Chapter 4
Major Coastal and Marine Resource Issues

Highlights

- ❑ Half of the nearly 269 million people living in the United States live in coastal counties, which represent some 10 percent of the continental United States.
- ❑ The primary sources of direct discharges into marine waters are dredged material, municipal sewage sludge, and industrial wastes.
- ❑ Nationally, the primary nonpoint sources of water pollution involve urban runoff and agricultural activities.
- ❑ The 48 contiguous states lost 52 percent of their original inland and coastal wetlands between the 1780s and the 1980s. In 1995, 46 percent of original wetlands remained.
- ❑ Increasing population, development, and conflicting natural resource policies have left coastal areas vulnerable to natural and human-made hazards—coastal storms, chronic erosion, and potential sea-level rise among them.

Major issues that often face coastal management programs include population, pollution, habitat loss, coastal hazards, marine/beach debris, oil spills, global climate change, overfishing, loss of biological diversity, and nonindigenous or “nuisance” species. Each of these topics is covered in this chapter.

Population

The number of people living in coastal areas, and their associated use of resources, has a tremendous effect on coastal areas. In 1997, 5.9 billion people inhabited the Earth, and that number is expected to rise to 9.3 billion by 2050. Nearly 269 million people live in the United States, and almost 50 percent live in coastal counties, which represent some 10 percent of the contiguous United States. At 341 persons per square mile, the average population density is more than four times greater in coastal counties than in noncoastal counties. According to the National Oceanic and Atmospheric Administration (NOAA), the coastal population is expected to climb significantly in the next decade.

Heavy population densities are by no means limited to the Atlantic and Pacific seaboards. The Great Lakes basin is home to more than one-tenth of the U.S. population and one-fourth of Canada’s population. Nearly 25 percent of Canadian agricultural production and 7 percent of U.S. agricultural production are located in the Great Lakes basin.

Increasing populations in coastal areas naturally demand more housing, transportation, commercial services, freshwater, and energy. These populations inevitably generate larger quantities of solid waste and place growing demands on community services, such as waste disposal and sewage treatment. These demands, alone and combined, challenge those who manage coastal resources.

Coastal population growth leads to increased land development, which also adds to pressures on wetlands, coastal forests, and other coastal resources. Land development, such as the construction of roads, parking lots, and buildings, reduces the amount of surface area that allows water to penetrate the ground and increases the amount of runoff from an area. Urban runoff can contain contaminants such as oils, greases, metals, and bacteria.

Reducing permeable surface areas also reduces groundwater recharge capacities. This situation leads to an increased potential for flooding and increases the seriousness of flooding when it occurs. Construction also can lead to increased erosion. The larger volumes of topsoil deposited in riverbeds, delta lands, and behind dams can increase flooding potential; impede power generation; reduce reservoir storage capacities; and lead to unexpected, and possibly undesirable, alterations in stream or river flows.

Pollution

Point Sources

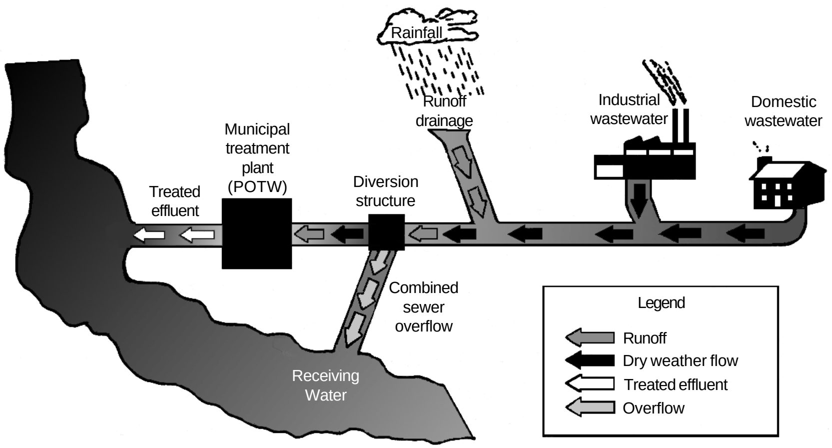
In the United States, approximately 2,000 sewage treatment plants and industrial facilities discharge effluent, treated to various extents, directly to estuaries and other coastal waters. Most sewage in the United States is treated to meet secondary treatment standards prior to disposal. The Clean Water Act (CWA) regulates discharges to marine waters under section 301(h) and requires that permits be issued for pipeline discharges from coastal municipalities and industrial facilities. Industrial and municipal discharges are regulated through a permitting system under the CWA's National Pollutant Discharge Elimination System (see chapter 5). Permits establish pollution limits and specify monitoring and reporting requirements.

More than four out of every ten gallons of water used in the United States are used for industrial purposes. Typically, about 20 percent of water used by the industry is used in the finished product; the remainder is treated and discharged back to coastal and inland waters.

Municipal discharges come from publicly owned treatment works that discharge into surface waters. About 2.3 trillion gallons of effluent are discharged from sewage treatment facilities into surface waters annually.

In some areas during heavy rains, the contents of storm sewers and sanitary sewers combine, bypassing the sewage treatment facilities and going directly into coastal and inland waters (see figure 4). Combined sewers are no longer constructed but are still

Figure 4
Typical Combined Sewer Collection Network during a Storm



Note: During a storm event, flow beyond the capacity of the treatment facility is diverted.

Source: Office of Technology Assessment 1987

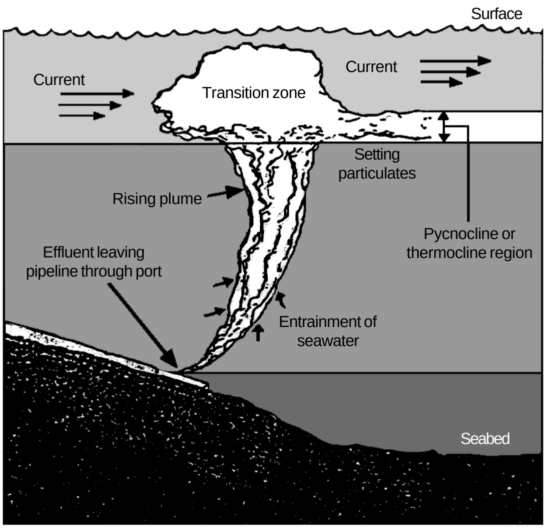
in operation in many older urban areas. In April 1994, the Environmental Protection Agency (EPA) issued a policy to control combined sewer overflows. The policy calls for communities to take immediate and long-term actions to address overflow problems. Measures specified in the policy include proper operation and regular maintenance of sewer systems and combined sewer overflows, as well as public notice in the event of overflows.

Regulation of ocean dumping began with passage of the Marine Protection, Research, and Sanctuaries Act (MPRSA) in 1972. Ocean dumping of municipal sewage sludges was phased out and ended in June 1992 under the Ocean Dumping Ban Act of 1988 (see chapter 5). MPRSA requires permits for disposal of dredged material into oceans. Figure 5 shows the general fate of effluent discharged into marine waters.

Nonpoint Sources

One- to two-thirds of the pollution in coastal waters originates from nonpoint sources, according to EPA. Nonpoint source pollution comes from many different sources and enters coastal

Figure 5
General Fate of Effluent Discharged into Marine Waters



Source: Office of Technology Assessment 1987

waters in several ways. For example, contaminants such as pesticides are picked up by rainwater as it washes over the land and drains into water bodies. Nonpoint source pollutants can enter water bodies through direct runoff, runoff through storm sewers and drains, wet or dry air deposition, and underground aquifers. Nonpoint sources of pollution include the following:

- Runoff from urban and suburban areas (oil, grease, lead, chromium, bacteria, lawn chemicals and fertilizers, and sediments)
- Runoff from farms (sediments, fertilizers, nutrients, and pesticides)
- Sedimentation and increased temperatures resulting from logging operations
- Sediment and toxic metals from construction sites and mining operations
- Atmospheric deposition of chemicals, heavy metals, nutrients, acid, and byproducts from fossil fuel combustion
- Other releases of pollutants (e.g., phenols from plastics, tributyltin leaching from ship hulls, and landfill leachates into groundwater and surface water)

Urban Runoff and Agricultural Activities. The primary sources of nonpoint source water pollution in the United States are urban runoff and agricultural activities. Pollutants include sediments from eroded or overgrazed lands, fertilizers, pesticides, and animal waste, which contains nutrients and bacteria. Excessive nutrients (forms of nitrogen and phosphorus) can be harmful to aquatic life because they stimulate the growth of algae and other plants and animals that may in turn deplete the supply of oxygen and trigger harmful algal blooms, red tides, and *Pfiesteria* outbreaks.

