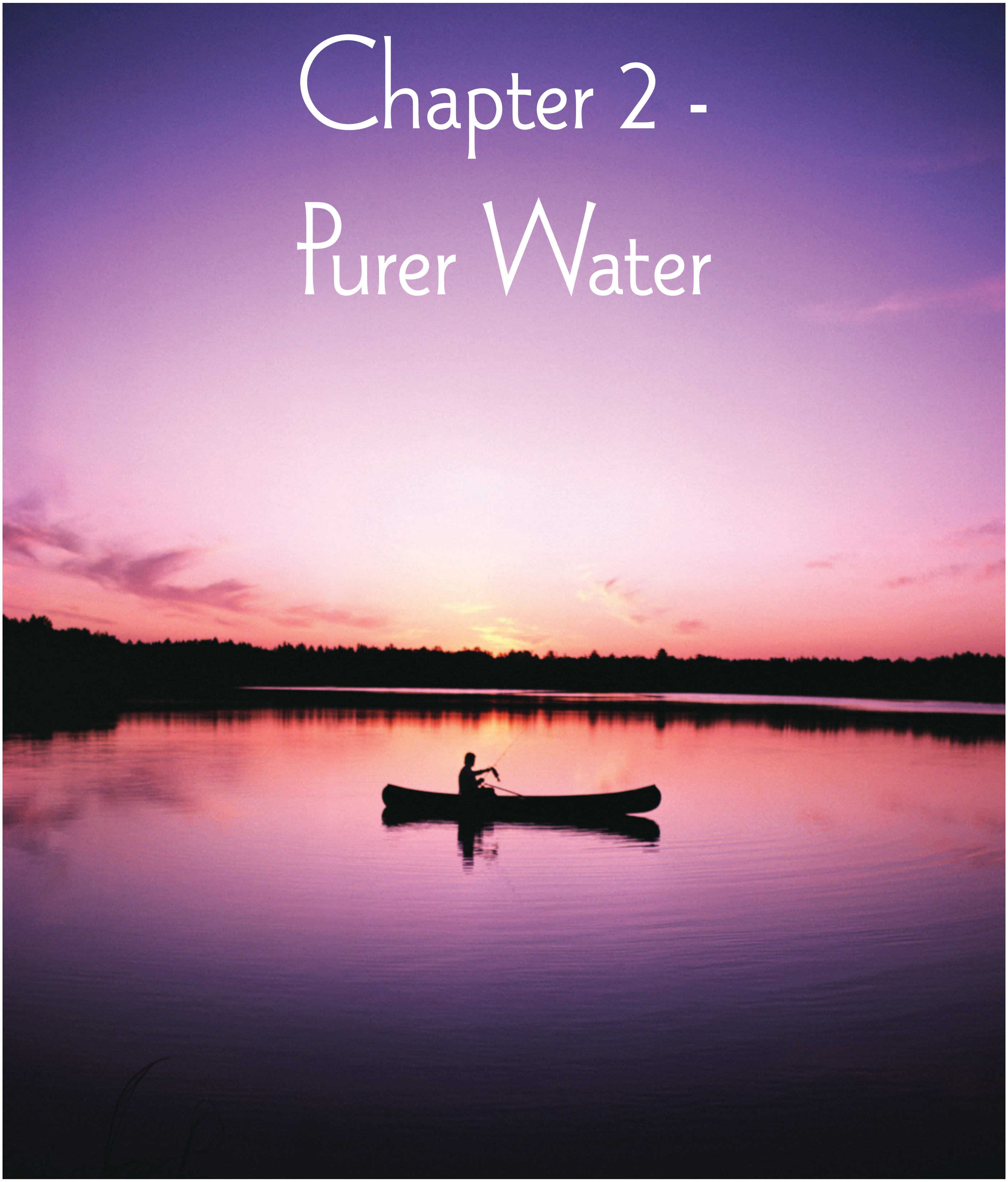
Chapter 2 - Purer Water

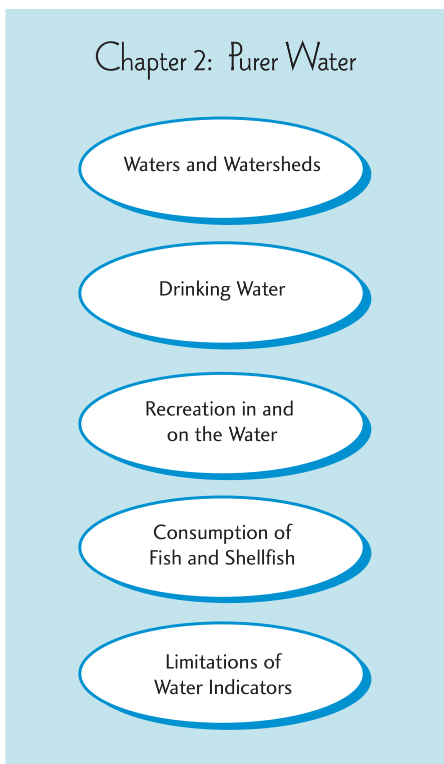


Introduction

Pristine waterways, safe drinking water, lakes for swimming and catching fish, and aquatic life habitat are treasured resources. The nation has made significant progress in protecting these resources in the last 30 years. Many Americans remember the burning of the severely polluted Cuyahoga River in the late 1960s, and the strong actions taken by many to reduce pollution to the nation's waters in the years since.

These actions have resulted in real progress, but water pollution problems and threats to surface and drinking water remain. For example, the aging of the nation's wastewater and drinking water infrastructure has highlighted the need to ensure that these critical resources are managed in a sustainable way. Other threats to water resources include landscape modification, invasive species, changes to water flow, overharvesting of fish and shellfish, and deposition of pollutants from the air.

This chapter describes what is known about the condition of waters, watersheds, coastal waters, and wetlands nationwide; the quality of the nation's drinking water; the condition of waters used for recreation; and the condition of waters supporting fish and shellfish consumption. Because the data are lacking—and often inconsistent—the picture is not complete. The chapter, therefore, also discusses the shortcomings of the data and the challenges that remain.



Waters and Watersheds

A watershed is a geographic area in which all the water drains to a common waterbody (e.g., river, lake, or stream). Watersheds may be as small as a few acres or larger than several states. For example, the Chesapeake Bay watershed extends across six states and the District of Columbia, whereas a small stream running through a farmer's field in Pennsylvania may drain only a few acres within the larger Susquehanna River watershed, which is a portion of the even larger Chesapeake Bay watershed.

Waters and Watershed Indicators

Water clarity in coastal waters

Dissolved oxygen in coastal waters

Benthic Community Index (coastal)

Wetland extent and change

Sources of wetland change/loss

Altered fresh water ecosystems

Percent urban land cover in riparian areas

Agricultural lands in riparian areas

Changing stream flows

Atmospheric deposition of nitrogen

Nitrate in farmland, forested, and urban streams and ground water

Total nitrogen in coastal waters

Phosphorous in farmland, forested, and urban streams

Total phosphorous in coastal waters

Phosphorous in large rivers

Atmospheric deposition of mercury

Chemical contamination in streams

Sediment contamination of inland waters

Sediment contamination of coastal waters

Pesticides in farmland streams and ground water

Toxic releases to water of mercury, dioxin, lead, PCBs, and PBTs

Healthy watersheds lead to cleaner water. Maintaining that health requires careful identification and management of human and natural activities that affect water. Although federal and state governments provide technical and financial support for watershed protection and restoration efforts, local stakeholders have led many such efforts.

Details on the extent of the nation's water resources (e.g., lakes, ponds, reservoirs, streams, rivers, wetlands, Great Lakes, and coastal areas) can be found in the Introduction of this report (see Exhibit i-2, "U.S. Environmental Protection in Context").

Water Quality Standards

The Clean Water Act sets a national goal to restore and protect the biological, chemical, and physical integrity of the nation's waters. Meeting that goal involves maintaining water quality that protects balanced indigenous populations of fish, shellfish, and wildlife and preserves recreational use of those waters. States, territories, and authorized tribes have the authority and responsibility to establish water quality standards for their waters. EPA assists by developing recommendations for criteria to protect human health and aquatic life. Pollutant standards are not the same from state to state because they address different designated uses and government policies, variations in natural conditions and ecosystem characteristics, and geological influences on the natural chemistry of water.

Ground Water

Of all the fresh water that exists, about 75 percent is estimated to be stored in polar ice and glaciers, about 25 percent is estimated to be stored as ground water, and less than 1 percent is stored as surface water. Ground water is the source of much of the water used for irrigation, is the principal reserve of fresh water, and represents much of the potential future water supply. It is a major contributor to flow in many streams and rivers. Indeed, hydrologists estimate that the ground water contribution to stream flow in the eastern U.S. may be as large as 40 percent.[1] Underground aquifers (or ground water) supply drinking water to about 50 percent of the U.S. population.[2]

Approximately 77 billion gallons per day of fresh ground water was pumped in the U.S. in 1995.[3] This amounts to about 18 percent of the estimated 1 trillion gallons per day of natural recharge to the nation's ground water systems.[4] The availability of ground water varies widely on a local scale.

What is the condition of waters and watersheds in the United States?

At this time, there is not sufficient information to provide a national answer to this question with confidence and scientific credibility. A great deal is currently known, however, about the condition of regional, state, and local waters due to the tremendous monitoring efforts of state and local authorities and watershed groups and citizens. What they have learned from these efforts has been useful in managing water resources.

States, territories, and authorized tribes have major responsibilities under the Clean Water Act, including the task of assessing the quality of their waters. That information is compiled by EPA and sent to Congress every two years in the National Water Quality Inventory. The assessments performed under Section 305(b) of the Act are to determine if water quality is supporting "designated uses" in state water quality standards. Typically, water quality is protected for use by aquatic life, for use as drinking water supplies, to support water for fish and shellfish for consumption, and for recreational, agricultural, industrial, and domestic uses.

Yet a number of factors limit what the Section 305(b) data can say about condition at the national level. Most states, territories, and tribes collect data and information on only a portion of their waterbodies. Also, their programs, sampling techniques, and standards differ. Many have targeted their monitoring programs to known problem areas. Although the use of targeted sampling informs local decision-making, it does not present a comprehensive understanding of the condition of water resources.

