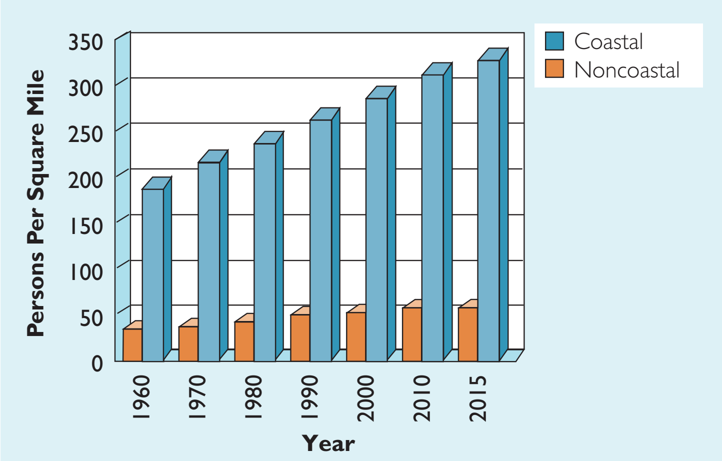


Figure 1-2. Population density from 1960 to 2015 (NOAA, 1998).

In addition to being a popular place to live, the U.S. coasts are a source of many other valuable commodities. Almost 31% of the Gross National Product (GNP) is produced in coastal counties. Almost 85% of commercially harvested fish depend on estuaries and nearby coastal waters at some stage in their life cycle (NRC, 1997). Beaches have become one of the most popular vacation destinations in America, with 180 million people using the coast each year (Cunningham and Walker, 1996). Estuaries supply water, provide a point of discharge for municipalities and industries, and support agriculture, commercial and sport fisheries, and recreational uses such as swimming, diving, and boating.

U.S. coastal waters are the largest economic and environmental zone of the nation in terms of surface area. These valuable coastal resources provide

- Habitat for a wide range of plant and animal species that are essential to the global ecosystem
- Fish and shellfish that support the majority of commercial and recreation fisheries
- Reserves of oil, gas, and other minerals
- Travel ways for coastal and international shipping and maneuvering area for the U.S. Navy
- Outdoor recreational opportunities such as swimming and boating
- A basis for tourism and recreation industries.

(ADEM, 1998)

Why Be Concerned about Coastal Condition?

Because a disproportionate percentage of the nation's population lives in coastal areas, the activities of municipalities, commerce, industry, and tourism have created environmental pressures that threaten the very resources that make the coast desirable. Population pressures include increased solid waste production, higher volumes of urban nonpoint runoff, loss of green space and wildlife habitat, declines in ambient water and sediment quality, and increased demands for wastewater treatment, potable water, and energy supplies.

Development pressures have resulted in substantial physical changes along many areas of the coastal zone. Coastal wetlands continue to be lost to residential and commercial development, while the quantity and timing of freshwater flow, critical to river and estuarine function, continue to be altered.

In 1998, states reported that the leading pollutants/stressors impairing estuaries were

- *Pathogens*
- *Oxygen-depleting substances*
- *Metals*
- *Nutrients*
- *Thermal modifications*
- *PCBs*
- *Priority toxic organic chemicals*

Indicators of Coastal Condition

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

- Coastal monitoring data from programs like EMAP and NOAA NS&T that have been analyzed for this report and used to develop indicators of condition
- Assessment and advisory data provided by states or other regulatory agencies and compiled in national databases.

Available coastal monitoring information is presented on a national scale for the conterminous United States; these data are then broken down and analyzed at four geographic levels: Northeast Coast, Southeast Coast, Gulf Coast, and West Coast (Figure 1-3). Chapters presenting

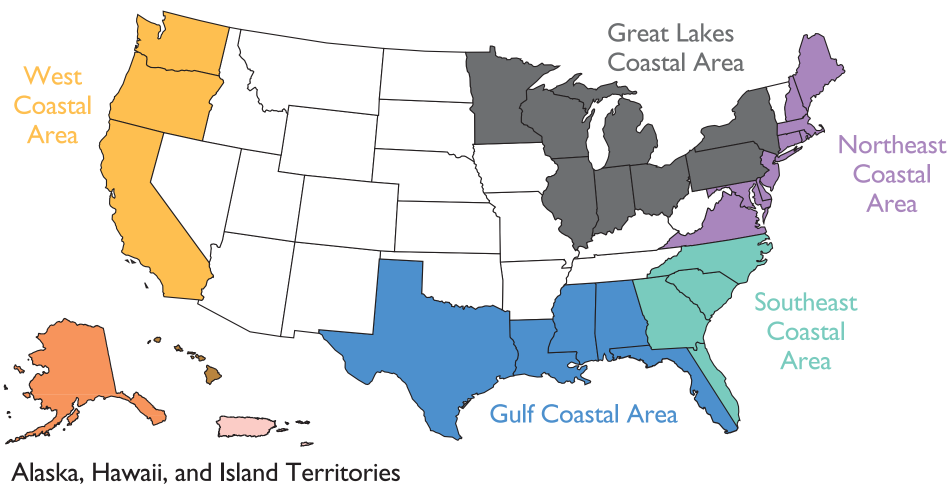


Figure 1-3. Coastal areas presented in the chapters of this report.

available data for Alaska, Hawaii, and Island Territories, as well as the Great Lakes, are also included. The assessment and advisory data are presented at the end of each chapter. Although inconsistencies in the way different agencies collect and provide data to these national programs prevent their use for comparing conditions between coastal areas, the information is valuable in that it helps identify and illuminate some of the causes of coastal impairment and the impacts of these impairments on human uses.

Shortcomings of Available Data

Very little information to support the kind of analysis used in this report (i.e., spatial estimates of condition based on indicators measured consistently across broad regions) exists for estuarine conditions in Alaska. Nearly 75% of the area of all the bays, sounds, and estuarine areas in the United States is located in Alaska, and no national report on estuarine condition can be truly complete without information on the condition of living resources and use attainment of these waters. Similarly, little information to support estimates of conditions based on the indicators used in this report is available for Hawaii and the Caribbean/Pacific commonwealths. Although these latter systems make up only a small portion of the nation's estuarine area, they do represent a unique set of estuarine subsystems (such as coral reefs and tropical bays) that are not located anywhere else in the United States with the exception of the Florida Keys and the Flower Gardens. These unique systems should not be excluded from future national assessments, and plans are already under way for monitoring programs in Alaska, Hawaii, and Puerto Rico.

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Coastal Monitoring Data

Data from several programs are used to evaluate coastal condition throughout this report. A large percentage of the data come from programs administered by EPA and NOAA. EPA's EMAP provides data on biota (plankton, benthos, and fish) as well as environmental stressors (water quality, sediment quality, and tissue bioaccumulation). NOAA's NS&T provides data on toxic contaminants and their ecological effects. NOAA also conducted the National Estuarine Eutrophication Assessment in the mid-1990s to assess the effects of nutrient concentrations based on existing data and expert opinion. Coastal condition is also evaluated using information from the U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory (NWI). The NWI provides information on the status of the nation's wetlands.

Data from these programs were used to evaluate overall coastal condition with respect to seven primary indicators: water clarity, dissolved oxygen, coastal wetland loss, eutrophic condition, sediment contaminants, benthic condition, and fish tissue contaminants. These indicators were selected because of the availability of relatively consistent data sets for these indicators for most of the country. These indicators do not address all characteristics of estuaries and coastal waters that are valued by society, but they do provide information on both ecological condition and human use of estuaries. In some areas, additional information, such as algae concentration and sediment toxicity data, is also available. These data are also presented where available to help provide an overall picture of the condition of the estuaries.

If multiple programs provided data for the same indicator (e.g., dissolved oxygen), program information that was quantitative was used over qualitative data in the assessment. If multiple sets of quantitative data existed, information based on quantitative field measurements was used over questionnaire data in this assessment.

Surveying the submerged habitat of Cordell Bank (Photo: Cordell Bank Expeditions).

How the Indicators Are Calculated

Overall condition for each coastal area was calculated by summing the scores for the seven indicators and dividing by 7, where good = 5, fair = 3, and poor = 1. The Gulf Coast, for example, received the following scores:

Indicator	Score
Water Clarity	3
Dissolved Oxygen	5
Coastal Wetland Loss	1
Eutrophic Condition	1
Sediment Contamination	1
Benthic Index	1
Fish Tissue Contaminants	1
Total Score Divided by 7 = Overall Score	13/7 = 1.86

To create the national indicator numbers, a weighted average for each of the seven indicators was calculated. The indicator scores are weighted by the percent area contributed by each geographic area (Figure 1-4). For example, the weighted average for water clarity would be calculated by summing the products of the regional water clarity scores and the area contributed by each region.

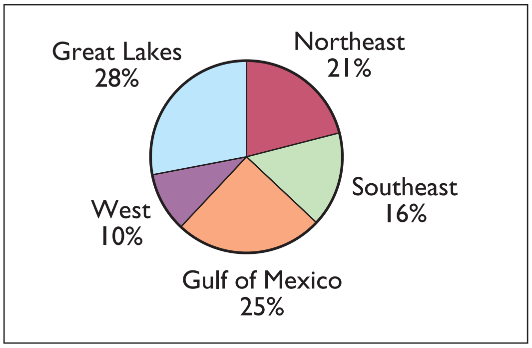


Figure 1-4. Percent estuarine area contributed by each geographic area assessed in this report.

The overall national score was calculated by summing each national indicator score and dividing by seven, similar to the method described in Table 1-1.

Table 1-1. Calculating the Water Clarity Indicator on a National Scale

Coastal Area	Water Clarity Score	Percent of Area Contributed by Region	Product of Score and Percent Area
Northeast	5	21	105
Southeast	4	16	64
Gulf of Mexico	3	25	75
West	5	10	50
Great Lakes	5	28	140
	Sum of Products Divided by Total Area = National Water Clarity Score		4.34/100 = 4.34 (Good)

Characterizing coastal areas using each of the seven indicators involves two value determinations. The first value is the definition of "poor" for an indicator. The definition of poor condition for each indicator is based on existing criteria, guidelines, or interpretation of scientific literature. For example, dissolved oxygen conditions are considered poor if dissolved oxygen concentrations are less than 2 ppm (2 parts of oxygen per million parts of water). This value is widely accepted as representative of hypoxic conditions, so this benchmark for poor condition is strongly supported by scientific evidence (Diaz and Rosenberg, 1995; U.S. EPA, 2000a). The second determination is how widespread a "poor" condition must be to result in a poor rating for an area as measured by the indicator. For example, in order for an area to be rated as poor with regard to the dissolved oxygen indicator, more than 15% of a coastal area must have dissolved oxygen measured at less than 2 ppm. The percent areas used for each indicator are value judgments and were largely determined by informally surveying environmental managers, resource experts, and the knowledgeable public.

Water Clarity

Clear waters are valued by society and contribute to the maintenance of healthy and productive ecosystems. Light penetration into estuarine waters is important for submerged aquatic vegetation, which serves as food and habitat for the resident biota. EMAP-Estuaries (EMAP-E) 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 clarity is considered poor if less than 10% of surface light reaches 1 meter. (This is equivalent to being able to see your hand 1 meter from your face under water.) The water clarity data presented throughout the report were collected by the EMAP-E program unless otherwise noted. This measure is used to determine water quality for an area as follows:

Good	Less than 10% of the coastal waters have poor light penetration.
Fair	10% to 25% of the coastal waters have poor light penetration.
Poor	More than 25% of the coastal waters have poor light penetration.

Caution about Indicator Data

Using indicators to compare estuarine conditions throughout the nation can be misleading because the natural state of estuaries varies throughout the nation. For example, estuaries in the Southeast tend to have poor water clarity due to high turbidity that results from naturally high productivity and strong sediment transport and resuspension processes. So the "fair" water clarity rating in southeastern estuaries does not necessarily mean that water quality is poor or degraded.

O_2 Dissolved Oxygen

Dissolved oxygen (DO) is a fundamental requirement for all estuarine life. A threshold concentration of 4 to 5 ppm (5 parts of oxygen per million parts of water) is used by many states to set their water quality standards. Concentrations below approximately 2 ppm are thought to be stressful to many estuarine organisms (Diaz and Rosenberg, 1995; U.S. EPA, 2000a). These low levels most often occur in bottom waters and impact the organisms that live in the sediments. Low levels of oxygen (hypoxia) or lack of oxygen (anoxia) often accompany the onset of severe bacterial degradation, sometimes resulting in the presence of algal scums and noxious odors. However, in some estuaries, low levels of oxygen, at least periodically, are part of the natural ecology. Therefore, while it is easy to show the conditions of the nation's estuaries concerning oxygen concentrations, it is difficult to interpret whether the observed effects are the result of natural processes or human intervention. The DO data presented throughout the report were collected under the EMAP-E program unless otherwise noted. This indicator is used to measure water quality for an area as follows:

Good	Less than 5% of the coastal waters have less than 2 ppm DO.
Fair	5% to 15% of the coastal waters have less than 2 ppm DO.
Poor	More than 15% of the coastal waters have less than 2 ppm DO.

Coastal Wetland Loss

Wetlands are the vegetated interface between aquatic and terrestrial components of estuarine ecosystems. Wetland habitats are critical to the life cycles of fish, shellfish, migratory birds, and other wildlife. These habitats also filter and process residential, agricultural, and industrial wastes, thereby improving surface water quality. Wetland habitats also buffer coastal areas against storm and wave damage. An estimated 95% of commercial fish and 85% of sport fish spend a portion of their life cycles in coastal wetland and estuarine habitats. Adult stocks of commercially harvested shrimp, blue crabs, oysters, and other species throughout the United States are directly related to wetland quality and quantity (Turner and Boesch, 1988). Wetlands throughout the United States have been and are being rapidly destroyed by human activities (e.g., flood control, agriculture, waste disposal, real estate development, shipping, commercial fishing, oil/gas exploration and production) and natural processes (e.g., sea level rise, sediment compaction, droughts, hurricanes, floods).

Data on wetland acreage are available for all coastal states for the 1780s (estimated) and 1980s (surveyed) and for the southeastern and Gulf states for the mid-1970s to mid-1980s. The indicator that has been used to characterize estuarine wetland condition is the percentage change for the 200-year period from 1780 to 1980 and the 10-year period from the mid-1970s to mid-1980s. The indicator used to measure the condition of coastal wetlands is as follows:

Good	Less than 25% decline in wetland acreage from 1780 to 1980 and/or less than 5% decline from the mid-1970s to mid-1980s.
Fair	Between 25% and 40% decline from 1780 to 1980 and/or between 5% and 10% decline from the mid-1970s to mid-1980s.
Poor	Greater than 40% decline from 1780 to 1980 and/or greater than 10% decline from the mid-1970s to mid-1980s.

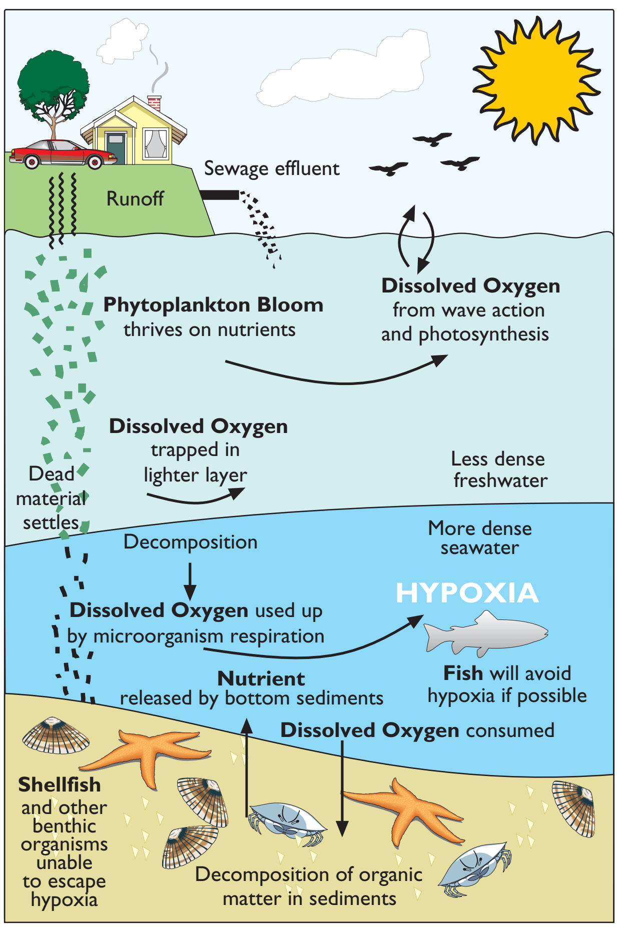


Figure 1-5. Eutrophication is when the concentration of available nutrients increases beyond normal levels.

Eutrophic Condition

Some nutrient inputs to coastal waters are necessary for a healthy, functioning estuarine ecosystem. When nutrients from various sources such as sewage and fertilizers are introduced into an estuary, the concentration of available nutrients will increase beyond natural background levels, resulting in a process called eutrophication, which may result in a host of undesirable conditions (Figure 1-5).

Eutrophication due to the accelerated input of nitrogen and phosphorus can promote a complex array of symptoms such as excessive growth of algae that may lead to other more serious problems. For its National Estuarine Eutrophication Assessment, NOAA developed a system that evaluates several symptoms of eutrophication in an estuary to provide a single categorical value to represent the status of overall eutrophic condition for each estuary (Bricker et al., 1999). This value is the measure of eutrophic condition presented in this report. The primary symptoms examined for this value are chlorophyll *a,* macroalgal abundance, and epiphyte abundance. Secondary symptoms include loss of submerged aquatic vegetation, harmful algae, and low dissolved oxygen. This indicator is used to measure water quality for an area as follows:

Good	Less than 10% of the coastal waters have symptoms indicating a high potential for eutrophication.
Fair	10% to 20% of the coastal waters have symptoms indicating a high potential for eutrophication.
Poor	More than 20% of the coastal waters have symptoms indicating a high potential for eutrophication.

Sediment Contaminants

Evaluation of the potential effects of contaminated sediments on estuarine organisms is difficult because few applicable state or federal regulatory criteria exist to determine "acceptable" sediment concentrations of all substances. Guidelines such as effects range low (ERL) and effects range medium (ERM) values provide environmental managers with benchmarks to determine if contaminated sediments have the potential to affect aquatic organisms adversely. The ERM criterion is the concentration of a contaminant that will result in ecological effects approximately 50% of the time based on literature studies. A more protective indicator of contaminant concentrations is the ERL criterion, which is the concentration of a contaminant that will result in ecological effects about 10% of the time. A poor rating for sediment quality is given to an estuary if the ERM criteria for one or more contaminants are exceeded or if the ERL criteria for five or more contaminants are exceeded. The sediment contaminants data presented throughout the report were collected by the EMAP-E program unless otherwise noted. This indicator is used to measure water quality for an area as follows:

Good	Less than 5% of the coastal waters exceed one ERM criterion or five ERL criteria.
Fair	5% to 15% of the coastal waters exceed one ERM criterion or five ERL criteria.
Poor	More than 15% of the coastal waters exceed one ERM criterion or five ERL criteria.

The ERL/ERM guidelines were first developed by NOAA researchers in 1990 (Long and Morgan, 1990) and further modified and improved over the next 10 years (Long et al., 1995; Long et al., 1998a; and Long et al., 1998b). However, these guidelines are still considered experimental, and several publications have questioned their reliability in assessing sediment toxicity (O'Connor et al., 1998).

Benthic Condition

The worms, clams, and crustaceans that inhabit the bottom substrates of estuaries are collectively called benthic macroinvertebrates or benthos. These organisms play a vital role in maintaining sediment and water quality and are an important food source for bottom-feeding fish, shrimp, ducks, and marsh birds. Benthos are often used as indicators of disturbances in estuarine environments because they are not very mobile and thus cannot avoid environmental problems. Benthic population and community characteristics are sensitive indicators of contaminant and dissolved-oxygen stress, salinity fluctuations, and disturbance and serve as reliable indicators of estuarine environmental quality. EMAP-E developed a benthic index of environmental condition for estuaries that incorporates changes in diversity and populations of indicator species to distinguish degraded benthic habitats from undegraded benthic habitats (Engle and Summers, 1999; Engle et al., 1994; Van Dolah et al., 1999; Weisburg et al., 1997). This index reflects changes in benthic community diversity and the abundance of pollution-tolerant and pollution-sensitive species. A high benthic index rating for benthos means that samples taken from an estuary's sediments contain a wide variety of species, a low proportion of pollution-tolerant species, and a high proportion of pollution-sensitive species. A low benthic index rating indicates that the benthic communities are less diverse than expected, are populated by more than expected pollution-tolerant species, and contain fewer than expected pollution-sensitive species. The benthic condition data presented throughout the report were collected by the EMAP-E program unless otherwise noted. This indicator is used to measure regional water quality as follows:

Good	Less than 10% of the coastal waters have a low benthic index score.
Fair	10% to 20% of the coastal waters have a low benthic index score.
Poor	More than 20% of the coastal waters have a low benthic index score.

Fish Tissue Contaminants

Chemical contaminants may enter a marine organism in several ways—direct uptake from contaminated water, consumption of contaminated sediment, or consumption of previously contaminated organisms. Once these contaminants enter an organism, they tend to remain in the animal tissues and so may build up with subsequent feedings. When fish consume contaminated organisms, they may "inherit" the levels of contaminants in the organisms they consume. This same "inheritance" of contaminants occurs when humans consume fish with contaminated tissues. Contaminant residues are examined in target fish and shellfish species and are compared to Food and Drug Administration (FDA) criteria, international standards, and EPA Guidance Values. In this report, if more than 10% of fish sampled have tissue residues greater than FDA and international criteria or 20% of fish sampled have tissue residues greater than EPA Guidance Values, then the estuary is determined to be in poor condition. The fish tissue contaminant data presented throughout the report were collected by the EMAP-E program unless otherwise noted. This indicator is used to measure regional water quality as follows:

Good	Less than 2% of the coastal estuaries have significant numbers of contaminated fish (>10% sampled).
Fair	2% to 10% of the coastal estuaries have significant numbers of contaminated fish (>10% sampled).
Poor	More than 10% of the coastal estuaries have significant numbers of contaminated fish (>10% sampled).

The FDA and international criteria have some limitations, as these values were developed to protect the average consumer from contaminated fish and shellfish sold in interstate commerce. These criteria are not intended to be protective of recreational, tribal, ethnic, and subsistence fishers who typically consume larger quantities of fish than the general population and often harvest the fish and shellfish they consume from the same local waterbodies repeatedly over many years. EPA has developed more stringent screening values to protect consumers from contaminants in noncommercial fish (e.g., recreational and subsistence) based on a human health risk assessment methodology (U.S. EPA, 2000b). This EPA methodology is currently used by most states to identify waterbodies where contaminant levels in locally caught fish may pose human health risks and is described in the following Assessment and Advisory Data section under State Fish Consumption Advisories.

Assessment and Advisory Data

The following programs maintain databases that are repositories for information about how well coastal waters support their designated or desired uses. These uses are important factors in public perception of the condition of the coast and also say a lot about the condition of the coast as it relates to public health.

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

States report water quality assessment information and water quality impairments under Sections 305(b) and 303(d) of the Clean Water Act. States and tribes rate water quality by comparing data to their state and tribal water quality standards. Water quality standards include narrative and numeric criteria that support specific designated uses and also specify goals to prevent degradation of good quality waters. States and tribes use their numeric criteria to evaluate whether the designated uses assigned to waterbodies are supported. The states then consolidate their more detailed uses into general categories so that EPA can present a summary of state and tribal data. The most common designated uses are

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

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

Fully Supporting	These waters meet applicable water quality standards, both criteria and designated use.
Threatened	These waters currently meet water quality standards, but states are concerned 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.

Waters classified as partially supporting or not supporting their uses are categorized as impaired. Section 303(d) of the Clean Water Act requires states to submit a list of these impaired waters. These waters are targeted for Total Maximum Daily Load (TMDL) development. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the state has designated.

The 305(b) assessment data reported by the states are stored in EPA's National Assessment Database (U.S. EPA, 2000d). Impaired waters are reported on state 303(d) lists, and the data are stored in EPA's TMDL Tracking System. These data are useful for analyzing whether or not efforts to improve water quality within a state are successful. Unfortunately, each state monitors water quality parameters differently, so it is difficult to make generalized statements about the condition of the nation's coasts based on these data alone.

State Fish Consumption Advisories

The 50 states, U.S. territories, and Native American tribes (hereafter referred to as states) have primary responsibility for protecting their residents from the health risks of consuming contaminated noncommercially caught fish and shellfish. (Sale of commercial fish in interstate commerce is regulated by the FDA.) States do this by issuing consumption advisories for the general population, including recreational and subsistence fishers, as well as for sensitive subpopulations (such as pregnant women, nursing mothers, and children). These advisories inform the public that high concentrations of chemical contaminants (such as mercury and polychlorinated biphenyls or 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 within a state (e.g., all coastal waters).

The 2000 National Listing of Fish and Wildlife Advisories (NLFWA) is a database—available from EPA—that can be searched on the Internet at http://www.epa.gov/ost/fish. This database contains fish advisory information provided to EPA by the states. The NLFWA database can generate national, regional, and state maps that illustrate any combination of advisory parameters.

Classified Shellfish-Growing Waters

NOAA's National Shellfish Register is published to summarize the status of the shellfish-growing waters around the country (Table 1-2 defines the classifications). Seven Registers have been published since 1966. The 1995 Register characterizes over 4,200 shellfish-growing waters in 21 coastal states, reflecting an assessment of nearly 25 million acres of estuarine and nonestuarine waters. Over 77 million pounds (meat weight) was harvested from these waters in 1995, with a dockside value of $200 million. The 1995 Register data are available on the Internet at http://sposerver.nos.noaa.gov/projects/95register. The 1995 Register will be the last published version. NOAA is currently investing their efforts into making state shellfish advisory data available on-line.

Table 1-2. Classifications for Shellfish-Growing Waters

Approved Waters	Shellfish may be harvested for direct marketing. Fecal coliform median or geometric mean most probable number (MPN) does not exceed 14 per 100 mL, and not more than 10% of samples exceed MPN of 43 per 100 mL for 5-tube decimal dilution test.
Conditionally Approved Waters	Growing waters meet approved classification standards under predictable conditions. Open to harvest when water quality standards are met, but closed at other times. Fecal coliform standards are the same as for Approved.
Restricted Waters	Shellfish may be harvested only if they are relayed or depurated before direct marketing. Fecal coliform median or geometric mean MPN does not exceed 88 per 100 mL, and not more than 10% of the samples exceed MPN of 260 per 100 mL.
Conditionally Restricted Waters	Growing waters do not meet the criteria for restricted waters, but may be harvested if shellfish are subjected to a suitable purification process. Fecal coliform standards same as for Restricted.
Prohibited Waters	Shellfish may not be harvested for marketing under any conditions.
Unclassified Waters	Waters that are part of a state's shellfish program but are inactive, and the state does not conduct any water quality monitoring or maintain a sanitary survey.

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 geographic information system (GIS) and database files from this site as well:

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

The NLFWA database includes information on

- Geographic location of each advisory
- Species and size ranges of fish and shellfish included in each advisory
- Chemical contaminants identified in the advisory
- Geographic extent of advisories in estuaries (square mileage) and coastal areas (miles)
- Population for whom the advisory was issued (general population or subpopulations).

http://www.epa.gov/ost/fish

EPA's BEACH Watch Website

EPA has created a new website called "BEACH Watch" to serve as an online directory of information about the water quality at beaches nationwide and about local protection programs. The website address is

http://www.epa.gov/ost/beaches

Beach Closures

There is growing concern in the United States about public health risks posed by polluted bathing beaches. Scientific evidence documenting the rise of infectious diseases caused by microbial organisms in recreational waters continues to grow. However, there is not enough information currently available to define the extent of beach pollution throughout the country. A primary goal of EPA's Beaches Environmental Assessment, Closure, and Health (BEACH) Program, established in 1997, is to work with state, tribal, and local governments to compile information on beach pollution to define the national extent of the problem.

A few states have comprehensive beach monitoring programs to test the safety of water for swimming. Many other states have only limited beach monitoring programs, and some states have no monitoring programs linked directly to water safety at swimming beaches. What we do know is that beach pollution is a persistent problem, based on the number of beach closings and swimming advisories that continue to be issued annually. In 1999, there were over 1,830 beach closures and advisories in coastal and Great Lakes waters. This represents a substantial increase over previous years, although changes in the number of closures may result from improved monitoring and reporting activities.

Photo: © John Theilgard

Purpose of This Report

The purpose of this report is to present a broad baseline picture of the condition of estuaries across the United States and, where available, snapshots of the condition of offshore waters. This report uses currently available data sets to discuss the condition of the nation's coasts. This report is not intended to be a comprehensive literature review of coastal information. The data sets presented in this report can begin to tell a story about coastal condition. For example, EMAP has monitoring data on a variety of indicators for the Virginian, Louisianian, and Carolinian provinces, which make up 70% of U.S. estuarine acreage. This report will serve as a useful benchmark for analyzing the progress of coastal programs in the future and will be followed in subsequent years by reports for more specialized coastal issues. It will also serve as a reminder of the data gaps and other pitfalls that we are constantly faced with and must try to overcome in the future in order to make more reliable assessments of how the condition of our nation's coastal resources may be changing with time.

This report also highlights several exemplary programs at the federal, state, tribal, and local levels that show coastal conditions at various regional scales. These highlights are not intended to be comprehensive or exhaustive of all coastal programs, but are presented to show that information about the health of coastal systems is being collected for decision-making at these local and regional levels.

NOAA's State of the Coast Report

Assessing the Health of the Nation's Coastal Resources

NOAA's State of the Coast Report is an account of the status of the environmental condition for the nation's coastal areas and resources. The report consists of a series of essays on important coastal issues ranging from population growth to the extent and condition of U.S. coral reefs to efforts to reduce the impacts of coastal hazards. The essays present information from the national, regional, and local perspectives. Each essay also includes the responses and opinions of an expert panel on two key questions relevant to the issue. Essays are currently available for 16 topics.

http://state-of-coast.noaa.gov

The Heinz Center

Designing a Report on the State of the Nation's Ecosystems

Selected Measurements for Croplands, Forests, and Coasts & Oceans

The Heinz Center Report on the State of the Nation's Ecosystems, funded by USDA, DOI, Departments of Defense and Energy, EPA, the National Aeronautics and Space Administration, NOAA, and the National Science Foundation, presents a framework for reporting ecological condition and applies this framework to coasts and oceans. The purpose of the report is to identify and present a suite of measures that can be used to gauge the condition and use of the nation's natural resources. One of the major findings of the report is that national data are available for only about one-third of the measures of condition for coasts and oceans.

http://www.us-ecosystems.org

Federal Programs and Initiatives That Address Coastal Issues

CWAP: Coastal Research and Monitoring Strategy

http://www.cleanwater.gov

The National Coastal Research and Monitoring Strategy was developed to address the lack of nationally consistent data for analyzing the status and trends of coastal conditions. The objectives of the strategy are to

- Document the status and trends in environmental conditions at scales necessary for scientific investigation and policy development
- Evaluate the causes and consequences of changes in environmental status and trends
- Assess environmental, economic, and sociological impacts of alternative policies for dealing with these changes
- Implement programs and policies to correct observed environmental problems.

The key attributes of the proposed Coastal Research and Monitoring Strategy include co-funding by federal and state programs; nested designs that allow state-specific issues to be addressed in a national context; and attention to specific state issues, collective reporting, and cross-system comparisons.

National Coastal Assessment – Coastal 2000

http://www.epa.gov/emfjulte/nca

EPA's National Coastal Assessment (also known as Coastal 2000 or C2000) is a 5-year effort led by EPA's Office of Research and Development to evaluate the assessment methods it has developed to advance the science of ecosystem condition monitoring. This program will survey the condition of the nation's coastal resources (estuaries and offshore waters) by creating an integrated, comprehensive coastal monitoring program among the coastal states to assess the coastal ecological condition.

The strategy for Coastal 2000 focuses on a strategic partnership with NOAA, USGS, and all 24 U.S. coastal states. Using a compatible, probabilistic design and a common set of survey indicators, each state will conduct the survey and assess the condition of its coastal resources independently, yet these estimates can be aggregated to assess conditions at EPA Regional, biogeographical, and national levels. The map in Figure 1-6 shows the states (and Puerto Rico) that are included in the survey, the intended number of sampling sites in each state for 2000-01, and the stage of development of the survey.

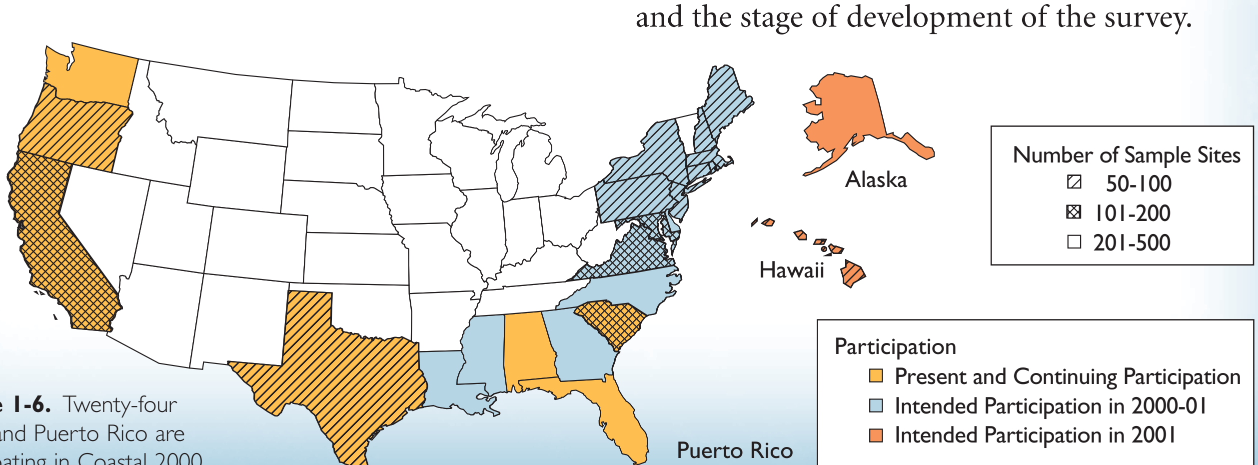


Figure 1-6. Twenty-four states and Puerto Rico are participating in Coastal 2000.

Environmental Monitoring and Assessment Program

http://www.epa.gov/emap

The Environmental Monitoring and Assessment Program (EMAP) conducts annual surveys to measure indicators of the health of plants and animals, the quality of their surroundings, and the presence of pollutants. The program, at present, is developing the appropriate designs and sets of indicator measurements to characterize the condition of the nation's resources. Once these developmental issues are addressed, the goal of the program is long-term monitoring activity that will provide information on the overall health of the environment and the effectiveness of pollution prevention and control measures.

EMAP-Estuaries (EMAP-E), implemented through partnerships between EPA, NOAA, U.S. Geological Survey (USGS), coastal states, and academia, will provide information on the ecological condition of the nation's estuaries as part of this larger program. Ecological health is being assessed by investigating the regional distributions of fish and bottom-dwelling organisms. EMAP-E is determining what portions of estuaries can support these plants and animals and finding out why certain areas do not support them.

The EMAP-E approach places all coastal waters, bays, and estuaries into defined areas for study (Figure 1-7). From 1990 to 1993, EMAP-E investigated the ecological condition of the estuaries of the Middle Atlantic states from Cape Cod, Massachusetts, to Cape Henry, Virginia (Virginian Province), and the estuaries of the Gulf of Mexico from Anclote Anchorage, Florida, to the Rio Grande, Texas (Louisianian Province). EMAP-E conducted provincewide monitoring in the Carolinian province from 1994 to 1995. The estuarine resources in these three provinces represent 70% of the estuarine acreage of the United States. EMAP-E also conducted monitoring of North Carolina's estuaries from 1994 to 1997 and site-specific sampling of the Neuse River during 1998 and 1999.

Figure 1-7. EMAP-Estuaries study areas.

Office of Ocean and Coastal Resource Management • National Ocean Service • National Oceanic and Atmospheric Administration

COASTAL ZONE MANAGEMENT

Coastal Zone Management Program

http://www.ocrm.nos.noaa.gov/czm

The Coastal Zone Management (CZM) Act of 1972 established a voluntary partnership between federal and state governments for management of the coast. The program provides funding through NOAA to coastal states (including the Great Lakes states) and territories (see Figure 1-8) for the development and implementation of measures to conserve and develop coastal resources (NRC, 1997). The CZM program focuses on efforts to protect the nation's coastal zones, assists states in their responsibilities for coastal zone management, develops special area management plans, and encourages the participation and coordination of all public and private stakeholders who affect the coastal zone. States have the flexibility to address their most pressing coastal issues, and many states have supported the revitalization of urban waterfronts and the reuse of waterfront sites impaired by contamination. States develop and implement coastal zone management programs with enforceable policies designed to meet national objectives (NRC, 2000). Over 99.7%, or 95,093 miles, of U.S. shoreline is managed by federally approved state coastal zone management programs (NRC, 2000).

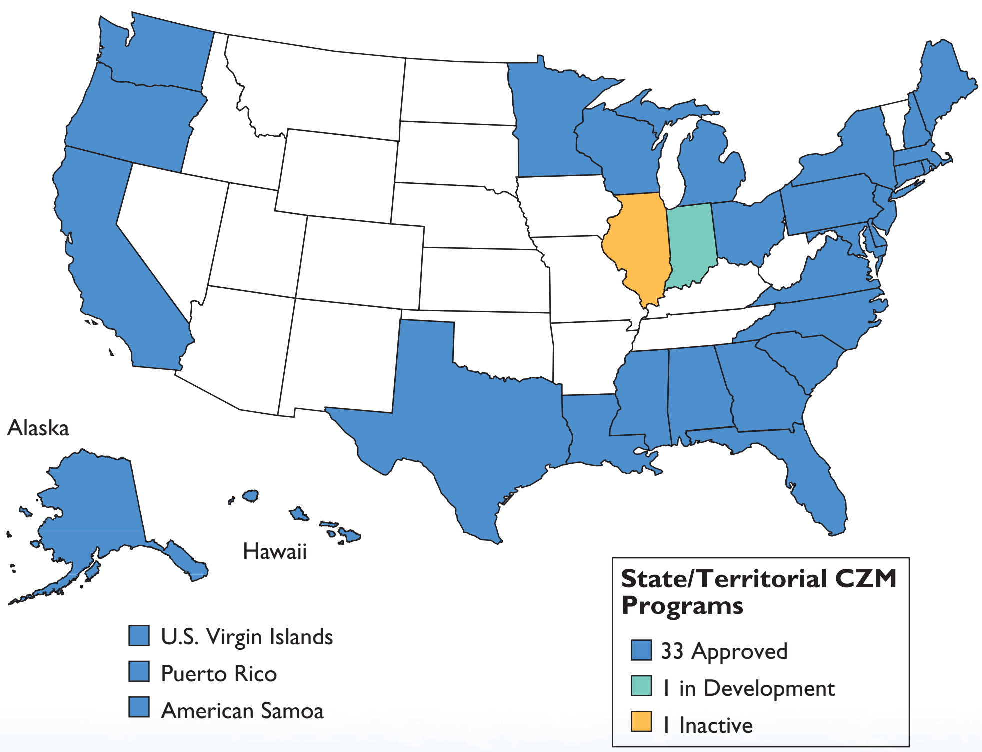


Figure 1-8. Coastal Zone Management Program.

National Marine Sanctuary System

http://www.sanctuaries.nos.noaa.gov

The National Marine Sanctuary (NMS) System, a network of 13 marine protected areas, was established in 1972 in response to public concern over ocean pollution and its impact on marine mammals and ecosystems (Figure 1-9).

National marine sanctuaries embrace part of our collective riches as a nation. Within their protected waters, giant humpback whales breed and calve their young, coral colonies flourish, and shipwrecks tell the story of our maritime history. The Sanctuary System is today administered under the National Ocean Service of the National Oceanic and Atmospheric Administration. The objectives of the NMS System program are to

- Identify and designate areas of special national significance as sanctuaries
- Develop and implement coordinated protection and managements plans for sanctuaries
- Facilitate public and private uses insofar as they are compatible with resource protection
- Support scientific research and public education in sanctuaries (NRC, 1997).

The system's objectives work to conserve, protect, and enhance the biodiversity, ecological integrity, and cultural legacy of our nation's oceans and Great Lakes. Marine sanctuaries contain natural classrooms for students and scientists, cherished recreational spots, and valuable cultural artifacts. National Marine Sanctuaries are committed to protecting American's ocean treasures for this and future generations.

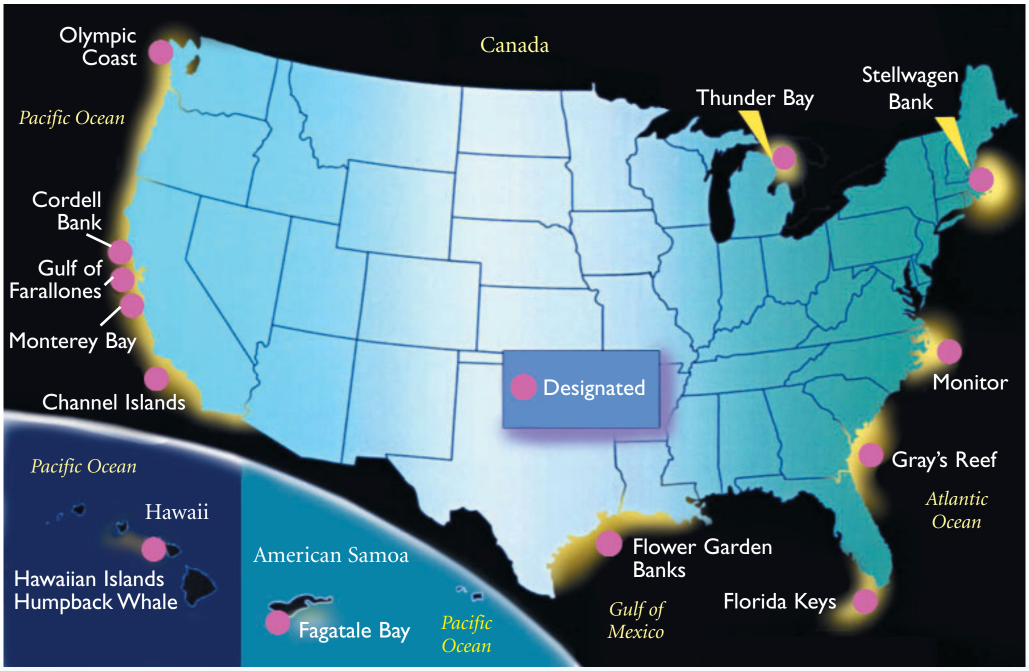


Figure 1-9. National Marine Sanctuaries.

National Estuary Program

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

The National Estuary Program (NEP) was established under Sections 317 and 320 of the Water Quality Act of 1987 (amendments to the Clean Water Act) to:

- Identify potentially significant estuaries that are threatened by pollution, development, or overuse
- Promote comprehensive planning for, and conservation and management of, nationally significant estuaries
- Encourage the preparation of management plans for estuaries of national significance and enhance the coordination of estuarine research
- Create a monitoring program to evaluate the management plan's effectiveness.

The mission of the NEP is to protect and restore the health of estuaries while supporting economic and recreational activities. To achieve this, EPA designates local NEPs to develop partnerships among the government agencies that oversee estuarine resources and the people who depend on these resources for their livelihood and quality of life. Each NEP brings together officials at the federal, state, and local levels; interest group representatives; the scientific and academic communities; and private citizens to work together as a management conference to develop a Comprehensive Conservation and Management Plan (CCMP). Twenty-eight estuary programs are currently working to safeguard the health of some of our nation's most important coastal waters (Figure 1-10).

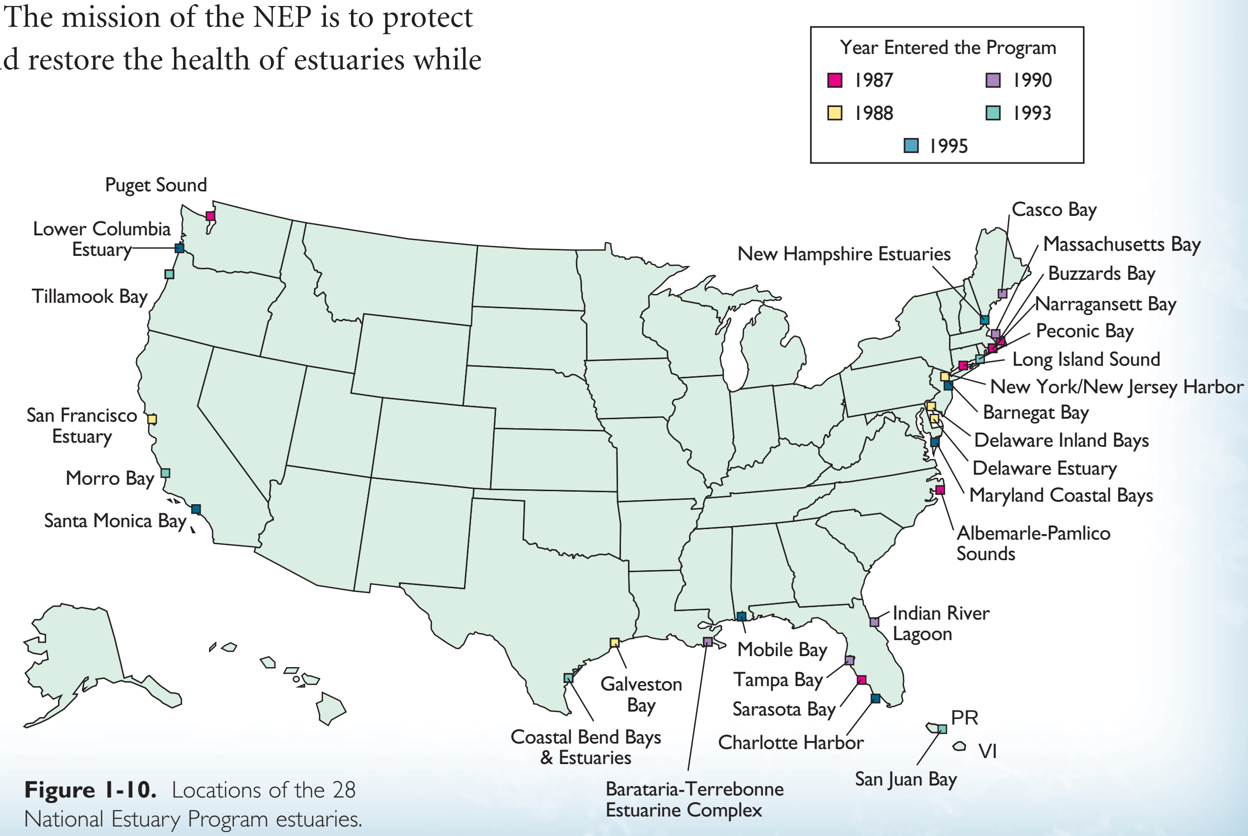


Figure 1-10. Locations of the 28 National Estuary Program estuaries.

NOAA's National Estuarine Research Reserve System

http://inlet.geol.sc.edu/cdmohome.html

The National Estuarine Research Reserve System (NERRS) is a network of protected areas established to develop and provide information that promotes informed resource management (Figure 1-11). The reserve system was created by the Coastal Zone Management Act of 1972. Currently, there are 25 reserves in the system representing the wide range of estuarine and coastal habitats found in the United States.

The reserves implement a System-Wide Monitoring Program (SWMP) to detect physical and biological change in estuaries. The SWMP provides critical information on national estuarine trends and allows flexibility to assess coastal issues of regional or local concern. The SWMP makes onsite research easier and promotes use of the reserves as demonstration sites for new approaches to estuarine management. The SWMP provides valuable long-term data and information to researchers, natural resource program managers, and other coastal decision makers.

The SWMP is an integrated monitoring program that consists of three components (phased in over several years):

- Estuarine water quality monitoring
- Biodiversity monitoring
- Land use and habitat change analysis.

Further details on SWMP and preliminary results are presented in a highlight on page 37 in Chapter 2.

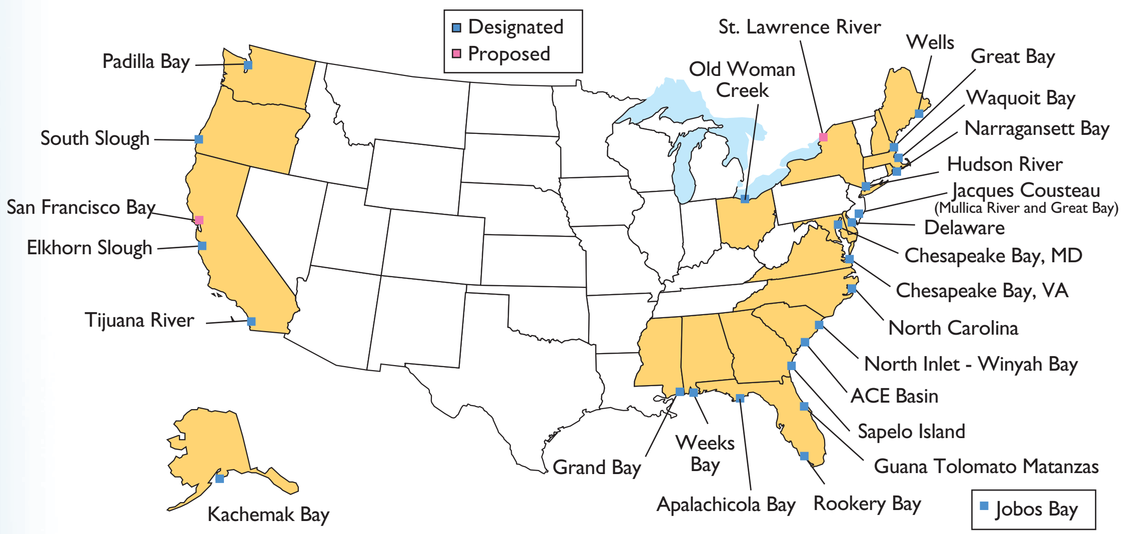


Figure 1-11. Locations of the 25 NERRS sites (NOAA).

NOAA's National Status and Trends (NS&T) Program

http://ccmaserver.nos.noaa.gov/NSandT/New_NSandT.html

In 1984, NOAA initiated the National Status and Trends (NS&T) Program to determine the current status of, and to detect changes in, the environmental quality of our nation's estuarine and coastal waters. NS&T sites are identified in Figure 1-12. The NS&T

- Conducts long-term monitoring of contaminants and other environmental conditions at more than 350 sites along the U.S. coast
- Studies biotic effects intensively at more than 25 coastal ecosystems
- Partners with other agencies in a variety of environmental activities
- Advises and participates in local, regional, national, and international projects related to coastal monitoring and assessment.

The NS&T Program comprises several projects: the Mussel Watch Project, the Quality Assurance Project, the Specimen Banking Project, Sediment Toxicity Surveys, Biomarkers, Environmental Indices, and Regional Assessment. Information from the NS&T Program is synthesized and reported to those responsible for managing coastal natural resources and to the public.

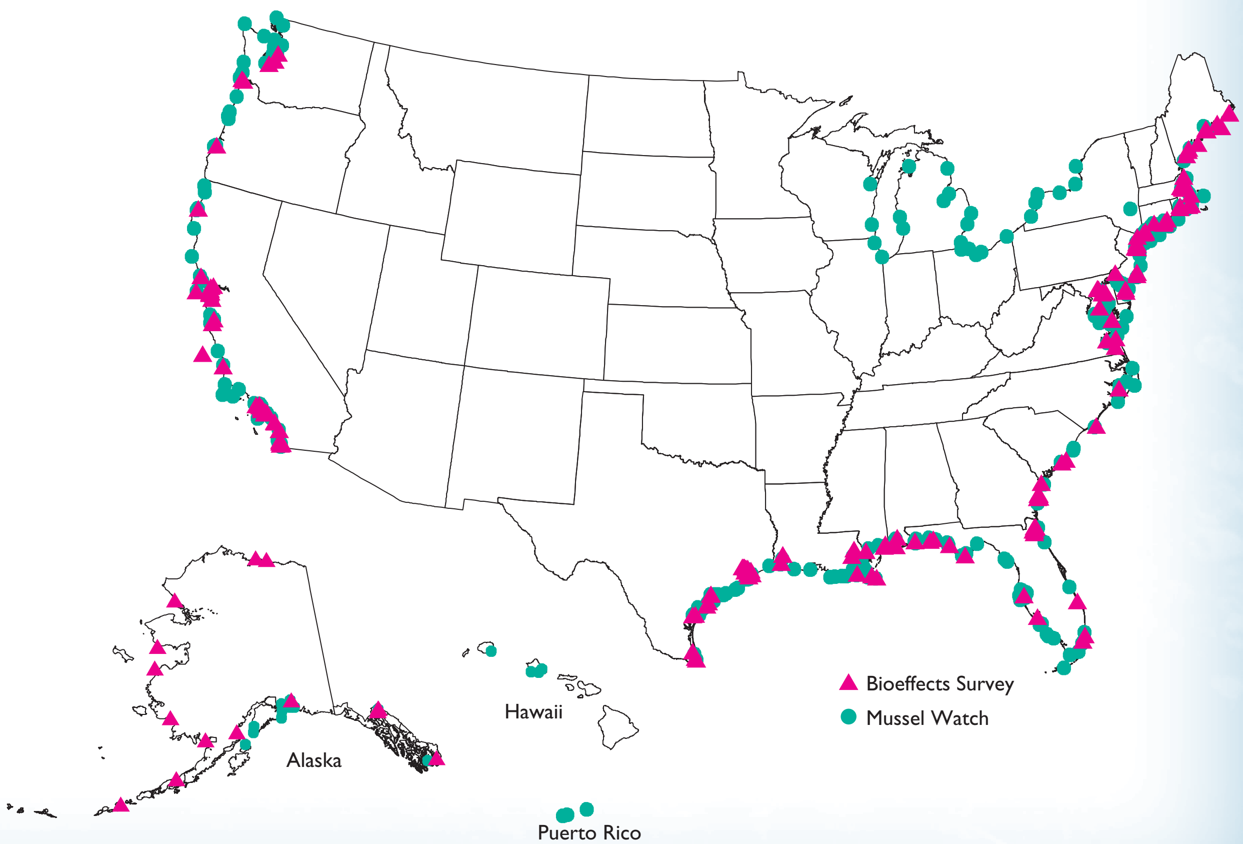


Figure 1-12. NOAA NS&T sites.

NOAA's National Marine Fisheries Service National Habitat Program

http://www.nmfs.noaa.gov/habitat/index.html

The Office of Habitat Conservation, within NOAA's National Marine Fisheries Service (NMFS), together with the five NMFS Regions make up the National Habitat Program. The Program works to manage, conserve, restore, and enhance habitats for fishery resources and protected marine species. Through research and management, the National Habitat Program's primary mandates focus on ensuring that living marine resources have sufficient healthy habitat to sustain populations of fish and shellfish. Those mandates emphasize wetlands, anadromous fish habitat, and habitat of managed fish species and invariably include close partnerships with state and federal agencies, industry, environmental groups, and academia (Figure 1-13).

Since the enactment of the Sustainable Fisheries Act of 1996, the Program has worked with regional fishery management councils in identifying habitats essential to the long-term sustainability of the nation's fishery resources. The identification of this essential fish habitat (EFH) supports the conservation and enhancement of habitat through coordination and consultation with other federal and state agencies that undertake activities affecting EFH. The Program is working to stem the tide of wetland loss in Louisiana, which is beset by the highest rate of coastal wetland loss in the nation. Through its mandated role in the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), the NMFS works to develop and implement habitat projects to restore salt marshes lost to erosion, subsidence, and hydrological alterations. The Program also seeks to restore, replace, or acquire the equivalent of resources injured as a result of discharges of oil or hazardous substances or other human-induced environmental disturbances.

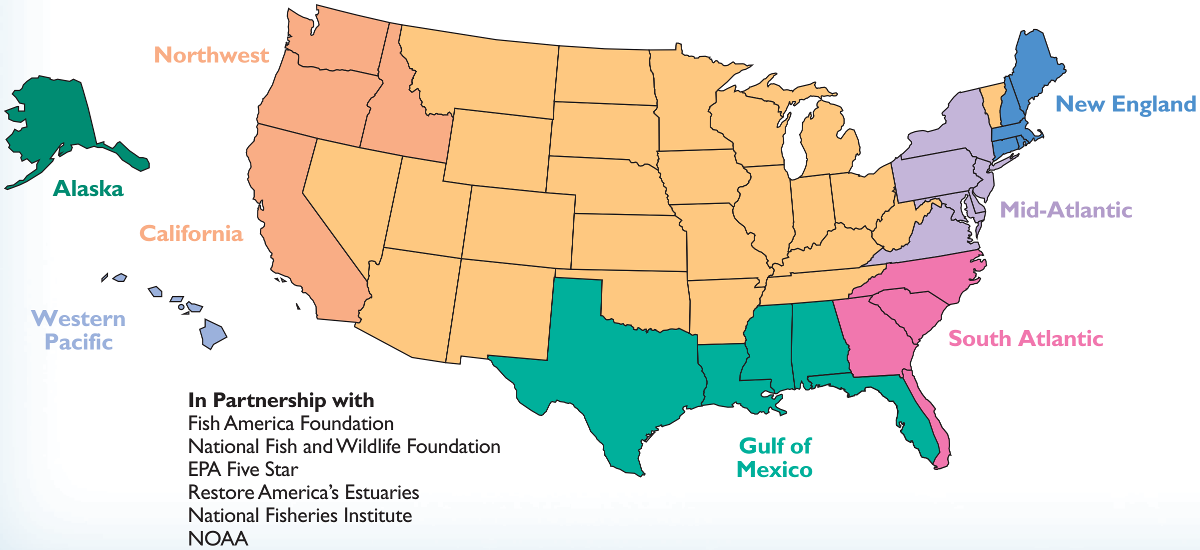


Figure 1-13. National Habitat Program.

EPA's Great Waters Program

http://www.epa.gov/oar/oaqps/gr8water

On November 15, 1990, in response to mounting evidence that air pollution contributes to water pollution, Congress amended the Clean Air Act and included provisions that established research and reporting requirements that related to the deposition of hazardous air pollutants to the "Great Waters." The waterbodies designated by these provisions are the Great Lakes, Lake Champlain, Chesapeake Bay, and certain other coastal waters (identified by their designation as NEP or NERRS sites, Figure 1-14). The amendments require EPA to establish deposition monitoring networks in the Great Waters, as well as conduct additional studies, such as assessing sources and deposition rates, evaluating adverse affects, and researching monitoring methods and biotic sampling. The amendment also requires EPA to report its findings to Congress in periodic reports. These reports to Congress address three main issues:

- Contribution of atmospheric deposition to total pollutant loading to the Great Waters
- Adverse effects on human health and the environments
- Sources of the pollutants.

The third report to Congress was completed in June 2000.

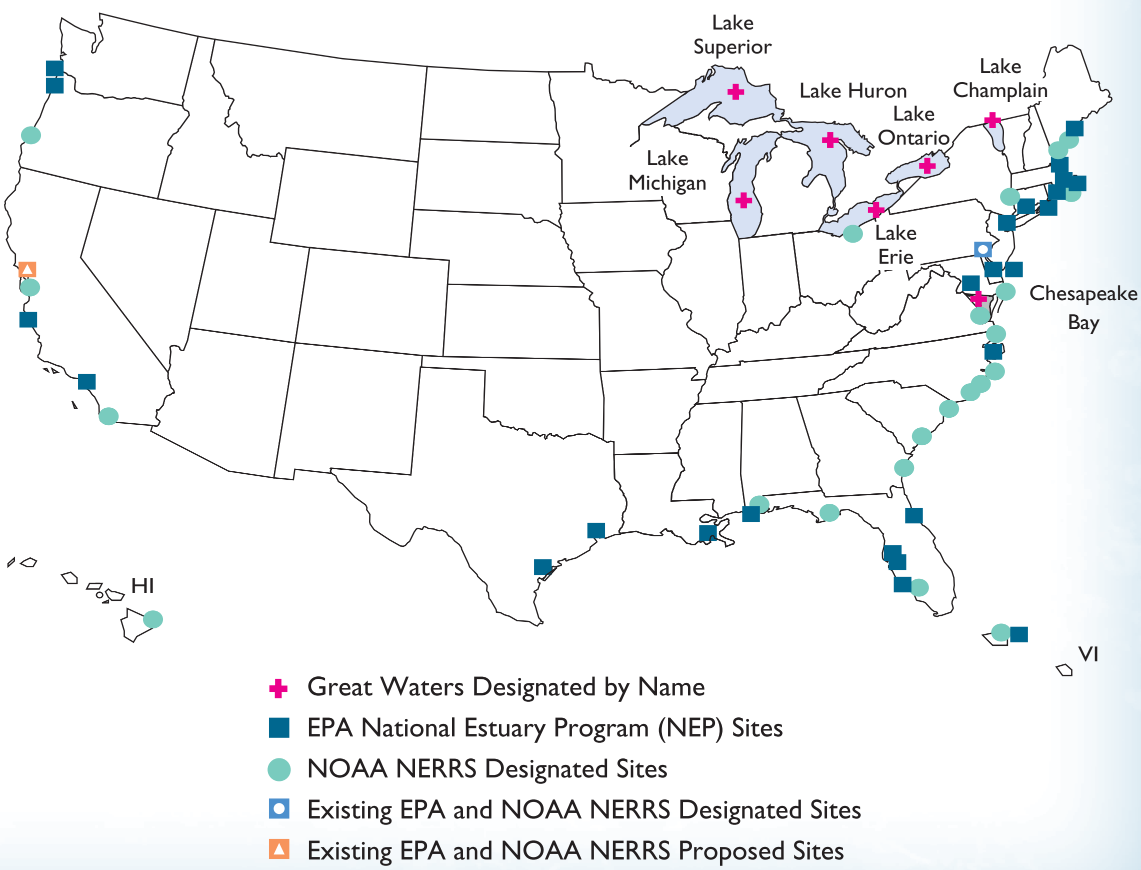


Figure 1-14. EPA's "Great Waters" as designated by the Clean Air Act.

National Streamgaging Program

http://water.usgs.gov/osw

The U.S. Geological Survey (USGS) National Streamgaging Program provides freshwater inflow data for estuary subsystems across the nation. Freshwater inflow, a major determinant of the physical, chemical, and biological characteristics of most estuaries, is measured by USGS river gauges. Freshwater inflow affects the concentration and retention of pollutants, the distribution of salinity, and the stratification of fresh and salt water within an estuary. These characteristics help define the ecological processes and habitats within an estuary and determine how human activities affect an estuary's overall condition.

The National Stream Water Quality Accounting Network (NASQAN, Figure 1-15) collects water chemistry and sediment data along the nation's largest streams that can be used to characterize large subbasins of these rivers and identify regional sources for the contaminants and sediments carried by the stream. NASQAN stations are sampled frequently enough to characterize variations in chemical and sediment concentrations that occur during a year, particularly the variation that occurs between low and high flows, during different seasons of a year, and during different hydrologic regimes such as periods when snowmelt dominates river discharge. By sampling a river under these different conditions, the amount of material that passes a station, known as the mass flux of a constituent (expressed as tons per day), can be reliably determined by multiplying the concentration of a constituent by the stream discharge.

Constituent mass fluxes can be compared among stations and across spatial scales. For example, yields of contaminants (expressed as tons per square mile) can be compared between stations; gains or losses in a river reach can be determined between any two stations; and amounts of materials delivered to a reservoir or estuary can be calculated. The ability to determine these three values—source, transport, and delivery of constituents—enables a broad range of scientific and policy issues to be addressed.

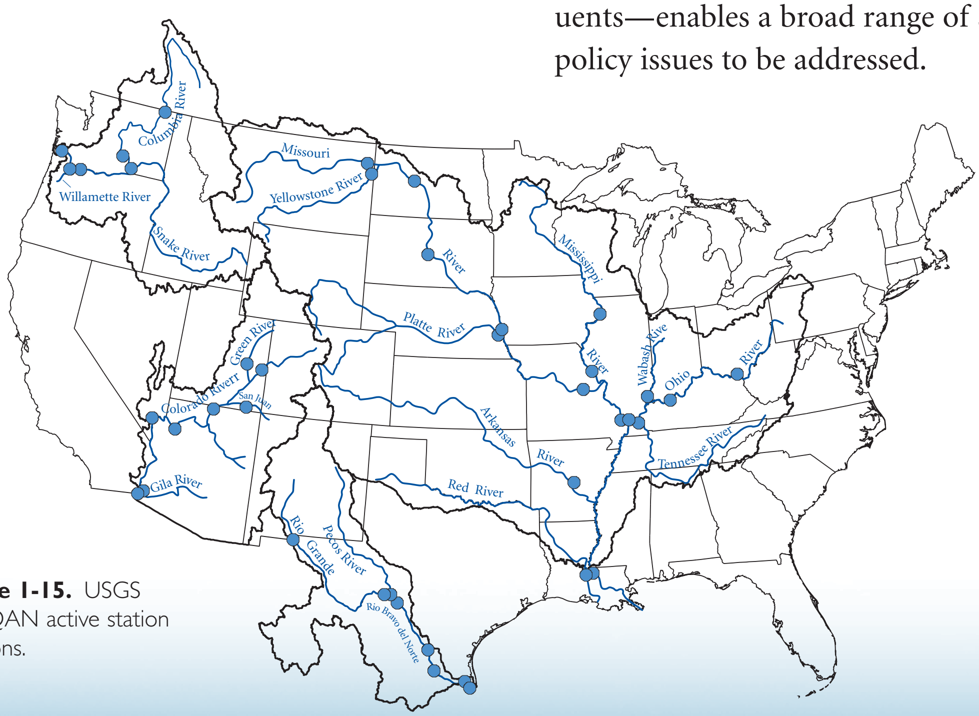


Figure 1-15. USGS NASQAN active station locations.

U.S. Fish and Wildlife Service Coastal Program

http://www.fws.gov/cep/coastweb.html

The U.S. Fish and Wildlife Service Coastal Program works with partners to conserve coastal habitats for the benefit of fish, wildlife, and people. Coastal Program biologists provide technical and financial assistance to a wide variety of partners, including other federal agencies, state and local governments, conservation organizations, local land trusts and watershed councils, businesses, and private landowners. The program forms cooperative partnerships that

- Restore coastal wetlands, uplands, and riparian areas
- Protect coastal habitats through voluntary conservation easements and fee-title acquisition from willing sellers
- Remove or retrofit barriers to fish passage in coastal watersheds
- Control exotic invasive species that threaten estuarine health. Program funds are more than tripled through leveraging with partners, and the focus is achieving on-the-ground results.

From 1994 to 1999, Coastal Program partnerships restored more than 46,550 acres of coastal wetlands, 17,130 acres of coastal uplands, and 320 miles of riparian habitat; protected more than 166,000 acres of coastal habitat through conservation easements and acquisition; and reopened 2,260 miles of coastal streams for access by anadromous fish.

In FY2000, the Fish and Wildlife Service's Coastal Program funded activities in 14 coastal watersheds around the country: Puget Sound, San Francisco Bay, San Diego Bay, Galveston Bay, South Florida, South Carolina, Albemarle/Pamlico Sound, Chesapeake Bay, Delaware Bay, New York Bight, the Gulf of Maine, the Great Lakes, Alaska, and the Pacific Islands (Figure 1-16).

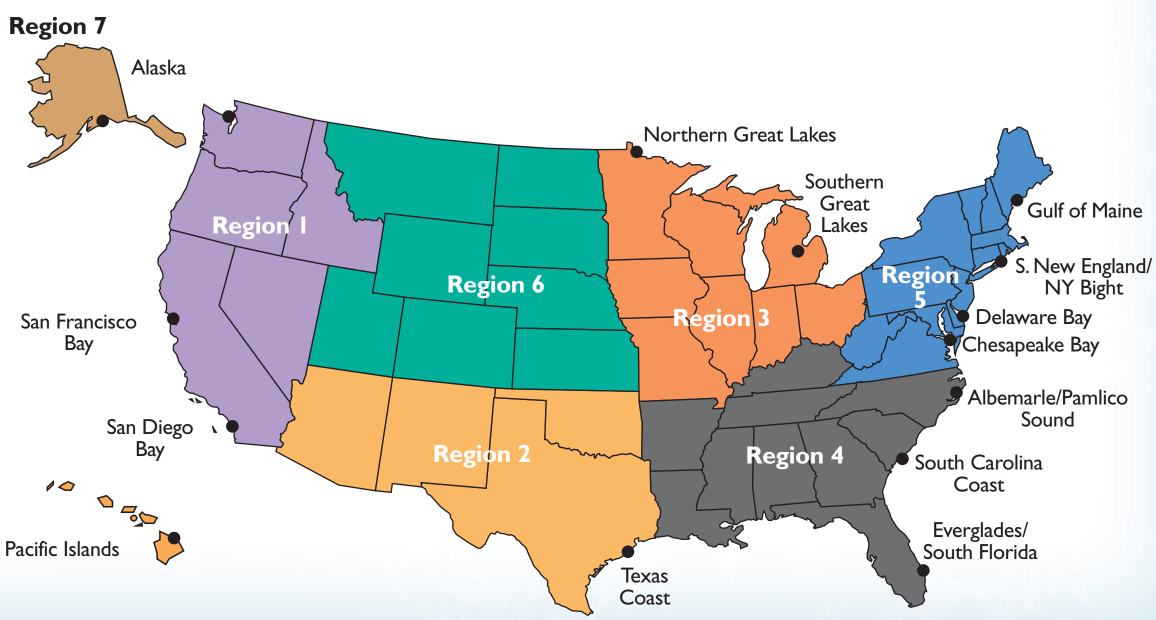


Figure 1-16. Location of Fish and Wildlife Service Coastal Program activities.