Various methods are being used to help reduce erosion, limit pesticide and fertilizer use, and reduce water contamination without decreasing agricultural productivity. The Natural Resources Conservation Service (NRCS), the EPA, and many state agencies are working to promote these methods and technologies, known as “best management practices,” mostly on a voluntary basis.

Development can also contribute to nonpoint source pollution. Land cleared of trees and plants for development has a reduced capacity to absorb water, therefore producing more and faster-flowing runoff. Runoff from land development projects can carry sediment and toxic materials. Runoff also increases in urban areas where rain water channels off rooftops and pavement rather than soaking into the ground.

Atmospheric Deposition. Pollution can enter the water from the atmosphere either as precipitation or in dry form. This type of nonpoint source pollution is particularly problematic in lakes throughout the northern and northeastern United States and Canada, as well as estuaries along the Atlantic and Gulf Coasts.

In many cases, atmospherically deposited pollutants have travelled substantial distances by wind currents. For instance, dichlorodiphenyl trichloroethane (DDT), polychlorinated biphenyls (PCBs), and heavy metals were found in Great Lakes precipitation in 1971 and on a remote island in Lake Superior, according to studies done for and by EPA and the International Joint

Commission. In some cases, DDT-tainted deposition traveled south-to-north across the entire United States from Mexico and Central and South America. Numerous studies indicate that 80 percent of the toxic chemicals entering Lake Superior result from atmospheric deposition rather than from water discharges. Along the Gulf Coast in Tampa Bay, 28 percent of total nitrogen loading enters bay waters directly through dryfall or precipitation.

"Acid precipitation" is the term used to refer specifically to wet atmospheric deposition—rain or snow containing significant amounts of sulfuric and nitric acid or other pollutants. Major sources include emissions from the combustion of fossil fuels used for transportation and the generation of electrical power.

Other atmospheric pollutants that may be deposited on surface water include organic substances, nutrients, pesticides, heavy metals, and radioactive residue, according to *Population and Water Resources* (see "Excessive Nutrients and Eutrophication" in this chapter). The 1987 United States-Canada Great Lakes Water Quality Agreement contains specific provisions on airborne toxic pollutants in an effort to better understand and allow for improved management of this problem.

Reducing Nonpoint Source Pollution. Progress in reducing nonpoint source pollution can be slow because nonpoint sources are more numerous and more difficult to identify than point sources. Traditional regulatory approaches used for direct discharges are not easily applied to nonpoint sources of pollution. Nonpoint source pollution, for the most part, results from how the land is used, and land-use management traditionally has been a function of local governments, with agriculture in many cases exempt from local control.

In 1987, Congress amended the CWA in an attempt to address the dichotomy between point and nonpoint source controls. Under the amendments, all 50 states have conducted assessments and prepared management programs to address nonpoint source pollution under their jurisdictions. However, these management programs are not required to implement or enforce measures to reduce nonpoint source pollution. In addition, Congress enacted the Coastal Zone Act Reauthorization Amendments of 1990, requiring states to develop coastal nonpoint source programs with regulatory mechanisms designed to reduce nonpoint source pollution of coastal waters.

Two general methods are used to reduce nonpoint source pollution: (1) reducing runoff by maintaining or increasing the ability of the land to retain water (e.g., decreasing disturbance of the land; increasing vegetation; protecting or restoring wetlands, soil, and nutrients; using natural channels and sedimentation ponds) and (2) minimizing the use of contaminating pollutants through product substitution or encouraging increased recycling and reuse of products (e.g., recycling used motor oil, better managing and controlling the application of pesticides and fertilizers).

Chemicals and Other Substances

Chemicals, pathogens, nutrients, and thermal pollution can affect marine ecosystems in different ways. Some examples of chemical and other toxic pollution in marine environments follow:

- ☐ Methyl mercury, a highly toxic form of mercury, has been found in large predatory fish, such as swordfish and tuna.
- ☐ Human carcinogens such as polycyclic aromatic hydrocarbons, petroleum hydrocarbons, dioxins, and PCBs have been found in seafood, leading to fishing bans in a number of cases.
- ☐ Forty-seven states, the District of Columbia, and the U.S. territory of American Samoa have issued consumption advisories for fish, bringing the United States advisory total to 2,193 in 1996. This is an increase of 26 percent from 1995 figures. The 1996 advisory listing applies to 100 percent of the Great Lakes waters and their connecting waters.
- ☐ In some areas, fish and shellfish have developed physiological and genetic defects, such as tumors in fish and chemical burns on lobster and crab shells.

- ❑ Areas on all of the U.S. coasts have been designated as Superfund sites because of high levels of water and sediment contamination.
- ❑ While PCB levels in the Hudson River have declined in recent years, striped bass from the Hudson are still considered unfit for human consumption because of PCB contamination.

Fish Advisories Online

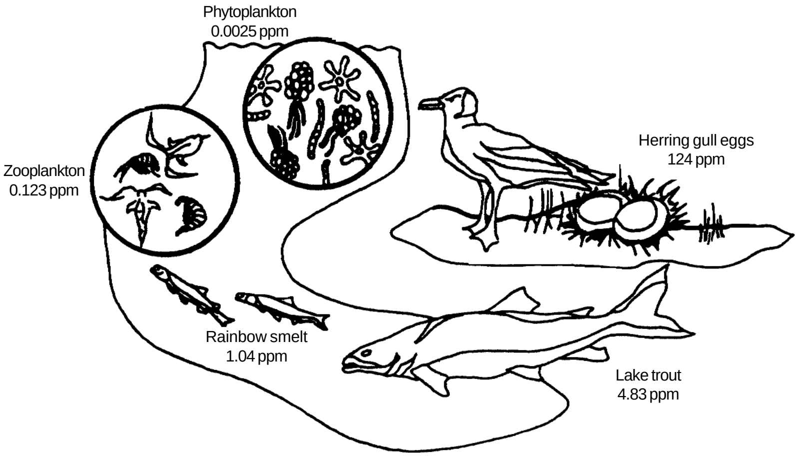
EPA's national listing of fish consumption advisories is available online at http://www.epa.gov/ost/fishadvice.

Chemicals. Chemical pollutants can threaten human and ecological health either directly or through bioaccumulation in and up the food chain. Certain chemicals can be particularly harmful—many pose risks even at very low concentrations and can remain potentially dangerous for long periods of time while they bioaccumulate in animal or human tissue.

According to data from the 1995 Toxics Release Inventory (TRI), more than 136 million pounds of toxic chemicals were released into U.S. surface waters in 1995. These chemicals include heavy metals and organic chemicals, some of which can be acutely poisonous to humans at low levels of exposure. The pollutants can settle to the bottom of water bodies, creating "hot spots" of contamination. Concentrations of contaminants gather in bottom-dwelling animals that work their way through the food chain, ultimately leading to human exposures (see figure 6). Although the TRI list includes high production volume chemicals, the list is limited to some 600 commercial chemicals. In addition, small firms and many nonmanufacturers are exempt from TRI reporting requirements.

The most severe problems are found in nonmigratory, bottom-feeding fish located around discharge points near urban and industrial areas. Shellfish, including oysters, mussels, and clams, remain in the same location throughout much of their lives and are

Figure 6
Bioaccumulation



Persistent organic chemicals, such as PCBs, can bioaccumulate. This diagram shows the degree of concentration in each level of the Great Lakes aquatic foodchain for PCBs in parts per million (ppm). The highest levels are reached in the eggs of fish-eating birds, such as herring gulls.

Source: Environment Canada and the U.S. Environmental Protection Agency 1987

especially vulnerable to contamination from toxic metals such as lead, mercury, cadmium, and chromium. Also of concern are long-lived, top-of-the-chain species, such as bluefish.

More than 350 different chemicals find their way into the Great Lakes alone, including PCBs, DDT, chlordane, and dieldrin, according to *Great Lakes, Great Legacy* published by the Conservation Foundation's Institute for Research on Public Policy. In 1990, EPA and Congress's General Accounting Office calculated that permitted industries alone were discharging 7.3 million gallons of oil and grease, 89,000 pounds of lead, 933 pounds of mercury, and 1,935 pounds of PCBs into the Great Lakes each year. The International Joint Commission (IJC) has identified 43 toxic hot spots in the Great Lakes. While paper mills built along the shores and tributaries of the Great Lakes have greatly reduced their discharges, they remain primary sources of mercury pollution.

Pathogens. Pathogens—substances that cause disease—can also contaminate fish and shellfish. The number of cases of illness linked to eating contaminated fish and shellfish remains a concern. The Centers for Disease Control and Prevention (CDC) documented 679 cases of shellfish-associated disease from 1988 through 1992. Many cases were caused by bacteria, resulting in intestinal irritation and illness. (Note that CDC surveillance data is typically underreported.)