To confidently assess the condition of the nation's waters using regional and state information, a consistent, representative sample design and comparable data collection and analysis procedures are needed. A number of states are implementing such programs (see box, "New Directions in State Water Quality Assessment Programs").

A number of other programs collect information that contributes to our understanding of the condition of the nation's waters (see box "Who Is Assessing Water and Watershed Conditions?"). Many of them specifically address the impor-

New Directions in State Water Quality Assessment Programs

- *In its "2002 State of the Environment Report,"[5] the Indiana Department of Environmental Management used a statistical survey to report stream-water quality assessments by major watersheds. Since 1996, the department's Watershed Monitoring Program has assessed 20 percent of the state's streams each year for their ability to support aquatic life. Indiana completed the first comprehensive assessment of more than 99 percent of its streams and rivers in 2001. Of the 35,430 stream miles assessed, approximately 64.5 percent were estimated to fully support the maintenance of well-balanced aquatic communities.*
- *Maryland Biological Stream Survey (MBSS) uses a probability-based survey design to assess the status of biological resources in Maryland's non-tidal streams. In the fifth year of the survey, it intends to (1) characterize biological resources and ecological conditions, (2) assess their condition, and (3) identify the likely sources of degradation. The state has developed an interim framework to apply "biocriteria" in its water quality inventory (its 305[b] report) and list of impaired waters (its 303[d] list). To date, the proposed biocriteria rely on two biological indicators from the MBSS, the Fish and Benthic Indices of Biotic Integrity. (Benthic organisms include worms, clams, and crustaceans that live at the bottom of streams, lakes, ponds, estuaries, and the sea.) A preliminary evaluation using MBSS 2000 data was conducted to identify watersheds that fail to meet the requirements of the interim biocriteria framework. For a portion of the state, three larger watersheds that were assessed passed, and six assessments were inconclusive. Of the 123 sub-watersheds studied, 69 failed, 32 passed, and 22 were inconclusive.*
- *Kentucky has published the results of probabilistic surveys on the first three of its basin management units. The state's 2004 water quality report is expected to include results of additional surveys covering the watersheds of the entire state.*
- *Other statistically designed studies are under way in Alabama, Delaware, Florida, Idaho, Iowa, Kansas, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, Oregon, South Carolina, Virginia, West Virginia, and Wisconsin. The studies will allow those states to provide statewide characterizations of the waters being sampled.*

tance of watersheds as geographical groupings of waters and landscapes. This allows a better characterization of conditions than focusing on the waters alone, as well as a better understanding of how stressors affect water quality and the plants and animals that depend on water. An improved ability to report nationally on the condition of surface waters would also require a collaboration of states, tribal authorities, and federal agencies.

What is the condition of coastal waters?

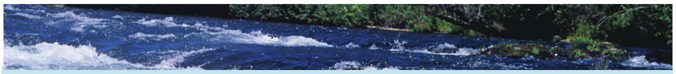
The 2001 *National Coastal Condition Report* found the nation's estuaries to be in "fair" to "poor" condition, varying from region to region (Exhibit 2-1). The study determined the overall condition of the estuaries based on measurements of seven coastal condition indicators: eutrophication, dissolved oxygen, water clarity, sediments, benthic condition, fish contamination, and loss of coastal wetlands. No overall assessments were completed for Alaska, Hawaii, or the island territories.

Estuaries are the most productive surface waters for plant and animal life. Near-coastal habitats provide critical spawning grounds, nurseries, shelter, and food for fish, shellfish, birds, and other wildlife. Coastal areas also provide essential nesting, feeding, and breeding habitat for 85 percent of the nation's waterfowl and other migratory birds.[6] Benthic organisms are important to the food chain. They are also key indicators of the health of coastal waters because they do not migrate and tend to have more concentrated interactions with their surroundings (e.g., sediment, water) than do many fish (Exhibit 2-1).

All seven indicators can help describe the condition of the nation's estuaries and near-coastal waters in more detail; this report focuses on three of them: eutrophication, dissolved oxygen, and water clarity.

Eutrophication

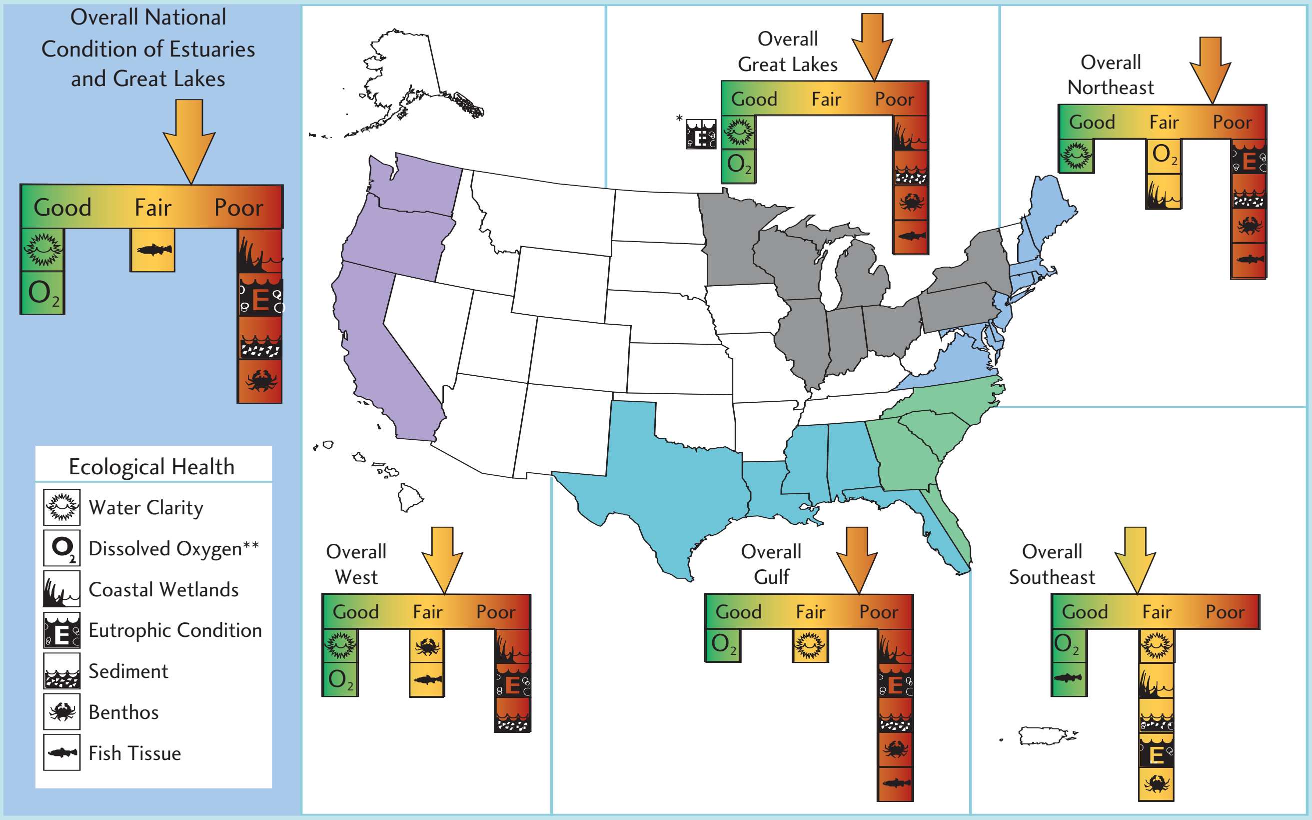
Eutrophication is a natural process characterized by a high rate of algal production. In recent years, human activities have substantially increased the delivery rate of nutrients to



Who Is Assessing Water and Watershed Conditions?

- *The U.S. Geological Survey's (USGS's) National Water-Quality Assessment (NAWQA) Program is a perennial program designed to provide consistent descriptions of the status and trends in some of the largest and most important streams and aquifer systems of the nation and to link the status and trends with an understanding of the natural and human factors that affect the quality of water. The studies cover 42 large hydrologic systems; however, the sampling for surface waters may not present statistically valid data for those systems.*
- *EPA's Environmental Monitoring and Assessment Program (EMAP) has conducted representative sampling of estuarine and stream resources, and then incorporated biological measures in estimates of condition. In most cases, however, those were one-time only assessments. In addition, geographic coverage for fresh water resources is limited to the mid-Atlantic region and the western states. Also, studies of estuarine resources were primarily limited to eastern areas south of Cape Cod, Gulf of Mexico coastal areas, and some western states.*
- *The National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends Program collects information on the chemical contamination of sediments and organisms, and on potential biological effects in the nation's coastal areas. Although the NOAA coastal studies of chemicals in sediments and bivalve tissues are multiyear in nature, most of the detailed chemical and toxicity assessments of estuarine areas are single point-in-time studies that were not meant to be repeated.*
- *The Natural Resources Conservation Service's (NRCS's) National Resources Inventory (NRI) is a statistically based sample of land use and natural resource conditions and trends on U.S. non-federal lands. NRI periodically collects data on land cover and use, soil erosion, prime farmland soils, wetlands, habitat diversity, selected conservation practices, and related resource attributes. No samples are taken on federally owned land.*
- *The U.S. Fish and Wildlife Service's (USFWS's) National Wetlands Inventory produces information on the characteristics, extent, and status of the nation's wetlands.*
- *Other major watershed protection programs collect data of local significance. The EPA Great Lakes National Program Office, for example, conducts statistically based monitoring of the open waters of the five Great Lakes covering trophic (nutrient level) conditions, nutrient concentrations, and biological indicators. Similar programs are found in the Chesapeake Bay, the Florida Everglades, Long Island Sound, and other areas. Atmospheric deposition of nutrients and toxic contaminants is monitored in many of these watersheds as well.*

Exhibit 2-1: Overall condition of estuaries and Great Lakes, 2000



* No indicator data available.

