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www.heinzctr.org/ecosystems

Coasts and Oceans

	What Indicators Are Used To Describe Coasts and Oceans?		Can we report trends? Are there other useful reference points?
SYSTEM DIMENSIONS			
◐	Coastal Living Habitats	What is the area of coastal wetlands, coral reefs, seagrasses, and shellfish beds?	Trends (where data are available)
◐	Shoreline Types	How much of the nation's shoreline is composed of beach, sand or mudflats, steep cliffs, wetlands and mangroves, and how much has bulkheads or riprap?	Current data only, regional comparison
CHEMICAL AND PHYSICAL CONDITIONS			
⊖	Areas with Depleted Oxygen	How extensive are areas with low dissolved oxygen levels?	No data reported.
◐	Contamination in Bottom Sediments	How contaminated are bottom sediments in estuaries and coastal ocean waters?	Current data only, federal guidelines
⊖	Coastal Erosion	How much of the nation's coastline is eroding?	No data reported
●	Sea Surface Temperature	What is the temperature of the ocean's surface?	Trends, regional comparison
BIOLOGICAL COMPONENTS			
⊖	At-Risk Native Marine Species	How many native marine species are at different levels of risk of extinction?	No data reported
(?)	Non-native Species	What is the extent of invasion by non-native species?	No data reported
◐	Unusual Marine Mortalities	How many marine mammals, turtles, and other animals die in unusual mortality events?	Trends
(?)	Harmful Algal Blooms	How frequent and extensive are harmful algal blooms?	No data reported
◐	Condition of Bottom-Dwelling Animals	What is the condition of small bottom-dwelling animals (worms, clams, snails, and shrimplike animals)?	Current data only, comparison to "undisturbed" conditions, regional comparison
◐	Chlorophyll Concentrations	What is the concentration of chlorophyll in coastal waters?	Current data only, regional comparison
HUMAN USES			
●	Commercial Fish and Shellfish Landings	What is the size of the commercial fish catch from U.S. waters?	Trends, regional comparison
◐	Status of Commercially Important Fish Stocks	What is the condition of commercially important fish stocks in U.S. waters?	Trends, regional comparison
⊖	Selected Contaminants in Fish and Shellfish	What is the concentration of DDT, PCBs, and mercury in fish caught in U.S. waters?	No data reported
⊖	Recreational Water Quality	How often are bacteria associated with human and animal waste found in bathing water?	No data reported

● All Necessary Data Available ◐ Partial Data Available ⊖ Data Not Adequate for National Reporting (?) Indicator Development Needed

Chapter 5:

Indicators of the Condition and Use of Coasts and Oceans

The coasts and oceans of the United States extend from the narrow ribbon of shoreline that defines the water's edge out some 200 miles into the open ocean. The cold and rocky coast of Maine and the mangrove swamps of Florida, the glacial fjords of Alaska and the black lava cliffs of Hawaii, the seagrass beds of the Chesapeake Bay and the pebble beaches of California—all these and more are found along the thousands upon thousands of miles of U.S. coastline. Offshore, kelp beds, coral reefs, and the open ocean provide habitat for fish, shellfish, birds, and mammals, as well as recreational and economic opportunities for many Americans (more than half of all Americans live within 50 miles of the coast). This vast expanse and the myriad plant and animal species that inhabit it are defined by the interaction between land and sea, between fresh water and salt water, an interaction that produces a rich mix of species and also of human activities.

What can we say about the condition and use of U.S. coasts and oceans?

Sixteen indicators describe the condition and use of America's coasts and oceans. Partial or complete data are available for nine of the indicators. Of these, five have a data record that is long enough to judge trends, and three have a federally adopted reference point or other type of benchmark for comparison. For seven indicators, we report no data. In five of these cases, some data exist, but they are of uncertain coverage or consistency and have not been aggregated for national reporting. Two indicators require additional refinement or other development before reporting is possible. Eight of the indicators are, or should be, reported on a regional basis.

After the following brief summaries of the findings and data availability for each indicator, the remainder of this chapter consists of the indicators themselves. Each indicator page offers a graphic representation of the available data, defines the indicator and explains why it is important, and describes either the available data or the gaps in those data.

Each of the indicators in this section focuses on some part of the overall "coasts and oceans" system: estuaries, bays, and the like; shorelines; waters within 25 miles of the coast; waters out to 200 miles; and combinations of these four components. See Table 5.1 (p. 68) for the reporting area for each indicator.

System Dimensions

Tracking changes in selected types of coastal land and water habitat is important for understanding the goods and services that this system can provide. There are two basic indicators of coastal system dimensions. The first tracks the changes in area of such key habitat types as coastal wetlands, coral reefs, and seagrasses; the second focuses on the nature of the shoreline itself—beach, wetlands, cliff, bulkhead, and so on.

- **What is the area of coastal wetlands, coral reefs, seagrasses, and shellfish beds?** These features are key habitat for many species of crabs, fish, and seabirds, as well as for the smaller creatures that serve as food for these larger animals. These habitats are unique in that they are created by living (or once-living) organisms, such as mangrove trees and coral. From the mid-1950s to the mid-1990s, wetland acreage on the Atlantic and Gulf coasts declined by about 400,000 acres, or about 8%, with the rate of loss slowing in the 1990s. Data are not adequate for national reporting on wetlands in other regions or on seagrasses, shellfish beds, or coral reefs.

- **How much of the nation's shoreline is composed of beach, sand or mudflats, steep cliffs, wetlands and mangroves, and how much has bulkheads or riprap?** More than two-thirds of the 37,000 miles of shoreline mapped to date is coastal wetlands, most of which are in the South Atlantic region. Sixteen percent, or 6,000 miles, is beach. Steep shorelines and mud and sand flats each make up about 8% of the total, and armored shorelines account for about 11%. (Some areas, such as sandy beaches backed by steep cliffs, may be counted twice.) These data are for the Pacific and South Atlantic coasts; data for other regions have not yet been analyzed.

Chemical and Physical Condition

Four quite varied indicators describe the chemical and physical condition of the nation's coasts and oceans. Oxygen and temperature are two key determinants of the kinds of marine plants and animals that can inhabit a region. Thus, we track the area of coastal waters with abnormally low oxygen levels and changes in regional sea surface temperature. Chemical contamination is also of concern, so we track changes in harmful man-made chemicals that can accumulate in bottom sediments. The fourth indicator will track the percentage of the nation's shoreline that is eroding.

- **How extensive are areas with low dissolved oxygen levels?** Low-oxygen (hypoxic) and no-oxygen (anoxic) conditions can cause mass mortalities among aquatic animals and disrupt migration patterns. Data are not adequate to report on the extent of these areas.
- **How contaminated are bottom sediments in estuaries and coastal ocean waters?** About 60% of the area of estuaries on the Mid-Atlantic, South Atlantic, and Gulf Coasts has levels of contaminants that might harm fish or wildlife, and 2% has levels that probably will harm these organisms. Neither trend data nor data on other regions are available.
- **How much of the nation's coastline is eroding?** Erosion can damage coastal properties and decrease the recreational value of beaches. Data are not adequate for national reporting on erosion and the opposite process, accretion, for the U.S. coastline.
- **What is the temperature of the ocean's surface?** Plants and animals are accustomed to certain water temperature ranges, and changes in temperature may cause species to disappear (or appear) in certain areas. Data for a 14-year period show neither warming nor cooling trends for waters within 25 miles of the U.S. coast.

Biological Components

Six indicators describe biological conditions within coastal waters. As in other ecosystems, one indicator tracks species that are at risk of extinction. Another records unusual "mortality events" among such marine animals as whales, sea turtles, seabirds, and fish, and a third considers the condition of worms, snails, and other bottom-dwelling animals. Three indicators, two still under development, focus on undesirable species or conditions. One of the indicators that needs further development would track the "blooms" of several toxic algae harmful to people or marine animals; the other would report on invasions of non-native species that can supplant more desirable natives. The last of the indicators measures the concentration of chlorophyll in coastal waters—chlorophyll is a measure of the presence of algae, which in excess can be harmful to fish and other animals and plants and interfere with swimming and other recreation.

- **How many native marine species are at different levels of risk of extinction?** The nation's coastal waters are home to a staggering diversity of plants and animals, from microscopic organisms to the world's largest animals. However, we know the status of only a very few of these species; data are not adequate for national reporting on marine species at risk of extinction.
- **What is the extent of invasion by non-native species?** More work is needed to develop this indicator, which will consider both the number of non-native species and what fraction of available habitat they occupy.

