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Marine and Coastal Systems: Resources, Impacts, and Conservation

Chapter Objectives

This chapter will help students:

Identify physical, geographical, chemical, and biological aspects of the marine environment

Describe major types of marine ecosystems

Outline historic and current human uses of marine resources

Assess human impacts on marine environments

Review the current state of ocean fisheries and reasons for their decline

Evaluate marine protected areas and reserves as innovative solutions

Lecture Outline

I. Central Case: Collapse of the Cod Fisheries

A. No fish had more impact on human civilization than the Atlantic cod.
B. This abundant groundfish (fish that feed on the bottom of the ocean) was a dietary staple in cultures on both sides of the Atlantic.
C. Cod provided the economic engine for many communities along coastal New England and Canada.
D. After decades of technologically advanced fishing techniques harvested many mature breeding adults, the cod populations in the Atlantic "crashed."
E. Government officials in Canada, followed by U.S. officials, closed fishing areas to all commercial fishing. In most of the areas, the cod have not rebounded.

1. It is believed that cod remain limited because the former prey of adult cod are now competing for food with and even eating young cod before they can mature.
2. A bright spot in the story is that areas of the Georges Bank are recovering due to elimination of destructive practices such as trawling. Some other species are recovering such as Ocean Scallops. There is evidence that young cod are beginning to appear as well.

II. The Oceans

1. The study of the physics, chemistry, and geology of the oceans is called **oceanography.**
2. **Oceans** influence global climate, teem with biodiversity, facilitate transportation and commerce, and provide us resources.

A. Oceans cover most of Earth's surface.

B. The oceans contain more than water.
   1. Ocean water is salty because the ocean basins are the final repositories for water that runs off the land.
   2. The salinity of ocean water generally ranges from 33 to 37 parts per thousand (ppt), varying from place to place because of differences in evaporation, precipitation, and freshwater runoff from land and glaciers.
   3. Seawater also contains nutrients such as nitrogen and phosphorus that play essential roles in nutrient cycling.
   4. Another aspect of ocean chemistry is dissolved gas content, particularly the dissolved oxygen upon which gill-breathing marine animals depend.

C. Ocean water is vertically structured.
   1. Water density increases as salinity rises and as temperature falls, giving rise to different layers of water.
   2. The waters of the surface zone are heated by sunlight each day and are stirred by wind.
   3. The *pycnocline* is the region below the surface zone in which density increases rapidly with depth.
   4. The deep zone of the ocean lies beneath the pycnocline and is not affected by wind and sunlight.
   5. Oceans help regulate Earth's climate by absorbing and releasing heat to the atmosphere.

D. Ocean water flows horizontally in **currents.**
   1. The ocean surface is composed of currents—vast, riverlike flows driven by density differences, heating and cooling, gravity, and wind.
   2. Currents transport heat, nutrients, pollution, and the larvae of many marine species.

E. Vertical movement of water affects marine ecosystems.
   1. **Upwelling** is the vertical flow of cold, deep water toward the surface, bringing nutrients from the bottom.
   2. **Downwelling** transports warm water rich in dissolved gases downward, providing oxygen for deep-water life.

F. Seafloor topography can be rugged and complex.

1. Parts of the ocean floor are just as complex as the terrestrial portion of the lithosphere.
2. In the bathymetric profile, gently sloping **continental shelves** underlie the shallow waters bordering continents.
3. Most of the seafloor is flat, but there are volcanic peaks, reefs, and deep trenches.
4. Oceanic zones differ greatly, and some support more life than others.
    a. The well-lit top 10 meters, called the *photic zone,* contains nearly all of the oceans' primary productivity.
    b. Between the ocean's surface and the floor are the **pelagic** habitats.
    c. On the ocean floor is the **benthic** area.

III. Marine Ecosystems

A. Open-ocean ecosystems vary in their biological diversity.
    1. Much of the ocean's life is concentrated near the surface in areas of nutrient-rich upwelling. These areas include a variety of photosynthetic species and many free-swimming animals.
    2. In the deep ocean, animals are adapted to deal with extreme water pressures and to live in the dark.
    3. Some extremely deep ecosystems cluster around hydrothermal vents.

B. **Kelp** forests harbor many organisms in temperate waters.
    1. Kelp is a large, brown algae, with some types reaching 200 feet in length.