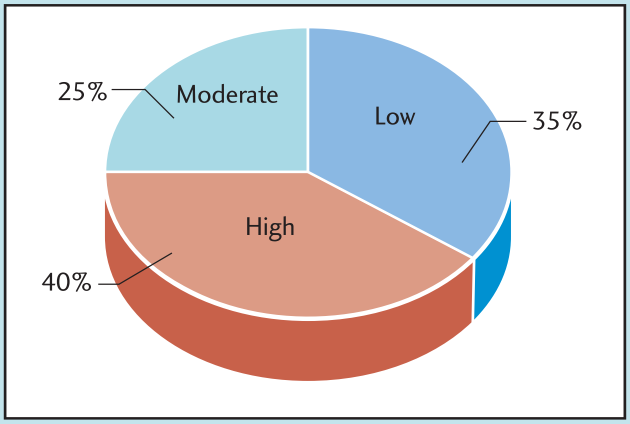
** Does not include the hypoxic zone in offshore Gulf of Mexico waters.

Note: no assessments were completed for Alaska, Hawaii, or island territories.

Source: EPA, Office of Research and Development and Office of Water. *National Coastal Condition Report*. September 2001.

many coastal waters, resulting in greater algal production than would have occurred naturally. A NOAA survey between 1992 and 1998 assessed symptoms of eutrophication, including high levels of algae and toxic algal blooms, lack of oxygen, and loss of aquatic plants that provide shelter and habitat for many species of bottom-living organisms (Exhibit 2-2).[7] Although the assessments were more a subjective determination of expert opinion than a systematic data analysis, they suggest that 40 percent of U.S. estuarine waters—as measured by surface area—are degraded by excess nutrients. That condition can lead to high levels of algae, and eventually to lower levels of oxygen in the water.

Exhibit 2-2: Percent of estuaries with high, moderate, and low levels of eutrophic condition, 1998

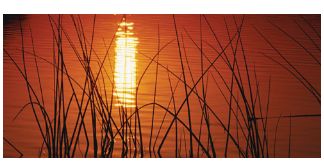


Source: Bricker, S.B. et al. *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries.* 1999; EPA, Office of Research and Development and Office of Water. *National Coastal Condition Report.* September 2001.

Dissolved Oxygen

Dissolved oxygen is a fundamental requirement for aquatic life. Low levels of dissolved oxygen, a condition called "hypoxia," are a problem in some coastal areas. This condition occurs when too many nutrients flow into coastal waters, overstimulating the growth of algae. The organic matter produced by the algae eventually decomposes, using up oxygen in the process. Hypoxia can contribute to algal scums, fish kills, noxious odors, habitat loss, and diminished aesthetic values. During hypoxic periods—which usually occur in the summer when high temperatures impede the mixing of oxygen from surface to deeper layers—dissolved oxygen levels fall below 2 parts per million (ppm, or 2 milligrams per liter [mg/L]), well below the 5 ppm needed to support healthy populations of aquatic life.[8] As oxygen levels fall, the effects on aquatic life become more severe. At about 3 ppm, bottom-living fish start to leave the area and the growth of some species is reduced. At levels less than 2 ppm, some juvenile fish and crustaceans start to die. At levels less than 1 ppm, fish totally avoid the area or begin to die in large numbers.

Generally, dissolved oxygen conditions in the nation's estuaries are good, judging from data gathered through EMAP. Similarly, according to the *National Coastal Condition Report*, 80 percent of sampled estuaries were in good condition with respect to levels of dissolved oxygen (more than 5 ppm dissolved oxygen), and 4 percent were in poor condition (less than 2 ppm dissolved oxygen). Low dissolved oxygen levels, however, are a seasonal problem in many estuarine systems such as the Neuse River Estuary in North Carolina and parts of Chesapeake Bay, Long Island Sound, and Tampa Bay. Further, although the report describes dissolved oxygen conditions in Gulf of Mexico estuaries as good, it also describes a hypoxic zone about the size of Massachusetts in the offshore waters of the northern Gulf (see box, "Hypoxia in the Gulf of Mexico and Long Island Sound").



Water Clarity

Water clarity, measured as the distance light penetrates into water, is another important characteristic of estuarine and coastal habitats and of all surface waters. Reduced light penetration is often the result of rainstorms, runoff from farmland and urban areas, eutrophic conditions, and algal blooms. Reduced clarity can impair normal algal growth and both the extent and vitality of submerged aquatic vegetation, which is a critical habitat component for many aquatic animals. EMAP data indicate that, overall, the nation's estuaries have good water clarity.

What are the extent and condition of wetlands?

Wetlands provide critical habitat, breeding grounds, resting places, and sources of food for fish, shellfish, birds, and other wildlife. They also filter pollutants, which helps protect water quality, limit flooding, and buffer coastal areas from storm damage. An estimated 95 percent of commercial fish and 85 percent of sport fish spend a portion of their lives in coastal wetlands.[9] Shellfish—shrimp, crab, and oysters—also rely on healthy wetlands for food and habitats.

Wetland extent serves as a partial surrogate to address wetland condition. The loss of wetlands in the landscape has a negative impact on the condition of the remaining wetlands by decreasing the physical connections among aquatic resources and decreasing diversity of the landscape, which lead to diminished opportunity for biological exchange and increased habitat fragmentation.

In 1997, the conterminous U.S. had approximately 105.5 million acres of wetlands, less than half the 220 million acres that likely existed in 1600. Nearly 95 percent, or 100.2 million acres, of those wetlands are fresh water, and about 5 percent—5.3 million acres—are intertidal marine and estuarine water.[10] Based on estimates made in the late 1980s, Hawaii had 51,800 acres of wetlands, and Alaska had 170 million.[11]

Exhibit 2-5 portrays the loss of wetlands since the mid-1950s. Until the 1970s, conversion to agricultural lands was the predominant cause of wetland loss. Since then, rates of annual wetland losses have been dropping—from almost 500,000 acres to less than 100,000 acres averaged annually since 1986. The U.S. Fish and Wildlife Service National Wetlands Inventory survey estimated the annual rate of loss at 58,500 acres per year between 1986 and 1997. That represents an 80 percent reduction in the rate of loss from the previous decade.[12]

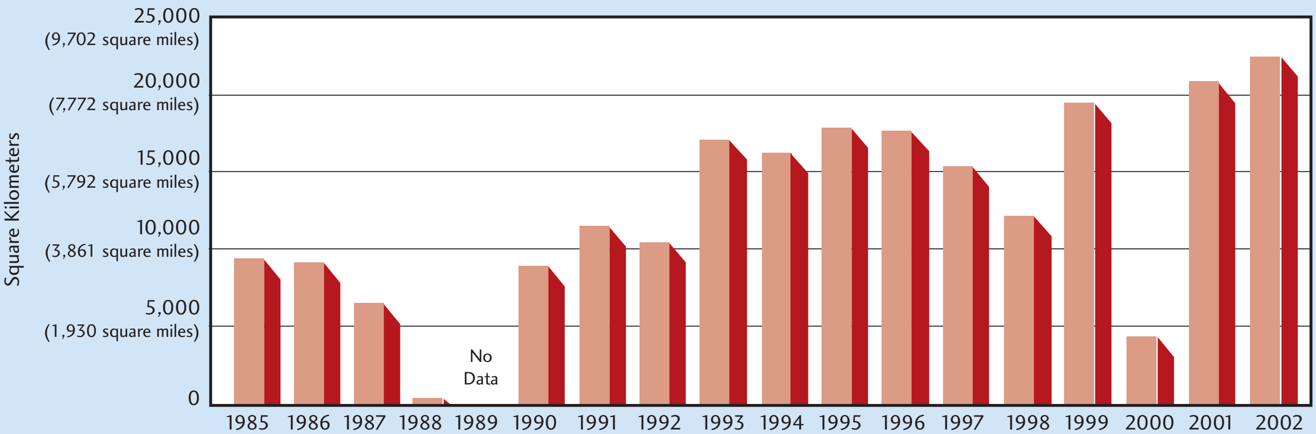
Hypoxia in the Gulf of Mexico and Long Island Sound

The area and duration of hypoxia are tracked in the Gulf of Mexico and Long Island Sound as indicators of the natural variability in those waterbodies to determine whether actions to control nutrients are having the desired effect and how local species are affected.

The largest zone of oxygen-depleted coastal waters in the U.S. is in the northern Gulf of Mexico on the Louisiana/Texas continental shelf. Hypoxic waters are most prevalent from late spring through late summer and are more widespread and persistent in some years than in others, depending on river flow, winds, and other environmental variables. Hypoxia occurs mostly in the lower water column, but can encompass as much as the lower half to two-thirds of the entire column.

The midsummer bottom areal extent of hypoxic waters in the Gulf of Mexico increased from 3,500 square miles (9,000 square kilometers) in 1985 to 8,500 square miles (22,000 square kilometers) in July 2002 (Exhibit 2-3). The primary cause of the hypoxic conditions is probably the eutrophication of those waters from nutrient enrichment delivered to the Gulf by the Mississippi River and its drainage basin.[13,14]

Exhibit 2-3: Areal extent of midsummer hypoxia in the Gulf of Mexico, 1985-2002



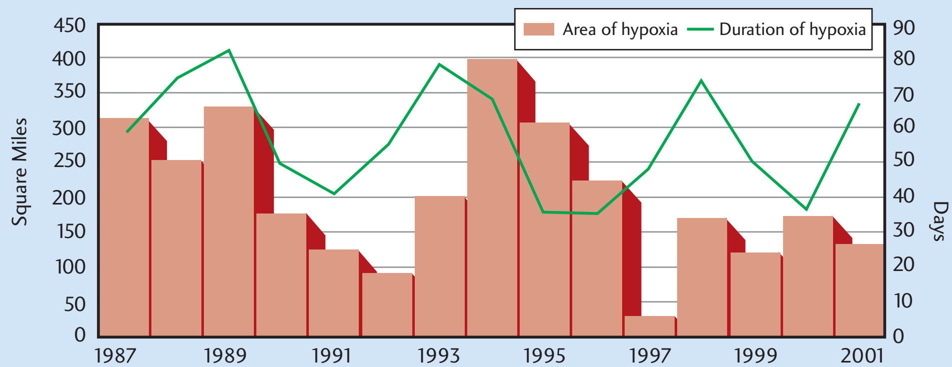
Note: Hypoxia in the Gulf is defined as less than 2.0 parts per million (ppm).

