The Nature of the Problem

Throughout history, the coast—the place where land and rivers meet the sea—has been an area of astounding biological abundance. Diverse and unique habitats and abundant fish and other wildlife have graced our coasts. Even Americans who live far inland reap the coasts’ benefits when they dine on succulent saltwater fish or visit the ocean shores.

In the United States today, our coasts are deceptive in their beauty. Surface appearances mask a crisis that extends from upper watersheds to depleted offshore coral reefs. The problem, simply put, is that we are loving our coasts to death.

Today, more than half the population of the United States lives in coastal counties. Yet, these counties comprise just 17 percent of the nation’s land area. As a result, population density along the coasts is about five times the national average. The latest census data indicate that this population will increase by another 20 percent by 2015 (Beach, 2002), as some 3,600 people move to the coasts each day.

Permanent residents are not the only source of pressure on coastal ecosystems, for the beach is a favorite destination. Tourism is the second largest contributor to the U.S. gross domestic product and coastal tourism and recreation account for 85 percent of all tourism revenue (NOAA, 1999). In California alone, coastal tourism is valued at nearly 10 billion dollars annually, far exceeding the 6 billion dollars generated...
Expansion of Metropolitan Coastal Areas

Geographic Information Systems (GIS) technology has recently made it possible to graphically depict the expansion of metropolitan areas.

The developed “footprints” (burgundy) of many coastal regions are expanding faster than the national average. The metropolitan regions of New York City (below, left) and San Francisco (at right) experienced physical growth rates far in excess of population growth.

Sources: NOAA, 2002; Map images for New York adapted from maps created by Craig Campbell, using data provided by a partnership of Regional Plan Association, the United States Geological Survey, and Cornell University. Source for San Francisco map images: United States Geological Survey.

Art: John Michael Yanson
Maps: Jerome N. Cookson
by port traffic and dwarfing the 550 million dollars generated by the state’s fisheries and mariculture, or saltwater aquaculture (Wilson and Wheeler, 1997).

With these throngs comes new development, which increases demand for housing, water, food, recreation, waste disposal, roads, and cars. All of this is polluting the water and air and endangering coastal habitats.

Habitat destruction and the decline of coastal water quality are the primary threats to species with which we share the coastal environment. Those threatened include many ecologically and economically important species, as well as rare and unique habitats. Urban sprawl, for example, contributed to the decline of 188 of the 286 California species that are listed under the Endangered Species Act, making it the leading cause of species decline in that state (Doyle et al., 2001).

We are fundamentally changing the natural ecosystems that attract us to the coasts. In some areas, we have converted expansive wetlands into cities, protected on all sides by levees. In others, we have converted sand dunes into irrigated golf courses and subdivisions.

The problem is not just one of population; our patterns of land use amplify the effects of population growth on coastal ecosystems. In addition, government agencies and programs have engaged in environmentally harmful development in coastal watersheds for decades.

The population explosion on our coasts will continue. It is up to us to manage that development in ways that protect coastal ecosystems. If not, we will find ourselves impoverished, along with our coasts.

**CHANGING LAND USE PATTERNS**

In the decades following World War II, Americans fled crowded inner cities in record numbers. Between 1950 and 1990, the urban population of the United States grew by about 15 percent and the rural population decreased...
slightly, while the suburban population more than tripled (Diamond and Noonan, 1996). During this period, affordable automobiles, cheap gasoline, and a rapidly expanding and heavily subsidized road system allowed—for the first time—large numbers of people to live miles from where they worked.

In many ways, the coasts led these changes. Coastal development extends from the floodplains of rivers and estuaries to barrier islands. Fourteen of the nation’s 20 largest cities and 19 of the 20 most densely populated counties lie along the coast. Furthermore, the rate of land consumption in many of these major metropolitan areas is four or more times the population growth rate (Figure One, page 50). If nationwide land development trends continue, by 2025 we can expect an additional 68 million acres—an area of land roughly the size of Wyoming—to be converted to residential and commercial use (Beach, 2002; Figure Two, page 51). Most of this growth will occur along our coasts.

Sprawl—low density, automobile-dependent development that separates residential areas from jobs, goods, and services—has become the predominant pattern of urban development in the United States. This approach to development is, by definition, inefficient in its use of land. The use of zoning ordinances to mandate large lot size and to separate residential development from commercial areas was intended to protect homeowners from the kind of crowding and pollution that originally drove people from the inner cities. But by spreading out development and separating residents from even the most basic goods and services, sprawl gobbles up land and exacerbates traffic and pollution.

Since 1960, the number of vehicle miles traveled by Americans has more than tripled (NRDC, 2001; Figure Three). As a result, vehicle exhaust is contributing a growing share of the total air pollution. We now know that atmospheric deposition—air pollution that eventually settles down on land or water—is a major source of nitrogen pollution in our nation’s waterways. This is particularly a problem along the Atlantic seaboard and in the

![Figure Three: Increases in Vehicle Miles Outstrip Increases in Population](image-url)
Mississippi River watershed, where high rainfall combines with air pollution to exacerbate atmospheric deposition (Puckett, 1994).

**MISGUIDED GOVERNMENT PROGRAMS**

Substantial growth in many American’s personal wealth, combined with cheap flood insurance and a period of relatively few hurricanes, have contributed to billions of dollars worth of real estate development in high-risk and environmentally fragile coastal areas. Low-cost federal flood insurance has substantially reduced the financial risk of this development, and government-financed flood control, beach restoration, and shoreline hardening projects have created a false sense of security for residents in these low-lying areas.

Government projects have dramatically altered our rivers and coastal waterways. These often-massive efforts spur development while paying scant attention to environmental consequences. The economic benefits they have provided—particularly to agriculture and shipping—come at a high ecological price (Box One, page 54). Habitats, species, and whole ecosystems are threatened by the elimination of wetlands, the channelization and damming of rivers, and the stabilization of inherently unstable beaches and barrier islands.