U.S. Fish and Wildlife Service National Wetlands Inventory

http://wetlands.fws.gov

The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service produces information on the characteristics, extent, and status of the nation's wetlands and deep water habitats. This information is used by federal, state, and local agencies, academic institutions, U.S. Congress, and the private sector. The Emergency Wetland Resources Act of 1986 directs the Service to map the wetlands of the United States. The NWI has mapped 89% of the lower 48 states and 31% of Alaska. The Act also requires the Service to produce a digital wetland database for the United States. About 39% of the lower 48 states' wetlands and 11% of Alaska's wetlands are digitized. Congressional mandates require the NWI to produce status and trends reports to Congress at 10-year intervals. In 1982, the NWI produced the first comprehensive and statistically valid estimate of the status of the nation's wetlands and wetland losses and in 1990 produced the first update. Future national updates are scheduled for 2000, 2010, and 2020. In addition to the status and trends reports, the NWI has produced over 130 publications, including manuals, plant and hydric soils lists, field guides, posters, wall-size resource maps, atlases, and state reports and has had numerous articles published in professional journals.

EPA's BEACH Watch Program

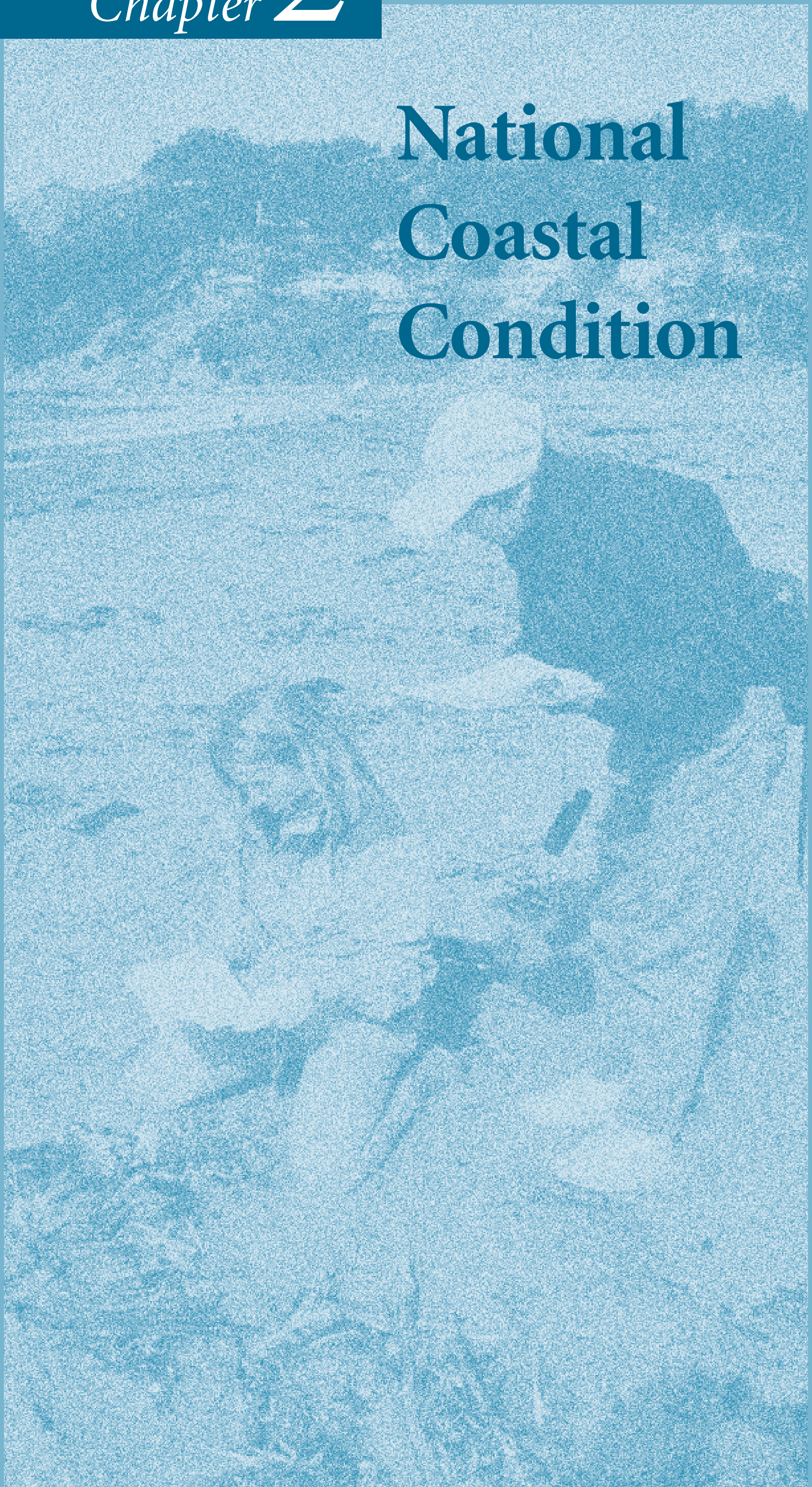
http://www.epa.gov/ost/beaches

EPA's BEACH Program was established in 1997 to strengthen U.S. beach water protection programs and water quality standards, better inform the public, and promote scientific research to further protect the health of beachgoers. The BEACH Program is designed to encourage government agencies at the federal, state, tribal, and local level to strengthen beach water quality standards and testing methods, use predictive water pollution models to better inform the public about beach water quality conditions, and make information about the risks associated with swimming in contaminated beach water available to the public. Under the BEACH Program, EPA will improve laboratory test methods for detecting contaminants in beach water; invest additional resources in beach water quality health and testing methods research; and help state, local, and tribal government agencies adopt and carry out effective water quality monitoring programs.

The Beaches Environmental Assessment and Coastal Health Act (BEACH Act) was passed in 2000 and amended the CWA to require that states with recreational beaches adopt new or revised water quality standards for pathogens and pathogen indicators. The BEACH Act amendment also authorizes EPA to award grants to states to help them develop and implement beach monitoring and public notification programs for pathogens. If a state does not have a monitoring program that meets EPA criteria, the BEACH Act requires EPA to perform the monitoring and notification activities in that state's coastal recreational waters.

Chapter 2

National Coastal Condition



Chapter 2

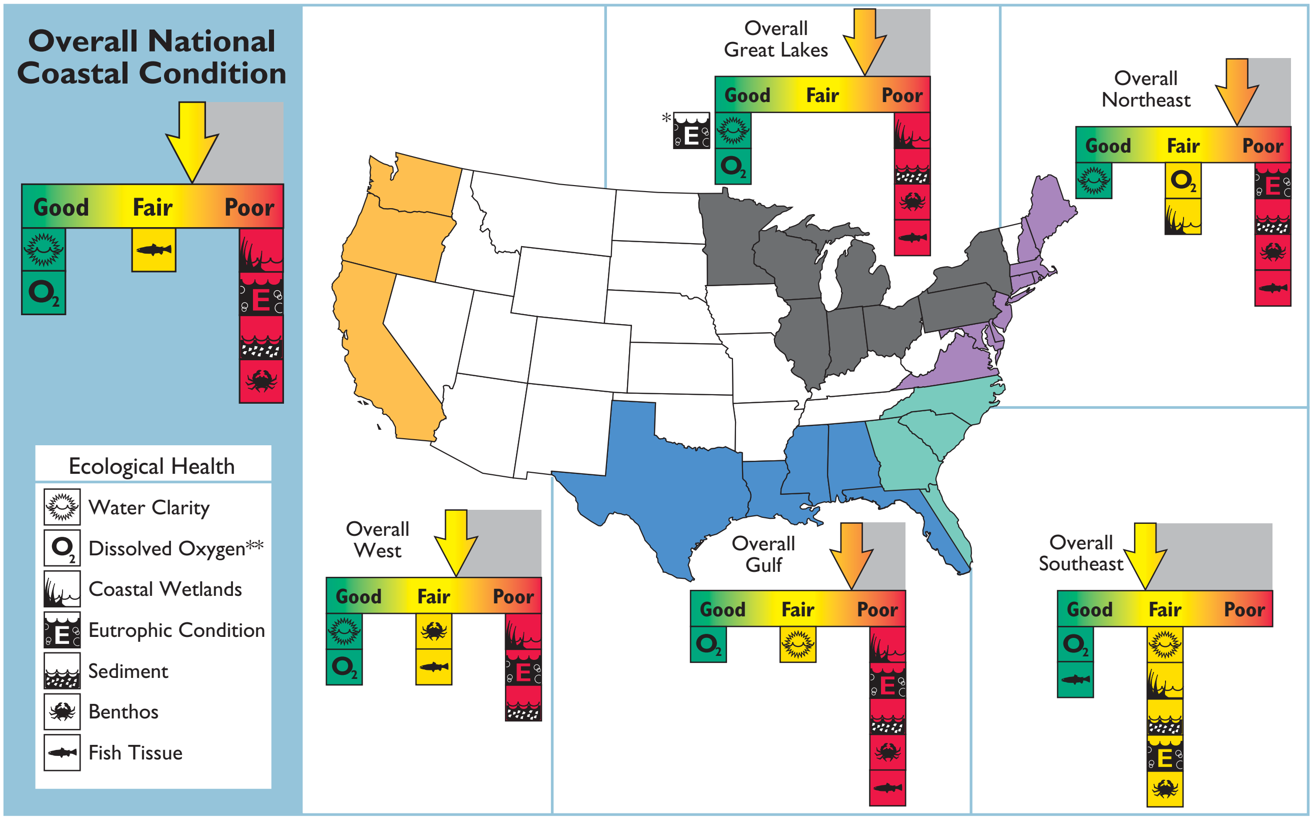
National Coastal Condition

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.

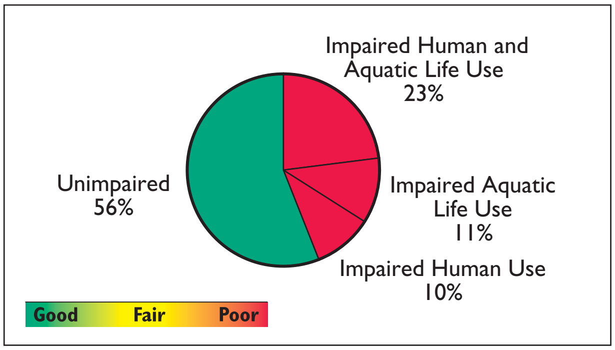


Figure 2-2. National estuarine condition (U.S. EPA/EMAP).

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.

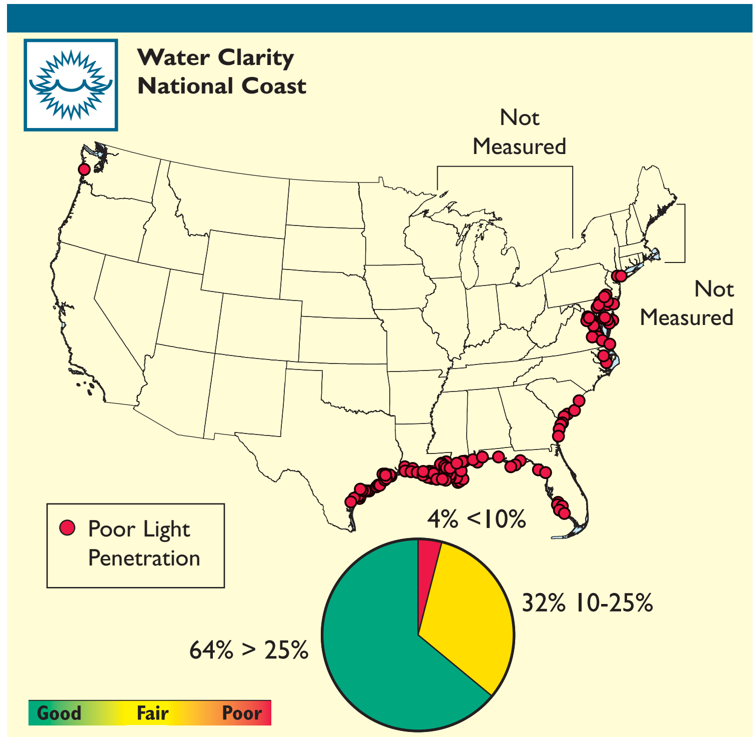


Figure 2-3. Light penetration data and locations for sites with <10% light penetration (U.S. EPA/EMAP).

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

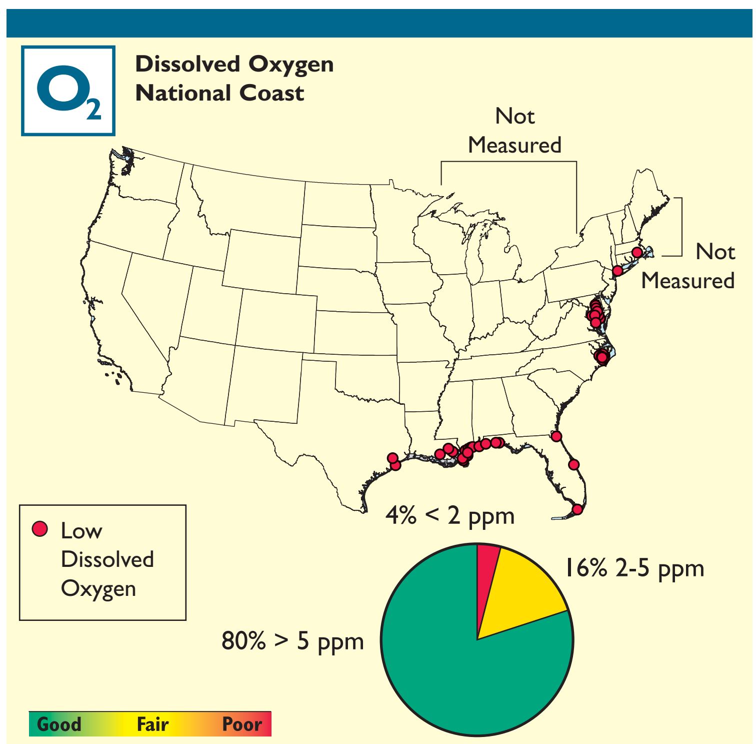


Figure 2-4. Estuarine sites with low dissolved oxygen and the distribution of dissolved oxygen data for all sampled sites (U.S. EPA/EMAP).

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.

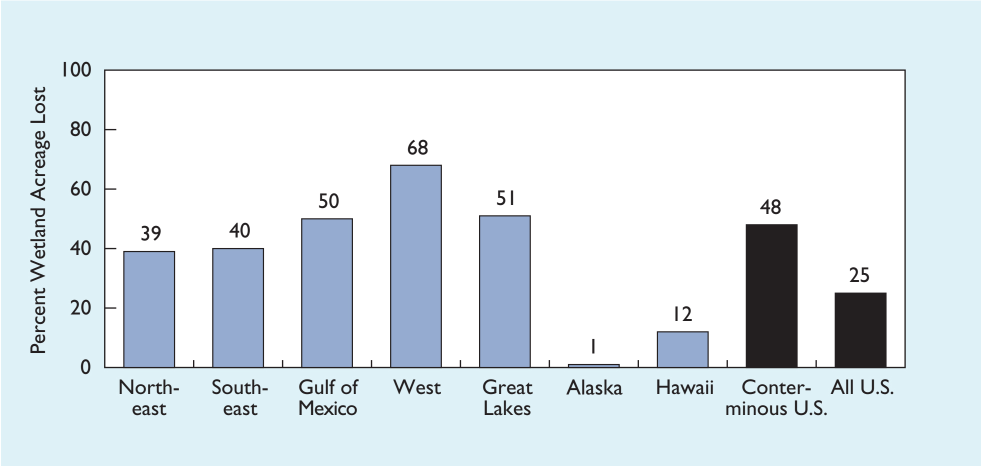
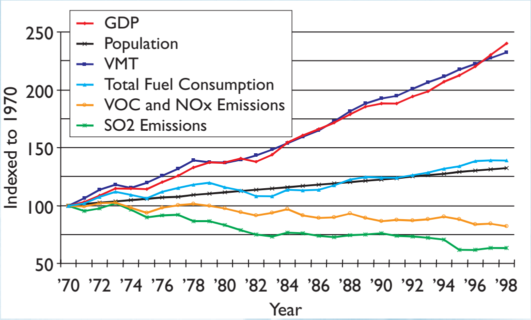


Figure 2-5. Proportion of total wetland acres existing in 1780 lost by 1980 in areas of the United States (Dahl, 1990; Turner and Boesch, 1988).

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.

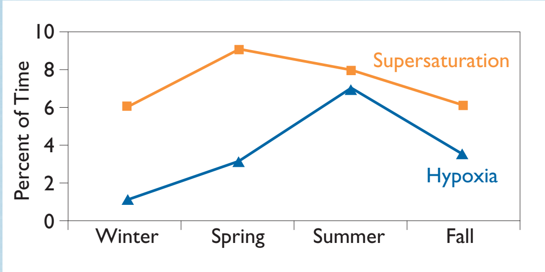
Many coastal waters have experienced eutrophication problems related to excess nitrogen in the water. Atmospheric deposition is a large contributor to the nitrogen load of many coastal waters. Depending on the waterbody and watershed being considered, it is estimated that roughly one-quarter of the nitrogen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

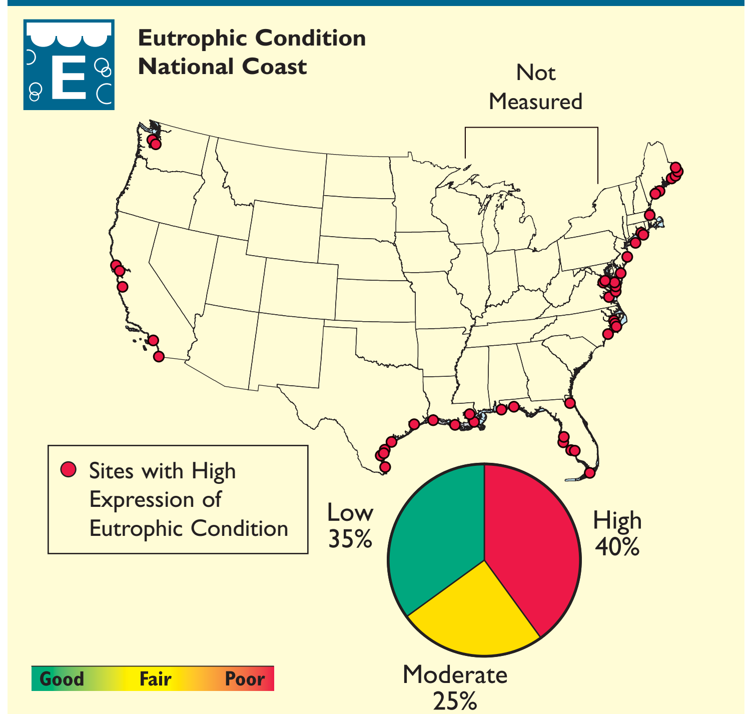


Figure 2-6. Eutrophic condition data and locations of estuaries with high expressions of eutrophic condition (NOAA/NOS).

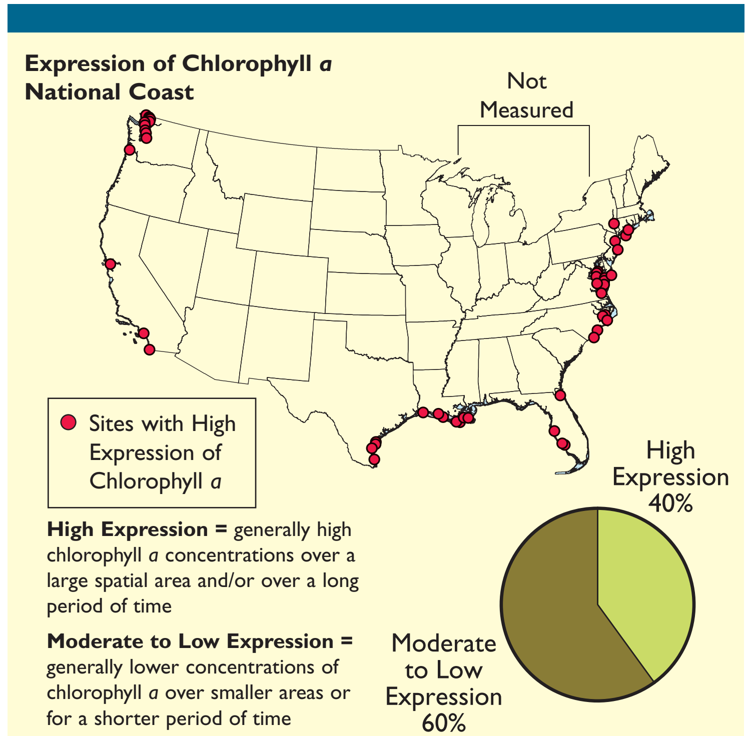


Figure 2-7. Chlorophyll *a* data and locations of estuaries with high expressions of chlorophyll *a* (NOAA/NOS).

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

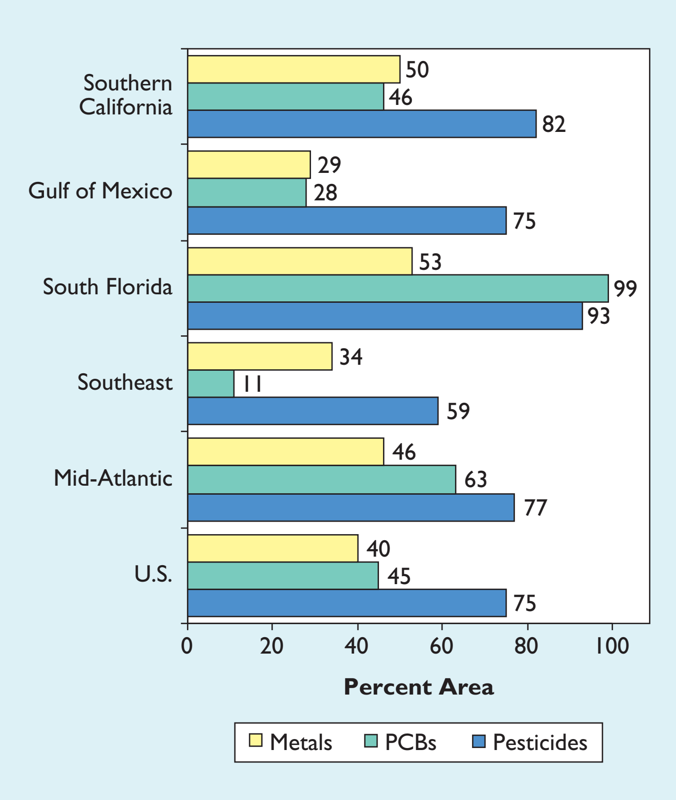


Figure 2-8. Regional sediment enrichment due to human sources.

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.

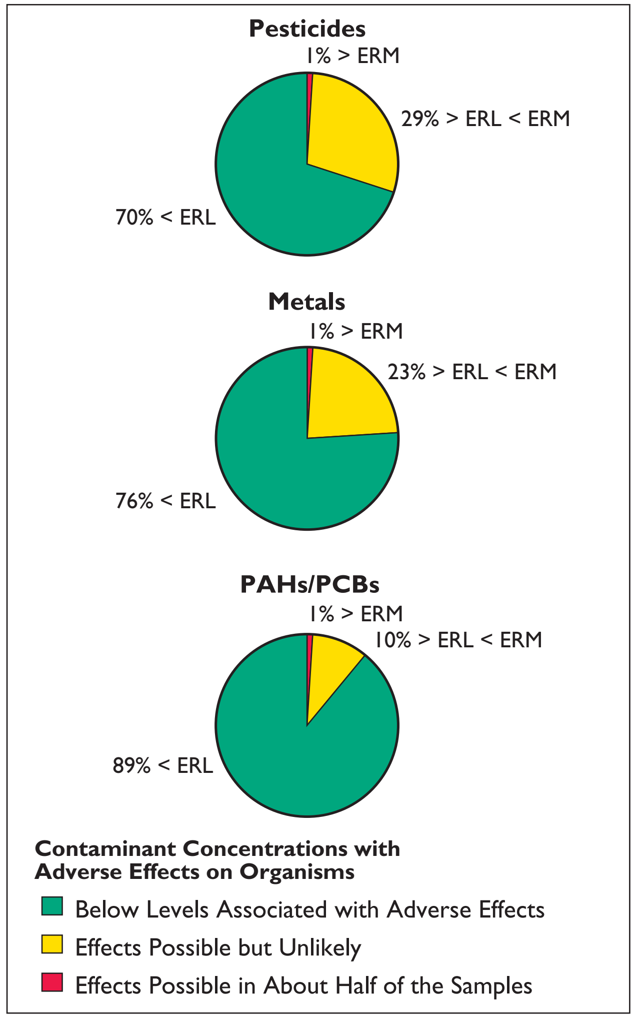


Figure 2-9. Distribution of sediment contaminants in sampled estuarine sites (NOAA and U.S. EPA).

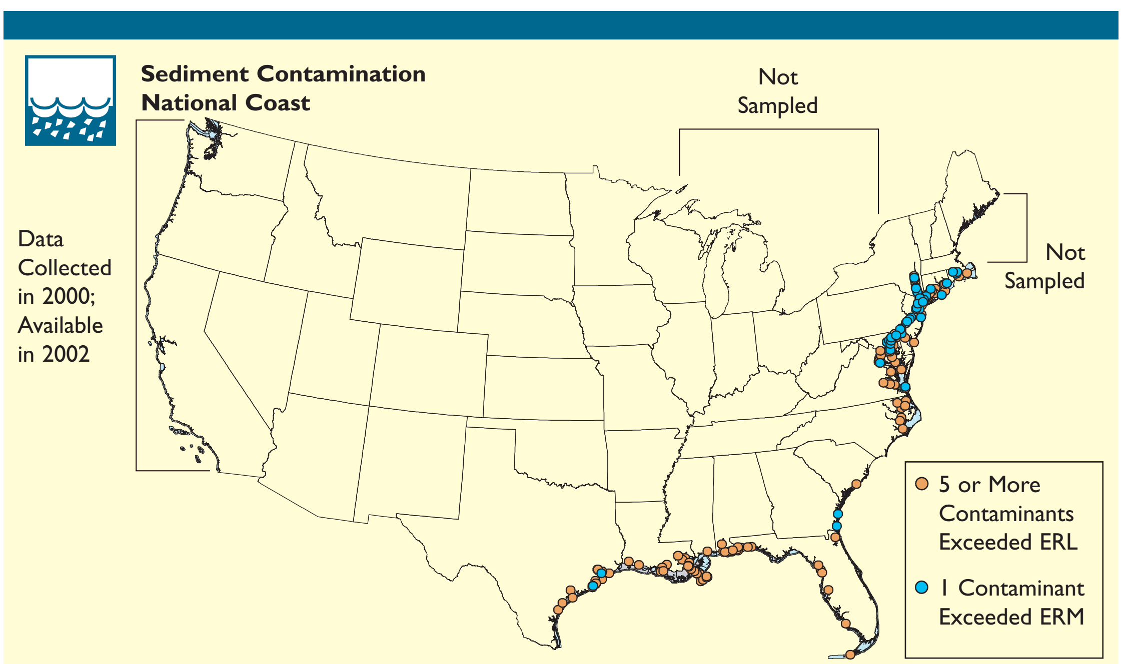


Figure 2-10. Sampled estuarine sites that exceed ERL or ERM criteria (U.S. EPA/EMAP).

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

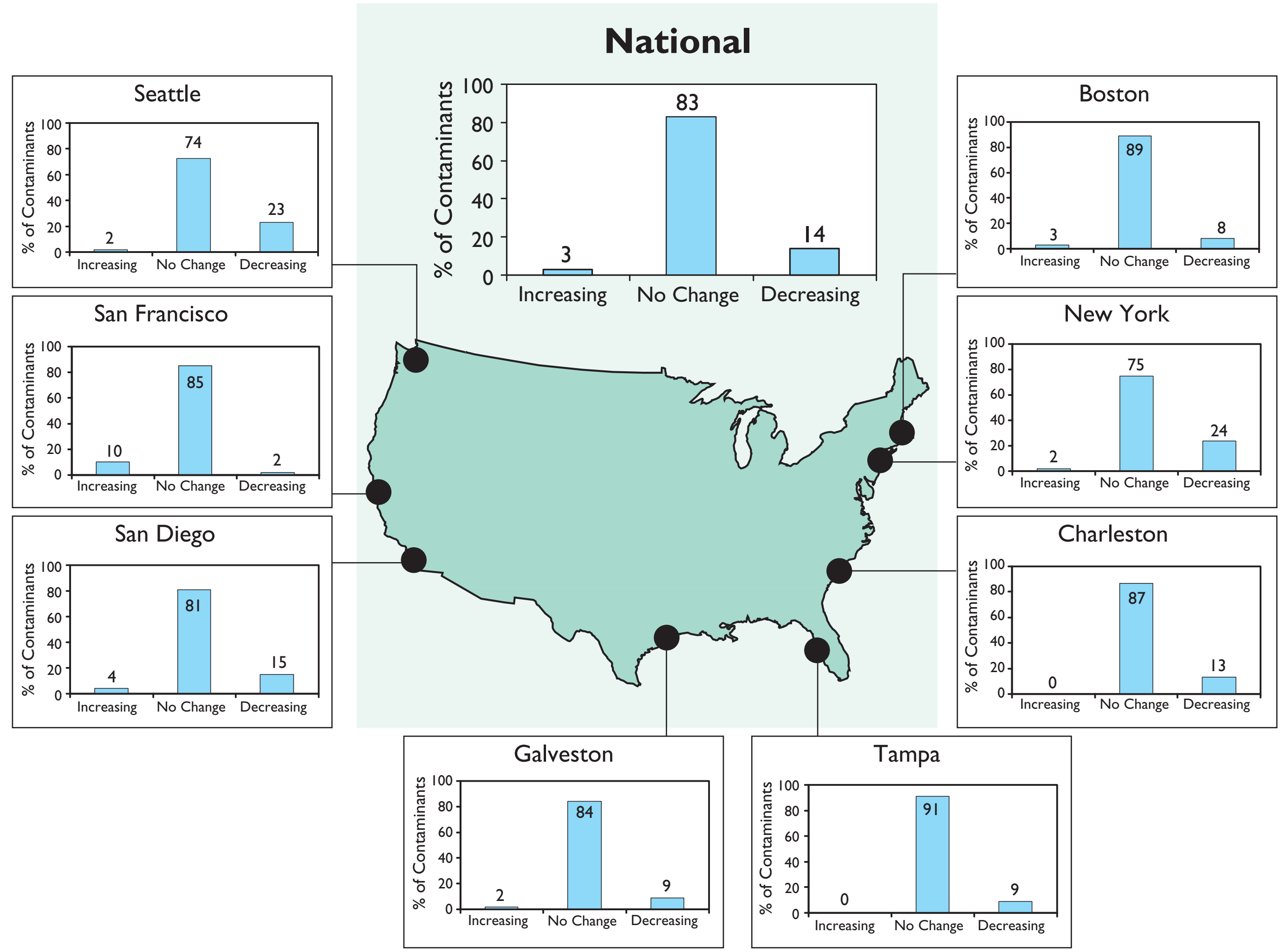
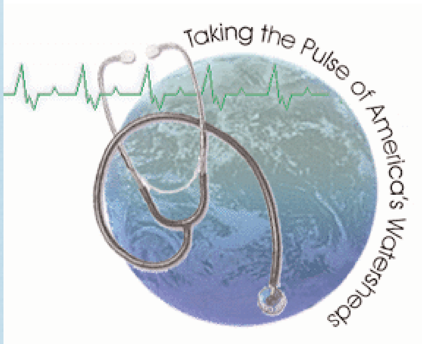


Figure 2-11. Trends in the bioaccumulation of contaminants in shellfish (NOAA/NOS).

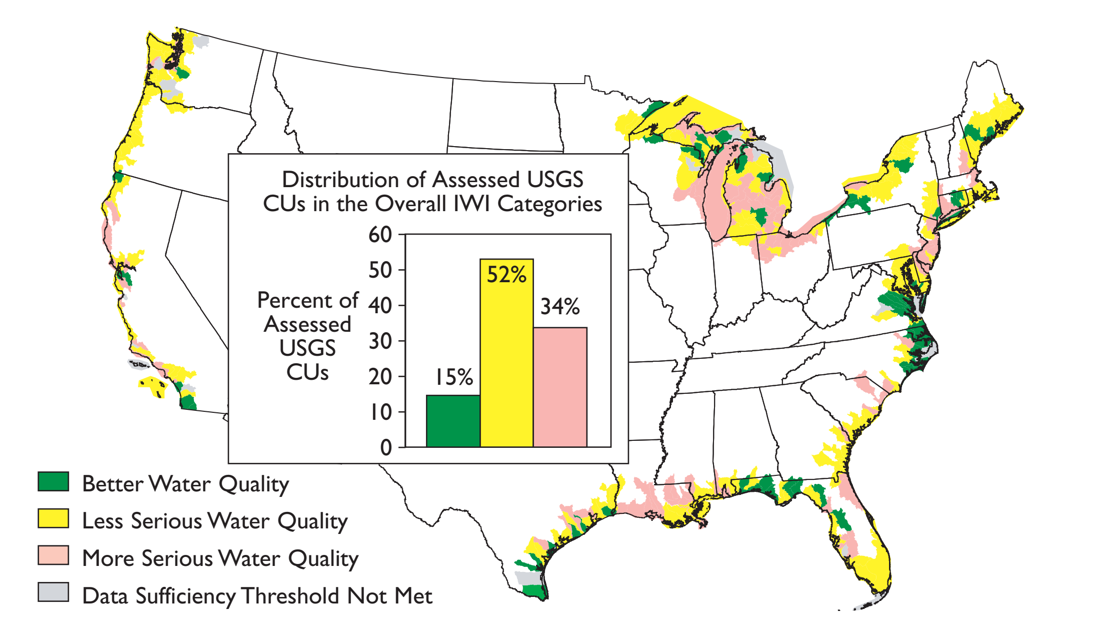
Index of Watershed Indicators



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

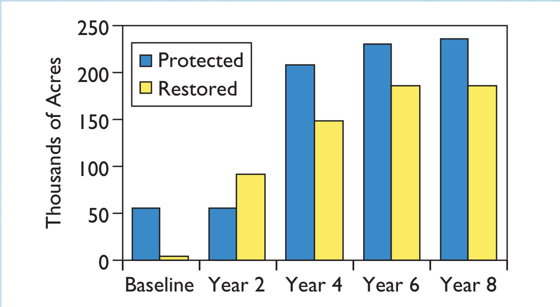
U.S. Department of Defense
- U.S. Army Corps of Engineers
- Defense Environmental Restoration Program

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.

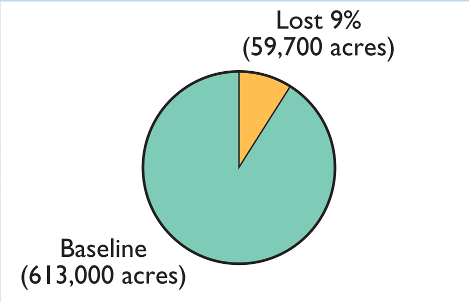
The National Oceanic and Atmospheric Administration Damage Assessment Restoration Program rehabilitates coastal habitat damaged by oil or other hazardous material spills. This program has rehabilitated 26 sites nationwide, including Prince William Sound in Alaska. The EPA's National Estuary Program has 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).

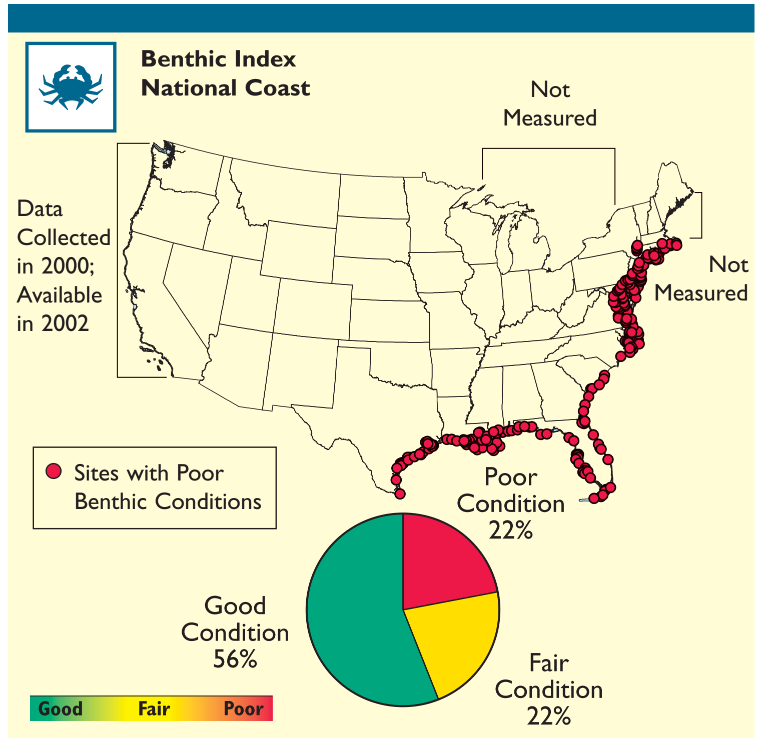


Figure 2-12. Benthic index condition data and locations with poor benthos (U.S. EPA/EMAP).

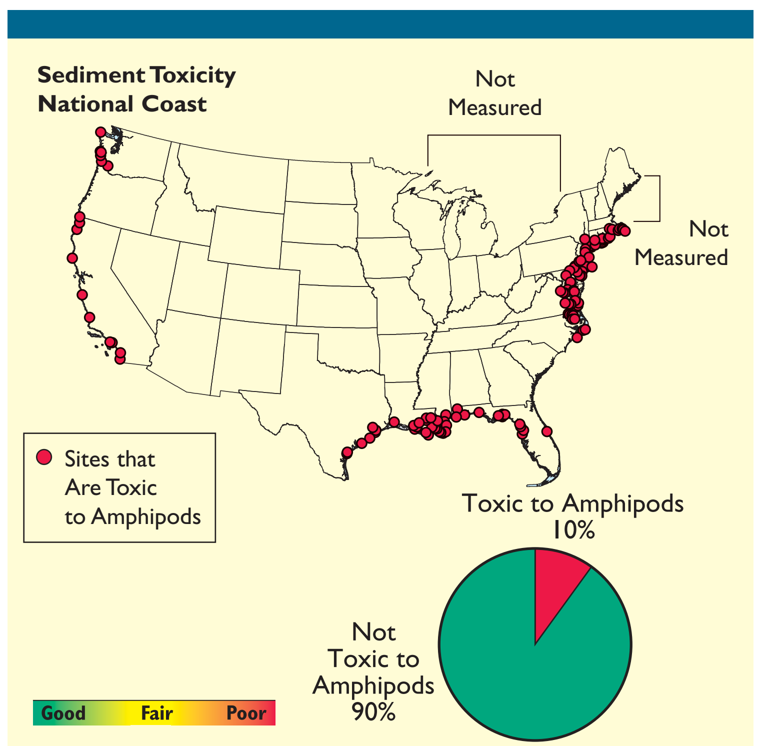


Figure 2-13. Amphipod data and locations of sites with toxic sediments (U.S. EPA/EMAP).

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.

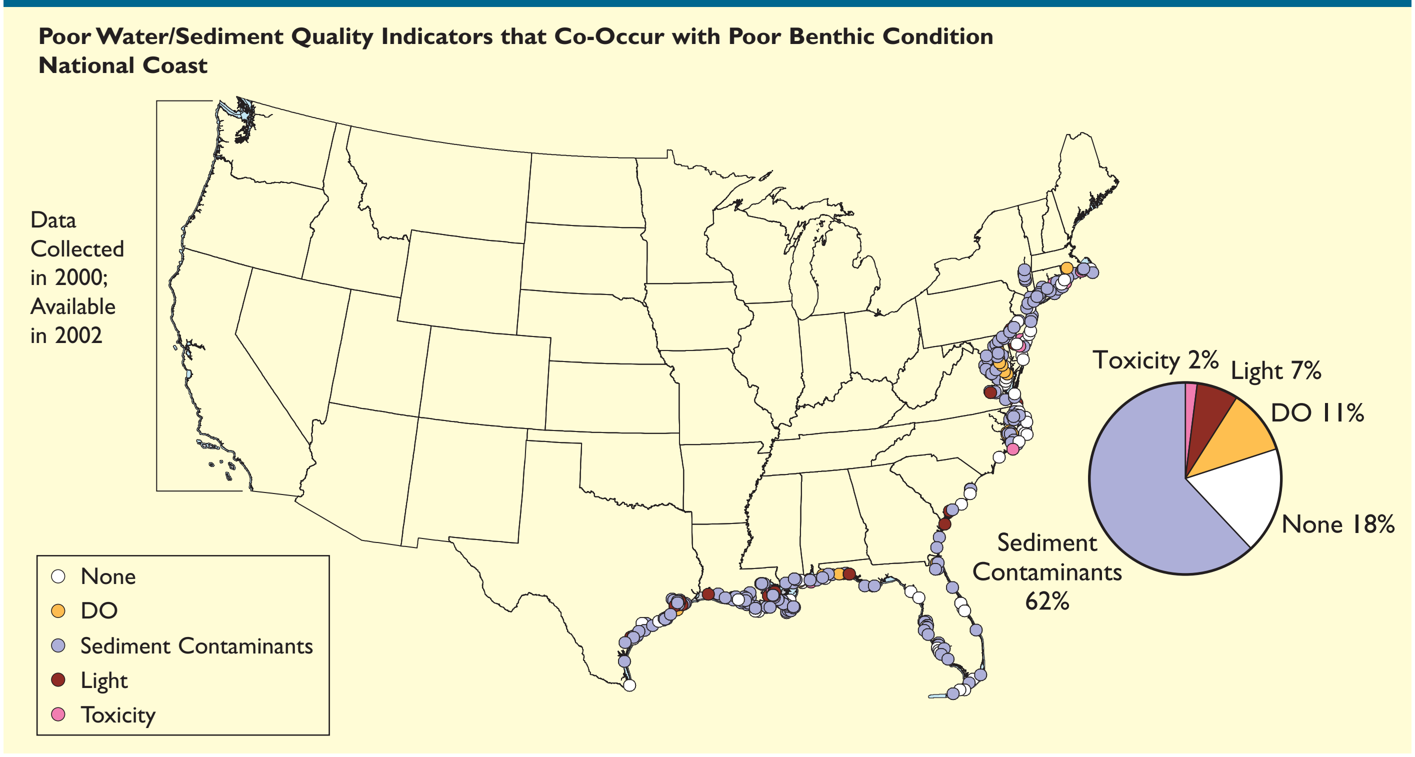
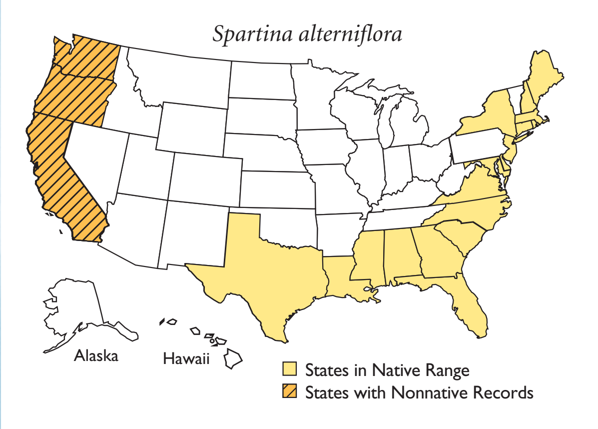


Figure 2-14. Indicators of poor water/sediment quality that co-occur with poor benthic condition in U.S. estuaries (U.S. EPA/EMAP).

highlight

Exotic Species in Coastal Environments

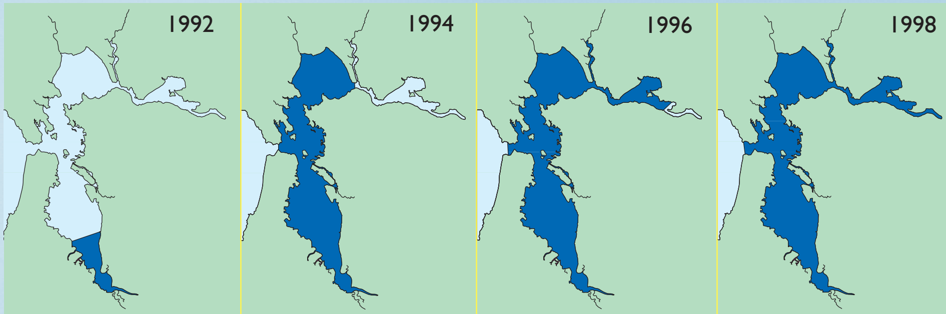
Scientists believe the spread of exotic species is one of the five most critical issues facing marine environments (Wilcove et al., 1998). Exotic species, also called nonindigenous, nuisance, or invasive species, or biotic invaders, are "species that establish a new range in which they proliferate, spread,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

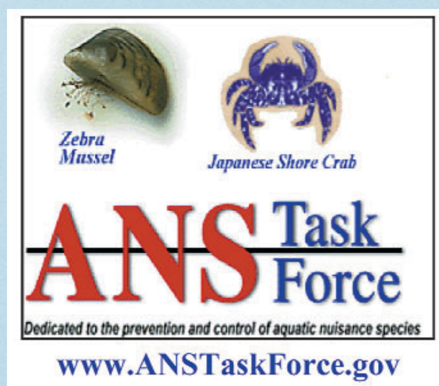
Over the past decade, an increasing number of nonindigenous aquatic fauna like the zebra mussel, Asian clam, Japanese shore crab, Chinese mitten crab, European green crab, and Asian green mussel; plant species such as *Spartina alterniflora*, purple loosestrife, Brazilian pepper, and Australian paperbark 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.

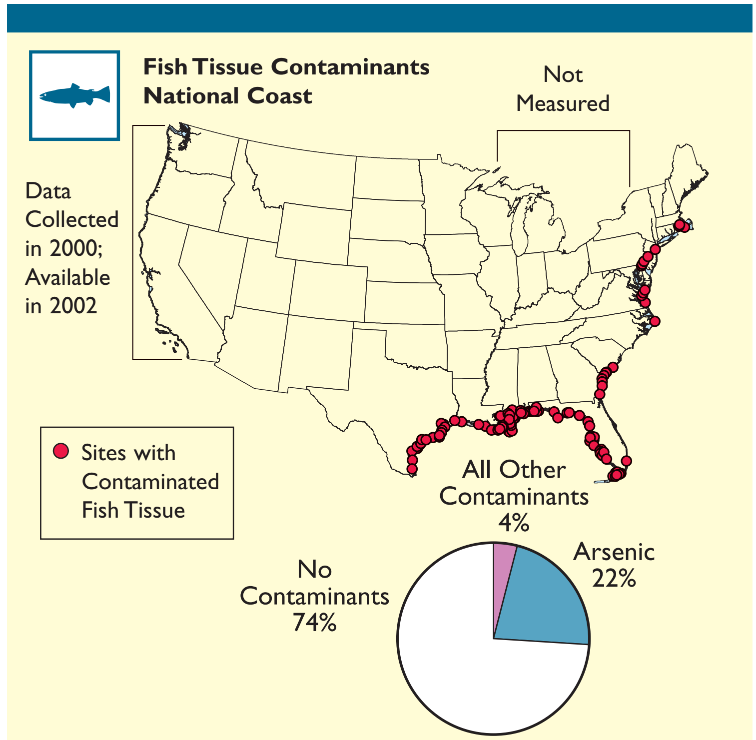


Figure 2-15. Contaminants in edible fish tissue (U.S. EPA/EMAP).

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).

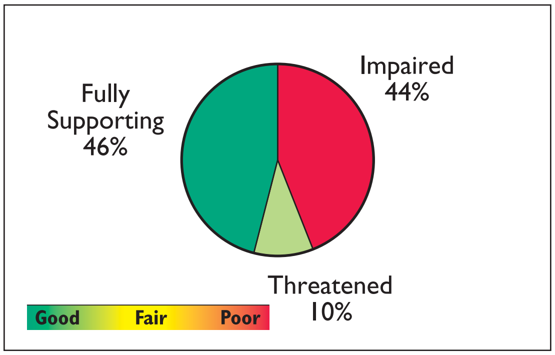


Figure 2-16. Water quality in assessed estuaries (U.S. EPA).

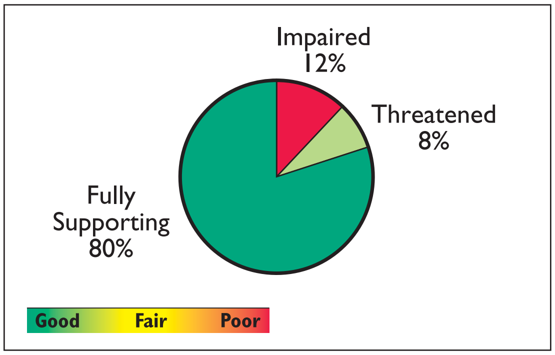


Figure 2-17. Water quality in assessed shoreline waters (U.S. EPA).

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.

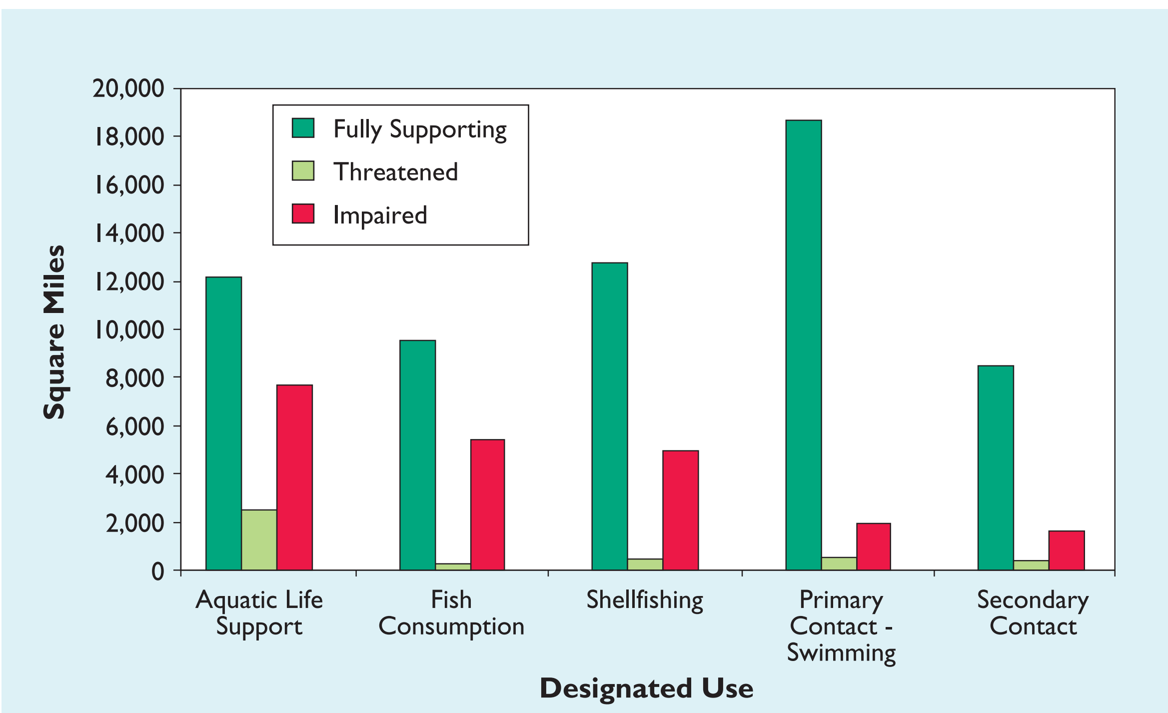


Figure 2-18. Individual use support for assessed estuarine waters (U.S. EPA).

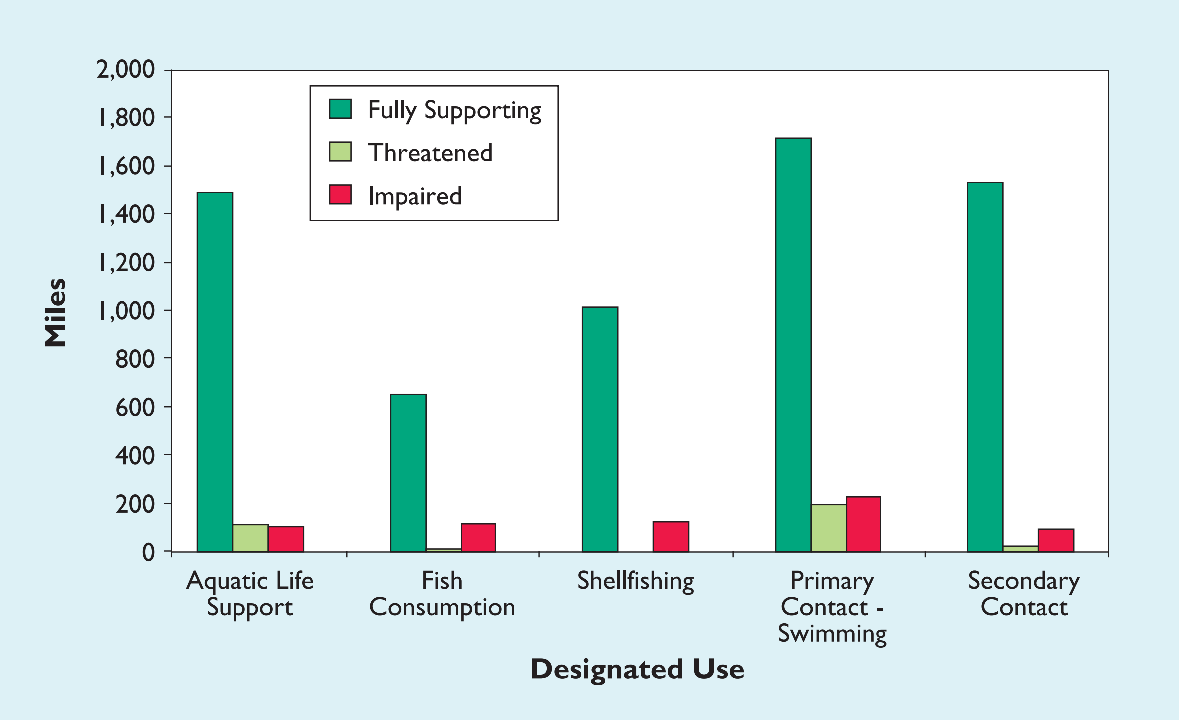


Figure 2-19. Individual use support for assessed coastal shoreline waters (U.S. EPA).

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

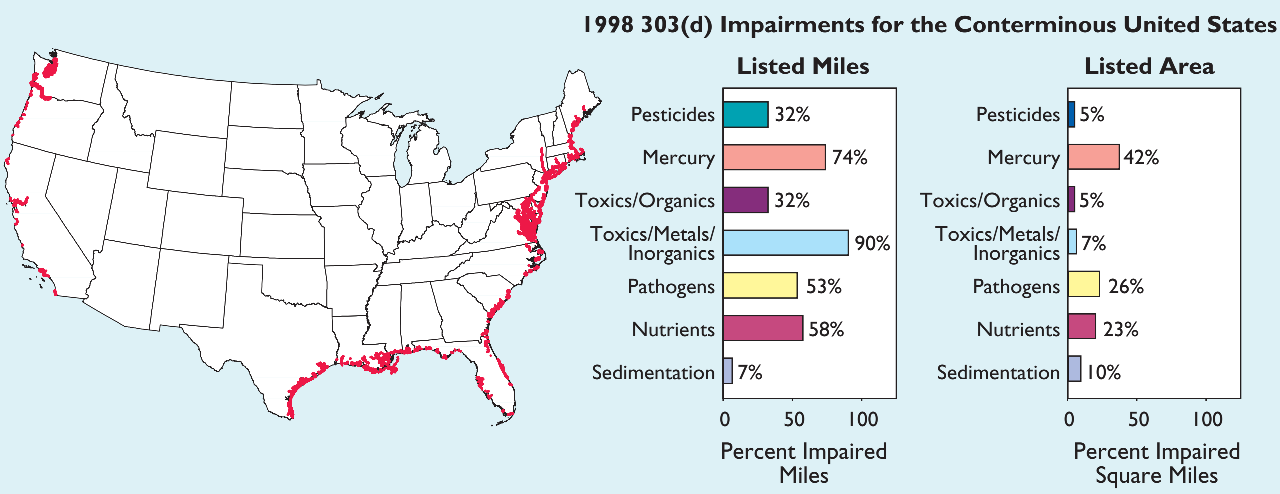
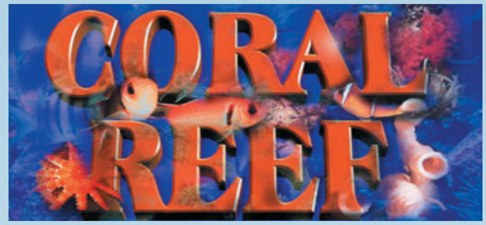


Figure 2-20. 1998 coastal 303(d) listed waters and the distance/area impaired by the top pollutants (U.S. EPA).



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

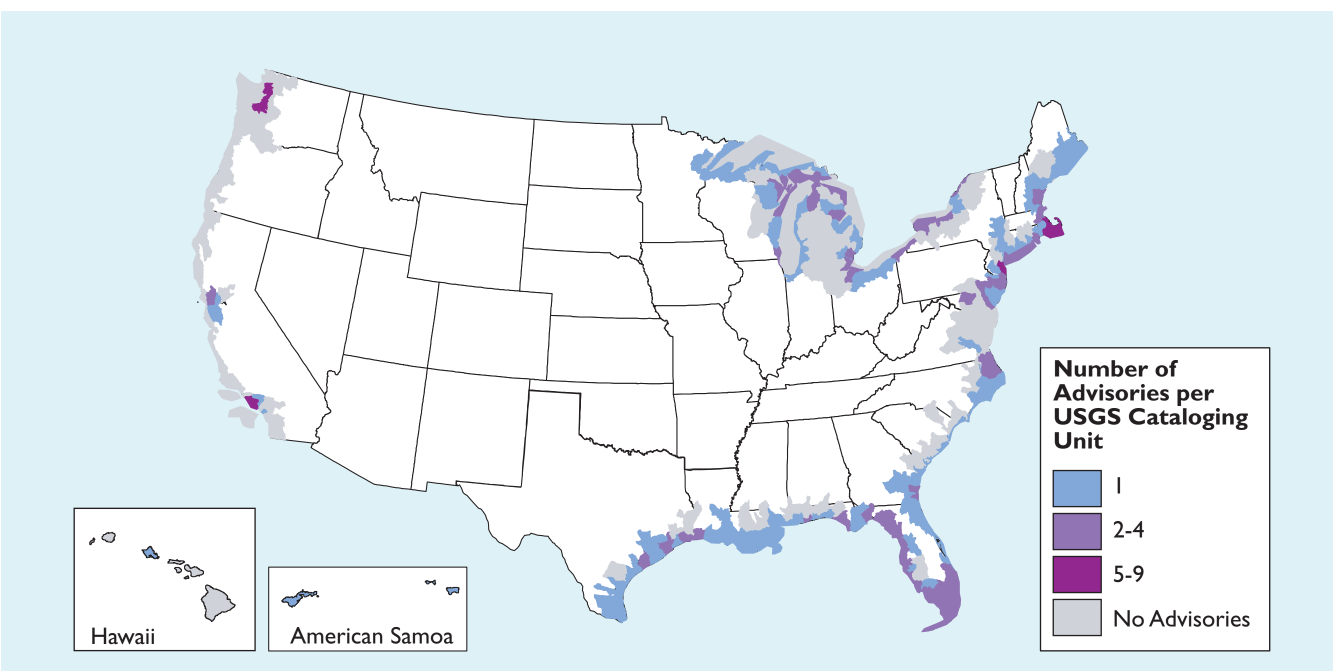


Figure 2-21. The number of coastal and estuarine fish consumption advisories per USGS cataloging unit. The count does not include advisories that may exist for noncoastal or nonestuarine waters. Alaska did not report advisories (U.S. EPA NLFWA, 2000c).

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

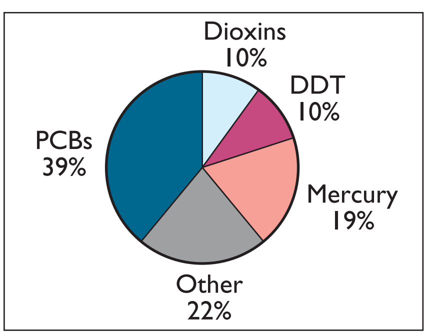


Figure 2-22. Percentage of estuarine and coastal marine advisories issued for each contaminant (U.S. EPA NLFWA, 2000c).

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.

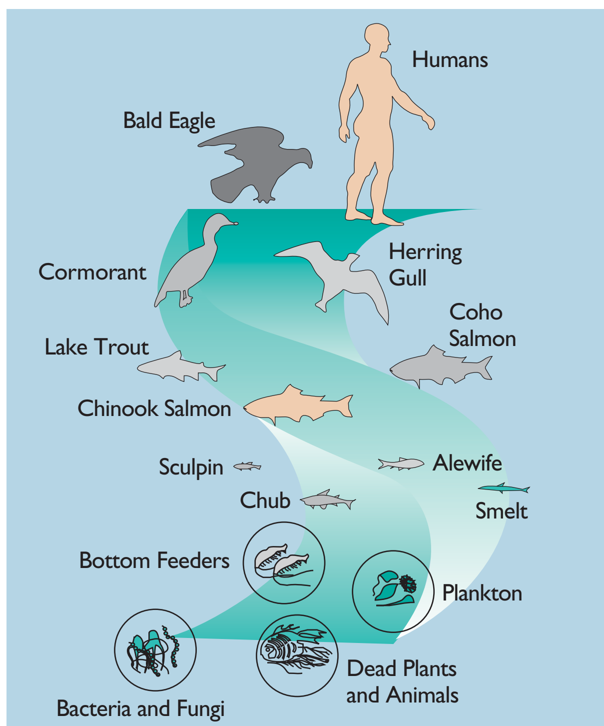


Figure 2-23. Bioaccumulation (U.S. EPA).

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).

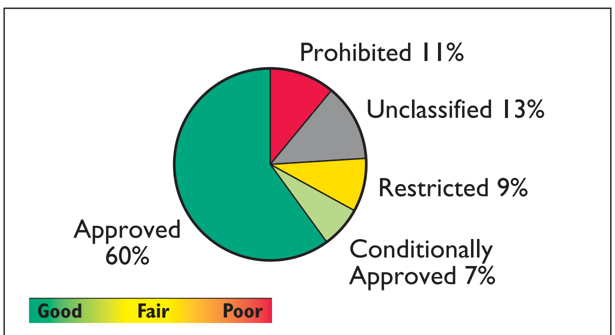


Figure 2-24. Classification of shellfish-growing waters (1995 Shellfish Register, NOAA, 1997).

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).

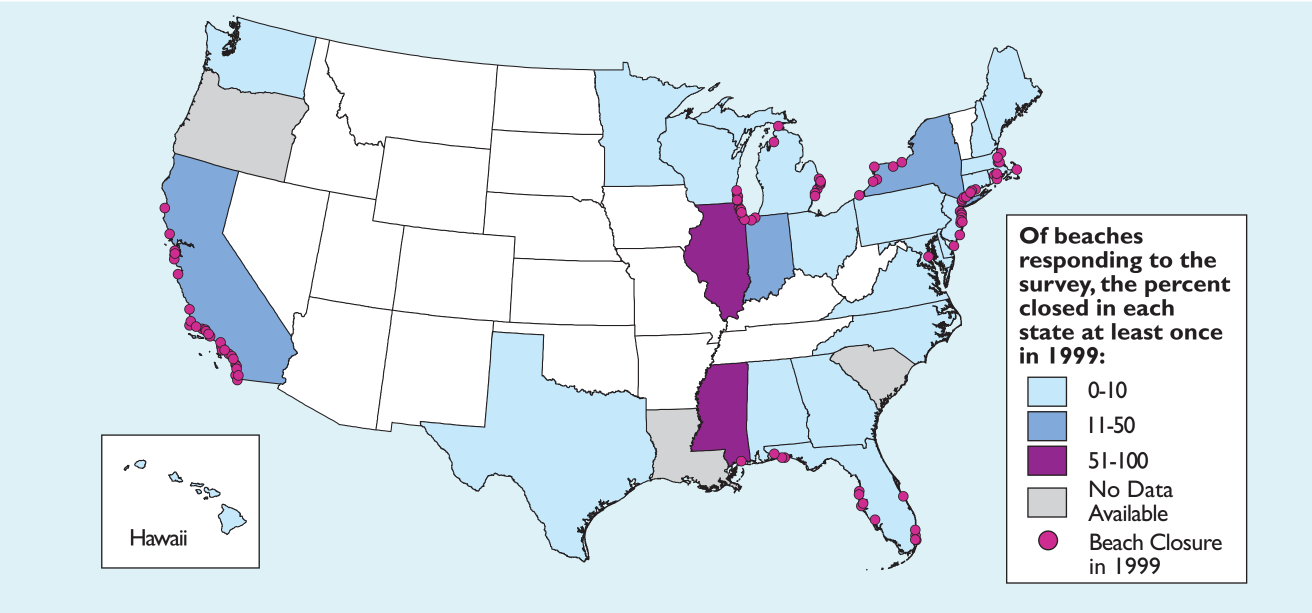


Figure 2-25. The percentage of beaches responding to the survey that closed at least once in 1999. Percentages are based on the number of beaches in each state that reported information, not the total number of beaches. There were no BEACH Watch Survey responses from Alaska (U.S. EPA).

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.

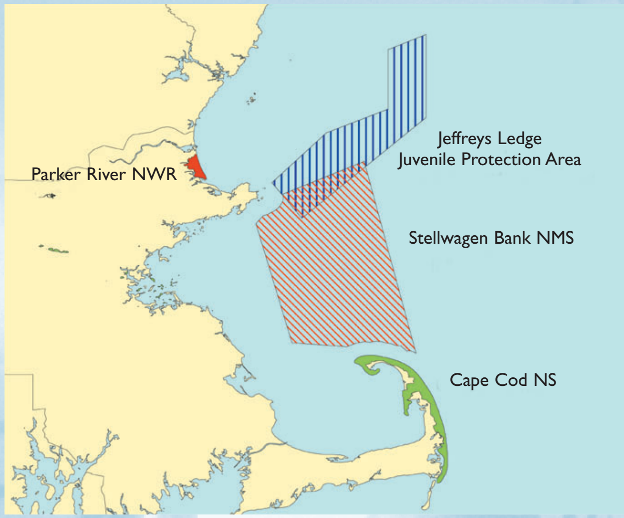
The issue of freshwater inflow is so important that several federal programs, including EPA's National Estuary Program (NEP), consider freshwater inflow a priority problem that must be addressed. According to a survey of directors from the 28 NEPs conducted in the fall of 1999, the Albemarle-Pamlico 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.

Developing a Nationwide Strategy for Marine Protected Areas



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.

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.

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.

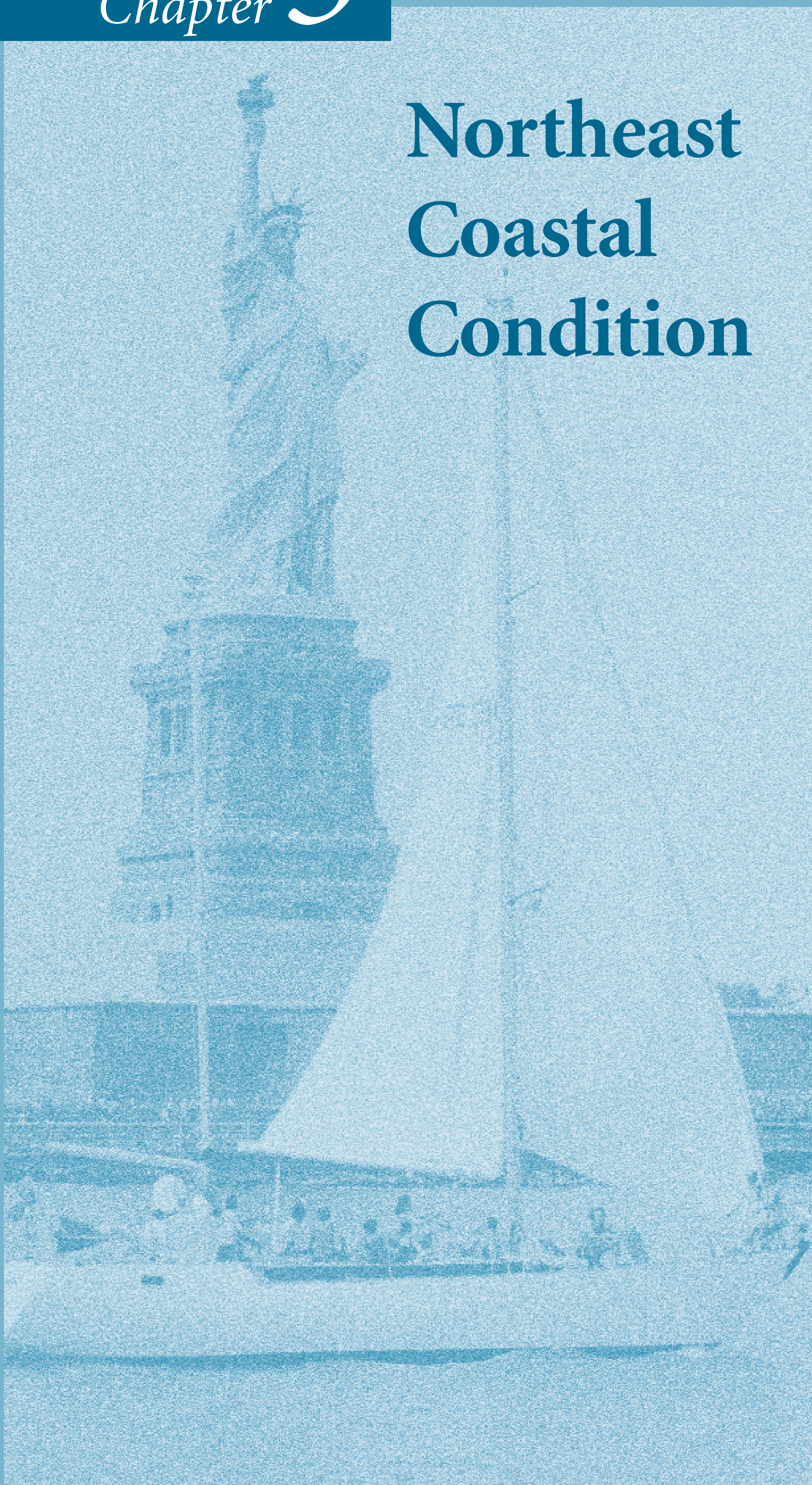
The order outlines actions to be taken by federal agencies to improve the management of MPAs (see sidebar). Federal agencies will work with an Advisory Committee composed of nonfederal scientists, resource managers, and other interested persons and organizations and will establish a National MPA Center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

Chapter 3

Northeast Coastal Condition



Chapter 3

Northeast Coastal Condition

Ecological conditions

in northeastern estuaries are borderline poor (Figure 3-1). EMAP data were collected in the Virginian province from 1990 to 1993. Over half of the area surveyed (57%) showed undegraded ecological conditions (Figure 3-2). However, 23% of the sediments were characterized by degraded biology, and 30% of the estuarine area had impaired human uses. These areas were widespread but were especially common in the Chesapeake Bay (and its tributaries), the Delaware River, the Hudson River, and western Long Island Sound.