C. **Coral reefs** are treasure troves of biodiversity.
    1. A coral reef is a mass of calcium carbonate composed of the skeletons of tiny colonial marine organisms called corals.
    2. Corals are tiny invertebrate animals related to sea anemones and jellyfish.
    3. Coral animals capture food with stinging tentacles and also derive nourishment from symbiotic algae, known as *zooxanthellae,* which inhabit their bodies and produce food through photosynthesis.
    4. Coral reefs host an incredible diversity of life, and they protect shores from damage by waves and storms.
    5. Coral reefs are experiencing worldwide declines, probably due to increased sea surface temperatures and the influx of pollutants.

D. **Intertidal** zones undergo constant change.
    1. The intertidal or **littoral** zone lies along shorelines between low tide and high tide.
    2. **Tides** are the periodic rising and falling of the ocean's height at a given location, caused by the gravitational pull of the moon and sun.
    3. The intertidal zone is a tough place to make a living, but is home to a remarkable diversity of organisms.
    4. The rocky intertidal zone is so diverse because environmental conditions change dramatically from the low part of the intertidal zone to the high part.

E. **Salt marshes** cover large areas of coastline in temperate areas where tides wash over gently sloping sandy or silty substrates.
    1. Salt marshes filter pollution, buffer the coastal regions from storm surges and are prime sites for development worldwide.
    2. Destruction of the salt marsh community near New Orleans, caused impact from Hurricane Katrina to be more severe.
F. **Mangrove** forests line coastlines throughout the tropics and subtropics.
    1. Mangroves are trees with unique types of roots that curve upward like snorkels to obtain oxygen.
    2. Mangrove forests serve as nurseries for fish and shellfish, providing economic benefit to residents.
    3. In south Florida and elsewhere, mangrove forests have been removed as people have converted coastal areas to residential, recreational, and commercial uses.
G. Freshwater meets salt water in **estuaries.**
    1. Estuaries are areas where rivers flow into the ocean, mixing freshwater with salt water.
    2. Estuaries provide critical habitat for many organisms.
    3. Estuaries around the world have been affected by urban and coastal development.

IV. Human Use and Impact

A. The oceans provide transportation routes.
B. We extract energy and minerals.
    1. By the 1980s, about 30% of our production of crude oil and nearly half of our natural gas came from exploitation of ocean deposits.
    2. **Methane hydrate** is an icelike solid consisting of molecules of methane (CH_4, the main component of natural gas) embedded in a crystal lattice of water molecules.
        a. The U.S. Geological Survey estimates that the world's deposits of methane hydrates may hold twice as much carbon as all known deposits of oil, coal, and natural gas combined.
        b. Destabilizing a methane hydrate deposit could lead to a catastrophic release of gas, which could cause a massive landslide and tsunami. This event would also release huge amounts of methane, a potent greenhouse gas, into the atmosphere, exacerbating global climate change.
    3. We extract minerals from the seafloor.
C. Marine pollution threatens resources.
D. Nets and plastic debris endanger marine life.
    1. Because most plastic is not biodegradable, it can drift for decades before washing up on beaches, and may be mistaken for food by marine mammals, seabirds, fish, and sea turtles, which may die as a result of ingesting it.
    2. Lost or discarded fishing nets frequently continue snaring animals for decades.
    3. In December 2006, the U.S. Congress responded to these threats and sent the Marine Debris Research, Prevention, and Reduction

Act to President George Bush for his signature.

E. Oil pollution comes from spills of all sizes.
    1. The majority of oil pollution comes not from large spills, but from the accumulation of innumerable widely spread small sources.
    2. Minimizing the amount of oil we release is important because petroleum pollution is detrimental to the marine environment and the human economies that draw sustenance from that environment.
    3. Over the past three decades, the amount of oil spilled in U.S. waters and worldwide has decreased, in part because of an increased emphasis on spill prevention and response.
F. Toxic pollutants can contaminate seafood.
    1. Mercury is a central nervous system toxin and can have severe neurological impact on a developing fetus.
    2. Mercury is emitted from combustion of coal in power plants.
G. Excess nutrients can cause algal blooms.
    1. The release of excess nutrients into surface waters can spur unusually high growth rates of algae, called **harmful algal blooms.** Some algal species produce reddish pigments, and blooms of these species are nicknamed **red tides.**
    2. Harmful algal blooms can cause illness and death among zooplankton, birds, fish, marine mammals, and humans as their toxins are passed up the food chain.