Human exposures can occur not only from eating contaminated shellfish, but also from swimming or engaging in water contact sports in contaminated water bodies. High levels of bacteria in waters at various times have led to beach closures, particularly along the North Atlantic coast and the Great Lakes. Beach closures can be a community's worst economic nightmare when they occur during a prime tourist season. Table 5 shows the number of ocean and bay beach closures and advisories from 1992 through 1996, according to the Natural Resources Defense Council.

Pathogens can come from agriculture and urban runoff, malfunctioning septic tanks or sewage plants, or combined storm/sanitary sewer overflows that bypass treatment during storms. Overboard discharges from small or recreational boat toilets can also introduce pathogens into the waterways.

Sewage treatment plants built and upgraded with grants under the CWA have significantly improved the situation in many areas, including the Great Lakes and Chesapeake Bay. Journalist Tom Horton, author of *Turning the Tide*, reports that far fewer areas are closed to swimming than would have been the case without these improvements.

Excessive Nutrients and Eutrophication. Excessive nutrients also can threaten the coastal environment. These nutrients, primarily nitrogen and phosphorus, come mostly from agricultural and urban runoff, as well as sewage treatment plants. Soil erosion contributes to nutrient enrichment because some nutrients, such as phosphorus, attach to soil particles washed into the water. Nitrogen is water soluble, so it can reach groundwater that discharges to coastal

Table 5
Ocean, Bay, and Great Lakes Beach Closings and Advisories 1992–1996

State	1992	1993	1994	1995	1996	Notes
AL	—	—	—	—	—	No regular monitoring of ocean or bay beaches for swimmer safety
CA	609 +1 (p) +1 (e)	1,397[a] +2 (p) +2 (e)	at least 910 +6 (p) +2 (e)	at least 1,305 +11 (p) +3 (e)	at least 1054 +9 (p) +7 (e)	Limited monitoring of ocean/bay beaches for swimmer safety
CT	at least 223	at least 174	at least 156 +1 (e)	at least 251 +1 (e)	at least 196 +2 (e)	
DE	5	0	0	0	16	
FL	773[b] +1 (e)	101[c] + 1 (e)	at least 215	at least 830[d]	at least 174 +1 (p) +2 (e)	Limited monitoring of ocean/bay beaches for swimmer safety
GA	—	—	—	—	—	No regular monitoring of ocean/bay beaches for swimmer safety
HI	29	6	22	16	70	Limited monitoring of ocean/bay beaches for swimmer safety
IL	*	73	36	55	66	
IN	*	at least 30	36	14	34	
LA	1 (p)	1 (p)	1 (p)	1 (p)	1 (p)	No regular monitoring of ocean/bay beaches for swimmer safety (since 1988)
ME	at least 3 (p)	35 +3 (p)	at least 15 +3 (p)	at least 10 +3 (p)	at least 20 +3 (p)	Limited monitoring of ocean/bay beaches for swimmer safety
MD	at least 6 +3 (p) +2 (e)	at least 106 +3 (p) +1 (e)	82 +3 (p)	200 +3 (e)	at least 241 +3 (p)	Limited monitoring of ocean/bay beaches for swimmer safety
MA	at least 60	at least 61	at least 58 +1 (e)	at least 132 +1 (p)	at least 152 +2 (p)	Limited monitoring of ocean/bay beaches for swimmer safety
MI	*	*	26 +2 (p) +3 (e)	96 +3 (e)	at least 18 +2 (e)	Limited monitoring of Great Lakes beaches for swimmer safety
MN	*	0	0	0	0	Limited monitoring of Great Lakes beaches for swimmer safety
MS	—	—	—	—	—	No regular monitoring of ocean/bay beaches for swimmer safety (since 1989)
NH	0	0	0	0	0	

Table 5
Ocean, Bay, and Great Lakes Beach Closings and Advisories 1992–1996

State	1992	1993	1994	1995	1996	Notes
NJ	112	88	238	86	87	
NY	799[e] +1 (e)	at least 212[f] +1 (e)	227 +1 (e) +24 days restricted use	283 +3 (e)	219 +4 (e)	Limited monitoring of Great Lakes beaches for swimmer safety
NC	—	—	—	—	—	No regular monitoring of ocean/bay beaches for swimmer safety
OH	*	0	96	262 +3 (e)	119	
OR	—	—	—	—	—	No regular monitoring of ocean/bay beaches for swimmer safety
PA	*	19	14	10	6	Limited monitoring of Great Lakes beaches for swimmer safety
RI	0	0	0	0	0	Limited monitoring of ocean/bay beaches for swimmer safety
SC	—	—	—	—	—	No regular monitoring of ocean/bay beaches for swimmer safety
TX	1 medical advisory	42	0	0	0	Limited monitoring of ocean/bay beaches for swimmer safety (one local program)
VA	0	0	0	0	0	Limited monitoring of ocean/bay beaches for swimmer safety
WA	—	—	—	—	—	No regular monitoring of ocean/bay beaches for swimmer safety
WI	*	94	148	114 +1(e)	at least 120	Limited monitoring of Great Lakes beaches for swimmer safety

* No data were gathered by NRDC for this year.

(p) Permanent beach closure (12 or more weeks)

(e) Extended beach closure (6 to 12 weeks)

[a] This increase appears to result from 700 San Diego County closings/advisories because of heavy winter storms.

[b] Does not include closings due to Hurricane Andrew.

[c] The decrease in the number of Florida closings/advisories appears to result from significantly less rainfall in 1993 compared with 1992, particularly in Pasco and Dade Counties.

[d] Includes 465 closings due to Hurricane Opal.

[e] Included in this total are 706 rainfall advisories issued in New York City.

[f] The decrease in New York closings/advisories appears to result from less rainfall in 1993 compared with 1992 and a change in New York City's standing rainfall advisory, which covered fewer beaches for a shorter period of time.

Note: NRDC counts every day of an advisory/closure as one “beach closing.” Because of inconsistencies in monitoring and closing practices, comparisons between states and trends over time based on this data are difficult to compile.

Source: Natural Resources Defense Council (NRDC) 1997 environments. When this occurs, control measures are costly and time consuming.

Eutrophication is caused by an overabundance of nutrients, particularly nitrogen and phosphorus. The excessive amounts of nutrients lead to the growth of microscopic algae that decrease water clarity and, upon decay, deplete the oxygen dissolved in the water. Decreased water clarity can lead to the loss of seagrasses. Oxygen depletion may kill or restrict the growth of fish, shellfish, and other marine organisms (see "hypoxia" in this chapter). Eutrophication may also cause blooms of algae, known as "red tides" or "brown tides" (see "*Pfiesteria*" in the next section), which discolor the water or produce toxins that are harmful to marine organisms or humans.

In the Great Lakes basin, primary sewage treatment plants, phosphate detergents, industrial discharges of nitrogen and phosphorus, and fertilizers in runoff from farmlands have contributed to eutrophication in Lake Erie and Lake Ontario, as well as in the bays of Lake Huron and Lake Michigan. The overgrowth of algae, and resulting depletion of oxygen in the lakes, has killed numerous native fish species. At the same time, it has brought about an increase in more pollution-tolerant types of fish, shifting the balance of the lakes' ecosystems.

In 1972, Lake Erie was thought to be "dying" as a result of eutrophic conditions. The solution was to reduce incoming phosphate load. Phosphorus was found not only in agricultural runoff, but also in sewage treatment plant effluents, in discharges from factories located along the shores and tributaries, and household laundry detergents. Regulations, funding, and a concerted international effort since that time have significantly reduced Lake Erie's phosphate levels, and the area of eutrophication has stabilized. Construction of secondary treatment plants has slowed algae growth and reduced sewage and seaweed on the beaches, but the dead zone remains.

Excessive nutrients are particularly harmful to coral reef ecosystems found in southern waters such as those off the Florida

Keys and the Gulf of Mexico. Algae can smother the corals and reduce the strength of their calcium carbonate skeletons, which can be fatal to the coral.

Pfiesteria. In the early 1990s, North Carolina State University research botanist JoAnn Burkholder identified *Pfiesteria* as a potential cause of fish kills in North Carolina that began in 1991. In 1997, *Pfiesteria piscidida* began attracting national attention as a result of several outbreaks of fish lesions and fish kills in a number of tributaries to the Chesapeake Bay.

Pfiesteria is a toxic, single-celled marine organism classified as a dinoflagellate. Although neither plant nor animal, dinoflagellates are typically referred to as “algae” or “algae-like.” The organisms that cause red tides are also dinoflagellates. Proliferations of these and similar organisms are sometimes called “harmful algal blooms.”

Current research indicates that warm, shallow, calm, brackish water; the presence of large schools of fish; and high nutrient levels work together to trigger *Pfiesteria* to bloom in a form that produces toxins. These toxins in turn may cause ulcer-like lesions on fish and result in fish kills. Toxic *Pfiesteria* blooms tend to occur between late spring and early fall and last for only very short periods of time—often only a few hours.

