

# Marine and Coastal Systems and Resources

## Chapter Objectives

This chapter will help you:

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

Explain how the oceans influence, and are influenced by, climate

Describe major types of marine ecosystems

Assess impacts from marine pollution

Review the 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 has had more of an 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 young cod and even eating them before they can mature.
2. A bright spot 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 sea scallops.

## II. The Oceans

### A. Oceans cover most of Earth's surface.

1. The world's five oceans—Pacific, Atlantic, Indian, Arctic, and Southern—are all connected, comprising a single vast body of water. This one “world ocean” covers 71% of Earth's surface and contains 97.5% of its water.

### B. Seafloor topography can be rugged.

1. To comprehend underwater geographic features, we can examine a stylized map that reflects *bathymetry* (the measurement of ocean depths) and *topography* (physical geography, or the shape and arrangement of landforms).
2. In bathymetric profile, gently sloping **continental shelves** underlie the shallow waters bordering the continents.
  - a. Continental shelves vary tremendously in width but average 80 km (50 mi) wide, with an average slope of just 1.9 m/km (10 ft/mi).
  - b. These shelves drop off at the *shelf-slope break*, where the *continental slope* angles more steeply downward to the deep ocean basin below.
3. Wherever reefs, volcanism, or other processes create physical structure underwater, life thrives.

### C. Ocean water contains salts.

1. Ocean water contains approximately 96.5% H<sub>2</sub>O by mass. Most of the remainder consists of ions from dissolved salts.
2. Ocean water is salty because the ocean basins are the final repositories for water that runs off the land.
3. Evaporation from the ocean surface then removes pure water, leaving a higher concentration of salts.
4. 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.
5. Seawater also contains nutrients such as nitrogen and phosphorus that play essential roles in nutrient cycling.

6. Another aspect of ocean chemistry is dissolved gas content, particularly the dissolved oxygen upon which gill-breathing marine animals depend.
- D. 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.
- E. Surface water flows horizontally in currents.
1. The ocean surface is composed of **currents**—vast, river-like flows driven by density differences, heating and cooling, gravity, and wind.
  2. Currents transport heat, nutrients, pollution, and the larvae of many marine species.
- F. 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.
- G. Currents affect climate.
1. The **thermohaline circulation** is a worldwide current system in which warmer, fresher water moves along the surface and colder, saltier water (which is denser) moves deep beneath the surface.
    - a. As this water releases heat to the air, keeping Europe warmer than it would otherwise be, the water cools, becomes saltier through evaporation, and thus becomes denser and sinks, creating a region of downwelling known as the *North Atlantic Deep Water (NADW)*.
    - b. Scientists hypothesize that interrupting the thermohaline circulation could trigger rapid climate change.
  2. Another interaction between currents and climate is the **El Niño–Southern Oscillation (ENSO)**, a systematic shift in atmospheric pressure, sea surface temperature, and ocean circulation in the tropical Pacific Ocean.

3. **El Niño** conditions are triggered when air pressure decreases in the eastern Pacific and increases in the western Pacific, weakening the equatorial winds and allowing the warm water to flow eastward.
  4. **La Niña** events are the opposite of El Niño events. In a La Niña event, cold waters rise to the surface and extend westward in the equatorial Pacific when winds blowing to the west strengthen, and weather patterns are affected in opposite ways.
- H. Climate change is altering the oceans.
1. The ocean's surface water may soon become saturated with as much CO<sub>2</sub> as it can hold.
  2. As ocean water soaks up CO<sub>2</sub>, it becomes more acidic. As **ocean acidification** proceeds, many sea creatures have difficulty forming shells because the chemicals they need are less available.

### III. Marine and Coastal Ecosystems

1. Regions of ocean water differ greatly, and some zones support more life than others.
  - a. The uppermost 10 m (33 ft) of water absorbs 80% of solar energy, so nearly all of the oceans' primary productivity occurs in the top layer, or **photic zone**.
  - b. Habitats and ecosystems occurring between the ocean's surface and floor are termed **pelagic**.
  - c. Those that occur on the ocean floor are called **benthic**.
- A. Open-ocean ecosystems vary in their biodiversity.
  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 have adapted to deal with extreme water pressures and to living in the dark.
  3. Some extremely deep ecosystems cluster around hydrothermal vents.
- B. Kelp forests harbor many organisms.
  1. **Kelp** is a large, brown algae; some types can reach 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 line temperate shorelines.
1. Along many of the world's coasts at temperate latitudes, **salt marshes** occur where the tides wash over gently sloping sandy or silty substrates.
  2. Salt marshes boast very high primary productivity and provide critical habitat for shorebirds, waterfowl, and many commercially important fish and shellfish species.
  3. Salt marshes also filter pollution and stabilize shorelines against storm surges.
- F. Mangrove forests line coasts in the tropics and subtropics.
1. **Mangroves** are some of the few types of trees that are salt-tolerant. They have unique types of roots that curve upward like snorkels to attain oxygen lacking in the mud or that curve downward like stilts to support the tree in changing water levels.
  2. Other than serving as nurseries for fish and shellfish that people harvest, mangroves also provide materials that people use for food, medicine, tools, and construction.
- G. Freshwater meets salt water in estuaries.
1. Many salt marshes and mangrove forests occur in or near **estuaries**, areas where rivers flow into the ocean, mixing fresh water with salt water.
  2. Sheltered from crashing surf, the shallow water of estuaries nurtures eelgrass beds and other plant life, producing abundant food and resources.