- **How many marine mammals, turtles, and other animals die in unusual "mortality events"?** For both major groups of marine mammals (whales, dolphins, and porpoises; and seals, sea lions, sea otters, and manatees), there were at least three years out of the last ten in which no unusual mortalities occurred. Years with high mortalities included 1992 (more than 2500 sea lions) and 1999 (215 harbor porpoises and 270 gray whales). Data are not adequate for national reporting on sea turtles, seabirds, fish, and shellfish.
- **How frequent and extensive are harmful algal blooms?** Harmful algae produce toxins that pose a danger to people as well as to marine animals. Data are not adequate for national reporting on this indicator.
- **What is the condition of small bottom-dwelling animals (worms, clams, snails, and shrimplike animals)?** About half the estuary area in along the Mid-Atlantic, South Atlantic, and Gulf coasts has bottom-dwelling communities that are considered to be in "undegraded" condition when compared to a relatively undisturbed site. About 20% are in "degraded" condition. Data are not available for reporting on other regions or for oceans.
- **What is the concentration of chlorophyll in coastal waters?** Chlorophyll is a measure of the abundance of algae, which are the source of food, directly or indirectly, for most marine animals, but too many algae can be harmful to other marine life. Only very short-term data are available for ocean waters (3 years); additional data are needed to establish trends. Data are not adequate for national reporting on estuaries.

Human Use

Four indicators describe the way people use the coasts and oceans. Three indicators focus on commercially important fish and shellfish: trends in commercial fish landings; trends in commercially important fish populations; and trends in chemical contaminants found in fish and shellfish, which might affect human health. The fourth indicator tracks contamination of beaches by bacteria from human or animal waste—a constraint to beach use that complements the core national outdoor recreation indicator (p. 60).

- **What is the size of the commercial fish catch from U.S. waters?** Since the late 1970s, landings of fish and shellfish from U.S. waters have totaled around 5 million tons per year. Over this time, and for most regions, landings have remained more or less constant (the catch in Alaska from U.S. boats has increased). Estimates of catches before the late 1970s are uncertain because of the presence then of large foreign fleets, which are no longer permitted to fish in U.S. waters.
- **What is the condition of commercially important fish stocks in U.S. waters?** Overall, about 40% of stocks with known populations were declining in size and 20% were increasing in size. However, data are not available on the population trends of about three-fourths of all U.S. fish stocks.
- **What is the concentration of DDT, PCBs, and mercury in fish and shellfish caught in U.S. waters?** Seafood containing high levels of these contaminants can be harmful to human health, but data are not adequate for national reporting on this indicator.
- **How often are bacteria associated with human and animal waste found in bathing water at the nation's beaches?** Swimming in sewage-contaminated waters can cause disease. Data are not adequate for national reporting on this indicator.

What do we mean by "coasts and oceans"?

"Coasts and oceans" consists of three components: estuaries, ocean waters under U.S. jurisdiction, and the shoreline along both estuaries and oceanfront areas.

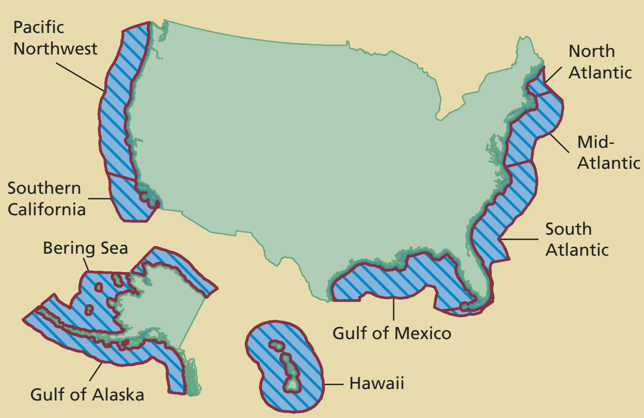
Estuaries are partially enclosed bodies of water (often referred to as bays, sounds, lagoons, fjords, and the like), where fresh water from the land is mixed with salt water from the ocean. They are generally considered to begin at the upper end of tidal or saltwater influence and end where they meet the ocean, although major rivers often have plumes of brackish water (mixed fresh and salt) that extend

Table 5.1. Reporting Areas for Coasts and Oceans Indicators

Shorelines	Estuaries	Estuaries and Ocean Waters within 25 Miles of Shore[a]	Estuaries and Ocean Waters to 200 Miles	Ocean Waters within 25 Miles of Shore[a]
■ Shoreline Types ■ Coastal Erosion ■ Recreational Water Quality	■ Non-native Species ■ Condition of Bottom-Dwelling Animals	■ Areas with Depleted Oxygen ■ Contamination in Bottom Sediments ■ Chlorophyll Concentrations	■ Coastal Living Habitats ■ At-Risk Marine Species ■ Unusual Marine Mortalities ■ Harmful Algal Blooms ■ Commercial Fish and Shellfish Landings ■ Status of Commercially Important Fish Stocks ■ Selected Contaminants in Fish and Shellfish	■ Sea Surface Temperature

[a] *While it would be preferable in many cases to adjust the width of the reporting zone to conform to the extent of brackish water, the lack of consistent national monitoring of the extent of brackish water makes this impractical at this time. Because of this, these indicators focus on the area within 25 miles of the coast, a relatively conservative value for the width of this zone.*

Map 5.1. Regions Used for Reporting Selected Coasts and Oceans Indicators



Note: The regions shown here conform to those used by the National Oceanic and Atmospheric Administration in its National Estuarine Eutrophication Assessment and the Environmental Protection Agency's Environmental Monitoring and Assessment Program; they also match the regional structure established for regional marine research under Public Law 101-593. For some indicators, regions are combined for reporting purposes.

for great distances. Many estuaries are highly productive, highly variable environments, and many have been greatly affected by human activities.

In general, ocean waters along the coast are largely influenced by the deep ocean, while terrestrial ecosystems are the main influence on estuaries. Both estuaries and ocean encompass a wide variety of habitats, including salt and brackish water, subtidal habitats (e.g., soft and hard bottom communities, coral and oyster reefs, and beds of seagrasses and kelp) and intertidal habitats (rocky shores, mud flats, marshes, and mangrove forests).

By definition, U.S. waters extend to the boundaries of the 200-mile Exclusive Economic Zone (EEZ),[1] but not all indicators report on this entire zone. In reporting the extent of coastal waters (see the core national extent indicator, p. 40), we have selected the area of "brackish water"—the area in which the influence of fresh water from rivers and groundwater reduces salinity below that of the open ocean. The width of this area varies; along the Pacific Coast it is relatively narrow, while along parts of the Atlantic Coast it may be as wide as 200 miles. Table 5.1 shows the reporting area for each of the 16 indicators.

A Note about Regions

Eight of the sixteen Coasts and Oceans indicators are reported on a regional basis, and they all make use of the same regional definitions (see Map 5.1). These indicators are shoreline types (p. 70); areas with depleted oxygen (p. 71), sea surface temperature (p. 74), at-risk species (p. 75), condition of bottom-dwelling animals (p. 79), chlorophyll concentration (p. 80), commercial fish and shellfish landings (p. 81), and the status of commercially important fish stocks (p. 82).

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[1] *The Exclusive Economic Zone of the United States was established in 1983 by presidential proclamation (#5030). See text at* http://www.nara.gov/fedreg/codific/procs/p05030.html. *According to the United Nations Convention on the Law of the Sea, nations have sovereign rights in a 200-nautical-mile exclusive economic zone (EEZ) with respect to natural resources and certain economic activities, and they exercise jurisdiction over marine science research and environmental protection in the EEZ.* http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm *(accessed November 21, 2001).*

SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent	Nutrients, Carbon, Oxygen	Plants and Animals	Food, Fiber, and Water
Pattern	Contaminants	Communities	Recreation and Other Services
	Physical	Ecological Productivity	

◐ Coastal Living Habitats (Coral Reefs, Wetlands, Seagrasses, and Shellfish Beds)

What Is This Indicator, and Why Is It Important? This indicator reports the acreage of coastal habitats whose defining feature is that they are composed of living organisms (such as seagrasses, mangrove forests, and coastal wetlands) or are built by them (such as coral reefs or shellfish beds). These areas provide habitat for many other organisms, and in some cases (such as shellfish beds) they continue to do so even after the animals that built them are no longer living.

Loss of habitat is a major cause of the decline of coastal species. The habitats described here are critical for many species of crabs, fish, and seabirds, as well as for smaller animals that provide food for these larger creatures. When these habitats decline in area, organisms that depend on them are lost or displaced.