NOAA and EPA are leading a national effort, coordinated with state and academic scientists, to develop short- and long-term research strategies on *Pfiesteria* and other harmful algal blooms. Although there is widespread belief that *Pfiesteria,* or a *Pfiesteria*-like organism, is responsible for fish kills and lesions in several Chesapeake Bay tributaries and in North Carolina, research is still underway to establish a clear, causal relationship and to determine what is responsible for *Pfiesteria* blooms. High nitrogen and phosphorus levels have been implicated in toxic outbreaks of

Additional Resources

Information on *Pfiesteria* is available from EPA online:
http://www.epa.gov/owow/estuaries/pfiesteria/index.html

Pfiesteria (evidence suggests that high levels of these nutrients are associated with other harmful algal blooms). According to EPA, the three most significant sources of nutrient pollution are human waste from septic systems or sewage treatment plants, agricultural runoff from fertilizer or animal waste, and air deposition from such sources as utility plants and motor vehicles. Human health effects (such as skin lesions, memory loss, headaches, and dizziness) have also been reported as a result of exposure to *Pfiesteria*-contaminated water, and research in this area is in progress. Thus far, there have been no reports of human illness resulting from consumption of fish exposed to *Pfiesteria*.

Hypoxic Waters and the "Dead Zone"

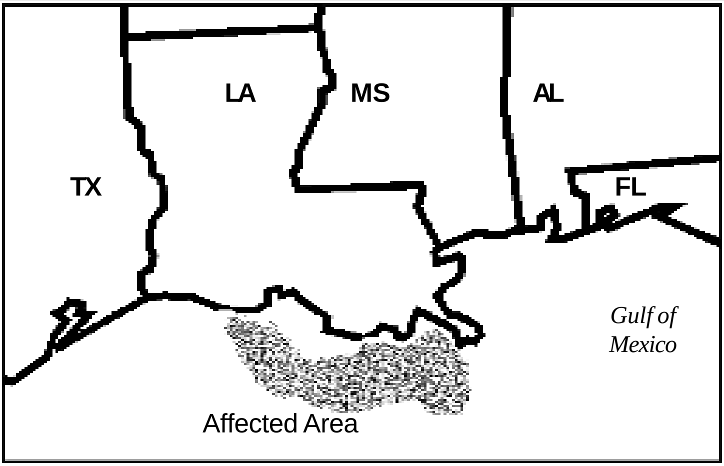
The terms "hypoxia" and "hypoxic waters" refer to waters with concentrations of less than two parts per million of dissolved oxygen, which is generally accepted as the minimum level required to support most animal life and reproduction. Oxygen depletion typically occurs in bottom waters, but can extend above them. Hypoxia is found in several large U.S. estuaries, including the Chesapeake Bay and Long Island Sound.

Hypoxic waters occur near the mouths of a number of large rivers around the world. An area in the northern Gulf of Mexico, on the inner continental shelf off the coast of Louisiana, constitutes one of the largest zones of oxygen-deficient bottom waters in the western Atlantic Ocean. According to EPA, this zone of hypoxic waters covers an area of up to 7,000 square miles during part of the year, mainly in the summer (see figure 7). This area of oxygen depletion is often called the "dead zone." From as early as February through as late as October, this zone may lack sufficient oxygen to support normal populations of fish and shellfish.

Additional Resources

Information from EPA's Office of Water and the Gulf of Mexico Program Office is available online: EPA at http://www.epa.gov/owow, and the Gulf of Mexico Program at http://pelican.gmpo.gov.

Figure 7
Hypoxic Waters in the Gulf of Mexico



Source: U.S. Department of Agriculture 1997

The causes of oxygen depletion in the northern Gulf of Mexico are complex, but current research identifies excess nutrients in the Mississippi River system as a contributing factor. A number of states along the Mississippi River add to its nutrient level through nitrogen and phosphorus runoff from fertilizers, animal manure, decaying plants, and other wastes. Other runoff sources include industrial and municipal point sources and air deposition. Appropriate levels of nutrients help water systems grow, but excess levels bolster the production of algae, creating algal blooms. As these blooms decompose, they consume nearly all the oxygen in the water.

Along the Gulf Coast the primary focus for addressing the hypoxia issue is on the importance of the nutrient contributions of the Mississippi and Atchafalya River systems. These rivers contribute 90 percent of the freshwater inflow to the Gulf of Mexico and drain the country’s industrial and agricultural heartland. According to studies by the U.S. Geological Survey, concentrations of nitrates in water discharged to the Gulf have increased threefold since the 1960s. This increase in nutrient load appears to be related to the increase in the size of the hypoxia area.

Concern about the “dead zone” is both environmental and economic. Approximately 40 percent of U.S. fisheries landings, including a substantial part of the nation’s most valuable fishery (shrimp), comes from this area. In 1995, the Sierra Club Legal Defense Fund (now Earthjustice), representing environmental and fishing organizations, petitioned EPA and Louisiana to address nonpoint source pollution in the Mississippi River.

According to New Orleans *Times-Picayune* reporter Mark Schleifstein in the 1997 Pulitzer Prize-winning series “Oceans of Trouble: The Dead Sea,” solutions to the dead zone may be “simple … but … politically impossible.” Among the potential solutions cited, some would likely require dramatic land-use changes in the Midwest:

- ☐ Creating a buffer of grass between fields and streams that will filter much of the nutrients before they reach the water
- ☐ Using farming methods that rely less on chemical fertilizers and pesticides, either through no-till farming or with new, satellite-based, computerized crop systems that measure the need for fertilizer more accurately
- ☐ Building wetlands at strategic points along the paths of agricultural runoff ditches to capture and treat fertilizer runoff

EPA’s Office of Water is developing partnerships with the agricultural community and others to alleviate hypoxia. National efforts are headed up by EPA and the Gulf of Mexico Program Office, a consortium of five Gulf Coast states, the U.S. Department of Agriculture, numerous public and private organizations, and 18 federal agencies, whose purpose is to develop voluntary, incentive-based strategies for protecting the Gulf of Mexico ecosystem. The group is expanding to include representation from states and tribes in the Mississippi River watershed. The national strategy focuses on (1) improving the understanding and characterization of the problem, (2) reducing the inputs of nitrogen and phosphorus to the surface water of the Mississippi River basin, and (3) developing efforts to prevent and reduce significant air and wastewater pollution sources.

Heated (Thermal) Water

Temperature is one of the most important environmental variables affecting aquatic life. Thermal pollution is the discharge of water sufficiently warm to harm aquatic life. If water temperatures rise too high, dissolved oxygen levels drop, directly threatening aquatic life and contributing to eutrophication. This process makes the water unusable for drinking and recreation, according to the National Audubon Society's *Population and Water Resources*.

Electric generating plants, which use large quantities of water for cooling, draw water from lakes, rivers, or the ocean and pump it through condensers at the plants before returning the water to its source. When the water is discharged, it is sometimes as much as 10 degrees Celsius (18 degrees Fahrenheit) warmer than the source waters. To minimize thermal pollution, most plants are now regulated to control the temperatures of discharged effluent. Cooling towers are used extensively to cool the heated water prior to returning it to the original waterbody.

Heated water from electric generating plants is not the sole source of thermal pollution. Urban runoff can be heated as it passes over highways, pavements, and buildings. This runoff can significantly increase the temperature of the bodies of water into which it flows.

Habitat Loss

Diversity of species is often greatest where two ecosystems meet. Changes in the balance of freshwater and saltwater in coastal ecosystems can lead to the loss of species sensitive to this balance. For example, if a barrier island becomes eroded, the tidal action can increase, raising the salinity levels in wetlands behind the island. The increased salinity can kill plants and destroy wetlands.

Wetlands

According to the Department of the Interior's Fish and Wildlife Service (FWS), the contiguous 48 states lost 52 percent of their wetlands between the 1780s and 1980s (see figure 8). In the 1700s an estimated 221 million acres of wetlands existed in the lower 48 states. In 1995, approximately 100.9 million acres of wetlands existed in the contiguous 48 states. Of that amount, 95 percent were inland, freshwater wetlands, and 5 percent were coastal or estuarine wetlands.

In a preliminary study released in 1997, the FWS examined wetlands trends from 1985 to 1995. The findings showed that while wetland acreage continues to drop, it is dropping at a slower rate than previously. The average annual net loss of wetlands between 1985 and 1995 was 117,000 acres. This rate of loss is 60 percent lower than the rate of loss reported between the mid-1970s and the mid-1980s.