3. Estuaries everywhere have been affected by coastal development, water pollution, habitat alteration, and overfishing.

#### IV. Marine Pollution

##### A. Nets and plastic debris endanger marine life.

1. Lost or discarded fishing nets can continue to ensnarl animals for decades.
2. 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.
3. In 2006, the U.S. Congress responded to ocean pollution by passing the Marine Debris Research, Prevention, and Reduction Act.

##### B. 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.

##### C. Toxic pollutants can contaminate seafood.

1. Mercury is a toxic heavy metal emitted from coal combustion, mine tailings, and other sources.
2. After settling onto land and water, mercury bioaccumulates in animals' tissues and biomagnifies as it makes its way up the food chain.
3. As a result, fish and shellfish at high trophic levels can contain substantial levels of mercury.
4. Eating seafood high in mercury is particularly dangerous for young children and for pregnant or nursing mothers, because the fetus, baby, or child can suffer neurological damage as a result.

##### D. Excess nutrients can cause algal blooms.

1. Excessive nutrient concentrations sometimes cause population explosions among several species of marine algae whose powerful toxins attack the nervous systems of vertebrates. Blooms of these algae are known as **harmful algal blooms**.
2. Some algal species produce reddish pigments that discolor surface waters, and blooms of these species are nicknamed **red tides**.

3. 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.
- B. Fishing has industrialized.
  1. Modern commercial fishing fleets use fossil fuels, huge boats, and powerful new technologies to harvest unimaginable amounts of ocean life.
  2. Many vessels can capture, process, and freeze their catch in a vertically integrated operation called *factory fishing*.
  3. Some vessels set out long *driftnets* that span large expanses of water. These chains of transparent nylon mesh nets are arrayed to drift with currents so as to capture fish, and are held vertical by floats at the top and weights at the bottom.
  4. *Longline fishing* involves setting out extremely long lines (up to 80 km (50 mi) long) with up to several thousand baited hooks spaced along their lengths.
  5. *Trawling* entails dragging immense cone-shaped nets through the water, with weights at the bottom and floats at the top.
- C. Fishing practices kill nontarget animals and damage ecosystems.
  1. **By-catch** is the accidental capture of animals, and it accounts for the deaths of many thousands of fish, sharks, marine mammals, and birds each year.
- D. Modern fishing fleets deplete marine life rapidly.
  1. Removing top trophic level feeders from marine ecosystems causes their prey species to proliferate.
  2. Many scientists conclude that marine ecosystems were probably very different 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 two decades.
  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. Analyses of fisheries data reveal that as fishing increases, the size and age of fish caught declines.
  - 2. We are also shifting from large, desirable species that have become rare to smaller, less desirable ones.
- G. Our purchasing choices 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
- H. 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 and shellfish stocks have plummeted.
  - 3. A suggested key change is to shift the focus from individual fish species toward considering the impacts of fishing practices on habitat quality, species interactions, and other factors that may have indirect or long-term effects on populations.
  - 4. One key aspect of such *ecosystem-based management* is to set aside areas of ocean where systems can function without human interference.
- B. We can protect areas in the ocean.
  - 1. Hundreds of **marine protected areas (MPAs)** have been established, mostly along coastlines of developed countries. Nearly all MPAs allow fishing and other extractive activities.
  - 2. Because of the lack of true refuges from fishing pressure, many scientists want to establish areas where fishing is prohibited. Such —no-take areas have come to be called **marine reserves**.
- 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. Studies are investigating how to optimize the size and spacing of reserves so that ecosystems are protected, fisheries are sustained, and people are not overly excluded from marine areas.

2. How large do reserves need to be, how many should there be, and where should they be placed?
3. Studies have estimated that from 10- 65% of the ocean should be protected in no-take reserves. Most estimates range between 20-50%.
4. Involving fishers directly in the planning process is crucial.

## **VII. Conclusion**

- A. Oceans cover most of our planet, and we are still exploring their diverse topography and ecosystems. As we learn more about marine and coastal environments, we also continue to have a big impact on their resources.
- B. Yet scientists are demonstrating that setting aside protected areas of the ocean can serve to maintain and restore natural systems and also to enhance fisheries.
- C. In the meantime, all of us can make consumer choices that help move us toward sustainable fishing practices.

## Key Terms for Chapter 16

benthic  
by-catch  
continental shelves  
coral reef  
currents  
downwelling  
El Niño  
El Niño–Southern Oscillation (ENSO)  
estuaries  
harmful algal blooms  
intertidal  
kelp  
La Niña  
littoral  
mangroves  
marine protected areas (MPAs)  
marine reserves  
ocean acidification  
pelagic  
photic zone  
red tides  
salt marshes  
thermohaline circulation  
tides  
upwelling