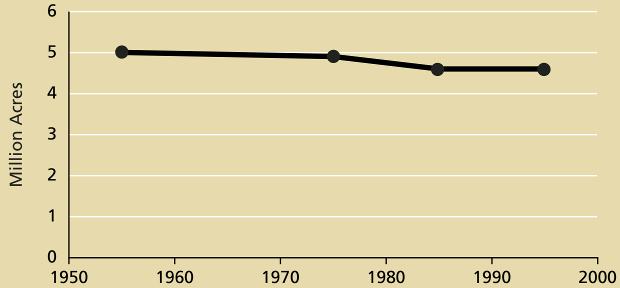
What Do the Data Show? From the mid-1950s to the mid-1990s, wetland acreage on the Atlantic and Gulf coasts declined by about 8%. Four hundred thousand acres of coastal wetlands, out of a total of 5 million acres, were lost, although the rate of loss slowed in the 1990s.

Coastal Living Habitats

Data Not Adequate for National Reporting on

- Seagrasses/Submerged Vegetation
- Shellfish Beds
- Coral Reefs
- Wetlands in Other Regions

Partial Indicator Data: Coastal Vegetated Wetlands (Atlantic and Gulf Coasts Only)



Data Source: U.S. Fish and Wildlife Service. Coverage: no data are available for the Pacific Coast, Alaska, Hawaii, U.S. Virgin Islands, or Puerto Rico.

Why Can't This Entire Indicator Be Reported at This Time? Data for coral reefs and seagrasses and other "submerged aquatic vegetation" are available for many areas, but these data have not been synthesized to produce national estimates. (A federal task force has developed a 5–7-year plan for mapping all coral reefs in U.S. waters.) Data on the area of shellfish beds are available, but changes in the area covered by monitoring programs may obscure changes in the area of shellfish beds. Data on vegetated wetlands are available only for the East (Maine to Florida) and Gulf coasts.

The technical note for this indicator is on page 218.

SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent	Nutrients, Carbon, Oxygen	Plants and Animals	Food, Fiber, and Water
Pattern	Contaminants	Communities	Recreation and Other Services
	Physical	Ecological Productivity	

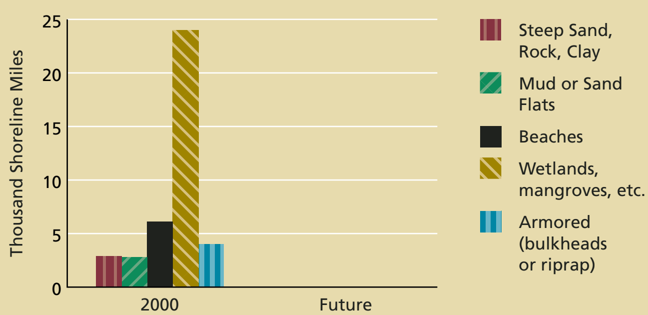
◐ Shoreline Types

Shoreline Types

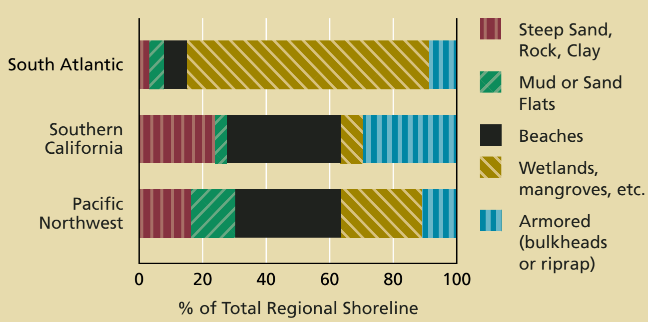
Data Not Adequate for National Reporting on

- North Atlantic
- Mid-Atlantic
- Gulf of Mexico
- Gulf of Alaska
- Bering Sea
- Hawaii

Partial Indicator Data: Shoreline Types (Pacific Northwest, Southern California, and South Atlantic Regions Only)



Partial Indicator Data: Shoreline Types, by Region (2000) (Pacific Northwest, Southern California, and South Atlantic Regions Only)



Data Source: National Oceanic and Atmospheric Administration.

What Is This Indicator, and Why Is It Important? This indicator reports the miles of coastline in several categories, including beach; mud or sand flats; steep sand, rock, or clay cliffs; wetlands; and coastline "armored" with bulkhead or riprap. The coastline includes ocean-front areas and the shoreline of estuaries and bays.

Whether a shoreline is, for example, beach, mudflat, or bulkhead determines how people and wildlife will use that shoreline. Armoring is usually intended to stabilize a beach or shoreline in an attempt to reduce erosion and property loss from storms, coastal flooding, and other processes (see Coastal Erosion, p. 73).

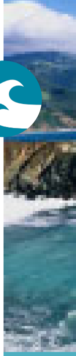
What Do the Data Show? Over two-thirds of the mapped shoreline (37,000 miles) in these three regions is coastal wetlands (24,000 miles), most of which are in the South Atlantic region. Sixteen percent, or 6,000 miles, of the mapped shoreline is beach. Steep shorelines and mud and sand flats each make up about 8% of the total (2,800 miles), while armored shorelines make up about 11% of the total (about 4,000 miles). (These numbers exceed the total shoreline miles because some locations contain multiple shoreline types, e.g., sandy beach backed by a steep cliff.)

Beaches account for about a third of the shoreline of both Southern California and the Pacific Northwest, but these regions differ greatly in other respects. Southern California has a much lower percentage of wetlands and mud or sand flats and a much higher proportion of both steep shorelines and armored shorelines. Three-quarters of the South Atlantic region's shoreline is wetlands, and nearly 10% is armored.

The National Oceanic and Atmospheric Administration is analyzing data for other regions, but the analysis is not yet complete.

Discussion Besides the benefits mentioned above, bulkheads and other "armoring" can have negative effects on natural coastlines, by isolating coastal wetlands from tidal influence, for example, which can dramatically alter the wetlands. In addition, these structures may provide only temporary erosion control and can ultimately result in complete loss of the beach.

The technical note for this indicator is on page 219.

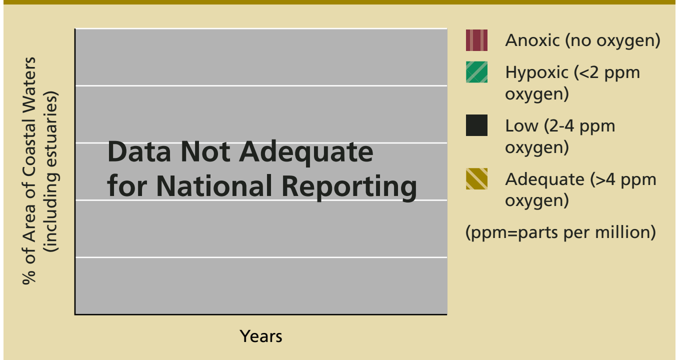


⊖ Areas with Depleted Oxygen

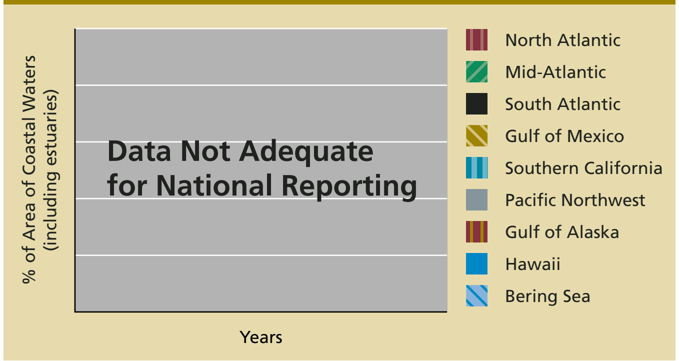
What Is This Indicator, and Why Is It Important? This indicator will report the percentage of area of estuaries and coastal waters out to 25 miles whose lowest oxygen levels fall within one of several concentration ranges for at least 1 month. These ranges are: anoxic (no oxygen present), hypoxic (up to 2 parts per million, or ppm), low (between 2 and 4 ppm), and adequate (more than 4 ppm). In addition, for each region the percentage of coastal and estuarine waters that are hypoxic for at least 1 month will be reported.

Most animals that live in the water need oxygen, and, except for air-breathing animals like turtles and whales, most use oxygen dissolved in the water. Natural processes and human pollution can cause serious reductions in dissolved oxygen. Both anoxia (no oxygen) and hypoxia (very low oxygen) are harmful to fish, shellfish and other marine animals. These conditions can result in mass mortalities (see p. 77) and increases in predation, reduce the area of suitable habitat, and form barriers through which migratory species such as striped bass and salmon cannot pass, keeping them from their spawning grounds.

Oxygen Levels—Nationally



Hypoxic Waters—By Region



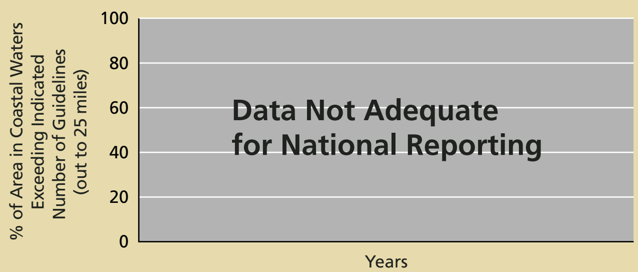
Why Can't This Indicator Be Reported at This Time? Too few estuaries and waters of the U.S. coastal ocean are sampled frequently or thoroughly enough to report on this indicator at a regional or national scale.