These changes have not been random. The Army Corps of Engineers, established in 1779, is the nation’s main water resources management agency. It is responsible for building and maintaining more than 1,500 federal water projects. These include the construction and maintenance of more than...
Louisiana is gripped by a major crisis brought on by decades of misguided development of our land and waters. Due to channels and levees constructed by the Army Corps of Engineers, the Mississippi itself now flows more like a ditch than a river, shunting fertilizers and pesticides downstream. One result is a low-oxygen dead zone in the Gulf of Mexico off the mouth of the Mississippi that can span more than 8,000 square miles of coastal ocean. The zone is caused by excess nutrients—mostly nitrogen—that drain into the ocean from agricultural lands along the Mississippi River. As they sink and decay on the bottom, algal blooms resulting from the excess nutrients drain oxygen from the Gulf waters.

The extensive channel and levee system along the Mississippi blocks sediments formerly supplied by floodwaters and exacerbate erosion and saltwater intrusion from the Gulf of Mexico. Navigation channels that crisscross the region also contribute to large-scale erosion of the delta. Thus, the delta has lost more than 1,000 square miles since 1950, and continues to lose 25 to 35 square miles per year. If current loss rates continue, more than 630,000 acres of Louisiana wetlands will be converted to open water by 2050.

The Commission heard testimony about this crisis at a public hearing in New Orleans. Following are excerpts from the testimony of King Milling, President of the Whitney National Bank, New Orleans, and chair of the governor-appointed Committee on the Future of Coastal Louisiana.

**DELTA BLUES**

Louisiana, the Mississippi Delta, and the Gulf of Mexico, as reflected by the hypoxia problem, are all victims of national policy. I don’t say this to assess blame. It’s a fact. The channelization of the Mississippi River and its tributaries, not to mention the dredging of numerous navigational waterways, has created an impact that shall absolutely devastate south Louisiana and the lower delta.

The loss of Louisiana’s marshes will incrementally destroy the economy, culture, ecology, and infrastructure, not to mention the corresponding tax base of this state and this region. From an ecological and environmental point of view, it is a clear disaster. An ecosystem contributing 30 percent of the commercial fish harvested in these United States will be destroyed.

As these wetlands are destroyed, the present insurable value of adjoining manufacturing, commercial, utility and other infrastructure will be placed at risk. Ultimately much of that infrastructure may become totally uninsurable.

This state, in cooperation with our federal partners, has to step back and develop a holistic engineering program to reestablish a sustainable coastline. Leading scientists and engineers believe that it can be done. The cost is 14 billion dollars. That is a lot of money. The cost of doing nothing shall be well in excess of 100 billion.

140 ports, the construction of an 11,000-mile network of inland navigation channels, 8,500 miles of levees and floodwalls, and more than 500 dams (Stein et al., 2000). The Corps also manages shoreline protection and restoration, construction of seawalls and jetties, and beach rebuilding. As a result, it has a profound effect on the environmental health of the nation’s waterways, floodplains, wetlands, and coastlines.

The Corps has long been criticized for
building expensive and environmentally damaging projects, often with dubious economic justification. Analyses of the Corp’s practices by the National Academy of Sciences, the General Accounting Office, the Army Inspector General, and independent experts have shown a pattern of flawed economic and environmental analyses, a process that is strongly biased in favor of project approval, and a failure to follow through with environmental mitigation. The projects resulting from this flawed approval process frequently fail to deliver predicted economic benefits while producing far more environmental damage than anticipated. In addition, the Corps has failed to complete much of the environmental mitigation required for its development projects.

According to Steve Ellis, of Taxpayers for Common Sense, “What Army Corps officials lose sight of when they promote a wasteful project is that the federal taxpayer is the primary client, and is the majority stakeholder of virtually all Corps projects. The Corps needs to be made accountable to the nation as a whole, and its mandate should be a civil works program that will benefit the overall national economy and the welfare of its citizens.”

Although perhaps the most influential, the Corps is not the only government agency or program whose actions unnecessarily harm coastal ecosystems. For example, as part of the Central Valley Project, the Bureau of Reclamation helped drain the vast wetlands of California’s Central Valley and channelized its rivers. The project resulted in the loss of 95 percent of the wetlands of the Sacramento River Delta. Winter run Chinook salmon have declined by more than 90 percent over the life of the project and an estimated 95 percent of salmon and steelhead spawning habitats are now gone (Koehler and Blair, 2001). This development program has necessitated a 20-billion-dollar restoration program for fish and wildlife in the river delta and San Francisco Bay.

**COASTAL DEVELOPMENT AND HABITAT LOSS**

Like Louisiana’s bayous, all coastal habitat types are affected by development to a greater or lesser degree, depending on their desirability for human uses and their sensitivity to nearby development. Maritime forests, for example, have largely disappeared under the plow
or by residential development. Rapid growth in south Florida has led to the destruction of mangroves and seagrass beds, depriving some fish of feeding and nursery grounds.

Residential and commercial construction destroys wildlife habitat, including habitat not actually built upon. The alteration of water flows; the loss of water quality; the breakup of large areas by roads, canals, and other infrastructure; and the creation of vulnerable exposed “edge” areas all degrade wildlife habitat.

Wetlands are particularly valuable and vulnerable. They support fish and wildlife populations of economic, ecological, and social importance. They also provide ecological services by slowing down and absorbing stormwater, filtering pollutants from urban and agricultural runoff, and buffering coastal areas from storms and erosion.

From the 1780s to the 1980s, the United States (excluding Alaska) lost more than half of its original wetlands (Dahl, 1991). With protection under the Clean Water Act and other statutes, the rate of wetlands loss has dramatically decreased from a peak of about 490,000 acres a year to about 60,000 acres a year today. Most wetland loss today stems from residential and commercial development rather than from agriculture, which previously accounted for the lion’s share of loss.

**RUNAWAY RUNOFF**

Probably the most harmful impact of development on marine and freshwater ecosystems is the degradation that results from polluted runoff. As evidenced by the dead zone in the Gulf of Mexico, transported pollutants can degrade water quality and habitats far from the sources of pollution.