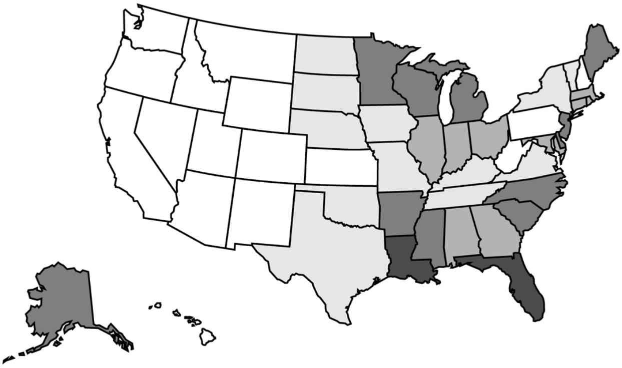
Both natural events and human activities contribute to coastal habitat loss and degradation (see table 6). Natural threats to wetlands include the following:

- ❑ Erosion
- ❑ Subsidence
- ❑ Sea level rise
- ❑ Droughts
- ❑ Hurricanes and other storms
- ❑ Overgrazing by wildlife

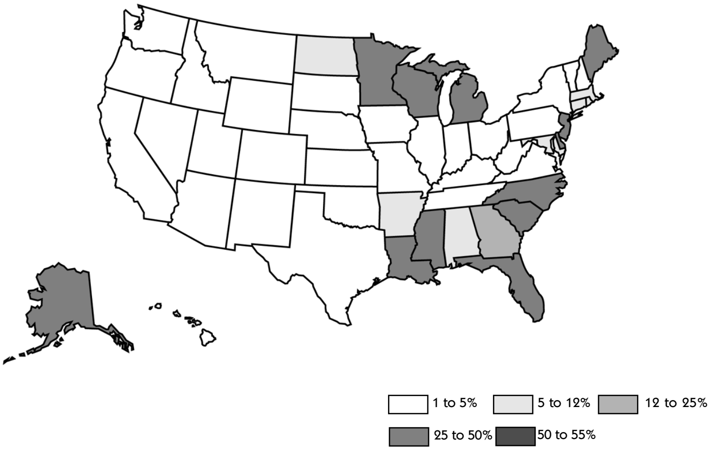
Human activities exacerbate or accelerate nearly of all these natural processes. Coastal wetland loss has resulted from human activities such as oil and gas exploration and river channelization that accelerate natural processes. Forested wetlands, inland

Figure 8
Percentage of U.S. Wetlands Present in the United States (1780s and the 1980s)

Wetland Distribution Circa 1780s



Wetland Distribution Circa 1980s



Source: U.S. Government Accounting Office 1991

marshes, and wet meadows that have been drained for agricultural uses cannot effectively respond to the natural processes and are damaged further.

Much of the coastal wetland loss has resulted from development. In addition, many coastal marshes in Louisiana have been

Table 6
Types of Wetlands Alteration

Physical

Clearing—removing vegetation by burning, cutting, and so forth
Diverting sediment—trapping sediment and inhibiting regeneration of wetlands
Diverting water—preventing water from entering the wetland (e.g., diking, damming), or adding more than normal amounts of water to a wetland
Draining—removing the water by ditching, tilling, pumping, and so forth.
Excavating—dredging and removing soil from wetlands
Filling—adding material to change the bottom level or replace with dry land
Flooding—raising water levels by damming or channeling water
Shading—placing platforms or bridges over wetlands, killing vegetation
Adjacent area activities—disrupting interaction between a wetland and an adjacent area

Chemical

Metals—increasing or decreasing metal levels in the local water or soil system
Nutrient levels—increasing or decreasing nutrient levels in the local water or soil system
pH—increasing or decreasing the acidity of water (e.g., acid mine drainage)
Toxics—adding toxic compounds to a wetland (intentional, such as herbicide treatment, or unintentional, such as oil from cars or spills)

Biological

Disrupting natural populations—reducing populations of existing species, introducing exotic species, or otherwise disturbing resident organisms
Grazing—consumption of, compaction of, and damage to vegetation by domestic or wild animals

submerged by rising Gulf of Mexico waters, land subsidence, and shoreline erosion. Over the past 25 years, Louisiana, which has more than 40 percent of the wetlands in the continental United States, lost valuable coastal wetlands at rates between 30 and 50 square miles per year. The Southeast region as a whole sustained a loss of 60,500 acres per year from 1985 to 1995.

While the wetlands losses are most severe in the Southeast (55 percent of the total loss from 1985 to 1995), the FWS’s 1997 report showed that the Northeast lost 22,800 acres per year (20 percent). West of the Mississippi, the losses are 34,100 acres per year (29 percent). In the last 200 years, California has lost 91 percent of its wetlands, and Connecticut has lost more than half of its coastal wetlands.

Other Coastal Habitats

Other coastal habitats have also been damaged. For example, the Chesapeake Bay watershed has only 10 percent of the submerged aquatic vegetation (SAV) or sea grasses that existed several decades ago. Tampa Bay had lost 80 percent of its original SAV by 1982. Activities that increase water turbidity—such as dredging, runoff, and increased nutrient loading—can have devastating effects on the seagrasses. About 150,000 acres (23 percent) of Florida's mangrove forests have been lost, and the coral reefs and barrier beaches have sustained serious damage.

Tidal flats, a major resource of the middle and lower Texas coastal zone, serve as a foraging area for wading birds and export nutrients to other estuarine habitats. However, tidal flats continue to be developed and destroyed.

Oyster reefs in the Gulf of Mexico, which provide a number of ecological and environmental benefits, are being threatened by point and nonpoint source pollution, as well as a lack of nutrients resulting from the construction of dams and reservoirs. Previously, oyster dredging depleted stocks severely.

Many barrier islands, unique habitats for a variety of plants and animals and protection for coastal mainland, are being overdeveloped.

Dredging and disposing of dredged material can also affect ocean life, altering the habitat of bottom-dwelling and marine plants. Dredging for navigation in harbors and inlets also removes sediment and can interfere with longshore movement of beach materials. Dredging in adjacent freshwater or brackish wetlands to create canals for navigation, pipeline installation, and drainage opens the way for saltwater intrusion and other hydrologic effects during storms and high tides.

In coastal Louisiana, the increased salinity associated with dredging for navigation and pipeline installation (as well as other effects from these activities) has damaged wetlands and accelerated land loss. In some areas where dramatic wetlands loss has occurred, clean dredged material has been used as a beneficial source of sediment to restore wetlands and other habitats. When the sediment is contaminated, however, toxins can bioaccumulate in fish and shellfish and pass up the food chain.

Dams, stream channels, and other hydromodification projects can also alter habitats by changing water flow or increasing sediment deposits. *Population and Water Resources* states that in coastal areas, where freshwater and saltwater meet and mix, any alteration of the coastal water system can damage the freshwater system by decreasing the amount of freshwater, transferring pollution, or increasing salinity.

Coastal Hazards

Increasing population and development have left coastal areas more vulnerable to a variety of hazards, including coastal storms, chronic erosion, and potential sea-level rise. Twenty-five percent of the 95,000 miles of United States coastline is experiencing significant chronic erosion. Storms are a primary cause of erosion along many coasts. Storms often bring strong winds and large waves, raising water levels as much as seven meters above normal, according to *Coasts in Crisis*.

The development of coastal areas can not only increase the risk to human life, but can also create a substantial financial risk. The federal government’s flood insurance program poses inestimable tax liabilities in the future to compensate for land and property damages brought about by coastal hurricanes, storms, erosion, flooding, or other hazards.

In many coastal areas, much of the sediment that maintains the coast is supplied by upstream rivers. Dams built for flood control and water catchment along these rivers inhibit the flow of sediment to the coastal area. Lacking the sediment, the coastal areas erode more quickly. Some areas of the Gulf of Mexico coast are eroding at a rate of 100 feet per year, according to EPA.

For example, the amount of sediment carried by the Mississippi River has declined by one-half, exacerbating the deterioration of Louisiana's wetlands. The U.S. Army Corps of Engineers is working to counteract wetlands loss by building structures to divert sediment-laden freshwater from the Mississippi to adjacent wetlands, reports the U.S. Geological Survey in *Coasts in Crisis*.

Increased sediment from erosion of stream banks also can cause problems—smothering aquatic plant life, clogging fish gills, and cutting off essential light to underwater plants. Stream bank erosion is typical in developed areas where pavement, compacted soil, and other nonpermeable surfaces prevent water infiltration and result in increased water and sediment runoff.

Sediment from soil erosion in tropical areas can be particularly harmful to reefs. The increased sedimentation "adversely affects the structure and function of reefs by smothering coral colonies and reducing the light available for photosynthesis by corals and algae," according to Caroline Rogers of the National Park Service.