Discussion High algae growth, often fueled by nutrients from runoff, sewage treatment plants, or deposition of airborne pollutants, can lead to increased bacterial activity (as bacteria decompose the algae); this increased activity can deplete available oxygen. Low oxygen levels generally affect bottom waters first and most severely. See the chlorophyll indicator, p. 80, and the national nitrogen indicator, p. 46.

The technical note for this indicator is on page 220.

◐ Contamination in Bottom Sediments

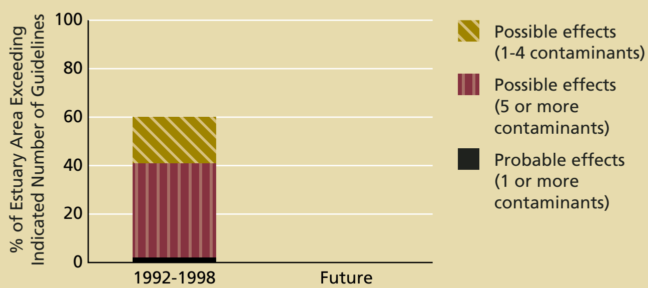
Sediment Contamination—Ocean



Sediment Contamination—Estuaries

Data Not Adequate for National Reporting on
- North Atlantic
- Pacific Coast
- Alaska
- Hawaii

Partial Data Indicator: Mid-Atlantic, South Atlantic, and Gulf Coast Regions Only



Data Source: U.S. Environmental Protection Agency, Environmental Monitoring and Assessment Program (EMAP). Guidelines are from the National Oceanic and Atmospheric Administration (NOAA).

What Is This Indicator, and Why Is It Important? This indicator reports the percentage of sediments that exceed federal guidelines for concentrations of four major classes of contaminants—pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals. The indicator reports on estuaries and ocean waters within 25 miles of the coast that have bottom sediments with varying degrees of contamination, the lowest indicating *possible* effects on fish and other aquatic organisms from 1 to 4 contaminants and the highest indicating *probable* effects from at least one contaminant.

Polluted sediments are a starting point for contamination throughout the food chain, potentially damaging marine life and affecting human health (see Selected Contaminants in Fish and Shellfish, p. 83). Pollutants from industrial discharges, burning of fossil fuels, and runoff from farms and urban and suburban areas are carried to coastal waters by rivers, rainfall, and wind, where they accumulate on the bottom. Small organisms incorporate these contaminants into their bodies, and when they are eaten by other organisms, the contaminants may move up the food chain (bioaccumulation). Areas with contaminated sediments may also be unsafe for swimming and other recreation.

Why Can't This Entire Indicator Be Reported at This Time? No program exists to provide nationally consistent data on sediment contamination in ocean waters along the coast. Data for estuaries in the North Atlantic, Southern California, and Pacific Northwest will be available in the future.

What Do the Data Show? Sediment contaminant levels in about 60% of the area of U.S. estuaries monitored are high enough to potentially harm fish and other aquatic organisms. In 19% of sediments, the concentration of 1 to 4 contaminants exceeds the guideline for *possible* harmful effects; in 39%, 5 or more contaminants exceed this level; and in 2%, contaminant levels exceed the guideline for *probable* harmful effects. (Note that all sites with contaminants exceeding the *probable* effects guidelines also had 5 or more compounds exceeding the *possible* effects level.)

Discussion The NOAA guidelines used here were developed as informal interpretive tools and are intended as the basis for regulatory decisions. The *possible* effects guidelines identify concentrations below which negative effects rarely occur, and thus levels above which such effects may occur. The *probable* effects guidelines indicate levels above which negative effects are likely.

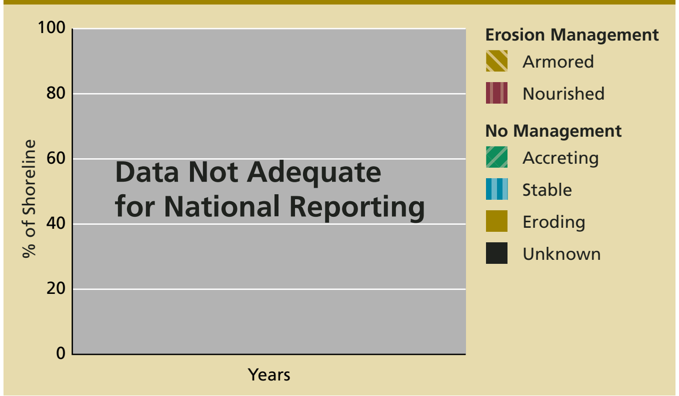
The technical note for this indicator is on page 220.

⊖ Coastal Erosion

What Is This Indicator, and Why Is It Important? The indicator will report how much of the U.S. coast is managed in an attempt to control erosion and how much remains in a "natural" state, with no erosion control. For unmanaged areas, the indicator reports what fraction is eroding, accreting (gaining land area), or stable.

Management methods include replacement of sand (often called "beach nourishment") and construction of bulkheads or other "armoring." Neither approach necessarily eliminates future erosion, but the effects of armoring generally last longer.

Coastal Erosion



Coastal erosion costs hundreds of millions of dollars a year, including damage caused by storms and flooding, costs of erosion prevention, and expenses to dredge channels and harbors. Poorly designed or sited development can lead to erosion, while measures to control erosion in one place may exacerbate it in others and may have significant environmental impacts of their own. Accretion may also create problems, as when inlets fill in, interfering with navigation. Also, many experts predict that continued global warming will be accompanied by rising sea levels, resulting in increased coastal erosion worldwide.

Why Can't This Indicator Be Reported at This Time? Assessments of shoreline stability are now conducted as short-term or single-purpose projects that are neither regional nor national in scope. Local assessments often use different methods, which makes it difficult to combine results into an accurate national picture.

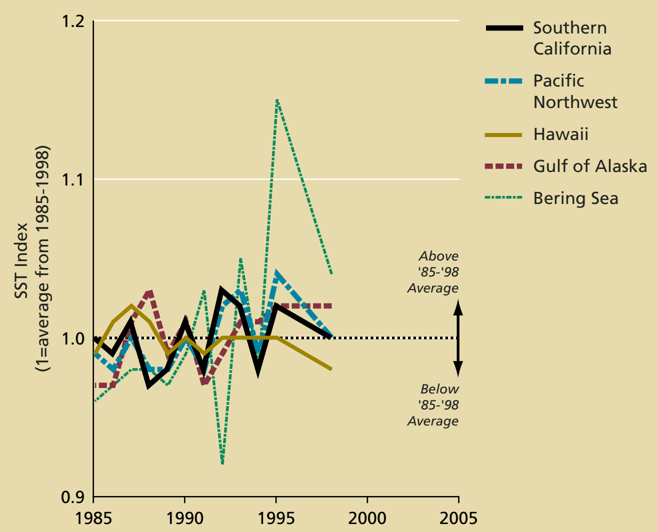
Discussion Scientists and coastal managers will need to agree on numerical definitions of "eroding" or "accreting" (this is likely to be in the range of from one-half to several feet horizontally per year). Further, how long a beach that has been nourished should be reported as "managed" needs to be determined.

Priority should be given to using the large amount of existing local data, which will require assessment of coverage, quality, and comparability. Also, standard methods and definitions should be developed for nationwide use, ensuring the compatibility of data collected in the future.

The technical note for this indicator is on page 221.

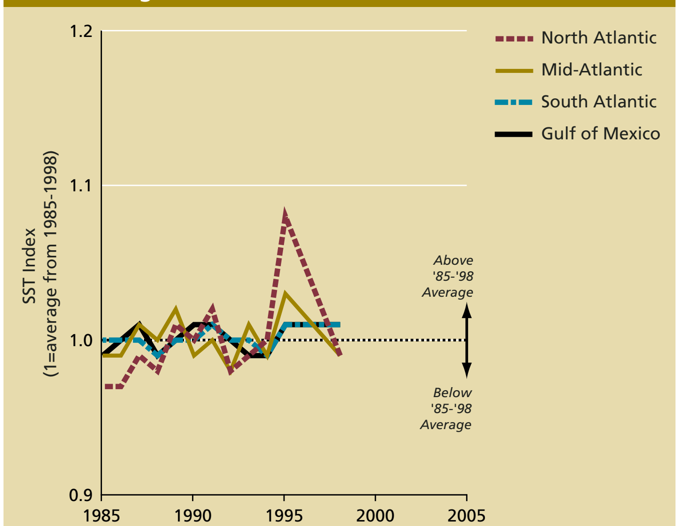
Sea Surface Temperature

Western Region



Data Source: National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration. Coverage: ocean waters within 25 miles of the coast, not including estuaries.