Surfaces that are impervious to water—such as paved roads, parking lots, and rooftops—greatly exacerbate the problem of runoff. A one-acre parking lot, for example, produces about 16 times the volume of runoff that comes from a one-acre meadow (Beach, 2002). Impervious surfaces affect watersheds in two major ways. First, they alter the pattern and rate of flow of rainwater to water bodies. Second, they collect pollutants—hydrocarbons and other harmful substances emitted by automobiles, as well as fertilizers and pesticides from lawns and golf courses—and provide a conduit for their rapid transfer to water bodies.

In general, the abundance and diversity of aquatic species decline as the amount of impervious surface in a watershed increases beyond about 10 percent (Schueler and Holland, 2000). Since suburban development averages about 40 percent impervious cover, environmental quality quickly begins to suffer in rural watersheds once suburban development begins. For example, in Maryland, the abundance of brown trout declines at about 10 to 15 percent of imperviousness as does the abundance of coho salmon around Seattle. Similarly, studies have shown that the diversity of aquatic insects plummets in urban streams.

**THE LOGIC OF WATERSHED PLANNING**

Watersheds—areas of land that drain to a common waterway—provide a logical and appropriate scale for protecting and restoring water quality. Identifying the major threats to
water quality, inventorying their sources, and determining the pollution reductions needed to protect, maintain, and restore water quality are best done on a watershed-by-watershed basis. Forty-six percent of the U.S. population inhabits coastal watersheds (NOAA, n.d.), but, in a sense, we all live in a coastal watershed since all rivers drain eventually to the sea.

At the local and regional levels, the sources, magnitude, and effects of nutrient and toxic pollution from both point and nonpoint sources vary dramatically. As a result, a one-size-fits-all approach to making our waters fishable and swimmable will not work. But approached on a watershed basis, we can address problems such as nonpoint source pollution, particularly nutrient pollution—the greatest threat to water quality in our rivers, bays, and coastal waters.

We need an approach that manages sources and effects across jurisdictional boundaries, provides the resources and incentives needed to achieve results, and is flexible enough to allow solutions tailored to meet local circumstances.

The essential programmatic elements of a watershed-based approach to water quality protection are already in place. The Clean Water Act requires the establishment of water quality standards for pollutants as well as the calculation of the maximum amount of a given pollutant that a water body can absorb and still satisfy water quality standards (the total maximum daily load, or TMDL). The act also requires an ongoing planning process for complying with water quality standards and maintaining designated uses of water bodies—such as fishing and swimming.

At its core, the problems of coastal development are about human beings and the demands we place on natural resources and ecosystems. We are currently making more demands on coastal and marine ecosystems than they can reliably meet. To preserve and restore the bountiful coastal environment that we have enjoyed in the past and that we want for our children and grandchildren, we must alter our relationship to the environment. Given the certainty of substantial future population growth in coastal areas, only by changing the way we live and the way our communities grow can we maintain, much less restore, healthy coastal ecosystems.

**SUMMARY OF RECOMMENDATIONS**

1. **Develop an action plan to address nonpoint source pollution and protect water quality on a watershed basis.**
   Addressing the complex array of point and nonpoint sources of pollution related to development requires a comprehensive, watershed-based approach to water quality protection. States should establish and enforce water quality standards for nutrients, thus providing an enforceable benchmark against which progress can be measured. The Clean Water Act and state water quality laws should be amended to require action to reduce nonpoint source pollution. States should determine the total maximum daily load (TMDL) of pollutants that a water body can accept and still attain water quality standards. The states should then implement meaningful plans for achieving the point and nonpoint source pol-
olution reductions indicated by TMDLs. Implementation also requires watershed-based water quality compliance planning, which the federal government can encourage by providing a complementary suite of incentives for improving water quality and disincentives for activities that harm water quality.

2. Identify and protect from development habitat critical for the functioning of coastal ecosystems. Congress should provide a significant, permanent, and dedicated source of funding for habitat protection. Comprehensive habitat-protection planning by the states is important to ensure that federal, state, and local funds provide the maximum benefit in protecting habitat and water quality. The broadest possible array of financial tools and incentives should be made available to government and private land-protection efforts. Lastly, strong partnerships among all levels of government, private land trusts and foundations, and the business community are crucial for large-scale habitat protection.

3. Institute effective mechanisms at all levels of government to manage development and minimize its impact on coastal ecosystems and their watersheds. Substantial changes in development patterns and practices on private lands are needed. Municipalities and counties should change their zoning and subdivision codes to promote compact growth in areas where it is desirable, to discourage growth in relatively undeveloped areas where it is not desirable, and to reduce impervious surface cover wherever possible. States should take an active role in developing a consensus on growth management, encouraging urban growth boundaries to protect agriculture and environmentally sensitive lands, and restricting state development funding to designated growth areas. Congress should make federal funding for transportation and development available only to states that comply with the Clean Water Act and other federal environmental laws. Federal grants and loans should be required to be used consistent with state and local growth-management efforts.

4. Redirect government programs and subsidies away from harmful coastal development and toward beneficial activities, including restoration. The Army Corps of Engineers should be reformed to ensure that its projects comport with the agency’s missions, are environmentally and economically sound, and reflect national priorities. Congress should transform the Corps into a strong and reliable force for environmental restoration, working in partnership with natural resource management agencies. Tax structures should be examined at all levels of government to ensure that they are supporting compact, appropriately sited growth. The National Flood Insurance Program should be reformed by setting premiums that reflect the true risk of coastal hazards, phasing out coverage of repetitive loss properties, and denying coverage for new development in hazardous or environmentally sensitive areas.
Chapter Five
CLEANING COASTAL WATERS

THE NATURE OF THE PROBLEM

The images of the Exxon Valdez oil spill in Prince William Sound, Alaska, in 1989, and the sight of trash washing up with the seaweed on our favorite beaches are all too familiar.