V. Emptying the Oceans

A. We have long overfished.
    1. A recent synthesis of historical evidence revealed that ancient overfishing likely affected ecosystems in astounding ways that we only partially understand today.
    2. Florida Bay is suffering today from the overhunting of green sea turtles in past centuries.
    3. If current trends continue, a comprehensive 2006 study in the journal *Science* predicts that all fish species humans harvest from the oceans will collapse by 2048.
B. Fishing has industrialized.
    1. Modern commercial fishing fleets use fossil fuel, huge boats, and advanced technologies to harvest unimaginable amounts of ocean life.
    2. Many vessels today are able to capture, process, and freeze their catch in a vertically integrated operation. This technique is called *factory fishing.*
C. Fishing practices kill nontarget animals and damage ecosystems.
    1. **By-catch** refers to the accidental capture of animals, and it accounts for the deaths of many thousands of fish, sharks, marine mammals, and birds each year.
    2. Driftnetting, longlining, and bottom-trawling are all techniques that are responsible for huge fish catches but also for massive catches of nontarget animals.
D. Modern fishing fleets deplete marine life rapidly.

1. The percentage of oceanic fish stocks that are overfished increased tenfold from 1950 to 1994.
2. A prime example of fishery collapse took place in the 1990s with groundfish fisheries in the North Atlantic off the Canadian and U.S. coasts.
3. Removing top trophic level feeders from marine ecoystems causes their prey species to proliferate. Many scientists conclude marine ecosystems were probably very different ecosystems prior to commercial fishing.

E. Several factors mask declines.
1. Despite the fact that fish stocks have been depleted in region after region as industrialized fishing has intensified, the amount of overall global fish production has remained stable for 15 years.
2. Fishing fleets travel longer distances, fish in deeper waters, spend more time fishing, and set out more nets and lines.
3. Improved technology, including sonar mapping, satellite navigation, and thermal sensing systems, also helps to explain high catches.

F. We are "fishing down the food chain."
1. Fisheries data reveal that as fishing increases, the size and age of fish caught decline.
2. We are also shifting from large, desirable species that have become rare to smaller, less desirable ones.

G. Some fishing practices kill nontarget animals and damage ecosystems.
1. Many fishing practices catch more than target species. **By-catch** refers to the capture of unintended animals including fish, sharks, marine mammals, and birds.
   a. Boats that drag *driftnets* through the water capture substantial numbers of large nontarget species. This method has been banned or restricted by many nations.
   b. *Longline fishing* involves dragging extremely long lines with baited hooks spaced along their lengths, resulting in a large by-catch.
   c. *Bottom-trawling* involves dragging weighted nets over the floor of the continental shelf to catch benthic organisms, resulting in damage to entire benthic ecosystems. Trawling crushes many organisms and leaves long swaths of damaged sea bottoms.

H. Consumer choice can influence fishing practices.
1. Purchasing ecolabeled seafood products exercises consumer choice, and thus influences the fishing industry.
2. Several nonprofit organizations have devised guides to help consumers make ecologically sound choices

I. Marine biodiversity loss erodes ecosystem services.

VI. Marine Conservation

A. Fisheries management has been based on maximum sustainable yield.

1. The goal of this strategy is to allow for maximal harvests of particular populations while keeping fish available for the future.
2. Despite such efforts, many fish stocks have plummeted.
3. A suggested key change is to shift the focus from individual fish species toward viewing the larger ecological system, considering the effects of fishing practices on habitat quality, and other factors.

B. We can protect areas in the ocean.
1. Large numbers of **marine protected areas (MPAs)** have been established, mostly along coastlines of developed countries. Nearly all MPAs allow fishing and other extractive activities.
2. The United States is now inventorying areas for inclusion in a national network of MPAs.
3. Because of the lack of refuges from fishing pressure, many scientists have urged the establishment of areas where no fishing is allowed. These areas are called **marine reserves** and are designed to preserve entire ecosystems intact and to improve fisheries.

C. Reserves can work for both fish and fishers.
1. Data indicate that marine reserves do work, boosting fish biomass and total catch while decreasing habitat destruction.

D. How should reserves be designed?
1. How large do reserves need to be, how many should there be, and where should they be placed?
2. Involving fishers directly in the planning process is crucial.
3. Studies have estimated that from 10% to 65% of the ocean should be protected in no-take reserves. Most estimates range between 20% and 50%.
4. Other studies are modeling how to optimize the size and spacing of individual reserves so that ecosystems are protected, fisheries are sustained, and people are not overly excluded from marine areas.

VII. Conclusion

A. In the Florida Keys and hundreds of other areas around the country, scientists are gradually demonstrating that setting aside protected areas can serve to maintain natural systems and enhance fisheries.

B. As historical studies reveal more information on how much biodiversity our oceans formerly contained and have lost, we may increasingly consider restoring the ecological systems that used to flourish.