Eastern Region



Data Source: National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration. Coverage: ocean waters within 25 miles of the coast, not including estuaries.

Note: The South Atlantic and Gulf of Mexico lines on the graph coincide for several years.

What Is This Indicator, and Why Is It Important? This indicator describes whether sea surface temperature (SST) is above or below average. Using an index, the indicator tracks how much regional average temperatures in any given year deviate from the average for the 14-year period, for waters within 25 miles of the coast. Thus, a “1.1” on the graph means that the SST for that region in that year was 10% warmer than the 14-year average for that region. The indicator defines “average SST” for a region as the average temperature for the warmest season in that region.

Water temperature directly affects the species of plants (such as algae, seagrasses, marsh plants, and mangroves) and animals (microscopic animals, larger invertebrates, fish, and mammals) that live in a particular region. In addition, increases in temperature are thought to be associated with the degradation of coral reefs (bleaching) and may increase the frequency or extent of blooms of harmful algae (see Harmful Algal Blooms, p. 78). There is widespread concern that global climate change may lead to increases in SST. Such changes could, in turn, lead to increases in the strength and frequency of storms and changes in ocean currents, such as the Gulf Stream, that would in turn lead to shifts in regional climate.

What Do the Data Show? While SST varies noticeably from year to year, and there are individual reports of gradually increasing temperatures in several of these ocean regions (see the technical note for citations), the data presented here do not show any trends.

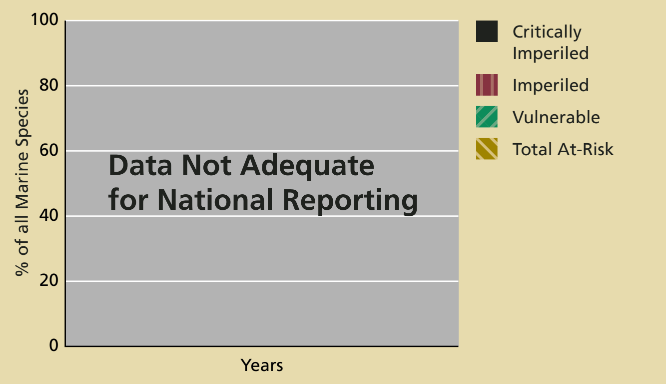
The technical note for this indicator is on page 222.

⊖ At-Risk Native Marine Species

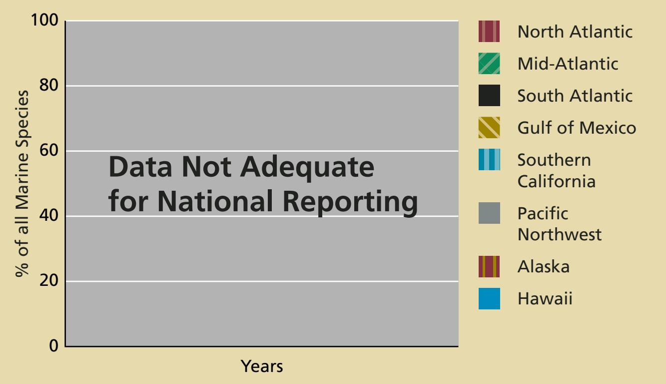
What Is This Indicator, and Why Is It Important? This indicator will report on the relative risk of extinction of native marine species, both plants and animals. The risk categories are based on such factors as the number and condition of individuals and populations, the area occupied by the species, population trends, and known threats. Degrees of risk to be reported here range from very high ("critically imperiled" species are often found in five or fewer places or have experienced very steep declines) to moderate ("vulnerable" species are often found in fewer than 80 places or have recently experienced widespread declines). Species ranked as "secure" or "apparently secure" would not be reported. The data would also be presented on a regional basis for estuaries and coastal waters out to 200 miles.

Species are valued for a variety of reasons: they provide products, including food, fiber, and genetic materials; they are key elements of ecosystems, which themselves provide valuable goods and services; and many people value them for their intrinsic worth or beauty.

At-Risk Marine Species, by Risk Category



At-Risk Marine Species, by Region



Why Can't This Indicator Be Reported at This Time? Data are available on the status of only a relatively small number of marine species, including those of commercial interest (see p. 82) and those that are listed for protection under the Endangered Species Act and Marine Mammal Protection Act. However, these programs do not address the status of a broad cross-section of marine species, as is needed for this indicator.

NatureServe and its member natural heritage programs (see www.natureserve.org) report on the status of about 22,000 U.S. species (see the forest (p. 124), freshwater (p. 144), grasslands and shrublands (p. 168), and core national (p. 52) at-risk species indicators). These programs provide a useful framework for reporting on marine species, but so far their datasets contain information on only a relatively small number of marine species.

There is no technical note for this indicator. The technical note for the core national indicator for at-risk species (p. 214) describes NatureServe's natural heritage programs.

Non-native Species

Non-native Species

Indicator Development Needed

What Is This Indicator, and Why Is It Important? This indicator will report the percentage of major estuaries with high, medium, or low influence by non-native species. Ratings of the degree of influence should incorporate both the number of different species present and the degree to which they occupy available habitat.

Non-native species often spread aggressively and crowd out species native to a region; they may act as predators or parasites of native species, cause diseases, compete for food or habitat, and alter habitat. These species—whose spread has been promoted by increased travel and trade—may also pose threats to human health (e.g., exotic diseases and harmful algae) and economic well-being (e.g., loss of shellfish production). Non-native species are also called nonindigenous, exotic, alien, or introduced species; particularly aggressive species are termed "invasive."

U.S. estuaries are now home to many non-native species. These include the Asian clam and the veined, or Asian, rapa whelk, which cause economic and ecological damage as they displace native clams and mussels, and the European green crab, which is blamed for the collapse of the soft-shelled clam industry in Maine. The problem is both worldwide and apparently growing: an introduced North American jellyfish has devastated the anchovy fishery in the Black Sea, and in San Francisco Bay three or four new non-native species are established each year.

Why Can't This Indicator Be Reported at This Time? There are neither nationwide monitoring programs for coastal non-native species nor agreed-upon methods for combining information on the number of species and the area they occupy into a single index. Individual studies have documented the occurrence of non-native species in major estuaries, but this information has not been gathered regularly or on a broad scale.

Discussion Several more decisions about the scope of this indicator are required: whether to focus on all non-natives or only on invasive species; whether North American species that are found outside their normal range should be treated as non-natives; and whether there is a time (e.g,. 50 or 100 years) after which an introduced species is considered to be native.

The technical note for this indicator is on page 222.

SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	**BIOLOGICAL COMPONENTS**	HUMAN USES
Extent	Nutrients, Carbon, Oxygen	**Plants and Animals**	Food, Fiber, and Water
Pattern	Contaminants	Communities	Recreation and Other Services
	Physical	Ecological Productivity	

◐ Unusual Marine Mortalities

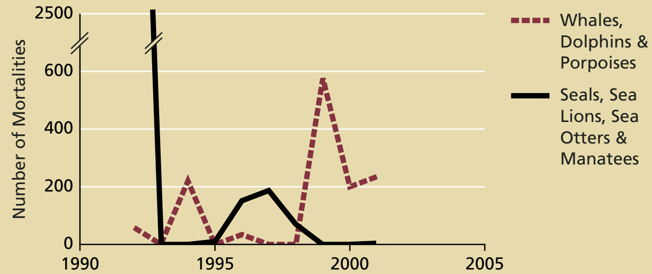
What Is This Indicator, and Why Is It Important? This indicator reports the occurrence of "unusual" mortalities of marine animals. Unusual mortality events (UME) are characterized by an abnormal number of dead animals or by the appearance of dead animals in locations or at times of the year that are not typical for that species. For larger animals like whales, dolphins, porpoises, seals, sea lions, sea otters, manatees, and sea turtles, where a small number of deaths is significant, the indicator will report the actual number of dead individuals. For smaller, more abundant, animals (seabirds, fish, and shellfish), the indicator will report the number of mortality events, rather than number of individual deaths.

Factors that may contribute to unusual mortalities include infectious diseases, toxic algae (see Harmful Algal Blooms, p. 78), and uncommon weather patterns. Trends in unusual mortalities are generally believed to reflect the integrity of an ecosystem.