What we are less aware of, however, is the amount of pollution that travels daily from each of our lawns, vehicle tailpipes, driveways, and the fields where our food is produced into our coastal waters. A recent study by the National Research Council found that the same amount of oil released in the Exxon Valdez spill—10.9 million gallons—washes off our coastal lands and into the surrounding waters every eight months (NRC, 2002). The Mississippi River, which drains nearly 40 percent of the continental United States, carries an estimated 1.5 million metric tons of nitrogen into the Gulf of Mexico each year (Goolsby et al. 1997). Overall, the amount of nitrogen released into coastal waters along the Atlantic seaboard and the Gulf of Mexico from anthropogenic, or human-induced sources, has increased about fivefold since the preindustrial era (Howarth et al., 2000).

The consequences of this polluted runoff are most acute along the coasts, where more than 13,000 beaches were closed or under pollution advisories in 2001 (NRDC, 2002). Two-thirds of our estuaries and bays are either moderately or severely degraded from eutrophication (Bricker et al., 1999). However, pollution’s reach extends far beyond our major cities. Scientists report that killer whales have higher PCB levels in their blubber than any animal on the planet and that fish species that live their entire lives far out in the Pacific are too contaminated with mercury to be safe to eat.

These are the signs of a silent crisis in our oceans.

Fortunately, we have set a good precedent for addressing water pollution. In response to public outcry over such environmental calamities as the burning of the Cuyahoga River in Ohio, Congress passed the Clean Water Act (CWA) in 1972. The law requires the U.S. Environmental Protection Agency (EPA) to establish national technology standards and science-based criteria for water quality protection. The states then control identifiable sources of pollution by issuing pollution discharge permits based on these technology and water quality requirements.

Efforts resulting from the provisions of the Clean Water Act have succeeded in removing the worst pollution from the rivers and lakes that surround us. Some coastal waters, such as those off Los Angeles and San Diego, have dramatically improved. There, inputs of many pollutants have been reduced by 90 percent or more over a 25-year period, leading to the recovery of kelp beds, fish communities, and certain seabird populations (Boesch et al., 2001).

I want my children to grow up unafraid to eat salmon and halibut and other wild foods that are part of our tribal heritage. But the traditional foods that we gather from the ocean have contaminants. My Aunt Violet points out that we aren’t just eating one contaminant. We eat the whole fish.

Shawna Larson
Alaska Community Action on Toxics
Pew Oceans Commission hearing, Anchorage, Alaska, August 15, 2001
But in the 30 years since the Clean Water Act was passed, as scientific knowledge and experience has improved, the focus of our concern has shifted. Although controlling point sources remains critical, the subtler problem of nonpoint sources has moved to the fore. In our oceans, now, we are experiencing a crisis as great as a burning river. It is a crisis we must address through changes in both policy and commitment.

Today, nonpoint sources present the greatest pollution threat to our oceans and coasts. Every acre of farmland and stretch of road in a watershed is a nonpoint source. Every treated lawn in America contributes toxics and nutrients to our coasts. Nonpoint pollutants include excess fertilizers and pesticides used in farming, oil and grease from paved surfaces, bacteria and nutrients from livestock manure, and acidic or toxic drainage from abandoned mines.

The current legal framework is ill equipped to address this threat. Rather than confronting individual cases, the situation requires that we apply new thinking about the connection between the land and the sea, and the role watersheds play in providing habitat and reducing pollution.

One of the major nonpoint pollutants is nitrogen, a nutrient that encourages plant growth. Although nitrogen is essential to life, in excess it can significantly damage and alter ecosystems. In fact, scientists now believe that nutrients are the primary pollution threat to living marine resources (NRC, 2000). Most nitrogen in the oceans arrives from nonpoint sources, including storm runoff from roads and agricultural fields, and airborne nitrogen emitted from power plants and car tailpipes.

We have also learned that marine species accumulate toxic substances. From single-celled marine life to top ocean predators, including humans, toxic substance levels in body tissue increase as predators consume contaminated prey. In addition, new forms of pollution are emerging. Non-native species, introduced by accident or design, have proliferated to stress entire ecosystems, crowding out native species, altering habitat, and in some instances, introducing disease. And human-generated sound in the oceans is affecting marine life in ways we are just beginning to understand.

Finally, we have not fully dispensed with the problem of point source pollution. Legal loopholes and poor enforcement allow significant point sources of pollution to go unregulated. These include cruise ships, ballast-water discharge from ships, and concentrated animal feedlots.
feeding operations. Animal feeding operations alone produce more than three times the amount of waste that people do—about 500 million tons of manure every year (EPA, 2002a).

Through witness testimony from around the country, commissioned papers, and its own research, the Commission investigated five types of pollution—nutrients, toxic substances, cruise ship discharges, invasive species, and anthropogenic sound. It reviewed the current state of our laws and changes necessary to control new and overlooked sources of pollution.

**WHEN NUTRIENTS POLLUTE**

The immediate cause of the 1991 event that killed one million menhaden in North Carolina’s Neuse River was a single-celled creature called *Pfiesteria piscicida*. Known as the killer alga, *P. piscicida* can emit a strong neurotoxin when in the presence of schools of fish. It feasts on the dead and dying fish, reproduces, and then settles back into the sediment. Scientists have found that *P. piscicida* thrives in coastal waters that are enriched with nutrients such as phosphorus and nitrogen.
The Neuse River outbreak was linked by analyses of the event to nutrients flowing from manure lagoons and other agricultural sources in the watershed.

We are degrading the environment along our coasts. Nutrient pollution has been linked to harmful algal blooms, such as the *Pfiesteria* outbreak. It has also been linked to dead zones, such as the area in the Gulf of Mexico that appears annually and has reached the size of Massachusetts (more than 8,000 square miles). In addition, this pollution results in the loss of seagrass and kelp beds, destruction of coral reefs, and lowered biodiversity in estuaries and coastal habitats (Howarth et al., 2000). The incidence of harmful algal blooms along the United States coastlines increased from 200 in the decade of the 1970s to 700 in the 1990s, and now includes almost every coastal state in the U.S. (Burke et al., 2000) One bloom off the coast of Florida was implicated in the deaths of more than 150 manatees (NOAA, 2002).