In sandy beach areas, destruction of dune grasses and compaction and alteration of dunes can increase wind velocities, tidal erosion, and the movement of beach materials. The result leaves the coastal area more vulnerable to storm damages. Increased sediment movement can also destroy breeding grounds for fish and require additional dredging of existing navigation channels.

Some areas—such as Cape May, New Jersey—have attempted to halt the natural drift of sand with jetties built out into the water. The beach expands on the updrift side of the jetty, while the downdrift side loses sand. However, jetties have become controversial because of concerns that they may actually increase coastal erosion.

Other areas have attempted to reduce coastal erosion by directly replenishing beach materials with sand brought in from

Coastal Property Rights

Issues surrounding individual property owners' rights on coastal properties are controversial, emotional, and frequently highly politicized. On the last day of its term in June 1992, the U.S. Supreme Court handed down a much anticipated decision in a case expected to influence public and private land-use issues well into the next century. While the *Lucas v. South Carolina Coastal Council* decision stands, its effect has been more limited than predicted in the early 1990s.

The case involves a Fifth Amendment takings challenge to the South Carolina Beachfront Management Act. Landowner David H. Lucas argued that in being forbidden to build permanent, habitable structures on his coastal lots, he had been deprived of the full economic value of his property. The state maintained that such buildings would lead to increased beach erosion. While a trial court awarded Lucas compensation for the taking, the South Carolina Supreme Court sided with the state's Coastal Council and ruled that the action under the state law did not constitute a compensable taking of Lucas's property.

But by a 6-2-1 majority, the U.S. Supreme Court reversed the South Carolina Supreme Court ruling. The majority decision, written by Justice Antonin Scalia, was "narrowly confined …, involving an alleged total deprivation of economic value," Rutherford H. Platt, University of Massachusetts geography professor and lawyer, wrote in the September–October 1992 issue of *The Environmental Forum*.

Platt, the author of *Land Use Control: Geography, Law, and Public Policy* (1991), wrote that the *Lucas* decision established a new standard "whereby the loss of all economic value due to public regulation will only be permitted if 'background principles of nuisance and property law' would have led to the same result." That approach "certainly invites landowner challenges to public land-use regulations of many types." Platt predicted that the holding would lead to more litigation over the terms "total economic value" and "background nuisance principles."

"If read carefully, *Lucas* need not be considered devastating either to coastal erosion management laws or to broader environmental regulatory programs such as wetlands, historic preservation, and growth management," Platt wrote in 1992. "However, its impact will not be limited to its fairly narrow area of application—'total takings.'"

In the nearly six years since the Supreme Court case, few decisions have expanded the Lucas decision. While the property rights issue likely will remain part of the political landscape in the future, in his 1996 book, *Land Use and Society: Geography, Law, and Public Policy*, Platt said that efforts to use the ruling "as a club to intimidate public officials seem to be losing credibility in the absence of many later decisions that follow or expand upon the *Lucas* decision."

elsewhere. The success of beach replenishment has been mixed. In the late 1970s, $64 million was spent to replenish Miami Beach. While not intended as a long-term solution, the Miami Beach restoration lasted more than a decade. Many replenished beaches endure only a briefer time—one-half of the replenished beaches on the East Coast lasted less than two years, according to *Coasts in Crisis*.

As with other threats to U.S. coastal and marine resources, the potential for harm is by no means restricted to the Atlantic and Pacific seaboards. The level of the Great Lakes varies significantly over short-term, seasonal, and long-term periods as a result of natural forces. The causes of the variations include annual changes in precipitation and runoff, long-term changes in precipitation and temperature, and short-term changes in winds. While wave and tidal action is generally limited in lakes, storm surges can quickly raise the lake water level and inflict considerable damage. Chicago's Lake Michigan shoreline contains many badly deteriorated structures built to protect the city from flooding after severe flood damages had occurred.

Concerns about flooding and erosion have led to many long-term IJC studies on managing levels and flows, diversion, and consumptive use. In the Great Lakes, the IJC is responsible for the levels and flows of the lakes, separate from its responsibility for water quality. The only regulation of water flow and lake level, designed to facilitate shipping, occurs on the St. Mary and St. Lawrence Rivers under the auspices of the IJC. Water is diverted at Niagara Falls for hydropower and then returned to the river, affecting the flow over Niagara Falls. Many experts say the effect of these controls is minimal compared to natural fluctuations.

Diversions—transfers of water from one watershed to another—were found to have little long-term effect on lake levels. Consumptive use—water that is withdrawn for use and not returned—was thought to have a negligible effect on the Great Lakes system because of its large size. According to the IJC study cited in *The Great Lakes: An Environmental Atlas and Resource*

Book, climate and weather changes affect the lake levels more than any human-made diversions or consumptive uses, especially if current trends are sustained.

The *Atlas* cites a 1993 IJC study that concluded that "the cost of major engineering works to further regulate the levels and flows of the Great Lakes and St. Lawrence River would exceed the benefits provided and would have negative environmental impacts." The alternative suggested by the IJC was coordinated land use and shoreline management programs that would apply to the entire Great Lakes basin. The programs would be designed to mitigate any further damages from floods and erosion.

Marine and Beach Debris

In addition to aesthetic harm to coastal areas, debris in marine environments directly affects fish and wildlife, commercial and recreational fishers, recreational boaters, marine merchants, and recreational users of coastal beaches. Wildlife can ingest debris or become entangled in it, either of which can be fatal. Of particular concern are plastics, such as monofilament fishing line, fishing nets, pellets, plastic bags, and balloons.

The increasing use of plastics for consumer and industrial products and processes has led to an increase in plastic debris in the ocean. According to the Center for Marine Conservation's (CMC's) *Citizen's Guide to Plastics in the Ocean*, "no one knows just how much plastic is out there." Plastic items are now the most common human-made objects sighted at sea, according to CMC.

The same characteristics that make plastic so useful—lightness, durability, and strength—also make it particularly harmful when disposed of improperly in the coastal or marine environment. Common types of marine debris include the following:

- ☐ Fishing gear (nets, lines, traps)
- ☐ Plastic strapping used in shipping

- Petroleum industry plastics, including hard hats and “write-enable” rings (plastic rings used to protect tapes used during seismic recording and other computer-related activities)
- Plastic pellets (the raw form of plastic before it is melted down for consumer goods)
- Sewage-associated plastic, including tampons, condoms, and disposable diapers
- Plastic bags
- Six-pack holder rings
- Domestic plastics (e.g., plastic utensils and polystyrene cups)

The image of a shore bird or sea turtle entangled in a six-pack holder has become a well-recognized symbol of the problem. Plastic nets, lines, and strapping can also trap and entangle wildlife (such as marine and terrestrial birds, mammals, and marine and freshwater fish), exhausting or suffocating them.

Sea turtles sometimes eat plastic bags, mistaking them for their favorite food, jellyfish. When ingested, plastics can damage an animal’s stomach lining or inhibit the animal’s hunger sensation and thus its hunger drive. Ingested plastic can also block the intestinal passages.

Plastic debris also affects commercial and recreational activities. In the Gulf of Mexico, concerns have been raised about plastic sheeting caught in fishing nets, disrupting fishing activity. Nets, lines, ropes, and plastic sheeting can ensnare vessels and entangle scuba divers. Plastic bags can also clog cooling-water intakes on boats, causing engine failures.

Water-based sources of marine debris include the following:

- Recreational fishing and boating wastes, such as fishing lines, floats, and lures
- Commercial fishing wastes, such as plastic rope, plastic light sticks, fishing nets, wood and metal fish and crab traps

- Barges carrying garbage to coastal landfills (lightweight litter can be blown off the barge decks and into the water)
- Operational wastes from merchant shipping vessels, such as plastic strapping bands and plastic sheeting
- Offshore petroleum activities, specifically garbage from oil drilling rigs and production platforms
- Galley-type wastes, such as egg cartons and bleach bottles, assumed to originate in ships' galleys
- Passenger cruise lines, which disposed of an estimated 62 million pounds of garbage into the sea each year prior to 1987 (new restrictions for plastic garbage have been in place since then; see chapter 5 for a description of the International Convention for the Prevention of Pollution from Ships)
- Military ships and vessels, which prior to 1987 could legally dispose of wastes overboard (see chapter 5 for a description of the International Convention for the Prevention of Pollution from Ships)

Land-based sources of marine debris include the following:

- Sewage-associated wastes, both from sewage treatment and from combined sewer overflow during heavy rainfall
- Plastics manufacturing and processing, including plastic pellets
- Litter from streets or sidewalks that is washed into storm sewers during rains and released into waterways
- Litter left on beaches by the general population (in Los Angeles County alone, for instance, beachgoers typically leave behind approximately 75 tons of trash a week)
- Trash carried by stormwater into rivers, lakes, and coastal waters

In 1988, CMC organized an annual nationwide beach cleanup project. The project is now an international event and takes place the third Saturday in September. In 1996, 277,710 volunteers representing 93 countries, including 55 U.S. territories and states, participated in the effort. CMC reported that 4,890,914 pounds of debris were removed from 9,128 miles of beach and coastline during the 1996 event. The beach cleanup has both practical and symbolic value, because it actively involves thousands of individuals in an environmental project that can have a lasting effect on those participants.