Unusual Mortalities: Marine Mammals and Sea Turtles

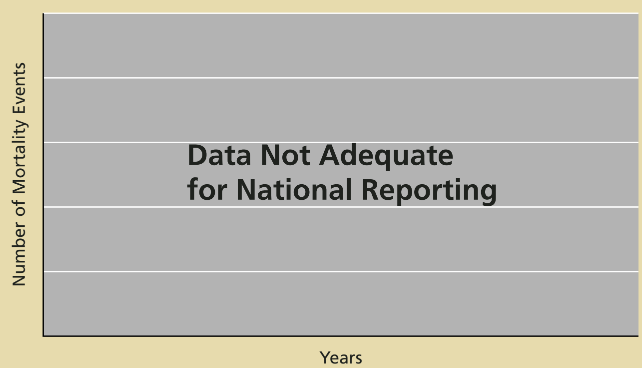
Data Not Adequate for National Reporting on
■ Sea Turtles

Partial Indicator Data: Marine Mammals



Data Source: National Marine Fisheries Service and Dierauf and Gulland (2001). Coverage: all U.S. waters.

Unusual Mortalities: Seabirds, Fish and Shellfish



Why Can't This Entire Indicator Be Reported at This Time? National data on turtle, seabird, fish, and shellfish mortality events are not available. Further work is required to define the criteria for UMEs for seabirds, fish, and shellfish.

What Do the Data Show? Over 2,500 California sea lions were involved in a UME in 1992—more than 10 times the total number of seals, sea lions, sea otters, and manatees lost in UMEs for any year since. The deaths of 150 manatees off the Florida coast during 1996 and 185 California sea lions in 1997 were the next largest events for this group. For whales, dolphins, and porpoises, perhaps the most striking finding is the peak in 1999; the 576 deaths in that year reflect the deaths of 215 harbor porpoises and 270 gray whales off the West Coast (unusual gray whale deaths continued over the next two years, during which some 400 more animals died).

Discussion Instead of reporting all observed mortalities, this indicator reports unusual events. By restricting reporting in this way, the indicator focuses on events that raise more serious concern about the state of the marine environment than would more typical mortalities, which may be caused by old age or "normal" interactions with people, such as recreational boat strikes or entanglement in fishing nets.

The technical note for this indicator is on page 223.

SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	**BIOLOGICAL COMPONENTS**	HUMAN USES
Extent	Nutrients, Carbon, Oxygen	Plants and Animals	Food, Fiber, and Water
Pattern	Contaminants	**Communities**	Recreation and Other Services
	Physical	Ecological Productivity	

ⓘ Harmful Algal Blooms

Harmful Algal Blooms

Indicator Development Needed

What Is This Indicator, and Why Is It Important? This indicator will report the number of harmful algal blooms (HABs) of low, medium, and high intensity for estuaries and ocean waters within 200 miles of shore. Harmful algal blooms are defined as an increased abundance of algae species that cause illness in people or marine animals or the actual occurrence of algae-caused illnesses.

HABs can cause mass mortalities of marine organisms (p. 77), are a public health risk, and can cause economic damage through declines in tourism, shellfish bed closures, and reductions in the market value of seafood. There are indications that HABs may be occurring more frequently, both in the United States and worldwide. The causes of HABS are not fully known, but changes in sea surface temperature (see p. 74) and nutrient inputs (see the national nitrogen indicator, p. 46) are believed to increase the likelihood of such events.

Why Can't This Indicator Be Reported at This Time? There are no nationwide monitoring or reporting programs for harmful algal blooms, nor are there generally accepted definitions of low, medium, and high intensity. High-intensity events might be defined as those that last for more than a month or affect an area of 40 square miles or more, low-intensity events as those that last for less than a week or affect less than 4 square miles and medium-intensity events as those that are intermediate in either size or duration. Because these definitions apply to a classic "bloom" event, they would have to be refined to include events that are characterized by illness in people or marine animals.

Discussion Algae, also called phytoplankton, are directly or indirectly the source of food for virtually all marine animals, including commercial and sport fish. Most species are not toxic, and most algal blooms do not involve species that produce toxins harmful to people or animals; however, they may reduce oxygen in coastal waters, which can harm fish and other animals (see the hypoxia indicator, p. 71). This indicator targets the most common species known to produce toxins; these species are listed in the technical note.

The technical note for this indicator is on page 224.

◐ Condition of Bottom-Dwelling Animals

What Is This Indicator, and Why Is It Important? This indicator describes the condition of worms, clams, snails, and shrimplike animals in bottom sediments ("benthic communities") by reporting the percentage of area in which these communities are in "undegraded," "moderate," and "degraded" condition. The indicator is calculated by comparing the number and kinds of animals found in a sampling site with those that would be expected in an undisturbed area of similar character (a reference site). The indicator would be reported for estuaries and for ocean areas within 25 miles of the coast.

Benthic communities reflect the influence of contaminants, oxygen levels, physical changes in habitat (such as from trawling), and shifts in temperature or salinity. They are a good indicator because contaminants accumulate in bottom sediments and hypoxia (lack of oxygen) is most severe there. Also, these animals live several years, so their response reflects exposure to these stresses over a long period, and they are fairly immobile, so their condition strongly reflects conditions at the site where they were collected (see the depleted oxygen and sediment contamination indicators, pp. 71 and 72).

Why Can't This Entire Indicator Be Reported at This Time? Data are available from estuaries in most regions of the country, but the tools needed to compare benthic communities with those in undisturbed sites have been developed for only three regions. Additional work is also needed to ensure that the indicators developed for different regions are comparable. Only limited data are available for ocean waters out to 25 miles.

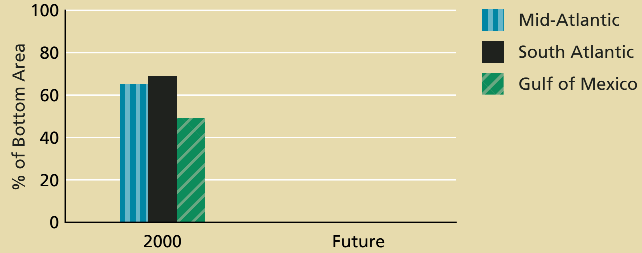
What Do the Data Show? At least half the estuary area in the Mid-Atlantic, South Atlantic, and Gulf of Mexico regions has "undegraded" bottom-dwelling animal communities. About 20% of estuary area in these regions has "degraded" bottom-dwelling animal communities.

Benthic Community Conditions

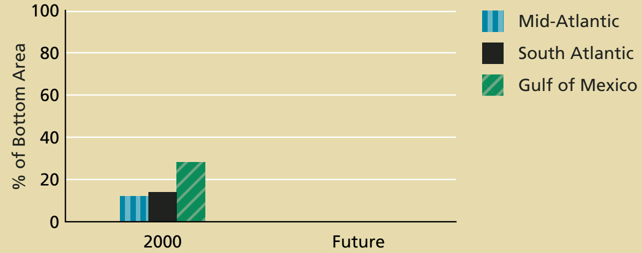
Data Not Adequate for National Reporting on

- Ocean: all regions
- Estuaries: North Atlantic, West Coast, Alaska, and Hawaii

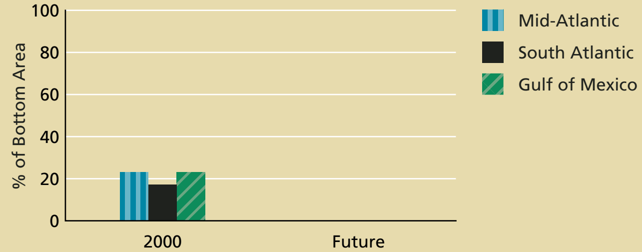
Benthic Community Condition: "Undegraded" (Estuaries Only in Regions Shown)



Benthic Community Condition: "Moderate" (Estuaries Only in Regions Shown)



Benthic Community Condition: "Degraded" (Estuaries Only in Regions Shown)



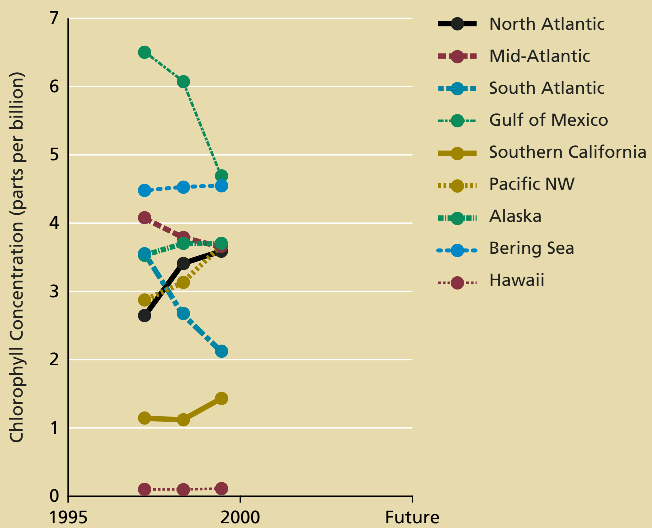
Data Source: U.S. EPA Environmental Monitoring and Assessment Program.