The continued loss of wetlands is further evidence of this trend in degradation. Wetlands serve a critical function as natural filters that remove nutrients before they can reach the sea, but they are being lost at the rate of approximately 60,000 acres per year (Dahl, 2000). If current practices of nutrient input and habitat destruction continue, nitrogen inputs to U.S. coastal waters in 2030 may be 30 percent higher than at present (Howarth et al., 2002).

When too many nutrients—particularly nitrogen—enter the marine environment, the result is eutrophication—the overenrichment of the water that stimulates extraordinary growth of phytoplankton and attached algae (Figure One, page 61). Phytoplankton blooms can be so dense they block the light needed by corals and by submerged vegetation such as seagrasses. Severe light deprivation will kill the plants and cause corals to expel the algae they host, which leads to coral bleaching.

After the phytoplankton die and sink to the ocean floor, bacteria decompose them. Decomposition pulls oxygen from the water, leaving the remaining plants and animals oxygen-starved. Areas with little oxygen, called hypoxic, are unable to support fish and shrimp populations, and the stress of hypoxia can make them more vulnerable to invasive species, disease, and mortality events. In addition to the well-known hypoxic dead zone at the mouth of the Mississippi River, hypoxic zones have developed in 39 estuaries around the U.S. coast (Bricker et al., 1999).

Of the myriad sources of nutrient pollution, agriculture is the most significant. Nitrogen in fertilizer is easily dissolved in and transported by water. Animal wastes are also nitrogen rich, and are generally applied to farmland, where the nitrogen can be washed into water bodies by rainstorms. Aggravating this problem, tile drainage systems constructed to collect and shuttle excess water from fields—particularly common in the corn and soybean fields of the Midwest—provide an expressway for nitrogen flowing into waterways.

Until recently, atmospheric deposition—the settling of airborne pollutants on the land and water—has been an overlooked source of nitrogen pollution in coastal waters. It is now clear that it is widespread and quantitatively important in some regions. Most atmospheric deposition of nitrogen originates as nitrogen oxide emissions from power plants and auto-
biles, and ammonia gas released from animal wastes (Boesch et al., 2001; Figure Two).

In addition to nonpoint sources, there are major point sources of nutrients, particularly concentrated animal feeding operations (CAFOs). Most animal wastes from CAFOs are stored in open lagoons, which can be larger than five and a half football fields and contain 20 to 45 million gallons of wastewater (NRDC and CWN, 2001). If not properly managed, lagoons can leach nutrients and other substances into waterways and overflow during rainstorms. The liquid effluent, rich in nitrogen and phosphorous, is sprayed onto agricultural fields as fertilizer, often at many times the amount needed for crop growth. On a day-to-day basis, the over-application of animal waste to land, which fouls waterways with runoff, is a significant environmental problem.

Although they are regulated under the CWA, CAFOs have largely avoided pollution restrictions because of exemptions in outdated regulations and the states’ failure to enforce permitting requirements. Of the approximately 15,500 operations that meet EPA’s definition triggering regulation, less than 30 percent have permits, reducing the government’s and the public’s ability to monitor and control CAFO-related pollution. EPA recently revised its CAFO regulations, which now expressly require all CAFOs over a certain size to obtain a point source discharge permit. EPA’s new regulations require CAFOs to develop a nutrient management plan by 2006, but EPA has not set
enforceable standards for these plans, which will be written by the operators and not subject to government or public review. In exchange for developing and implementing a nutrient management plan, CAFOs are shielded from liability for pollution that is discharged off the facility’s land application area.

Regardless of its source, nitrogen has become one of the most pervasive and harmful pollutants in coastal waters. A revitalized pollution policy must reflect this understanding.

**TOXIC WATERS**

When the *Exxon Valdez* ran aground in Alaska and spilled its oil cargo in March 1989, scientists, managers, and hundreds of volunteers rushed to rescue thousands of seabirds and sea otters. They picked the birds off soiled beaches and attempted to clean their plumage before the birds lost their ability to float and to stay warm. In the end, some 30,000 seabirds perished as well as 1,000 or more sea otters, and untold numbers of fish. Congress has since passed the Oil Pollution Act to reduce the risk of similar tanker accidents.

New evidence strongly suggests that components of crude oil, called polycyclic aromatic hydrocarbons (PAHs), persist in the marine environment for years and are toxic to marine life at concentrations in the low parts-per-billion range (Carls et al., 1999). Chronic exposure to PAHs can affect development, increase susceptibility to disease, and jeopardize normal reproductive cycles in many marine species.

PAHs represent just one class of toxic substances that threaten the health of marine species and of humans who depend upon them for food. The Commission focused on three toxic substances of particular concern: PAHs, PCBs (polychlorinated biphenyls), and heavy metals like mercury. These substances are both pervasive and persistent. They are decomposed very slowly, if at all, by bacteria, and do not leave the marine environment quickly or completely. Although now banned in domestic manufacture of electrical transformers, plastics, paints, and other materials, PCBs are still present in many imported materials and at many industrial and military sites. Mercury levels are on the rise in some regions. Nearly 80 percent of the mercury in the marine environment arrives as air emissions from coal-fired power plants and other combustion sources, some of them overseas (Heintz et al., 1999).

Landfills, urban runoff, ocean dumpsites, ocean vessels, and the burning of fossil fuels are just a few of the pathways that bring toxic substances to the oceans.

Toxic compounds enter marine food chains either directly from the water or from concentrated deposits in sediments. Organisms accumulate toxic substances in their tissues, where they may be passed up the food chain. Some of these compounds are concentrated at each step in the chain. The ocean’s top predatory fish and marine mammals therefore often have the highest concentrations of toxic compounds in their bodies. Killer whales, walruses, and tuna are among those most contaminated.