Annual midsummer cruises have been conducted systematically over the past 15 years (with the exception of 1989). Hypoxia in bottom waters covered an average of 8,000-9,000 km^2 in 1985-92 but increased to 16,000-20,000 km^2 in 1993-99.

Source: For 1985-1999 data years: Rabalais, Nancy N. et al. *Characterization of Hypoxia: Topic 1 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico.* May 1999, updated July 2000; for 2000-2002 data years: Rabalais, Nancy N., Louisiana Universities Marine Consortium. Unpublished data, personal communication. February 11, 2003.

The maximum area of hypoxia in Long Island Sound averaged 201 square miles (521 square kilometers) from 1987 through 2001. The largest area was 395 square miles (1,023 square kilometers) in 1994, and the smallest was 30 square miles (78 square kilometers) in 1997 (Exhibit 2-4). The duration of hypoxia averaged 56 days during the same period, with a low of 34 days in 1996 and a high of 82 days in 1989. Hypoxia is typically more severe in the western portions of the sound, where the nitrogen load is higher and mixing of fresh and salt water is more restricted.[15]

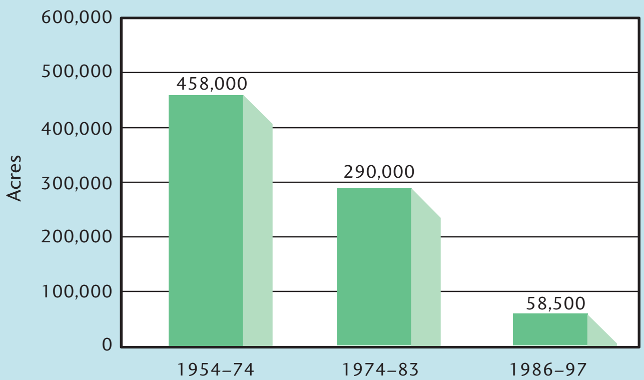
Exhibit 2-4: Maximum area and duration of hypoxia in Long Island Sound, 1987-2001



Note: Hypoxia in Long Island Sound is defined as less than 3.0 parts per million (ppm).

Source: EPA, Long Island Sound Office. *Sound Health 2001: Status and Trends in the Health of Long Island Sound.* 2001.

Exhibit 2-5: Average annual wetland loss, 1954-1974, 1974-1983, 1986-1997



Source: Frayer, W.E. et al. *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States 1950s to 1970s*. 1983; Dahl, T.E. and C.E. Johnson. *Wetland Status and Trends in the Conterminous United States 1970's to 1980's*. 1991; Dahl, T.E. *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997*. 2000.

Between 1986 and 1997, 98 percent of all wetland losses in the conterminous U.S. were fresh water wetlands. Since the 1950s, fresh water emergent wetlands (marshes) have declined by nearly 24 percent, and 10.4 million acres of fresh water forested wetlands have been lost. Coastal and estuarine losses during the same time were much lower on an absolute scale—about 1.4 million acres—but that loss represents a nearly 12 percent decline in coastal and estuarine wetlands.[16]

Loss of land to open water is a particular problem in Louisiana, whose 3.5 million acres of coastal wetlands represent about 40 percent of all of the coastal wetlands in the continental U.S. The state has lost more than 600,000 acres of coastal vegetated wetlands and is now losing coastal wetlands at an average annual rate of 16,000 to 19,000 acres per year.[17] In addition to flood controls and altered channels to facilitate navigation, rising sea level, marshland sloughing (sections breaking off) into deeper bays and sounds, and land subsidence (sinking) may have contributed to those losses.[18]

Additionally, major ecological effects have occurred from the conversions of one wetland type to another: clearing trees from a forested wetland or excavating a shallow marsh to create an open water pond, for example. Such conversions change habitat types and community structure in watersheds and have an impact on the plant and animal communities that depend on them.

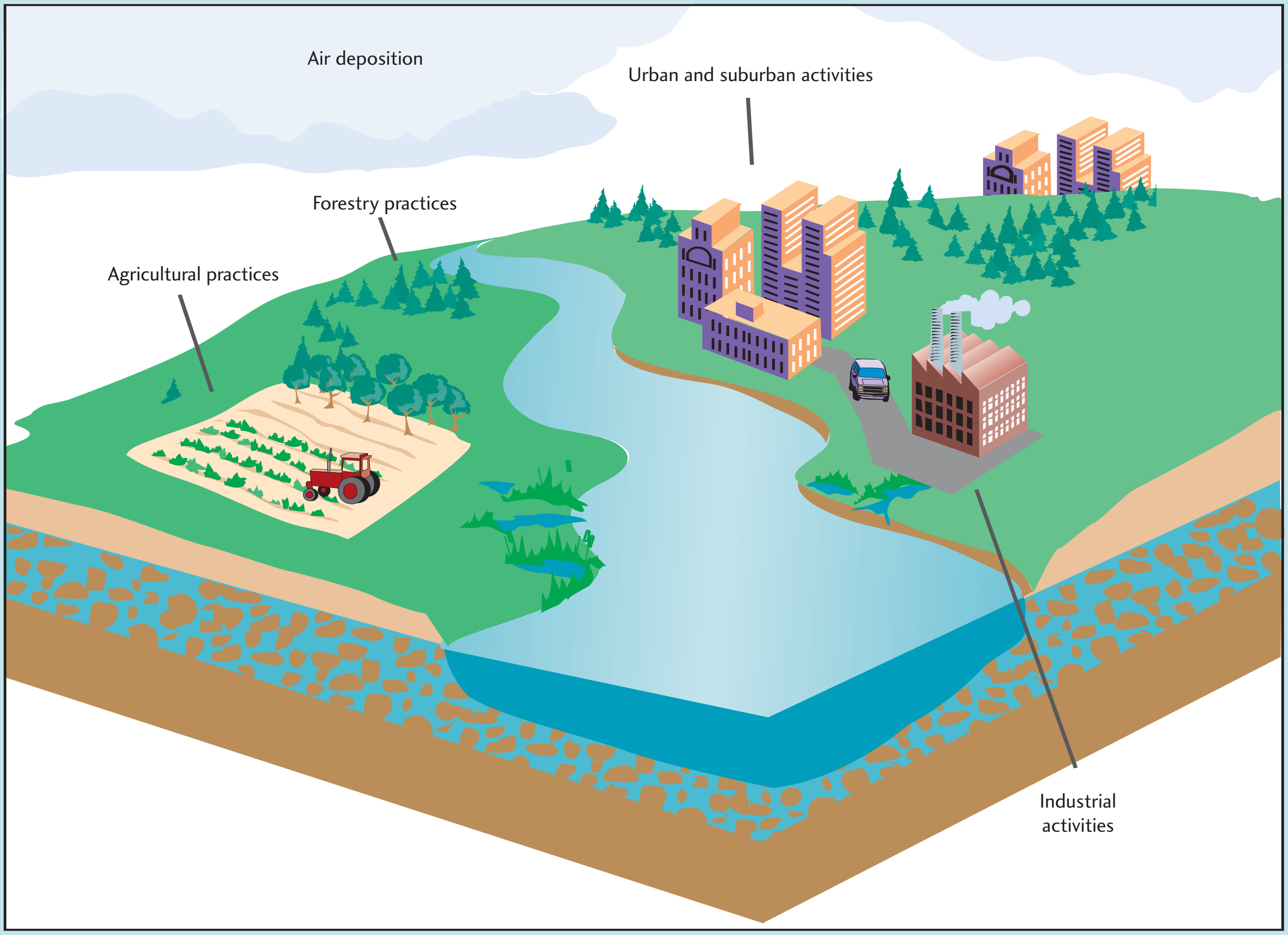
What are stressors to waters and watersheds?

Stressors affecting waters include alteration of natural water ecosystems, excess nutrients, toxic chemicals, and viruses and bacteria (pathogens, which are described in the following sections covering Drinking Water, Recreation in and on the Water, and Consumption of Fish and Shellfish). Some human activities associated with these stressors are illustrated in Exhibit 2-6. The indicators presented here to identify water stressors are drawn from national surveys or assessments. There are, however, strong indications from state-reported causes of impaired waters that stressors responsible for locally degraded water quality include sediments from non-point sources, nutrients from point and non-point sources, pathogens from point and non-point sources, and metals—largely as a result of point source discharges from years ago and atmospheric deposition.[19] All these conditions and situations may harm humans and aquatic species, reduce recreational opportunities, and increase the treatment costs for drinking water.

Under the Clean Water Act, states evaluate their waters and list impaired waters for potential reductions in point and non-point sources or for habitat restoration. In 1998, more than 20,000 waterways were identified as impaired under Section 303(d) of the Clean Water Act.[20] States have identified the principal causes of such impairments as siltation, pathogens, metals (particularly mercury), nutrients, habitat alteration, pesticides, organic enrichment/low dissolved oxygen, thermal modifications, low or high pH, and fish consumption advisories. The major transport mechanism for mercury is atmospheric deposition, which is also a significant source of nitrogen to waters.

Losing natural areas adjacent to waterbodies—and forested areas to development and agricultural activities—raises concerns about both water quality and quantity, especially in fast-growing areas such as the southeastern U.S. When impervious surfaces—asphalt and concrete, for example—impede or accelerate natural flows, water cannot percolate through soil. As a result, rain water rushes off, picking up pollutants and overwhelming local streams. Recent trends toward low-density development leave fewer pristine natural areas and

Exhibit 2-6: Selected activities affecting water, watersheds, and drinking water resources



fewer trees and expose more land to pesticides and chemical fertilizers. (For a more detailed discussion of those stressors, see the "Land Use" section of Chapter 3 – Better Protected Land.)

Physical alteration of a waterbody—damming or cutting channels in a river, or developing along shorelines or on adjacent wetlands—can have significant effects on water and on aquatic life. Although waterbodies are usually modified to achieve some gain—flood control, easier navigation, reduced erosion, or more area for farming or development—such alterations may also reduce fish and wildlife habitat, disrupt the patterns and timing of water flows, block the movement of wildlife, and reduce or eliminate the natural filtering of sediment and pollutants.