Discussion "Undegraded" means that the benthic animals found at a site are similar in number and type of species to those expected in an undisturbed site in that region. "Degraded" means that the animals found are quite different from those at a reference site, reflecting one or more negative influences.

The technical note for this indicator is on page 225.

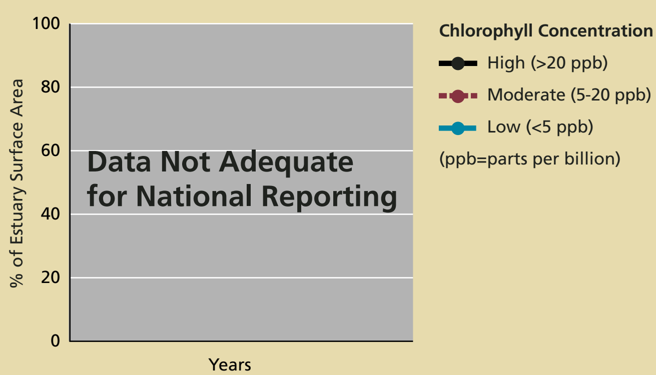
◐ Chlorophyll Concentrations

Chlorophyll Concentrations: Ocean Waters



Data Source: National Ocean Service, National Oceanic and Atmospheric Administration; National Aeronautics and Space Administration. Coverage: all U.S. waters, including Alaska and Hawaii, within 25 miles of the coast.

Chlorophyll Concentrations: Estuaries



What Is This Indicator, and Why Is It Important? This indicator reports the chlorophyll concentration in estuaries and ocean waters within 25 miles of shore. For ocean waters, the indicator reports the average value for the season with the highest concentration, for each region. For estuaries, the indicator will report the percentage of area in three ranges: below 5 parts per billion (ppb), between 5 and 20 ppb, and above 20 ppb, using data for the season with the highest average concentration.

Chlorophyll concentration is a measure of the abundance of algae, also called phytoplankton, which account for most of the plant production in the ocean. Phytoplankton are difficult to measure directly, yet they are the direct or indirect source of food for most marine animals.

Although increasing algae growth (as measured by chlorophyll) tends to support larger fish populations, excessive growth often leads to degraded water quality—for example, decreases in water clarity, noxious odors, oxygen depletion (see p. 71), and fish kills (see p. 77)—and may be linked to harmful algal blooms (see p. 78). Excessive algae growth appears to occur as a consequence of increases in nutrient inputs (especially nitrogen—see the national nitrogen indicator, p. 46) and in response to declines in the abundance of filter-feeding organisms like oysters, clams, and mussels.

Why Can't This Entire Indicator Be Reported at This Time? Most estuaries are not sampled frequently enough or thoroughly enough to produce comparable data on seasonal chlorophyll levels.

What Do the Data Show? Ocean data from 1998–2000 suggest that chlorophyll levels are higher in the Gulf of Mexico than in the waters off Hawaii and Southern California; differences between other regions may not be meaningful. The time series is too short to establish trends.

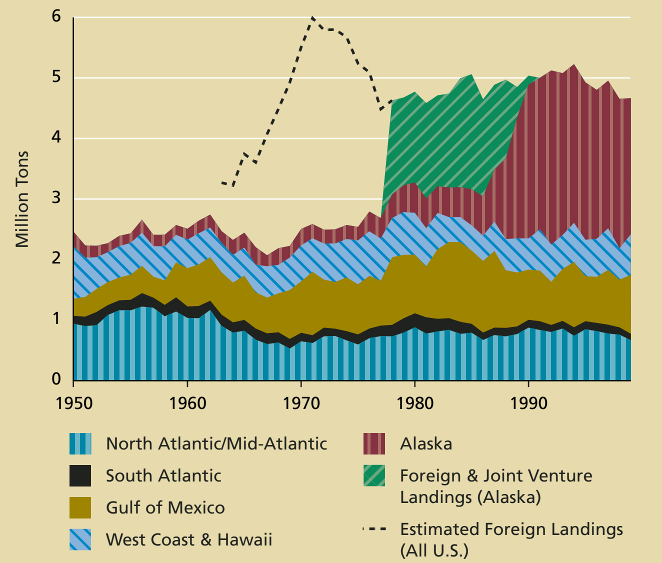
The technical note for this indicator is on page 226.

Commercial Fish and Shellfish Landings

What Is This Indicator, and Why Is It Important? This indicator reports the weight of fish, shellfish, and other products taken from U.S. waters. Landings, plus certain aquaculture harvests, are shown for five regions that cover all waters out to the 200-mile territorial limit.

The amount of fish and shellfish caught for food, meal, and oil is a measure of society's reliance on the seas for these products. Of total landings, about 70% is for human consumption, about 20% is for meal, oil, and other industrial purposes, and the remainder is used for bait and animal feed.

Commercial Fish and Shellfish Landings



Data Source: National Marine Fisheries Service. Coverage: all U.S. waters, including Alaska and Hawaii.

What Do the Data Show? Since the late 1970s, yearly landings of fish and shellfish from U.S. waters have totaled nearly 5 million tons. In the late 1970s, the United States established a Fishery Conservation Zone (FCZ), covering hundreds of thousands of square miles of formerly international waters. Foreign fishing in these waters was eliminated, except in Alaska, where it was phased out, ending completely in 1991. The total foreign catch in the FCZ is uncertain, as indicated by the dotted line on the graph, and pre-1963 estimates are not available. In most regions, landings by U.S. vessels have remained more or less constant over the past 30 years. In Alaska, an expanding fleet has substantially increased U.S. landings.

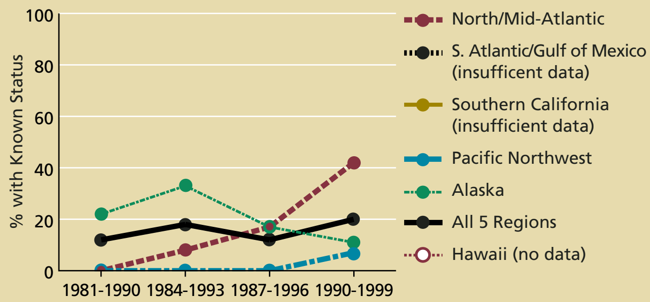
Discussion This indicator does not provide information on the condition of fish stocks (see Status of Commercially Important Fish Stocks, p. 82). Furthermore, these aggregate landing figures do not reveal that, over the years, fishing efforts have repeatedly shifted from species that have been depleted or overfished to others that have been relatively unexploited.

In 1999, about 84% of landings were fish, about 14% shellfish, and about 2% other products, including sea urchins and worms. These data include some aquaculture production.

The technical note for this indicator is on page 226.

◐ Status of Commercially Important Fish Stocks

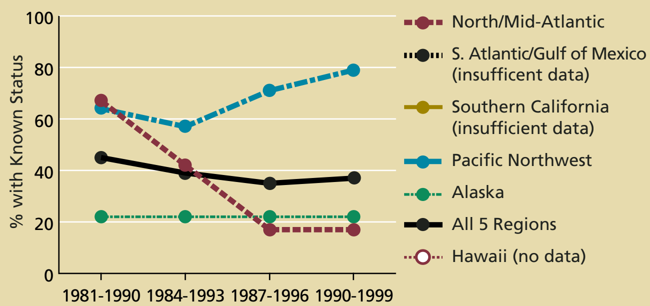
What Percent of Stocks Were Increasing?



Data Source: NOAA National Marine Fisheries Service, analyzed by Natural Resources Consultants, Inc. Coverage: does not include Hawaii. Nearshore stocks (generally in state waters within 3 miles of shore) are excluded.

Note: "All 5 regions" includes some data from South Atlantic/Gulf of Mexico and Southern California, but these data are insufficient to provide regional trends.

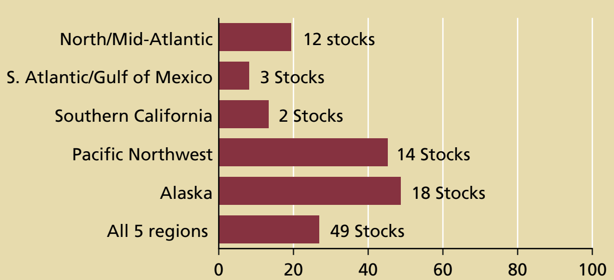
What Percent of Stocks Were Decreasing?



Data Source: NOAA National Marine Fisheries Service, analyzed by Natural Resources Consultants, Inc. Coverage: does not include Hawaii. Nearshore stocks (generally in state waters within 3 miles of shore) are excluded.

Note: "All 5 regions" includes some data from South Atlantic/Gulf of Mexico and Southern California, but these data are insufficient to provide regional trends.