Accumulated toxic substances disrupt hormone cycles, cause birth defects, suppress the immune system, and cause disorders resulting in cancer, tumors, and genetic abnor-
malities. In some instances, accumulated toxic substances can even cause death in marine animals (MMC, 1999).

The contamination of certain commercial species may pose particular problems for humans. Recent studies sponsored by The Mobile Register indicated that the presence of methylmercury (the bio-available form of mercury, and the form most prevalent in fish) in several species of fish in the Gulf of Mexico, including ling, amberjack, and redfish, may be so great that Food and Drug Administration standards would prohibit selling them to the public. In 2001, of the 2,618 fish advisories issued in U.S. waters, almost 75 percent were for mercury contamination (EPA, 2002b). In Alaska and other polar regions, the evidence of correlation between increased toxic loads and declining health in humans and animals alike is mounting (AMAP, 2002).

The Arctic and Antarctic are hard hit by certain persistent toxics, especially heavy metals and organochlorines, which include PCBs, due to the peculiar mechanisms by which these compounds are preferentially transported to the polar regions. Airborne toxics are repeatedly deposited and volatilized as they are swept by atmospheric circulation from their points of origin toward the polar regions. This process is known as the grasshopper effect because the substances “hop” from their sources to their ultimate repositories in the polar marine environment.

Not enough is being done to address the dangers that toxic substances pose to marine species and to humans. There are no water quality standards for PAHs under the CWA, no ambient air quality standards for mercury under the Clean Air Act (CAA), no systematic monitoring of toxics levels in most species consumed by humans, and there is insufficient effort to clean up toxic contaminants in sensitive marine environments. These policy shortcomings should be addressed without delay.

**CRUISE SHIPS**

Cruise ships can offer spectacular views and unparalleled wildlife experiences. For many Americans, cruises provide their only exposure to the oceans and marine wildlife, and the popularity of this activity is increasing. In
recent years the cruise ship industry has grown at an average annual rate of eight percent, and expansion continues. In 2001, the North American cruise industry set a record when it carried 8.4 million passengers. In San Francisco Bay, a new cruise terminal is expected to more than double the number of ship visits per year. Cruise ships make frequent stops in Florida, the Caribbean, along the West Coast, Maine, and Alaska.

While taking a cruise can provide an invaluable experience for passengers, cruise ships can pose a particular risk to the very environments they seek to explore. With as many as 5,000 people onboard, a cruise ship is akin to a floating city, where people go about many of the same activities as they do at home: showering, cleaning, cooking. In addition, cruise ships offer such amenities as photo developing, hairdressing, and dry cleaning. The waste from these activities, however, is not regulated like waste produced from cities.

In one week, a typical cruise ship generates 210,000 gallons of black water (sewage), 1,000,000 gallons of gray water (shower, sink, dishwashing water), 37,000 gallons of oily bilge water, more than eight tons of solid waste, millions of gallons of ballast water containing potential invasive species, and toxic wastes from dry cleaning and photo processing laboratories* (Royal Caribbean Cruises Ltd., 1998; Eley, 2000; Holland America, 2002). This effluent, when discharged untreated—as too often happens—delivers human pathogens, nutrients, and hazardous substances directly to the marine environment. The wastewater pollution from these ships is compounded by air pollution from burning trash and fuel emissions that enter the marine environment via atmospheric deposition.

Despite the fact that cruise ships discharge waste from a single source, they are exempted from regulation under the CWA point source permitting system. The CWA allows the discharge of untreated black water anywhere beyond three miles from shore, and does not require any treatment of gray or ballast water. Only in Alaskan waters are cruise ships required to meet federal effluent standards; treat gray water discharges; and monitor, record, and report discharges to state and federal authorities. In addition, the CWA authorizes the U.S. Coast Guard to inspect the discharge logs and pollution control equipment aboard ships. However, Coast Guard officers are not required to test discharges for compliance.

The CWA and the Act to Prevent Pollution from Ships together regulate bilge water, which must be run through an oil-water separator before it is discharged. The National Invasive Species Act encourages all oceangoing vessels to exchange ballast water but does not require them to do so. The air emissions from ships are covered under the CAA amendments of 1990, but the EPA has yet to impose regulations.

In short, the legal regime that covers cruise ships is complex but not comprehen-

*Based on a 3,000-passenger cruise ship and EPA estimates of per capita waste generation.
sive. Unless we take greater steps to control discharges and reduce pollution, we will continue to harm the very places we love to visit.

**INVASIVE SPECIES**

Invasive species—non-native species whose introduction harms or is likely to harm the environment, economy, or human health—present one of the most significant threats to biodiversity and healthy ecosystems (GISP, 2002). Once introduced, they have the potential to establish themselves alongside, or in place of, existing species. They can compete with native species for prey and habitat, facilitate the spread of diseases, introduce new genetic material, and even alter landscapes. Invasive species can impede endangered species conservation and restoration efforts. In the marine environment, some compete with commercially significant fish species for food and habitat, or they clog nets and eat bait. On land and in the sea, invasive species are responsible for about 137 billion dollars in lost revenue and management costs in the U.S. each year (Pimentel et al., 1999).

Invasive species are hard to identify and eradicate before they take hold in an ecosystem, which can occur remarkably quickly. For example, every 14 weeks, a new invasive species is discovered in the San Francisco Bay (Cohen and Carlton, 1998).

Ballast water is the primary vector for the release of invasive species into marine waters (Carlton, 2001). Ballast water—and all the living creatures contained within it—is pumped into and out of oceangoing vessels for stabilization. Often it is taken up in one port and discharged in another. Every day, some 7,000 species are transported around the world via ballast water (Carlton, 2001).

Another important vector is aquaculture. Species such as Atlantic salmon, grown on the western coasts of the U.S. and Canada, act as invasive species if they escape or are released unintentionally from aquaculture facilities into the surrounding waters. Once in the wild, they can compete with native species for food, shelter, and other resources, as well as spread disease. In some cases, species raised for aquaculture may interbreed with native species, potentially threatening the viability of native stocks.