An analysis of rivers, streams, lakes, and reservoirs (excluding very small streams where data were not collected), based on remote sensing and U.S. Geological Survey (USGS) data, found that 23 percent of the stream banks, lake shorelines, and adjacent wetlands had been altered by use as croplands or by urban development. The natural habitat and function of those waterbodies is probably altered as well.[21] The data are not collected in a manner that allows for aggregation to provide a national perspective. At present, data for lakes and reservoirs are aggregated, even though a reservoir is a man-made structure or seriously altered habitat. Data on the degree to which streams and rivers are channelized, leveed, or dammed are not available, but these alterations result in similar impacts.

Although nitrogen and phosphorus are beneficial plant nutrients, human activities have increased their flow into waterbodies—in some cases to harmful levels. Runoff from farms and urban and suburban areas, nitrogen from power plants, emissions from vehicles and industry, and discharges from sewage treatment plants and septic systems can be sources of excess nutrients, causing excessive algae and plant growth. The resulting eutrophication harms aquatic life, fouls swimming beaches, causes odor from excess decaying algae, and may increase blooms of harmful algae such as red or brown tides.[22]

Ground water in agricultural areas often has higher nitrogen concentrations than that in non-agricultural areas. For example, approximately 10 percent of streams and 20 percent of wells in farming areas exceed federal drinking water standards for nitrate.[23]

Contaminated sediments can be a serious problem in certain areas and may be associated with industrial activity that predated awareness of the harmful effects of certain pollutants and the adoption of pollution control programs.[24] Pollutants such as dioxins, mercury, lead, polychlorinated biphenyls (PCBs), and other persistent bioaccumulative toxic chemicals in sediments can affect water quality and aquatic life. Industrial releases of metals, as reported through the Toxics Release Inventory, remain potential stressors to water quality. Some toxic sediments kill benthic organisms, reducing the food available to larger animals such as fish. Some contaminants in sediment are taken up by organisms, which are then eaten by next-level predators. In that way, contaminants can move up the food chain in increasing concentrations, affecting fish, shellfish, waterfowl, and mammals, including people.

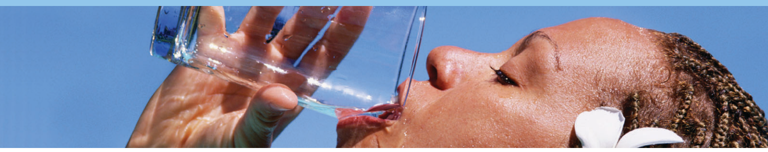
The USGS has synthesized contaminant and nutrient data from its 1992–1998 National Water Quality Assessment (NAWQA) program on 36 study units. Some of the major findings include: detectable concentrations of pesticides are widespread in urban, agricultural, and mixed-use area streams; streams in urban areas generally have higher concentrations of insecticides than streams in agricultural areas; elevated (above background) levels of selected heavy metals are found in waters; and widespread volatile organic compounds are seen in shallow urban ground water.[25]

What ecological effects are associated with impaired waters?

Biological communities reflect the cumulative effect of virtually all watershed stressors over time. Waters stressed by increased chemical contamination or altered habitats become impaired, which changes their structure, composition, and function. Pollution-sensitive species, along with organisms that require particular habitats, yield to more pollution-tolerant species and organisms that can adapt to a variety of habitat alterations and changes. Such changes can ultimately lead to a loss of aquatic diversity and abundance.

Several federal, regional, state, and tribal monitoring programs examine factors that affect aquatic communities. They have established direct and indirect relationships between the pressures on a community and its organisms by noting the changes in the structure, composition, and function of the animals and plants. Those "biological response signatures" help provide clues to watershed problems—including the types and sources of pressures.

The Macroinvertebrate Index of Biotic Integrity (IBI) and the Fish IBI are examples of such response signatures. They are indices that can measure incremental changes in the condition of waters and provide clues to the pressures affecting aquatic communities. IBIs have also been developed for coastal waters, wetlands, and lakes, and their use is growing at the regional, state, tribal, watershed, and local levels.[26] (See Chapter 5 – Ecological Condition, for further discussion of IBIs.) IBIs for benthos were assessed for the Northeast, Southeast, and Gulf Coastal areas. Assessments showed that 56 percent of the coastal waters were in good condition, 22 percent were in fair condition, and 22 percent were in poor condition. Of the 22 percent with poor benthic condition, 62 percent also had sediment contamination, 11 percent had low dissolved oxygen concentrations, 7 percent had low light penetration, and 2 percent showed sediment toxicity.[27]



Drinking Water

What is the quality of drinking water?

In 2002, state data reported to EPA showed that approximately 251 million people were served by community water systems that met all health-based standards (i.e., reported no health-based violations). This number represents 94 percent of the total population served by community water systems, up from 79 percent in 1993 (Exhibit 2-7).[28] Underreporting and late reporting of violations data by states to EPA, however, affect the accuracy of these data. The water used by community water systems comes from both surface water and ground water.

The nation has some 55,000 community water systems (a subset of all public water systems), all of which must test their water and treat it as needed to remove contaminants to specified levels before distributing it to customers. In 2002, community water systems served about 268 million people. Large-scale water supply systems usually rely on surface waters; smaller water systems tend to use ground water. Non-community water systems are also required to test and treat water. There are no national treatment or monitoring requirements for private wells. (The "Ground Water" discussion, under the "Waters and Watersheds" section of this chapter, provides more detail on the use of ground water as a drinking water resource.)

National drinking water standards apply to public water systems, which include municipally or privately owned water systems, homeowner associations, and other entities such as some schools, businesses, campgrounds, and shopping malls that draw their own water. National health-based standards exist for about 90 regulated contaminants. These intensive technical evaluations include many factors: occurrence in the environment; human exposure and risks of harmful health effects in the general population and sensitive subpopulations; analytical methods of detection; technical feasibility; and impacts of the regulation on water systems and public health.

Drinking Water Indicators

Population served by community water systems that meet all health-based standards

National drinking water standards also prescribe protocols, frequencies, and locations for monitoring. Water systems monitor at treatment plants and also in distribution systems for contaminants such as disinfection by-products and coliform bacteria that may form or recur there. Monitoring locations generally depend on the contaminant of interest. Annually, community drinking water suppliers report their overall water test results to their customers. Suppliers also must notify their customers of violations that pose an immediate threat to health. Non-community public water systems are not required to provide this annual report but are required to notify customers when drinking water standards are violated.

Exhibit 2-7: Population served by community water systems with no reported violations of health-based standards, 1993-2002

Fiscal Year	Population served by CWSs that had no reported violations	Percent of CWS-served population that was served by systems with no reported violations
2002	250,596,287	94
2001	239,927,650	91
2000	239,299,701	91
1999	229,805,285	91
1998	224,808,251	89
1997	215,351,842	87
1996	213,109,672	86
1995	208,700,100	84
1994	202,626,433	83
1993	196,229,162	79

Source: EPA, Office of Water. *Safe Drinking Water Information Systems/Federal version (SDWIS/FED)*. 2003.

What are sources of drinking water contamination?

Microbiological, chemical, and radiological contaminants can enter water supplies as a result of human activity and release from natural sources. For instance, chemicals can migrate from disposal sites or underground storage systems and contaminate sources of drinking water. Animal wastes, pesticides, and fertilizers may be carried to lakes and streams by rainfall runoff or snow melt. Nitrates from fertilizers also can be carried by runoff and percolate through soil to contaminate ground water (see Chapter 3 – Better Protected Land, for more discussion of nitrates). Arsenic and radon are examples of naturally occurring contaminants that may be released into ground water as it travels through rock and soil.

Human wastes from poorly managed or maintained septic and sewage systems as well as wastes from animal feedlots and wildlife carrying microbial pathogens (e.g., *Giardia, Cryptosporidium,* and *E. coli)* may get into waters ultimately used for drinking. All drinking water supply systems in the U.S. that use surface water or ground water with close hydrological connections to surface water must disinfect water and most must also filter it to remove pathogens. Disinfecting drinking water is a key element of treatment because it provides a barrier against harmful microbes. Disinfectants such as chlorine, however, react with naturally occurring organic matter in source water and in distribution systems to form chemical by-products such as trihalomethane and haloacetic acid compounds. Generally, the older a system's infrastructure, the greater the risk for breaches or infiltrations in the distribution system, which increase the risk of contamination.

What human health effects are associated with drinking contaminated water?

The potential health effects of consuming contaminated drinking water range from minor to fatal. Drinking inadequately treated water could result in nervous system or organ damage, developmental or reproductive effects, or cancer.[29]

The Safe Drinking Water Act

The Safe Drinking Water Act, as amended in 1996, mandates that EPA, states, and water systems implement multiple barriers to protect consumers from the risks of unsafe drinking water. Key activities include protection of source water, development and implementation of regulations based on sound science and risk assessments, improvements to drinking water infrastructure, certification of water system operators, technical assistance to water systems, and improving consumer awareness.

Consuming water with nitrates at sufficiently high levels can result in potentially fatal alterations in the hemoglobin (the iron-containing pigment in red blood cells) of infants and very young children, called "blue baby syndrome."[30] National standards for public water systems are designed to provide levels of treatment that are protective against adverse health effects.

The consequences of consuming water contaminated with pathogens can include gastrointestinal illnesses that cause stomach pain, diarrhea, headache, vomiting, and fever (see box, "Waterborne Disease Outbreaks Associated with Drinking Water 1971–2000," and discussions on "Waterborne Diseases" and "Gastrointestinal Illnesses" in Chapter 4 – Human Health). A microbial outbreak of *Cryptosporidium* in Milwaukee in 1993 sickened about 400,000 people and killed more than 50, most of whom had seriously weakened immune systems.[31]

Disinfection of drinking water is one of the major public health advances of the 20th century and has been a critical factor in reducing the incidence of waterborne diseases, including typhoid, cholera, hepatitis, and gastrointestinal illness in the U.S.[32] By-products of disinfection have also been associated with potential cancer, developmental, and reproductive risks, although the extent of risk posed is still uncertain. Limiting concentrations of disinfection by-products in drinking water, while ensuring that microbes are kept in check, will have a positive effect on public health.