What Percent of Stocks Had Known Population Trends? (1991–1999)



Data Source: NOAA National Marine Fisheries Service, analyzed by Natural Resources Consultants, Inc. Coverage: does not include Hawaii. Nearshore stocks (generally in state waters within 3 miles of shore) are excluded.

Note: "All 5 regions" includes some data from South Atlantic/Gulf of Mexico and Southern California, but these data are insufficient to provide regional trends.

What Is This Indicator, and Why Is It Important? This indicator tracks the percentage of commercially important fish species, or "stocks," that are increasing or decreasing in size. Only stocks whose population increased or decreased by at least 25% are reported. Trends are based on the estimated weight, or "biomass," of the entire stock.

Americans take large amounts of fish from U.S. waters (see Commercial Fish and Shellfish Landings, p. 81). Landings of a given stock cannot be maintained indefinitely if that stock's population declines. If declines persist, stocks can become too small to fish, with attendant economic and social consequences; declines may also lead to significant changes in the marine ecosystem.

What Do the Data Show? The North/Mid-Atlantic region stands out as having, over time, more fish stocks with increasing populations and fewer stocks with declining populations. However, we know trends for only 20% of the stocks in this region. In contrast, the number of declining stocks went up in the Pacific Northwest, where we know trends for more than 40% of the stocks; by the 1990s, about 80% of Pacific Northwest stocks with known trends were declining. There are no clear trends in the other regions. However, when all five regions are considered together, about 40% of stocks had decreasing trends over the time period, while about 20% of stocks had increasing population trends.

Discussion An increasing population trend may signal an increased ability of a stock to support commercial fishing, or it may reflect the recovery of an overfished stock. This latter case is likely in the Northeast, where strict catch restrictions have been imposed in response to severe stock declines.

While the data presented here represent only about 25% of all commercial fish stocks, the stocks for which population trends do exist, and which are reported here, account for about 75% of the weight of fish caught each year in the United States.

The technical note for this indicator is on page 227.

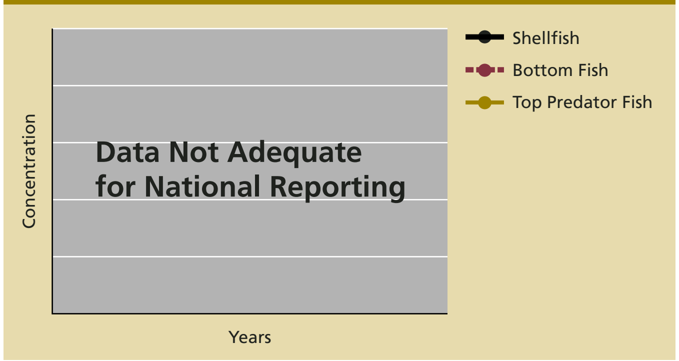
⊖ Selected Contaminants in Fish and Shellfish

What Is This Indicator, and Why Is It Important? This indicator measures the concentration of PCBs, mercury, and DDT in the edible tissue of seafood from U.S. coastal waters. For comparison, the graphs would also include information on the levels at which the Environmental Protection Agency (EPA) and Food and Drug Administration (FDA) recommend that action (such as consumption advisories) be taken.

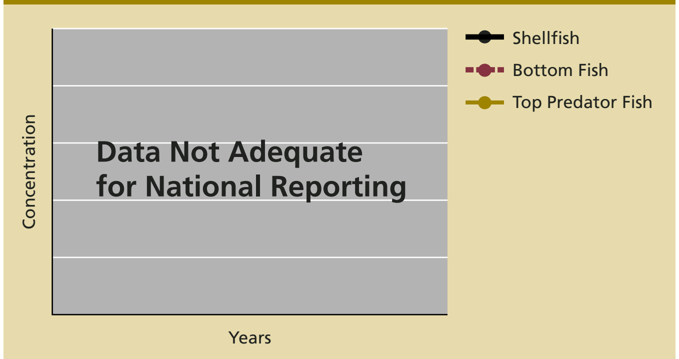
These compounds can reach concentrations that are harmful to humans, especially in larger fish. Many coastal environments are contaminated with synthetic toxic substances like DDT and PCBs, and mercury is ubiquitous in the marine environment. Bottom-dwelling organisms that ingest these contaminants are eaten by fish that are in turn eaten by larger fish—a process called bioaccumulation. Elevated concentrations of both PCBs and DDT are a concern both in bottom-feeding fish and shellfish and in predators such as tunas, swordfish, and some sharks, while mercury is concentrated primarily in predators.

While the manufacture and distribution of PCBs and DDT has been banned in the United States since the 1970s, historical deposits in coastal watersheds and sediments continue to provide an active source of contamination. Mercury can come from industrial releases, abandoned mines, the burning of fossil fuels for electric power generation, and the weathering of rock. Human health risk assessments have shown that consumption of certain species of fish in certain locations produces a measurable risk of cancer from one or more of these contaminants. These risk assessments are the basis of consumption advisories that suggest limiting the intake of particular species, especially for groups at higher risk, such as children, pregnant women, and nursing mothers.

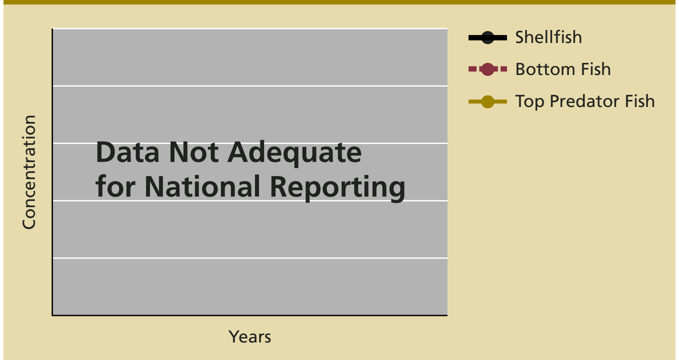
Selected Contaminants: PCBs



Selected Contaminants: Mercury



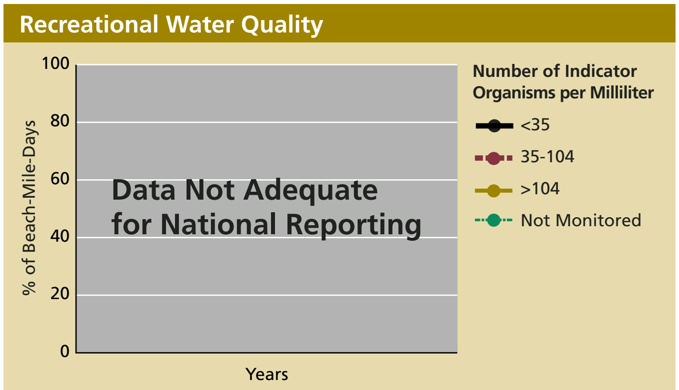
Selected Contaminants: DDT



Why Can't This Indicator Be Reported at This Time? While the FDA, EPA, and state governments have a variety of monitoring and reporting programs in place, these programs do not provide the basis for national reporting on contaminant concentrations.

The technical note for this indicator is on page 228.

⊖ Recreational Water Quality



What Is This Indicator, and Why Is It Important? This indicator will report the percentage of "beach-mile-days" affected by various levels of *Enterococcus,* a bacterium that indicates contamination with human or animal waste. A "beach-mile-day" is one mile of beach affected for one day—100 miles of beach affected for one day would count the same as 1 mile affected for 100 days.

Swimming in sewage-contaminated waters can cause minor ailments, like sore throats and diarrhea, as well as more serious, even fatal, illnesses like severe gastroenteritis, meningitis, and encephalitis. Beach-based activities, like sunbathing, surfing, and swimming, are popular (see the national recreation indicator, p. 60), add billions of dollars to the economy, and contribute to the value of coastal properties. Poor water quality threatens these benefits.

Why Can't This Indicator Be Reported at This Time? A great deal of information is collected on coastal recreational water quality, but the data are scattered, incomplete, and inconsistent. Beach monitoring is typically conducted by city or county health departments, which frequently use different methods, while many areas choose not to monitor at all. Recent federal legislation provides increased incentives to monitor using nationally consistent methods, so data for this indicator should be available in the future.

Discussion There is no national standard for closing beaches because of sewage contamination; such decisions are made locally, using many different standards. This indicator reports the most commonly used indicator organism (*Enterococcus*), which is also recommended by EPA, but some monitoring relies upon other organisms. There are other aspects of water quality, such as the presence of contaminated sediments (see p. 72), that are not addressed by this indicator.

The contamination reported by this indicator may be caused by sewage treatment plant malfunctions, overflow of combined sewer systems during rain storms, discharges from boats, leaking septic systems, and runoff after heavy rains that may contain animal waste from farms, urban lawns, and streets.

The technical note for this indicator is on page 228.