Invasive species, such as these Chinese mitten crabs, represent one of the greatest threats to biodiversity. Invasive species compete with native species for prey and habitat, and are responsible for about 137 billion dollars in lost revenue and management costs in the U.S. each year.
A green alga known as *Caulerpa taxifolia*—native to tropical waters of the world—became popular as a decorative plant in saltwater aquariums after a fast-growing, cold-tolerant strain of the species was cultivated. If released into the wild, this seaweed can proliferate, carpeting the ocean floor and crowding out native species that provide food and shelter within the ecosystem. It is unpalatable to most fish because of a toxin it contains. A piece as small as one centimeter can grow into an infestation.

In the early 1980s, *C. taxifolia* was introduced into the Mediterranean Sea. By 2001, it had spread across more than 30,000 acres of the seafloor, displacing native communities in its path. Scientists believe the alga is so widespread in the Mediterranean Sea that eradication is no longer a possibility.

In June 2000, two divers in California discovered *C. taxifolia* in native seagrass beds in a coastal lagoon in Carlsbad. They reported their discovery to an algal expert, who alerted government authorities. Scientists suspect the seaweed was inadvertently released into a lagoon from a home aquarium.

A rapid response team was formed, and an effort to eradicate the invading seaweed was mobilized within a few days. Biologists surveyed the infested areas, identifying patches of the seaweed. They covered the patches with heavy plastic tarps to contain the seaweed and injected chlorine under the tarps—a treatment that killed not only *C. taxifolia* but also everything else under the tarps.

Eradication efforts appear to have been effective. A survey in the fall of 2002 found no trace of the seaweed, but scientists caution that it could reappear when summer brings increased sunlight and warmer waters.

Intensive media coverage of the Carlsbad invasion led to the discovery of a second infestation in Huntington Harbour, near Los Angeles. Biologists are treating this invasion in a similar manner with equally encouraging results. Scientists hope that the rapid response to this threat will prevent an invasion like the one in the Mediterranean Sea. Two invasions of the alien seaweed have also occurred in Australia.

The experience with *C. taxifolia* in the U.S. demonstrates the merits of prevention to avoid the uncertainties and costs of eradication. So far, nearly 2 million dollars have been spent to fight the California invasion. In January 2003, California approved an additional 1.3-million-dollar grant for further eradication efforts.

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**BOX ONE**

**INVADING SEAWEED**

A green alga known as *Caulerpa taxifolia*—native to tropical waters of the world—became popular as a decorative plant in saltwater aquariums after a fast-growing, cold-tolerant strain of the species was cultivated. If released into the wild, this seaweed can proliferate, carpeting the ocean floor and crowding out native species that provide food and shelter within the ecosystem. It is unpalatable to most fish because of a toxin it contains. A piece as small as one centimeter can grow into an infestation.

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Other vectors include the home aquarium industry, ship hulls, oil platforms, and marine debris. Invasive species arrive in seaweed used to pack live bait and via the pet trade industry. They also reach U.S. waters as live food imports. The Internet has significantly aided the introduction of new species. Today, consumers need only a credit card, access to a computer, and a delivery address to purchase marine life for food, for use as bait, or as pets. In an increasingly global economy, all this mobility represents a serious threat to the health of living marine resources.

Our laws are not equipped to deal with these threats. Biological pollution by invasive species is the focus of the National Invasive Species Act of 1996 (NISA). However, under the NISA structure, invasive species are managed on a case-by-case, crisis-by-crisis basis, and the national focus is on terrestrial invasive species.
To the extent that NISA addresses marine species, it does so almost exclusively in the context of ballast-water discharges, despite the existence of many other vectors. Ballast-water exchange (BWE) is a procedure in which ships in the open ocean dump ballast water taken aboard in foreign ports. Its purpose is to lessen the chance of introducing coastal invasive species into potentially hospitable habitats in destination ports. However, BWE does not always dislodge species and it does not apply to coastwise travel, which can also allow species to be transported to new environments. Additionally, BWE is not mandatory under NISA. Although the U.S. Coast Guard is required to check ship logs to determine whether an exchange occurred, it is not required to check the ballast tanks. Current guidelines encourage ship operators to report voluntary exchange, but compliance with this minimal requirement is weak.

There is little law focusing on other vectors of invasive species. For example, there is no uniform regime in place to track live imports either entering or traveling around the country. There is no systematic process for determining which management approach is best when a species is found, no central source of information for researching species, and no dedicated source of funding to control invasive species. For species like the destructive seaweed, Caulerpa taxifolia, which grows as much as three inches a day, any delay in response could have severe environmental and economic ramifications (Box One).

Currently, agencies at different levels of government report commodities using a different nomenclature and verification system. With such inconsistency, neighboring states could simultaneously be working to promote and eradicate the same species, and one agency’s food list could be another agency’s most wanted list of invaders. The lack of regulatory clarity was brought home by the discovery of the invasive snakehead fish in a Maryland pond. Federal regulations did not prohibit the importation or interstate transportation of this Asian fish and state law provided only a mild penalty for release of the fish, for which the statute of limitations had expired. Furthermore, state managers had no clear legal authority to eradicate the population that had established itself. This type of confusion results in invasive species—literally—slipping through the regulatory cracks and getting into the environment without anyone noticing.

**SOUND**

The use of anthropogenic sound as a tool in the ocean has become enormously valuable for scientists, engineers, fishermen, and the military. It allows fishermen to locate schools of fish and to keep predators from raiding or becoming entangled in their nets. The use of sound also helps mariners detect icebergs and other obstructions, biologists study behavior changes in marine species, oceanographers map the bottom of the ocean floor, geologists find oil and gas, climatologists research global climate change, and the U.S. Navy detect submarines.