Northeastern coastal areas represent an extremely important commercial, population, and tourism center for the United States. The population of coastal counties on the Northeast Coast increased 52% between 1970 and 1990 (U.S. Bureau of the Census, 1996). Northeastern coasts are also a critical ecological habitat for many important species of fish and migratory birds. This area includes two biogeographic provinces: the Virginian and the Acadian. The Virginian biogeographic province extends from Cape Henry, Virginia, at the mouth of the Chesapeake Bay to Cape Cod, Massachusetts. The Acadian province reaches from Cape Cod to

Figure 3-1. The overall condition of northeastern estuaries is borderline poor.

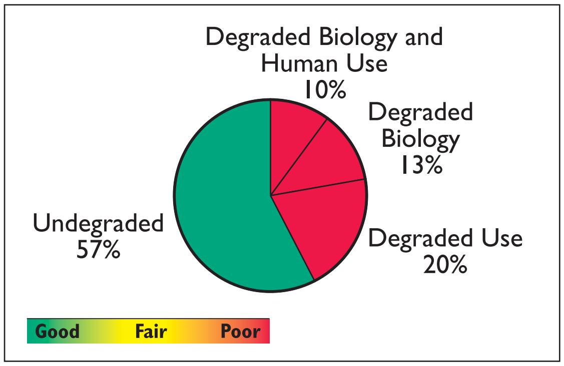


Figure 3-2. The condition of estuaries on the Northeast Coast (U.S. EPA/EMAP).

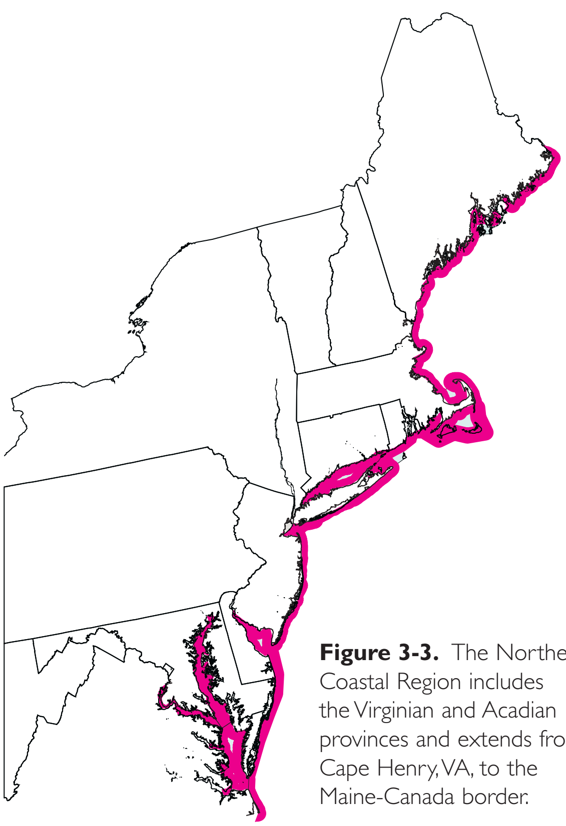


Figure 3-3. The Northeast Coastal Region includes the Virginian and Acadian provinces and extends from Cape Henry, VA, to the Maine-Canada border.

the Maine-Canada border (Figure 3-3). Coastal monitoring data exist for the northeastern United States from EMAP, NOAA's NS&T Program, and NOAA's National Estuarine Eutrophication Assessment. EMAP data are available for the Virginian biogeographic province, and NOAA's programs cover the Virginian province and the Acadian province to the U.S.-Canada border. Coastal 2000 monitoring information will be available for the Acadian province in 2002.

The Virginian province contains more than 9,073 mi^2 of estuarine area. Approximately 70% of estuarine surface area is in 12 large (>100 mi^2) estuaries, including 4,427 mi^2 in Chesapeake Bay, 1,291 mi^2 in Long Island Sound, and 795 mi^2 in Delaware Bay. A number of large urban and industrial centers (e.g., New York City, Philadelphia, and Baltimore) are close to the coast. In the Virginian province, coastal areas are densely populated, ranging from over 250 people per square mile in Delaware to almost 1,500 people per square mile in New York and Pennsylvania (Culliton et al., 1990). Coastline areas in the Virginian province are used extensively for industrial developments, port facilities, residential and commercial establishments, and recreational activities.

The Acadian province extends along the Northeast Atlantic Coast from the Avalon Peninsula at the Canadian border to Cape Cod and is characterized by well-developed algal and biotic communities. The shoreline is heavily indented and frequently rocky. This region is not as densely populated as the Virginian province, but it does contain several population centers such as Portland, Maine, and Boston, Massachusetts. Some coastal counties of Massachusetts and New Hampshire have almost 1,300 people per square mile, and populations are projected to grow as much as 25% by 2015 (Culliton et al., 1990). Although no EMAP data exist for this biogeographic province, the NOAA National Estuarine Eutrophication Assessment examined the trophic state of 18 estuaries encompassing approximately 2,008 mi^2 in this region.

Coastal Monitoring Data

Water Clarity

Water clarity for the Northeast received a rating of good. EMAP data show degraded water clarity (less than 10% light penetration to 1 meter depth) in 6% of estuarine waters in the Virginian province and reduced water clarity (less than 25% light penetration to 1 meter depth) in 21% of estuarine waters in this region (Figure 3-4).

Water clarity can affect ecosystem health in coastal and estuarine habitats. Submerged aquatic vegetation (SAV) requires sunlight for photosynthesis and is particularly sensitive to reductions in water clarity. SAV provides habitat for a number of estuarine and near-shore species—especially for juvenile fish—and is thus critical for maintaining the ecological integrity of these systems. Loss of SAV was reported in 12 of the 22 estuaries surveyed in NOAA's National Estuarine Eutrophication Assessment. Severe loss of SAV is occurring in the main stem Chesapeake Bay, Patuxent River, Choptank River, Tangier/Pocomoke Sounds, and Gardiners Bay. Degraded water clarity was found in tributaries to the Chesapeake Bay, the Delaware River, western Long Island Sound, and the Hudson River.

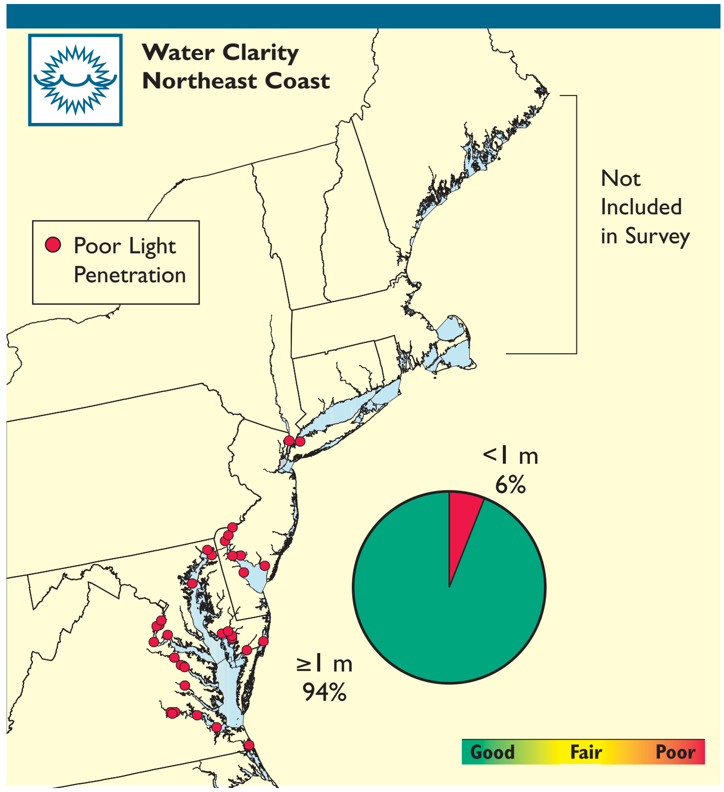


Figure 3-4. Light penetration data and locations for sites with <10% light penetration along the Northeast Coast (U.S. EPA/EMAP).

Dissolved Oxygen

Overall, levels of dissolved oxygen in Northeast estuaries are fair. EMAP studies found fair oxygen conditions (between 2.0 and 5.0 ppm O_2) in 20% of the bottom waters sampled and poor levels of dissolved oxygen (less than 2.0 ppm O_2) in 5% of bottom waters (Figure 3-5). Severe oxygen deficiencies occurred primarily within main stem Chesapeake Bay and the Potomac River, with isolated occurrences in the Rappahannock River (Virginia), western Long Island Sound, and the waters near Providence, Rhode Island.

Coastal Wetland Loss

Wetland losses in the Northeast are high—nearly 40% of all wetlands existing in 1780 disappeared by 1980 (Figure 3-6). Losses ranged from 9% in New Hampshire to nearly 75% in Connecticut and Maryland (Dahl, 1990).

Eutrophic Condition

Estuaries in the Northeast are in poor condition according to measures of eutrophic condition. Eutrophic conditions are high in 60% of the estuarine area (Figure 3-7), including Chesapeake Bay and its tributaries, Delaware Inland Bays, Barnegat Bay, Great South Bay, Boston Harbor, Narraguagus Bay, Casco Bay, Sheepscot Bay, Englishman Bay, Cobscook Bay, and the St. Croix River.

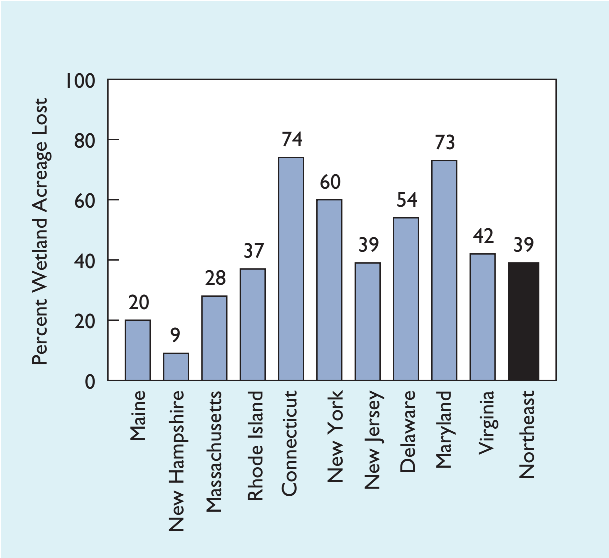


Figure 3-6. Percent wetland habitat lost from 1780 to 1980 by state and for the Northeast Coast overall (Dahl, 1990; Turner and Boesch, 1988).

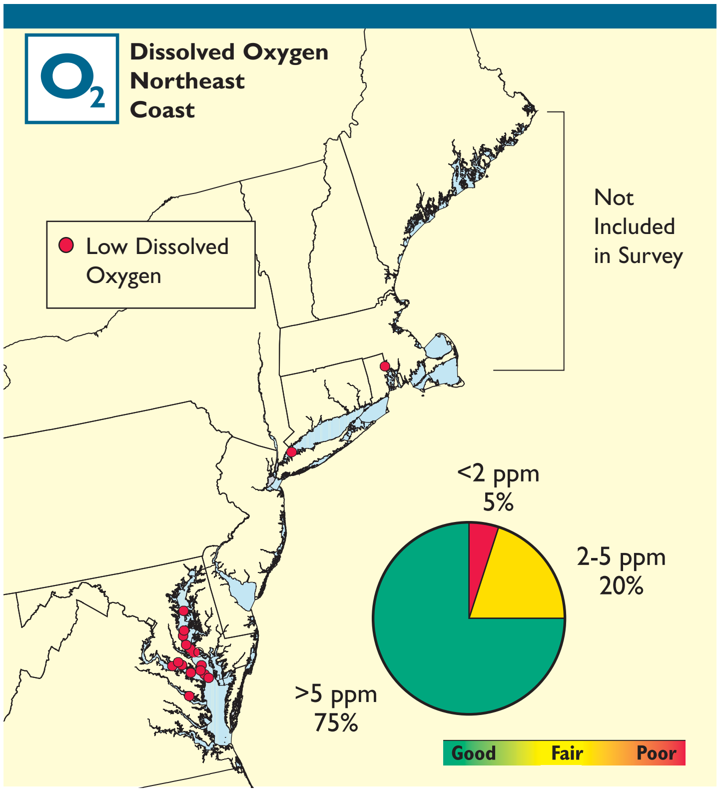


Figure 3-5. Dissolved oxygen data for sampled sites and locations for sites with less than 2 ppm for the Northeast Coast (U.S. EPA/EMAP).

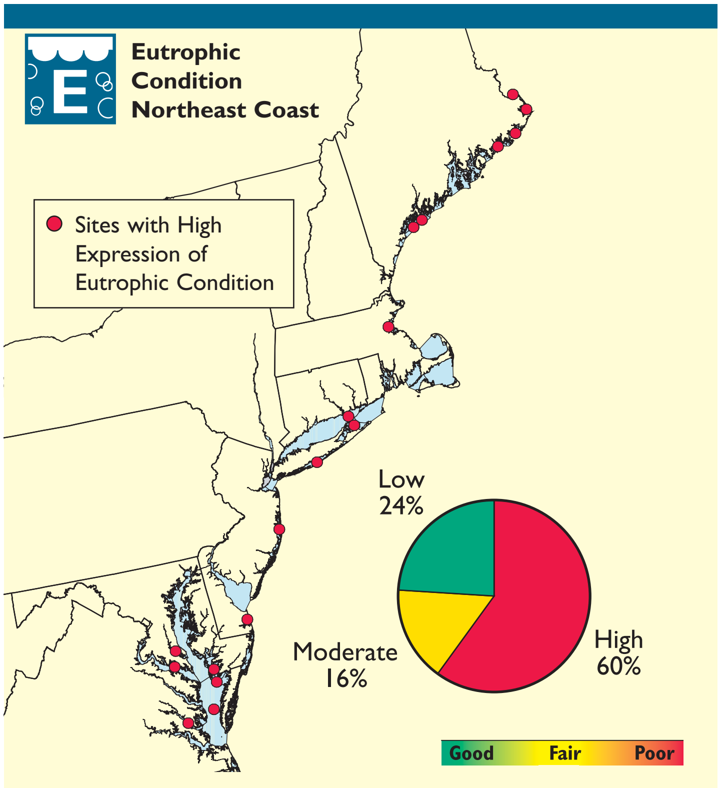


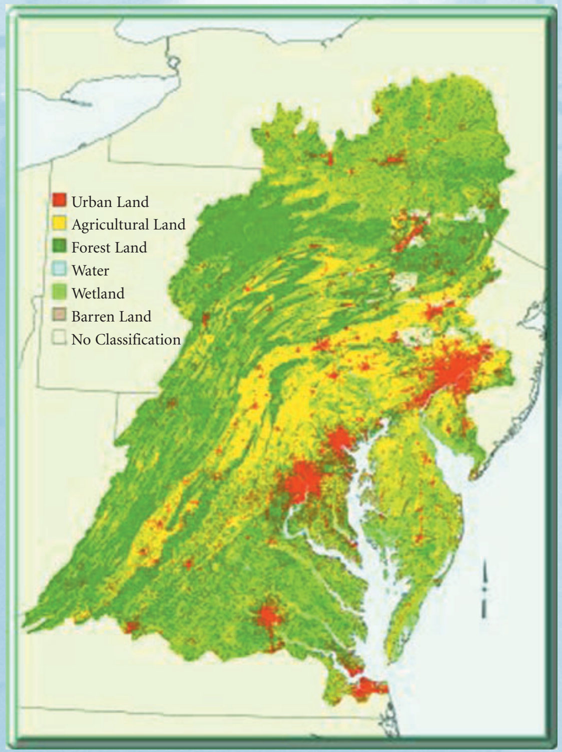
Figure 3-7. Eutrophic condition data and locations of estuaries with high expression of eutrophic condition along the Northeast Coast (NOAA/NOS).

highlight

Water Quality of the Near Coastal Mid-Atlantic Waters

The near coastal waters of the Mid-Atlantic are significantly affected by discharges from three major coastal systems—the Hudson, the Delaware, and the Chesapeake. The Delmarva Peninsula is uniquely positioned between two of these major systems, where it serves as a major zone of influence on the near coastal water quality conditions of the Mid-Atlantic. As in most coastal areas, a wide range of point and nonpoint sources contribute nutrient enrichment to the marine waters of the Mid-Atlantic. Changes over time in coastal waters are likely to be related to activities in the contributing watersheds. Population growth, development, and changes in land use patterns (see figure) can all have consequences on the condition of coastal waters.

An 18-year study on the state of the Mid-Atlantic near-shore coastal waters, summarized in a forthcoming report from EPA, showed that, although phosphorus levels were declining, the levels of dissolved inorganic nitrogen (DIN) in the area revealed significant increases in the range of 7% to 35% per year. Over the 10-year period from 1982 to 1992, DIN increased significantly in the Mid-Atlantic Bight overall, which implies that biological productivity in the area may be affected and perhaps lead to eutrophic conditions. The increasing DIN concentrations in the Mid-Atlantic Bight are cause for some concern because the situation may eventually threaten both the economic and aesthetic value of the region.



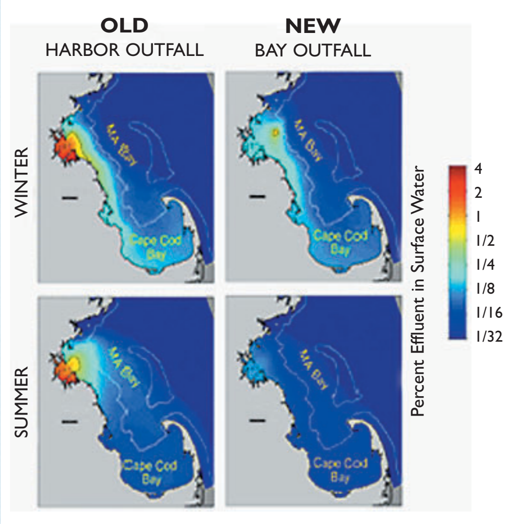
Land cover of the Mid-Atlantic region (U.S. EPA).

Massachusetts Bay

Boston Harbor, once one of the most polluted waterways in the nation, is in the final stages of a major cleanup. For 300 years, the harbor was the waste disposal site for a growing metropolitan center. By the 1980s, harbor fish were diseased, shellfish beds were closed, and swimming beaches were periodically unsafe. A $3.8 billion cleanup program, begun by the Massachusetts Water Resources Authority (MWRA), has significantly improved the environmental quality of the harbor. Since 1989, the U.S. Geological Survey (USGS) has been conducting research to understand and predict the fate of contaminants introduced to Massachusetts' coastal waters.

Earth Science Applied to Public Concerns

Relocating the sewage outfall from the harbor mouth to a new location 9 miles offshore in Massachusetts Bay was a controversial step in the cleanup program. Stellwagen Bank National Marine Sanctuary, which supports commercial and recreational fisheries and is home to endangered species of whales, sea turtles, and birds, is within 15 miles of the new sewage outfall. Concern that the new sewage outfall might threaten the environmental quality of the Bay prompted a series of computer simulations by the USGS. The simulations of effluent dilution indicated that the effluent concentrations from the new outfall would remain low throughout most of Massachusetts Bay (see figure).



Computer simulations of effluent dilution from old and new outfalls (USGS).

What Is the Future of Contaminants?

Understanding this coastal system and conducting long-term monitoring are essential in order to assess environmental change. Despite cleaner waters, pollutants that settle to the bottom with sediments can accumulate in the ecosystem, creating the potential for long-term problems. USGS studies in Boston Harbor and Massachusetts Bay are designed to provide an understanding of how sediments and associated contaminants are transported and where they accumulate in the Massachusetts Bay system. The results of these ongoing studies and maps and simulations can be accessed on the Internet at http://geology.wr.usgs.gov/wgmt/bostonharbor/boston.html. Additional information about coastal systems in the Northeast can be accessed on the Internet at http://woodshole.er.usgs.gov.

NOAA's National Estuarine Eutrophication Assessment divides estuaries of the Northeast into two distinct zones: the North Atlantic and Mid-Atlantic. This division follows the division between the Acadian and Virginian biogeographic provinces with estuaries of the North Atlantic including all estuaries from Cape Cod, Massachusetts, to Cobscook Bay, Maine, near the U.S.-Canada border. The Mid-Atlantic region includes estuaries from Buzzards Bay, Massachusetts, to Tangier and Pocomoke Sounds near the mouth of Chesapeake Bay. Many northeastern estuaries exhibit eutrophic conditions. Of the 52 estuaries constituting the Northeast in the NOAA assessment, 16 (58% of estuarine area) exhibited elevated levels of chlorophyll *a* (Figure 3-8). However, in the far Northeast (Acadian province), these conditions are believed to be a natural occurrence with human inputs being only a minor contribution. Human impact is believed to be high in Boston Harbor and Plum Island Sound.

Eutrophic condition in Mid-Atlantic estuaries tells a very different story. Human impacts are believed to be high in 16 of the 22 estuaries assessed. Nearly half of the estuaries displayed high levels of eutrophication, and all estuaries showed at least some symptoms of eutrophication. Every estuary reported at least moderate expression of elevated chlorophyll *a* concentrations and all estuaries reported some problems with low oxygen. Thirteen of the estuaries experienced nuisance algae blooms with severe problems in Barnegat Bay, Delaware Inland Bays, and the Patuxent River. The Choptank River, Tangier/Pocomoke Sounds, and Long Island Sound showed some expression of all six symptoms assessed in NOAA's study.

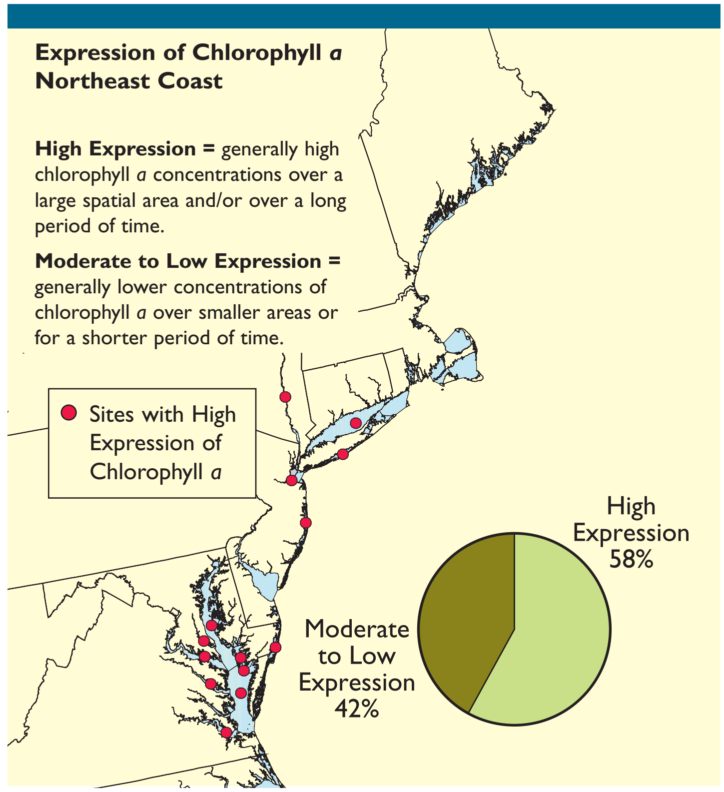


Figure 3-8. Chlorophyll *a* data for surveyed estuaries along the Northeast Coast and locations of estuaries with high expression of chlorophyll *a* (NOAA/NOS).

Sediment Contaminants

Sediment contaminant conditions in Northeast estuaries are poor. Sediments collected in EMAP sampling were analyzed for pesticides, metals, PCBs, and PAHs. For metals, ERM was exceeded in 4% of the area of estuarine sediments and ERL was exceeded in 41% of the area of estuarine sediments (Figure 3-9). This translates into more than 3,668 mi^2 of sediments within the Virginian province with metals at concentrations high enough to cause effects in 10% of animals exposed. PCBs and PAHs exceeded ERM in 3% of the sediments of northeastern estuaries and exceeded ERL in 27% of these sediments. Sediment pesticide

Sediment Contaminant Criteria

ERM (Effects Range Medium) – The concentration of a contaminant that will result in ecological effects approximately 50% of the time based on literature studies.

ERL (Effects Range Low) – The concentration of a contaminant that will result in ecological effects about 10% of the time.

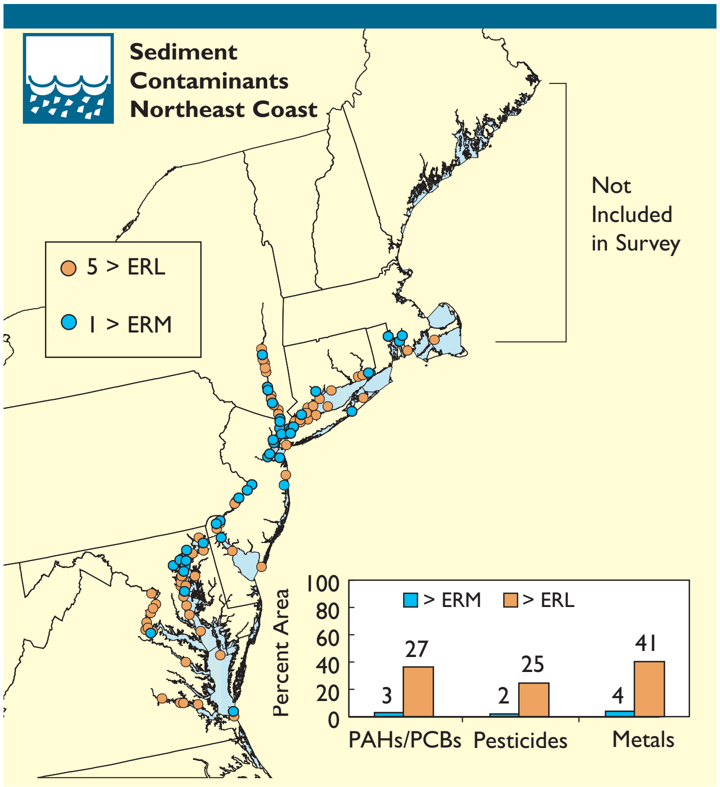


Figure 3-9. Sediment contamination for sampled sites and locations of sites with 5 > ERL or 1 > ERM along the Northeast Coast (U.S. EPA/EMAP).

concentrations exceeded ERM in 2% of the area of estuarine sediments and exceeded ERL in 25%. In other words, over 2,317 mi^2 of sediments within the Virginian province contained elevated concentrations of PCBs, PAHs, or pesticides that were high enough to cause biological effects. Sediments exceeding ERM levels occurred throughout the Northeast but tended to be concentrated at the head of the Chesapeake Bay, the lower Hudson River and western Long Island Sound, and the Delaware River. Multiple ERL exceedances occurred in these same areas but also included regions of the upper Potomac River, the James River, the mid-Chesapeake Bay, and the western half of Long Island Sound.

Benthic Condition

Benthic communities in northeastern estuaries are in poor condition (Figure 3-10). For the locations that showed poor benthic community quality, the co-occurrence of poor

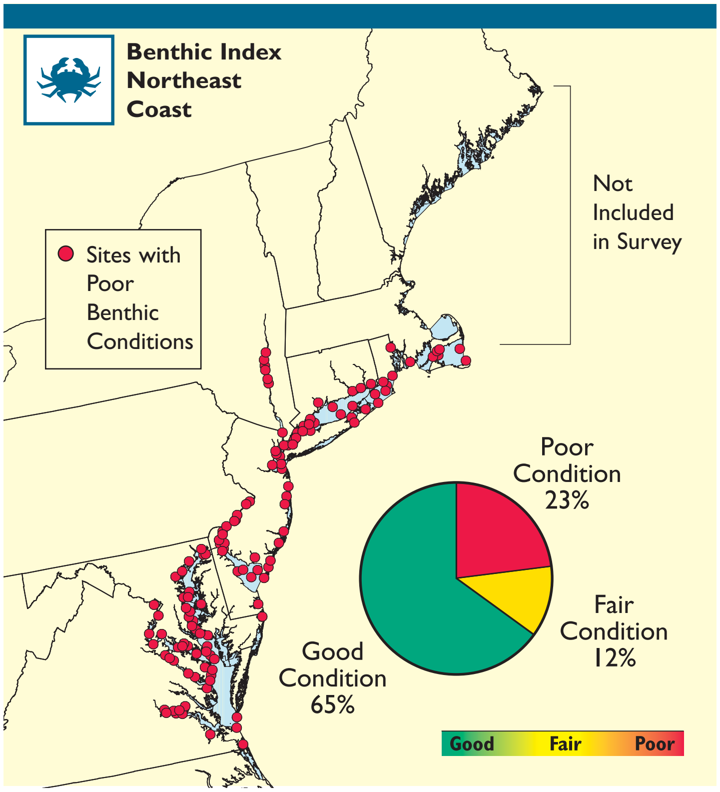


Figure 3-10. Benthic index condition data and locations with poor benthos along the Northeast Coast (U.S. EPA/EMAP).

environmental quality (exposure) is shown in Figure 3-11. Of the 23% of the northeastern estuarine area that had poor benthos, 21% also showed hypoxic conditions, 35% showed contaminated sediments, 9% showed sediment toxicity, and 2% showed poor light conditions (high levels of total suspended solids). One-third of the locations that showed poor benthic community conditions had no sediment or water quality degradation (as measured by the EMAP program), although several of these sites are suspected of having poor nutrient water quality. These locations were spread throughout the nine Mid-Atlantic states.

A bioassay for sediment toxicity showed less than 80% survival of *Ampelisca* in 9% of the area sampled throughout the region. Again, these stations tended to cluster in the Chesapeake Bay, Delaware River, Raritan Bay, and Long Island Sound. However, the highest incidence of sediment toxicity occurred in small estuaries, where 13% of sediments were toxic to the test organism (Figure 3-12). Severe toxicity (less than 60% survival) occurred in 2% of the estuary sediments assayed.

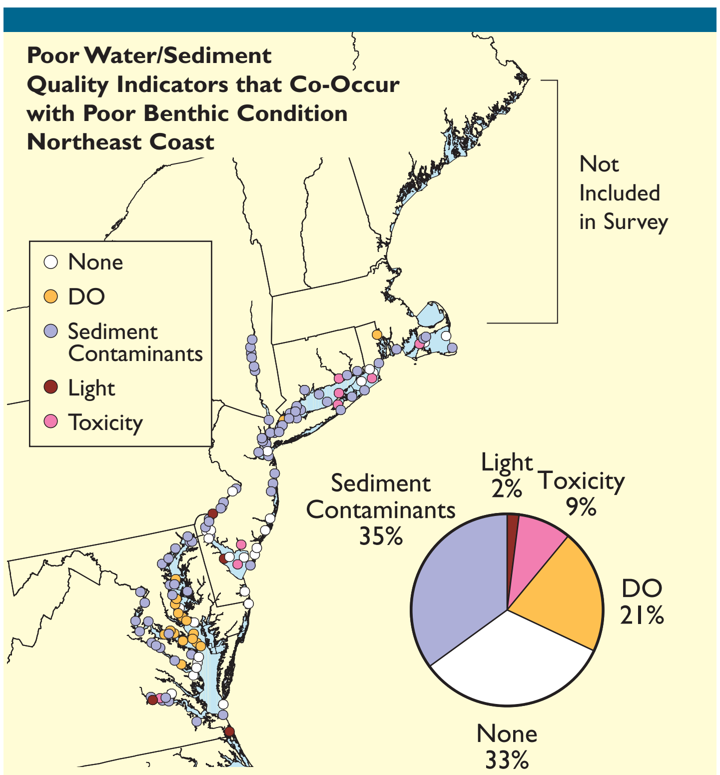


Figure 3-11. Indicators of poor water/sediment quality that co-occur with poor benthic condition in northeastern estuaries (U.S. EPA/EMAP).

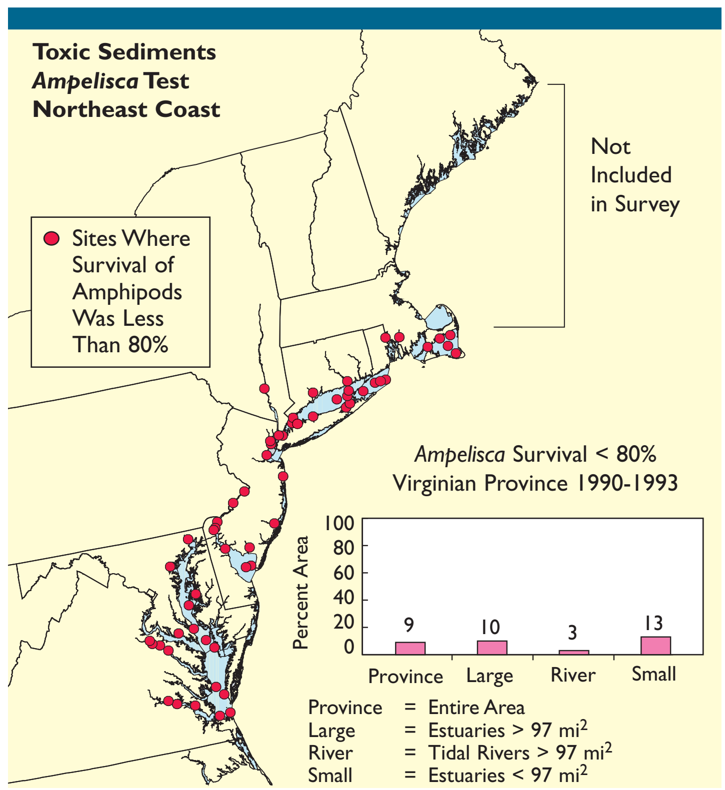


Figure 3-12. Amphipod data and locations with toxicity > 20% along the Northeast Coast (U.S. EPA/EMAP).

Fish Tissue Contaminants

Conditions of estuaries in the Northeast as measured by fish tissue contaminants are poor. Analyses for tissue residue contaminants in the edible portions of selected fish were conducted throughout the Virginian province. Toxic levels of contamination were detected in the filets of fish caught at four locations within the Delaware River, several locations in the mainstem of the Chesapeake Bay, and single sites in Raritan Bay, Narragansett Bay, and Buzzards Bay, amounting to about 30% of the fish examined (Figure 3-13). However, almost all of these elevated concentrations were for arsenic (21%) and almost all arsenic ingested by fish is converted to a nontoxic form (arsenobetaines). Thus, 9% of fish examined (white perch, weakfish, catfish, and Atlantic croaker) contained elevated levels of contaminants (primarily metals). Only 0.4% of over 13,000 fish examined showed signs of external pathologies.

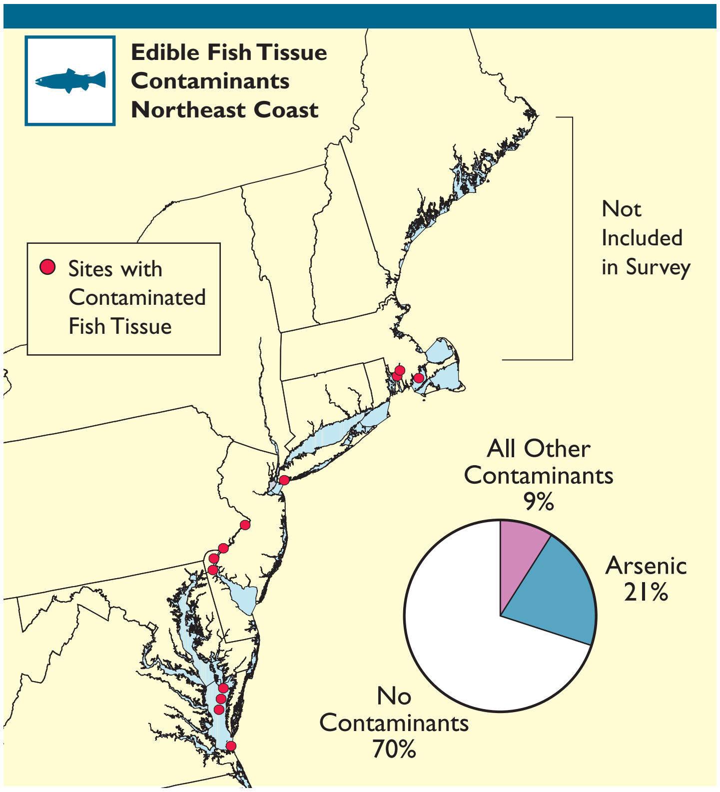
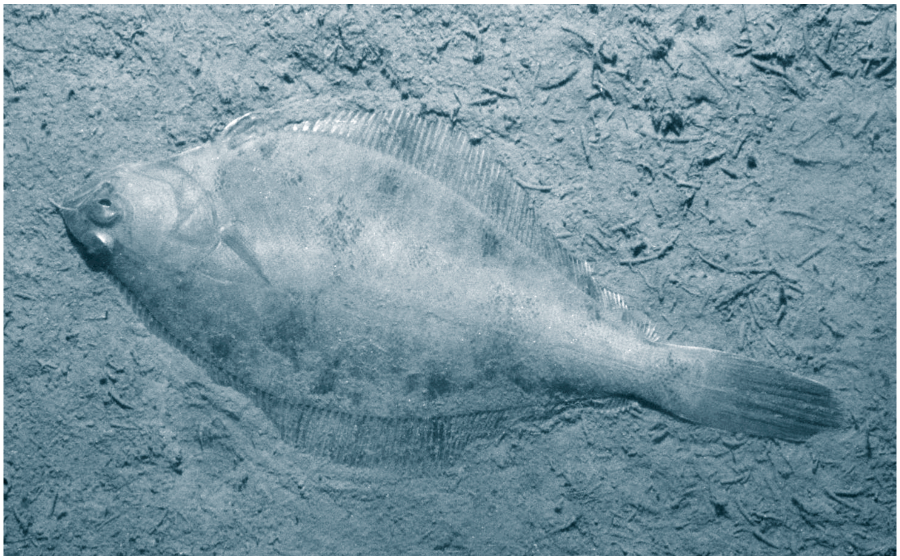
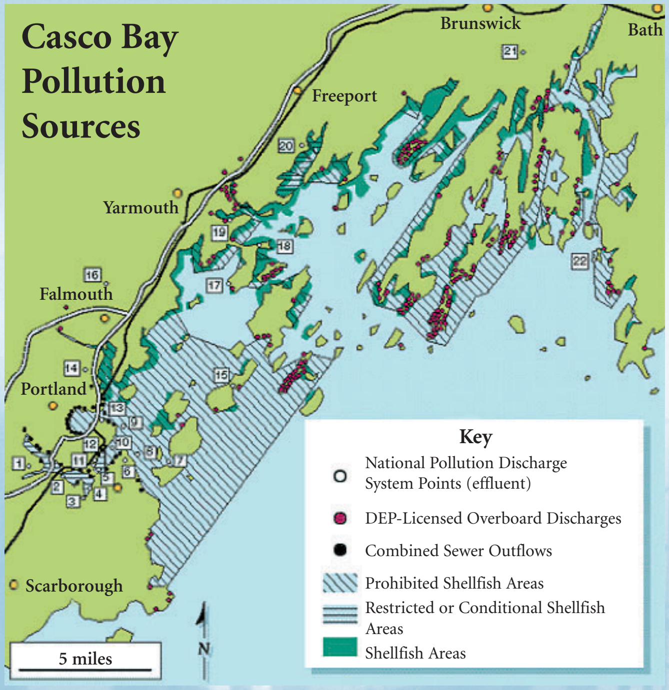


Figure 3-13. Contaminants in edible fish tissues for sampled sites along the Northeast Coast (U.S. EPA/EMAP).



This flounder is one of several flatfish species found on the banks and in the basins of the Stellwagen Bank National Marine Sanctuary (Photo: Dann Blackwood and Page Valentine, USGS).

Casco Bay Estuary Project



Pollution sources of Casco Bay (Casco Bay Estuary Project).

The Casco Bay Estuary Project is a cooperative effort between concerned citizens and local, state, and federal governments to protect Casco Bay, which lies at the heart of Maine's most populated area. Although the Casco Bay watershed represents only 3% of Maine's total land mass, it holds nearly 25% of the state's population. Residents depend on the bay and its watershed for multiple needs such as drinking water, recreation, food, transportation, industry, and waste disposal. However, when the Casco Bay Estuary Project began in 1990, few scientific studies had assessed the human impact on the pollutant levels of Casco Bay. Little was known about the pollutants in the sediments, the circulation patterns, or the sources of pollution (see figure). To ensure a better scientific basis for making policy decisions, the Casco Bay Estuary Project commissioned several major studies.

One study used Maquoit Bay as an example of predicting loadings of nitrogen and bacteria through the use of water quality loading models. Maquoit Bay is small, shallow, free from point sources of pollution and extensive urban development, and subject to excess concentrations of fecal coliform bacteria, and it suffered from a harmful algal bloom in 1988. Marine algal blooms are often triggered by excess nitrogen, so a model was developed to assess Maquoit Bay's potential sources of nitrogen (e.g., agricultural and residential runoff, sewage). The study found that septic systems, particularly failing ones, and manure or fertilizer were the largest sources of nitrogen and bacteria entering the bay. This finding provided a basis for developing measures to reduce pollutant loading to the bay.

Visit the Casco Bay Estuary Project on the Internet at http://www.cascobay.usm.maine.edu.

Delaware River Basin Commission

Approximately 6.4% of the nation's population relies on the waters of the Delaware River Basin for drinking and industrial use, and the Delaware Bay is only a day's drive away for about 40% of the U.S. population; yet the basin drains only 0.4% of the total continental U.S. land area. These figures indicate the tremendous potential for anthropogenic pressures to be placed on the estuary and the need for a strong governing body to manage and protect the water quality of the river and estuary.

The Delaware River Basin Commission (DRBC) was formed in 1961 by the signatory parties to the Delaware River Basin Compact (Delaware, New Jersey, New York, Pennsylvania, and the federal government) to share the responsibility of managing the water resources of the Basin. The Compact created a regional body with legal powers to oversee a unified approach to managing the river system without regard to political boundaries.

Today, the cleanup of the Delaware is hailed as one of the world's top water quality success stories. As a result of cleanup efforts, shad and other fish species are increasing in number. Currently, there is a major program on PCBs under way, resulting in fish consumption advisories covering the Delaware Bay and estuary. Other recent action by the DRBC has targeted certain toxic pollutants to ensure that stream quality objectives in the tidal Delaware River are met as part of a continuing program to protect human health and aquatic life. Two of the pollutants, 1,2-dichloroethane (DCE) and tetrachloroethene (TCE), have been identified by EPA as "probable human carcinogens." Under the resolution adopted by the DRBC, dischargers of DCE and TCE will be required to collect 1 year of effluent data to measure the magnitude and variability of these pollutants. This will be done before wasteload allocations are established for individual discharges.

The DRBC also plays an active role in community outreach and education efforts and conducts an annual water quality "snapshot" effort in which community participants are asked to collect and analyze water samples for water quality indicators such as dissolved oxygen and nitrates. This event and the resulting report bring attention to the Basin and to the public's interest and commitment to protecting its water resources.

Visit the DRBC online at www.state.nj.us/drbc.

Assessments and Advisories

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

The states on the Northeast Coast assessed 11,791 (77%) of their 15,173 estuarine square miles for their 1998 305(b) reports. Forty-eight percent of the assessed estuarine waters fully support their designated uses, 16% are threatened for one or more uses, and the remaining 36% are impaired by some form of pollution or habitat degradation (Figure 3-14). Individual use support for estuaries is shown in Figure 3-15.

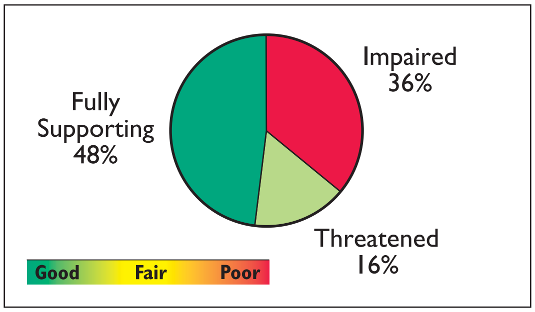


Figure 3-14. Water quality in assessed estuaries on the Northeast Coast (U.S. EPA).

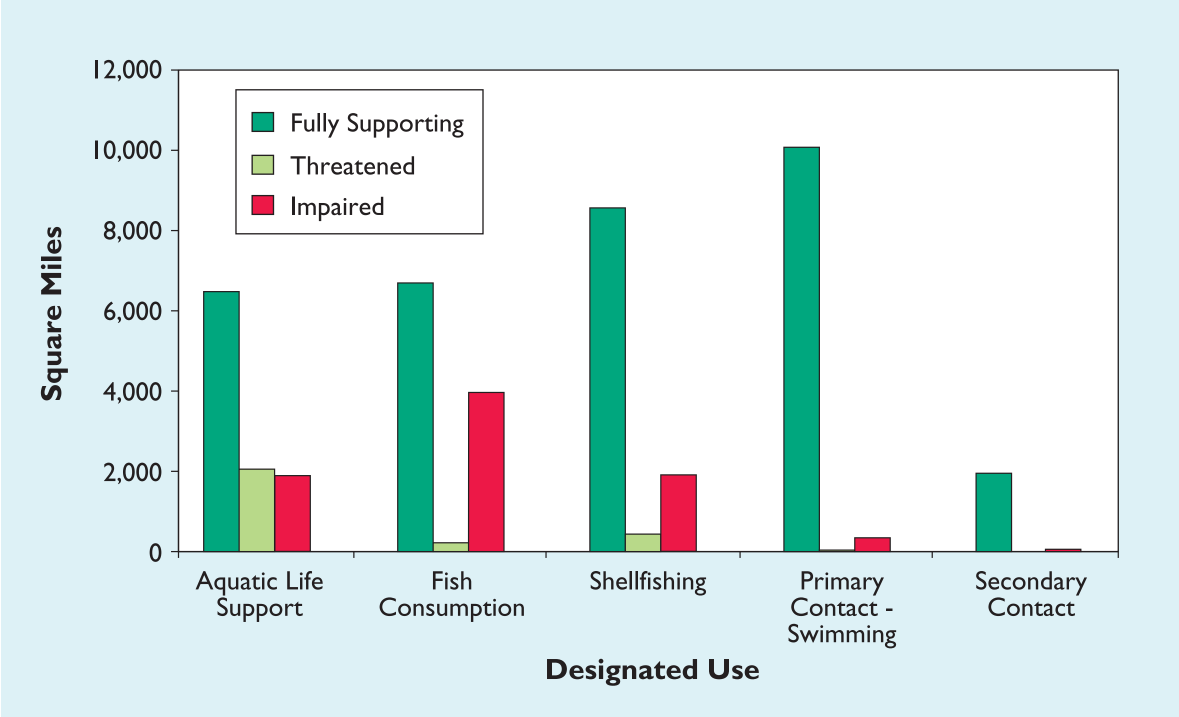


Figure 3-15. Individual use support in assessed estuaries on the Northeast Coast (U.S. EPA).

The states on the Northeast Coast assessed 401 (5%) of their 7,669 shoreline miles. Ninety-five percent of the assessed shoreline miles fully support their designated uses and no uses are reported as threatened, but 5% are impaired by some form of pollution or habitat degradation (Figure 3-16). Individual use support for the Northeast shoreline is shown in Figure 3-17.

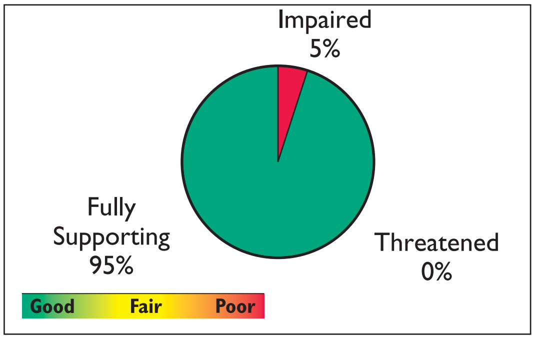


Figure 3-16. Water quality in assessed shoreline waters on the Northeast Coast (U.S. EPA).

The states reported individual use support for their assessed estuarine and coastal waters as shown in Table 3-1.

Table 3-1. Individual Use Support for Assessed Coastal Waters Reported by the States on the Northeast Coast under Section 305(b) of the Clean Water Act

Individual Uses	Assessed Estuaries Impaired (mi^2)	Assessed Shoreline Impaired (mi)
Aquatic Life	1,875 (18%)[a]	0
Fish Consumption	3,934 (36%)	18 (36%)
Shellfish Harvesting	1,488 (14%)	18 (7%)
Swimming	272 (3%)	0
Secondary Contact	40.2 (2%)	0

[a] Represents percentage of assessed waters impaired for each individual use.

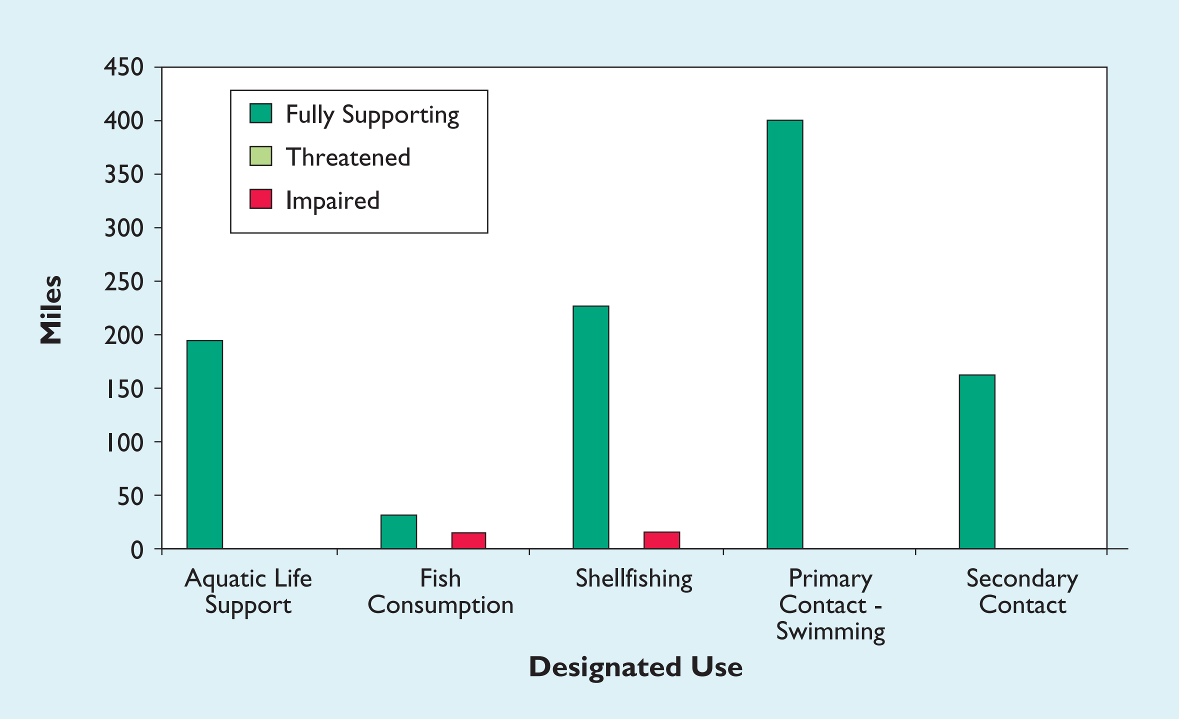
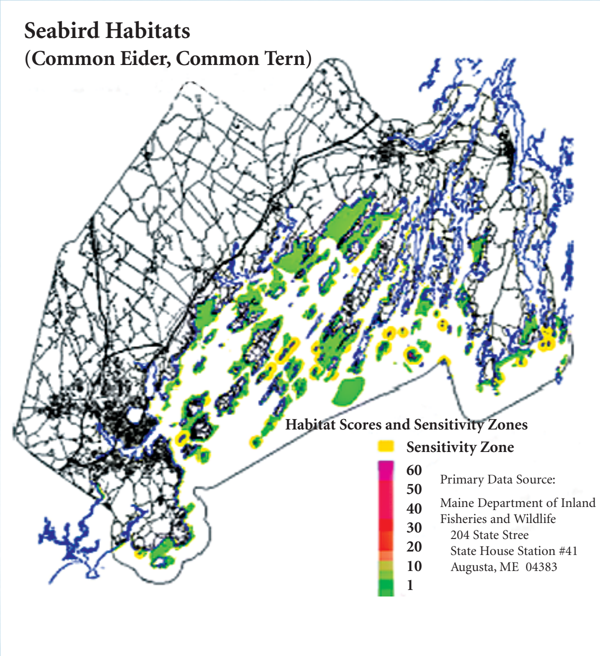


Figure 3-17. Individual use support for assessed shoreline waters on the Northeast Coast (U.S. EPA).

Coastal Habitat Study of the Gulf of Maine



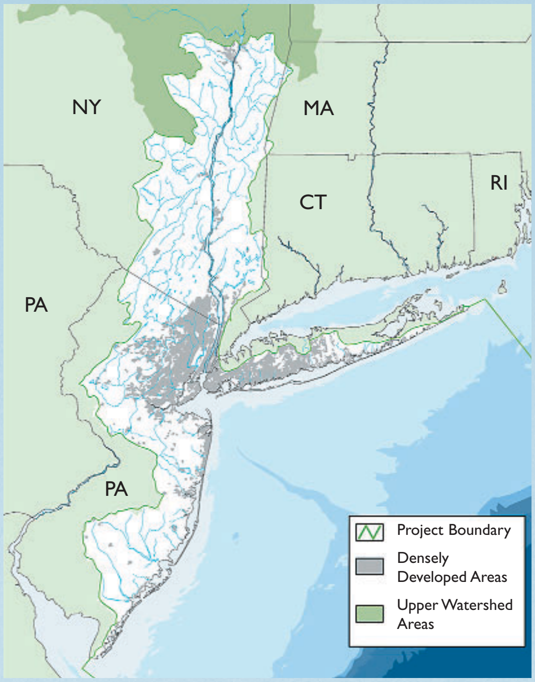
Casco Bay Seabird habitats, showing sensitive areas in yellow. Source: U.S. FWS Gulf of Maine Program.

The Gulf of Maine watershed includes more than 43,000 square miles of land in Maine, New Hampshire, and Massachusetts. The watershed includes the biologically productive Gulf of Maine as well as coastal habitats (salt marshes, mudflats, sandy beaches, intertidal zone, and islands) and inland streams, rivers, lakes, ponds, bogs, deciduous and coniferous woodlands, grasslands, and alpine tundra. The Gulf of Maine watershed provides productive nurseries for many marine fish; riverine pathways for historically abundant populations of anadromous fish; important habitat for breeding, migratory, and wintering waterbirds and neotropical migrants; and vital habitat for nationally threatened and endangered species. Unfortunately, increasing habitat loss and degradation from sprawling development, wetland and associated upland loss, overharvesting, oil spills, pollution, and other cumulative effects of development threaten the integrity of the Gulf of Maine watershed.

The U.S. Fish and Wildlife Service's Gulf of Maine Coastal Program has initiated a comprehensive project to identify, map, and rank important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed. Biologists selected more than 60 species that regularly inhabit the Gulf of Maine watershed and are experiencing decline. Biologists are identifying, ranking, and mapping habitat for all of these species—from actual sitings or by developing habitat suitability models reflecting the environmental requirements for each species. Once species-specific maps are created using in-house geographic information system (GIS) technology (see figure), composite maps ranking habitats for all species will be developed. All of the data collected are available on a CD-ROM that will help land use planners and decision makers focus conservation efforts in areas of greatest biological value (Contact: Stewart Fefer, U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, 207-781-8364).

More information is available on the Internet at http://gulfofmaine.fws.gov.

Comprehensive Study of Habitat Complexes of the New York Bight Watershed



Areas of the coastal habitat project in the New York Bight watershed (U.S. FWS Coastal Program).

The U.S. Fish and Wildlife Service's Southern New England-New York Bight Coastal Program study *Significant Habitats and Habitat Complexes of the New York Bight Watershed* identifies and describes essential habitats of key marine, coastal, and terrestrial species inhabiting the New York Bight watershed study area to help guide ecologically sound land use decisions and land protection efforts. This habitat assessment includes 20 million acres of habitat, ranging from deep marine waters to freshwater wetlands and encompasses New York-New Jersey Harbor, the tidal waters of the Hudson River, the watersheds of the harbor and tidal Hudson, and the upland drainages of New Jersey and southern Long Island (see map).

The GIS analysis of habitat data identified 35 large, landscape-scale habitat complexes, such as barrier beaches, coastal lagoons, unfragmented blocks of forest or wetland areas, pine barrens, and freshwater tidal marshes. These large habitat complexes contain individual habitat units identified as important to a single species, multiple species, or communities.

Specific site narratives describe the location, boundaries, ecological communities and processes, various habitat subunits, general ownership or protected status, and the ecological significance or uniqueness for each large habitat complex. Site narratives also assess threats to the long-term integrity of both species populations and the physical structure of the habitat and recommend conservation considerations and protection/restoration strategies. The report's overview chapters discuss physiographic regions, marine zones, regionally significant populations, species groups, and natural communities.

You can view the New York Bight study on the Internet at http://www.fws.gov/r5snep/snep5.htm.

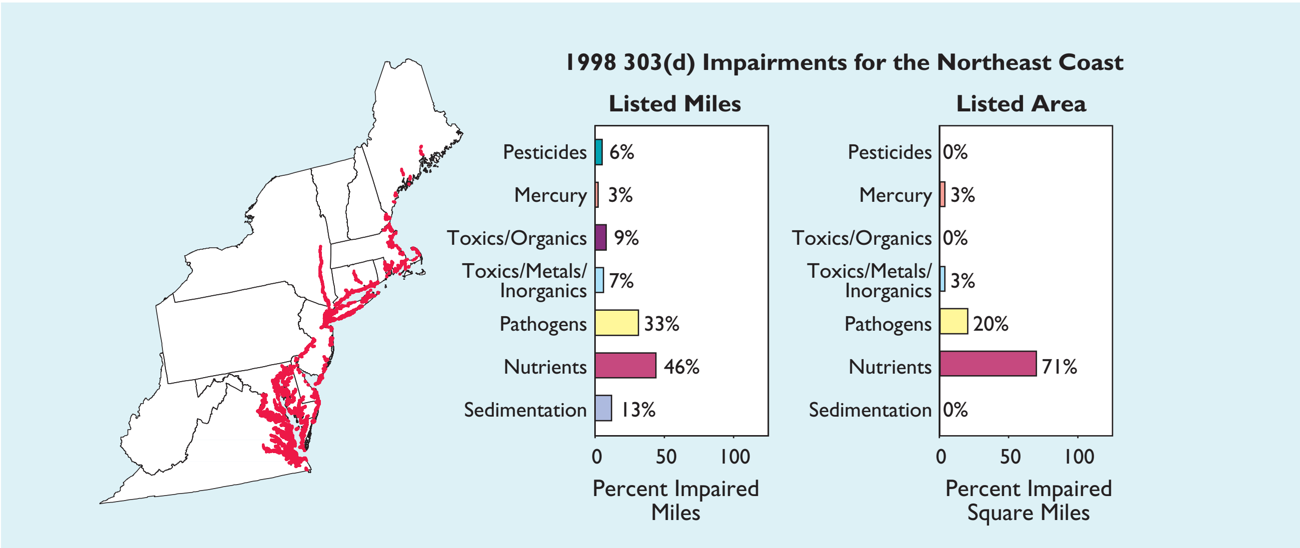


Figure 3-18. 303(d) listed waters on the Northeast Coast and the percentage of miles impaired by the major pollutant categories (note that a listing may be impaired by multiple pollutants) (U.S. EPA).

There are 697 waters located on the Northeast Coast that are listed as impaired under Section 303(d) of the Clean Water Act. The percentage of listed waters impaired by each of the major pollutant categories is shown in Figure 3-18.

State Fish Consumption Advisories

In 2000, 7 of the 10 Northeast Coast states (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, and Rhode Island) had statewide consumption advisories for fish in coastal waters, placing 100% of their coastal and estuarine areas under advisory. Due in large part to these statewide advisories, an estimated 81% of the coastal miles of the Northeast Coast and 67% of the estuarine area were under fish consumption advisories. A total of 36 different advisories were active in 2000 for the estuarine and marine waters of the Northeast Coast (Figure 3-19).

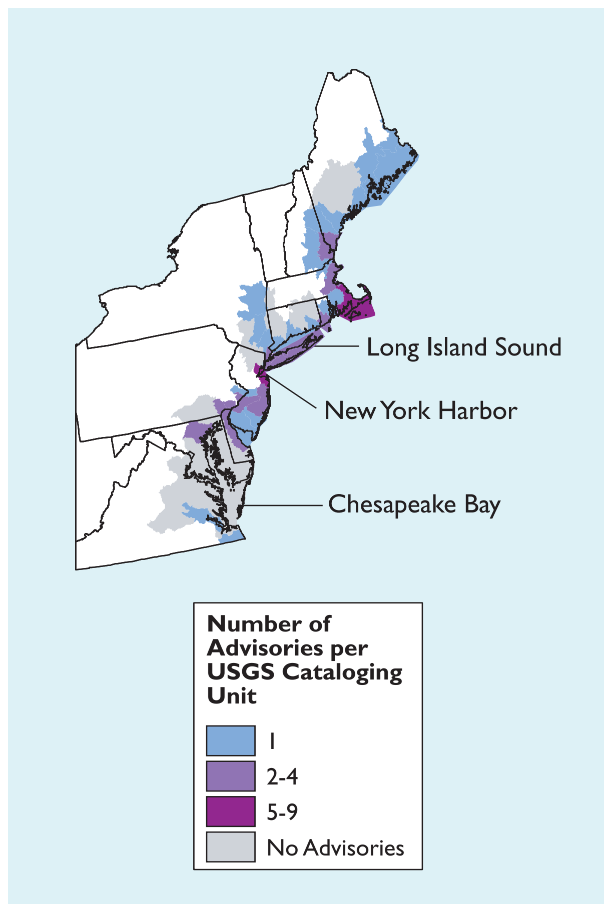


Figure 3-19. The number of fish consumption advisories on the Northeast Coast active in 2000 (U.S. EPA).

Advisories in the Northeast were in effect for 10 different pollutants (Figure 3-20). The majority of the listings (51%) were for PCBs. The James River estuary in Virginia was listed for kepone, while Boston Harbor was listed for multiple pollutants.

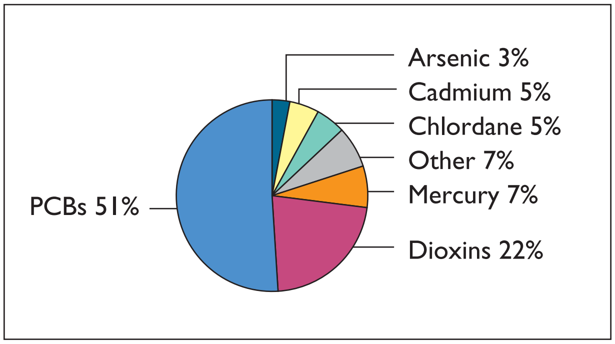


Figure 3-20. Pollutants responsible for fish consumption advisories in northeastern coastal waters (U.S. EPA NLFWA, 2000c).

These species were under advisory in 1999 for at least some part of the Northeast Coast:

White catfish	Flounder	Bivalves
American eel	Goldfish	Lobster
Largemouth bass	Atlantic needlefish	Lobster (tomalley)
Smallmouth bass	White perch	Rainbow smelt
Striped bass	Scup	Tautog
Bluefish	Blue crab	Walleye
Common carp	Blue crab (hepatopancreas)	
Channel catfish		

Classified Shellfish-Growing Waters

In the Northeast, 9.6 million acres of shellfish waters (44% of the national total) were classified for shellfish harvest in 1995 (Figure 3-21). Of the classified acreage, 82% were approved and 18% were harvest-limited. Of the region's classified acreage, 37% is located in estuarine waters and 63% in nonestuarine waters. The top four pollution sources affecting harvest limitation in estuarine and nonestuarine waters are wastewater treatment plants, urban runoff, direct discharges, and upstream sources.

Two of the top shellfish species in the Northeast (rated high or medium in abundance) are hard clams (1.2 million acres) and surf clams (1.5 million acres). Twelve percent of surf clams and 28% of hard clams are located in waters that do not allow direct harvesting (i.e., restricted, conditionally restricted, and/or prohibited).

Total classified acreage in the Northeast has increased by over 1.5 million acres since the 1990 Register. While all three North Atlantic states (Maine, New Hampshire, and

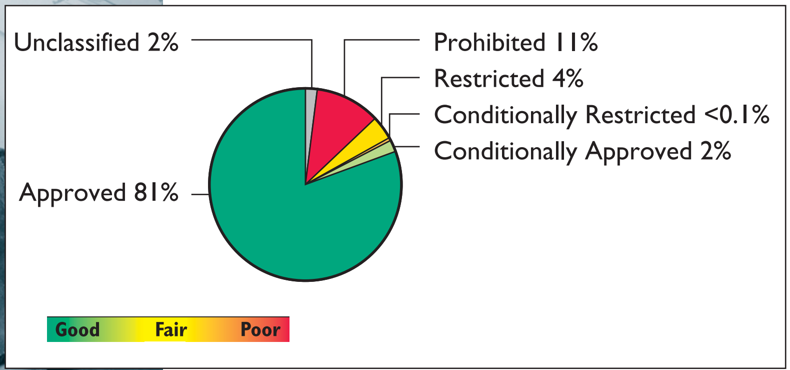


Figure 3-21. Classification of shellfish-growing waters for the Northeast (1995 Shellfish Register, NOAA, 1997).

Massachusetts) reported increases in the total amount of classified acreage, the biggest change occurred in Massachusetts, where classified nonestuarine acreage almost tripled. In the Mid-Atlantic states (Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia), approved waters increased from 79% in 1990 to 84% in 1995. Five of the eight Mid-Atlantic states reported a decline in classified acreage located in estuarine waters.

Beach Closures

Of 566 coastal beaches in the Northeast that reported information to EPA, only 8.8% (50 beaches) closed for any period of time in 1999. The highest percentage of closed beaches was in New York, where 19% of the 26 beaches providing information were closed at least once in 1999. Figure 3-22 shows the percentage of beaches in each county that were closed at least once in 1999 and the locations of beach closures. Four states (Delaware, Maine, New Hampshire, and Virginia) did not have any coastal beach closings in 1999.

Over 98% of the beaches in the Northeast that reported information have monitoring programs. Virginia had the lowest percentage of monitored beaches in 1998, but in 1999 five of the six beaches reporting from Virginia had a monitoring program in place.

Causes for beach closures in the Northeast were primarily related to elevated bacteria levels. The sources of bacteria were generally different types of runoff, such as stormwater, and sewer overflows. In a number of cases, the elevated bacteria levels were thought to have been caused by wildlife. Often beaches were preemptively closed due to the threat of potentially high bacteria levels. In New Jersey, a number of beaches were closed due to raw sewage spills.

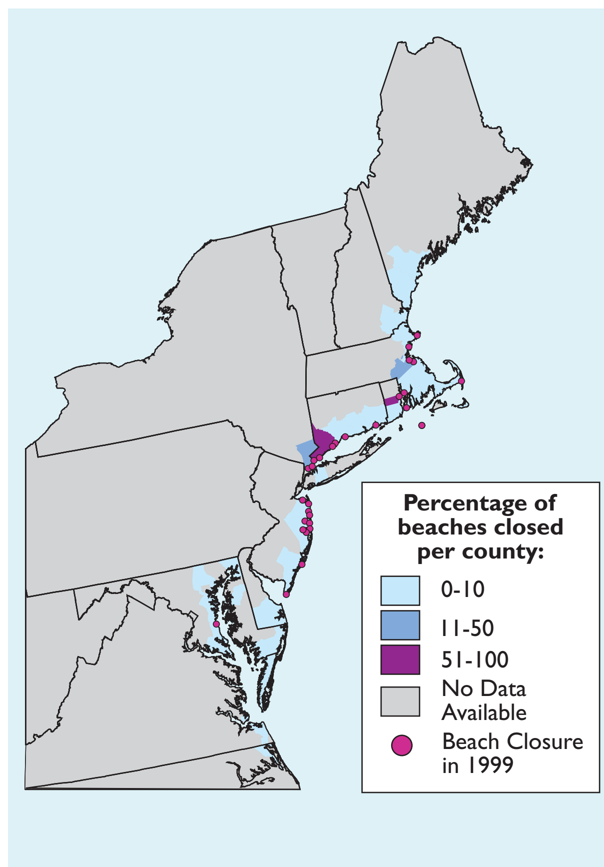


Figure 3-22. Percentage of beaches in each county that were closed at least once in 1999, of those beaches providing information to EPA.