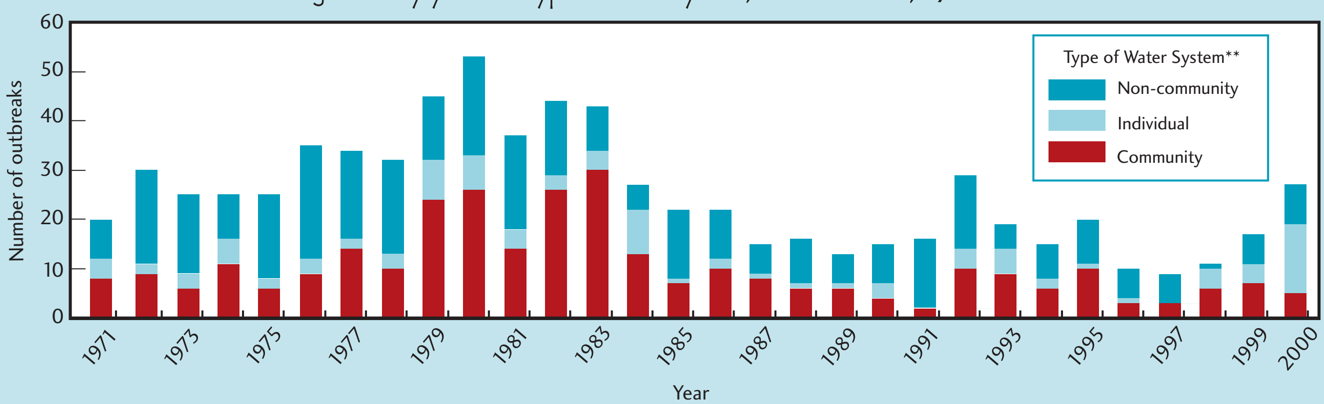
Waterborne Disease Outbreaks Associated with Drinking Water 1971-2000

Since 1971, the Centers for Disease Control and Prevention (CDC), EPA, and the Council of State and Territorial Epidemiologists have maintained a collaborative surveillance system for the occurrences and causes of waterborne disease outbreaks (WBDO). These data are only a small part of the larger body of information related to drinking water quality in the U.S. State, territorial, and local public health agencies are primarily responsible for detecting and investigating WBDOs and voluntarily reporting them to CDC. These data are used to identify types of water systems, their deficiencies, the etiologic agents (e.g., microorganisms and chemicals) associated with outbreaks, and to evaluate current technologies for providing safe drinking water and safe recreational waters. This system reports outbreaks and estimated numbers of people who become ill. It does not provide information on non-outbreak related or endemic levels of waterborne illness. Moreover, the focus is on acute illness. The system does not address chronic illnesses such as cancer, reproductive, or developmental effects. CDC and EPA are collaborating on a series of epidemiology studies to assess the magnitude of non-outbreak waterborne illness associated with consumption of municipal drinking water.

Between 1971 and 2000, there were 751 reported waterborne disease outbreaks associated with drinking water from individual, non-community systems, and community water systems (Exhibit 2-8). During 1999-2000, a total of 44 outbreaks (18 from private wells, 14 from non-community systems, and 12 from community systems) associated with drinking water were reported by 25 states.[33]

However, these data should be interpreted with caution. Many factors can influence whether a WBDO is recognized and investigated by local, territorial, and state public health agencies. For example, the size of the outbreak, severity of the disease caused by the outbreak, public awareness of the outbreak, whether people seek medical care or report to a local health authority, reporting requirements, routine laboratory testing for organisms, and resources for investigation can all influence the identification and investigation of a WBDO. This system underreports the true number of outbreaks because of the multiple steps required before an outbreak is identified and investigated. Thus, an increase in the number of outbreaks reported could either reflect an actual increase or improved surveillance and reporting at the local and state level.

Exhibit 2-8: Number of reported waterborne disease outbreaks* associated with drinking water by year and type of water system, United States, 1971-2000 (n=751)



*A WBDO is defined as an event in which (1) more than two persons have experienced an illness after either the ingestion of drinking water or exposure to water encountered in recreational or occupational settings, and (2) epidemiologic evidence implicates water as the probable source of illness.

****Non-community water systems** are systems that either (1) regularly supply water to at least 25 of the same people at least 6 months per year, but not year round (e.g., schools, factories, office buildings, and hospitals that have their own water systems), or (2) provide water in a place where people do not remain for long periods of time (e.g., a gas station or campground).

Individual water systems are not regulated by the Safe Drinking Water Act and serve fewer than 25 persons or 15 service connections, including many private wells.

Community water systems provide water to at least 25 of the same people or service connections year round.

Source: Based on data presented in Craun, G.F. and R.L. Calderon. *Waterborne Outbreaks in the United States, 1971-2000.* 2003.

Recreation in and on the Water

Federal, state, and local governments monitor the water quality at many beaches, and issue advisories or close beaches when the water is contaminated and may pose health risks.

What is the condition of waters supporting recreational use?

EPA collects information from 237 agencies on beach closings and advisories through its National Health Protection Survey of Beaches, which is one way to measure the condition of recreational waters. Between 1997 and 2001, the percentage of beaches affected by advisories or closings rose from 23 to 27 percent. During the same period, the number of local, state, and federal agencies participating in the survey increased from 159 in 1997 to 237 in 2001. Survey respondents (primarily for coastal and Great Lakes beaches) reported that beaches were closed or under advisory on more than 19,000 beach days, or about 6 percent of total beach days, during the 2001 swimming season.[34] (The increase in the percentage of beaches affected is likely a reflection of more consistent monitoring and reporting.)

Recreational Water Indicators

Number of beach days that beaches are closed or under advisory

Because reporting under the survey is voluntary and data are drawn primarily from coastal and Great Lakes beaches rather than inland beaches, the survey's reliability as a national indicator is unknown. Furthermore, monitoring and reporting vary by state, with some states having very aggressive programs.[35]

California, for example, has one of the most highly developed beach monitoring and notification programs in the nation. State law requires frequent monitoring at high-use beaches and establishes well-defined thresholds for issuing beach advisories. A committee made up of state, federal, and local agency officials, as well as representatives from the environmental community and the Beach Water Quality Workgroup helps coordinate the efforts.

California beaches are monitored at least once a week, with some in Southern California monitored 5 to 7 days each week. Other states generally monitor once a week, although some monitor twice a month or less. The monitoring involves testing for several indicators including total coliform bacteria, fecal coliform, and the EPA-recommended indicator *Enterococcus*. If a standard is exceeded, local health departments use various methods to notify the public promptly.

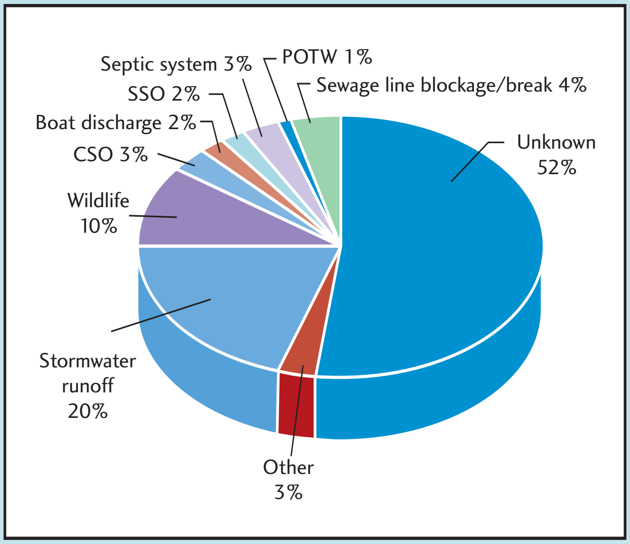
What are sources of recreational water pollution?

EPA asks survey respondents to identify the sources of pollution that cause advisories or closings. Without precise information, respondents use their best judgment to identify sources. In more than half the cases, the source is unknown (Exhibit 2-9). The most frequently identified source is storm water runoff that contains harmful contaminants such as bacteria from livestock or pet waste, inadequate sewage treatment, or poorly designed or operated septic systems.[36]

What human health effects are associated with recreation in contaminated waters?

The health effects of swimming in contaminated waters are usually minor and temporary—sore throats, ear infections, and diarrhea—but can be more serious, even fatal. Waterborne microbes can cause meningitis, encephalitis, and severe gastroenteritis.[37] However, data on the effects and number of occurrences are limited. The number of occurrences may be underreported because people may not link common symptoms with exposure to contaminated recreational waters and, unless symptoms are debilitating, do not seek medical attention. Additional research and information are needed to improve understanding of the types and extent of health effects associated with swimming in contaminated waters (For additional information see the discussions on "Waterborne Diseases" and "Gastrointestinal Illnesses" in Chapter 4 – Human Health).

Exhibit 2-9: Reported sources of pollution that resulted in beach closings or advisories, 2001



CSO - Combined Sewer Overflow
SSO - Sanitary Sewer Overflow
POTW - Publicly Owned Treatment Works

Source: EPA, Office of Water. *EPA's BEACH Watch Program: 2001 Swimming Season.* May 2002.

Consumption of Fish and Shellfish

Fish and shellfish are important and desirable sources of nutrition for many people. However, chemical and biological (bacteria, pathogens) contaminants can accumulate in fish and shellfish, making it unhealthy to consume them, especially in large quantities.

What is the condition of waters that support consumption of fish and shellfish?

Most states sample fish in their waters and then issue fish consumption advisories as a way of informing the public of risks associated with eating certain types and sizes of fish from certain waterbodies. Advisories are based on fish tissue monitoring data collected by states and tribes and are largely focused on areas of known or suspected contamination.

In the U.S., 14 percent of the river miles, 28 percent of lake acreage, and 100 percent of the Great Lakes and their connecting waters are under fish consumption advisories.[38] Those percentages have increased in recent years (Exhibit 2-10). The increases are most likely the result of more consistent monitoring and reporting and decreases in concentration criteria, and are not necessarily an indication that conditions are getting worse.