In the 1996 event, plastic was the most abundant material, accounting for almost 61 percent of all trash. While the single most numerous item collected was cigarette filters, they did not account for a large percentage of debris volume. Glass and paper each accounted for 10 percent of the debris volume; metal accounted for 11 percent; and rubber, wood, and cloth accounted for 3 percent. Because many types of items are in general use, identifying the debris source is difficult, although in some cases types of sources or even specific sources were identified.

Oil Spills

Although oil spills from ships account for only 5 percent of the oil in the oceans, spills can cause major short-term damage to marine and coastal environments. Petroleum hydrocarbons at sufficient concentrations are toxic to a wide variety of marine organisms. In addition to fouling shorelines and killing wildlife, petroleum hydrocarbons can reduce growth, alter feeding behavior, and lower reproductive success of marine life, according to the Natural Resources Defense Council's *Ebb Tide for Pollution*.

From 1973 to 1993, most oil spill incidents occurred in rivers and canals, according to the U.S. Coast Guard pollution incident report. Pipelines were the most frequent spill source; however, tankships spilled the largest volume of oil into the environment. Crude oil was the most frequently spilled oil cargo and accounted for the largest oil spill volume. In general, 95 percent of reported spills are smaller than 1,000 gallons and constitute only 5 percent of the spill volume. The remaining 5 percent of reported spills account for 95 percent of the spill volume. By nearly every measure, the volume of oil spilled in U.S. coastal waters has steadily declined from 1973 to 1993. In 1993, 8,972 reported oil spills dispersed 2,067,388 gallons of oil into the waters of the United States. The volume of oil spilled into the environment has declined in large part because of regulatory changes resulting from periodic spill disasters, such as the *Exxon Valdez*.

The March 1989 *Exxon Valdez* grounding in Alaska's Prince William Sound was the largest spill (10.8 million gallons, or 257,000 barrels) in U.S. history and unquestionably one of the most widely reported environmental disasters ever, both domestically and internationally. According to the Alaska Department of Environmental Conservation, the spill covered more than 1,240 miles of shoreline. More than 980 sea otters, 135 bald eagles, and 33,000 seabirds were found dead as a result of the spill. Some estimates put the number of birds that died because of the spill at more than 500,000.

Such spills have occurred worldwide at the rate of three to five per year since 1967, according to the U.S. Congress's Office of Technology Assessment. Iraqi President Saddam Hussein's 1991 intentional oil spills during the Persian Gulf War were the largest in history, an estimated 6 million barrels of oil, 23 times the amount from the *Exxon Valdez*. The Persian Gulf spill, covering about 600 square miles of water and blackening about 300 miles of shoreline, is seen as the first extensive and deliberate use of environmental terrorism as part of a war strategy.

Varied methods are used to combat oil spills, but a common lesson learned from most spills is that the best strategy is to avoid the spill in the first place. Once sizable amounts of oil are spilled into the marine environment, cleanups are inevitably difficult.

Mechanical spill cleanups, involving containment booms and oil recovery skimmers, are the primary U.S. oil spill response methods. Dispersants also are used, although concerns have been raised about their potential toxicity and their overall effectiveness.

An Office of Technology Assessment report, *Coping with an Oiled Sea*, found that cleanup efforts recovered less than 10 percent of the oil discharged in large ocean tanker spills. The report states that contingency plans have often been found to be ineffective in big spills. In fact, recent experiences with major spills in coastal areas is showing that cleanup activities sometimes can prove more harmful than not cleaning up, according to David Kennedy of the NOAA's Hazardous Materials Division. The image of Exxon company employees and contractors washing rocks after the Valdez spill may be convincing on the national evening news, but serious doubts arise over whether such high-publicity steps actually help or hurt the environment in the long run. (About 12 percent of the oil from the *Exxon Valdez* spill eventually was recovered, about 30 percent eventually evaporated, and more than half remains in the environment, according to the Alaska Department of Environmental Conservation.)

To help prevent oil spills, the 1990 Oil Pollution Act, enacted in response to the *Exxon Valdez* spill, requires double hulls on oil tankers, but calls for a 25-year phase-in period. Although the benefits of double hulls are widely recognized, some naval engineers fear double-hulled ships are more vulnerable to capsizing. As with other environmental issues, trade-offs may arise, and double-hulled ships are by no means "invincible." For instance, on 5 December 1992, a double-hulled Greek tanker, the *Aegean Sea*, ran aground off the coast of La Coruma, Spain, damaging more than 60 miles of rocky coastline with a crude oil slick reportedly covering some 19 square miles.

Not all oil spills into the marine environment inflict permanent or serious environmental damage. The 1990 *Mega Borg* spill of some 5 million gallons of light crude oil in the Gulf of Mexico, for instance, is believed to have avoided causing major damage because of a variety of factors: temperature and ocean current conditions, the nature of the crude oil itself, and the ability of spill response teams to limit the amount of oil that actually reached the shoreline and the most vulnerable areas and species.

The effects of an oil spill and the success of cleanup efforts depend on the characteristics of the water and land nearby, as well as weather conditions. In some cases, luck—good or bad—plays the prominent role in determining the severity of a spill. The shallower the water, the greater the likelihood of damage to life on the bottom. High winds and ocean currents can spread oil faster and impede cleanup efforts. Tidal mud flats and shallow grass beds are especially difficult to clean up. The time of day a spill occurs also can be important, because adequate sunlight and good visibility increase the effectiveness of response efforts.

Smaller, routine, and nonaccidental disposals, on land and in the water, can be as damaging as large spills. Though newspapers carry few headlines or stories about the 180 million gallons per year of used motor oil dumped in sewer drains or landfills by do-it-yourself mechanics, Americans dispose of more oil from their crankcases each year than was spilled by the *Exxon Valdez*.

None of this discussion is intended to minimize or downplay the potential environmental harm that can result from oil spills into the marine environment. Instead, its purpose is to illustrate the need to examine each incident and its effects individually, mindful of the wide array of factors that can either mitigate or exacerbate the environmental effects.

Offshore drilling operations can also cause coastal pollution through the disposal of wastes, which are mostly made up of drilling muds. The drilling muds, which lubricate the drill bit and maintain downhole pressure, sometimes contain toxic chemicals. The Natural Resources Defense Council has estimated that each offshore drilling can lead to the discharge of some 1,500 to 2,000 tons of drilling muds and cuttings into surrounding waters. These discharges are subject to regulation under the CWA.

Global Climate Change

Global climate change refers to climatic changes resulting from the buildup of greenhouse gases and stratospheric ozone depletors such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (CFCs). While the environmental effects of global climate change are uncertain, climate changes inevitably will influence the global water cycle.

The buildup of greenhouse gases results primarily from a 25 percent increase in the total amount of atmospheric carbon dioxide since the beginning of the Industrial Revolution. Carbon dioxide comes from burning fossil fuels (coals, oil, and gas) and destroying forests. Deforestation releases carbon dioxide whether the trees are burned or left to rot. Deforestation also destroys a primary source of carbon dioxide absorption and oxygen production—the trees' leaves. Increases in methane concentrations have resulted in part from increased wetland cultivation of rice and from increased livestock rearing. CFCs—manufactured chemicals used in refrigeration, air conditioners, foam, and insulation, as well as solvents and cleaners in electronics manufacturing—make up about one-quarter of the pollutants responsible for the Earth's greenhouse effect, according to the NOAA. Internationally, the use of CFCs in electronics has now been phased out.

Potential consequences of a warming Earth include a rise in sea level resulting from melting polar ice caps and thermal expansion of ocean waters. A sea-level rise could cause coastal flooding, which would erode shorelines; destroy some coastal urban areas and much of the remaining wetlands; increase salinity of rivers, bays, and groundwater; and substantially lower the Great Lakes because of increased evaporation. An increase in severe storms, which some speculate to be an effect of global warming, would exacerbate coastal flooding. Precipitation patterns would change as a result of changes in the water cycle. Some areas with limited freshwater supplies (e.g., California) may receive less precipitation, further decreasing the crucial supply of freshwater to estuaries. Other areas may receive more precipitation, resulting in increased runoff, decreased estuarine salinity, and increased delivery of nutrients from nonpoint sources.

Along much of the U.S. coast, a one-foot rise in sea level could cause the erosion of up to 2,000 feet of beach. The cost of protecting beaches and coastal structures along the Atlantic coast alone has been estimated at $10 billion to $100 billion.