Summary

Ecological conditions in northeastern estuaries are borderline poor (Figure 3-23). The primary problems in northeastern estuaries are sediment contamination, high eutrophic condition, significant loss of wetlands, and poor fish and benthic condition. Over 25% of sediments are enriched or exceed the ERL/ERM guidance. Sixty percent of the northeastern estuarine area has a high potential of increasing eutrophication or existing high concentrations of chlorophyll *a*. About 10% of fish have elevated levels of contaminants in their edible tissues. Nearly 40% of all wetlands along the Northeast Coast were eliminated between 1780 and 1980. Although some of these problems are improving, benthic community degradation, fish tissue contamination, and increasing eutrophic condition are worsening. Figure 3-23 displays the condition of the major indicators of ecological condition in northeastern estuaries. Although hypoxia issues exist in the deep trough of the Chesapeake Bay, dissolved oxygen conditions are generally fair for northeastern estuaries. Water clarity is generally in good condition. However, benthic community condition is borderline poor in these estuaries and appears to be worsening. Eutrophic condition, sediment contamination, and fish tissue contamination are considered to be in poor condition throughout the Northeast. The condition of these resources indicates that the estuaries of the Northeast Coast are among the most threatened in the country. However, major programs are being implemented and designed to address the existing problems. Continued monitoring is also necessary to track the progress of cleanup efforts and to prevent the worsening of conditions throughout the Northeast.

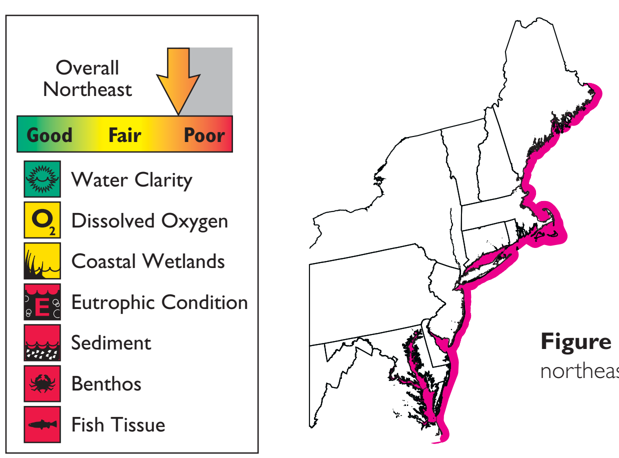


Figure 3-23. The overall condition of northeastern estuaries is borderline poor.

highlight

The Chesapeake Bay Program

The Chesapeake Bay Program is a unique regional partnership directing and conducting the restoration of the Chesapeake Bay since the signing of the historic Chesapeake Bay Agreement of 1983. The Chesapeake Bay Program partners are the states of Maryland, Pennsylvania, and Virginia; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; and EPA.

Chesapeake Bay Program
A Watershed Partnership

In the late 1970s, scientific and estuarine research on the Bay pinpointed three areas requiring immediate attention: nutrient overenrichment, dwindling underwater bay grasses, and toxic pollution. Once the initial research was completed, the Bay Program evolved as the means to restore this exceptionally valuable resource, with its highest priority being the restoration of the Bay's living resources—its finfish, shellfish, bay grasses, and other aquatic life and wildlife.

The second Chesapeake Bay Agreement was signed in 1987, which created the infrastructure and policy vision for which the Chesapeake Bay Program is known. The centerpiece of the 1987 Agreement was a goal to reduce nutrients entering the Bay by 40% by 2000. This history of setting strong numerical goals within a date-certain timeframe has become a hallmark of the Bay Program and is repeated in the new Chesapeake 2000 agreement.

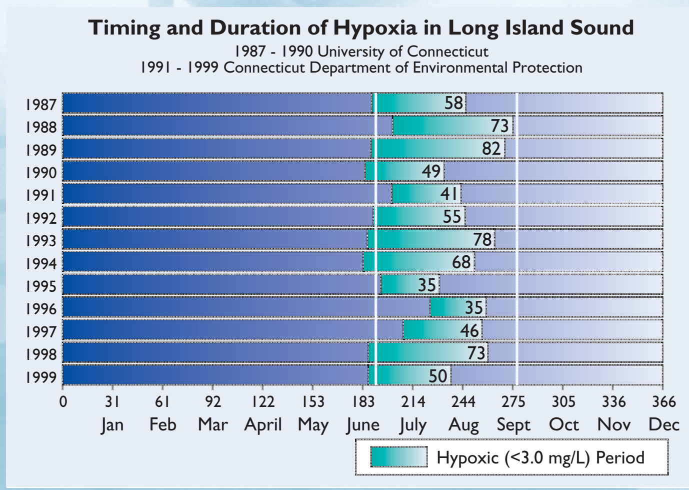
The Chesapeake 2000 agreement lays the foundation and sets the course for the Bay's restoration and protection for the next decade and beyond. Highlights include

- **Water Quality** – "By 2010, correct the nutrient and sediment related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove [them] from the list of impaired waters under the Clean Water Act."
- **Sprawl and Growth Commitments** – A commitment to reduce the rate of harmful sprawl development of forests and farms by 30% by 2012 and to permanently preserve 20% of the Bay watershed by 2010 (currently about 16.4% is preserved).
- **Mixing Zone Elimination** – Voluntary elimination of mixing zones for both bioaccumulative and persistent chemicals by 2010.
- **Wetlands** – Commits to a "no net loss" of existing wetlands, a net gain of 25,000 acres by 2010, and a commitment to develop and implement locally generated wetlands preservation plans on 25% of the land area of the Chesapeake Bay watershed by 2010.
- **Education and Public Access** – Provide every school student in the Bay watershed with an outdoor Bay or stream experience by the time he or she graduates from high school. Also, increase public access to the Bay and its tributaries by 30% by 2010 and add 500 miles of water trails by 2005.
- **Oysters/Crabs** – The new agreement commits to a tenfold increase in the oyster population by 2010 and to setting of new Baywide harvest targets for blue crabs in 2001.

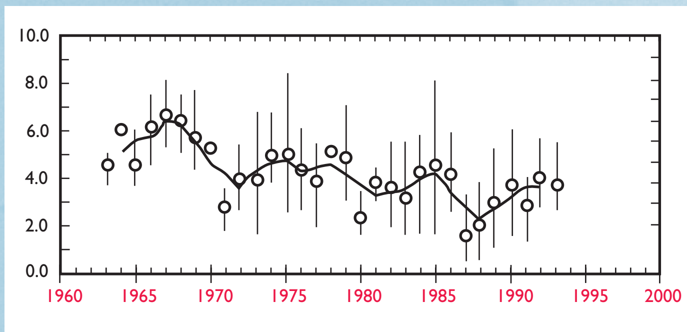
Long Island Sound Dissolved Oxygen

The Long Island Sound drainage basin is one of the most densely populated areas in the country. Approximately 8.4 million people live within the basin, including 3.5 million in New York City. Intense resource use and human population pressures have placed a significant strain on Long Island Sound. Passage of the Clean Water Act has led to measurable improvements in water quality, and many sources of pollution are now regulated. However, the problem of low dissolved oxygen remains a significant concern to the overall health of the sound.

Low dissolved oxygen occurs primarily during the summer months in the central and west portions of Long Island Sound. When dissolved oxygen levels fall below 3 mg/L, the health of aquatic life tends to suffer. Water in Long Island Sound tends to be highly stratified in the late summer months and has probably always experienced some periods of low dissolved oxygen. However, human inputs of nutrients add to the problem, resulting in more significant damage to ecologically and economically important organisms.



A time series of average dissolved oxygen concentrations in Long Island Sound shows generally decreasing measurements from 1963 to 1993. Conditions appear to improve from 1987 to 1993, but remain substantially degraded with respect to measurements made prior to 1970.



Average Bottom Dissolved Oxygen Concentrations (mg/L) from 1963 to 1993. Yearly averages reveal generally decreasing dissolved oxygen concentrations with stabilizing conditions from 1973 to 1987 and a slight recovery from 1987 to 1993.

Chapter 4

Southeast Coastal Condition

Chapter 4

Southeast Coastal Condition

The condition of southeastern estuaries is fair, although monitoring has shown evidence of human-induced stress in some areas (Figure 4-1). From 1994 to1995, EMAP collected environmental stressor and response data from approximately 200 locations throughout southeastern estuaries. In 1996 and 1997, a smaller number of sites were examined in North Carolina. Approximately 54% of the estuarine area of the southeastern United States was in good ecological condition, meaning that, in the most stressful period of the year, neither environmental stressors (nutrients, contaminants, etc.) nor conditions for aquatic life showed any signs of impairment (Figure 4-2). Alternatively, 35% of the estuarine area showed indications of impaired aquatic life use and 17% showed impairments to human use.

The estuaries of the southeastern United States (Carolinian province) extend from Cape Henry, Virginia, through the southern end of the Indian River Lagoon along the east coast of Florida (Figure 4-3). Also included in southeastern estuaries is a region of the West Indian province from Indian River Lagoon through Biscayne Bay. The population of coastal counties along the Southeast Coast increased 64% from 1970 to 1990 (U.S. Bureau of the Census, 1996). The estuarine resources are diverse and extensive, covering an estimated 4,487 square miles.

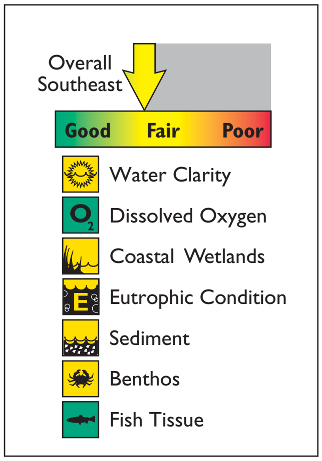


Figure 4-1. The overall condition of southeastern estuaries is fair.

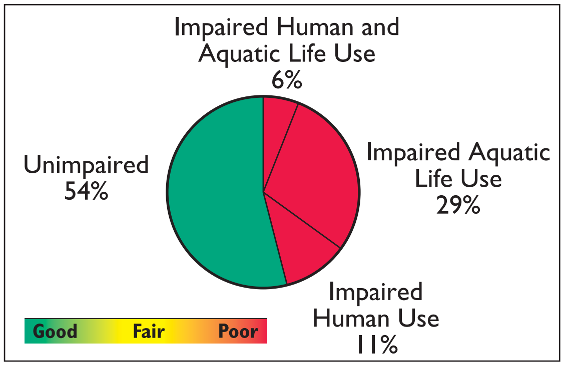


Figure 4-2. The condition of estuaries on the Southeast Coast; estimates are within ±10% based on 4 years of sampling (U.S. EPA/EMAP).

Figure 4-3. Southeastern estuaries (Carolinian province).

There is an increasing need for effective management of these resources given the predicted influx of people and businesses to southeastern coastal states over the next few decades and the ensuing pressures on the coastal zone of this region. Culliton et al. (1990) estimated that the coastal population in the southeastern United States will have increased by 181% over the 50-year period from 1960 to 2010 (the largest percentage increase in the country).

To help support resource management needs, EPA and NOAA initiated a comprehensive study of the quality of southeastern estuaries in 1994 by coordinating components of two nationwide monitoring efforts, the EPA Environmental Monitoring and Assessment Program and the NOAA National Status and Trends Program. The southeastern study was designed to provide yearly estimates of the condition of estuaries based on a variety of biological, chemical, toxicological, and aesthetic indicators (see Hyland et al., 1996; Hyland et al., 1998). Prior to this study, there was no comprehensive regionwide ecological information available. In addition to this monitoring effort, the Coastal 2000 initiative includes follow-up monitoring in the four southeastern states (North Carolina, South Carolina, Georgia, and Florida). Also, since the late 1980s, NOAA's NS&T Program and its Intensive Bioeffects Surveys have collected contaminant bioavailability and sediment toxicity data from several southeastern locations (Long et al., 1996).

Coastal Monitoring Data

Water Clarity

Water clarity in southeastern estuaries is fair. Water clarity was estimated by light penetration through the water column using a Secchi disc. Poor water visibility was defined as a Secchi depth of less than 0.5 m. This is equivalent to 10% of surface light reaching 1 meter. About 4% of southeastern estuaries had a Secchi depth of less than 0.5 meter (Figure 4-4).

The presence of debris introduced by humans ("trash") in surface and bottom waters provides an obvious sign of degradation. Floating debris was observed in about 2% of southeastern estuaries, and bottom debris was observed in about 17% (Figure 4-5). Two other indicators of human disturbance are the presence of oil and grease and the presence of noxious odors. Oil was observed in 4% of the sediments in southeastern estuaries, and noxious odors were detectable in 24% of these sediments.

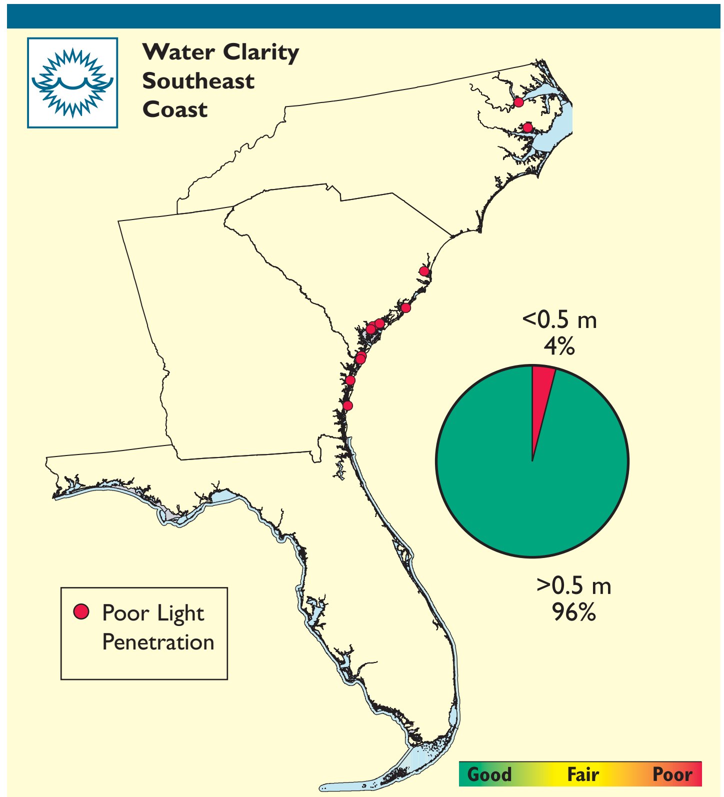


Figure 4-4. Light penetration data and locations for sites with a Secchi depth of <0.5 m (U.S. EPA/EMAP).

The sand makes a temporary rest in the broad deltas that form where the outflowing freshwater collides head-on with the incoming saltwater (Photo: Gray's Reef NMS).

Dissolved Oxygen

Dissolved oxygen conditions in southeastern estuaries are generally good. EMAP estimates for southeastern estuaries show that about 2% of the bottom waters in southeastern estuaries have low dissolved oxygen (less than 2 ppm) on a continuing basis in late summer (Figure 4-6). Most of this 2% is in the Neuse River and southern portions of Pamlico Sound.

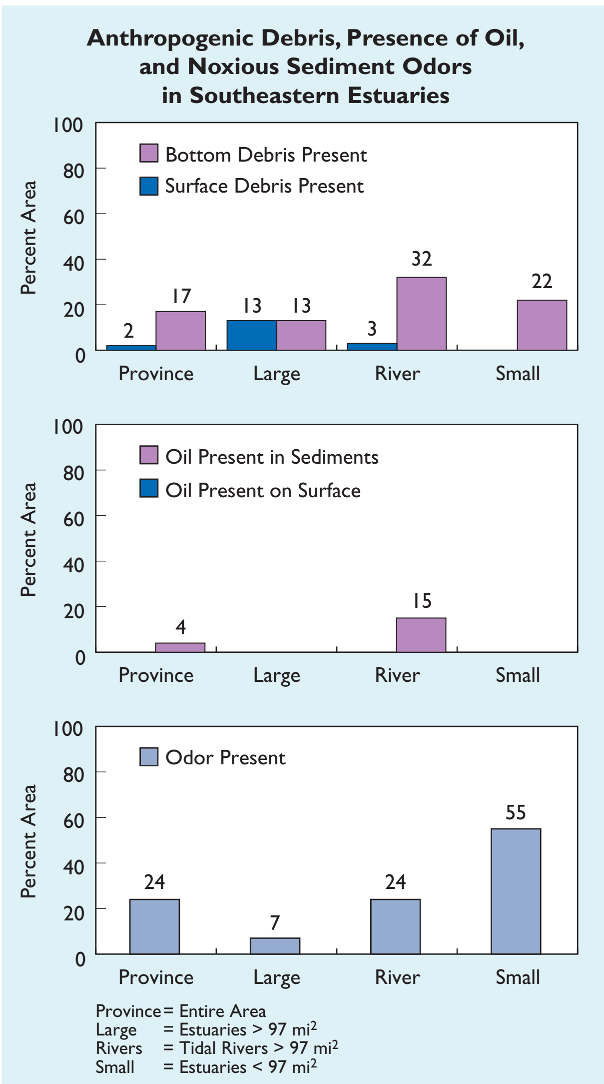


Figure 4-5. The presence of anthropogenic debris provides an obvious sign of degradation.

Coastal Wetland Loss

Wetland losses in the Southeast are high—40% of all wetlands existing in 1780 had disappeared by 1980 (Figure 4-7). Losses ranged from 23% in Georgia to nearly 50% in North Carolina (Dahl, 1990).

From the 1970s to the 1980s, acreage of wetlands has continued to decline

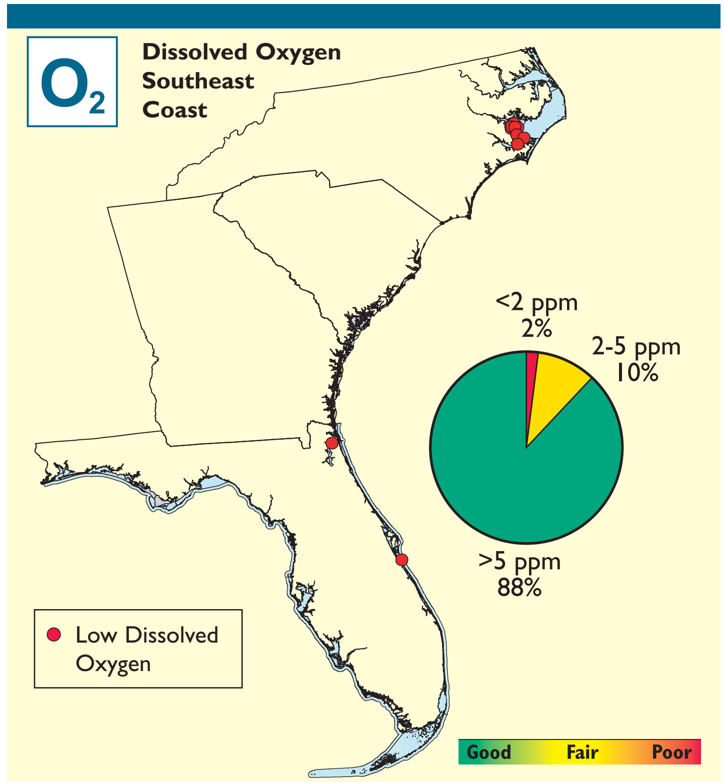


Figure 4-6. Dissolved oxygen data for sampled sites and locations for sites with less than 2 ppm for the Southeast Coast (U.S. EPA/EMAP).

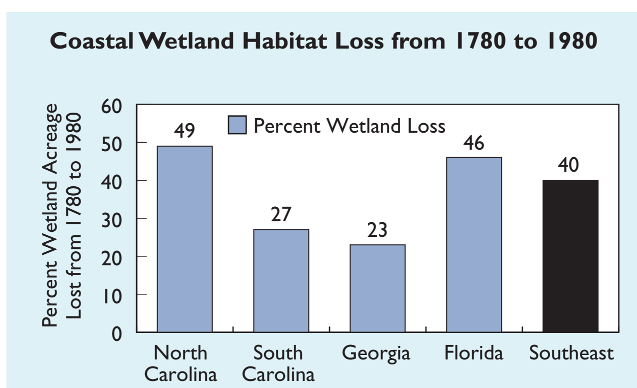


Figure 4-7. Percent wetland habitat lost from 1780 to 1980 by state and for the Southeast overall (Dahl, 1990; Turner and Boesch, 1988).

throughout all the states in the Southeast (Figure 4-8). These losses range from 1% decline in this decade for Georgia to a 16% decline in North Carolina.

Eutrophic Condition

The condition of southeastern estuaries as measured by eutrophic condition is fair. High eutrophic conditions were observed in only 13% of the area of southeastern estuaries (Figure 4-9). However, estimates predicted an expected increase in eutrophic condition in nearly all southeastern estuarine waters by 2020. Expression of eutrophic condition was high in four North Carolina estuarine river systems (Pamlico, Pungo, Neuse, and New Rivers) and in the St. Johns River in Florida. No estuarine systems in Georgia or South Carolina or the remainder of the east coast of Florida expressed high eutrophic conditions, although five others showed moderate conditions.

High expressions of chlorophyll *a* were observed during NOAA's National Estuarine Eutrophication Assessment for about 14% of the area of southeastern estuaries. These high expressions were observed predominantly in estuaries in North Carolina and for a single estuary in Florida (Figure 4-10).

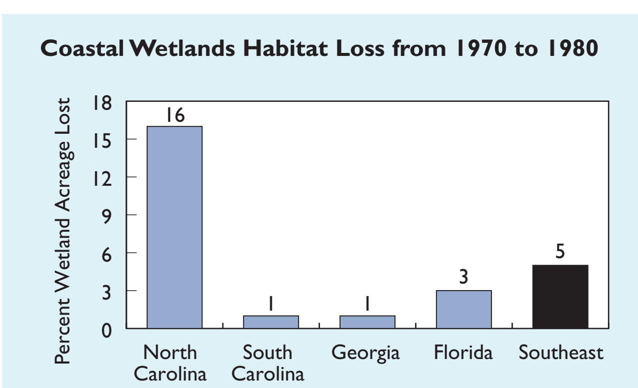


Figure 4-8. Percent decline in acreage of wetlands from 1970 to 1980 by state and for the Southeast overall (Hefner et al., 1994).

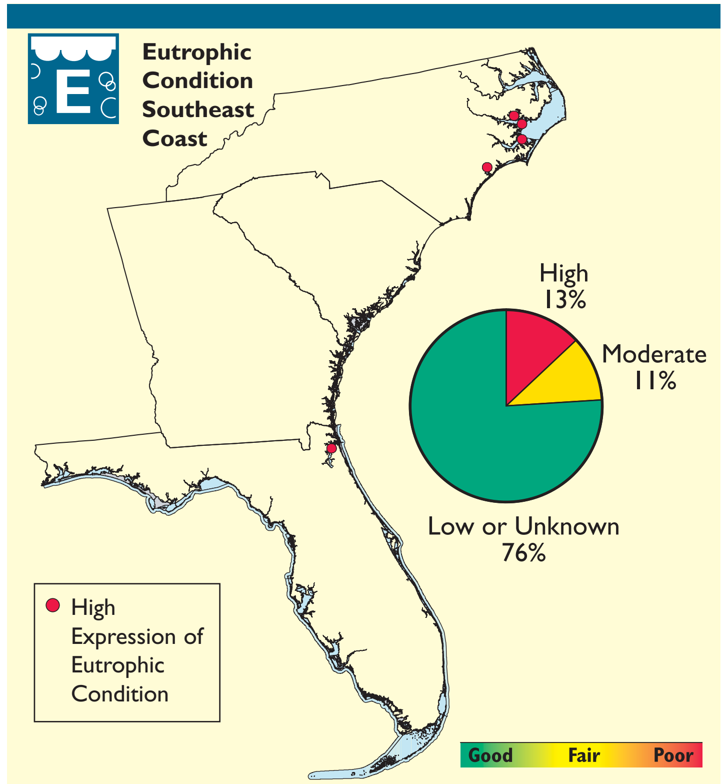


Figure 4-9. Eutrophic condition data and locations of estuaries with high expression of eutrophic condition along the Southeast Coast (NOAA/NOS).

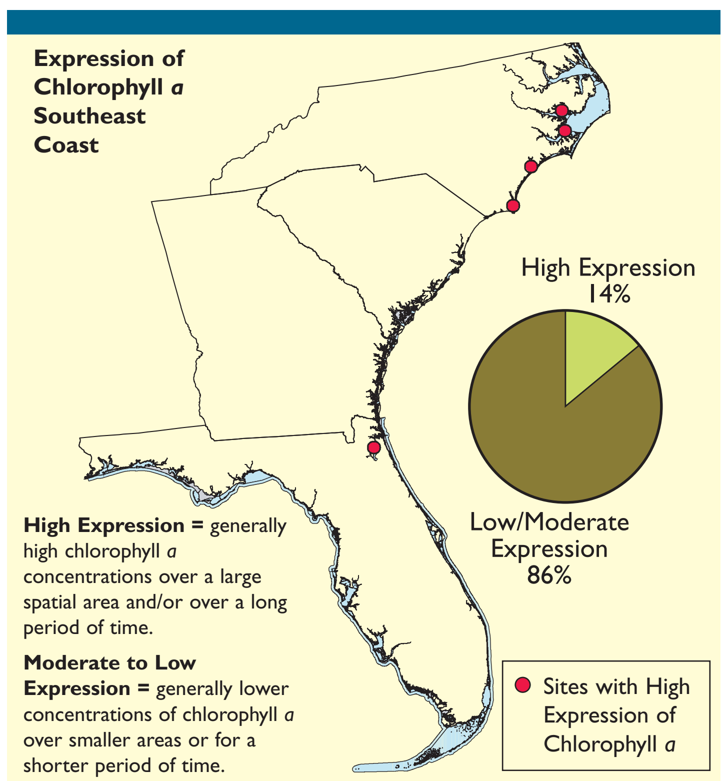


Figure 4-10. Chlorophyll *a* data for surveyed estuaries along the Southeast Coast and locations of estuaries with high expression of chlorophyll *a* (NOAA/NOS).

Sediment Contaminants

The condition of southeastern estuaries as measured by sediment contamination is fair. Sediment contaminants have been estimated by EMAP and NOAA (bioeffects surveys) for the estuaries of the southeastern United States. Sediment contaminant concentrations measured by NOAA NS&T bioeffects surveys rarely exceeded ERM guidelines (Long et al., 1996), with exceedances occurring only for pesticides in two estuarine systems (Mud River and Cumberland River, Georgia, Figure 4-11). EMAP reported that ERL guidelines were exceeded for all of the major groups of sediment contaminants, albeit at low rates (5% of area) for PAHs and PCBs. There were greater ERL exceedances for pesticides (33%) and heavy metals (39%), although most of the pesticide ERL exceedances were for DDT metabolites, dieldrin, and lindane. Total DDT (DDT plus metabolites DDE and DDD) exceeded 6 ppm in nearly 27% of estuarine sediments and ranged from 0 to 214 ppm. Lindane exceeded its ERL value in 12% of sediments. Concentrations of some chemicals (pyrene, chlordane, DDT and its metabolites, dieldrin, and lindane) were found in the EMAP survey in excess of upper-level ERM guidelines in a few places (similar to the low incidence of ERM exceedances found in NOAA's NS&T bioeffects surveys). While concentrations of most sediment contaminants are relatively low, enrichment rates for southeastern estuarine sediments range from 11% (PCBs) to nearly 99% (PAHs) (Figure 4-12). Only three contaminants (total DDT, arsenic, and nickel) exceeded ERL guidelines for more than 15% of the southeastern estuarine sediments. Therefore, sediment contamination is rated fair for the Southeast.

Sediment Contaminant Criteria

ERM (Effects Range Medium) – The concentration of a contaminant that will result in ecological effects approximately 50% of the time based on literature studies.

ERL (Effects Range Low) – The concentration of a contaminant that will result in ecological effects about 10% of the time based on literature studies.

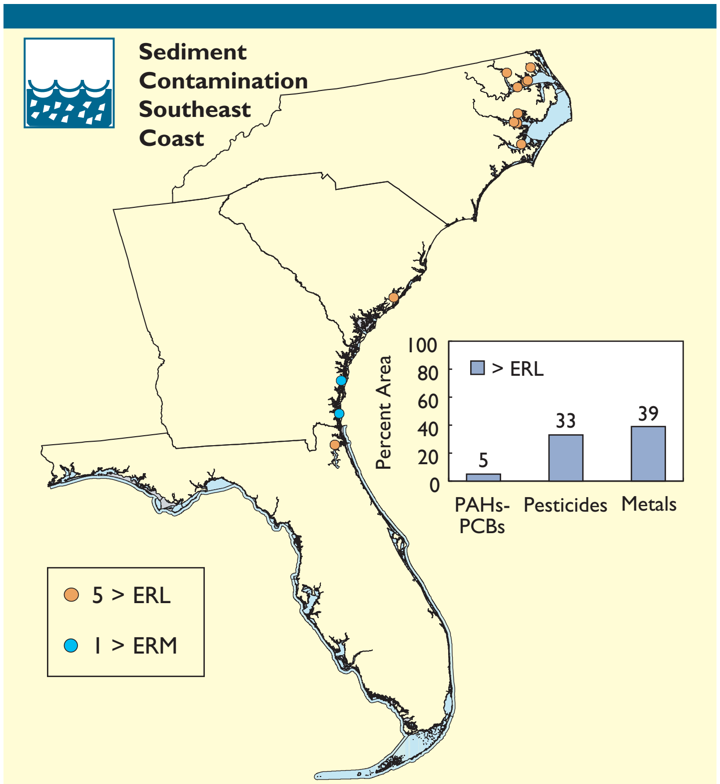


Figure 4-11. Sediment contamination for sampled sites and locations of sites with 5 > ERL along the Southeast Coast (U.S. EPA/EMAP).

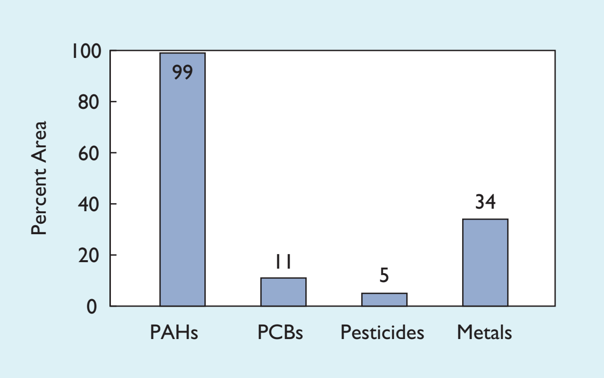


Figure 4-12. Percentage of estuarine sediments in southeastern estuaries that are enriched and range from 11% (PCBs) to nearly 99% (PAHs) (U.S. EPA/EMAP).

Benthic Condition

Benthic indicators in southeastern estuaries are fair. Benthic index estimates (Hyland et al., 1996; Hyland et al., 1998; Van Dolah et al., 1998), based on EMAP surveys, indicate that 17% of the estuarine area has highly degraded benthic resources (Figure 4-13). Of the 4,487 square miles in the Carolinian province, nearly 772 square miles were ecologically degraded with respect to benthos. Examination of the distributions of the benthic index in the three sampling strata within the southeastern United States (large estuaries, large rivers, and small estuaries/rivers) showed that large tidal rivers (Neuse and Pamlico Rivers and Indian River Lagoon) had the largest proportion of their estuarine bottom area represented by poorer than expected benthic communities (about 70%), while large estuaries (open areas such as Pamlico Sound) had the smallest proportional representation (about 5%). Degraded benthic conditions were observed throughout the Southeast.

Sediment toxicity from EMAP and NOAA NS&T bioeffects data show that small proportions of southeastern sediments are toxic based on bioassays with the marine amphipod *Ampelisca abdita* (Figure 4-14). NOAA bioeffects surveys of Winyah Bay, Charleston Harbor, Leadenwah Creek, Savannah River, and St. Simons Sound showed 0 to 1.2% of their sediments to be toxic. EMAP surveys generally confirm these findings, but show no toxicity associated with sediments from Savannah River or St. Simons Sound. In addition, EMAP surveys showed significant sediment toxicity associated with the Chowan River, some small estuaries in North Carolina, and Newfound Harbor on the Indian River Lagoon in Florida.

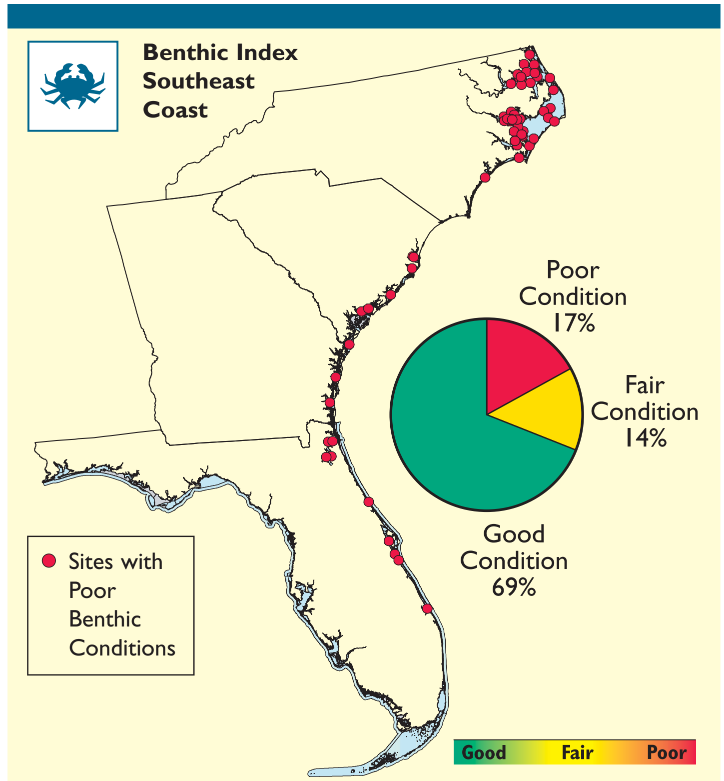


Figure 4-13. Benthic index condition data and locations with poor benthos along the Southeast Coast (U.S. EPA/EMAP).

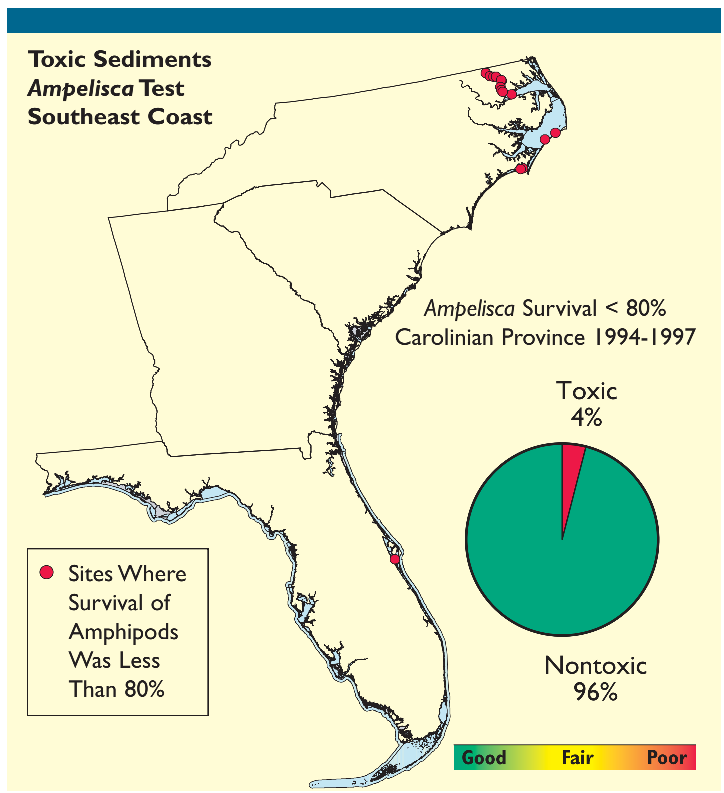


Figure 4-14. Amphipod data and locations with toxicity > 20% along the Southeast Coast (U.S. EPA/EMAP).

For the locations that showed poor benthic community quality, the co-occurrence of poor environmental quality (exposure) is shown in Figure 4-15. Of the 20% of the southeastern estuarine area that had impaired benthic assemblages, 61% also showed contaminated sediments, 1% showed sediment toxicity, 17% showed hypoxia, and 1% showed poor light conditions (high levels of total suspended solids). Of the locations that showed poor benthic community conditions, 20% had no sediment or water quality degradation (as measured by the EMAP program). Locations without obvious associations between adverse biological and exposure conditions occurred primarily in Pamlico Sound and Indian River Lagoon. Recently, Pamlico Sound has displayed some tendencies to hypoxic conditions in late summer, and Indian River Lagoon has shown increasing nutrient concentrations.

Fish Tissue Contaminants

The condition of southeastern estuaries as measured by fish tissue contaminants is good. Samples of spot, Atlantic croaker, blue crab, and penaeid shrimp were analyzed for presence of contaminants in edible tissues. All measured analytes in these samples were below corresponding Food and Drug Administration action levels for PCBs, pesticides, and mercury. Using international guidelines for other metals and pesticides, it was shown that arsenic guidelines were exceeded at 16% of sampled locations or in about 8% of the fish population examined (Figure 4-16). Arsenic found in fish and shellfish is almost completely altered into organic arsenobetaines that are not toxic to humans. Thus, only one location (about 1% of fish examined) showed elevated levels of nonarsenical contaminants in edible tissues.

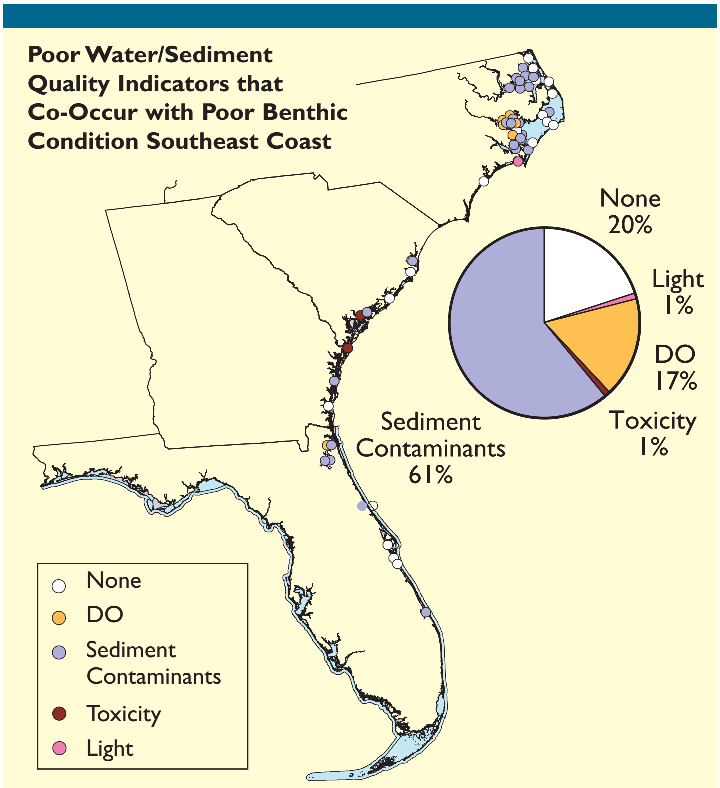


Figure 4-15. Indicators of poor water/sediment quality that co-occur with poor benthic condition in southeastern estuaries (U.S. EPA/EMAP).

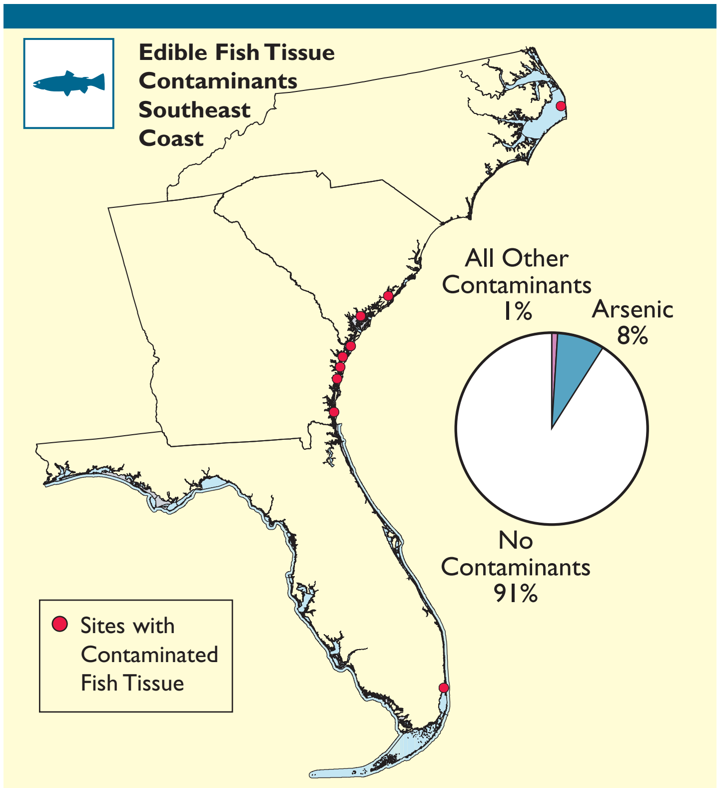


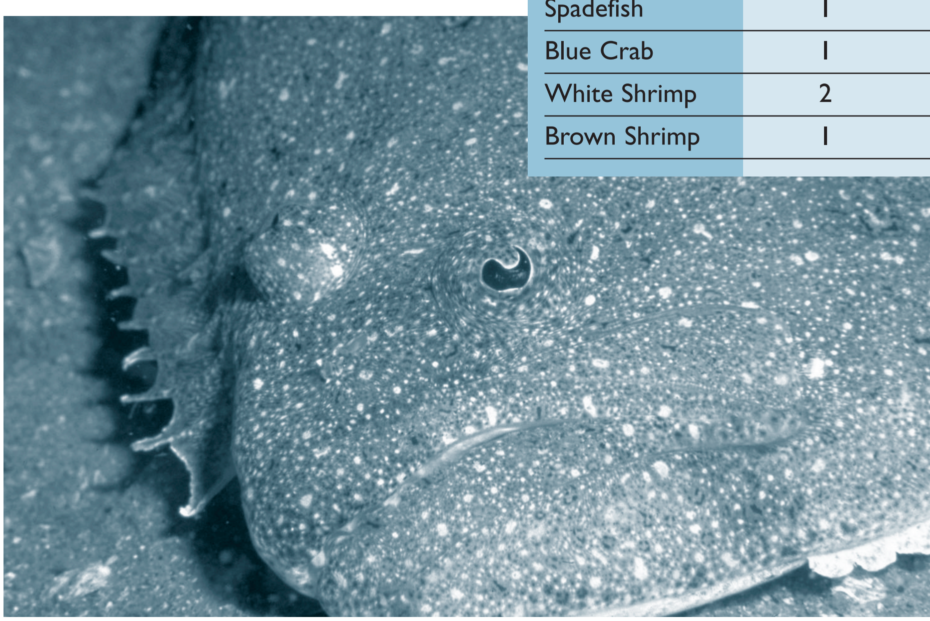
Figure 4-16. Contaminants in edible fish tissues in sampled sites along the Southeast Coast (U.S. EPA/EMAP).

Less than 0.1% of the approximately 14,586 fish and shellfish examined from the region in 1995 had visible pathologies (Hyland et al., 1998) (Table 4-1). Growths, ulcerations, and fin rot were observed in 0.2% of fish, with white perch showing the highest incidence (3.4%). Shellfish showed shell disease in 0.2% of blue crabs and cotton disease in 0.07% of white and brown shrimp.

In summary, available data show that about 54% of southeastern estuaries are in good condition. The remaining 46% are showing some signs of environmental stress, although no obvious connections between adverse biological and exposure conditions related to human activities could be detected throughout much of this area. For example, co-occurrences of degraded benthos and adverse exposure conditions (high sediment contamination in excess of sediment bioeffects guidelines and/or significant sediment toxicity based on standard assays) were much less extensive, occurring in only about 12% of the total area of these estuaries. While the overall level of degradation in southeastern estuaries is moderate, it occurred frequently enough, with respect to spatial extent and number of indicators, that condition should be measured periodically to ensure that increasing degradation does not occur. Programs like the Coastal 2000 Program implemented throughout North Carolina, South Carolina, Georgia, and Florida will provide this continuing surveillance.

Table 4-1. Number of Fish and Shellfish with Gross Pathologies in Southeastern Estuaries

Species	Number of Pathologies	Number of Fish	Percent with Pathologies	Standard Error of Estimate
Atlantic Croaker	1	3,564	0.03	0.01
White Perch	5	146	3.40	0.10
Spadefish	1	74	1.40	0.30
Blue Crab	1	483	0.20	0.03
White Shrimp	2	3,390	0.10	0.01
Brown Shrimp	1	543	0.20	0.02



The dusky flounder (*Syacium papillosum*) is usually left unnoticed buried and camouflaged by sand (Photo: Dean De Philipo/ Passage Productions).

Assessments and Advisories

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

The states on the Southeast Coast assessed 5,616 (63%) of their 8,956 estuarine square miles for their 1998 305(b) reports. Of the assessed estuarine waters on the Southeast Coast, 74% fully support their designated uses, 4% are threatened for one or more uses, and the remaining 22% are impaired by some form of pollution or habitat degradation (Figure 4-17). Individual use support for assessed estuaries is shown in Figure 4-18. The states on the Southeast Coast did not assess any of their 9,070 shoreline miles. Although Florida reports water quality information for coastal waters for 305(b), it is not possible from that report to distinguish between Atlantic Coast and Gulf Coast listings. So 305(b) assessment information for Florida is included in its entirety in this section.

Table 4-2 shows individual use support reported by states for their assessed estuarine and coastal waters.

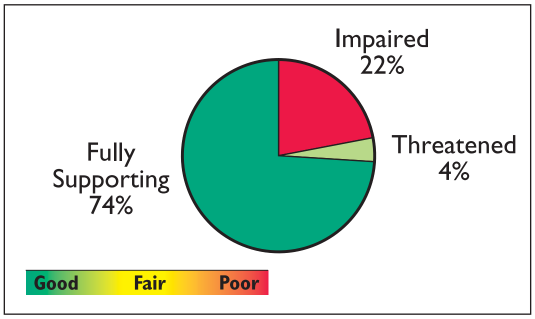


Figure 4-17. Water quality in assessed estuaries on the Southeast Coast (U.S. EPA).

Table 4-2. Individual Use Support for Assessed Coastal Waters Reported by States on the Southeast Coast under Section 305(b) of the Clean Water Act

Individual Uses	Estuaries Assessed as Impaired (mi^2)	Percent of Total Area Assessed
Aquatic Life	504	30%
Fish Consumption	340	29%
Shellfish Harvesting	874	34%
Swimming	361	22%
Secondary Contact	333	23%

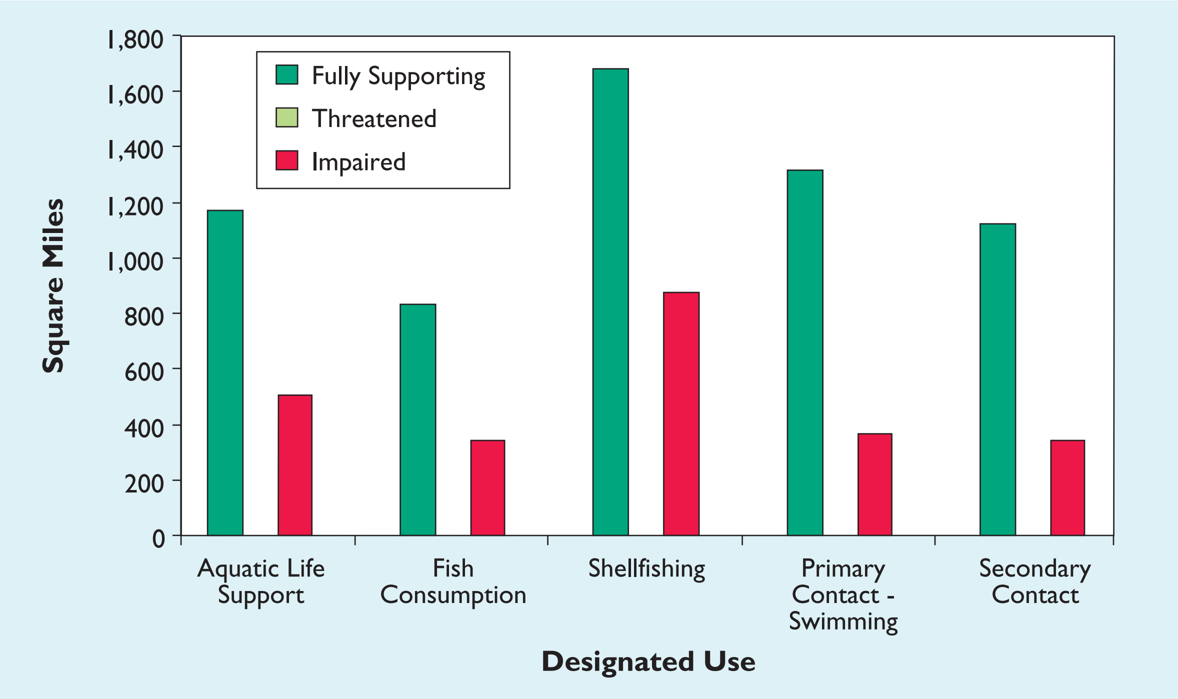


Figure 4-18. Individual use support for assessed estuaries on the Southeast Coast (U.S. EPA).

There are 134 waters on the Southeast Coast that are listed as impaired under Section 303(d) of the Clean Water Act. The percentage of listed waters impaired by each of the major pollutant categories is shown in Figure 4-19.

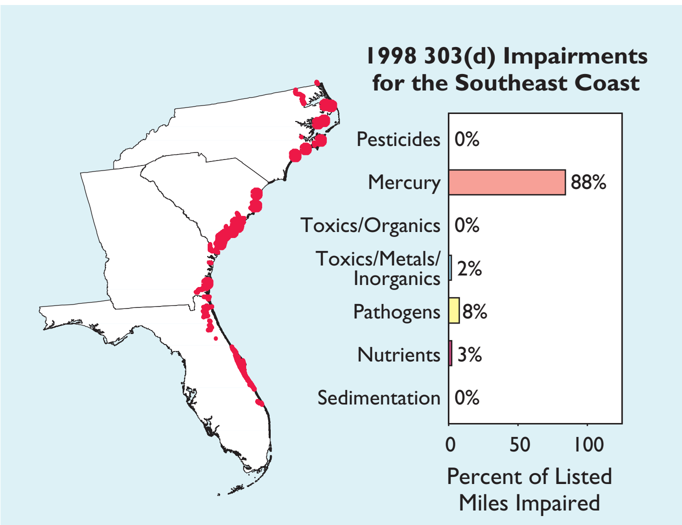


Figure 4-19. 303(d) listed waters on the Southeast Coast and the percentage of listed waters impaired by the major pollutant categories (note that a listing may be impaired by multiple pollutants) (U.S. EPA).

State Fish Consumption Advisories

Eight fish consumption advisories were active in the coastal waters of the Southeast in 2000 (Figure 4-20). All four coastal states had statewide advisories covering all coastal waters and estuaries to warn citizens against consuming large quantities of king mackerel because of potential mercury contamination. Because of these statewide advisories, 100% of the total coastline miles of the Southeast were under advisory.

The following species were under advisory for at least some portion of the Southeast Coast during 2000:

Spotted sea trout	Mussels	Clams
Largemouth bass	Silver perch	Blue crab
Atlantic croaker	Jack crevalle	Oysters
Red drum	Flounder	King mackerel
Black drum	Ladyfish	

The majority of fish consumption advisories on the Southeast Coast (64%) were the result of mercury contamination (Figure 4-21). Advisories were only issued for two other pollutants, PCBs and dioxins. All PCB advisories were in Georgia, and the one dioxin advisory was in North Carolina's Albemarle Sound.

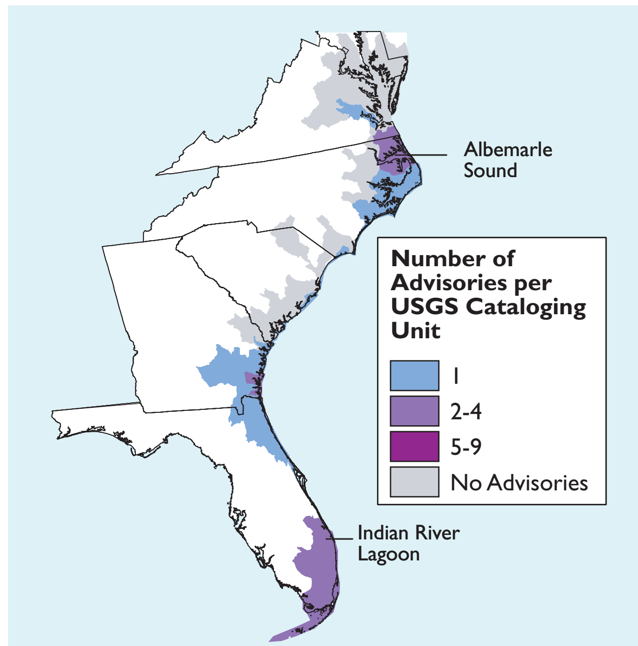


Figure 4-20. The number of fish consumption advisories per USGS Cataloging Unit in southeastern coastal waters. These data are for 2000 (U.S. EPA NLFWA, 2000c).

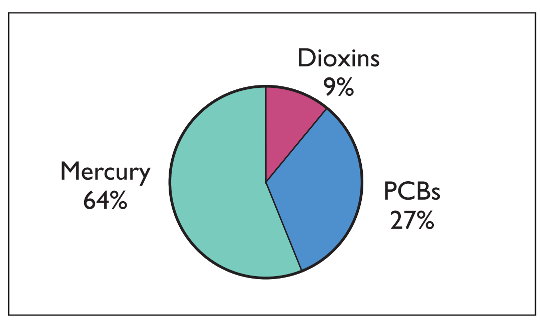


Figure 4-21. Pollutants responsible for fish consumption advisories in coastal waters of the Southeast (percent of 2000 advisories issued for each pollutant) (U.S. EPA NLFWA, 2000c).

Classified Shellfish-Growing Waters

Shellfishing plays an important role in the ecology and economy of southeastern states. In the Southeast, 3.9 million acres were classified for shellfish harvest in 1995. Of these, 71% of waters were approved, 16% were harvest-limited, and 13% were unclassified (Figure 4-22). Nationally, the Southeast Coast ranks second in the percentage of approved waters. Of the classified acreage, 64% is located in estuarine waters and 36% in nonestuarine waters. The top three pollution sources affecting harvest limitation are wildlife, urban runoff, and agricultural runoff.

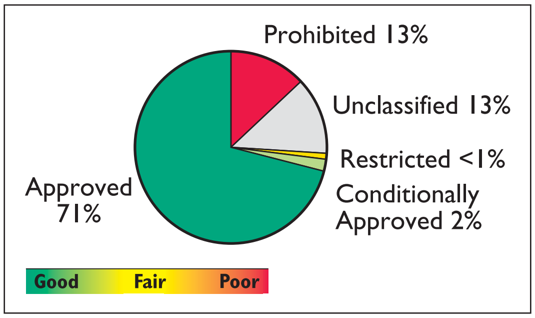


Figure 4-22. Classification of shellfish-growing waters for the Southeast (1995 Shellfish Register, NOAA, 1997).

The top two shellfish species (rated high or medium in abundance) in the Southeast are hard clams (463,711 acres) and eastern oysters (417,483 acres). Hard clams and eastern oysters are found at high or medium relative abundance in 11% of the region's shellfish-growing waters. Nine percent (43,179 acres) of hard clams and 27% (111,327 acres) of eastern oysters are located in waters that do not allow direct harvesting (i.e., restricted, conditionally restricted, and/or prohibited).

Beach Closures

A total of 127 beaches in the Southeast reported information to EPA's BEACH Program on beach monitoring activities and beach closings during 1999. The only beach closings reported on the Southeast Coast (seven beaches) occurred in Florida (Figure 4-23). All of the reported beach closures resulted from elevated bacteria levels due to storm water runoff, pipeline breaks, and boat discharges.

All of the beaches reporting information in North Carolina, South Carolina, and Georgia had monitoring programs in 1999. However, only 61% of beaches reporting from the east coast of Florida had monitoring in place for bacteria levels. None of the beaches in Georgia contributed information to the EPA survey because the state did not have a monitoring or beach closure program; however, Georgia began a monitoring program in 1999 and reported monitoring information from four beaches.

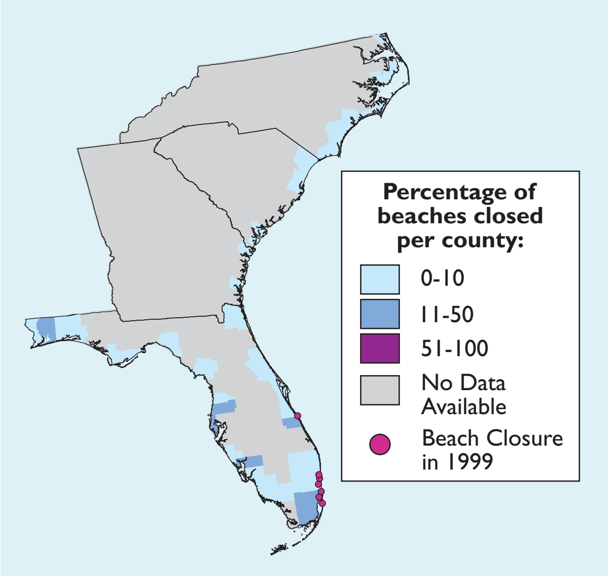
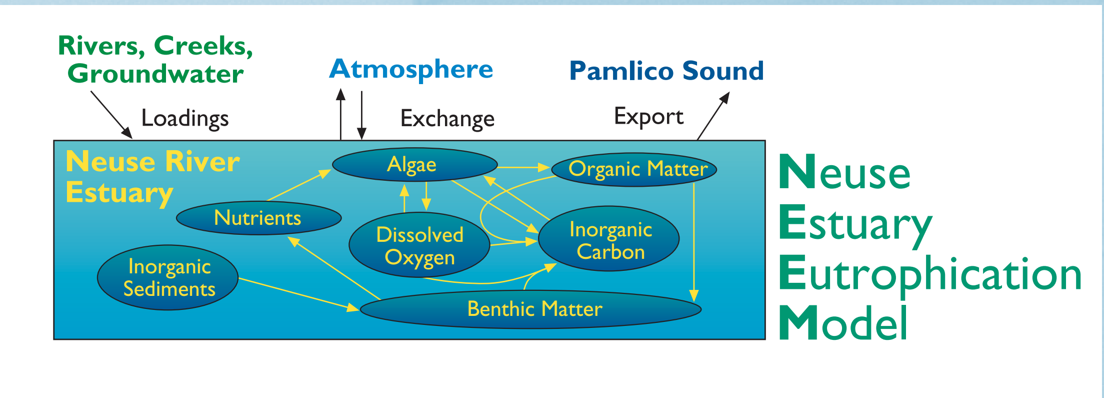


Figure 4-23. The only beach closings in 1999 reported to EPA for the Southeast Coast occurred in Florida. Other closings may have occurred but were not reported to EPA.

Eutrophication Studies in the Neuse River Estuary

The Neuse River Estuary is home to some of North Carolina's most economically valuable commercial and recreational fish and shellfish, in addition to being a highly valued recreational and industrial resource. However, the slow-flowing waters of the estuary provide near perfect conditions for algal blooms and eutrophication when combined with the increased nitrogen loading that has taken place in the last 3 to 4 decades. Recently, the state legislature mandated a 30% reduction in nitrogen loading to reduce the unwanted symptoms of eutrophication (nuisance algal blooms, hypoxia, fish kills). Because it is often difficult to predict or identify the effects of water quality management decisions, the plan to reduce nitrogen loading by 30% has created an opportunity for scientists to conduct a large-scale experiment using data collected before, during, and (eventually) after the reduction.

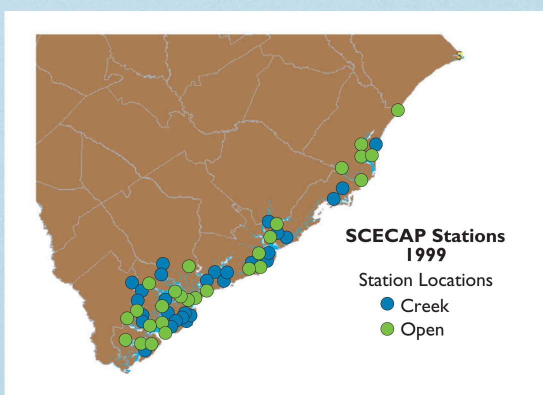
The multidisciplinary Neuse Modeling and Monitoring (MODMON) project was designed to collect monitoring data to establish the status and trends of water, sediment, and habitat quality in the estuary. Another aspect of MODMON was to create short-term and long-term water quality models such as the Neuse Estuary Eutrophication Model (see figure). Results of different model scenarios can be found on the Internet: http://www.marine.unc.edu/neuse/modmon.



This model simulates the processes used to predict water quality in the Neuse River for various nutrient loading and hydrologic scenarios.

South Carolina Estuarine and Coastal Assessment Program

In 1999, the South Carolina Department of Natural Resources (SCDNR) and the South Carolina Department of Health and Environmental Control (SCDHEC) initiated a major new collaborative coastal monitoring program. The goal of the South Carolina Estuarine and Coastal Assessment Program (SCECAP) is to monitor the condition of the state's estuarine habitats and associated biological resources annually. This program significantly expands current ongoing monitoring efforts being conducted by SCDNR and SCDHEC by drawing upon the expertise of both in a cooperative effort. SCECAP integrates measures of water and sediment quality with multiple measures of biological condition at a large number of sites throughout the state's coastal zone. It also expands historical monitoring activities that have focused primarily on open water habitats (e.g., bays, sounds, tidal rivers) to include an assessment of conditions in tidal creeks, which serve as important nursery habitat for most of the state's economically valuable species (see figure). Many of these tidal creeks are also the first point of entry for nonpoint source runoff from upland areas and, therefore, can provide an early indication of anthropogenic stress.



Sampling sites for SCECAP in 1999.

Summary

Ecological conditions in southeastern estuaries are fair (Figure 4-24). The primary problem in southeastern estuaries in the 1990s has been wetland loss and sediment contamination. Sediment contamination received a rating of fair, with high levels of contaminants being detected over moderate areas, but with additional low-level contamination detected over broader areas (particularly for pesticides and metals). Resulting health of resident benthic fauna was considered fair, with evidence of impaired benthic assemblages detected in about 17% of these estuaries. Wetland losses in the Southeast are substantial and receive a fair rating. Dissolved oxygen conditions are considered good and the condition of fish is also considered good, based on the low occurrence of contaminated tissues in fish sampled in southeastern estuaries. Increasing population pressures in this region of the country will require additional programs and increasing environmental awareness in order to correct existing problems and ensure that indicators that appear to be in fair condition do not worsen.

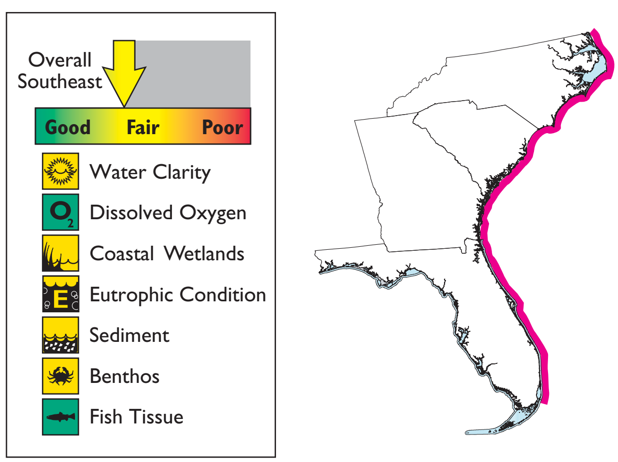
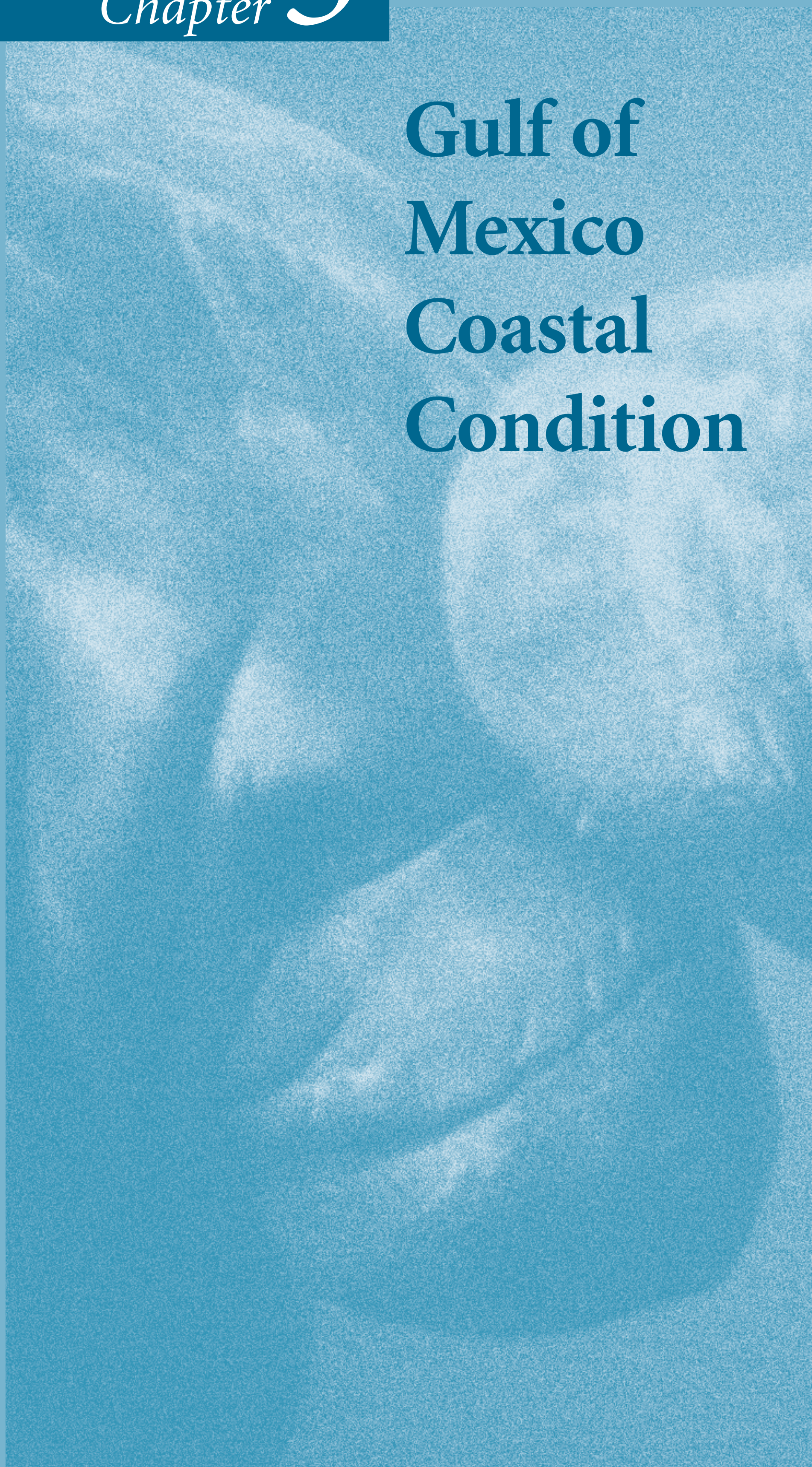


Figure 4-24. Ecological conditions in southeastern estuaries are fair.

Chapter 5

Gulf of Mexico Coastal Condition



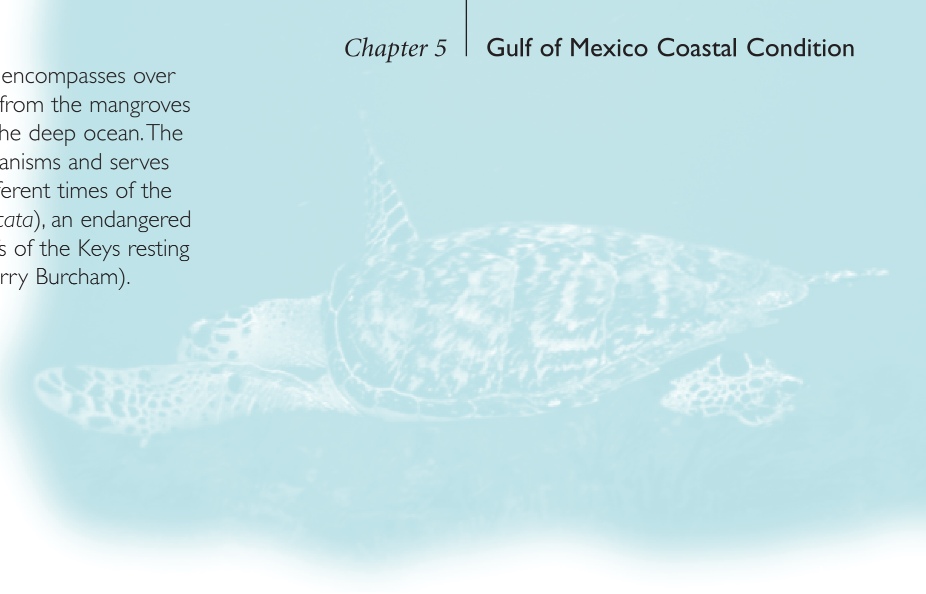
Chapter 5

Gulf of Mexico Coastal Condition


The Florida Keys National Marine Sanctuary is visited by several marine mammal species, including the endangered West Indian manatee (Photo: Laurel Canty-Ehrlich).