Many marine species, including marine mammals, turtles, and fish, also rely on sound. They use vocalizations and their ability to hear to detect predators, prey, and each other. In the oceans, as on land, sound is essential
Anthropogenic sound in the ocean is on the rise, mainly due to increased vessel traffic. Coastal development is bringing more pleasure craft, and globalization and international trade require more commercial vessels. In addition, the navies of the United States and other nations are increasingly using active sonar systems to patrol coastal waters for enemy submarines. Meanwhile, oil and gas operations on the outer continental shelf are expected to spread into deeper waters.

Climate change, too, may have a significant effect on sound levels in the ocean. Not only does sound travel faster in warmer water, but also rising temperatures and melting ice at the poles may open new shipping channels in areas that have previously experienced little vessel traffic.

Sound sources differ in both their intensity and frequency, and thus can have varied effects on species. Sounds in the same frequency ranges used by marine species can mask acoustic communication among animals and interfere with detection of prey and predators. High-intensity sounds can cause pain and, in some circumstances, tissue and organ damage. If the pressure resulting from the sound is intense enough, the animal can experience internal bleeding and subsequent death.

A mass stranding of whales in 2000 heightened concerns about the effects of sound in the oceans. In March of that year, at least 17 whales were stranded on beaches in the northern Bahama Islands. Most of the animals were alive when they stranded and eight of them were returned to the sea. The other nine animals died; pathology reports revealed bruising and internal organ damage. The stranding occurred about the time that ten U.S. Navy vessels were operating their mid-frequency sonar systems nearby. Investigations conducted cooperatively by the Navy and the National Marine Fisheries Service suggested that the sonar transmissions were a critical factor in the strandings (NOAA, 2001).

Low-intensity sounds can disrupt behavior and cause hearing loss, ultimately affecting longevity, growth, and reproduction. Frequent or chronic exposure to both high- and low-intensity sounds may cause stress, which human and terrestrial animal studies indicate can affect growth, reproduction, and ability to resist disease. Impulse sounds, such as those produced by explosions and seismic air guns, may damage or destroy plankton, including fish eggs and larvae, as well as damage or...
destroy tissues and organs in higher vertebrates (Hastings et al., 1996; Gisiner, 1999).

The Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and the National Environmental Policy Act (NEPA) all provide legal mechanisms for addressing sound. However, the MMPA and ESA apply only to marine mammals and endangered species, and are only capable of protecting individuals from particular sound-related projects, such as drilling operations or sonar activities. In addition, the federal government has recently proposed to exempt certain activities from environmental review under NEPA. Because review under these statutes is triggered only on a case-by-case basis and does not effectively address cumulative impacts on marine ecosystems, underwater sound as a source of potentially significant pollution in the marine environment has not received comprehensive treatment. A new policy framework is needed to adequately address this emerging pollution concern.

**ACTION TO REDUCE MARINE POLLUTION**

For too long our oceans have been dumping grounds. Within U.S. waters, ecosystems are subjected to insults from nonpoint, unregulated point, and nontraditional types of pollution from both land- and ocean-based sources. Nutrients, toxics, cruise ship discharges, acoustic and biological pollution, and invasive species all harm marine ecosystems, and the legal regimes in place do not match the nature of today’s pollution threats. For each of these pollution sources, policy changes can and should be made as quickly as possible.

**SUMMARY OF RECOMMENDATIONS**

1. **Revise, strengthen, and redirect pollution laws to focus on nonpoint source pollution on a watershed basis.**

   EPA and the states should establish water quality standards for nutrients, especially nitrogen, as quickly as possible. EPA and the states should also ensure that water quality standards are in place for other pollutants—such as PAHs, PCBs, and heavy metals such as mercury—where these are identified as problematic on a watershed-by-watershed basis. Congress should amend the Clean Water Act to require the use of best management practices to control polluted runoff resulting from agriculture and development. Congress and the executive branch should provide substantial financial and technical support for the adoption of such practices. Congress should link the receipt of agricultural and other federal subsidies to compliance with the Clean Water Act.

   Finally, Congress and the Environmental Protection Agency should ensure that air emissions of nitrogen compounds, mercury, and other pollutants are reduced to levels that will result in a substantial reduction of their impact on marine ecosystems.

2. **Address unabated point sources of pollution.**

   Concentrated animal feeding operations should be brought into compliance with existing provisions in the CWA. Congress should enact legislation that regulates wastewater discharges from cruise ships under the CWA by establishing uniform minimum standards for discharges in all state waters and prohibiting discharges with-
in the U.S. Exclusive Economic Zone that do not meet effluent standards. Congress should amend NISA to require ballast-water treatment for all vessels that travel in U.S. waters, and regulate ballast-water discharge through a permitting system under the CWA. Finally, the International Maritime Organization draft convention on ballast-water management should be finalized and its provisions implemented through appropriate U.S. laws.

3. Create a flexible framework to address emerging and nontraditional sources of pollution.

A national electronic permitting system should be created under NISA to facilitate communication and track imports of live species that may result in aquatic introductions. Each state should inventory existing species and their historical abundance, in conjunction with the development of the regional ocean governance plans under the National Ocean Policy Act. Congress should provide adequate funding for developing statewide invasive-species management plans that include provisions for inventorying, monitoring, and rapid response. With regard to sound, a comprehensive research and monitoring program should be developed to determine the effects of sound sources on living marine resources and ecosystems. Consideration should be given to requiring the utilization of best-available control technologies, where the generation of sound has potential adverse effects. Finally, the environmental ramifications of any sound-producing project should be taken into formal consideration—pursuant to NEPA or other applicable statutes—at the planning stages of the project, before significant resources, time, and money have been devoted to its development.

4. Strengthen control of toxic pollutants.

The U.S. should ratify the Stockholm Convention on Persistent Organic Pollutants (POPs), and implement federal legislation that allows for additions to the list of the “dirty dozen” chemicals. In concert with this effort, EPA should develop and lead a comprehensive monitoring program to quantify levels of particular toxic substances in designated ocean habitats and species, and sufficient resources should be devoted to studying the effects of toxics on marine species. This monitoring program should be coordinated with Food and Drug Administration and EPA seafood contaminant advisory efforts, so that people know where their seafood comes from and what it contains.