Overfishing

The Magnuson-Stevens Fishery Conservation and Management Act, as amended in 1996, defines overfishing as “a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.” Overfishing has biological and environmental, as well as economic and social, implications. A summary report from a 1991 Smithsonian Institution conference on oceans noted that “because of their integral roles in marine food webs, drastic fluctuations in fish populations will have reverberations throughout marine ecosystems.” Overfishing of oysters, for example, can harm water quality because oysters play an important role in filtering and cleaning water.

According to a September 1997 report to Congress by the National Marine Fisheries Service (NMFS), 86 of the 279 fish species that have been assessed are classified as overfished. Magnuson-Stevens provides for conservation and management of fishery resources within the U.S. exclusive economic zone (EEZ), as well as fishery management authority over continental shelf resources and some migratory species beyond the EEZ. This authority does not apply within a foreign nation’s territorial sea or recognized fishery conservation zone.

Overfishing is most severe along the New England and Pacific coasts (the Pacific jurisdiction includes Hawaii and Guam). Among the 86 overfished species are cod, some flounder, Atlantic swordfish, Atlantic sea scallops, American lobster, and many southeastern U.S. snappers and groupers. Of the remaining assessed stocks, 183 species are not considered overfished, and 10 species are approaching overfished status. The status of 448 species is unknown, and those species may not be surveyed because of their low commercial value. Under the 1996 Magnuson-Stevens amendments, NMFS must report annually to Congress on the status of U.S. fisheries. In addition to continually evaluating fisheries, the amendments call for efforts to rebuild fisheries, including creating regional "essential fish habitats," which are the waters and environment needed to ensure that fish spawn, breed, feed, and grow to maturity.

Depleted fisheries stocks result in significant losses of productivity, jobs, and recreational fishing opportunities. NMFS estimates that rebuilding the nation's overfished fisheries and efficiently managing the nation's living marine resources could substantially benefit commercial fishing, as well as provide many new jobs. Similar economic benefits, and countless hours of fishing pleasure, would also be generated in the recreational fishing sector.

Another issue that contributes to overexploitation and economic loss is incidental capture, or bycatch, of species in the course of commercial fishing. Bycatch affects almost all U.S. fisheries to some extent, but it is especially severe in trawl fisheries. Bycatch in other fisheries can undermine the management of many stocks, including the recovery of protected species of marine mammals and sea turtles. The recovery of depleted reef fishes in the Gulf of Mexico, for example, may be slowed or prevented by bycatch of young reef fish by shrimpers. Finding a management scheme that allows full use of productive species while protecting other species from incidental capture is a significant challenge.

Technological advances have also contributed to overfishing. Throughout the 1980s and 1990s, commercial and recreational fishers have benefited from a tremendous increase in the availability of improved technology, including sonar, radar, computerized navigational devices, better boats and engines, and electronic fish finders. As a result of these improvements, pressures on fishery resources have increased at a faster rate than the numerical increase in boats and fishers might suggest.

Although overfishing clearly remains a problem, some efforts are under way to address it. The NMFS Office of Science and Technology is, for example, evaluating the distressed red snapper fishery in the Gulf of Mexico. A special review panel has been formed to examine the red snapper stock to protect it from commercial and recreational overfishing, reduce bycatch of red snapper by Gulf shrimpers, and investigate the biological traits that make red snapper vulnerable to overfishing.

Loss of Biological Diversity

Ecologists examine the differences in the composition of species in ecosystems, the physical structure of ecosystems, and the way they function. The three levels of biological diversity, as described by CMC, are as follows:

- Species diversity, which varies enormously over the surface of the Earth and over time
- Genetic diversity, a lower level consisting of the genetic variation among different individuals within each species, providing the raw material for evolution and selective breeding
- Ecosystem diversity, the highest level of biological diversity or the diversity of communities of organisms in their physical settings

CMC also identifies five major classes of threats to biological diversity:

- Human overexploitation of living things, both intentional and unintentional
- Physical destruction of ecosystems, from sea grass beds and mangrove forests to the soft seabed
- Pollution of all sorts
- Global atmospheric change, including stratospheric ozone depletion and global climate change
- The introduction of nonindigenous species (such as the blue crab species once native to the United States that is now well established in the Mediterranean)

Many issues addressed in this chapter can cause a loss of biological diversity. Twenty-nine marine mammals and birds in American coastal waters are listed as threatened or endangered marine species. Table 7 lists threatened and endangered marine and marine edge species (i.e., those species that depend on coasts, near-coastal areas, or intertidal areas for food, shelter, or breeding).

Nonindigenous or "Nuisance" Species

According to James Carlton, director of the Maritime Studies of Williams College/Mystic Seaport program in Connecticut, the introduction of nonindigenous species can "cause fundamental irreversible alterations in the structure of aquatic communities. No introduced marine organism, once established, has ever been successfully removed or contained."

Public awareness of the potential risks of introducing nonindigenous, or "nuisance," species has been raised by experiences associated with introduction of zebra mussels from the Black Sea to the Great Lakes. The mussels can block pipes and cause extensive ecological damage. The zebra mussels were unintentionally brought to North America from the Mediterranean Sea via ballast water (water pumped into a ship's hull).

In the Great Lakes, accidental and deliberate introduction of nuisance species such as the sea lamprey, zebra mussels, and round goby played a part in the decline of fisheries. Today, the sea lamprey is controlled with a chemical lampreycide. According to the Georgian Bay Association, however, alternatives to chemical treatments are being explored, coupled with efforts to reduce chemical lampreycide use by 50 percent by 2000. Efforts to control nuisance species are costly; Great Lakes municipalities and industries have spent a total of $120 million to combat nuisance species from 1989 to 1994.

The U.S. Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 was reauthorized by the National Invasive

Table 7
Marine and Marine-Edge Species Protected by
the U.S. Endangered Species Act[1]

Marine Species	Endangered	Threatened
Mammals	Blue Whale Bowhead Whale Finback Whale Gray Whale+ Humpback Whale Right Whale Sei Whale Sperm Whale Vaquita (Cochito) Dugong West Indian Manatee Marine Otter Caribbean Monk Seal Hawaiian Monk Seal Mediterranean Monk Seal Saimaa Seal	Southern Sea Otter Steller Sea Lion Guadalupe Fur Seal
Reptiles	Hawksbill Sea Turtle Kemp's Ridley Sea Turtle Leatherback Sea Turtle American Crocodile Saltwater Crocodile+	Green Sea Turtle* Olive Ridley Sea Turtle* Loggerhead Sea Turtle
Fishes	Sockeye Salmon+ Shortnose Sturgeon Coho Salmon+ Totaba (Seatrout) Umpqua River Culthroat Trout	Chinook Salmon* Central California Coast Gulf Sturgeon
Birds	Short-tailed Albatross** Amsterdam Albatross Abbott's Booby Cahow (Bermuda Petrel) Madeira Petrel Mascarene Black Petrel Hawaiian Dark-Rumped Petrel Andrew's Frigatebird Audouin's Gull Brown Pelican+ Galapagos Penguin California Least Tern Canarian Black Oystercatcher Madagascar Sea Eagle	Marbled Murrelet Newell-Townsend Shearwater+ Roseate Tern*

Table 7
Marine and Marine-Edge Species Protected by the U.S. Endangered Species Act[1]

Marine-Edge Species	Endangered	Threatened
Mammals	Alabama Beach Mouse Anastasia Island Beach Mouse Choctawhatchee Beach Mouse Perdido Key Beach Mouse Pacific Pocket Mouse Saltmarsh Harvest Mouse Shark Bay Mouse Morro Bay Kangaroo Rat False Water Rat Florida Salt Marsh Vole	Southeastern Beach Mouse
Birds	Laysan Duck Chinese Egret Nordmann's Greenshank New England Shore Plover California Clapper Rail Lightfooted Clapper Rail+ Cape Sable Seaside Sparrow	Piping Plover*
Fishes	Tidewater Goby	
Reptiles	None	Atlantic Marsh Snake
Invertebrates	Morro Shoulderband Snail (Banded Dune)	Northeastern Beach Tiger Beetle
Plants	None	Seabeach Amaranth

[1] Includes species that require marine habitats (or their edges) to survive.
* Denotes threatened species that are endangered throughout certain portions of their range or species with endangered breeding populations.
\+ Denotes species that are endangered or threatened only in certain portions of their range.
** Denotes species that are endangered/threatened in their entire range, except for a certain limited portion of their range.

Source: Crouse 1997

Species Act of 1996. The act, created in response to the Great Lakes zebra mussel population increase, called for programs to prevent, research, and monitor aquatic nuisance species. The act focuses on ballast water, including the development of new technologies to prevent transport of aquatic nuisance species through ballast water.