The overall condition of Gulf Coast estuaries is fair to poor (Figure 5-1). From 1991 to 1995, EMAP collected environmental stressor and response data from 500 locations from Florida Bay, Florida, to Laguna Madre, Texas. Fifty-one percent of the assessed estuaries of the Gulf of Mexico were in good ecological condition, meaning that, in the most stressful period of the year, neither environmental stressors (nutrients, contaminants, etc.) nor aquatic life communities showed any signs of degradation (Figure 5-2). Another 37% showed indications of poor aquatic life conditions and 27% were impaired for human uses.

Gulf of Mexico estuaries (Figure 5-3) provide critical feeding, spawning, and nursery habitats for a rich assemblage of fish, wildlife, and plant species. Hundreds of species of birds, recreational and commercial fish and shellfish species, native cypress and mangroves, and threatened and endangered species such as sea turtles, Gulf sturgeon, beach mice, and manatees can be found in Gulf estuary habitats. These estuaries support



The Florida Keys National Marine Sanctuary encompasses over 2,800 square nautical miles of ocean waters from the mangroves and beaches of the Keys all the way out to the deep ocean. The Sanctuary is home to a wide diversity of organisms and serves as a resting place for migrating animals at different times of the year. The hawksbill turtle (*Eretmochelys imbricata*), an endangered species, can occasionally be seen on the reefs of the Keys resting or feeding on sponges and jellyfish (Photo: Jerry Burcham).

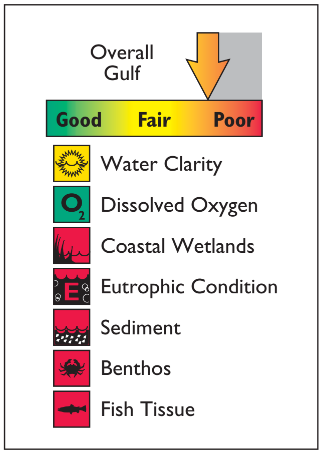


Figure 5-1. The overall condition of Gulf of Mexico coastal resources is fair to poor.

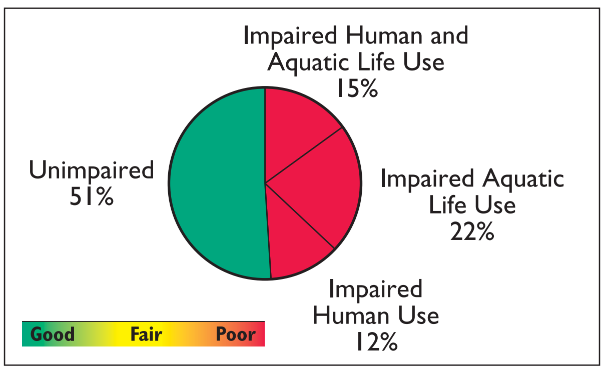


Figure 5-2. The condition of estuaries on the Gulf of Mexico Coast; estimates ±6% based on 5 years of sampling (U.S. EPA/EMAP).

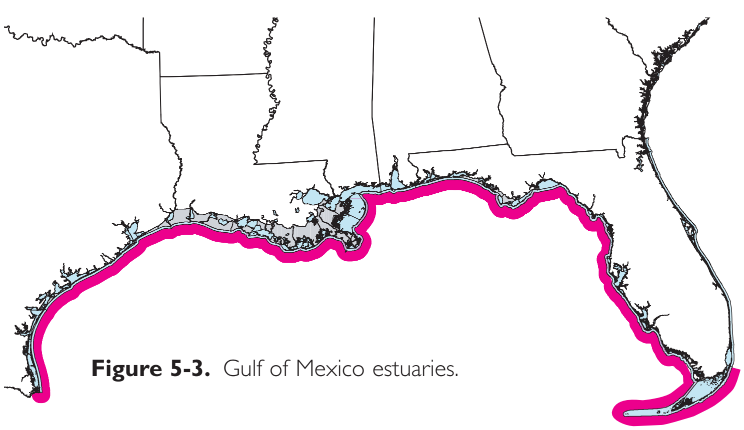


Figure 5-3. Gulf of Mexico estuaries.

submerged aquatic vegetation communities that stabilize shorelines from erosion, reduce nonpoint source loadings, improve water clarity, and provide habitat.

The population of coastal counties along the Gulf Coast increased 52% between 1970 and 1990 (U.S. Bureau of the Census, 1996). Despite the increasing human impacts on the Gulf Coast, relatively little attention has been focused on the environmental concerns of the Gulf of Mexico estuaries or upon the condition of its estuarine resources. EMAP focused its coastal monitoring efforts on the Gulf of Mexico estuaries from 1991 to 1999 (Macauley et al., 1999; U.S. EPA, 1999). The Joint Gulf States Comprehensive Monitoring Program (GMP, 2000) began in 2000 in conjunction with EPA's Coastal 2000 Program. In addition, since the late 1980s, NOAA's NS&T Program has collected contaminant bioavailability and sediment toxicity data from several Gulf of Mexico locations (Long et al., 1996).

Coastal Monitoring Data

Water Clarity

Water clarity in Gulf Coast estuaries is fair. Water clarity was estimated by light penetration through the water column. For approximately 22% of the waters in Gulf of Mexico estuaries, less than 10% of surface light penetrated to a depth of 1 meter (Figure 5-4).

Dissolved Oxygen

Dissolved oxygen conditions in Gulf Coast estuaries are generally good, except in a few highly eutrophic regions. EMAP estimates for Gulf of Mexico estuaries show that about 4% of the bottom waters in the Gulf estuaries have hypoxic conditions or low dissolved oxygen (<2 ppm) on a continuing basis in late summer (Figure 5-5). These areas are largely associated with Chandeleur and Breton Sounds in Louisiana, some shoreline regions of Lake Pontchartrain, northern Florida Bay, and small estuaries associated with Galveston Bay, Mobile Bay, Mississippi Sound, and the Florida panhandle.

While hypoxia resulting from anthropogenic activities is a relatively local occurrence in Gulf of Mexico estuaries, accounting for less than 5% of the estuarine bottom waters, the occurrence of hypoxia in the Gulf's shelf waters is much more significant (Figure 5-6). The Gulf of Mexico hypoxic zone is the largest zone of anthropogenic, or human-caused, coastal hypoxia in the Western Hemisphere (CAST, 1999). Since 1993, midsummer bottom water hypoxia in the northern Gulf of Mexico has been larger than 3,861 square miles, and in 1999, it reached 7,722 square miles (CENR, 2000) (Figure 5-7). This hypoxia occurs in

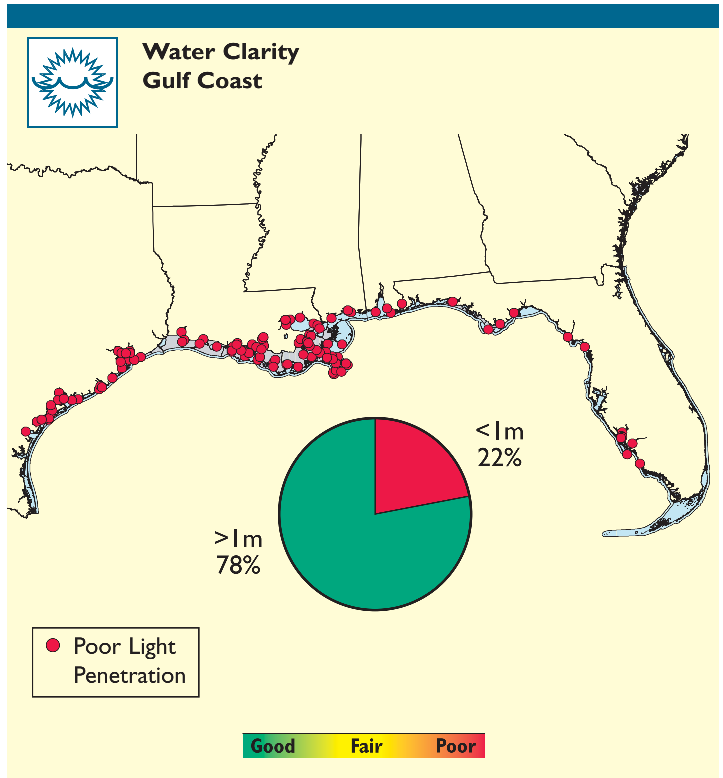


Figure 5-4. Light penetration data and locations for sites with <10% light penetration along the Gulf Coast (U.S. EPA/EMAP).

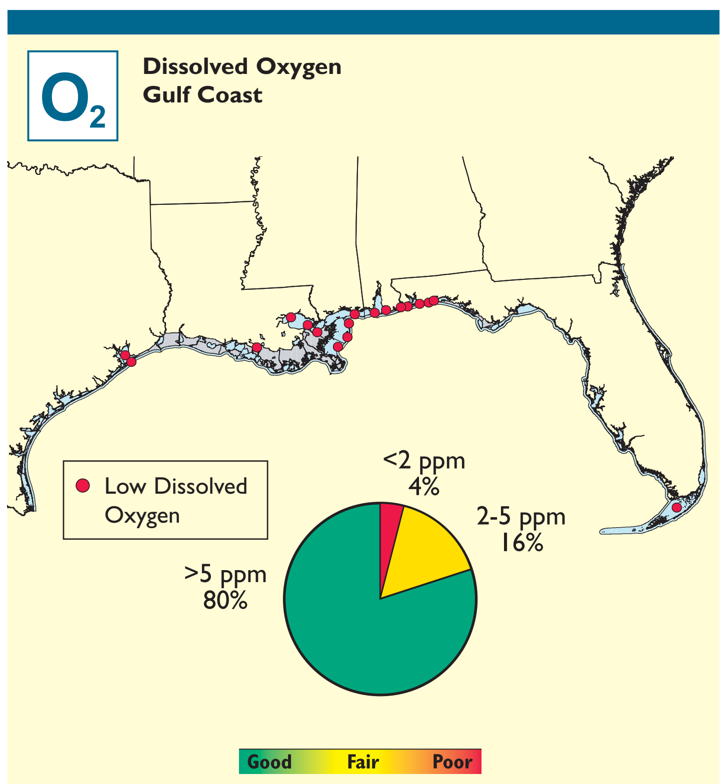


Figure 5-5. Dissolved oxygen data and locations for sites with less than 2 ppm for the Gulf Coast (U.S. EPA/EMAP).

Figure 5-6. Mississippi-Atchafalaya River Basin and Gulf of Mexico hypoxic zone.

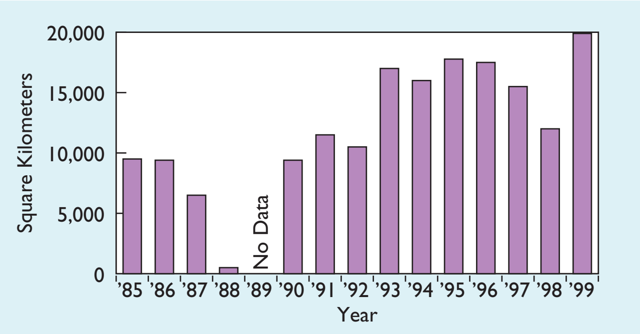


Figure 5-7. Areal extent of mid-summer hypoxia in the Gulf of Mexico (1985-1999) (CENR, 2000).

the Gulf of Mexico waters receiving flow from the Mississippi-Atchafalaya River Basin and results from (1) nutrients delivered from the watershed that foster large-scale phytoplankton production in shelf waters or (2) decomposition of organic material delivered from that watershed. Sediment cores from the hypoxic zone show that shelf algal reproduction was significantly lower in the first half of the 20th century, suggesting that anthropogenic changes to the basin and its discharges have resulted in the increased hypoxia (CENR, 2000).

Since 1980, the basins providing discharge to this portion of the Louisiana shelf have averaged nearly 2 million tons of nitrogen to the Gulf annually. Increases have been observed since the 1950s, primarily of nitrate nitrogen with total nitrate flux tripling from the 1960s and 1970s to the 1980s and 1990s. Over half of the nitrogen load comes from nonpoint sources north of the confluence of the Ohio and Mississippi Rivers, with much of the loading coming from the drainage of agricultural lands (CENR, 2000). Gulf of Mexico ecosystems and fisheries are affected by the widespread hypoxia. Mobile organisms leave the hypoxic zone for more oxygen-rich waters, and those that cannot leave frequently die.

Estimates of Gulf of Mexico hypoxia have not been included in the estimates of Gulf estuarine hypoxia. Thus, a determination of a low proportion of estuarine bottom waters having hypoxic conditions and, consequently, a "good" rating in estuaries for dissolved oxygen should not be indicative of offshore conditions. Using similar standards (similar to those for estuarine waters), Gulf of Mexico shelf bottom waters would be rated "poor" for dissolved oxygen conditions.

Much of this discussion of Gulf hypoxia is taken from six science topic reports and an integrated scientific assessment of Gulf of Mexico hypoxia produced by the National Science and Technology Council Committee on Environment and Natural Resources (CENR, 2000). The six topic reports underwent rigorous peer review with oversight by an independent editorial board. The report, integrated assessment, and the comments are available on the Internet at http://www.nos.noaa.gov/products/pubs_hypox.html. The Council for Agricultural Science and Technology (CAST) also produced a report that provides recommendations to help better understand all aspects of hypoxia in the Gulf of Mexico and to decrease the Gulf hypoxic zone. This report is available on the Internet at http://www.cast-science.org/castpubs.htm. Specific action to address this environmental issue is highlighted in this chapter.

Coastal Wetland Loss

The coastal wetlands indicator for the Gulf of Mexico receives a score of poor. Wetland losses along the Gulf of Mexico from the 1780s to 1980s are among the highest in the nation (Figure 5-8). Losses over the 200-year timespan were 50% throughout the Gulf and ranged from 46% declines in Florida and Louisiana (although the absolute losses in these states were the highest) to a 59% decline in Mississippi. During the 1970s to 1980s, the Gulf lost 5% of its wetlands, with the largest declines seen in Texas (Figure 5-9). Not all of the wetland losses in the Gulf of Mexico are due to coastal development. Sea-level rise, coastal subsidence, and interference with normal erosional/depositional processes also contribute to wetland loss.

Coastal Wetland Habitat Loss from 1780 to 1980

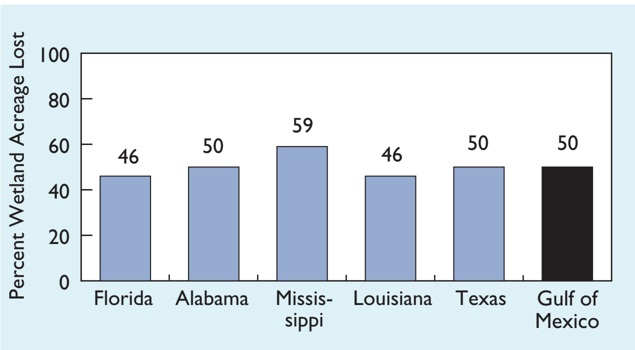


Figure 5-8. Percent wetland habitat loss from 1780 to 1980 by state and for the Gulf of Mexico region overall (Dahl, 1990; Turner and Boesch, 1988).

The red mangrove (*Rhizophora mangle*), the colonizing mangrove, is the largest of the mangroves and is usually the first tree found when coming ashore in the Florida Keys. The red mangrove has prop roots often characterized as "walking" roots due to their resemblance to a person's legs while walking. The black mangrove (*Avicennia germinanas*) is found upland of the red mangrove. This tree has pneumataphores, aerial roots that resemble limbs growing upwards, that assist the tree in obtaining oxygen in its anaerobic substrate. The white mangrove (*Laguncularia racemosa*) grows farther inland and is not continuously inundated with saltwater. It does feel the effects of the salty environment though, and has two pores at the base of its leaves that excrete the excess salt (Photo: Florida Keys NMS).

Coastal Wetland Habitat Loss from 1970 to 1980

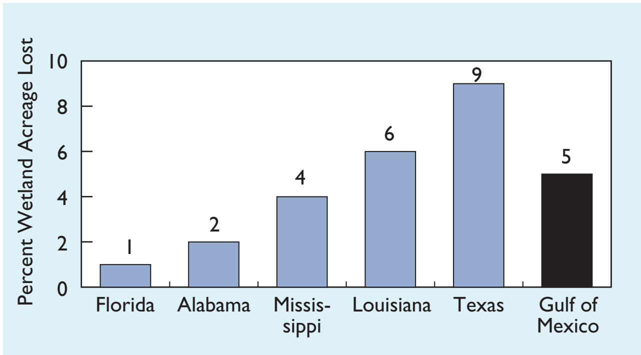


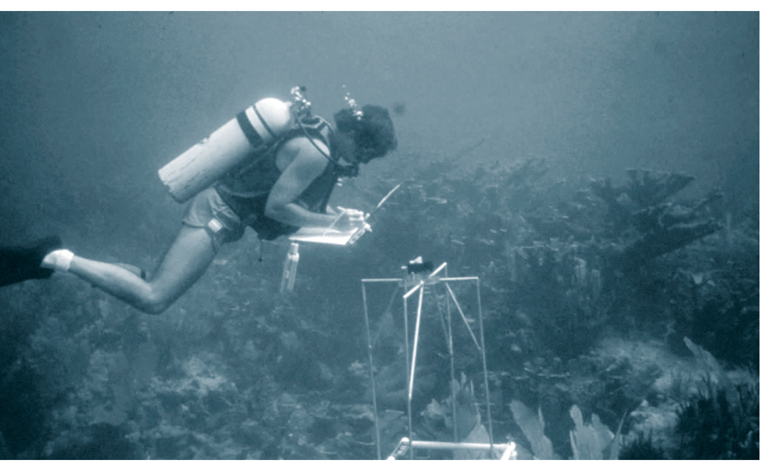
Figure 5-9. Percent decline in acreage of wetlands from the 1970s to 1980s by state and for the Gulf of Mexico region overall (Hefner et al., 1994).

Eutrophic Condition

The condition of Gulf Coast estuaries as measured by eutrophic condition is poor. Expression of eutrophic condition was high in 38% of the area in Gulf estuaries (Figure 5-10). The symptoms of eutrophic condition are expected to increase in over half of Gulf of Mexico estuaries by 2020.

High expressions of chlorophyll *a* were determined for about 30% of the estuarine area of the Gulf of Mexico. The areas with high chlorophyll *a* were largely in Louisiana, Laguna Madre, Tampa Bay, and Charlotte Harbor (Figure 5-11).

One area worthy of discussion is Florida Bay, which has a high eutrophic condition but low chlorophyll *a*. Concentrations of about 50 µg/L were used to classify an estuary as having a high concentration of chlorophyll *a*. Chlorophyll *a* concentrations in Florida Bay as low as 20 µg/L have been shown to be potentially eutrophic due to the physical, chemical, and ecological dynamics of that system.



Scientists from other local, state, regional, and national governmental resource protection agencies, universities, and nongovernment organizations conduct much of the research in the Florida Keys National Marine Sanctuary. In this picture, photomonitoring of the corals is being done as part of a long-term monitoring program used to indicate changes and trends in the health of the coral reef (Photo: Mike White, Florida Keys NMS).

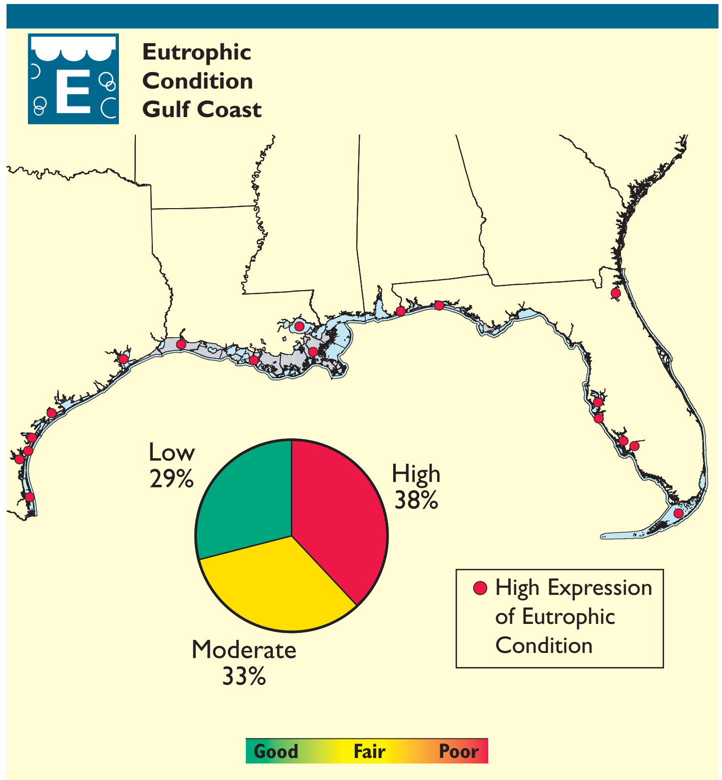


Figure 5-10. Eutrophic condition data and locations of estuaries with high expression eutrophic condition along the Gulf Coast (NOAA/NOS).

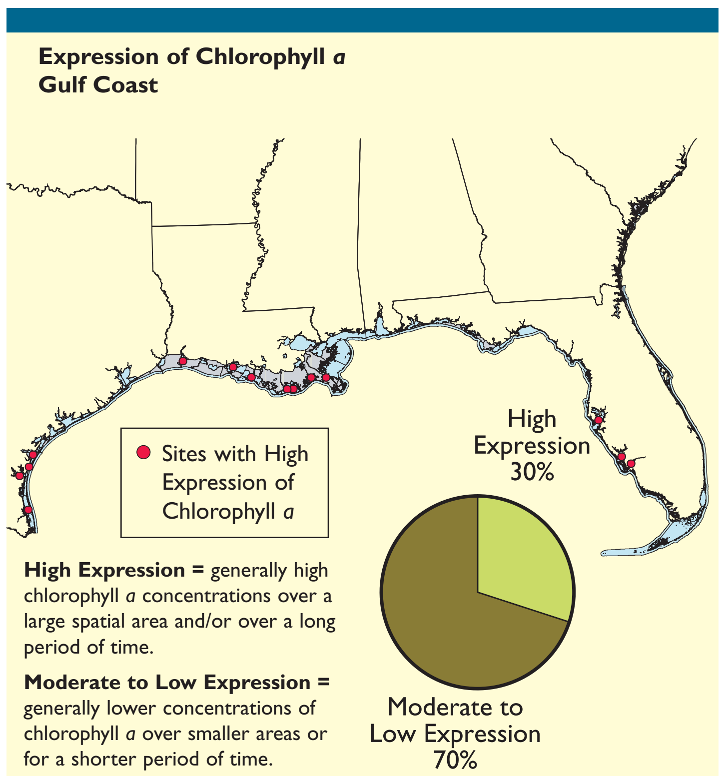


Figure 5-11. Chlorophyll *a* data in surveyed estuaries along the Gulf Coast and locations of estuaries with high expressions of chlorophyll *a* (NOAA/NOS).

highlight

A National Strategy To Address Hypoxia in the Gulf of Mexico

The best current science indicates that excessive nutrient input, particularly nitrogen, from the 31-state Mississippi/Atchafalaya River Basin contributes to the annual formation of a hypoxic zone in the northern Gulf of Mexico. This low-oxygen condition, which threatens the vast ecological habitat, has averaged about 5,405 square miles over the past 5 years (1995-2000). Detailed information on the size of the hypoxic zone and nitrogen inputs from almost two-thirds of the United States is presented in this chapter. Concern over the environmental and economic impacts of this annual event has led to a national effort to assess and address the causes and solutions for reducing its adverse effects.

In 1998, Congress passed the Harmful Algal Bloom and Hypoxia Research and Control Act, which contained specific requirements for addressing Gulf of Mexico hypoxia. The first requirement was to produce an integrated assessment of causes and consequences, and the second was to produce a plan of action to reduce, mitigate, and control hypoxia. As a result of this legislation, NOAA, as directed by the National Science and Technology Council, led a scientific assessment team to investigate the causes and effects of the hypoxic zone as well as approaches for reducing its size and consequences. Teams with experts from within and outside the government developed and produced six interrelated, peer-reviewed reports that became the foundation for the overall integrated assessment published in May 2000.

To fulfill the second requirement, the National Science and Technology Council requested that an existing group, the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, lead the effort for developing the plan of action. EPA provided leadership for this Task Force, which included senior management members from 9 states, 2 tribes, and 10 federal agencies. Using the information provided in the scientific assessment along with other supplemental information, the Task Force produced a draft action plan that is available on the Internet at http://www.epa.gov/msbasin/fr-actionplan.html).

Following an October 2000 meeting in Baton Rogue, Louisiana, the Task Force finalized the action plan for delivery to the White House and ultimately to Congress. The final action plan includes a coastal goal for reducing the 5-year running average areal extent of the Gulf of Mexico hypoxia to less than 1,930 square miles by the year 2015. This will be accomplished through implementation of specific, practical, and cost-effective voluntary actions by all partners within the Basin aimed at achieving a 30% reduction (from the average discharge in the 1980-1996 time frame) in nitrogen discharges to the Gulf. Approaches for accomplishing the reductions include creating and restoring wetlands, increasing the efficiency of agricultural and urban non-point-source nutrient management practices, upgrading sewage treatment facilities for nitrogen removal, and continuing research and monitoring efforts within the Mississippi River Basin and the Gulf of Mexico. These efforts will all contribute to overall improved water quality within the Mississippi River Basin and reduction of the hypoxic condition in the Gulf of Mexico.

Sediment Contaminants

The condition of Gulf Coast estuaries as measured by sediment contaminants is poor. Sediment contaminant concentrations were rarely observed at greater than ERM guidelines (Long et al., 1996), but northern Galveston Bay and the Brazos River in Texas showed high sediment contaminant concentrations. EMAP reported that ERL guidelines were exceeded for all of the major groups of sediment contaminants, albeit at very low rates (less than 1% of area) for PAHs and PCBs (Figure 5-12). There are greater ERL exceedances for pesticides (43%) and heavy metals (32%), although most of the pesticide ERL exceedances are for dieldrin and endrin (both pesticides have ERL levels approximating their detection limits). The next pesticides with the largest areal exceedances of their ERL values are DDT (a chemical banned since 1972) at 12% and chlordane at 4%.

However, while concentrations of all sediment contaminants are relatively low, enrichment rates for Gulf of Mexico estuarine sediments range from 34% (heavy metals) to nearly 99% (PAHs and PCBs) (Figure 5-13).

Sediment Contaminant Criteria

ERM (Effects Range Medium) – The concentration of a contaminant that will result in ecological effects approximately 50% of the time based on literature studies.

ERL (Effects Range Low) – The concentration of a contaminant that will result in ecological effects about 10% of the time based on literature studies.

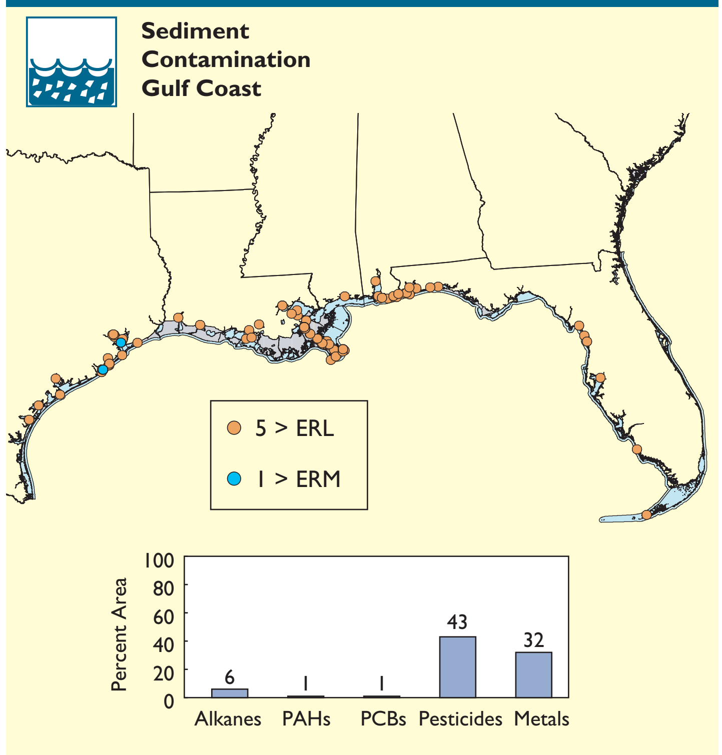


Figure 5-12. Sediment contamination for sampled sites and locations of sites with 5 > ERL or 1 > ERM along the Gulf Coast. (U.S. EPA/EMAP).

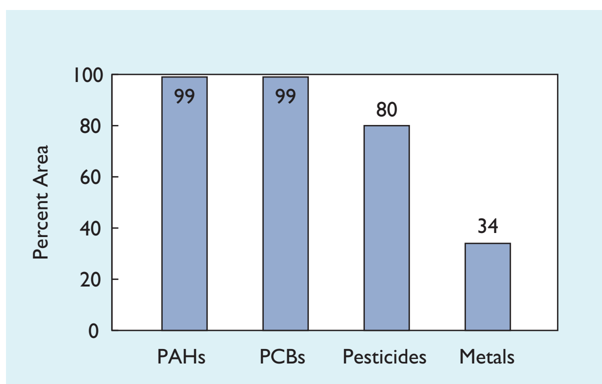


Figure 5-13. Sediment enrichment rates in Gulf of Mexico estuaries.

Benthic Condition

The condition of benthic indicators in Gulf Coast estuaries is poor. Benthic index estimates (Engle and Summers, 1999) based on EMAP surveys indicate that 23% of the estuarine area has degraded benthic resources (Figure 5-14). Of the 9,932 mi^2 in the Louisianian Province (Tampa Bay, Florida, to Laguna Madre, Texas) and of the 2,054 mi^2 of the West Indian Province located along the Gulf Coast, over 4,247 mi^2 were ecologically degraded with respect to benthos. Examination of the distributions of the benthic index in the three sampling strata within the Gulf of Mexico (large estuaries, large rivers, and small estuaries/rivers) showed that the Mississippi River had the largest proportion of its estuarine bottom area represented by poorer than expected benthic communities (82%), while large estuaries had the smallest proportional representation (18%). With the exception of the Big Bend and Ten Thousand Islands regions of Florida, most Gulf of Mexico estuarine regions showed some level of benthic degradation.

For the locations that showed poor benthic community quality, the co-occurrence of poor environmental quality (exposure) is shown in Figure 5-15. Of the 23% of the Gulf of Mexico estuarine area that had poor benthos, 70% also showed contaminated sediments, 1% showed sediment toxicity, 7% showed hypoxia, and 12% showed poor light conditions (high levels of total suspended solids). Only 10% of the locations that showed poor benthic community conditions had no sediment or water quality degradation. These locations

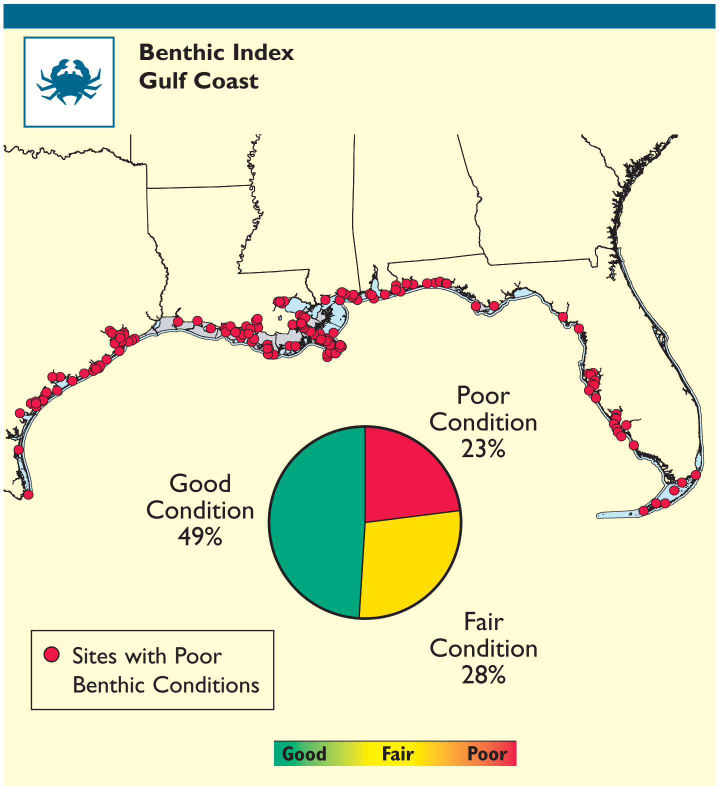


Figure 5-14. Benthic index condition data and locations with poor benthos along the Gulf Coast (U.S. EPA/EMAP).

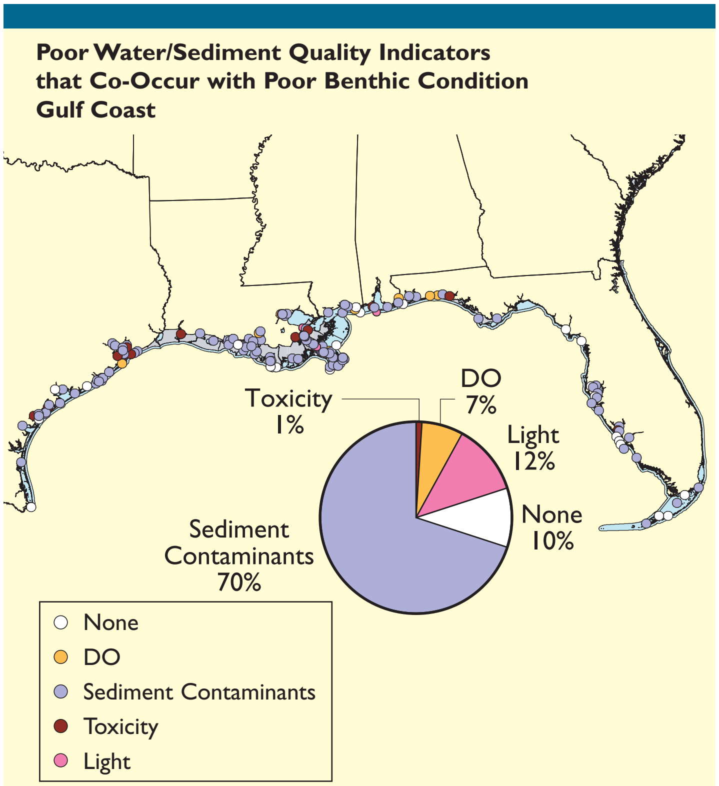


Figure 5-15. Indicators of poor water/sediment quality that co-occur with poor benthic condition in Gulf of Mexico estuaries (U.S. EPA/EMAP).

were spread throughout the five Gulf of Mexico states, although several of these sites are suspected of having poor nutrient water quality.

Sediment toxicity from EMAP and NOAA bioeffects data show that small proportions of Gulf of Mexico sediments are toxic (6% of sediments causing greater than 20% mortality in test organisms) (Figure 5-16). NOAA bioeffects surveys of Tampa Bay, Apalachicola Bay, St. Andrews Bay, Choctawhatchee Bay, Pensacola Bay, and Sabine Lake showed less than 1% of sediments to be toxic. EMAP surveys generally confirm these findings, although their surveys showed toxicity associated with Choctawhatchee River sediments, Bayou Texar in Pensacola Bay, and the Sabine Lake Canal. In addition, EMAP showed toxic sediments in several Big Bend, Florida, estuaries, lower Mississippi River and Atchafalaya River sediments, portions of Galveston Bay, western Lake Pontchartrain, as well as several other small estuarine systems in the Gulf of Mexico.

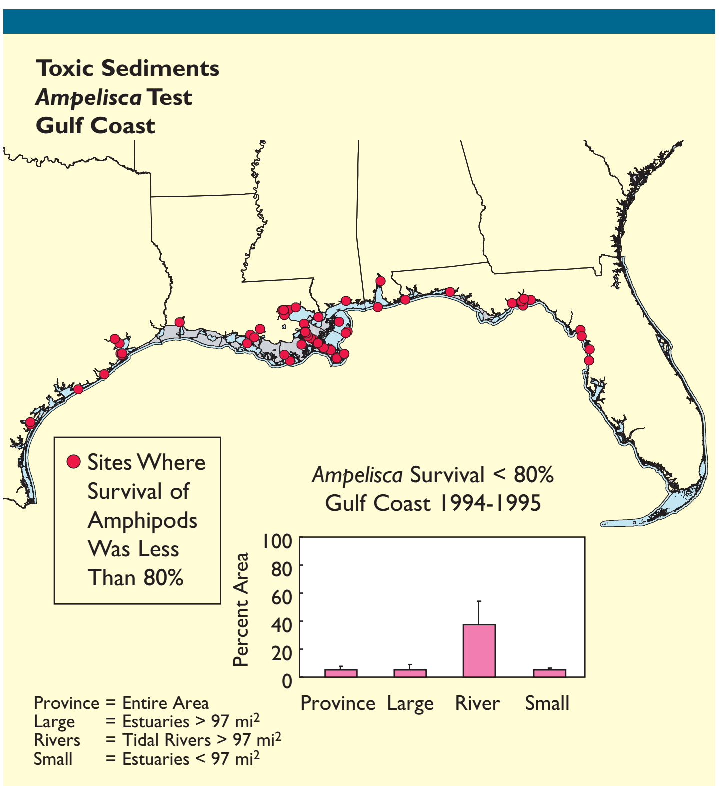


Figure 5-16. Amphipod data and locations with toxicity > 20% along the Gulf Coast (U.S. EPA/EMAP).

Fish Tissue Contaminants

The condition of Gulf Coast estuaries based on fish tissue contaminants is poor. Based on FDA limits for 15 of the 49 contaminants examined by EMAP, contaminant concentrations in edible fish and shellfish were low for all pesticides tested. However, guidance concentrations for metals were exceeded in all species examined. Concentrations of arsenic, chromium, copper, and selenium exceeded guidance values for 4% of shrimp, 9% of Atlantic croaker, and 32% of catfish. An estimated 20% of fish examined contained concentrations of metals exceeding guidance criteria (Figure 5-17), although 80% of these exceedances were for arsenic (16% of fish examined). Arsenic found in fish and shellfish is almost completely altered into organic arsenobetaines that are not toxic to humans. Thus, only about 4% of fish examined showed elevated levels of contaminants, with about 3% of catfish, 4% of shrimp, and 5% of croakers (Figure 5-18) showing elevated concentrations in edible tissues.

Less than 1% of the approximately 64,100 fish examined from the region had visible pathologies (Fournie et al., 1996) (Table 5-1). External pathologies were prevalent in upper trophic level fish (e.g., sea trout and permit) (1%), while demersal species exhibited an incidence of external pathologies in about 0.5% of the fish

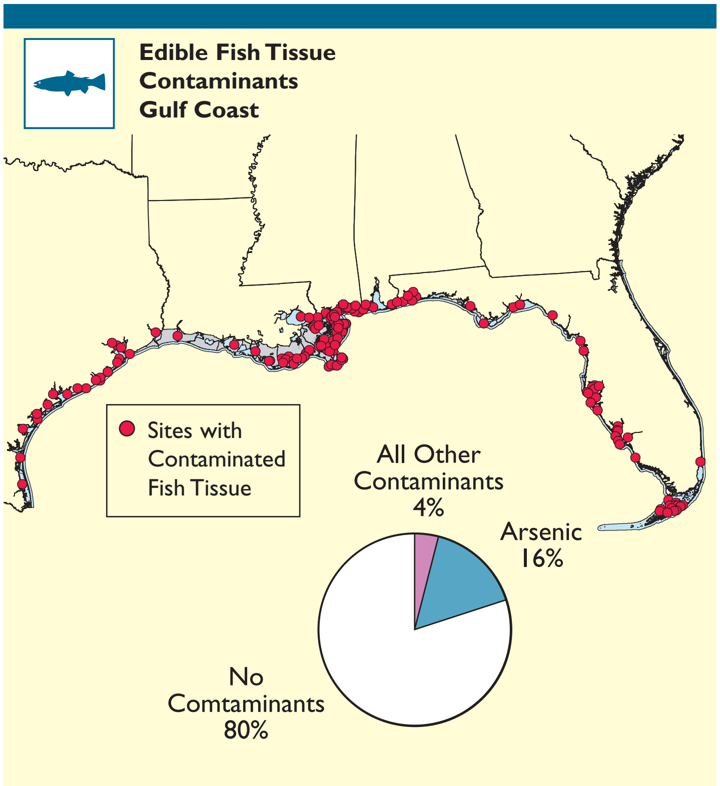


Figure 5-17. Contaminants in fish tissue, including arsenic (U.S. EPA/EMAP).

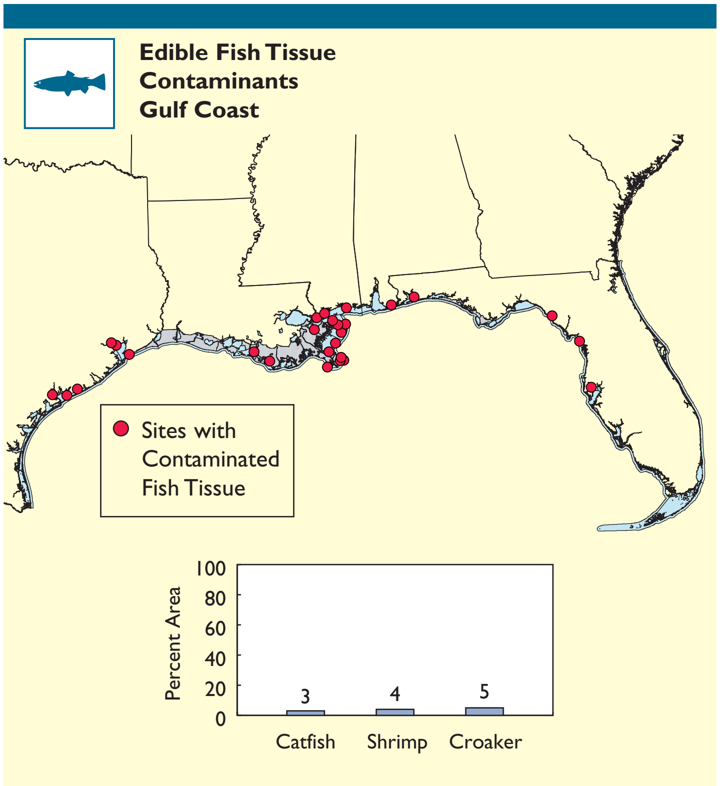


Figure 5-18. Contaminants in fish tissue, not including arsenic (U.S. EPA/EMAP).

examined. The estimation error associated with these percentages is about 0.0001%.

In summary, ecological conditions in the Gulf of Mexico show that about 50% of estuaries are in good condition. The remaining 50% are showing some signs of degradation; however, these signs are generally being seen in benthic communities and often represent chronic effects (e.g., changes in biodiversity and community structure) due to prolonged exposures to low levels of contaminants, increasing nutrients, and habitat degradation. While the level of estuarine degradation in Gulf of Mexico estuaries is low, it occurs relatively frequently and must be measured periodically to ensure that increasing degradation does not occur. Programs like the Joint Gulf States Comprehensive Monitoring Program jointly sponsored by the Gulf of Mexico states and EPA's Gulf of Mexico Program and Coastal 2000 will provide this continuing surveillance.

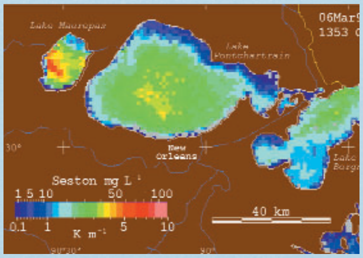
Table 5-1. Number of Fish with Gross Pathologies in Gulf of Mexico Estuaries

Group	Number of Pathologies	Number of Fish	Percent with Pathologies	Standard Error of Estimate
Demersal	198	44,781	0.442	0.000
Upper Trophic	43	4,179	1.028	0.002
Commercial/ Recreational	151	14,217	1.062	0.000
Pelagic	163	13,299	1.225	0.000

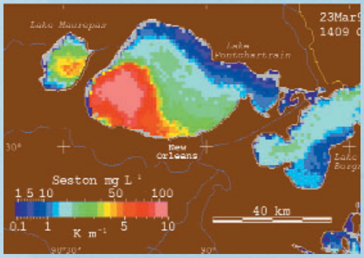
Lake Pontchartrain, Louisiana's Troubled Urban Estuary

Concentrated rapid population growth in the area between Lake Pontchartrain and the Mississippi River began nearly 300 years ago with the influx of European settlers. Development and urbanization in the New Orleans area is projected to continue and place even greater stress on the Pontchartrain Basin environment. Today, the Basin faces many challenges, including continued loss of wetlands and estuarine habitats, pollution of water and sediments, and potential impacts on the circulation patterns of Lake Pontchartrain from future freshwater diversions from the Mississippi River. The U.S. Geological Survey conducts a number of long-term studies in Lake Pontchartrain to provide scientific information to help managers and planners deal with these environmental challenges.

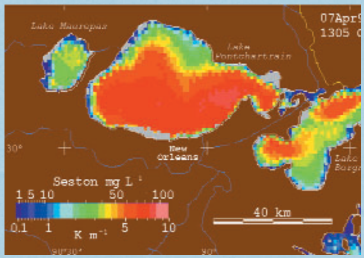
The opening of the Bonnet Carré Spillway, which connects the Mississippi River to Lake Pontchartrain, serves as one example of the human-induced environmental challenges in the estuary. In March 1997, the Spillway was opened to help divert flood waters from the Mississippi into Lake Pontchartrain. Satellite imagery revealed an increase in suspended material in the lake as a result of the diversion of flood-waters. Below are images derived from the Advanced Very High Resolution Radiometer (AVHRR) instrument onboard National Oceanic and Atmospheric Administration polar-orbiting satellites. The images illustrate the increase in suspended material in the lake as a result of the diversion of floodwaters. Dark red indicates more suspended sediment.



March 6,1997



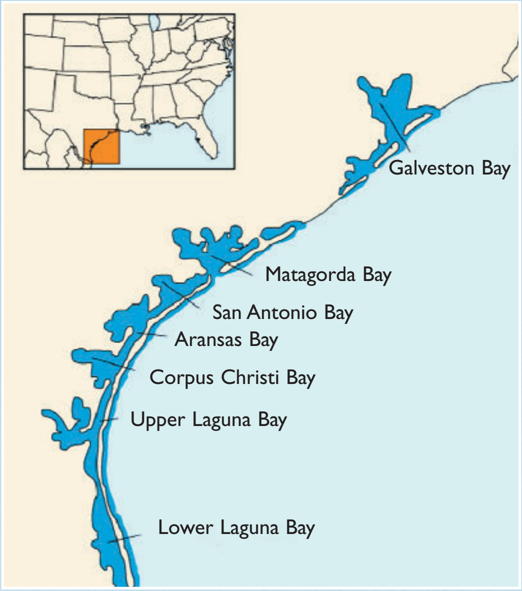
March 23,1997



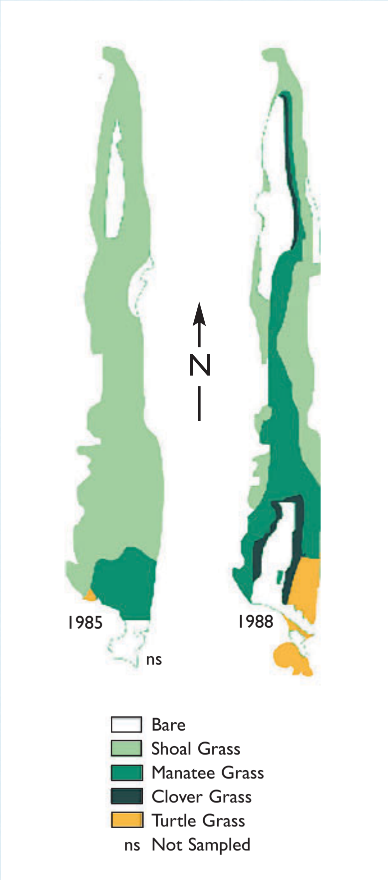
April 7,1997

Seagrass Meadows in Laguna Madre

Laguna Madre is a very shallow, naturally hypersaline (saltier than seawater) coastal body of water located in southern Texas near the Mexican border (see map). It covers over 600 square miles and averages only 2.5 feet in depth, but the deepest areas are over 5 feet deep. Seagrasses currently cover over 70% of both the upper and lower Laguna Madre. However, dramatic changes are taking place in the coverage and species composition of the seagrass communities.



The Texas coast.



Increased turbidity and changes in salinity are leading to dramatic changes in the seagrass meadows of the lower Laguna Madre (Onuf, 1995).

The upper Laguna Madre saw large increases in seagrass coverage from 1967 to 1988. Since 1988, seagrass meadows have been declining, particularly in the deeper areas of the lagoon. Current research suggests that recent declines are due to a persistent bloom of the phytoplankton *Aureoumbra lagunensis* (Texas brown tide). The bloom reduces water clarity and results in shading of deeper seagrasses, which are then unable to survive.

Seagrass coverage in the lower Laguna Madre is also declining, and species composition is changing rapidly. Historically, shoal grass (*Halodule wrightii*) dominated seagrass meadows in Laguna Madre. These meadows serve as overwintering grounds for redhead ducks (*Aythya americana*) that feed on shoal grass during the winter months. Since 1988, however, shoal grass coverage has been reduced 60% (left). Bare areas in the lagoon are increasing and shoal grasses are being replaced by manatee grass (*Syringodium filiforme*) and turtle grass (*Thalassia testudinum*). While declines appear largely due to brown tides, sediments suspended by maintenance dredging may have also contributed to reducing the amount of light reaching seagrasses and damaging the meadows.

Assessments and Advisories

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

Gulf Coast states assessed 7,276 (48%) of the 15,316 square miles that make up the Gulf Coast estuaries for their 1998 305(b) reports. Although Florida reports water quality information for coastal waters for 305(b), it is not possible from that report to distinguish between Atlantic Coast and Gulf Coast listings, so 305(b) assessment information for Florida is included in its entirety in this section. Thirty-two percent of the assessed estuarine waters on the Gulf Coast fully support their designated uses, and 6% are threatened for one or more uses (Figure 5-19). The remaining 62% of assessed estuarine waters on the Gulf Coast are impaired by some form of pollution or habitat degradation. Individual use support for estuaries is shown in Figure 5-20.

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

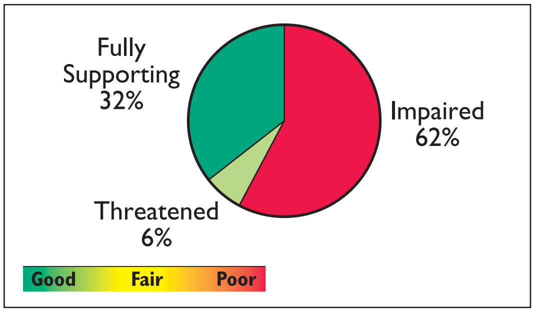


Figure 5-19. Water quality in assessed Gulf Coast estuaries (U.S. EPA).

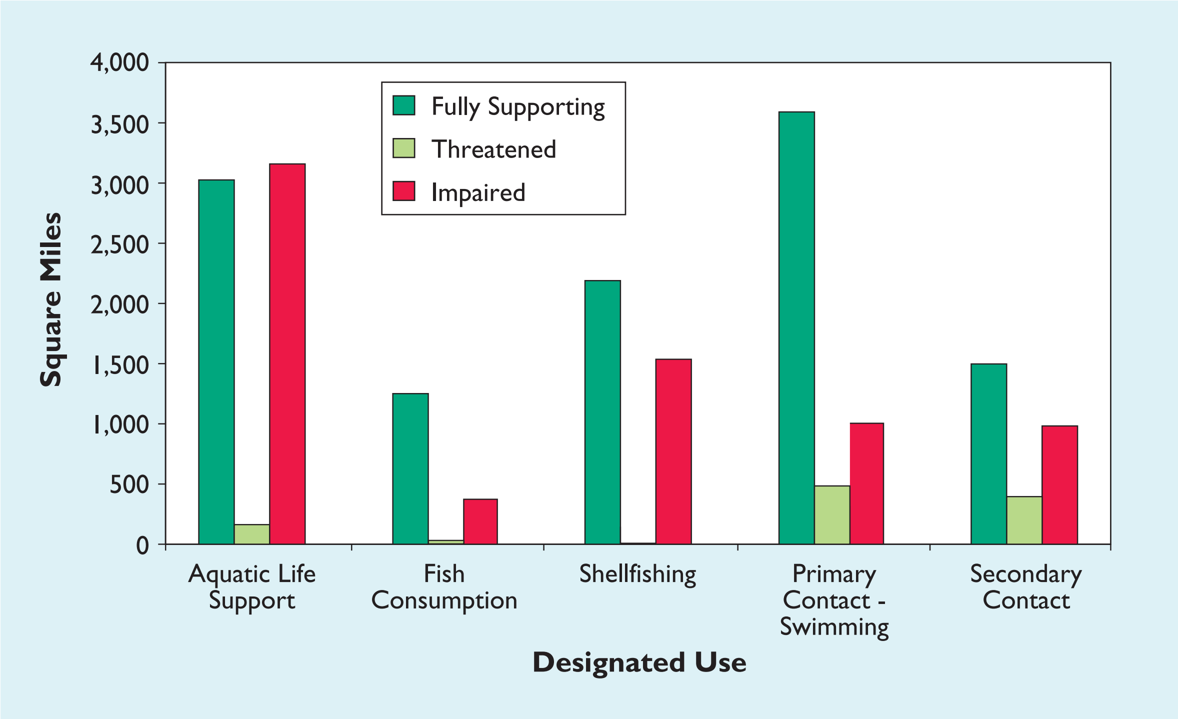


Figure 5-20. Individual use support for assessed estuaries on the Gulf Coast (U.S. EPA).

The Gulf Coast states assessed only 184 miles (0.02%) of their 10,063 coastal shoreline miles. Of the assessed shoreline miles, 60% fully support their designated uses, 2% are threatened for one or more uses, and 38% are impaired by some form of pollution or habitat degradation (Figure 5-21). Individual use support for assessed shoreline is shown in Figure 5-22.

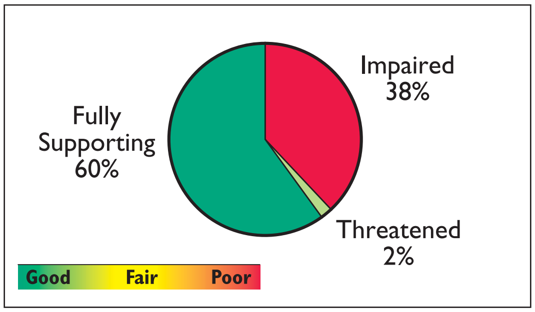


Figure 5-21. Water quality for assessed shoreline on the Gulf Coast (U.S. EPA).

The states reported the following individual use support for their assessed estuarine and coastal waters (Table 5-2).

Table 5-2. Individual Use Support for Assessed Coastal Waters Reported by Gulf Coast States under Section 305(b) of the Clean Water Act

Individual Uses	Estuaries Assessed as Impaired (mi^2)	Percent of Total Area Assessed (%)	Shoreline Assessed as Impaired (mi)	Percent of Total Shoreline Assessed (%)
Aquatic Life	3,144	50	0	0
Fish Consumption	356	21	0	0
Shellfish Harvesting	1,533	41	46	48
Swimming	997	20	26	31

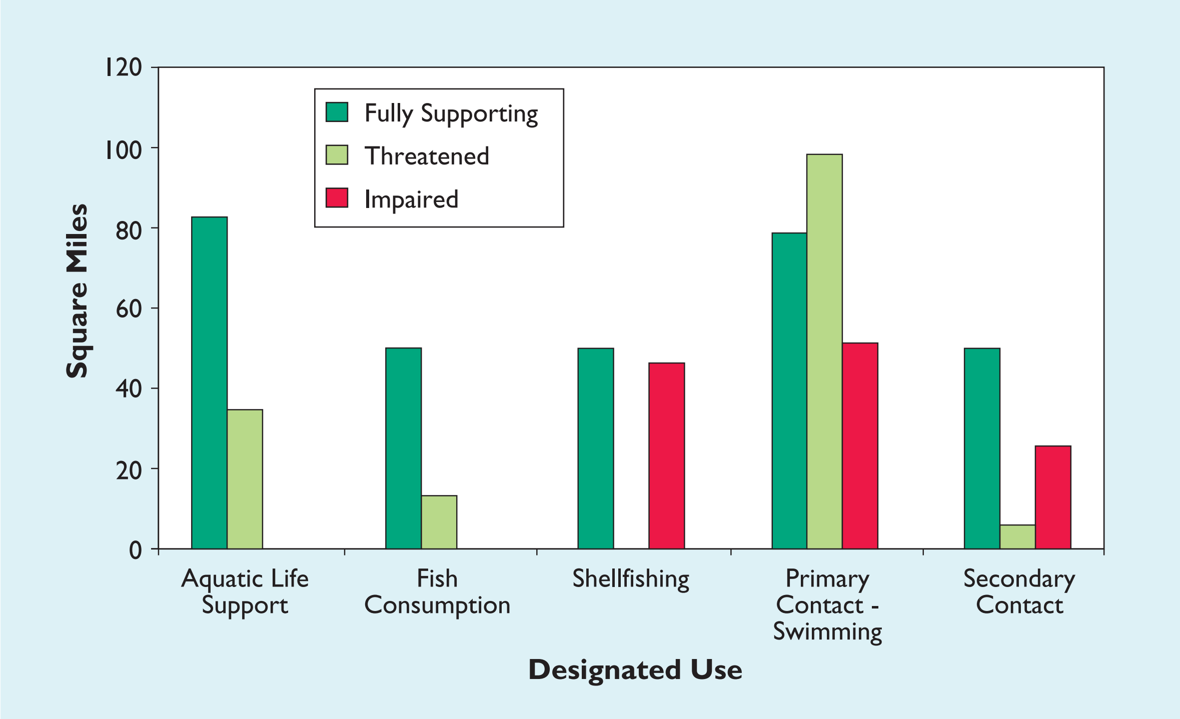


Figure 5-22. Individual use support for assessed shoreline on the Gulf Coast (U.S. EPA).

There are 233 waters located on the Gulf Coast that are listed as impaired under Section 303(d) of the Clean Water Act. The percentage of listed waters impaired by each of the major pollutant categories is shown in Figure 5-23.

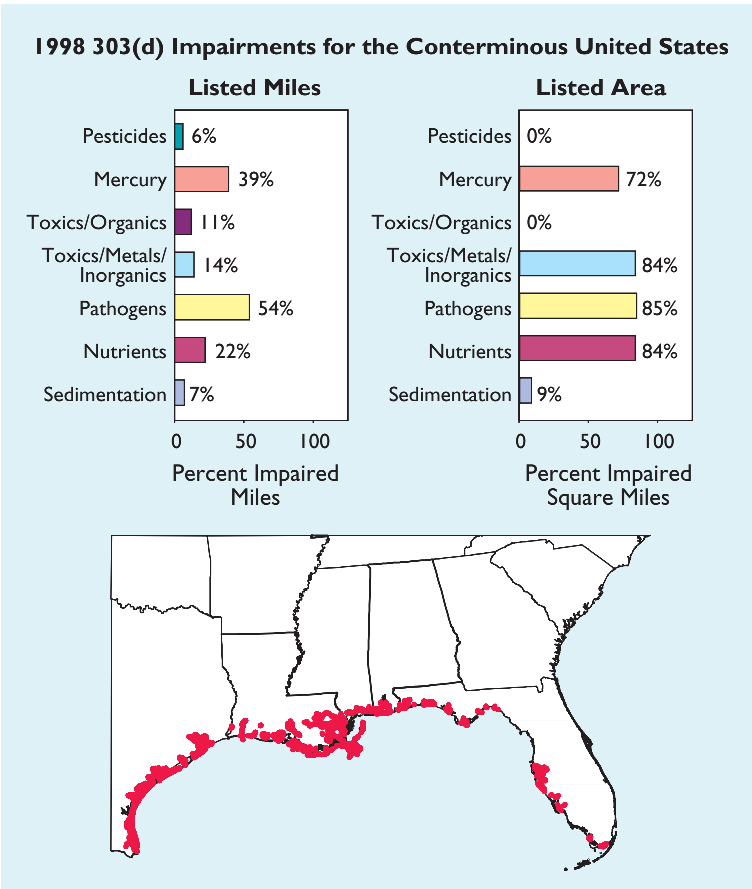


Figure 5-23. 1998 303(d) listed waters on the Gulf Coast and the percentage of listed waters impaired by the major pollutant categories (Note: A 303(d) listing may be impaired by multiple pollutants.) (U.S. EPA).

State Fish Consumption Advisories

In 2000, 14 fish consumption advisories were in effect for the estuarine and marine waters of the Gulf Coast. The majority of the advisories (10) were issued for mercury, and each of the five Gulf states had one statewide coastal advisory in effect for mercury in king mackerel (for fish greater than 39 inches). The statewide king mackerel advisories covered all coastal and estuarine waters in Florida, Mississippi, and Alabama, but covered only coastal waters in Texas and Louisiana. As a result of the statewide advisories, 100% of the coastal miles of the Gulf Coast were under advisory and 63.7% of the estuarine square miles were under advisory in 2000 (Figure 5-24).

Advisories placed on specific waterbodies included additional pollutants and fish species (Figure 5-25). For example, Bayou d'Inde in Louisiana, a small estuary, was under an

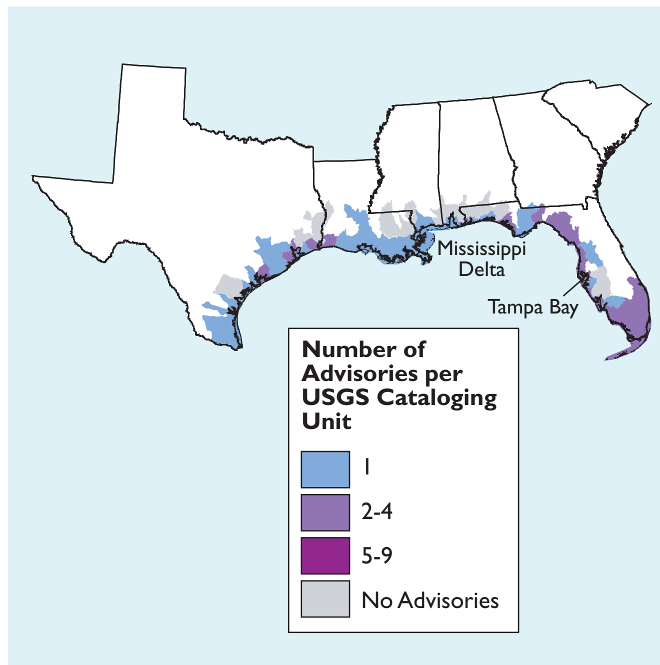


Figure 5-24. The number of fish consumption advisories active in 2000 (U.S. EPA NLFWA, 2000c).

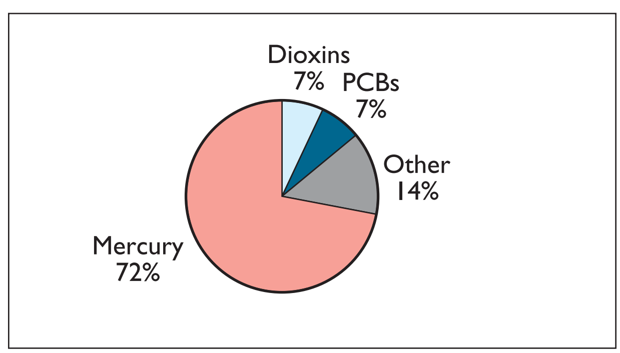


Figure 5-25. Percentage of estuarine and coastal marine advisories issued for each contaminant on the Gulf Coast (U.S. EPA NLFWA, 2000c).

advisory for all fish and shellfish due to the risk of contamination by PCBs, mercury, hexachlorobenzene, and hexachlorobutadiene. Florida had four additional mercury advisories, in addition to the statewide coastal advisory. In Texas, the Houston Ship Channel was under advisory for catfish and blue crabs due to the risk of contamination by dioxins/furans.

Classified Shellfish-Growing Waters

In the Gulf of Mexico region, 7.6 million acres (35% of the national total) were classified for shellfish harvest in 1995 (Figure 5-26). Of the classified acreage, 47% were approved and 53% were harvest-limited. Nationally, the Gulf Coast ranks first in the total amount of classified waters and last in the percentage of approved waters. Of the Gulf's classified acreage, 83% is located in estuarine waters and 17% in nonestuarine waters. The top three pollution sources affecting harvest limitation are upstream sources, individual wastewater treatment systems, and wildlife.

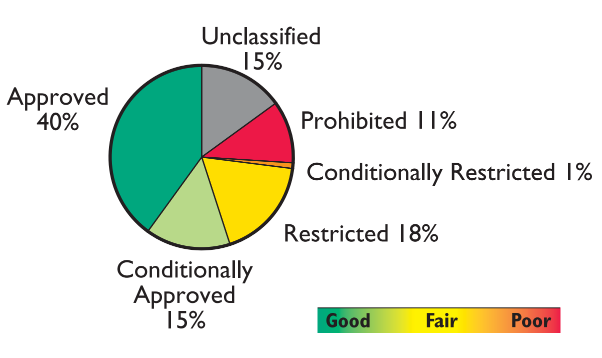


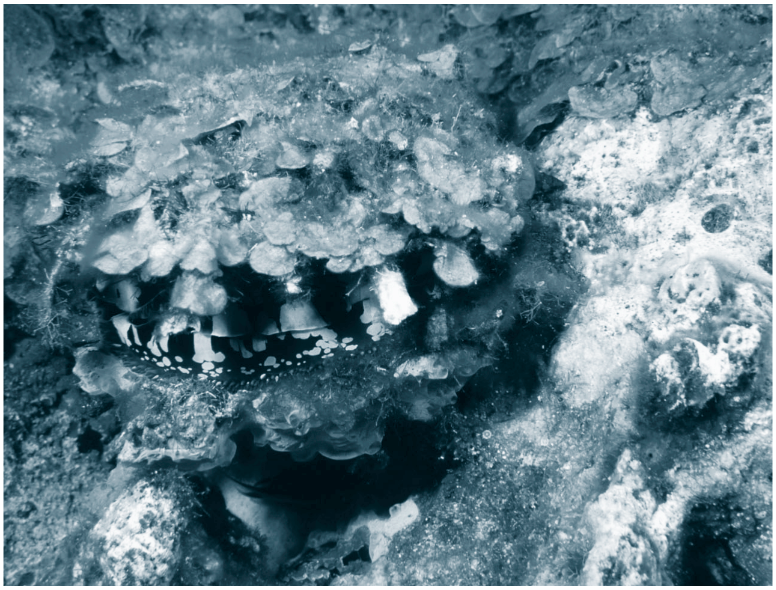
Figure 5-26. Classification of shellfish-growing waters in the Gulf of Mexico (1995 Shellfish Register, NOAA, 1997).

The Gulf's top shellfish species, the eastern oyster, was rated high or medium in abundance in 3 million acres (39% of the region's growing waters). Seventeen percent (517,459 acres) of eastern oysters are located in waters that do not allow direct harvesting (i.e., restricted, conditionally restricted, and/or prohibited).

Total classified acreage in the Gulf of Mexico has increased by over half a million acres since the 1990 Register. All of this new acreage is located in nonestuarine waters. Approved waters decreased slightly, from 48% in 1990 to 47% in 1995. All five Gulf of Mexico states reported a decline in classified acreage located in estuarine waters. At the same time, Florida and Louisiana each added over half a million acres of classified shellfish-growing areas in nonestuarine waters.

Summary of fish and shellfish under advisory for at least some part of the Gulf Coast:

Ladyfish	Shark	Shellfish
Catfish	King mackerel	Crab
Gafftopsail catfish	Spanish mackerel	Blue crab
Jack crevalle	Spotted sea trout	



Atlantic thorny-oyster (Spondylus americanus) are seen filter feeding on all three banks of the Flower Gardens as well as on the underwater structures of the platforms (photo: Frank and Joyce Burek).

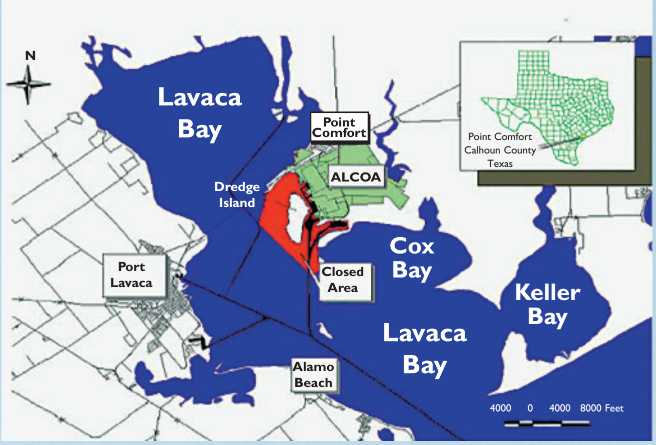
Mercury Contamination of Fishery Resources

Mercury cycles in the environment as a result of natural sources and human activities. It accumulates most efficiently in the aquatic food web, and many recreational and commercial fish species at the top of the food chain can accumulate high concentrations of mercury.

The Gulf of Mexico Program (GMP), a partnership of federal agencies, the Gulf states, citizens, and the private sector, was established to manage and protect resources of the Gulf and has recently released a collection of data on the occurrence of mercury in Gulf coastal fishery resources. The data were compiled from numerous sources, including fish tissue monitoring programs in all five Gulf states, EPA's EMAP, NOAA's NS&T Program, the National Marine Fishery Service, and the scientific literature.