Fish advisories that limit or restrict consumption, especially of top-level predators (e.g., walleye and lake trout), are widespread across the U.S. Advisories are issued for various contaminants—mercury, dioxin, and PCBs are responsible for many of the advisories throughout the U.S. In January 2001, EPA and the U.S. Food and Drug Administration issued a nationwide advisory for women who are pregnant or may

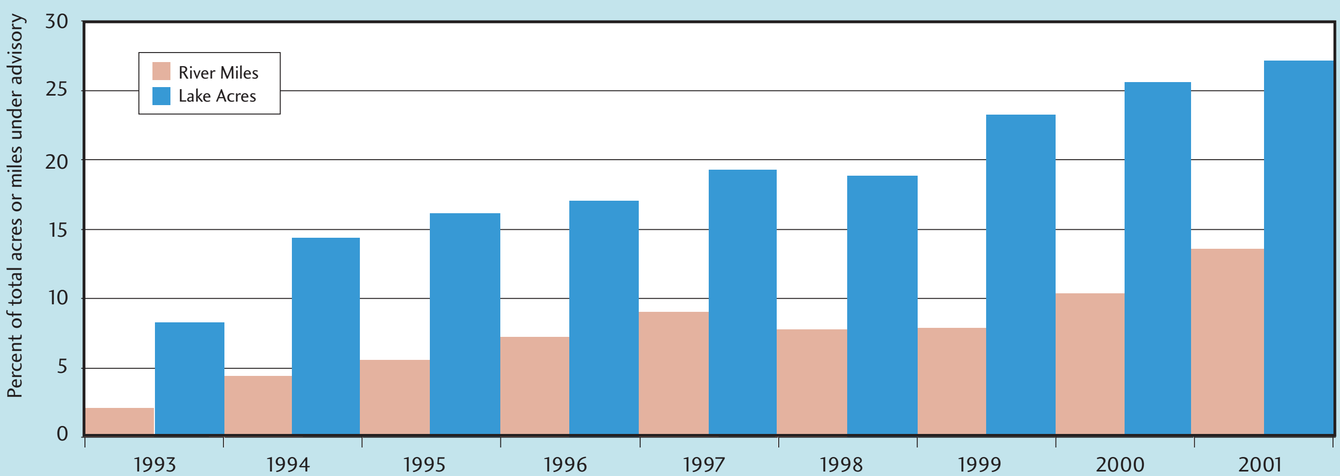
Consumption of Fish and Shellfish Indicators

Percent of river miles and lake acres under fish consumption advisory

Contaminants in fresh water fish

Number of watersheds exceeding health-based national water quality criteria for mercury and PCBs in fish tissue

Exhibit 2-10: Trends in percentage of river miles and lake acres under fish consumption advisory, 1993-2001



Source: EPA, Office of Water. *Update: National Listing of Fish and Wildlife Advisories.* May 2002.

become pregnant, nursing mothers, and young children to limit the consumption of certain species of fish that may contain mercury to one meal per week. The jointly issued nationwide advisory applies to fresh water fish and fish bought from stores and restaurants (i.e., commercially caught fish, including ocean and coastal fish).

Criteria used to issue advisories vary among states. Some have more stringent criteria and more robust advisory programs than others. Fish advisory data presented in Exhibit 2-10 are intended to show total number of miles and acres under advisory—rather than the number of advisories—to clearly represent the amount of area covered and to track trends.

Coastal states also identify, survey, and classify waters where shellfish grow and then prohibit the harvesting of shellfish if the water quality does not meet certain federal standards. Data indicate improvements since testing began in 1966. The percentage of prohibited waters decreased from a high of 26 percent in 1974 to 13 percent in 1995.[39] Because the survey has not been repeated since 1995, information on more recent conditions is not available.

What are contaminants in fish and shellfish, and where do they originate?

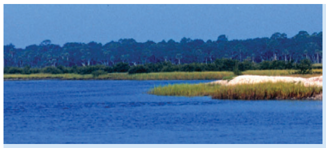
Most advisories about fish consumption involve one or more of five primary contaminants: DDT, PCBs, chlordane, dioxins, and mercury.[40] Mercury is a naturally occurring element that is present throughout the environment and in plants and animals. Human activity can release some of that mercury, increasing the amount available to accumulate in humans and other animals. Mercury, which is detectable in most U.S. waters, comes from a number of sources (e.g., from burning fossil fuels and from wastes that create mercury emissions that settle on land and water). In some areas, mercury contamination is the result of activities and practices that have ceased. In soils and sediments, bacteria convert mercury to highly toxic methylmercury, which is absorbed by fish and accumulates in their tissue.

Some synthetic toxic substances such as DDT and PCBs are common in fresh and coastal waters. Although manufacture and use of PCBs and DDT have been banned in the U.S. for many years, sediments deposited years ago, and residual amounts in soil, continue to contaminate U.S. watersheds (Although production ceased in 1997, PCBs can be found in some products manufactured prior to the ban (e.g., electrical transformers).[41] PCBs, DDT, and mercury can contaminate fish and shellfish and be carried up the food chain to larger fish, such as large-mouth bass, tuna, swordfish, and some sharks. Such concerns led to the nationwide mercury advisory.

Officials in the Great Lakes region are using a multimedia approach to focus on persistent toxic chemicals in air, sediments, and fish tissue (see box, "Bioaccumulative Toxics in the Great Lakes: A Multimedia Look"). Threats to shellfish also include bacterial contamination from human and animal wastes and naturally occurring toxins that shellfish accumulate from consuming certain algae.[42] Although closings of shellfish beds generally result from excessive coliform concentrations, other pathogens are not always measured and could be a concern. In addition, state and local agencies use different procedures to determine what factors (e.g., presence of chemical contaminants) should be used to dictate closings.

What human health effects are associated with consuming contaminated fish and shellfish?

The effects of eating contaminated fish or shellfish vary greatly. The greatest risks come from consuming contaminated fish and shellfish regularly over a period of time. Assessments show a measurable risk of cancer from some chemical contaminants that are sometimes found in fish tissues (e.g., DDT, PCBs). Mercury is toxic in sufficient quantities, especially to the nervous system. Shellfish contaminated



Bioaccumulative Toxics in the Great Lakes: A Multimedia Look

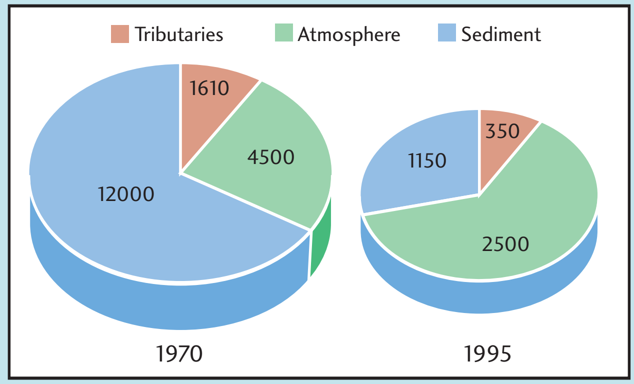
Toxic chemicals enter the water of the Great Lakes (and therefore fish) from the atmosphere, tributaries, and sediments. These chemicals can be retained by plants and animals and increase in concentration though the food chain, a process called "bioaccumulation." Environmental data and modeling were used to estimate the relative contributions from each pathway to Lake Michigan. Total contaminant loads have decreased since the 1970s, and atmospheric deposition has increased in importance over time because of decreases in direct discharges to the lake and levels in sediments (Exhibit 2-11).

The Integrated Atmospheric Deposition Network (IADN) and the Great Lakes Fish Monitoring Program (GLFMP) monitor persistent bioaccumulative toxic (PBT) pollutants in the air and fish, respectively, of the Great Lakes. Both programs show decreases in PBTs over time (Exhibits 2-12 and 2-13). In spite of these downward trends, levels of PCBs and other PBTs in certain types of fish still exceed health protection levels in all five lakes. Air data from Chicago showing elevated PCB levels suggest that cities still contain significant sources of PCBs.

GLFMP samples are also being used to identify the presence of "new" bioaccumulating pollutants in the Great Lakes, such as certain brominated flame retardants.

Exhibit 2-11: Lake Michigan polychlorinated biphenyls (PCBs) sources, 1970 and 1995

Values in kilograms per year

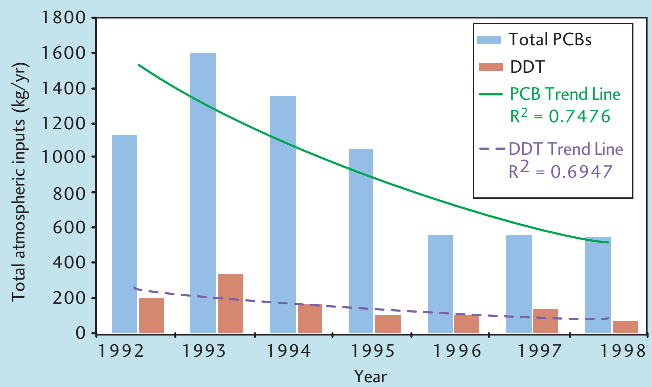


Note: This graphic was created for this report by the EPA Great Lakes National Program Office and the EPA, Office of Research and Development's Large Lakes Research Station using MICHTOX, a mass balance and bioaccumulation model, and air, water, and sediment data drawn from the Great Lakes Environmental Monitoring Database (GLENDA). The 1970 model run was based on available data and extrapolations. The 1995 model run was based on data collected during the Lake Michigan Mass Balance Study that collected over 25,000 samples at 200 locations in 1994-1995.

Source: EPA, Great Lakes National Program Office. *Great Lakes Environmental Monitoring Database (GLENDA)*. 2002.