The results of the GMP data summary show that three species (king mackerel larger than 39 inches, bluefish, and blacktip shark) have a Gulfwide mean mercury concentration between 0.81 and 1.0 ppm. Fish consumption advisories are issued at different levels in each state, but generally a mercury level of 1.0 ppm will trigger an advisory for the general public to limit consumption. Special populations, such as children and pregnant women, may be advised to limit consumption when mercury levels reach 0.5 ppm. Other species with mercury levels greater than 0.5 ppm include Spanish mackerel, jack crevalle, and sand sea trout. Find the Gulfwide Mercury in Tissue Database on the Internet at http://www.duxbury.battelle.org/gmp/hg.cfm.

Lavaca Bay, TX – A Case Study



Alcoa/Lavaca Bay Superfund Site.

The Aluminum Company of America (ALCOA) Point Comfort Operations (PCO) Plant is located in Calhoun County in southeast Texas near the city of Point Comfort. The Plant is bordered by Lavaca Bay on the west, and Cox Creek/Cox Lake on the east. From 1966 into the 1970s, ALCOA operated a chlorine-alkali plant that produced chlorine gas and sodium hydroxide. Part of this process involved the use of mercury cathodes. Wastewater containing mercury was discharged into Lavaca Bay through outfalls located on an offshore gypsum lagoon located on Dredge Island. Dredge spoils, contaminated with mercury, were disposed of in several areas on the site. Bay sediments are now contaminated with the waste mercury.

In March 1994, EPA and ALCOA signed an Administrative Order of Consent for ALCOA to conduct a Remedial Investigation, risk assessment, and feasibility study for the site. Major sampling conducted during the Remedial Investigation included an evaluation of sediments and surface water in the "Closed Area" of Lavaca Bay (see figure) and the remainder of Lavaca Bay (including Cox Lake, Cox Marsh, and portions of western Matagorda Bay) as well as sampling and analysis of finfish, shellfish, and prey items from Lavaca Bay. The primary contaminants of concern for the bay system include mercury and PAHs.

In April 1988, the Texas Department of Health (TDH) issued an order prohibiting the taking of finfish and crabs from the "Closed Area" of Lavaca Bay due to levels of mercury in fish tissue above Food and Drug Administration standards. In January 2000, the TDH reduced the size of the "Closed Area" based on the reductions of mercury contamination in fish tissue.

Following the completion of the Remedial Investigation, the feasibility study, and a baseline risk assessment, a Proposed Plan will provide the EPA's proposed remedial action for the site. The remedial action decided upon will be presented in a Record of Decision (ROD) following public meetings and public comment. The ROD will present the cleanup measures determined to be protective of human health and the environment. These cleanup measures should eventually result in TDH rescinding the Fish Closure order. This would enable the community to keep fish and shellfish from all areas of Lavaca Bay.

Beach Closures

Four of the five Gulf Coast states reported information about monitoring and beach closures to EPA in 1999 (Louisiana did not). Overall, a total of 85 beaches responded, with the majority of the respondents (85%) located in Florida. Of these 85 Gulf beaches, 79% (67 beaches) had a water quality monitoring program (Figure 5-27).

In Florida, 81% of the beaches responding reported that monitoring was conducted in 1999. It is estimated that at least 60 miles of beach coastline were covered by this monitoring. Ten beaches (14% of reporting beaches) on Florida's Gulf Coast reported closing at least once in 1999 (Figure 5-28). The primary reason for beach closures was elevated bacteria levels due to storm water and other runoff.

In Mississippi, only one coastal beach responded to EPA's survey. The Mississippi beach reported the existence of a monitoring program that covered the entire 40 miles of beach coastline and was partially closed twice in 1999. One beach in Louisiana, on the south shore of Lake Pontchartrain, was closed throughout the year in 1998 due to elevated bacterial levels from sanitary sewer overflows and pipe breaks. However, in 1999, no Louisiana beaches reported information to EPA.

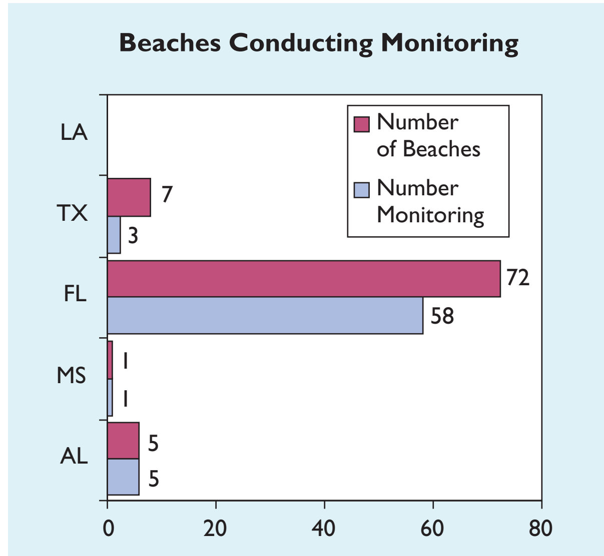


Figure 5-27. Number of beaches in each state that responded to the survey versus the number of beaches that are monitored (U.S. EPA).

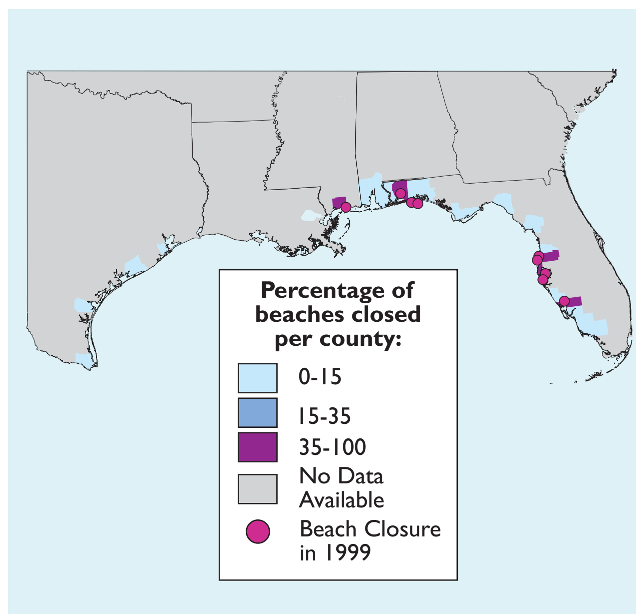


Figure 5-28. Locations of beaches for which information is available. Of the beaches submitting information, 13% were closed at least once in 1999.

Summary

Ecological conditions in Gulf estuaries are fair to poor (Figure 5-29). The primary problems in Gulf Coast estuaries in the 1990s are sediment contamination, wetland losses, poor benthic conditions, and high expression of eutrophic condition. Over 25% of sediments are enriched or exceed ERL guidance. Although this problem may be improving, benthic community degradation (23% of sediments), expression of eutrophic conditions (currently 32%), and wetland losses (currently about 5% per decade) are worsening. Unless these problems are addressed in the early 21st century, improvements in sediment contaminant quality will be overshadowed by decreases in the quality of biotic communities and increases in coastal eutrophication. Although eutrophic condition is an issue for many estuaries, dissolved oxygen conditions are good in Gulf of Mexico estuaries (excluding the hypoxia issues on the Gulf of Mexico shelf off of Louisiana). Fish condition is poor with several consumption advisories throughout the Gulf Coast. Because population growth in coastal areas along the Gulf of Mexico is expected to increase in the 21st century, many (if not all) of these environmental problems will be exacerbated in the next 10 to 20 years. The Gulf Coast of Florida alone is home to more than 4 million people and is currently experiencing explosive growth and development. Clearly this is a region of the country requiring continued monitoring and environmental programs to clean up existing problems and prevent the worsening of conditions throughout the Gulf.

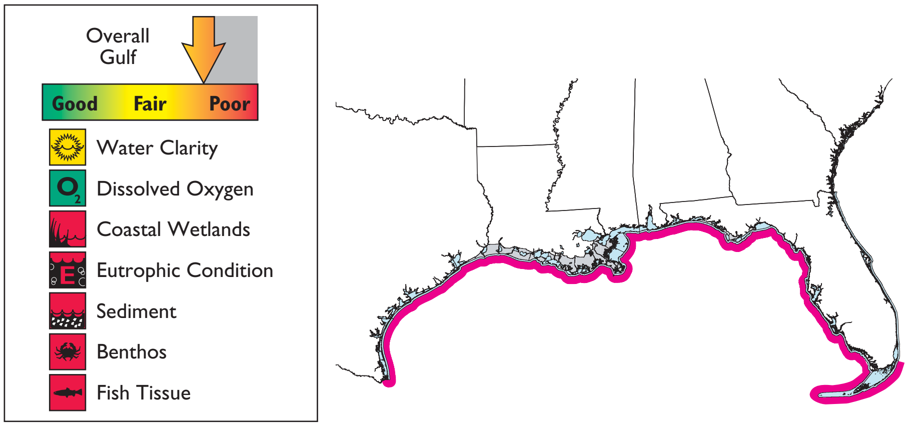
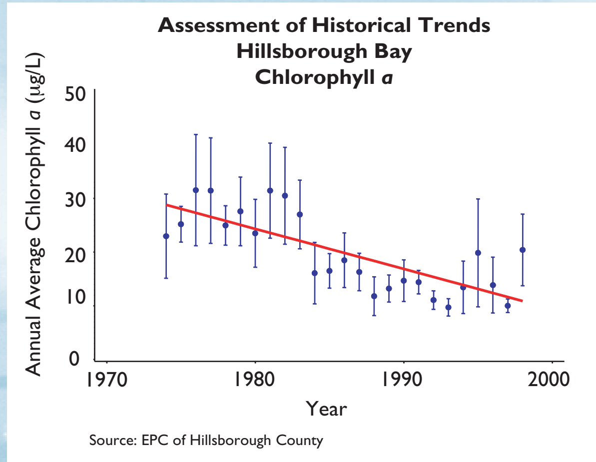


Figure 5-29. The overall condition of Gulf of Mexico coastal resources is fair to poor.

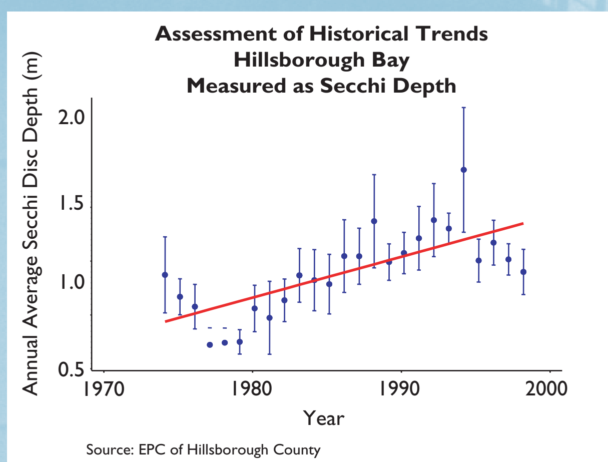
Habitat Improvements in the Gulf Coast – The Tampa Bay Estuary Program

In the late 1960s and early 1970s, the ecological condition of Tampa Bay declined dramatically. Polluted wastewaters, dredging and filling of habitat, and rapid development of the shoreline posed serious threats to the future of the bay. The Tampa Bay Estuary Program estimates that more than 40% of the seagrass meadow acreage was lost from 1950 to 1984. A centerpiece of Florida's Gulf Coast, Tampa Bay is home to more than 2 million residents, receives 8 million visitors each year, and contributes almost $5 billion annually to the area's economy (Liner et al., 1994).



Average annual concentration of chlorophyll *a* in Hillsborough Bay, a section of Tampa Bay, dropped steadily as wastewater management plans were implemented.

Initiatives to improve wastewater management and treatment led to dramatic improvements in water quality and, eventually, bay habitat. Beginning in 1984, the frequency and duration of phytoplankton blooms declined, water clarity and oxygen levels began to improve, and seagrasses began to recover. Improvements in water quality can be seen in long-term trends in chlorophyll *a*—a measure of the amount of phytoplankton in the water (top right). Reductions in chlorophyll *a* also correspond to increases in water clarity, presented here as Secchi depth (bottom right). Historical trends also show a marked recovery in seagrass meadows. Surveys record over 5,000 acres of recovered seagrass meadow in Tampa Bay since 1984. Although the rate of seagrass expansion has decreased in some areas of the bay in the last few years, current baywide expansion rates are approximately 350 acres of seagrass per year.

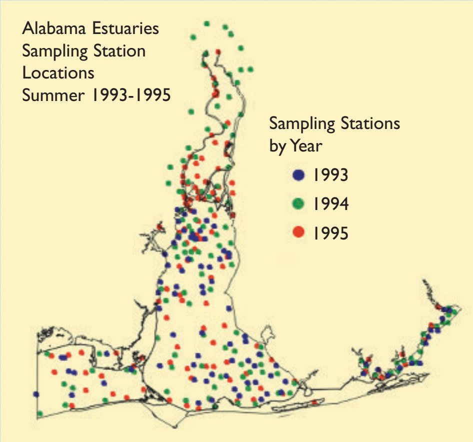


Water clarity improved throughout the 1980s and most of the 1990s in Hillsborough Bay.

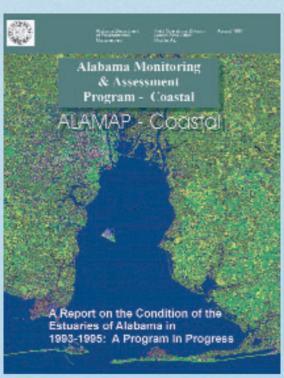
Alabama Environmental Monitoring and Assessment Program

In 1993, the Alabama Department of Environmental Management (ADEM) initiated an environmental monitoring and assessment program (ALAMAP-C) for Alabama's coastal waters. The goal of ALAMAP-C is to provide information on the overall health of the coastal environment and to track changes over time. ALAMAP-C has conducted annual surveys of estuaries to measure various coastal water quality parameters. Ecological health is assessed by investigating the spatial distribution of physical, biological, and chemical indicators of water quality. ALAMAP-C determines the portions of estuaries that support conditions favorable for both aquatic life and human use. ALAMAP-C also attempts to determine why certain areas may not be favorable for either aquatic life or human use.

The overall sampling design and strategy for monitoring indicators of ecological condition was inspired by the U.S. Environmental Protection Agency's EMAP-Estuaries efforts in the Gulf of Mexico (see map). ALAMAP-C has successfully completed sampling efforts during the summer months of 1993-2000 in all of Alabama's near-coastal waters. During the period 1993-1999, ALAMAP-C investigated the ecological condition of Alabama's estuarine waters, including Mobile Bay, Perdido and Wolf Bays, the Alabama section of Mississippi Sound, and the tidal/delta portions of the Mobile and Tensaw Rivers. In 2000, ALAMAP-C became an integral part of EPA's Coastal 2000 Program and the Gulf of Mexico Program's Joint Gulf States Comprehensive Monitoring Program.

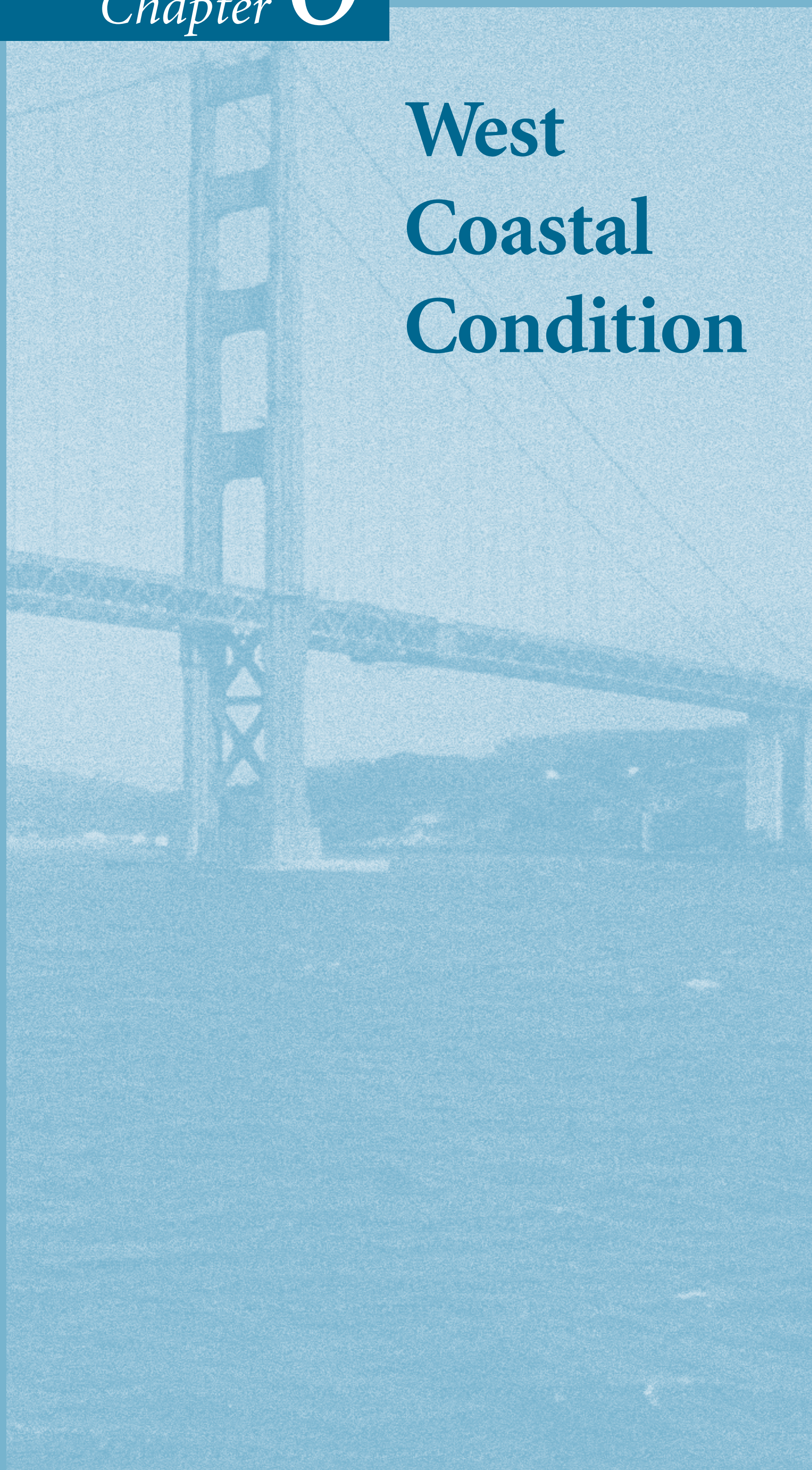


ALAMAP-C sampling stations.



In 1998, ADEM published *A Report on the Condition of the Estuaries of Alabama in 1993-1995: A Program in Progress*, describing the initial years of the program. The 1998 report represents the first in a planned series of reports on the state of Alabama's coastal waters based on the information collected by ALAMAP-C. As the program progresses, subsequent reports will seek to strengthen the statistical certainty and provide a series of documents portraying the changing conditions of Alabama's coastal waters. In 2001, ADEM will publish the second in its series of continuing reports covering the years 1996 to 1999.

Chapter 6



West Coastal Condition

Chapter 6

West Coastal Condition

Just beyond the Golden Gate of San Francisco lies an ocean wilderness awaiting discovery (Photo: Gulf of the Farallones NMS).

Ecological conditions in western estuaries are fair, based on the information available from various monitoring efforts (Figure 6-1). The estuaries of the West Coast of the United States represent a valuable resource that contributes to the local economies of the area and enhances the quality of life for those who work in, live in, or visit there. The population of coastal counties on the West Coast increased 45% between 1970 and 1980 (U.S. Bureau of the Census, 1996). The western coastline comprises 410 estuarine systems (4,648 mi^2) although three systems—San Francisco Bay, Columbia River, and Puget Sound—make up 72% of the total surface area. Smaller estuarine systems associated with these large systems make up another 28% of the total surface area.

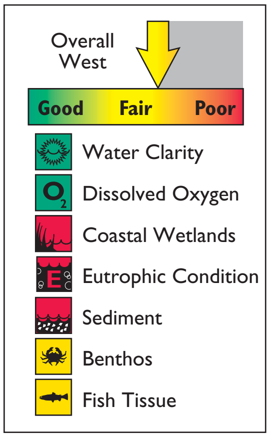
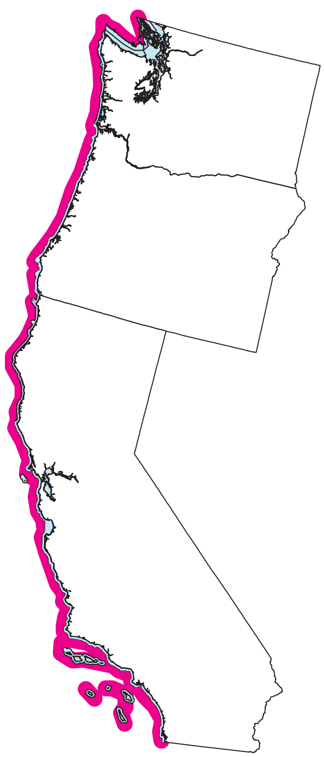
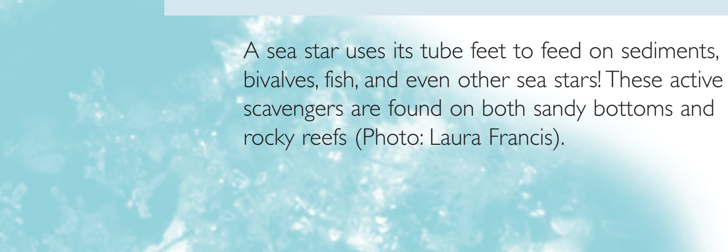


Figure 6-1. The overall condition of western estuaries is fair, although dissolved oxygen and water clarity conditions are good.



Probabilistic surveys like those completed for the Northeast, Southeast, and Gulf Coasts do not exist for the estuarine areas of the West Coast except in selected areas. Therefore, spatial estimates of ecological condition consistent with those described in earlier chapters cannot be determined except for the Southern California Bight and Puget Sound. However, monitoring data from other programs have been used to assess ecosystem condition to the extent possible. The Coastal 2000 program is collecting probabilistic data from all West Coast estuarine systems in 1999-2000.



A sea star uses its tube feet to feed on sediments, bivalves, fish, and even other sea stars! These active scavengers are found on both sandy bottoms and rocky reefs (Photo: Laura Francis).

Coastal Monitoring Data

Very little consistent monitoring has been completed on the West Coast to examine estuarine condition. Unlike condition estimates developed for East and Gulf Coast estuaries, there are no consistent surveys of condition in the West Coast estuaries. Limited available data have been used to provide a qualitative, but statistically unsupported, estimate of condition. Estuarine-specific surveys for San Francisco Bay and Puget Sound have been completed, and these waterbodies continue to be monitored. In 1999, the Washington Department of Ecology, Oregon Department of Environmental Quality, Southern California Coastal Water Resources Project, and California Fish and Game jointly assessed the 400 small estuaries and small tidal rivers making up the West Coast (Washington, Oregon, and California) by using a probabilistic design to sample 210 locations within these systems. Sampling was completed in 1999 for water quality, sediment quality, and biota. Information for dissolved oxygen, light penetration, and sediment toxicity is currently available. Information for sediment contaminants, tissue residues, fish community parameters, and benthic communities was collected in 2000 and will be available in 2002.

Relatively few "national" programs have monitoring stations in western estuaries. NOAA's NS&T Program and Bioeffects Surveys have data for several western locations, but these sites are not representative of all western estuaries. EMAP began sampling in western estuaries in 1999, and only a small amount of information is currently available. NOAA's National Estuarine Eutrophication Assessment examined a number of eutrophication variables for western estuaries through the use of a survey questionnaire. In addition, EMAP-like surveys have been completed in the Southern California Bight (SCCWRP, 1998). This offshore survey represents the only probabilistic survey of ecological condition for nearshore coastal waters to date.

The following discussions will be broken into five categories—overall west, small estuaries of the West Coast, San Francisco Bay, Puget Sound, and Southern California Bight.

Overall West

Regional data were available for two of the seven indicators for the West Coast—coastal wetlands and eutrophic condition.

Coastal Wetland Loss

During the 200-year period from the 1780s to the 1980s, the West Coast experienced the greatest proportional losses of wetlands of anywhere in the United States (Figure 6-2), however, the absolute losses are not as large as in most other regions. Throughout the West Coast, wetland losses of 68% were observed, ranging from 31% in Washington to 91% in California.

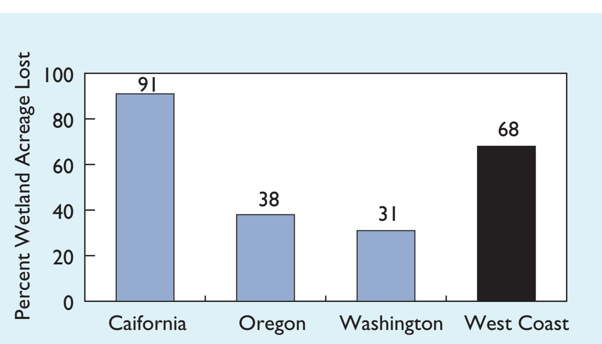


Figure 6-2. Percent wetland habitat loss from 1780 to 1980 by state and for the West Coast overall (Dahl, 1990; Turner and Boesch, 1988).

Eutrophic Condition

The condition of West Coast estuaries as measured by expression of eutrophic condition is poor. Estuaries with high expression of eutrophic condition represent 20% of the surface area of western estuaries (Figure 6-3).

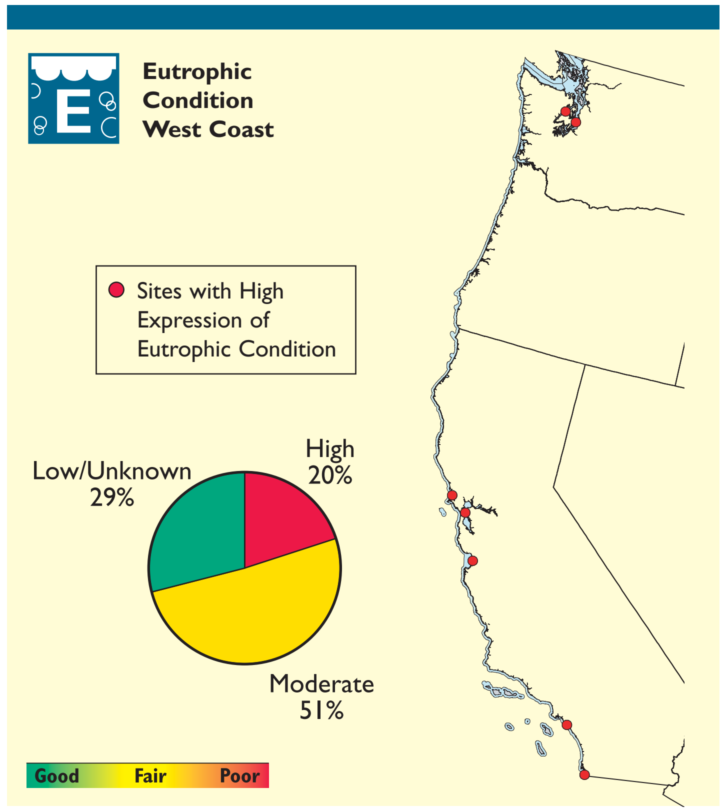


Figure 6-3. Eutrophic condition data for West Coast estuaries and locations of sites with high expression of eutrophic condition (NOAA/NOS).

Small Estuaries of the West Coast

Small estuaries along the West Coast are defined as those that are less than 97 square miles in size and are not part of Puget Sound or San Francisco Bay. These small estuaries make up about 28% of the estuarine area of the West Coast (excluding Puget Sound and its small systems, San Francisco Bay and its small systems, and the Columbia River).

Water Clarity

Water clarity in small estuaries on the West Coast is good. Light penetration was poor at only one of the 210 sites sampled, representing less than 1% of the total area of these small systems (Figure 6-4). This number represents water clarity only in late summer and does not represent high-flow springtime conditions. The poor water clarity site is located on Grass Creek, Washington.

Dissolved Oxygen

Dissolved oxygen conditions in small estuaries on the West Coast are good. Dissolved oxygen was never measured below 2.0 ppm.

Sediment Contaminants

No data are currently available for small West Coast estuaries. Sediment contaminant data were collected in 2000 and will be available in 2002.

Benthic Condition

No data are currently available for small West Coast estuaries. Benthic index data were collected in 2000 and will be available in 2002.

Sediment toxicity was determined for these small estuaries using a static 10-day acute *Ampelisca abdita* bioassay. Greater than 15% control-corrected mortality would result in a sediment's being deemed toxic. For small estuaries along the West Coast (Washington and California only), 25% of sediments were toxic to the amphipod (Figure 6-5). These toxic sediments were located largely in Grays Harbor, Willapa Bay, and Grays Bay in

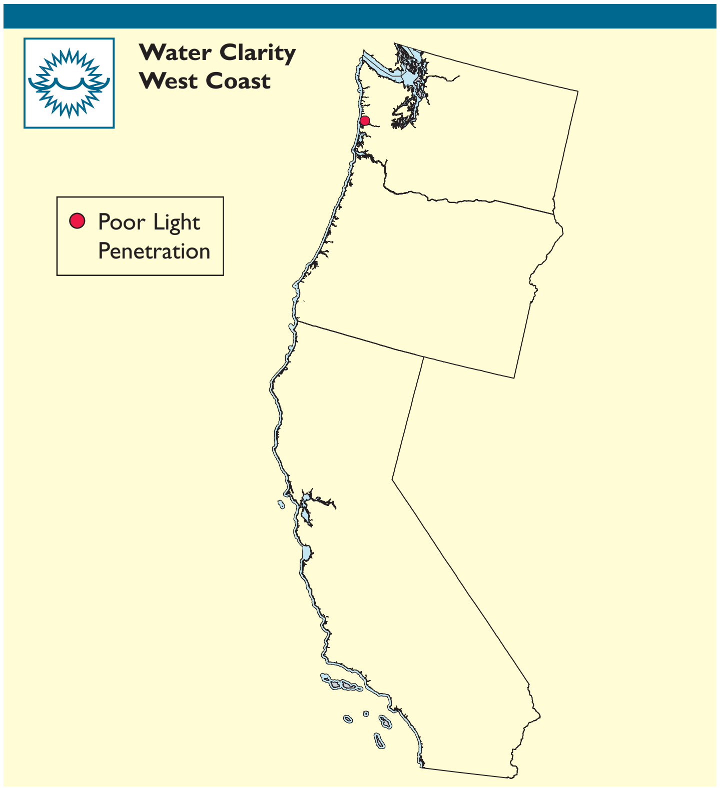


Figure 6-4. Sites with <10% light penetration along the West Coast (U.S. EPA/EMAP).

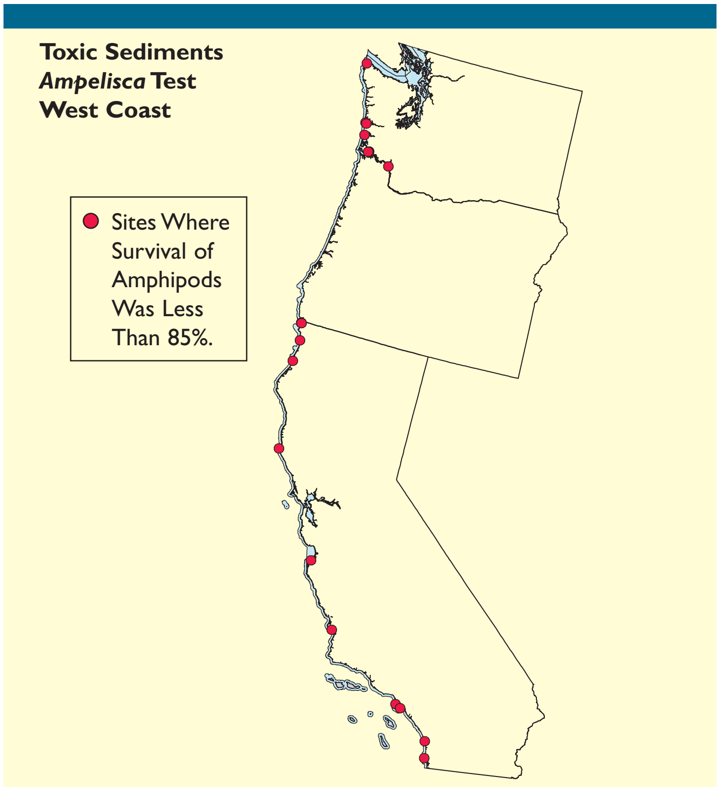


Figure 6-5. Locations with toxic sediments on the West Coast (U.S. EPA/EMAP).

Washington and in San Luis Obispo Bay, Santa Monica Harbor, and several small river systems (e.g., Smith River, Garcia River, Klamath River, Los Angeles River, and San Diego River) in California.

Southern California Bight (Offshore)

The Southern California Bight (SCB) is defined as the 186 miles of recessed coastline between Point Conception, California, and Cabo Colnett, Mexico. Figure 6-6 shows the U.S. portion of the SCB. The dramatic change in the angle of the coastline creates a large backwater eddy in which equatorial waters flow north nearshore and subarctic waters flow south offshore. This unique oceanographic circulation pattern creates a biological transition zone between warm and cold waters that contains over 500 marine fish species and more than 5,000 invertebrate species.

Human uses of the coastline and ocean waters of the Bight include recreation, tourism, aesthetic enjoyment, sport and commercial fishing, coastal development, and industry. Ocean-dependent activities contribute approximately $9 billion to the economies of coastal communities surrounding the SCB and support over 175,000 jobs. The area bordering the SCB is also home to nearly 20 million people, making it one of the most densely populated shorelines in the United States. Almost the entire SCB coastline has been subjected to development, waste discharges, or other forms of resource utilization.

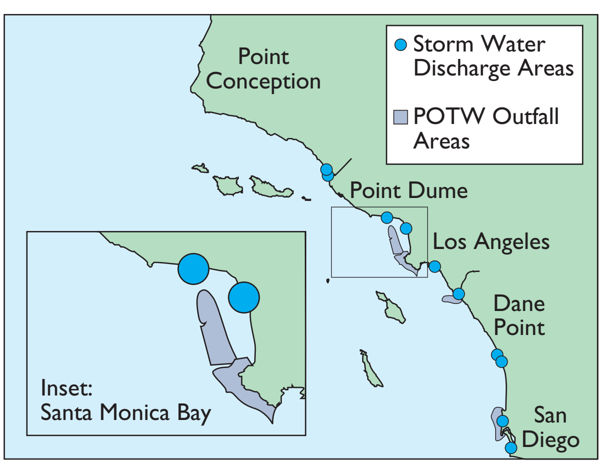


Figure 6-6. The Southern California Bight (SCB).

Prior to 1994, the Southern California Coastal Water Resources Project (SCCWRP) conducted monitoring programs at numerous sites within the SCB amounting to $10 million in monitoring annually. However, this monitoring could not address concerns about the ecological condition of the Bight and the direct effects of discharges on the SCB (only 5% of the area was represented in sampling). In 1994, recognizing the need for integrated assessment of the SCB, 12 government organizations (including the four largest municipal wastewater dischargers) collaborated to complete the first comprehensive regional monitoring survey of the SCB under the name of the Southern California Bight Pilot Project (SCBPP). SCBPP sampled 261 sites in the SCB between July and August 1994. Sampling sites included all coastal and oceanic areas within the Bight between 98 and 2,133 feet in depth.

Water Clarity

Water clarity was good throughout the SCB.

Dissolved Oxygen

Dissolved oxygen conditions in the SCB are good. Almost all of the surface waters were fully saturated with oxygen and more than

99% of SCB waters met California Ocean Plan water quality objectives for temperature, pH, light transmittance, and dissolved oxygen.

Sediment Contaminants

Sediment contaminant conditions in the Southern California Bight are poor. ERM values were exceeded in 12% of SCB sediments with most exceedances due to DDT. Over half (55%) of SCB sediments were characterized by contaminant concentrations greater than the ERL guideline but less than the ERM. With 67% of sediments having contaminants that could potentially have ecological effects, the SCB has the most contaminated sediments in the United States (Figure 6-7). Sites exceeding the ERL and ERM thresholds were widespread throughout the SCB. The constituent that had the greatest areal extent for potential biological impairment was total DDT, exceeding screening levels in 64% of SCB sediments (866 mi^2 > ERL) and 10% of sediments exceeding ERM. Total PCBs was the next constituent with greatest areal extent (1% > ERM and 15% > ERL).

Sediment Contaminant Criteria

ERM (Effects Range Medium) – The concentration of a contaminant that will result in ecological effects approximately 50% of the time based on literature studies.

ERL (Effects Range Low) – The concentration of a contaminant that will result in ecological effects about 10% of the time based on literature studies.

Sediment contaminants introduced by human activity were present in 89% of the SCB. The pesticide DDT was the most widespread contaminant. It was found in 82% of the SCB sediments (Figure 6-8). The highest concentrations of DDT occurred on the Palos Verde shelf. Most of the observed DDT represents DDT metabolites and is the result of chemical degradation from DDT discharges over the past 40 to 50 years. Elevated levels of PCBs and trace metals were found in approximately half of the sediments of the SCB. The highest metal concentrations were typically found in Santa Monica Bay.

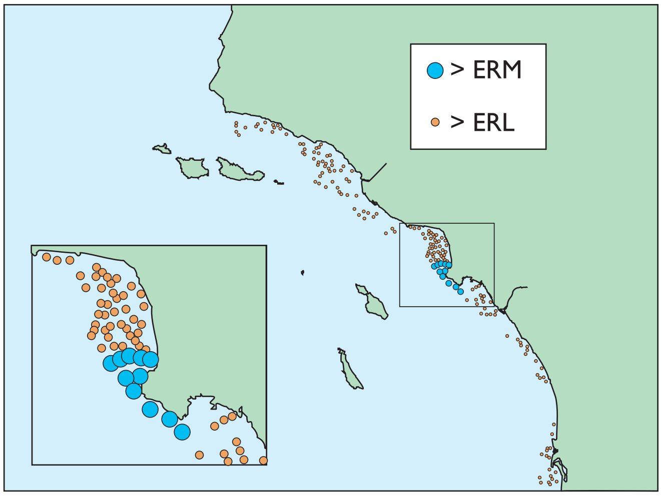


Figure 6-7. Sites exceeding ERL (small circles) and ERM (large circles) were widespread throughout the Southern California Bight (SCBPP).

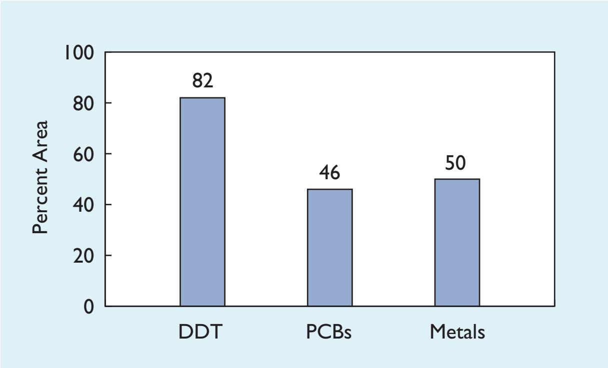


Figure 6-8. Sediment contaminants introduced by human activity were present in 89% of the Southern California Bight (SCBPP).

Benthic Condition

Benthic communities in the Southern California Bight are in good condition. Benthic communities showed degradation in only 9% of SCB sediments compared to reference sites (Figure 6-9). Of these degraded communities, most (7%) showed minor deviations representing small shifts in community composition. Only 2% showed losses in biodiversity. These observations support the toxicity findings, showing that, although the sediments are contaminated, the contamination is resulting in few biological and/or toxicological effects.

While extensive sediment contamination was observed in SCB sediments, acute toxicity tests using *Ampelisca abdita* showed none of the sediments to be significantly more toxic than control sediments. The toxicity results from the SCBPP, when compared to results from studies performed in bays and estuaries throughout the United States, indicate that the quality of the sediments in the SCB is generally higher than that in the remainder of the United States. This apparent contradiction is explained by the fact that, although the SCB sediments are among the most contaminated in the United States, they are not biologically available because of the way in which they are bound to the sediments.

Fish Tissue Contaminants

The condition of SCB as measured by fish tissue contaminants is poor. Contaminants in fish tissues were widespread—the livers of nearly all individuals of two target species of flatfish (Pacific sanddab and longfin sanddab) contained DDT and PCBs (Figure 6-10). All samples of a third flatfish, Dover sole, were contaminated by DDT. The three highest observations of DDT and PCB concentrations in fish livers occurred in fish collected from or near the Palos Verde shelf. However, both DDT and PCB concentrations found in fish livers throughout the SCB were 95% lower than those measured in the 1970s. Both DDT and PCB concentrations in fish livers from reference areas were 5% of the concentrations observed during the last two decades. No other contaminants were observed in fish tissues in 1994.

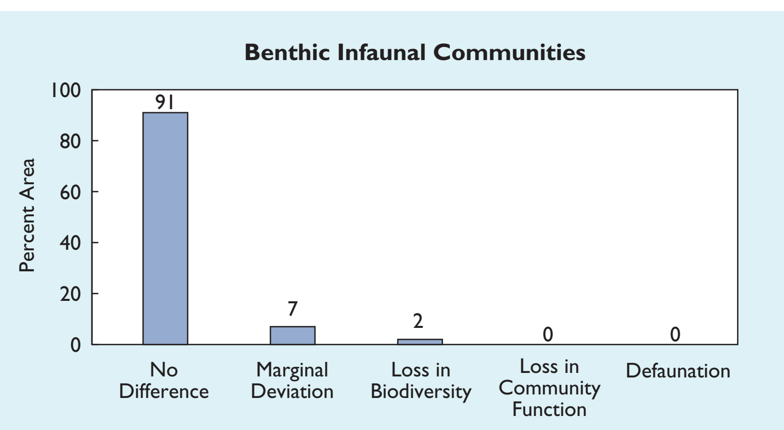


Figure 6-9. Benthic communities showed degradation in only 9% of SCB sediments compared to reference sites (SCBPP).

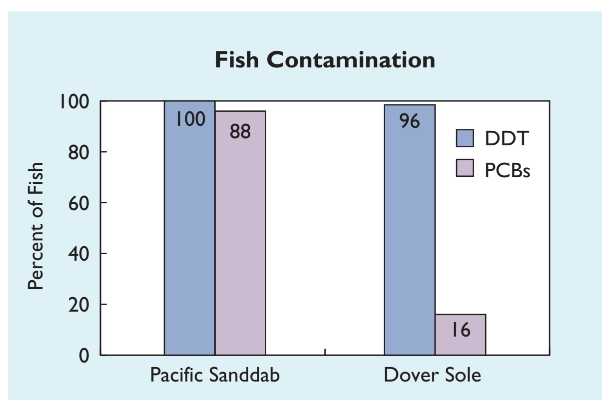


Figure 6-10. Contaminants were found in the livers of nearly all individuals of two target species of flatfish (SCBPP).

Fish communities in the SCB were largely healthy, and their status has improved noticeably over documented conditions in the 1970s. External fish diseases and pathologies were prevalent in the 1970s and were virtually absent in 1994.

San Francisco Bay

San Francisco Bay is one of the largest single estuarine resources along the western coastline of the United States. Because of its tectonic development, San Francisco Bay is unlike many estuaries in the United States and has its own, relatively unique circulation and depositional patterns and exchange rates with the Pacific Ocean. In addition, significant water withdrawal for agricultural use from the San Joaquin and Sacramento Rivers results in increased movements of high-saline waters into areas of the Bay that were traditionally mesohaline or oligohaline. Monitoring and assessment efforts in the San Francisco Bay have been active since the early 1990s. The San Francisco Estuary Institute (http://www.sfei.org), in collaboration with the San Francisco Bay Estuary Project (http://www.abag.ca.gov/bayarea/sfep), is examining and assessing water quality, sediment quality, and fish tissue residues as part of the Regional Monitoring Program (RMP) (May et al., 2000).

Water and sediment provide habitat for most of the estuary's biota, including the foundation of the estuarine food web—phytoplankton. Surveys to date have concentrated on whether water quality and sediment quality meet contaminant guidelines, the condition of benthic communities, and the tissue residue concentrations in selected fish populations. For water, the guidelines consider both laboratory studies and field observations and are aimed at protecting a particular set of qualities valued by the society. For sediment quality, guidelines were based on concentrations shown to result in adverse effects (Long et al., 1995). For fish tissue residues, guidelines were calculated by the Regional Water Quality Control Board in conjunction with EPA and are intended to protect the fish-consuming population.

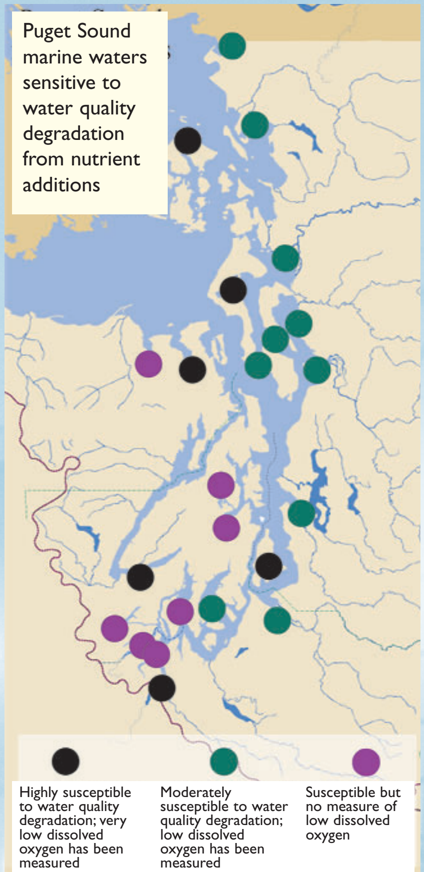
Water Clarity

The water clarity data available for San Francisco Bay are not included in this report due to differences in the sampling design used to collect the data. These data are not comparable to the data used to establish indicators for the other coastal regions throughout the report.

Dissolved Oxygen

The dissolved oxygen data available for San Francisco Bay are not included in this report due to differences in the sampling design used to collect the data. These data are not comparable to the data used to establish indicators for the other coastal regions throughout the report.

Puget Sound Ambient Monitoring Program (PSAMP)



Areas of Puget Sound sensitive to eutrophication (PSAMP).

The protected marine waters of Puget Sound provide valuable habitat for fish and wildlife, and they also support one of the leading trade centers on the West Coast. The region's natural and economic resources have led to booming population growth, which places increasing stress on Puget Sound. As pressures on the environment of the Sound become greater, the need for a coordinated monitoring program to direct management goals and actions is clear. The Puget Sound Ambient Monitoring Program (PSAMP) is a long-term effort to investigate environmental trends and to improve environmental management decision-making. PSAMP is conducted by local, state, and federal agencies including the Washington State Departments of Ecology, Fish and Wildlife, and Health and Natural Resources; EPA; and the National Marine Fisheries Service. Through PSAMP studies, data on marine and fresh waters, fish, sediments, and shellfish in Puget Sound have been collected since 1989; surveys of nearshore habitat have been conducted since 1991; marine bird populations have been surveyed since 1992; and marine bird contamination has been studied since 1995.

PSAMP releases a report on the status and trends of Puget Sound environmental variables every 2 years. According to the 2000 Puget Sound Update report (available at www.wa.gov/puget_sound on the Internet), 23 areas of Puget Sound (representing 54% of the areas that are monitored) show either low dissolved oxygen or susceptibility to eutrophication (see figure), although general water quality is considered to be improving. The 2000 report identifies pollution, loss of habitat, and continuing development as the greatest threats to the health of the Sound. Despite improvements such as the reopening of several commercial shellfishing areas and the declining trend of PCBs found in harbor seals, a number of indicators show that the health of the Sound remains threatened. For instance, the levels of fecal coliform bacteria violate the state standards at more than half of the river and stream monitoring stations in the basin, and the populations of many fish species living in the Sound, such as Pacific herring and chinook salmon, are in peril. In 1999, chinook salmon in Puget Sound were listed as "threatened" under the Endangered Species Act.

The Lower Columbia River

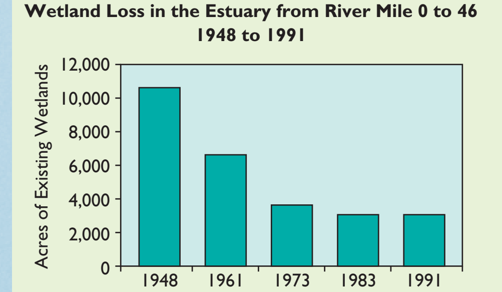
Lower Columbia River

http://www.lcrep.org

The Lower Columbia River is home to some of the most spectacular scenery on the North American continent. Over 2.5 million people live and work in this region. This area is extremely rich in living resources including shellfish, Dungeness crabs, sturgeon, anadromous fish, and nearly 175 species of shorebirds. The Columbia River also supports the world's largest hydroelectric system and the second largest port area on the West Coast. Six major pulp and paper mills line the lower Columbia River. The Lower Columbia River Estuary Program has developed a management plan designed to balance human interests while safeguarding this area's wealth of natural resources.

Human activity over the last century has strained the natural resources. The lower 46 miles of the Columbia River have lost as much as 70% of their tidal wetland acreage since 1948 (see chart). Resource managers estimate that salmon stocks are currently less than 10% of their historic size, and artificial stocks make up 75% of the returning salmon. Twelve species of anadromous fish, including five species of salmon, are either threatened or endangered in the Lower Columbia River. In all, the Lower Columbia River system contains 25 threatened or endangered species. Current trends suggest that the human population in this region will increase 30% by 2010. Accommodating human population growth while preserving this area's natural wealth is a challenge for resource managers.

The Lower Columbia River Estuary Program has developed a management plan to address these issues. The Comprehensive Conservation and Management Plan emphasizes habitat restoration, education, and environmental monitoring. The Management Plan calls for 16,000 acres to be restored or protected by 2020. The Program also places priority on education programs for young citizens. By building the capacity of existing education activities, the Program hopes to fill information gaps about the river. To measure the health of the river over time, the Program is also implementing a long-term monitoring program.



Loss of wetland acreage in the lower 46 miles of the Columbia River since 1948 (Lower Columbia River Estuary Program).

Sediment Contaminants

Sediment contaminant conditions in San Francisco Bay are poor. All samples taken from 1993 to 1998 at each of 16 sites within San Francisco Bay exceeded sediment guidelines for at least one contaminant (Figure 6-11). These exceedances generally occur for 10% to 35% of contaminants measured in sediments (about 30 contaminants at each site) (Figure 6-12). Of sediment quality parameters measured, 39% exceeded levels set by sediment quality guidelines.

Using the same approach, 40% to 100% of samples (6 to 16 samples) taken from San Francisco Bay from 1993 to 1998 exceeded water quality guidelines (Figure 6-13) for one or more contaminants. Figure 6-14 shows the percentage of measurements (45 contaminants measured at each site) that were over guideline values. Approximately 5% to 20% of all contaminant measurements in water exceeded guidelines in the period 1993 to 1998.

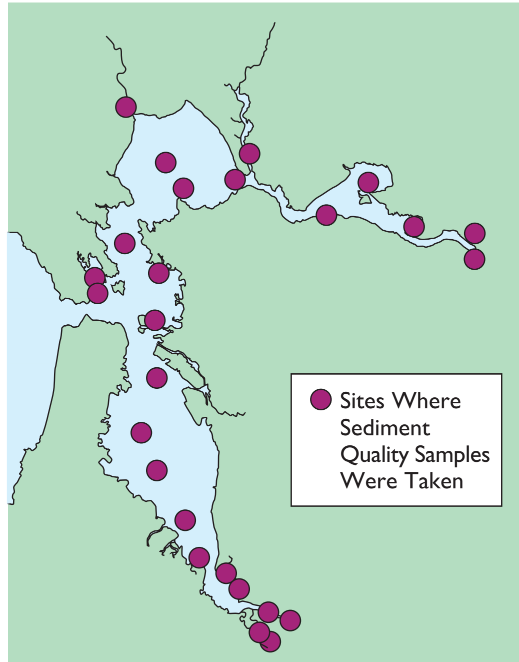


Figure 6-11. All samples taken from 1993 to 1998 at each of the 16 sites within San Francisco Bay exceeded sediment guidelines for at least one contaminant. Four to 12 samples were taken at each site (from San Francisco Bay RMP, May et al., 2000).

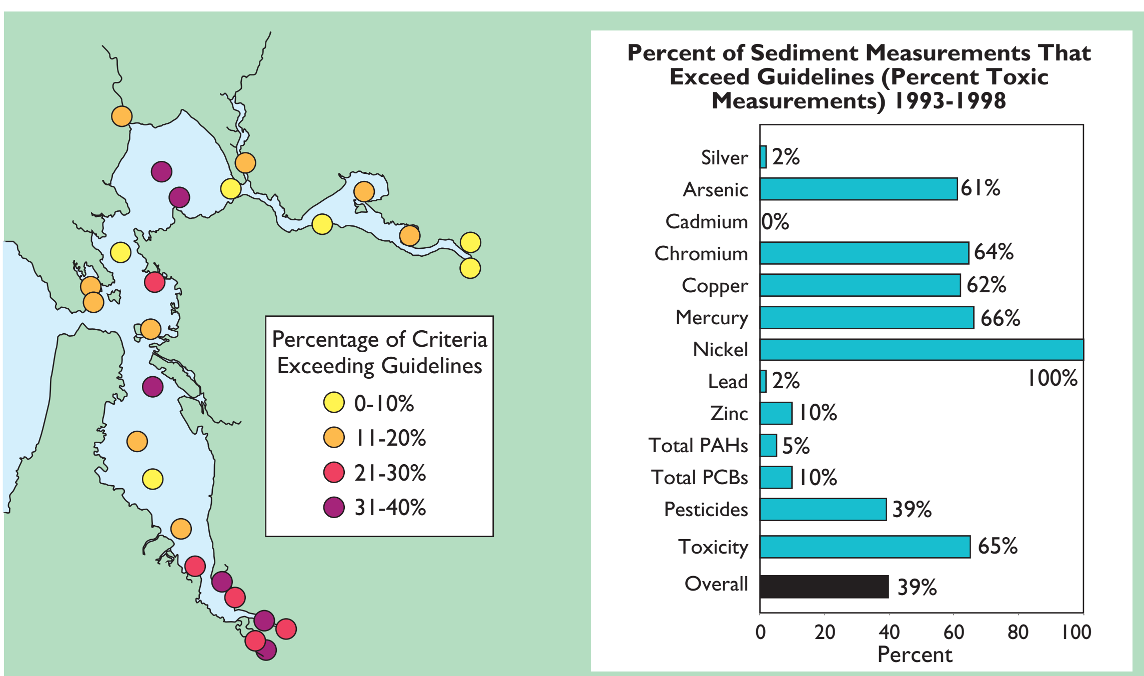


Figure 6-12. The percentage of sediment quality parameters that exceeded guideline values. A total of 119 to 354 measurements were taken at each site (from San Francisco Bay RMP, May et al., 2000).

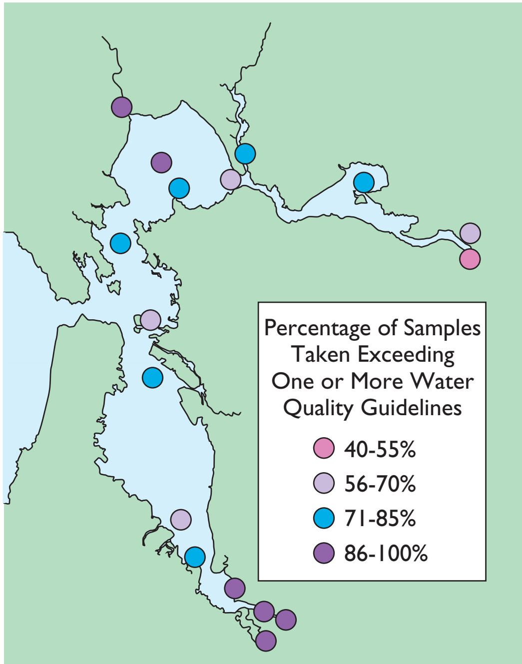


Figure 6-13. Of samples taken from 1993 to 1998 at each of 16 sites within San Francisco Bay, 40% to 100% exceeded water quality guidelines for at least one contaminant. Six to 18 samples were taken at each site (from San Francisco Bay RMP, May et al., 2000).

Figure 6-14 shows the percentage of water quality parameters that exceeded guidelines for water for each of the major contaminants examined. Of water quality parameters measured, 18% exceeded levels set by water quality guidelines. Table 6-1 shows the trend in the percentage of contaminants meeting the guidelines.

Table 6-1. Contaminants Meeting Water Quality Guidelines from 1994 to 1998

Contaminant	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)
Chromium	94	91	93	85	82
Copper	83	85	88	90	97
Mercury	79	80	87	67	75
Nickel	83	83	85	81	84
Lead	96	94	96	90	92
Selenium	100	100	100	97	99
Zinc	96	98	99	92	92
PAHs	61	69	53	59	25
Diazinon	93	100	94	100	100
Dieldrin	80	96	94	55	87
Chlordanes	100	93	84	87	89
DDTs	98	92	90	88	91
PCBs	7	13	8	19	20

Source: May et al., 2000.

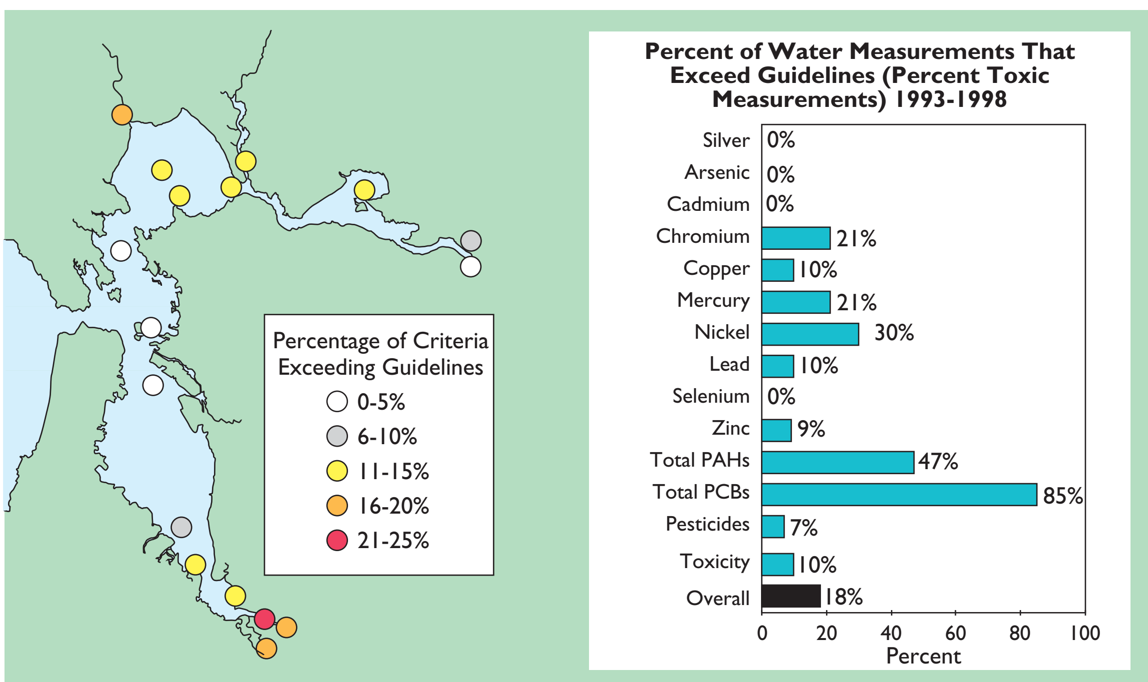


Figure 6-14. The percentage of water quality parameters that exceeded guideline values (from San Francisco Bay RMP, May et al., 2000).

Benthic Condition

The benthic condition data available for San Francisco Bay are not included in this report due to differences in the sampling design used to collect the data. These data are not comparable to the data used to establish indicators for the other coastal regions throughout the report.

Fish Tissue Contaminants

The condition of San Francisco Bay in terms of fish contaminants is poor. In 1997, the RMP examined over 300 fish for contaminant residues. The fish in the estuary contain several contaminants at levels high enough to raise concern for the health of both humans and wildlife (e.g., harbor seals). Exceedance of the "screening values" (developed to reflect the potential for human health concerns and a need for further study) showed that over 50% of fish examined exceeded these values for mercury and PCBs (Figure 6-15). Seven fish were subsampled to analyze for dioxin concentrations, and 100% of those fish examined exceeded the dioxin screening value. Screening values for DDT, chlordane, and dieldrin were exceeded in 15% to 37% of the fish sampled. PCBs and pesticides were highest in white croaker and shiner surfperch, while mercury was highest in striped bass and leopard sharks. The fish collected from the Oakland Harbor region contained the highest concentrations of contaminants.

Some estuarine contaminants in San Francisco Bay are clearly reduced from peak levels seen in earlier decades (May et al., 2000). Nevertheless, there are several indications that the level of contamination is still high enough to impair the health of the San Francisco Bay estuary. As a whole, the estuary would be assessed as being moderately contaminated. Overall, the sites in the lower South Bay, the Petaluma River mouth, and San

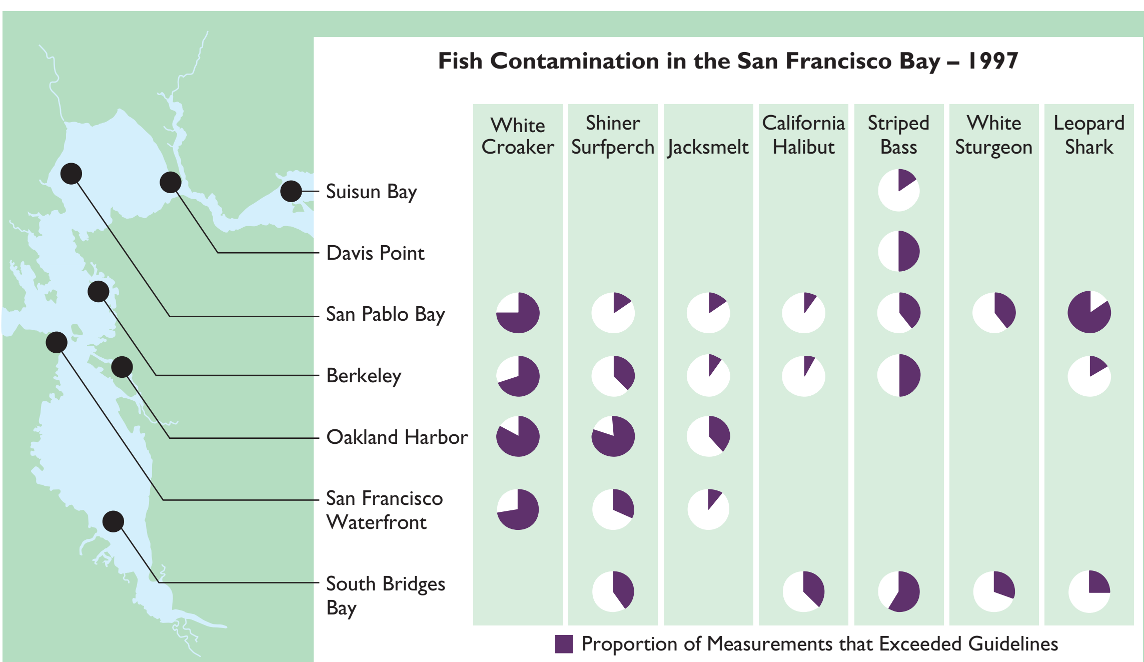


Figure 6-15. The fish in the estuary contain several contaminants at levels high enough to raise concern for the health of both humans and wildlife (from San Francisco Bay RMP, May et al., 2000).

Pablo Bay are more contaminated than other Bay sites. Of the contaminants measured by the RMP, mercury, PCBs, diazinon, and chlorpyrifos are of the highest concern, followed by copper, nickel, zinc, DDT, chlordane, dieldrin, dioxins, and PAHs. In 2000, the RMP initiated an intensive characterization of the water quality, sediments, and biota of the estuary with EPA. One hundred eighty locations will be examined during this characterization.

Puget Sound (Northern Sound Only)

Washington's Department of Ecology (WDOE— http://www.ecy.wa.gov) and the Puget Sound Ambient Monitoring Program (PSAMP—http://www.wa.gov/puget_sound/Programs/PSAMP.htm) have been monitoring Puget Sound using fixed stations since 1989 and using probabilistic sites for the benthic triad since 1997. The PSAMP monitoring effort (1989-1995) sampled 34 sites annually and 42 additional sites on a 3-year rotational basis. Sediments were analyzed to determine the extent of chemical contamination, sediment toxicity, and the structure of macroinvertebrate communities. In 1997, WDOE, jointly with NOAA, examined the bioeffects associated with toxicants in Puget Sound with 100 sites sampled annually using a stratified random sampling approach. This monitoring effort was divided into three 1-year efforts—north Puget Sound (1997) (Figure 6-16), mid-Puget Sound (1998), and south Puget Sound (1999) (Figure 6-17). Results from the north Puget Sound have been completed (Long et al., 1999), and results from the remaining areas will be completed by 2001.

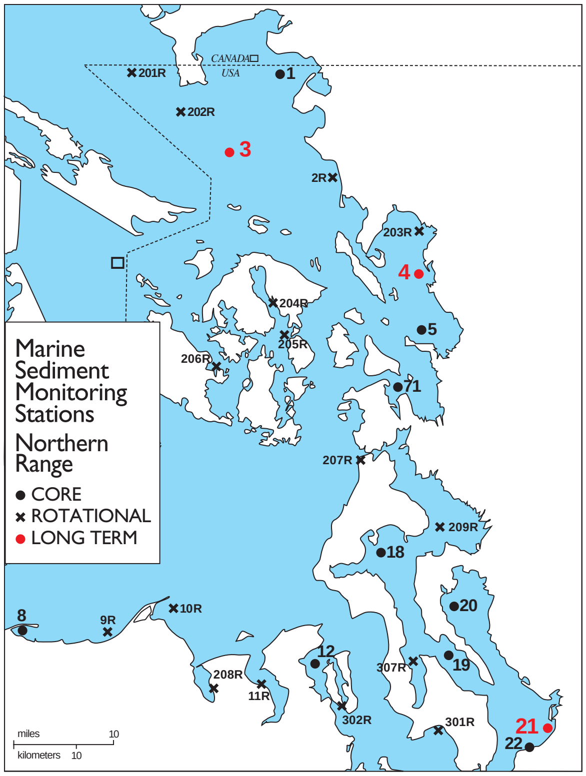


Figure 6-16. Marine sediment monitoring stations in the northern range of Puget Sound.

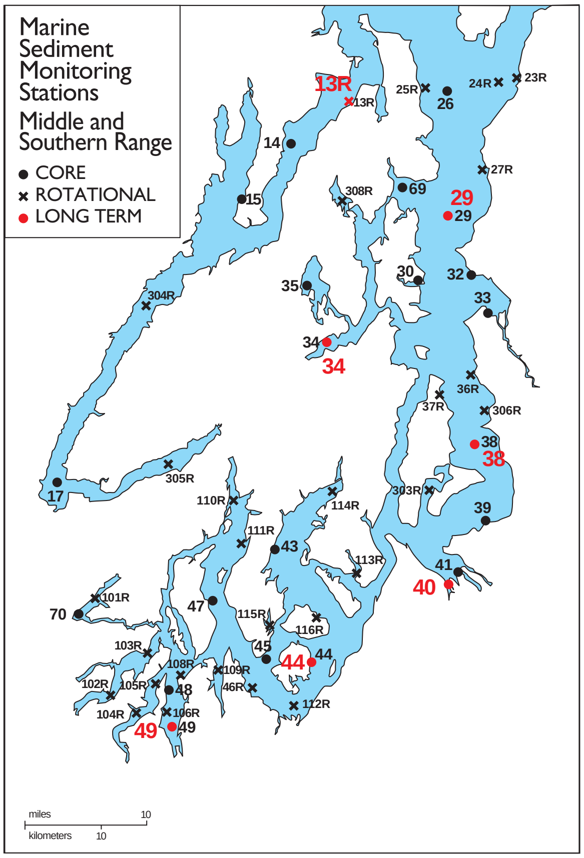


Figure 6-17. Marine sediment monitoring stations in mid-Puget Sound and south Puget Sound.

In 1999-2000, the WDOE, in conjunction with EPA and NOAA, resampled a subset of the 1997-1999 Puget Sound sites and approximately 40 additional sites to examine water quality, fish community structure, and tissue residues. In addition, in 1999, WDOE sampled 50 non-Puget Sound sites throughout coastal Washington to examine water quality, sediment quality, and biotic conditions. These data will be available in 2001-2002.

Water Clarity

The water clarity data available for Puget Sound are not included in this report due to differences in the sampling design used to collect the data. These data are not comparable to the data used to establish indicators for other coastal regions throughout the report.

Dissolved Oxygen

The dissolved oxygen data available for Puget Sound are not included in this report due to differences in the sampling design used to collect the data. These data are not comparable to the data used to establish indicators for other coastal regions throughout the report

Sediment Contaminants

The condition of Puget Sound as measured by sediment contaminant concentrations is good. Chemical analyses of sediments at these sites indicated a relatively wide range of concentrations across the sampled area. However, only a small proportion of the samples had elevated concentrations of pesticides/PCBs (Figure 6-18). Overall, chemical concentrations were highest in sediments from the two most urbanized embayments in northern Puget Sound—Everett Harbor and Bellingham Bay. This pattern was evident for several trace metals and two classes of PAHs. Lower concentrations of PAHs (greater than ERL) were found in Fidalgo Bay.

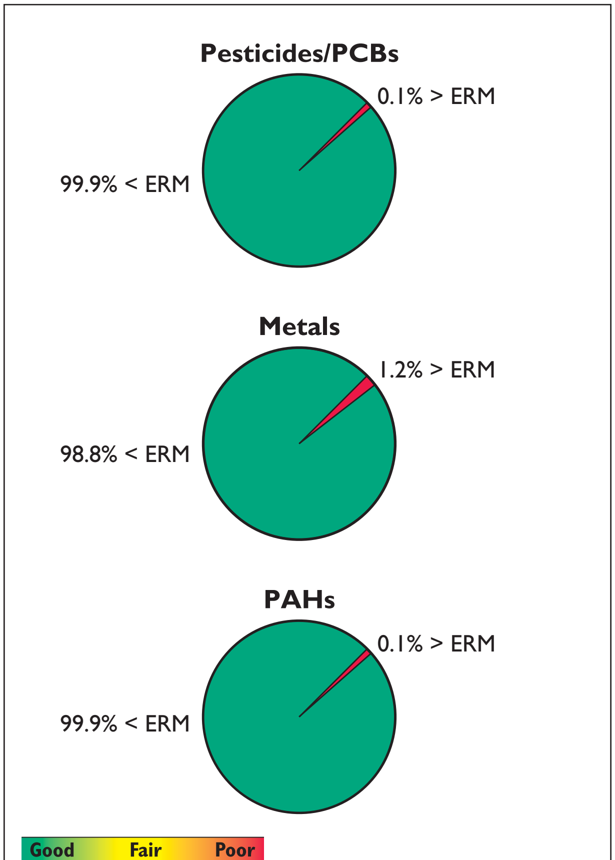


Figure 6-18. Sediment concentration in Northern Puget Sound.

Benthic Condition

Benthic index scores in Puget Sound are generally very good, with only isolated pockets of degraded conditions. Benthic community composition indicated a wide variety of abundance and diversity throughout the 100 sampling locations. Several indices of benthic structure showed strong relationships to sediment contaminant concentrations and sediment toxicity.

Results from four sediment toxicity tests using macroinvertebrate survival rates indicated that a very small proportion (5%) of the northern Puget Sound survey area was highly toxic. Everett Harbor showed the greatest toxicity. Drayton Harbor, Whatcom Waterway, portions of Bellingham Bay, inner Padilla Bay, March Point, Fidalgo Bay, Port Susan, and Port Gardner showed less severe sediment toxicity.

Fish Tissue Contaminants

The fish tissue contaminant data available for Puget Sound are not included in this report due to the differences in the sampling design used to collect the data. These data are not comparable to the data used to establish indicators for other coastal regions throughout the report.

Assessments and Advisories

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

The states on the West Coast assessed 3,413 (83%) of their 4,118 estuarine square miles for their 1998 305(b) reports. Of the assessed estuarine miles on the West Coast, 32% fully support their designated uses, 1% are threatened for one or more uses, and 67% are impaired by some form of pollution or habitat degradation (Figure 6-19). Individual use support for the West Coast estuaries is shown in Figure 6-20.

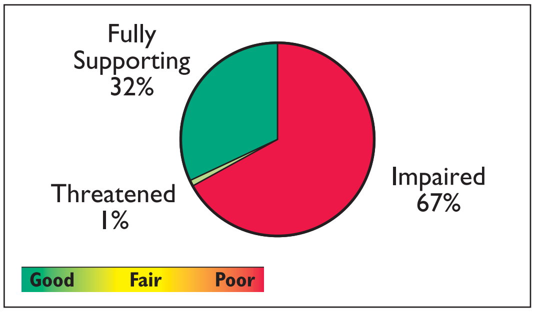


Figure 6-19. Water quality in assessed West Coast estuaries (U.S. EPA).

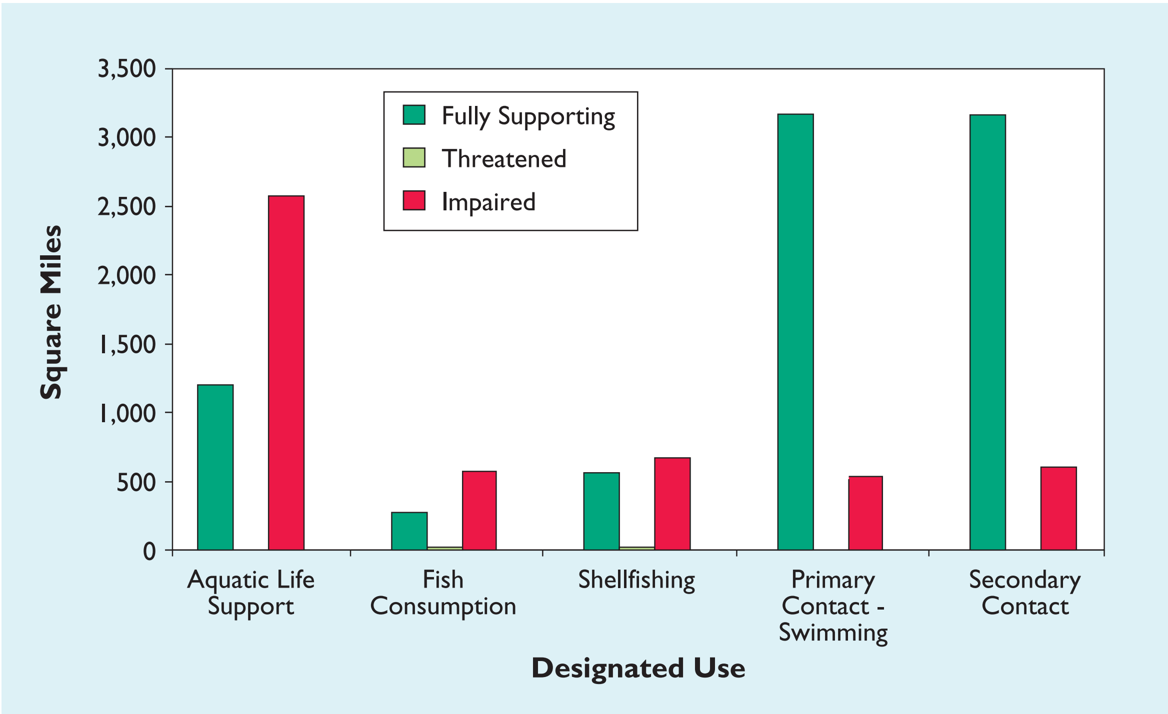


Figure 6-20. Use support for West Coast assessed estuaries (U.S. EPA).

The West Coast states assessed 919 (43%) of their 2,134 shoreline miles. Eighty-seven percent of the assessed shoreline miles fully support their designated uses, no uses are reported as being threatened, and 13% of the shoreline is impaired by some form of pollution or habitat degradation (Figure 6-21). Individual use support for the West Coast shoreline miles is shown in Figure 6-22.

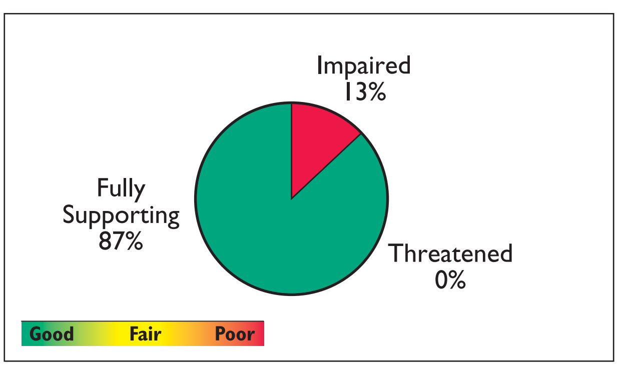


Figure 6-21. Water quality of the assessed shoreline on the West Coast.

The states reported individual use support for their assessed estuarine and coastal waters as shown in Table 6-2.

Table 6-2. Individual Use Support for Assessed Coastal Waters Reported by West Coast States under Section 305(b) of the Clean Water Act

Individual Uses	Assessed Estuaries Impaired, mi^2	Assessed Shoreline Impaired, mi
Aquatic Life	2,571 (68%)[a]	51 (6%)[a]
Fish Consumption	595 (68%)	88 (14%)
Shellfish Harvesting	672 (54%)	55 (7%)
Swimming	541 (15%)	116 (14%)
Secondary Contact	615 (16%)	55 (7%)

[a]Represents percent of assessed waters impaired for each individual use.

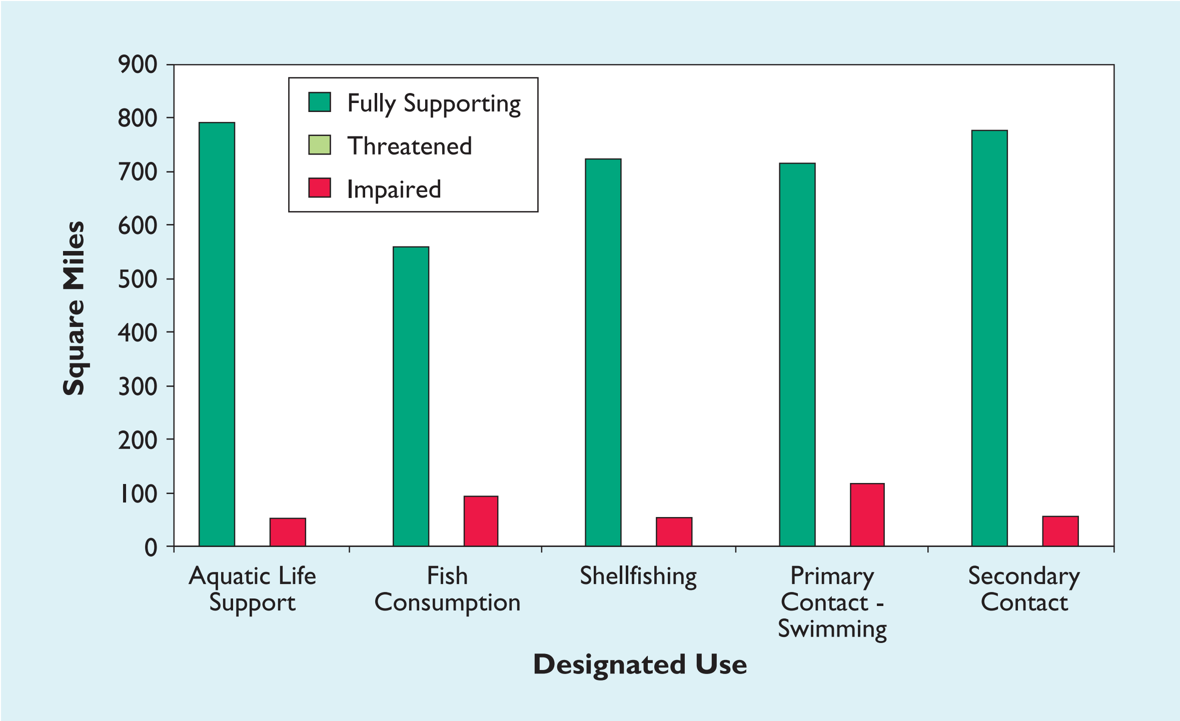


Figure 6-22. Individual use support for assessed shoreline on the West Coast (U.S. EPA).

There are 340 waters on the West Coast that are listed as impaired under Section 303(d) of the Clean Water Act. The percentage of listed waters impaired by each of the major pollutant categories is shown in Figure 6-23.

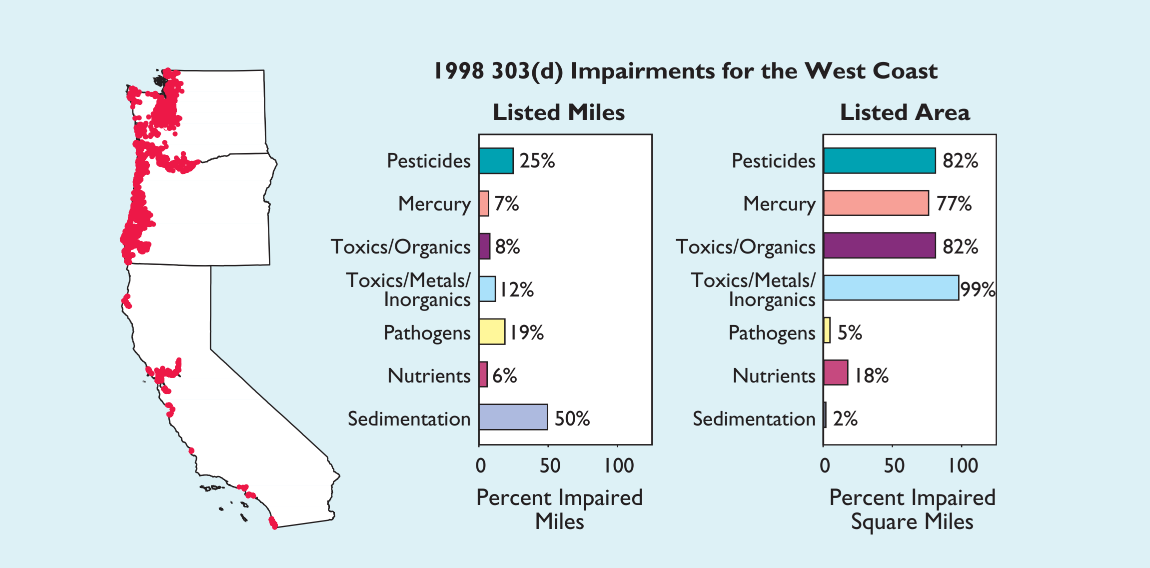


Figure 6-23. 303(d) listed waters on the West Coast and the percentage of listed waters impaired by the major pollutant categories (note that a listing may be impaired by multiple pollutants) (U.S. EPA).

State Fish Consumption Advisories

There were 43 fish consumption advisories active in 2000 for the estuarine and coastal waters of the West Coast (Figure 6-24). Only 9.5% of the coastal miles were under advisory, with half of these miles located in southern California and the other half coastal shoreline in Washington's Puget Sound. A total of 29.8% of the estuarine square miles of the West Coast was under advisory in 2000, and all of the estuarine area under advisory was located within the San Francisco Bay/Delta region or within Puget Sound. None of the West Coast states (California, Oregon, or Washington) had statewide coastal advisories in effect in 2000. Oregon did not list any fish consumption advisories for estuarine or coastal waters.

There were 13 different contaminants or groups of contaminants responsible for West Coast fish advisories in 2000, and 10 of those contaminants (representing 32% of advisories) were listed only in the waters of Puget Sound and bays emptying into the Sound (dioxins, chlorinated pesticides, creosote, industrial and municipal discharge, metals, PAHs, pentachlorophenol, tetrachloroethylene, vinyl chloride, and VOCs). PCBs in California and Washington were responsible for 35% of advisories (Figure 6-25). Twelve advisories for DDT (28%), all in California, were active in 2000.

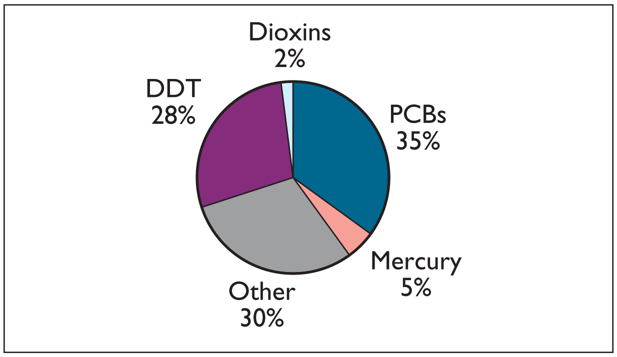


Figure 6-25. Contaminants responsible for fish consumption advisories in the waters of the West Coast in 2000 (U.S. EPA NLFWA, 2000c).

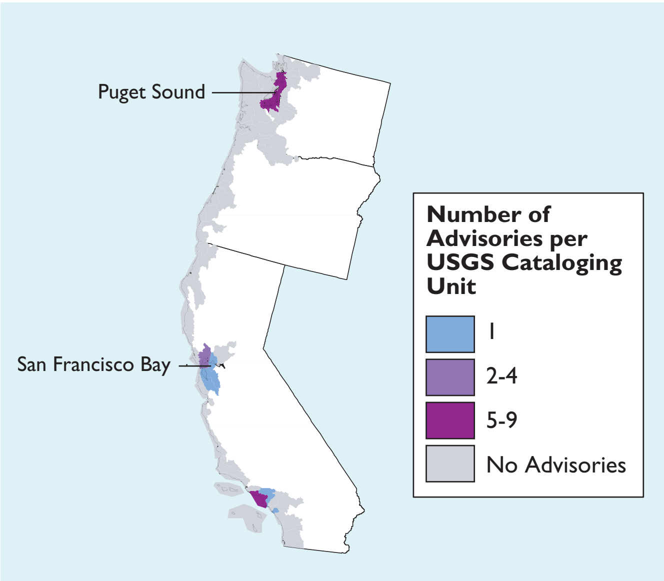


Figure 6-24. The number of fish consumption advisories per USGS cataloging unit for the West Coast (U.S. EPA NLFWA, 2000c).

The following species were under advisory in at least some part of the coastal waters of the West Coast in 1999:

Kelp bass	White croaker	Sculpin
Striped bass	Black croaker	Shark
Bullhead	Gobies	Shellfish
Corbina	Queenfish	Crab
Croaker	Rockfish	Surfperch

Classified Shellfish-Growing Waters

On the West Coast, 423,000 acres (2% of the national total) of shellfish waters were classified for shellfish harvest in 1995. Of those classified, 49% were approved and 51% were harvest-limited. Nationally, the West Coast ranks last in the total amount of classified waters, with only 29% of the waters classified, as shown in Figure 6-26. Of the classified acreage, 84% is located in estuarine waters and 16% in nonestuarine waters. The top three pollution sources affecting harvest limitation are upstream sources, agricultural runoff, and individual wastewater treatment systems.

The top three shellfish species (rated high or medium in abundance) on the West Coast are softshell clams (55,625 acres), Pacific oysters (42,212 acres), and native littleneck clams (25,049 acres). Softshell clams are found at high or medium relative abundance in 13% of the region's shellfish-growing waters, Pacific oysters in 10%, and native littleneck clams in 6%. Eighty-seven percent (48,575 acres) of softshell clams, 13% (5,607 acres) of Pacific oysters, and 24% (6,069 acres) of native littleneck clams are located in waters that do not allow direct harvesting (i.e., restricted, conditionally restricted, and/or prohibited).

Total acreage of approved waters decreased from 52% in 1990 to 49% in 1995. Both Oregon and Washington reported increases in the total amount of classified acreage; however, the biggest change occurred in California, where total classified acreage decreased from 130,000 acres in 1990 to 24,000 acres in 1995.

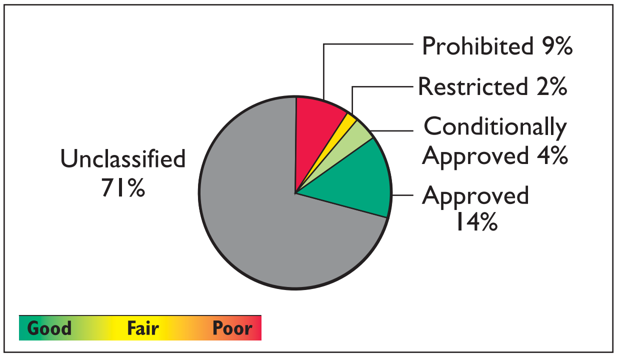


Figure 6-26. The majority of shellfish-growing waters on the West Coast were unclassified (1995 National Shellfish Register, NOAA, 1997).

Beach Closures

Of the three West Coast states, only California and Washington submitted beach monitoring and closing information to EPA in 1999. Ninety-eight percent of the West Coast beaches reporting are in California. There is no regular water quality monitoring of ocean and bay recreational beaches for swimming or for other water contact activities in Oregon.

Of 243 beaches in California that reported information to EPA, 59 (24%) were closed at least once during 1999. The two counties with 50% of the closed beaches were San Diego and Los Angeles Counties (Figure 6-27).

All but five of the California beaches responding to EPA's survey reported the existence of beach monitoring programs in 1999. Beach closings were primarily the result of sewage and elevated bacteria levels caused by pipeline breaks and storm water or other unknown causes.

Kids experience the fun of body boarding in the surf of the Gulf of the Farallones Sanctuary (Photo: Gulf of the Farallones NMS).

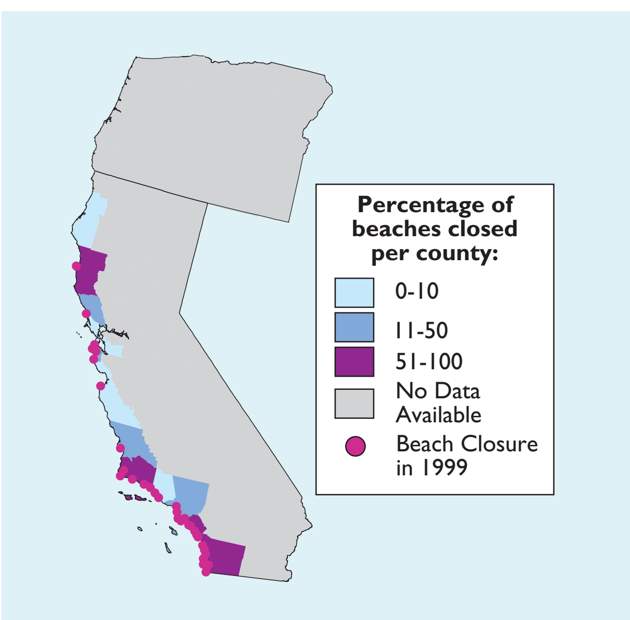


Figure 6-27. Percentage of beaches, of those reporting to EPA, that were closed at least once in 1999.

Washington did not report monitoring information for any beaches in 1998. However, in 1999, Washington reported the existence of water quality monitoring programs for five beaches. None of these beaches experienced closures in 1999.

Summary

Based on available data, ecological conditions in western estuaries are fair (Figure 6-28). Although currently data are not available for all estuarine systems, consistent information throughout western estuarine systems (like that shown earlier for East Coast and Gulf of Mexico estuaries) will be available in 2002. The available data indicate that the primary problem in western estuaries and the Southern California Bight in the 1990s is sediment contamination. Over 25% of sediments are enriched or exceed ERL/ERM guidelines. While problems with sediment contamination are decreasing, the potential for benthic community degradation and fish contamination in selected estuaries is increasing. Concentrations of contaminants in fish tissue in some western estuaries are elevated, creating poor conditions. Dissolved oxygen conditions (except in some isolated regions of Puget Sound) and water clarity are considered good for western estuaries. Contaminant concentrations in fish tissue, benthic community condition, and eutrophic condition are fair in these estuaries but appear to be worsening. Clearly, this is a region of the country where increasing population pressures (particularly in the Seattle-Tacoma region, San Francisco Bay, and southern California) require continued environmental awareness and programs to correct existing problems and to ensure that environmental indicators in fair condition do not worsen.

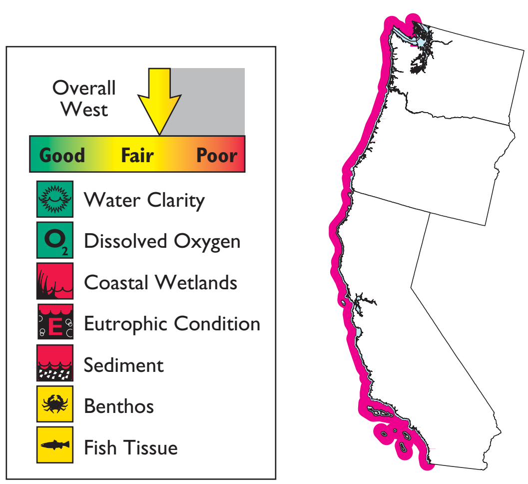


Figure 6-28. Overall ecological condition of estuaries on the West Coast.

San Francisco Bay Estuary Project

http://www.abag.ca.gov/bayarea/sfep

The San Francisco Bay-Delta Estuary is a rich and treasured resource. It is the largest estuarine system on the west coasts of North and South America and includes the waters of San Francisco Bay, San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta. The Estuary drains over 40% of California's land, provides drinking water to two-thirds of California's 34 million people, and irrigates 4.5 million acres of farmland and ranches.

Because of its highly dynamic and complex environmental conditions, the estuary supports an extraordinarily diverse and productive ecosystem. Half of the birds migrating along the Pacific Flyway use the estuary's wetlands for wintering. In certain seasons, the estuary's mudflats and saltflats support more than 1 million shorebirds. Hundreds of thousands of native and hatchery-bred salmon migrate through the Bay-Delta waters on their way to spawning grounds upriver. The Bay-Delta also supports many important economic activities including commercial and sport fishing, shipping, industry, agriculture, recreation, and tourism.

The San Francisco Bay-Delta Estuary has been described as the major estuary in the United States most modified by human activity. The San Francisco Estuary Project (SFEP) was created by EPA's National Estuary Program to develop a more coordinated approach to dealing with the estuary's varied management issues such as intensified land use, decline of biological resources, freshwater diversions, and altered flow regime. The SFEP has enacted a long-term management plan calling for stronger planning, improved regulation, and increased acquisition and restoration of wetlands in the Bay area.

Since its inception, the SFEP has developed a network of demonstration projects for watershed protection and is fast growing into a model of how to make local actions have regional impact. The most notable improvements include declining rate of wetland loss, reduced pollutant loads of municipal and industrial sources, and improved regulation of dredging. Over 26,000 acres of wetlands have been acquired and over 28,000 acres of wetlands restored since 1993. Urban expansion, however, continues to deplete the stock of valuable upland wildlife habitats, wetlands, and riparian areas and to increase loadings of many point and nonpoint pollutants. Population growth fuels the increasing demand for fresh water. Water development projects continue to influence the estuary's primary productivity and habitat quality and to adversely affect populations of valuable commercial and sport fish and other species.

Northwest Indian Fisheries Commission

http://www.nwifc.wa.gov

During the past 2 decades there has been a steady decline of many wild salmon stocks originating from Puget Sound and the Washington coast, brought about in part by the loss of critical wild salmon spawning and rearing habitat. As a result of the decline in wild salmon stocks, in 1999 the National Marine Fisheries Service listed Puget Sound chinook salmon, Lake Ozette sockeye, and Hood Canal summer chum stocks as "threatened" under the federal Endangered Species Act (ESA).

The Northwest Indian Fisheries Commission (NWIFC), an organization of the treaty Indian tribes in western Washington, responded to the salmon ESA listings by intensifying their watershed recovery efforts through the state/tribal cooperative Wild Stock Restoration Initiative (WSRI) program. The aim of the effort is to inventory local salmon stocks and habitat, then develop guidelines to restore the most critical stocks and habitats. Indian tribes and the Washington Department of Fish and Wildlife (WDFW) have cooperatively developed a joint assessment of the status of salmon and steelhead stocks in Washington State in response to concerns about declining populations.

The tribes and WDFW created the Wild Stock Restoration Initiative in 1991 in response to wild salmon and steelhead stock concerns. The following approach was established to address wild stock status and recovery:

- Inventory status of stocks and their habitat
- Review management strategies (harvest, habitat, and hatcheries)
- Develop recovery and management plans
- Monitor and evaluate.

Tribal, state, and federal governments and their fisheries managers realize the need for a more focused approach to protect, restore, and manage this resource. Fisheries managers have responded to salmon declines with historic cutbacks in fisheries—as much as 80% in the last decade. But fishery closures and reductions have resulted in severe economic hardship for tribal fishermen on reservations, where unemployment runs as high as 80%.

Chapter 7

Great Lakes Coastal Condition

Chapter 7

Great Lakes Coastal Condition

Based on available information from various monitoring efforts, ecological conditions in the Great Lakes are borderline poor (Figure 7-1). The open waters of the approximately 290,000 square miles of the Great Lakes are monitored annually by EPA's Great Lakes National Program Office (GLNPO), in conjunction with NOAA and USGS. A fixed site design has been used to characterize water quality and, in recent years, the composition of the phytoplankton, zooplankton, and benthic communities. The limnology (lake science) program provides information on key environmental factors that influence the aquatic ecosystem of the Great Lakes. Annual monitoring began in 1983 for Lakes Michigan, Huron, and Erie; in 1986 for Lake Ontario; and in 1992 for Lake Superior (Figure 7-2). The sampling strategy is to collect water and biota samples at specific water depths from a select set of locations in each lake twice a year. The limnology program focuses on the open lake basins (water greater than 98 feet in depth and greater than 3 miles from shore). At key stations, and as part of special studies, sediment samples are taken as well. For known or suspected problem areas, such as the Great Lakes Areas of Concern, sampling is also performed in the nearshore zone. This zone includes numerous bays and rivers connecting the lakes.

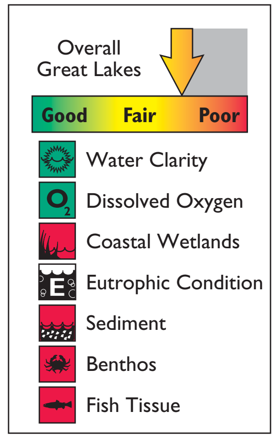


Figure 7-1. Overall condition of the Great Lakes as measured by the seven indicators.

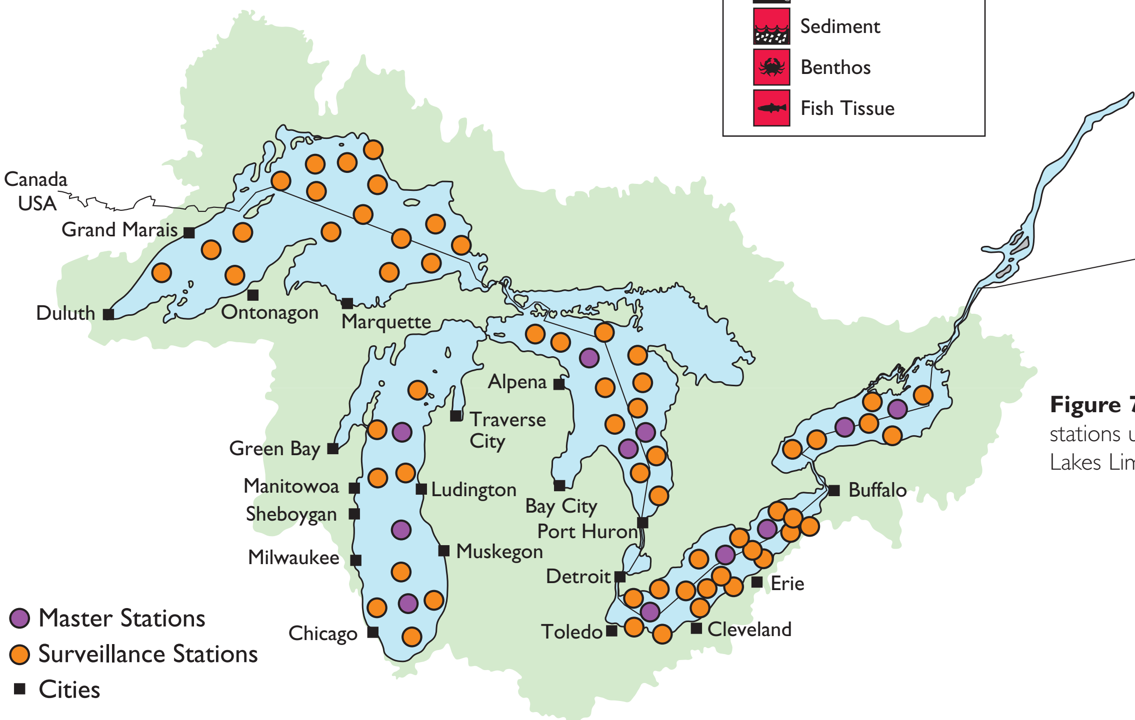


Figure 7-2. Monitoring stations used by the Great Lakes Limnology Program.

Probabilistic surveys like those completed for the Northeast, Southeast, and Gulf Coasts do not exist for the Great Lakes region. Therefore, spatial estimates of ecological condition consistent with those calculated in earlier chapters cannot be determined. However, existing monitoring data from long-standing programs have been used to assess ecosystem condition to the extent possible.

Fishing from the Great Lakes shore (Courtesy of USDA Natural Resources Conservation Service).

Coastal Monitoring Data

Water Clarity

Water clarity in the Great Lakes is good. Water clarity, as measured by a Secchi disc, has increased in all lakes except Lake Erie over the last decade. Lake Ontario Secchi disc depths have increased nearly 100%. In Lake Ontario, for example, light penetration has increased from 3.1 meters (pre-1990 measurements) to 6.7 meters (post-1990 measurements).

Dissolved Oxygen

Dissolved oxygen conditions in the Great Lakes are generally good. However, dissolved oxygen in Lake Erie continues to be a persistent problem. Anoxic conditions (less than 0.5 mg/L) often occur in late August and continue until turnover occurs in fall. Although the frequency and extent of oxygen depletions have decreased considerably from the 1970s and 1980s, that trend leveled off in the late 1990s.

Coastal Wetland Loss

During the 200-year period between the 1780s and the 1980s, 51% of wetlands in the Great Lakes area were lost (Figure 7-3). The largest reductions were observed in Ohio (90%) and the smallest in Minnesota (42%).

Eutrophic Condition

The Great Lakes were not included in NOAA's National Estuarine Eutrophication Assessment, so data similar to those used in previous chapters to assess eutrophic condition are not available. However, chlorophyll *a* concentrations (a symptom of eutrophication potential) are stable throughout the lakes with the exception of the central and western basins of Lake Erie.

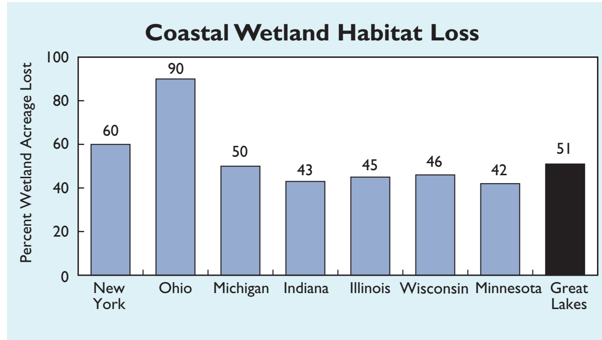
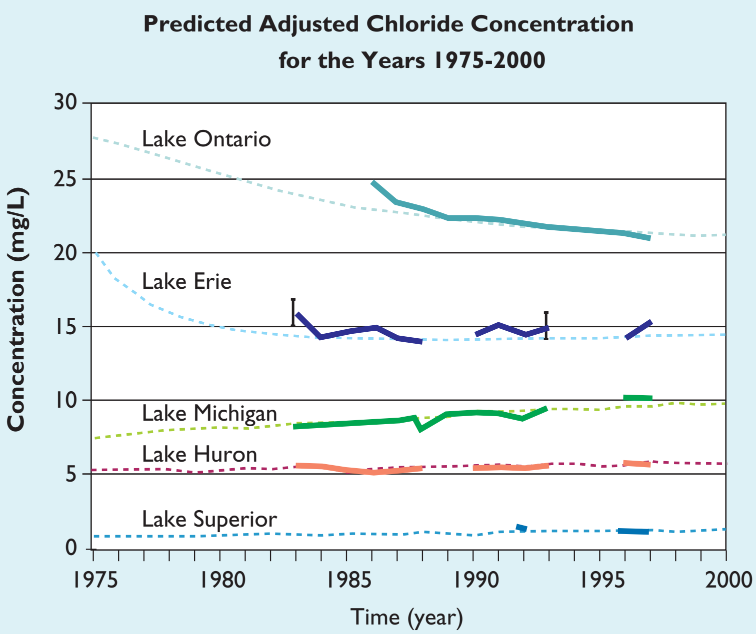


Figure 7-3. Percent wetland habitat loss from 1780 to 1980 by state and for the Great Lakes overall (Dahl, 1990; Turner and Boesch, 1988).

Data are also available for nutrient input into the Great Lakes. Nitrate and silica continue to increase in all lakes. Phosphorus concentrations have stabilized in all lakes with the exception of Lake Ontario, where phosphorus continues to decline at a slow rate of 0.3 mg/L per year. Only Lake Erie exceeds the phosphorus objectives set by the United States and Canada (15 mg/L), by about 60% in the western basin and by about 10% to 20% in the central and eastern basins. Input of chloride compounds from human activities (brines, road salt, etc.) has resulted in increased chloride concentrations in the Great Lakes. The rate of increase is slow (0.1 mg/L per year) in Lakes Michigan, Huron, and Superior (Figure 7-4), and it is decreasing from previously elevated levels in Lakes Erie and Ontario. Overall water quality in Lakes Superior, Michigan, and Huron is good, with elevated chloride levels being observed in Lake Ontario and elevated phosphorus concentrations observed in Lake Erie.



Estimated Chloride Loads

Lake	kg/day	ton/yr
Superior	$7.76(10^5)$	$2.84(10^5)$
Michigan	$2.46(10^6)$	$9.01(10^5)$
Huron	$1.18(10^6)$	$4.31(10^5)$
Erie	$4.63(10^6)$	$1.69(10^6)$
Ontario	$5.05(10^6)$	$1.84(10^6)$

Error bars indicate data for years 1983-1993, ±1 standard deviation. Dashed lines indicate predicted values. Solid lines indicate actual values.

Figure 7-4. Predicted chloride concentrations in the Great Lakes from 1975 to 2000.

Photo: © John Theilgard

Great Lakes Indian Fish and Wildlife Commission Issues Fish Consumption Information for Tribal Members

http://www.GLIFWC.org

Eleven sovereign tribal governments, located in Minnesota, Wisconsin, and Michigan, make up the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). The Commission's purpose is to protect and enhance treaty-guaranteed fishing on the Great Lakes and inland territories ceded under the Chippewa treaties and to provide cooperative management of these resources.

As part of its responsibilities, the GLIFWC publishes booklets and reports to inform tribal members of the health benefits and risks of consuming fish caught in the wild. Eating a diet rich in fish offers many health benefits, including the prevention of heart disease by regular consumption of omega-3 fatty acids found in fish. Consuming fish can also be potentially harmful because of the levels of contaminants such as mercury that are found in fish from some Great Lakes areas.

The GLIFWC website (www.GLIFWC.org) provides access to reports, pamphlets, and maps to help tribal members decide where to fish, how much fish to eat, and what types of fish to eat. For example, the GLIFWC has developed maps of mercury contamination in walleye for a number of different fishing areas. The maps, which are available on the website and in seasonal publications from the GLIFWC, indicate the locations where walleye of certain sizes may contain harmful levels of mercury. The publications also issue specific advice for sensitive subpopulations, such as women of childbearing age and children under age 15, who are more susceptible to harm from contaminants.

The International Joint Commission

Formed under the 1909 Boundary Waters Treaty, the International Joint Commission (IJC) acts as an objective advisor to both the United States and Canada in the management of transboundary waters. IJC is involved in issues affecting all transboundary waters including the Columbia River Basin, Red River Basin, and Great Lakes/St. Lawrence River Basin. The IJC provides a comprehensive assessment every 2 years of progress made to meet the goals set in the 1978 Great Lakes Water Quality Agreement (GLWQA). It accomplishes this through the actions of several councils, including the Great Lakes Science Advisory Board, Great Lakes Water Quality Board, and Council of Great Lakes Research Managers. The IJC releases biennial reports on the progress of the parties in meeting the terms of the Agreement; these are followed up by review meetings called by the parties to undertake actions under the terms of the Agreement. Additionally, the Annex 2 Advisory Committee provides guidance and review of Remedial Action Plans (RAPs) and Lakewide Management Plans (LaMPs) developed under GLWQA.

International Joint Commission
Commission mixte internationale

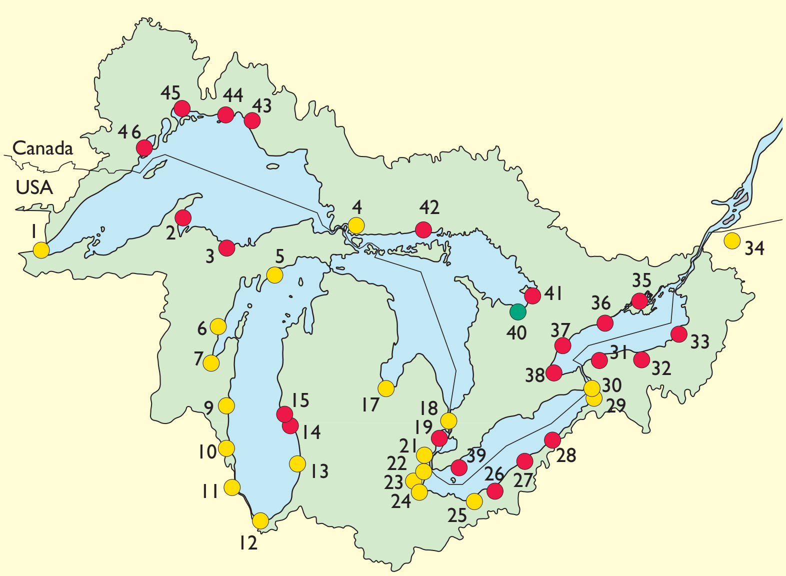
Members of the International Joint Commission

- Annex 2 Advisory Committee
- Council of Great Lakes Research Managers
- Great Lakes Science Advisory Board
- Great Lakes Water Quality Board
- International Lake Champlain Board of Control
- International Lake Superior Board of Control
- International Niagara Board of Control
- International St. Lawrence River Board of Control
- International Air Quality Advisory Board

Sediment Contaminants

EPA's Great Lakes National Program Office has determined that polluted sediments remain as the largest major source of contaminants to the Great Lakes food chain. Under the Great Lakes Water Quality Agreement, the governments of the United States and Canada identified 43 Areas of Concern having significant impairments of beneficial use (Figure 7-5). Over 2,000 miles (20%) of the shoreline are considered impaired because of sediment contamination, and fish consumption advisories remain in place throughout the Great Lakes. On the U.S. side of the border, sediments have been assessed at 26 Great Lakes locations, and over 1.3 million cubic yards of contaminated sediments have been remediated over the past 3 years. However, the challenge is so great that sediment remediation has so far been completed at only 1 of the 43 Areas of Concern.

Areas Receiving or Awaiting Remediation for Sediment Contamination in the Great Lakes



Awaiting Remediation

2. Torch Lake
3. Deer Lake
14. Muskegon Lake
15. White Lake
19. Clinton River
26. Cuyahoga River
27. Ashtabula River
28. Presque Isle Bay
31. Eighteen Mile Creek
32. Rochester Embayment
33. Oswego River
35. Bay of Quinte
36. Port Hope
37. Metro Toronto
38. Hamilton Harbour
39. Wheatly Harbour
41. Severn Sound
42. Spanish River Mouth
43. Peninsula Harbor
44. Jackfish Bay
45. Nipigon Bay
46. Thunder Bay

Some Remediation Completed

1. St. Louis River
4. St. Mary's River
5. Manistique River Harbor
6. Menominee River
7. Fox River
9. Sheboygan River/Harbor
10. Milwaukee Estuary
11. Waukegan Harbor
12. Grand Calumet River/ Indiana Harbor
13. Kalamazoo River
17. Saginaw River
18. St. Clair River
21. Rogue River
22. Detroit River
23. River Raisin
24. Maumee River
25. Black River (Ohio)
29. Buffalo River
30. Niagara River
34. St. Lawrence River

Remediation Completed

40. Collingwood Harbour

Figure 7-5. Great Lakes Areas of Concern receiving or awaiting remediation for sediment contamination.

Benthic Condition

The condition of the Great Lakes according to benthic indices is poor. Benthic invertebrate communities were sampled during the summers of 1997 and 1998 (Figure 7-6). Deep water sites in the Great Lakes support relatively taxa-poor benthic assemblages. Lakes Superior, Michigan, Huron, and Erie support fairly distinct benthic communities with significant similarity among sampling sites within each lake. In contrast, Lake Ontario benthic assemblages varied greatly from site to site. Recent studies undertaken in cooperation with NOAA and others have revealed precipitous declines in populations of certain benthic invertebrates, particularly a small shrimp-like crustacean (*Diporeia spp*), which resides at the base of the benthic food chain. *Diporeia* populations in Lake Michigan, for example, have plummeted in all 10 sites sampled; further studies are under way to identify the causes.

Much more data are available for biotic communities sampled in open water in the Great Lakes. Diatom collections were completed in all five lakes in the spring and summer of 1998 (Figure 7-7). Diatoms are used in the Great Lakes monitoring as an overall indicator of ecological condition. Phytoplankton populations in spring were overwhelmingly dominated by centric diatoms with the exception of Lake Superior. Within-lake communities were relatively homogeneous with the exception of Lake Erie. Both diatom dominance and species richness decreased in the summer, as would be expected. Zooplankton surveys were completed in conjunction with the diatom sampling. Zooplankton represent an indicator of primary consumers in Great Lakes food chains and are food items for many fish species. Unlike phytoplankton communities, zooplankton communities exhibited very low species richness in the spring throughout the Great Lakes. All lakes were dominated by copepods with abundances and species richness increasing through the summer months.

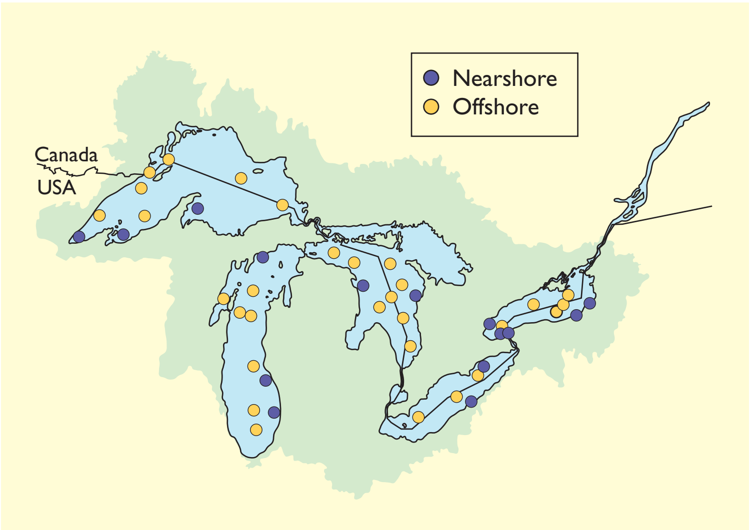


Figure 7-6. Sites sampled for benthic invertebrates in 1997 and 1998.

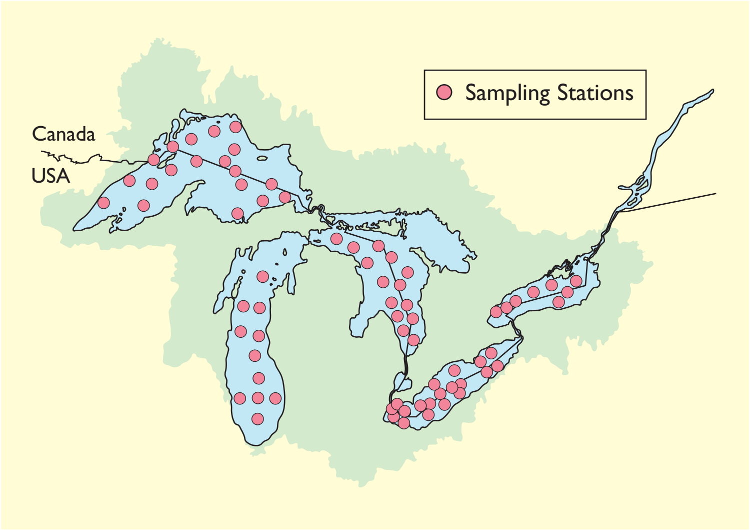


Figure 7-7. Sampling stations used for diatom collection in 1998.

Invasion of the lakes by the zebra mussel (*Dreissena polymorpha*) in the 1980s has dramatically altered the food web of the Great Lakes and considerably altered the community composition of phytoplankton, zooplankton, and benthos, favoring some fish species at the expense of others and changing the pathways and impacts of bioaccumulative contaminants. Populations of certain lesser-known invertebrate invaders, such as the spiny water flea (*Bythotrephes cederstroemi*) and the fishhook flea (*Cercopagis pengoi*), are also burgeoning in some locations, with *Cercopagis* outnumbering all other zooplankton species in specific parts of Lake Ontario in a 1999 survey. These species both compete with and prey upon native zooplankton, while serving as less desirable forage for most Great Lakes fish.

Overall, the condition of phytoplankton, zooplankton, and benthic communities in the Great Lakes varies considerably from lake to lake and within each lake. Lake Superior appears healthy and diverse, in part because of its upstream location and because it is too cold to favor certain invading organisms, such as the zebra mussel. The condition of the biotic communities of the lower four lakes is more mixed. More information on Great Lakes National Program Office (GLNPO) indicators is available on the Internet: http://www.epa.gov/glnpo/monitor.html.

Fish Tissue Contaminants

The condition of the Great Lakes as measured by fish tissue contaminants is poor, although levels of contaminants in fish and wildlife have declined dramatically from peak levels in the 1970s and 1980s. Chemical contamination resulting in fish consumption advisories is one of the greatest environmental problems in the Great Lakes.

In summary, the overall condition of the Great Lakes has improved dramatically despite local occurrences of sediment contamination and lake-by-lake fish advisories. However, ecological conditions of the Great Lakes are still in question as the continuing impacts of invasive species are sorted out. The success of efforts to remediate sediments in these areas will continue to be realized in further reductions in fish tissue contaminant concentrations—although advisories are still in effect throughout the lakes. Substantial challenges remain and conditions must be measured periodically to ensure that improvement continues. Programs like the multiagency Coastal Monitoring and Research Strategy (part of the Clean Water Action Plan) and Coastal 2000 will support GLNPO in providing this continuing surveillance.

Assessments and Advisories

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

The Great Lakes states assessed 4,950 miles (90%) of their 5,521 miles of Great Lakes shoreline for their 1998 305(b)water quality reports. Only 2% of the assessed shoreline waters fully support their designated uses, 2% are threatened for one or more uses, and the remaining 96% are impaired by some form of pollution or habitat degradation (Figure 7-8). Individual use support for Great Lakes shoreline is shown in Figure 7-9.

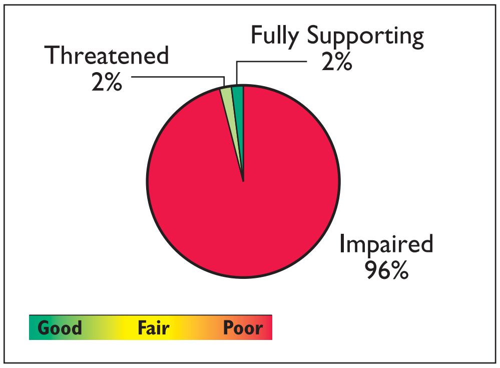


Figure 7-8. Water quality for assessed Great Lakes shoreline (U. S. EPA).

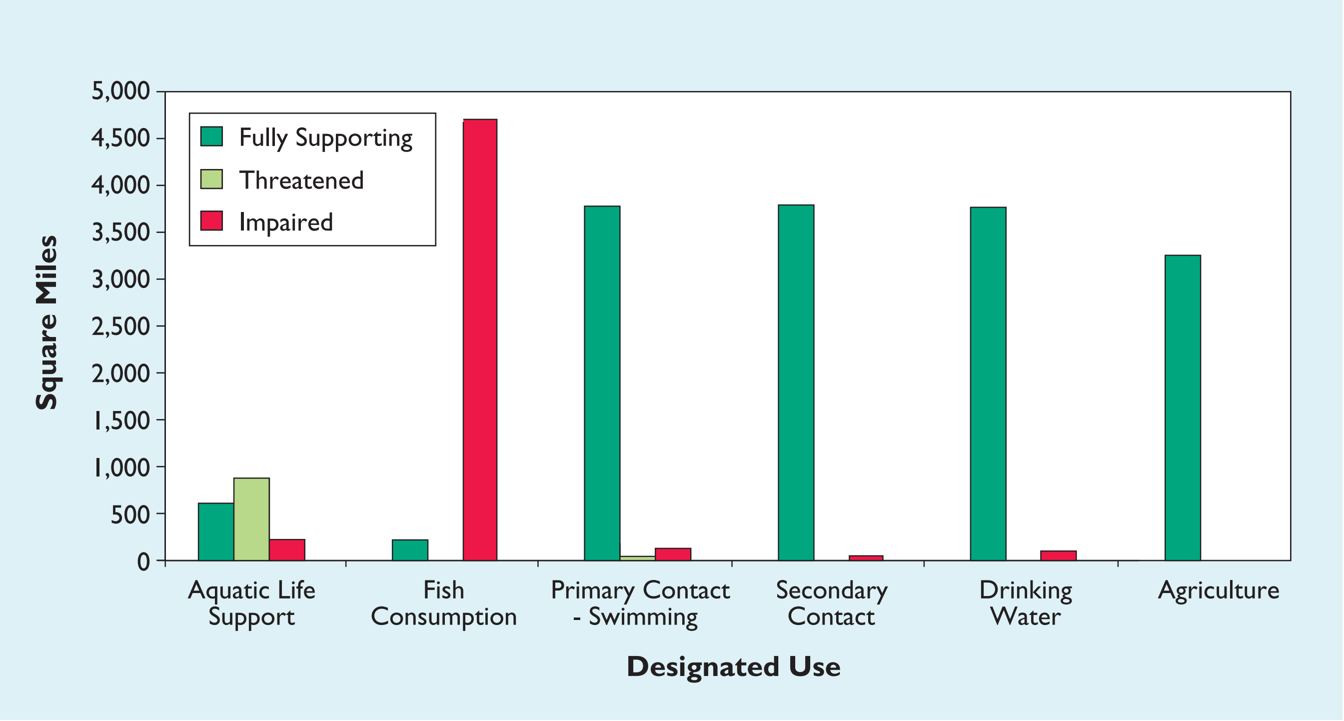


Figure 7-9. Individual use support for assessed Great Lakes shoreline (U.S. EPA).

The states reported the following individual use support for their assessed estuarine and coastal waters (Table 7-1). Figure 7-10 shows the leading pollutants that cause use impairments.

Table 7-1. Individual Use Support for Assessed Coastal Waters Reported by States on the Great Lakes under Section 305(b) of the Clean Water Act

Individual Uses	Shoreline Assessed as Impaired (mi)	% of Total Shoreline Assessed
Aquatic Life	210	12%
Fish Consumption	4,747	96%
Swimming	101	3%
Secondary Contact	41	1%
Drinking Water	80	2%
Agriculture	0	0

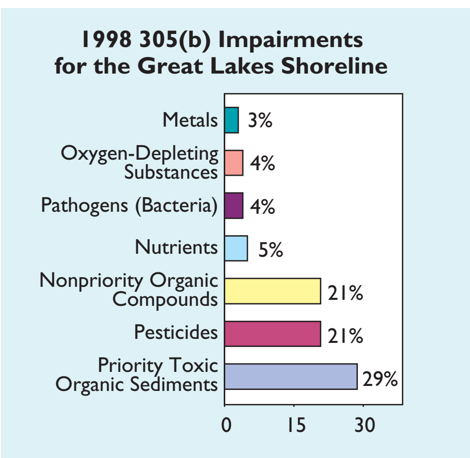


Figure 7-10. The leading pollutants that cause use support impairment of assessed Great Lakes shoreline (U.S. EPA).

State Fish Consumption Advisories

Fishing in the Great Lakes area is a way of life and a valued recreational and commercial activity for many people. To protect their citizens from the risks of eating contaminated fish, the eight states bordering the Great Lakes had a total of 32 fish consumption advisories in effect in 2000 for waters of the lakes and the connecting waters. Every Great Lake was under at least one advisory, covering 100% of the U.S. coastline (Figure 7-11). Michigan, which borders four of the five Great Lakes and encompasses four of the six connecting waterbodies, issued the greatest number of advisories (eight).

Great Lakes fish consumption advisories were issued for a total of five pollutants: mercury, mirex, chlordane, dioxins, and PCBs.

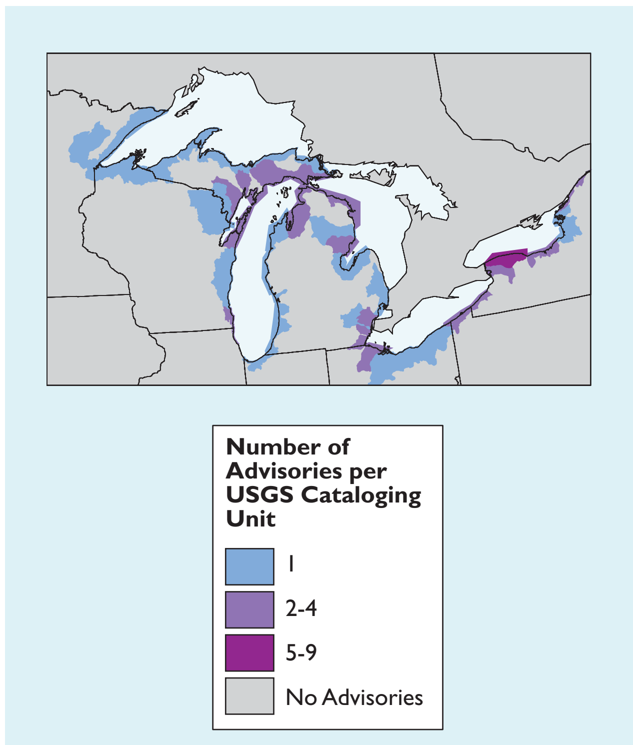


Figure 7-11. 100% of U.S. Great Lakes shoreline was under fish consumption advisory in 2000.

Most of the advisories (48%) were issued for PCBs (Figure 7-12). Lake Superior, Lake Michigan, and Lake Huron were under advisory for three pollutants each in 1999 (Table 7-2). It should be noted that some of the advisories were of limited geographic extent, and advisories in most locations apply primarily to larger, older specimens high in the food chain.

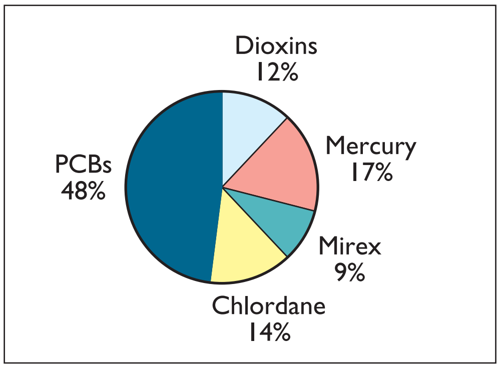


Figure 7-12. Great Lakes advisories were issued for five pollutants (U.S. EPA NLFWA, 2000c).

Table 7-2. Fish Advisories Issued for Contaminants in Each of the Great Lakes

Great Lakes	PCBs	Dioxins	Mercury	Chlordane	Mirex
Lake Superior	●		●	●	
Lake Michigan	●		●	●	
Lake Huron	●	●		●	
Lake Erie	●				
Lake Ontario	●	●			●

Species under fish consumption advisory in 1999 in at least one of the Great Lakes or connecting waters:

Largemouth bass	Round goby	Freshwater drum
Rock bass	American eel	Bluegill sunfish
Smallmouth bass	Lake herring	Brook trout
White bass	White perch	Brown trout
Bloater	Yellow perch	Lake trout
Bowfin	Northern pike	Rainbow trout
Brown bullhead	Redhorse	Siscowet trout
Burbot	Silver redhorse	Splake trout
Common carp	Chinook salmon	Steelhead trout
Quillback carpsucker	Coho salmon	Walleye
Catfish	Pink salmon	Whitefish
Channel catfish	Gizzard shad	Lake whitefish
Chub	Smelt	White sucker
Black crappie	Lake sturgeon	Longnose sucker

Beach Closures

EPA's Great Lakes National Program Office has conducted a beach closures monitoring program since 1983. Since 1998, the program has been merged into EPA's national tracking program. Health authorities in all eight Great Lakes states submitted beach monitoring and closing information to EPA in 1999. Of the 583 beaches on the U.S. side of the Great Lakes, information was submitted on 327. About 20% of the 327 reported beaches (67 beaches) were closed at least once during the 1999 season (Figure 7-13). Of the reporting beaches that had closures, all but one had monitoring programs in place. Most beach closures were the result of elevated bacteria levels and sewage caused by runoff, stormwater, wildlife, sanitary and combined sewer overflows, or other unknown causes. A few beaches were closed because of weather, wave action, or presence of aquatic weeds.

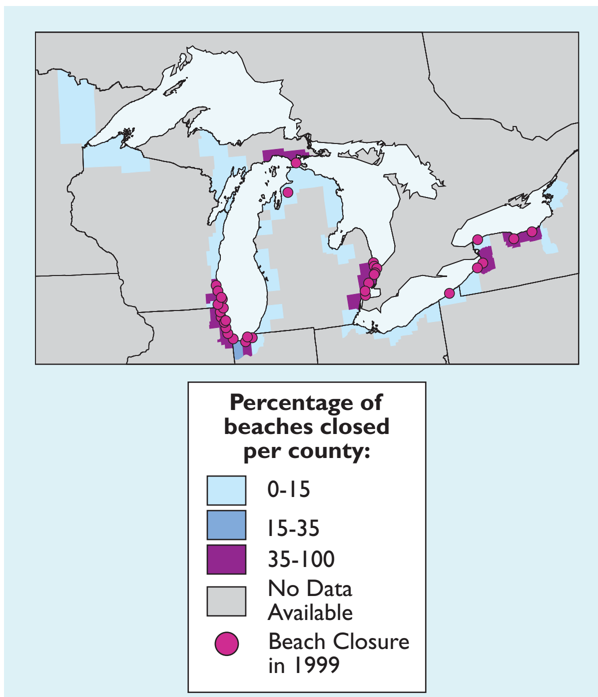


Figure 7-13. Great Lakes beach closings in 1999.

Summary

Ecological conditions in the Great Lakes, based on available information, are borderline poor (Figure 7-14). The primary problems in the Great Lakes in the 1990s were sediment contamination, benthic community condition, coastal wetland loss, and fish contaminants. Over 25% of sediments are enriched or exceed ERL/ERM guidance, benthic communities are in poorer than expected condition, and contaminant levels in fish tissue result in numerous advisories. While some improvements in these areas are being observed, there is still the potential for further degradation of benthic communities, increased fish contamination in selected areas, and decreases in dissolved oxygen.

Figure 7-14 displays the condition of the major indicators of ecological condition in the Great Lakes. Sediment contamination, benthic community condition, coastal wetland loss, and fish tissue contaminant concentrations are considered in poor condition throughout sampled portions of the Great Lakes. Dissolved oxygen conditions and water clarity are considered good for the Great Lakes. Significant strides have been made in improving the condition of the Great Lakes. However, these efforts must be continued and potentially strengthened throughout the lakes to ensure continued environmental improvement.

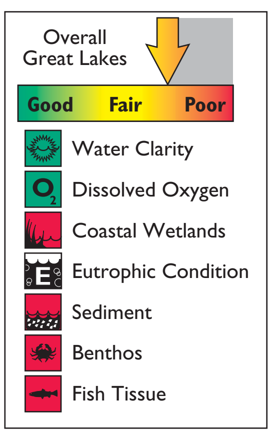
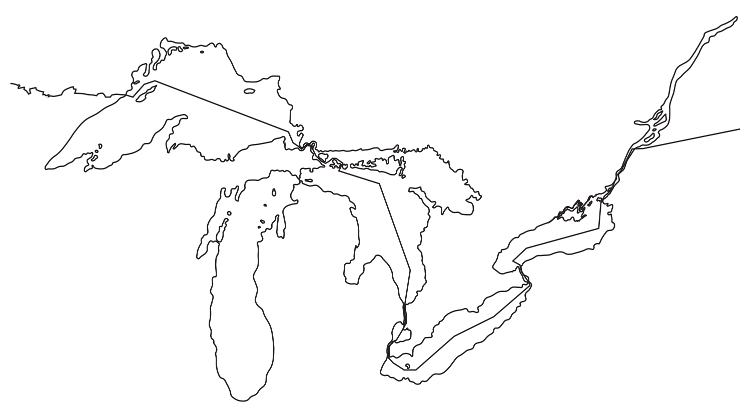


Figure 7-14. Ecological conditions in the Great Lakes are borderline poor. The primary problems in the Great Lakes are sediment contamination, benthic community condition, coastal wetland loss, and fish contaminants.



The Great Lakes National Program Office

The Great Lakes National Program Office (GLNPO), established by Congress in 1987 under Section 118 of the Clean Water Act, provides an institutional framework for efforts to protect and restore the Great Lakes ecosystem in the United States. Current GLNPO activities include

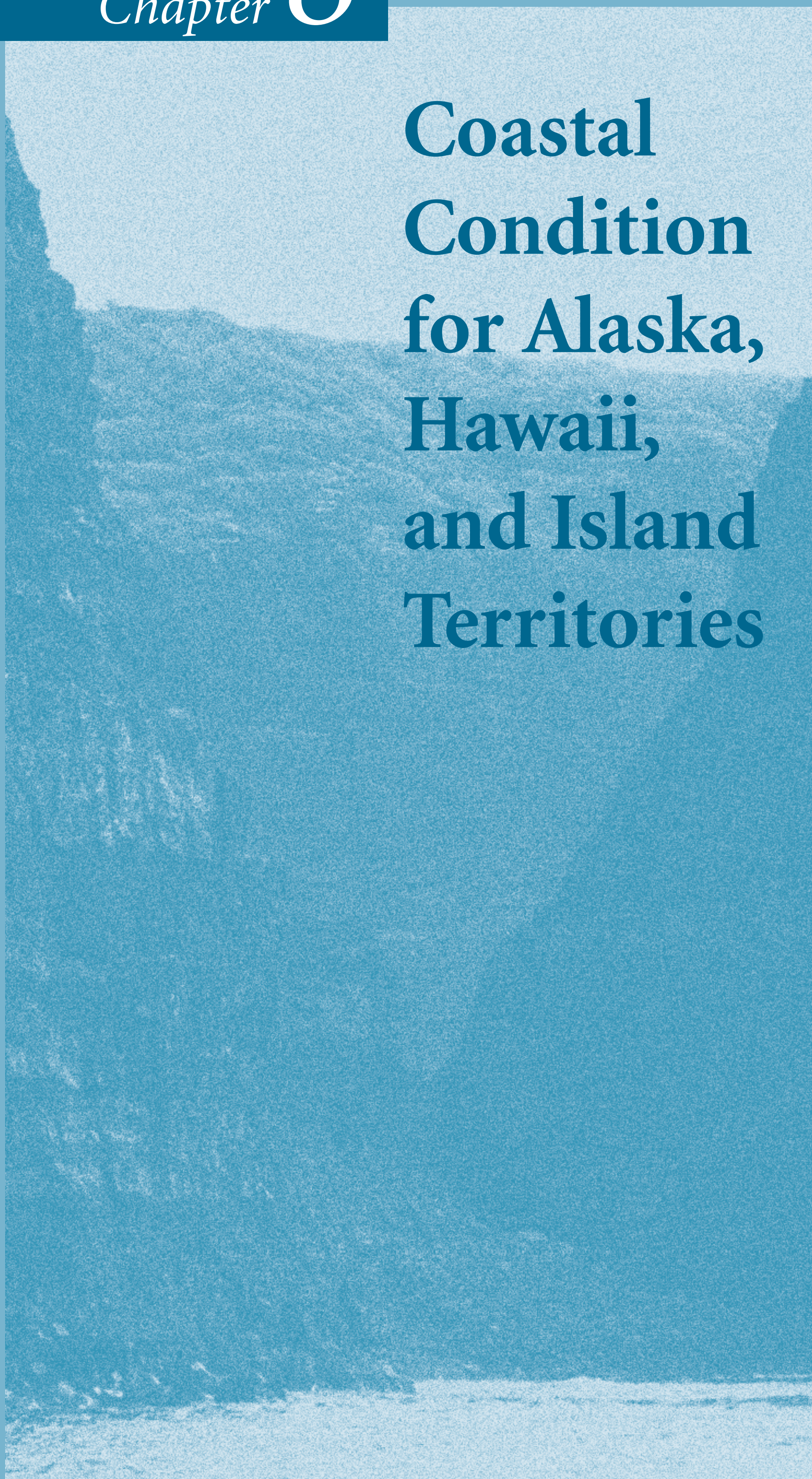
- Conducting open-lake sediment, biota, and water quality monitoring
- Funding habitat restoration and protection projects
- Coordinating Great Lakes protection efforts at all levels of government
- Working with both its Canadian counterparts and the International Joint Commission to negotiate and implement the Great Lakes Water Quality Agreement.

As part of the Great Lakes Water Quality Agreement, GLNPO and Environment Canada convene a biennial conference called the State of the Lakes Ecosystem Conference (SOLEC). Following the conferences, *State of the Great Lakes* reports were issued in 1995, 1997, and 1999. In 1998, a suite of 80 indicators was proposed to be "necessary and sufficient" to adequately represent the major Great Lakes ecosystem components, including the nearshore and offshore waters, coastal wetlands, nearshore terrestrial, human health, societal, and land use. In 2000, summary reports were prepared for 31 of the 80 indicators. These reports are available on the Internet on the SOLEC website (http://www.on.ec.gc.ca/solec) by following the links to each SOLEC conference. Additional information on SOLEC and the indicators project is available on the Internet at http://www.epa.gov/glnpo/solec.

Working with state and provincial governments, GLNPO and Environment Canada have identified 42 Areas of Concern (AOC) throughout the Great Lakes. These are the most polluted areas that will require the most immediate action. For each AOC, a Remedial Action Plan (RAP) is to be prepared by the cognizant jurisdiction, usually a state (on the U.S. side), with local involvement. For each Great Lake, a Lakewide Management Plan (LaMP) is to be prepared to address contaminant and habitat issues on a whole-lake scale. Five of the RAPs and four of the LaMPs are binational, and the LaMP for Lake Erie involves three EPA regions. The LaMPs are to be prepared cooperatively among the governments and jurisdictions with EPA as the U.S. lead.

Chapter 8

Coastal Condition for Alaska, Hawaii, and Island Territories



Chapter 8

Coastal Condition for Alaska, Hawaii, and Island Territories

The dazzling peaks off the island of Kahoolawe are just one of the many types of coastlines throughout Hawaii. Shorelines range from white sandy beaches on Oahu to the tallest sea cliffs in the world on Molokai. Each island offers its own unique habitat for marine life (Photo: Marc Hodges).