Exhibit 2-12: Atmospheric deposition of PCBs and DDT in the Great Lakes, 1992-1998

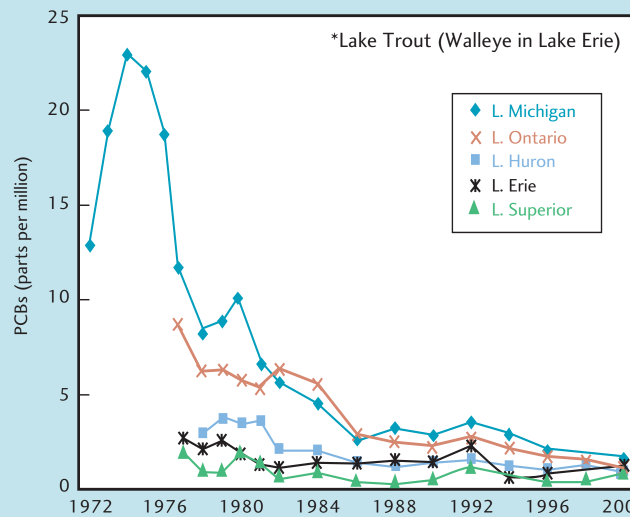
Total Atmospheric Inputs (Wet + Dry + Gaseous Absorption)



Note: Note: R^2 is the coefficient of determination. It gives a measure of the strength of the correlation.

Source: Buehler, S., et al. *Atmospheric Deposition of Toxic Substances to the Great Lakes: IADN Results through 1998*. 2001.

Exhibit 2-13: Polychlorinated biphenyls (PCBs) trends in Great Lakes fish tissue,* 1972-2000



Source: EPA, Great Lakes Fish Monitoring Program. Toxics in Top Predator Fish. February 24, 2003 (April 4, 2003; *http://www.epa.gov/glnpo/glindicators/fishtoxics/topfishb.html*).

Minnesota Chippewa Tribe: Fish Consumption

The Minnesota Chippewa are a federally recognized tribal confederation with approximately 40,000 members. The tribe's six reservations occupy approximately 1.8 million acres in the northern portion of Minnesota, including 667 lakes covering approximately 700,000 acres, 702 miles of streams, and 250,000 acres of wetlands. Because water is an abundant natural resource for the tribe, its members rely heavily on fish caught in those waters as a source of food.

The major, widespread contaminants in Minnesota Chippewa tribal waters are mercury, DDT, PCBs, and dioxin and furans. Fish consumption is the primary route of human exposure to these contaminants. Thus, the tribe chose as a primary environmental indicator the quantity of fish from its waters that can be consumed safely by its most at-risk members: women of childbearing age, nursing mothers, and children.

The tribally designated, treaty-protected quantity of preferred fish consumption is 224 grams (about 8 ounces) per day. The quantity of preferred fish that may be consumed safely by the most at-risk citizens is limited to 5 percent (about 0.4 ounces) or less of that 8 ounces.

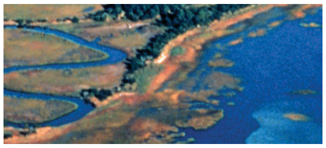
Lake-specific guides for fish consumption are prepared for members of the tribe. The guides offer recommendations on the pounds per month of several fish species that it is safe to consume.[43]

with pathogens associated with human or animal wastes can cause gastrointestinal illness—even death in people with compromised immune systems (see Chapter 4 – Human Health). Mollusks, mussels, and whelks are the main shellfish that can carry biotoxins causing common symptoms, such as irritation of the eyes, nose, and throat as well as tingling lips and tongue.[44]

Contaminated fish and shellfish are a particular concern to people in either of two high-risk categories: those with conditions that put them more at risk (e.g., pregnant women, nursing mothers, children, or people with compromised immune systems); and people who consume fish as a primary food source (e.g., some tribes and ethnic groups). Because of their higher consumption rates, some communities have developed their own guidance to identify specific types of fish of concern (see box, "Minnesota Chippewa Tribe: Fish Consumption").

Limitations of Water Indicators

Many sources of data support indicators that help to answer questions about the condition of water and watersheds, the quality of drinking water, the quality of water supporting recreation in and on the water, and consumption of fish and shellfish—as well as the potential stressors and effects associated with these. Other indicators show potential stressors and associated effects, but the data have limited ability to fully answer the questions.



Water and Watersheds

It is difficult to use existing data to give a complete and accurate picture of the state of U.S. surface waters to support aquatic life for several reasons:

- Only a portion of waters is sampled to assess the condition of the whole; many have targeted their monitoring programs to known problem areas.
- States and tribes do not use a consistent set of monitoring procedures for water quality.
- Monitoring designs are not structured across agencies to assess the condition of all U.S. waters. Sampling techniques, sampling locations, and even data analysis procedures are inconsistent.
- States define "quality" in different ways. The standards of each state accommodate both the state's policies and the important physical and ecological differences that can exist between waters.

The situation is similar for watersheds. Given existing data and differing monitoring approaches, a comprehensive nationwide assessment of watershed condition has not been achieved. More comprehensive and consistent monitoring is needed, particularly when the changing face of the American landscape is considered. Building dams and channels, withdrawing water for irrigation, and expanding development are changing the shape and flow of streams, but there are insufficient data on the effects of those activities on aquatic habitats. There are, however, some very strong state and regional programs that collect data on pollution loads and their effects on aquatic habitats. The Chesapeake Bay Program's suite of indicators is an excellent example (see box, "Chesapeake Bay Program Suite of Indicators").

Human Uses of Water Resources

Similar problems occur in gathering information on other water-related issues. For example, underreporting and late reporting of community water system violations data by states to EPA continue to affect the ability to report accurately on the quality of the nation's drinking water. Of the 49 states that issue fish advisories, six do not use a risk-based approach. An EPA study of 268 contaminants in freshwater fish tissue is in the first of four seasons of monitoring, but cannot yet contribute to an understanding of the national scope of this issue. The data on beach closings and advisories include most coastal and Great Lakes beaches but few inland beaches. Reporting is voluntary, and not all states report consistently. Similarly, data on the effects of contamination on animals and plants are lacking. Monitoring designs are not yet structured across agencies to assess the condition of the entire country.

Chesapeake Bay Program Suite of Indicators

EPA's Chesapeake Bay Program uses indicators extensively for making decisions, informing the public about conditions and trends, and measuring progress toward specific environmental goals. The indicators presented below were selected from more than 90 existing environmental management measures.

Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission, EPA (representing 21 federal agencies), participating citizen groups, local governments, and scientific advisory groups are all involved in the development, peer review, and approval of the indicators and goals.

Trends in Blue Crab: Mature Females

The number of mature female crabs is well below the long-term average and has declined since the early 1990s.

Acres of Bay Grasses

Acres of bay grasses increased to more than 85,000 acres in 2001 from a low point of 38,000 acres in 1984.

Water Clarity

As of 2001, most of the mainstem bay, larger embayments, and lower regions of large tributaries meet the minimum light requirement for submerged aquatic vegetation; upper regions of large tributaries and many minor tributaries do not.

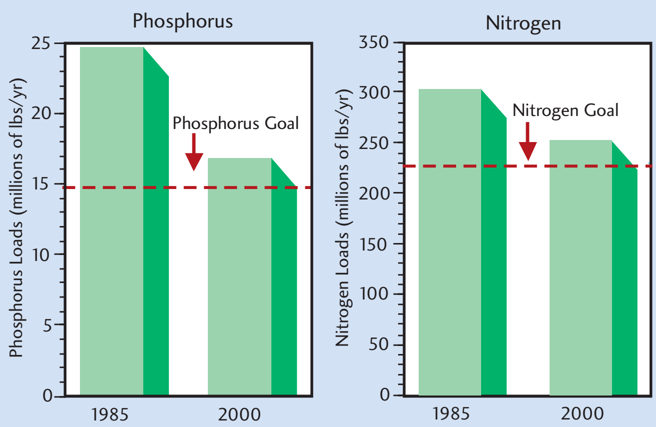
Nutrient Loads Delivered to the Bay

Between 1985 and 2000, nutrient loads to the bay decreased significantly: annual phosphorus loads decreased by 8 million pounds per year; and annual nitrogen loads decreased by 51 million pounds per year (Exhibit 2-14).

Riparian Forest Buffer– Conservation and Restoration

Between 1996 and August 2002, 2,283 miles of riparian forest were restored (Exhibit 2-15).

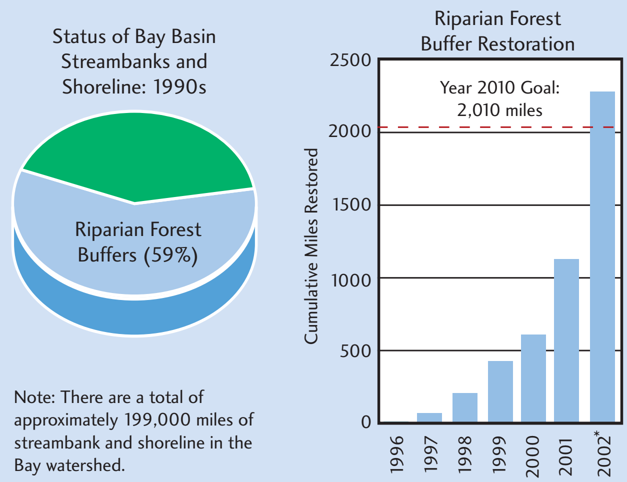
Exhibit 2-14: Total nutrient loads delivered to the Chesapeake Bay from MD, PA, VA, and DC, 1985 and 2000



Note: Data include total nitrogen and phosphorus loads delivered to the Bay from point and nonpoint sources, from Chesapeake Bay Agreement jurisdictions: MD, PA, VA, and DC.

Source: EPA, Chesapeake Bay Program. Phase 4.3 Watershed Model. Last updated July 2002.

Exhibit 2-15: Riparian forest buffer conservation and restoration, 1996-2002



Note: There are a total of approximately 199,000 miles of streambank and shoreline in the Bay watershed.

*Through August 2002.

Source: EPA, Chesapeake Bay Program. Chesapeake Bay Riparian Forest Buffer Inventory. September 1996; EPA Chesapeake Bay Program. Chesapeake Bay Program Office Data Center. June 1998; EPA Chesapeake Bay Program Office Forestry Workgroup. Riparian Forest Buffer Conservation and Restoration. January 2, 2003. (April 7, 2003; *http://www. chesapeakebay.net/status/cfm?sid=83*).

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