Monitoring of coastal resources in Alaska, Hawaii, and the island territories (e.g., Guam, Puerto Rico, U.S. Virgin Islands) is largely nonexistent. Although EPA Regions 2 (Puerto Rico and the U.S. Virgin Islands), 9 (Hawaii and Pacific Islands), and 10 (Alaska) and the attendant state resource agencies conduct some water quality monitoring, no consistent programs covering all coastal resources exist. Efforts through EPA's Coastal 2000 Program are intended to fill this void for Alaska, Hawaii, and Puerto Rico. No plans exist for the development of coastal monitoring efforts in the Pacific Islands (beyond Hawaii). This chapter examines the available information for these areas.

Alaska

The surface area of the coastal resources of Alaska dwarfs the coastal resources that exist in the remaining 49 states. The total surface area of estuarine resources for the continental United States is 33, 211 square miles; for Alaska, it is 97,838 square miles. Unfortunately, most monitoring strategies have excluded Alaska because of the logistical problems in implementing a monitoring program there. However, no estimate of U.S. coastal condition can be complete without information concerning Alaska.

The vast majority of Alaska's coastal resources are presumed to be in relatively pristine condition due to Alaska's size, sparse population, and general remoteness. However, the past 20 years have seen a general increase in Alaskan populations in coastal areas, and several environmental accidents have occurred in coastal regions (e.g., the *Exxon Valdez* oil spill). Water quality has been found to be impaired in coastal areas surrounding port facilities along Prince William Sound, seafood processing facilities in the Aleutian Islands, and cruise ship docking facilities and corridors near Juneau and along the southeastern coastline. At present, the Alaska Department of Environmental Conservation assesses less than 1% of its total coastal resources. Of the assessed resources, 99% are impaired for one or more uses. No consistent information is available for the remaining estuarine resources.

In 2002, EPA's Office of Research and Development, Region 10, and Alaska's Department of Environmental Conservation will initiate a comprehensive pilot monitoring program to examine water quality, sediment quality, and condition of biotic resources in the coastal ecosystems of south-central Alaska. The Alaska-National Coastal Assessment Program will sample approximately 70 locations throughout the south-central region (Figure 8-1). Information from this survey should be available in 2003.

For its 1998 305(b) report, Alaska assessed 237 (1%) of its 33,257 estuarine square miles. Alaska reports on an Overall Use Support classification only, and 235 square miles (99% of assessed waters) are impaired for Overall Use Support. It should be noted that Alaska's assessment data are biased toward those waters with known impairments. Efforts are under way to assess other waters across the state. Alaska has 43 coastal 1998 303(d) listed waters.

Causes of Impairment for Alaska's 1998 303(d) Listed Waters

- Debris
- Dissolved oxygen
- Fecal coliform
- Metals
- Petroleum products
- Phosphorus
- Sediment
- Turbidity
- Residue
- Seafood residue
- Toxic and other deleterious substances

Alaska did not report any fish consumption advisories in 1999 or beach closings in 1998.

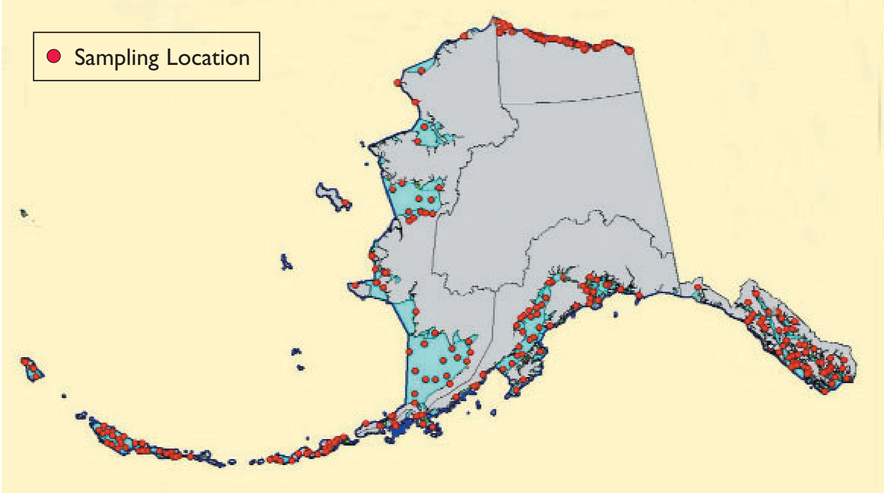


Figure 8-1. Proposed Coastal 2000 sampling design for Alaska.

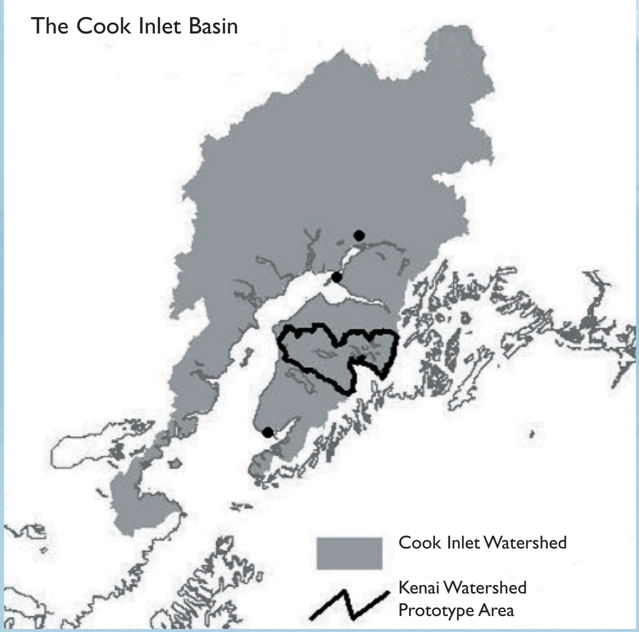
highlight

Cook Inlet Information Management & Monitoring System

CIIMMS
COOK INLET INFORMATION MANAGEMENT/MONITORING SYSTEM

Cook Inlet Information Management & Monitoring System (CIIMMS) is an Internet-based clearinghouse of data pertaining to the Cook Inlet watershed. Funded by the *Exxon Valdez* Oil Spill Trustee Council, the project seeks to provide stakeholders and decision makers with access to a broad range of data pertaining to the ecological health and management of the Cook Inlet Watershed.

Environmental management on an ecosystem or watershed level requires information on a range of topics covering a relatively large area. CIIMMS seeks to foster greater integration and coordination of projects within the Cook Inlet watershed by connecting decision makers with data relevant to management and recovery of Cook Inlet habitats and resources. The CIIMMS database is available on the Internet at http://info.dec.state.ak.us/ciimms.

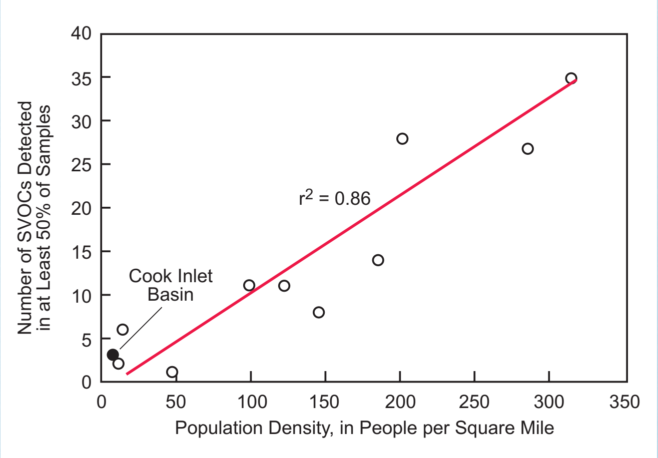


Cook Inlet, Alaska

U.S. Geological Survey assessed the condition of waters composing the Cook Inlet watershed as part of the National Water Quality Assessment (NAWQA) Program. Work began on Cook Inlet in 1997 and is scheduled to continue until 2002. The Cook Inlet watershed is more than 38,610 square miles and has a human population of approximately 347,000, with 254,000 being concentrated in the Municipality of Anchorage. The watershed includes Anchorage, the Matanuska-Susitna Valley, part of Denali National Park, and sections of the Kenai Peninsula. The well-known salmon runs in this area make it a popular location for recreational fishing. The Kenai River, for example, experienced an estimated 321,000 angler-days in 1997. Water quality was generally good but did suffer in several highly populated locations.

Slimy sculpin *(Cottus cognatus)*
Species assayed for presence of organic contaminants and trace elements.

Tests for organic compounds showed very low contamination throughout the watershed with several notable exceptions within Anchorage. Of 32 organochlorine pesticides assayed, only 3 were detected: dieldrin, DDE (a metabolic product of DDT), and hexachlorobenzene. Only hexachlorobenzene exceeded minimum reporting limits. However, Chester Creek in Anchorage, Alaska, showed concentrations of PAHs, phenols, and phthalates that were nearly 50 times greater than the national median. In all, 24 organic contaminants, including PCBs, were detected in the tissue of sculpins from Chester Creek. The results place Chester Creek in the highest 25% of stations tested nationally for organic compounds. Throughout the Cook Inlet basin, the number of organic contaminants detected at each location correlated strongly with human population density (r^2=0.86).



Comparison of population density and semivolatile organic compounds (SVOC) detections among selected NAWQA study units.

Hawaii

Hawaii does not have a comprehensive coastal monitoring program. Some monitoring is done on the islands of Oahu and Hawaii and some monitoring is planned for Hawaiian coral reefs, but no comprehensive programs are currently operating. Most monitoring efforts in Hawaii have been targeted to specific problem areas—nonpoint source runoff, offshore discharges, or specific bays. For example, Kaneohe Bay is rather heavily studied in comparison to other Hawaiian coastal resources; however, there is still not enough data to determine the spatial extent of its problems. Another example is Mamala Bay, where an intensive examination of the public wastewater outfalls from Oahu into the bay showed that the areas adjacent to the discharges were not statistically different from reference areas. However, no comprehensive spatial examination of Mamala Bay was conducted so that these findings could be placed in a regional or statewide context. The Coastal 2000 efforts in Hawaii in 2001 will examine the coastal resources throughout the island chain (main islands only) and examine the condition of Mamala Bay, its inland estuarine resources, and the nearshore effects of these inland features on Mamala Bay's ecological condition.

In 2001, the Coastal 2000 effort will be undertaken by EPA's Office of Research and Development, Region 9, the University of Hawaii, and state and local resource agencies in Hawaii. This effort will be the first comprehensive survey of the ecological conditions of the coastal resources of Hawaii. The survey will examine water quality, sediment quality, and biotic condition at 50 locations throughout the primary island chain (Figure 8-2). Information from this survey should be available in 2003.

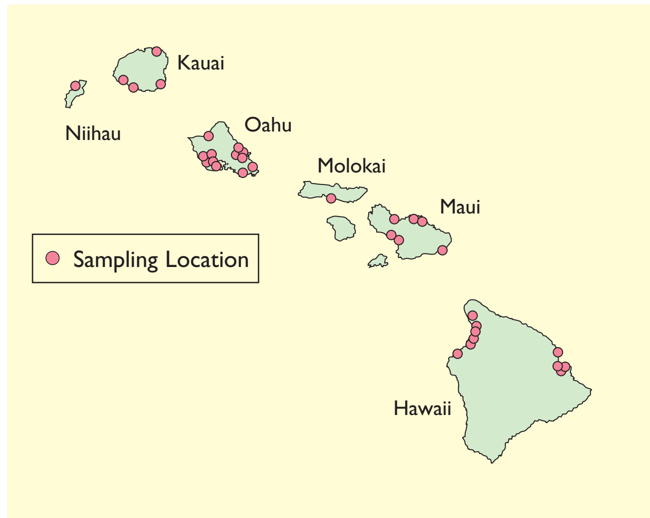


Figure 8-2. Proposed Coastal 2000 sampling design for Hawaii.

The state of Hawaii assessed 54.8 square miles of estuaries (100%) and 884 (84%) of its 1,052 miles of shoreline for its 1998 305(b) report. Of the assessed estuaries, 43% fully support their designated uses, 1% are threatened for one or more uses, and 56% are impaired by some form of pollution or habitat degradation (Figure 8-3).

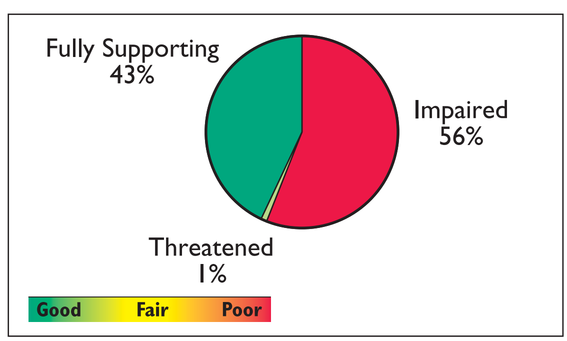


Figure 8-3. Water quality in assessed estuaries in Hawaii (U.S. EPA).

Of assessed shoreline, 89% fully supports its designated uses, 1% is threatened for one or more uses, and 10% is impaired by some form of pollution or habitat degradation (Figure 8-4). Hawaii did not report on individual use support.

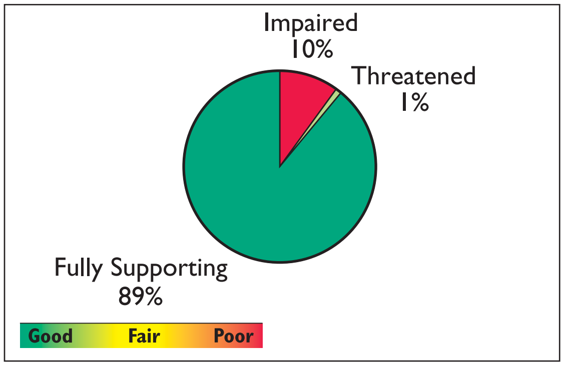


Figure 8-4. Water quality for assessed shoreline in Hawaii (U.S. EPA).

Hawaii has 18 waters that are listed as impaired under Section 303(d) of the Clean Water Act. The percentage of listed waters impaired by each of the major pollutant categories is shown in Figure 8-5.

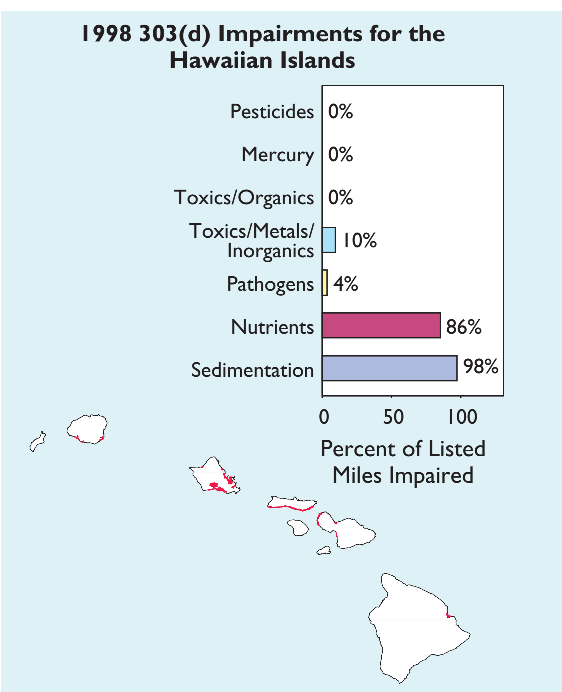


Figure 8-5. 1998 303(d) listed waters in Hawaii and the percentage of miles impaired by the major pollutant categories (note that a listing may be impaired by multiple pollutants) (U.S. EPA).

Hawaii and American Samoa each had one active fish consumption advisory for estuarine waters in 2000. Pearl Harbor in Hawaii was listed for PCBs, and Inner Pago Pago Harbor in American Samoa was listed for chromium, copper, DDT, lead, mercury, PCBs, and zinc in 2000. Both of these advisories warned of contaminant levels in all species of fish and shellfish within the designated waterbodies.

Hawaii is the only state that continues to grow geographically each year. Here, a spectacular display of molten lava pouring into the ocean off the southern coast of the Big Island (Photo: Susan Scott).

Puerto Rico

No consistent monitoring program for coastal resources exists for Puerto Rico. A National Estuary Program, the San Juan Bay Estuary Program (SJBEP), was established in 1992. Some monitoring with regard to water quality and tissue residue burdens has been completed by Region 2, SJBEP, and the Caribbean Environmental Protection Division, although these surveys focus almost exclusively on the San Juan area. The primary environmental concerns for coastal regions in Puerto Rico include pathogens, toxic contaminants, nutrient addition, and habitat loss.

In 2000, EPA's Office of Research and Development, Office of Water, and Region 2 initiated a comprehensive survey of Puerto Rico's estuarine ecosystems to examine water quality, sediment quality, and biotic condition. The survey consists of 50 locations throughout the estuaries of Puerto Rico (Figure 8-6). Information from this survey will be available in 2002.

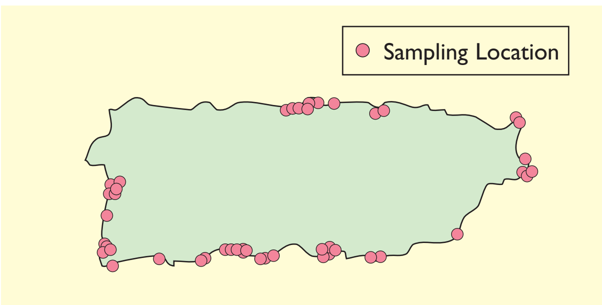


Figure 8-6. Coastal 2000 sampling design for Puerto Rico.

Puerto Rico assessed 175.4 square miles of estuaries and 550 miles of shoreline (100%) for its 1998 305(b) reports. Of estuarine square miles, 15% fully support their designated uses, 84% are threatened for one or more uses, and 1% are impaired by some form of pollution or habitat degradation (Figure 8-7). Of ocean shoreline, 60% fully support its designated uses, 33% is threatened for one or more uses, and 7% is impaired by some form of pollution or habitat degradation (Figure 8-8). Individual use support for assessed shoreline in Puerto Rico is shown in Figure 8-9.

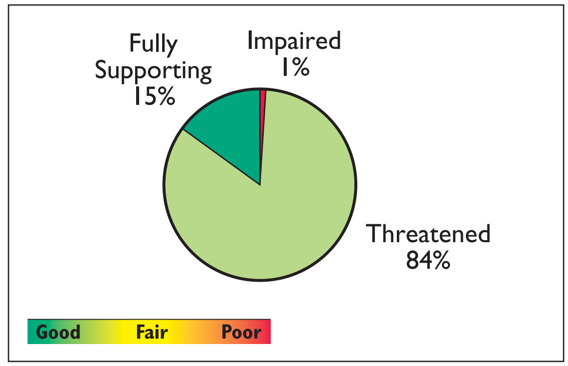


Figure 8-7. Water quality in assessed estuaries in Puerto Rico (U.S. EPA).

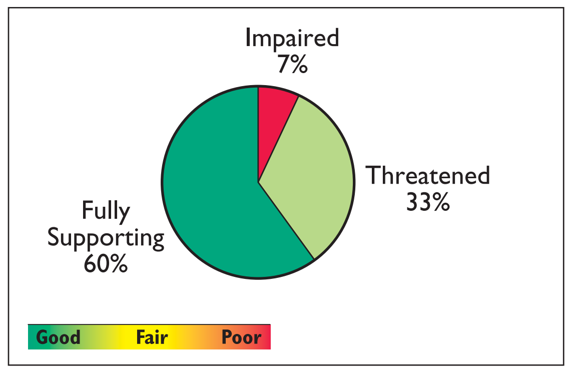


Figure 8-8. Water quality for assessed shoreline in Puerto Rico (U.S. EPA).

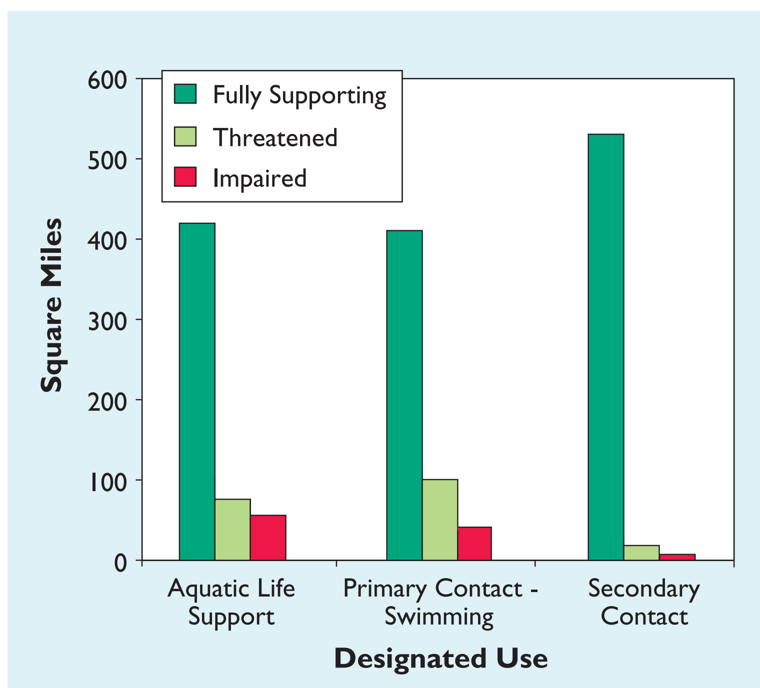


Figure 8-9. Individual use support for assessed shoreline in Puerto Rico (U.S. EPA).

Other Island Systems

No consistent coastal monitoring programs exist for Guam, the U.S. Virgin Islands, the Northern Mariana Islands, or American Samoa. At present, no plans exist for the development of coastal monitoring systems for these territories.

The U.S. Virgin Islands assessed 727 (79%) of its 921 estuarine square miles and 173 miles (100%) of coastal shoreline for its 1998 305(b) reports. Of its estuarine waters, 73% fully support their designated uses, 27% are threatened for one or more uses, and 0.1% are impaired by some form of pollution or habitat degradation (Figure 8-10). Of its shoreline miles, 73% fully support their designated uses, 21% are threatened for one or more uses, and 6% are impaired by some form of pollution or habitat degradation (Figure 8-11). Individual use support for assessed U.S. Virgin Island shoreline is shown in Figure 8-12.

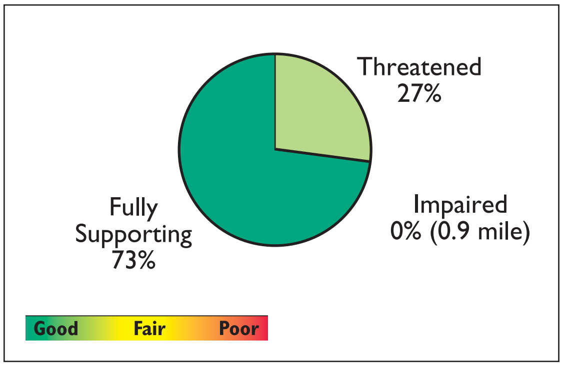


Figure 8-10. Water quality in assessed estuaries in the U.S. Virgin Islands (U.S. EPA).

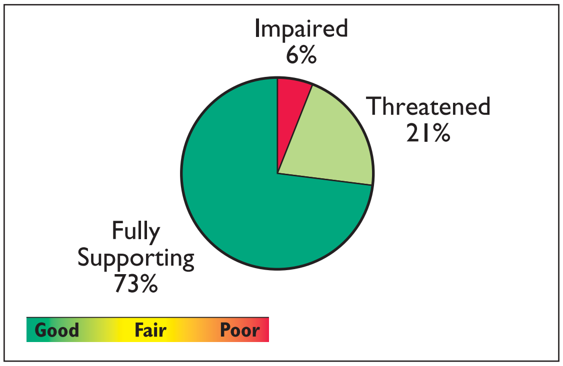


Figure 8-11. Water quality for assessed shoreline miles in the U.S. Virgin Islands (U.S. EPA).

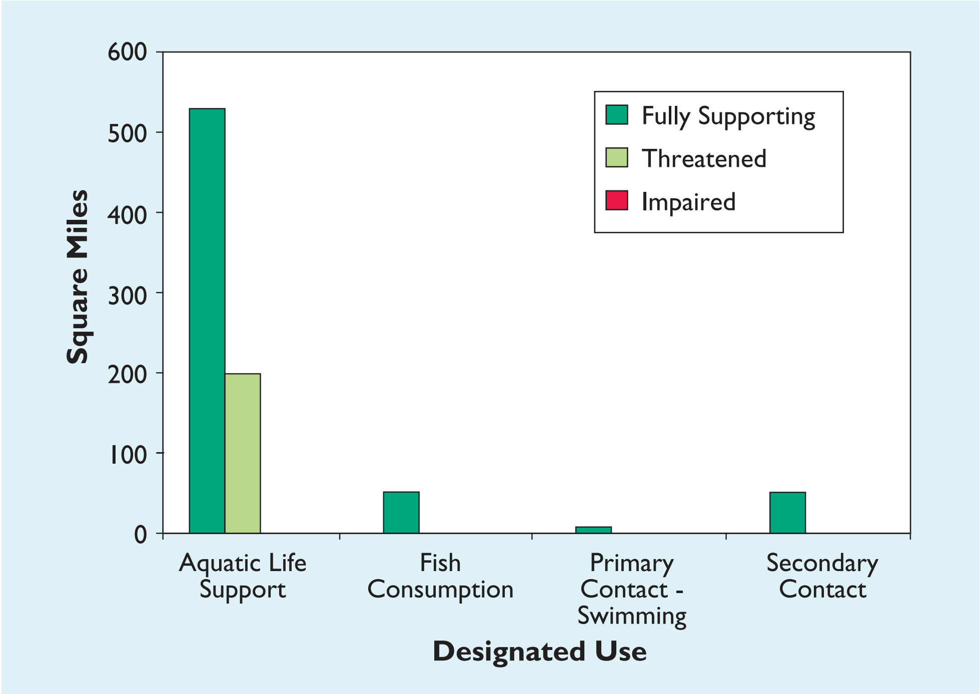


Figure 8-12. Individual use support for assessed estuaries in the Virgin Islands (U.S. EPA).

The U.S. Virgin Islands has nine waters listed as impaired under Section 303(d) of the Clean Water Act.

Guam assessed 14 miles (12%) of its 117 miles of ocean shoreline waters for its 1998 305(b) report. All 14 miles of assessed waters are impaired for swimming.

Guam and the U.S. Virgin Islands reported on beach closings for EPA's BEACH Watch Program. In Guam, information was reported for 35 beaches, and all but one had a monitoring program in place in 1999 to test water quality. There were no beach closings in Guam in 1999. Information on 27 beaches on St. Croix in the U.S. Virgin Islands was reported to EPA, and each of the 27 beaches was closed at least once in 1999.

Causes of Impairment for the Virgin Islands 1998 303(d) Listed Waters

- Organic Enrichment/Low Dissolved Oxygen
- Benthic Impacts
- Turbidity
- Pathogens
- Phosphorus

Ulua, also known as Skipjack (*Caranx ignoblis*), are large predatory fish found in deeper waters around Hawaii. The *Ulua* is considered a delicacy to local residents (Photo: U.S. Fish and Wildlife Service).

Summary

Ecological conditions of the coastal resources in Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands are largely unknown. Alaska assesses less than 1% of its coastal estuaries and shoreline. Hawaii's 305(b) data suggest that 56% of Hawaii's estuarine area is impaired by some form of pollution or habitat degradation, while only 10% of its coastal shoreline is impaired. Hawaii's sampling effort in estuaries is focused on known areas of concern, so it is difficult to interpret these results. Surveys planned for 2001 will provide a less biased view of estuarine condition. Hawaii's 1998 303(d) data suggest that the primary causes of estuarine impairment are increased concentrations of total suspended solids and nutrients. Coastal resources in Puerto Rico are believed to be in good condition but are threatened to become impaired, based on Puerto Rico's 305(b) data. The 305(b) information for the U.S. Virgin Islands suggests that its estuarine and coastal resources are in good condition.

highlight

Kaneohe Bay, Hawaii – A Coastal Intensive Research Site

Kaneohe Bay, characterized as "one of the most intensively studied coral reef systems in the world," is located on the windward coast of Oahu, Hawaii. The Bay is also one of the most oligotrophic embayments in the United States, and land use in the watershed ranges from urban to agricultural, presenting a variety of effects on the water quality of the Bay. Kaneohe Bay is protected from the ocean by a barrier coral reef, which, together with the patch reefs inside the Bay, provide habitat and shelter to coral reef fishes, invertebrates, algae, and seagrasses.

A long-term project to monitor water quality and sediment processes in Kaneohe Bay was initiated in 1998. This project is part of the nationwide Coastal Intensive Site Network (CISNet) program, a cooperative effort funded by EPA, NOAA, and the National Aeronautics and Space Administration (NASA). CISNet was designed to research the ecological responses to anthropogenic stresses in coastal environments, to examine the relationships between changes in environmental stressors, and to provide intensively monitored sites for development and evaluation of change in coastal systems.

Kaneohe Bay, Oahu, Hawaii (Photo: Frank Stanton)

The specific focus of the Kaneohe Bay CISNet project is to examine the linkages between watershed land use patterns and events and the responses of the Kaneohe estuarine/coral reef ecosystem. Another important goal of the project is to serve as a central clearinghouse for environmental data related to Kaneohe Bay and to begin other projects that might make use of these data sets.

Recently collected data on water column and sediment parameters, such as chlorophyll and nutrient profiles, are available on the Internet: www.hawaii.edu/cisnet.

Marine Alien Species Workshop in Hawaii

Recent investigations of the introduction of nonnative marine species indicate that up to 20% of all marine organisms found within the harbors of the main Hawaiian Islands are alien species. To raise the level of understanding about the impact of these marine alien species in Hawaii and provide a forum for the discussion of control and management methods, the U.S. Fish and Wildlife Service led a workshop on May 18, 2001, in Honolulu. The workshop brought together federal and state agency representatives, local conservation groups, and academics. A follow-up meeting was held on October 5, 2001.

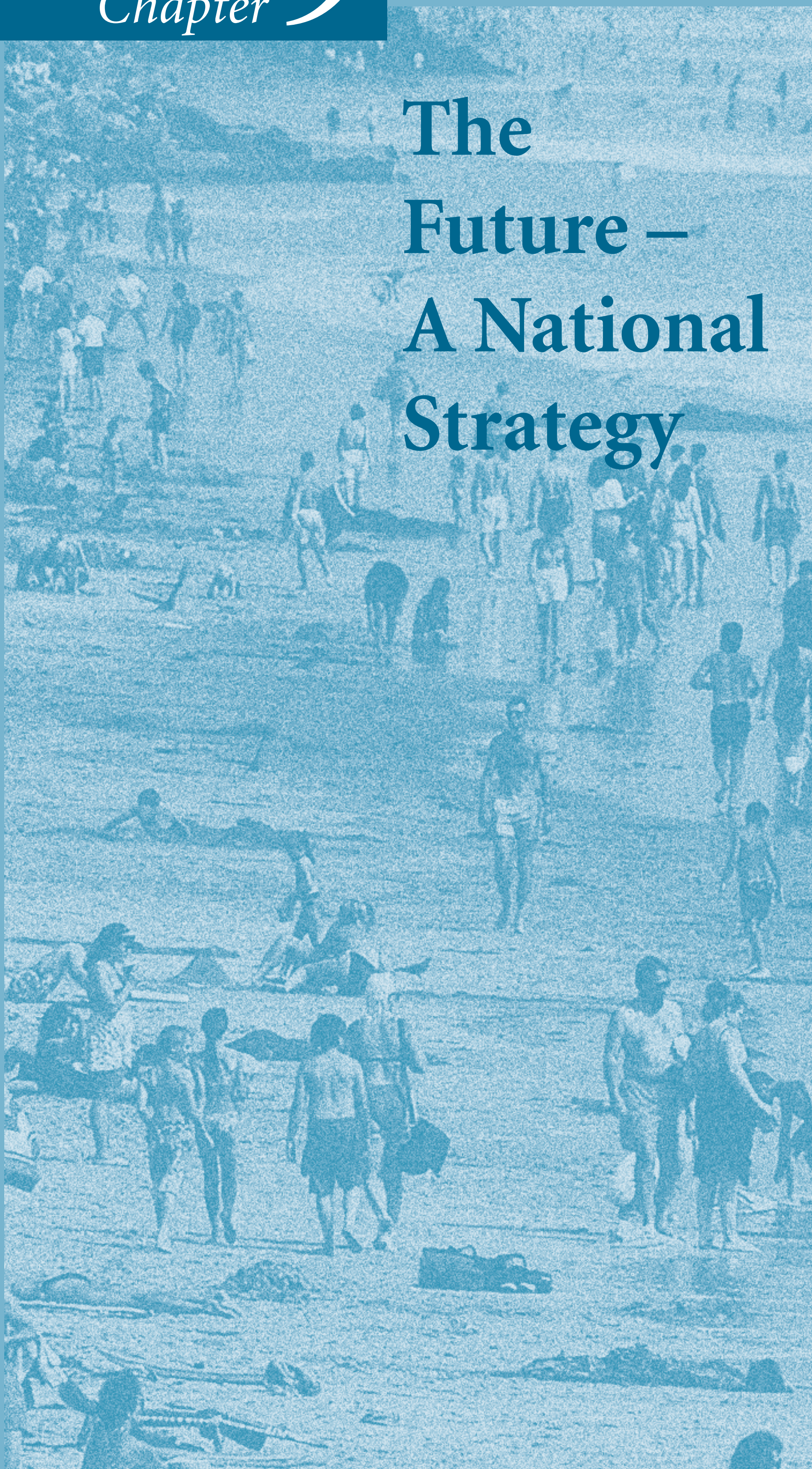
The workshop and accompanying literature included information on the following: lists of established marine alien species of fish, invertebrates, and algae in Hawaii's waters; habitat types most frequently invaded; avenues of introduction; likely future marine alien invaders; impacts that established alien species have on native ecosystems; potential control methods for established marine aliens; and interdiction methods to minimize further introductions. More detailed information and wet-lab samples will be provided for selected species.

Results of the workshop will be made available in booklet and CD-ROM formats. The booklet and CD-ROM are intended to be evolving documents that will be revised periodically to reflect updated information about current alien species as well as information about as-yet unintroduced species. Also, the following guidebook was completed using grants from the Packard Foundation, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service to the B.P. Bishop Museum and the University of Hawaii: "A Guide of Introduced Marine Species in Hawaii," edited by L.G. Eldredge and C.M. Smith. Bishop Museum Technical Report 21, August 2001.

For more information, contact Kevin Foster, Marine Alien Species Coordinator, U.S. Fish and Wildlife Service Pacific Islands Region, (808) 541-3441.

Chapter 9

The Future – A National Strategy



Chapter 9

The Future – A National Strategy

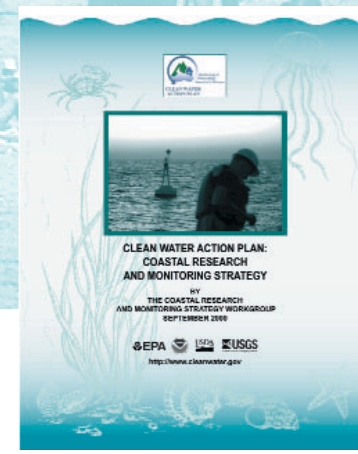
Coastal areas are among the most popular places to live and locate industry in the United States. The coastal zone, defined as all areas within 50 miles of the shoreline, constitutes 17% of the U.S. land area and is inhabited by more than 53% of the nation's population. Coastal populations continue to grow, a trend that could result in 75% of the U.S. population living in the coastal zone by 2020. The high density of people and industry in coastal areas is a potential threat to the ecological condition of our nation's coastal environments.

Currently, no single comprehensive monitoring program provides the data necessary to produce an integrated assessment of the ecological condition of the nation's coastal areas. Even when data are compiled from existing federal and state coastal monitoring programs, there are still large data gaps and data collection inconsistencies that make it

difficult to generalize about the condition of the nation's coasts as a whole. Competing objectives, levels of funding, and varying scopes of interest have resulted in a proliferation of data in some areas (like Chesapeake Bay), while data are sparse or nonexistent in other areas (like Alaska).

There are several national programs that can contribute information about the nation's coasts, but they cannot be used to formulate a complete picture of the nation due to limitations in the scope of parameters assessed or area monitored. EMAP's regional surveys provide consistent data for the mid-Atlantic, Southeast, and Gulf of Mexico coasts; however, budget constraints precluded the implementation of these regional surveys in other regions of the United States (e.g., the West Coast, Alaska). Data from the Coastal 2000 program will address many of these issues. NOAA's National Status and Trends (NS&T) Program provides information for representative locations across the United States on a specific set of environmental parameters focused on toxic contaminants. This program is designed only to monitor contaminant levels and trends in sentinel organisms and sediments. The NS&T Program is not designed to support probability-based estimates of the spatial extent of degraded versus nondegraded resources across regional to national scales.

EPA's Clean Water Act Section 305(b) water quality data for coastal resources are reported by coastal states, which use a variety of approaches for data collection. Data reported range from environmental parameters collected at specific locations with known problems to larger-scale characterization of state watersheds based on evaluations of existing data and professional judgment. Many states do not have the resources to conduct comprehensive coastal monitoring to collect data for their 305(b) assessments. States like Alaska, Washington (excluding Puget Sound), Oregon, California (north of San Francisco Bay), North Carolina, Georgia, and Maine have little or no coastal monitoring in place and receive little or no financial support to create comprehensive coastal monitoring programs. The lack of monitoring data for Alaska is particularly bothersome because Alaskan estuaries represent nearly 75% of all U.S. estuarine resources, yet very little



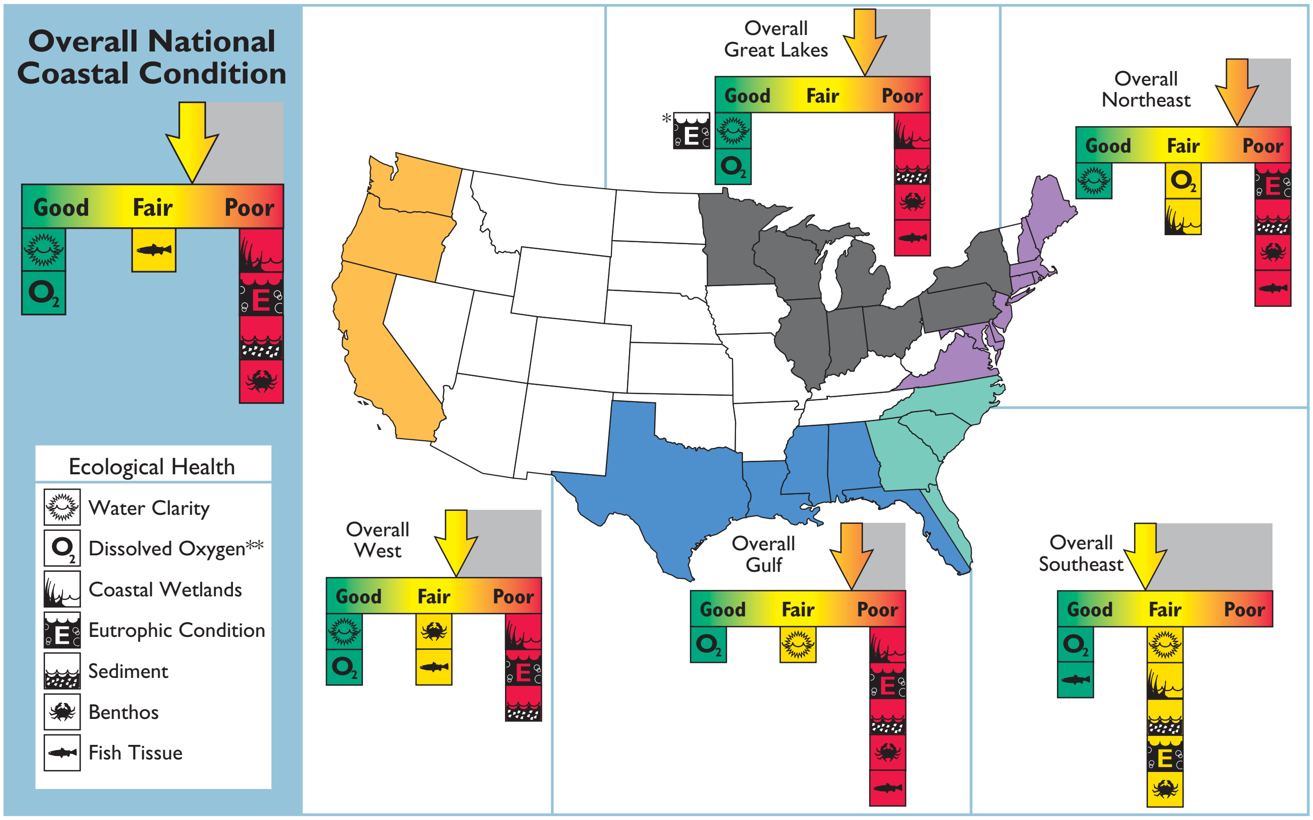
The CWAP Coastal Research and Monitoring Strategy outlines a plan to develop a comprehensive integrated framework for assessing the condition of the nation's coasts.

information to support the kind of analysis used in this report is available (i.e., spatial estimates of condition based on indicators measured consistently across broad regions).

Due to the current state of information, we are unable to characterize quantitatively the condition of all of the nation's coastal waters. Moreover, at present, the assessments must be based on a limited number of ecological indicators for which there are consistent data sets available to support estimates of condition over as broad an area as possible.

In this report, we have compiled existing information to provide a preliminary picture of the condition of estuarine waters in the United States. Although it may appear that this report accomplishes that goal, it falls short of the "comprehensive report on the condition of the nation's coastal waters" called for by the Clean Water Action Plan due to a lack of nationally consistent data. What has been accomplished is the best assessment of coastal condition that can be made with existing data. Figure 9-1 represents our best perspective of ecological condition in estuaries. It is based on substantial information on the Mid-Atlantic, Southeast, and Gulf of Mexico Coasts but scattered and sparse information from New England, the West Coast, Alaska, the Pacific Islands, and the Caribbean. One of our greatest needs for the 21st century is a coordinated, comprehensive, and integrated coastal monitoring program that examines all aspects of coastal condition at national, regional, state, and estuary-specific scales. The program should include estuaries, beaches, coastal wetlands, the Great Lakes, and coastal waters throughout the 24 coastal states and the Pacific and Caribbean commonwealths. The *Clean Water Action Plan: Coastal Research and Monitoring Strategy* (www.cleanwater.gov), established under authority of the Clean Water Action Plan (U.S. EPA, 1998), presents the conceptual framework for coastal monitoring

and research to be conducted in partnership among federal agencies, state resource agencies, and academia. The framework will guide the direction of coastal monitoring and research across federal agencies to address current and future environmental issues of the coast. The recommended coordination and collaboration of federal agencies will permit future coastal research and monitoring activities to benefit from the specific knowledge and experience of each agency—the resulting decision-making capability will be greater than the sum of the parts.



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

Figure 9-1. Overall national coastal condition.

Due to the unique marine environment surrounding the Channel Islands, the Channel Islands National Marine Sanctuary (CINMS) is home to a diverse array of marine life, making the region highly valuable to scientific research. The CINMS routinely conducts research to monitor, preserve, and protect the Sanctuary's rich resources. In 1998, the CINMS participated in a regional monitoring survey of the Southern California Bight coordinated by the Southern California Coastal Water Research Project (SCCWRP). Trawl and sediment samples from randomly selected sights around the islands were collected to measure the distribution and health of the island's marine life (Photo: Channel Islands NMS).

Objectives of Research and Monitoring within an Integrated Assessment Framework

The complex and changing nature of the coastal waters, bays, estuaries, and wetlands often requires the integration of physical, chemical, biological, and ecological data to assess coastal environmental conditions and often requires the integration of research with monitoring to improve or extend our assessment capabilities. For the past decade, academic, federal, state, and private sector scientists have been working on new approaches to this integration (Messer et al., 1991; NSTC, 1997). These integrated assessment efforts appear to have roughly the same common goal:

> *Provide the national, regional, and local capabilities to measure, understand, analyze, and forecast ecological change (natural and anthropogenic) that can affect coastal economies, public safety, and the integrity and sustainability of the nation's coastal ecosystems.*

Integrated assessments provide an effective format for bridging science and policy and, therefore, are the appropriate context for designing a research and monitoring strategy. Integrated assessments have the following objectives:

- Document status and assess trends in environmental conditions at the necessary scales for scientific investigation and policy development.
- Evaluate the causes and consequences of changes in environmental status and trends.
- Assess environmental, economic, and sociological impacts of alternative policies for dealing with these changes.

Research is necessary to improve both the assessment techniques and the monitoring done to support these assessments. The research necessary to support these activities includes

- **Predict change and create an early warning detection system**.
- **Analyze environmental, economic, and sociological impacts of coastal policy**. A large number of national, state, and tribal policies direct the expenditure of billions of

dollars of public and private money to protect the coastal zone. It is important to understand if these investments are well spent—if the coastal zone has been protected or restored.

- **Understand coastal physical and ecological processes.** An understanding of the physical and ecological processes of the coastal zone underlies all of the other objectives. Investments in research to improve this understanding are paid back directly or indirectly by our increasing ability to truly understand current status, predict future trends, and determine the significance of change.
- **Improve or enhance monitoring and assessment tools.** Our ability to perform the above objectives rests on our ability to use federal investments wisely. Advancements in field monitoring and observation, remote sensing, and data management and display technology have created opportunities to acquire, manage, and disseminate coastal environmental data more efficiently and economically than was thought possible 10 years ago. The challenge is to select wisely from or improve upon the traditional, new, or emerging technologies that will provide information needed for policy or management decisions.

The effective integration of monitoring and research will enable comprehensive assessments of the nation's coastal resources and eventual remediation of the problem. This approach is essential to differentiate between actual and perceived environmental issues in the coastal zone so that (1) we address all major coastal environmental issues appropriately and in a timely manner and (2) we avoid unnecessary environmental regulation or environmental damage. It follows that an integrated monitoring and research strategy focused on supporting the comprehensive management of our coastal resources requires an integration of key assessment and management elements with monitoring and research objectives (Figure 9-2). Monitoring is crucial to documenting status and assessing trends, determining associations between stressors and impacts, and assessing the effectiveness of management actions. Research is an important part of environmental monitoring and is particularly important for improving our ability to interpret monitoring data and improve our assessment capability. Additionally, research is key to predicting impacts as a result of emerging trends and to forecast and assess the impacts and benefits of management actions.

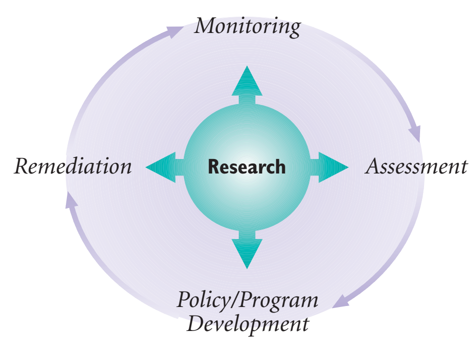


Figure 9-2. Monitoring-research-assessment-remediation cycle that gauges coastal ecological condition and the effectiveness of remediation policies and programs.

These objectives capture the intent of the *Coastal Research and Monitoring Strategy*—to observe coastal status and to differentiate between real and perceived coastal water issues and to provide informed and expert judgment necessary for coastal policy and management. The objectives are, to a large extent, derived from national environmental monitoring and research objectives presented in *Integrating the Nation's Environmental Monitoring and Research Networks and Programs*, the national framework established by the National Science and Technology Council (NSTC, 1997). The NSTC objectives, as modified to address specific issues of coastal waters, overlap with charters of the departments and agencies represented in the Coastal Research and Monitoring Strategy Workgroup.

To be effective, an integrated assessment strategy for monitoring and research activities must be designed to accomplish all of these objectives. Only by addressing all components can the effectiveness of management actions be tracked.

The Gulf of the Farallones has over 100 dedicated volunteers for the BEACH Watch program. BEACH Watch volunteers survey their designated sanctuary beaches once a month and receive 80 hours of classroom and field training (Photo: Gulf of the Farallones NMS).

Monitoring

The Coastal Research and Monitoring Strategy addresses the physical, chemical, biological, and ecological conditions of coastal waters, bays, estuaries, beaches, wetlands, and the Great Lakes. A national coastal monitoring strategy must simultaneously meet the needs of the nation, the coastal states, and tribal nations. This strategy is the most effective way to satisfy needs at these scales, but it is also essential to receive the necessary cooperation from the coastal states and tribes. Only through this cooperation can the longevity of any national coastal monitoring effort be assured. The mechanisms to achieve this interaction are beyond the scope of this strategy. However, key attributes of the proposed approach should include cofunding by federal and state programs, nested designs to allow state-specific issues to be addressed in a national context, a uniform reporting protocol to facilitate data and information exchange, and further attention to specific state issues, collective reporting, and cross-system comparisons.

The coastal ecosystems addressed by this strategy include estuaries, coastal waters, beaches, wetlands, and the Great Lakes. Because the scale and dimensions of these systems vary considerably, the "optimal" monitoring design is one that allows adaptation to each ecosystem while maintaining a similar core design that would allow intercomparison and tiered estimates of condition. Attempts to design one program that fits all cases generally fail because all temporal and spatial scales are pertinent and important. Therefore, the design proposed here incorporates a flexible, nested strategy that uses a base design (common to all), with details designed by the appropriate stakeholders at each level.

The strategy for a national coastal monitoring design is based on the three-tiered approach developed by EPA (Messer et al., 1991) and recommended by NSTC (1997). The three-tiered monitoring strategy addresses several of the major attributes of an integrated assessment:

- Characterization of the problem
- Diagnosis of causes
- Remediation actions
- Assessment of effectiveness of actions
- Reevaluation of causes
- Continued assurance of effectiveness of actions.

These attributes, in combination with the formulation of management actions, create the cycle of monitoring and attendant research necessary to identify, solve, correct, and manage environmental problems. The proposed three-tiered national coastal monitoring design features:

- **Characterization of the Problem (Tier I)**—Broad-scale ecological response properties as a base determined by survey, automated collection, and/or remote sensing.
- **Diagnosis of Causes (Tier II)**—Issue- or resource-specific surveys and observations concentrating on cause-effect interactions.
- **Diagnosis of Interactions and Forecasting (Tier III)**—Intensive monitoring and research index sites with higher spatial and temporal resolution to determine specific mechanisms of interaction needed to build cause and effect models.

Data and information generated at each tier help in the interpretation of results from the other tiers. For example, Tier I (characterization) data provide geographic context for data collected at Tiers II and III (e.g., how widespread is the problem and how much of the nation's resources are affected by its occurrence?). Tier II (diagnosis of causes) and Tier III (diagnosis of interactions) aid in understanding the seriousness of a particular relationship or issue. Tier III also aids in interpreting results at Tiers I and II and links process research with long-term ecological and environmental measurements to strengthen cause and effect linkages and predictive models that relate stresses and environmental responses.

As more locations are studied for invasive species and as the protocols for monitoring become more standardized, more systematic knowledge will be gained of anecdotally known regional variations in invasion rates and species. Intensive study at specific locations where invasions have taken place, as well as at ecologically and climatically similar locations with invasion observed to a different extent or by different species, will help establish what factors put a particular area at risk from what species or types of species.

Characterization of the Problem (Tier I)

Measurements in Tier I are designed to characterize problems by tracking the natural dynamics of coastal ecosystems in order to identify large-scale existing and emerging issues. Therefore, these measurements focus on the first step of integrated assessments—

documenting status and trends in order to characterize the problem(s). Tier I measurements would generally be taken at fairly coarse spatial and temporal scales based on probabilistic approaches except for those that can be generated by remote platforms (e.g., satellites) where coverages may be complete. This approach is state-oriented and, through consistency of design and measurements, produces a national coverage. In accordance with the most recent work in this area (CENR, 2000), indicators to be measured in Tier I include (1) measures of community and ecosystem structure and function (productivity, abundances and distributions of plants and animals, diversity, and important attributes of nutrient and chemical cycling) and (2) environmental stressors (primary stressors of coastal ecosystems) and habitat variables (measures required to interpret natural variability in rapidly changing coastal environments).

Many measurements in Tier I can be derived through automated sensors (e.g., satellites, aircraft reconnaissance, and buoys). However, several measurements must still be conducted through field sampling and laboratory analysis. These measures, collected using an integrated probabilistic design including all coastal states, would provide a comprehensive, integrated assessment of the "health" of each state and, through integration, the nation's coastal resources. The number of sites likely to be included at this level would be 50 for each coastal state for each coastal environment (e.g., wetlands, estuaries, beaches, Great Lakes, offshore).

Diagnosis of Large-Scale Causes (Tier II)

To assess the causes of problems identified in Tier I, Tier II monitoring would be conducted only in areas identified as impacted by Tier 1 monitoring or through other available databases (e.g., the TMDL Tracking System). This "national" sampling tier would be stratified by environmental issue, with a monitoring program associated with each stratum. Examples of strata are

- Eutrophic condition
- Contamination by metals and organics
- Contamination by microbial organisms
- Invasive species
- Habitat degradation
- Fisheries declines
- Harmful algal blooms
- Hypoxia.

The primary purpose for the collection of monitoring data at the Tier II level would be to quantify the relationships among ecosystem response variables (e.g., productivity, benthic abundance, bird abundance) and environmental stressors (e.g., nutrients, low dissolved oxygen, habitat loss) in order to diagnose the cause(s) of the observed environmental problem. It is through this quantification that better stewardship and better correctional operations can be determined. The number of sampling sites for each issue stratum would be determined largely by the number of locations and regions displaying the particular issue, although an expectation of about 100 to 250 sites per issue stratum seems to be reasonable.

Tier II alone is not sufficient for understanding relationships well enough to develop predictive capabilities. The integration of Tiers II and III should provide that predictive power.

Diagnosis of Interactions and Forecasting (Tier III)

Monitoring at Tiers I and II provides information that can be used to develop policies and actions to correct the environmental problems found throughout the nation. However, many problems are the result of complex interactions of stressors, habitats, natural environments, and anthropogenic activities. To determine these interactions and forecast the likely environmental response of these interactions, this strategy proposes the development of Tier III sites. At these sites, measurements are spatially and temporally intensive and are completed at few locations over relatively short time periods (weeks to years). Much of the research necessary to develop indicators or indices with forecasting power will be accomplished at these sites in conjunction with the intensive monitoring. Approximately 25 to 50 of these sites would be identified.

The data and information generated at each tier helps in interpretation at the remaining tiers. Tier I information places Tiers II and III information into perspective—how broad a problem is the issue and how much of the nation's resources are affected by its occurrence, correction, and understanding? Tiers II and III provide an understanding of the seriousness of a particular relationship or issue. At Tier I, all problems are, in essence, treated equally, but work at Tiers II and III may show that losses of some species distributions are more important than others. Tier III aids in interpreting results at Tiers I and II and links process research with long-term measurements of ecological and environmental measures to strengthen cause and effect linkages and predictive models relating stresses and ecosystem response.

Scientists retrieve a Tucker net, which has three nets to sample different depths and obtain discrete samples of tiny organisms that make up the base of the food web in the Cordell Bank Sanctuary (Photo: Jamie Hall).

These three monitoring tiers correspond to the characterization of the problem and diagnosis of causes and interactions of existing environmental problems within the integrated assessment model. Regardless of the requirements for specific spatial and/or temporal scales, these monitoring tiers provide information for the assessment of the effectiveness of actions and continued assurance of that effectiveness.

The Olympic Coast National Marine Sanctuary is recognized for its profound ecological value. The Sanctuary's parent agency, the National Oceanic and Atmospheric Administration (NOAA), commits significant technical resources, including its research ships (like the McArthur, shown here), to understand how ecological processes work (Photo: Olympic Coast NMS).

Research

The interaction of research in the development, execution, and revision of monitoring coastal ecosystems is a closely paired activity. Integrated assessments adapt current monitoring approaches by taking advantage of information that has been accumulated over time such as previous monitoring results, research that has been completed to enhance the measurement of indicators, new understanding of cause and effect relationships, and improved sampling approaches to reduce uncertainty.

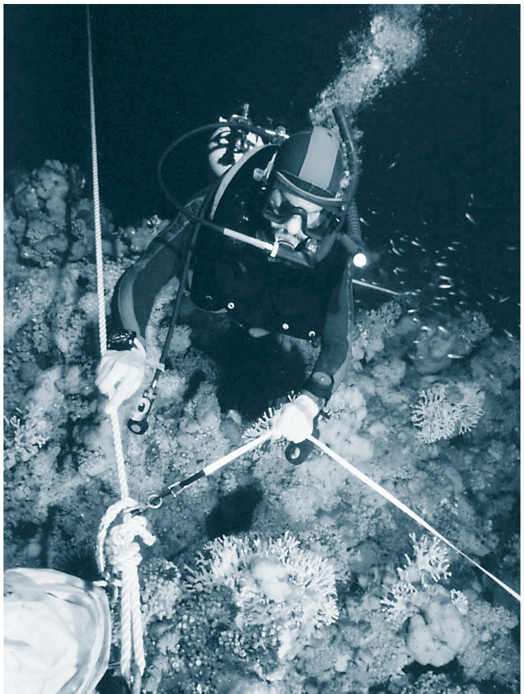
Research activities must occur at all three tiers, but represent distinct research programs. Indicator research and development of survey methods and tools enhances our ability to characterize ecosystem condition (Tier I). Initial monitoring activities to characterize (Tier I) must, of necessity, be based on available, tested, proven, and understandable indicators. This does not imply that they are the best indicators of ecosystem condition, just the best available, and continuing research should produce better, more certain indicators. Cause and effect research drives our understanding of what the information collected during monitoring represents. This research, whether at the larger scale (Tier II) or intensive scale (Tier III), provides the necessary interpretive information to bridge the gap between status and trend information and management actions.

Prediction of environmental problems is the long-term goal of the monitoring and research interaction. Currently, our monitoring approaches and research programs must be reactive—monitoring results driving the research agenda and the research results modifying the monitoring approach. As cause and effect monitoring and research progresses, the results will provide the basis for predictive modeling, forecasting emerging environmental problems, and separating changes due to natural variability from those resulting from anthropogenic stress. Once forecasting abilities can be verified, the interactive roles of monitoring and research (particularly at Tiers II and III) will change, adapting to these new abilities to focus efforts in an unbiased manner rather than approaching the coastal environment as one large population.

After characterizing the coastal environment, predicting the probability of change from human activity, and diagnosing the likely causes of these changes, environmental managers and stakeholders must make decisions on future policies, programs, and actions. Decisions include continuation of current activity (no action), control of future inputs, remediation of environmental contamination, or restoration of the coastal ecosystem to a desired state. Some of the uncertainties associated with these decisions are based on a lack of understanding of coastal system response. Research is needed to support the management decision element of the integrated assessment model, including:

- Development of standardized protocols for environmental remediation and restoration, which ensure consistent outcomes.
- Evaluation of costs and effectiveness of management actions.
- Development of decision analysis methods to help managers establish relevant goals and to facilitate consistent cost-effective decisions.

Therefore, research plays a vital role in interpreting outputs from, and methods used in, monitoring programs and represents a key to the integrated assessment model. Research supports all phases of the assessment process. Characteristic research activities that support the integrated assessment process are described in the remainder of this section.



A Cordell Bank Expeditions research diver over a bed of filter-feeding invertebrates. The food-rich currents over Cordell Bank offer habitat for filter-feeding animals (Photo: Cordell Bank Expeditions).

Research To Support Characterization of the Problem (Tier I)

In addition to improving our ability to document status and trends, research at this level can also establish a means to provide early warnings. Ecological characterization is a description of particular attributes at points in space and time and comparison of those attributes with expectations or criteria. It is clearly impossible to do this for all environmental parameters and their changes, so indicators of these parameters are often sought. Indicators are properties that summarize elements of environmental change and provide the greatest information return for the least investment. The key question in indicator research is defining which parameters serve as appropriate surrogates for system condition and response. This is a challenge because ecosystem processes are poorly understood, the distribution and intensity of stressors and their threats to ecological resources are uncertain, and it is not known which stressors place ecosystems at the most serious risk or the extent to which critical ecological processes are being impaired. Another important issue is reliability/predictability. It is important to select biological indicators, for example, that are able to predict stress where stress should be occurring (due to presence of pollutants) in a high percentage of cases.

To help characterize systems, research is needed to address four basic questions:

- **What should be measured**? Answering this question requires an understanding of the important components of structure and function of the system (i.e., a conceptual model), an evaluation of the appropriate levels of biological organization relevant to the monitoring purpose, and the classes of stressors that are potentially important for that resource and scale.

- **How should the indicator be measured**? The answer to this question requires that a standard protocol be defined.
- **How responsive is the indicator**? It is important to determine the degree to which a particular indicator actually responds to various stressor gradients at multiple scales or if a stressor indicator responds to modification of input.
- **How variable is the indicator**? Ecological condition reflects the combined effects of natural variability and anthropogenic stress. Research is needed to determine methods by which natural or introduced fluctuations can be distinguished to allow detection of actual status and trends in ecological conditions.

Research To Support Diagnosis of Large-Scale Causes (Tier II)

This step determines the causes and consequences of detected changes. Cause and consequence are usually determined by integrating relevant process-oriented research with tools to diagnose and predict system dynamics. This step determines the causes and consequences of detected changes. Cause and consequence are usually determined by integrating relevant process-oriented research with tools to diagnose and predict system dynamics. Once conditions and trends for an ecological system have been described, it is important to identify which parts of the system are changing, why they are changing, and whether particular environmental policies will be effective in dealing with those changes. To answer these questions, it is necessary to understand and be able to predict how a system will respond to individual or multiple stresses (i.e., develop a "load-response" relationship that describes how properties of concern relate to changes in natural and human inputs). To couple monitoring results with causes of system change and to predict system responses, research must address three basic questions:

- **How are measures extrapolated across scales of organization**? Historically, much of the stressor-effects data used in ecological assessment have been obtained from laboratory tests focused on responses at lower levels of biological organization. An implicit assumption in applying such results at the ecosystem level is that processes and mechanisms occurring at lower levels of organization are sufficient to describe the behavior of systems at higher levels of organization. This may have limited utility to identify properties that emerge only at higher levels. Greater understanding is needed about how impacts measured at lower levels of ecological organization reflect impacts at higher levels. Further research is also needed to evaluate how impacts measured in one estuary can be extrapolated to other estuaries.
- **How do human activities propagate through the ecosystem**? For many human activities, pathways of transmission and adaptation in ecosystems are poorly understood, hindering development of accurate assessment of ecological effects due to human activities. Additional research is

Seagrass is one of the most productive and important ecosystems in the Keys, and it is being destroyed at an alarming rate. Much of this damage is due to recreational boaters operating in shallow water. Propeller scars can take up to 10 years to recover (Photo: Harold Hudson).

needed to understand how human-induced changes in the landscape alter hydrologic and biogeochemical cycles in the coastal areas, and how adaptations or buffers in the system mitigate those changes.

- **What changes in system structure and function are due to changes in inputs?** Addressing this question requires a sound basis to link an ecological response and a change in input. In large, complex systems, these links are usually developed based on observation of co-occurrence of input and response and analysis of the strength and consistency of that co-occurrence. Due to lack of appropriate data at large scales, our current understanding is insufficient to ensure correct identification of the cause of change in many systems or to predict the result of human activities on an ecosystem.

Research To Support Diagnosis of Interactions and Forecasting (Tier III)

This step determines the causes, consequences, and interactions of detected changes at small or local spatial scales, particularly with regard to natural environmental changes. Cause and consequence, at this scale, are usually determined by integrating relevant process-oriented research at specific locations with tools to diagnose and predict system dynamics. The research questions at Tier III are identical to those at Tier II with the exception that at Tier III the scale is local, the importance of interactions may be greater, and the role of natural variability may be greater. Because of this similarity, the specific research questions for Tier III will not be repeated here.

Research To Support Development of Policy and Environmental Remediation Programs

Although this research does not specifically correspond to one of the monitoring tiers, it is essential to the integrated assessment process. This level of research helps to determine if coastal environmental policies are having the desired effect, or if the same goals could be achieved in another manner. While monitoring can determine if management actions are achieving their desired goal, research is needed to reduce the uncertainties in ecological cause and effect relationships—the basis of predictions. Also, because management actions often involve behavior modification, it is important that economic and social considerations, inherent in the decision-making process, are assessed. Specific questions that must be addressed include the following:

- **How are multiple management options evaluated to select the best option?** This requires development of methods to model coastal ecosystem responses to changes so that future scenarios under different management alternatives can be simulated.

- **How are ecological services and capital reserves valued in the decision process?** This requires the ability to integrate and predict economic consequences of ecological change in coastal areas. Methods to assess and predict nonmonetary benefits and impacts to society, such as aesthetic or cultural requirements, are also needed.
- **How is human response to management actions measured?** Achieving desired results from many management decisions rests on the willingness and efficacy of humans to change behavior. Indicators are needed to measure this change in behavior.

While the objectives and the conceptual framework for the *Coastal Research and Monitoring Strategy* have been finalized, important aspects of the Strategy can be defined only as the Strategy evolves into a workable program. The *Coastal Research and Monitoring Strategy* identifies the programmatic actions identified by the Workgroup as next steps; further development of action plans for each of the following recommendations and implementation of those recommendations is beyond the charter of the Workgroup.

We are all drawn to the ocean's edge to wonder at life's most basic questions and marvel at the ocean's astonishing diversity (Photo: Olympic Coast NMS).

Summary

This report compiles available information to describe the overall ecological condition of the estuarine waters of the United States. The characterization is based on the use of information to create an impression of existing condition. At times, that impression is based on large amounts of information (e.g., Chesapeake Bay); at other times, it is based on a paucity of information (e.g., Alaska).

One outcome of this report has been to demonstrate that we do not have adequate information to make clear and encompassing statements regarding ecological condition for the nation's coastal resources regardless of spatial scale (national, regional, state, estuary). However, it should also be clear that federal and state programs exist to collect much of this information in some areas but are nonexistent in others. In order to realize its full potential, coastal monitoring must be addressed through new and innovative partnerships among federal agencies, state agencies, and local municipalities. No single agency can accomplish this task. Only through a coordinated and integrated effort can coastal monitoring be successful at all the levels at which it is necessary to preserve, protect, manage, and enhance the coastal resources of the United States.

Chapter 10

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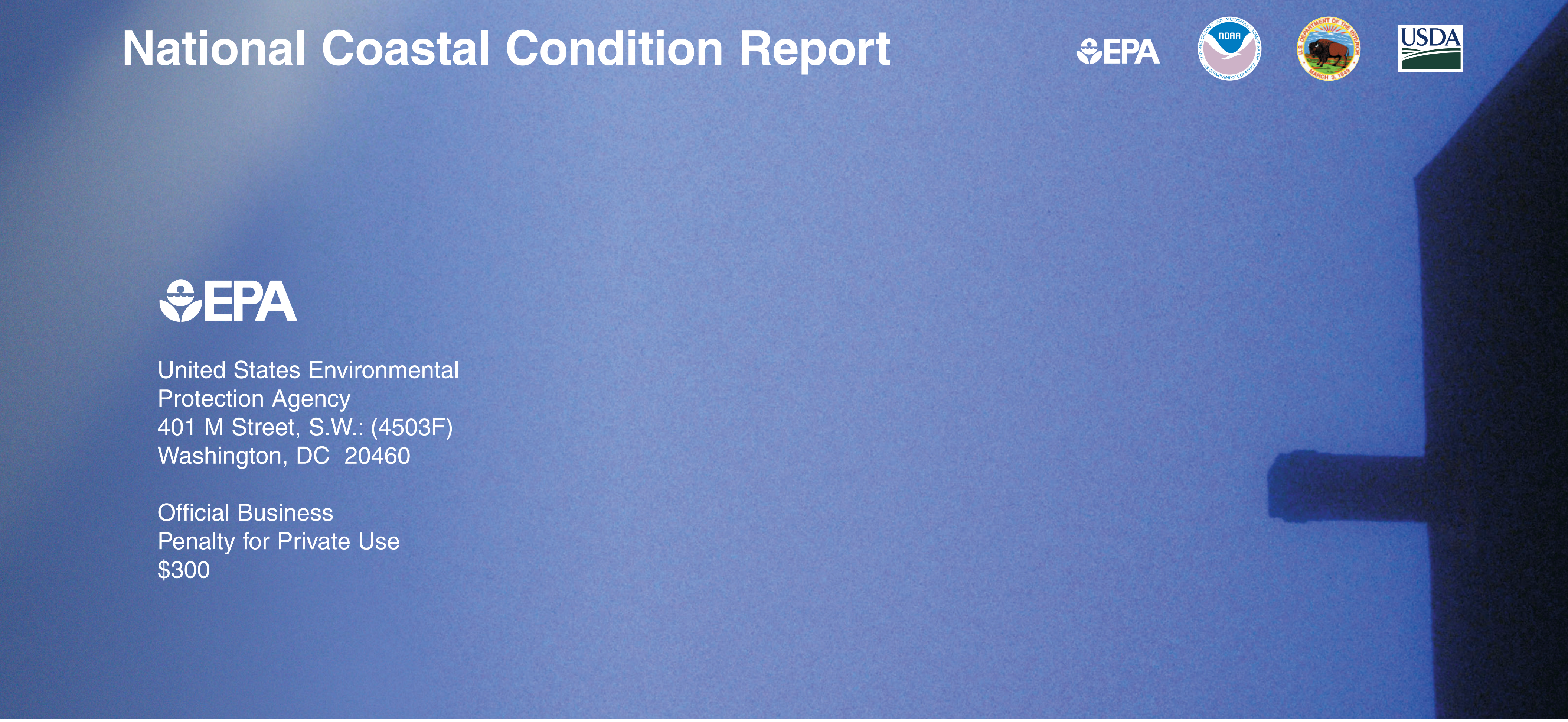

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