



Chapter 12 **Sustaining Aquatic Biodiversity**



“It’s A Small World After All”

Outline

Aquatic Biodiversity

We know very little about the earth’s aquatic biodiversity because there has been so little exploration of the water on this ‘water planet.’

A. Three patterns of marine biodiversity are:

1. The greatest marine biodiversity occurs in coral reefs, estuaries, and on the deep-sea ocean floor.
2. Biodiversity is higher near the coasts because of great variety of producers, habitats and nursery areas.
3. Biodiversity is higher in the bottom region than in the surface region of the ocean because of the greater variety of habitats and food sources.
4. Scientific investigation of poorly understood marine and freshwater aquatic systems is a research frontier.

B. Marine systems provide a variety of ecological and economic services. Conservative estimates value their ecological services at \$21 trillion per year with at least 3.5 billion people—more than half of the world’s human population, dependent on seas for their primary source of food.

1. Antibiotic and anticancer chemicals have also been extracted from a variety of algae, sea anemones, sponges, mollusks and several species of fish.
2. Freshwater systems important ecological and economic services as well.

Human Impacts on Aquatic Biodiversity

A. The greatest threat to the biodiversity of oceans is loss and degradation of habitats

1. Twenty percent of the world’s coral reefs have been destroyed and another 20% have been damaged.
2. Rising sea levels, 10-25 centimeters during the past 2100 years and 9-88 cm over then next century.
3. We have removed more than ½ of the world’s ecologically important mangrove forests.
4. More than half of the world’s coastal wetlands have disappeared.
5. Many sea bottoms are degraded and destroyed by dredging and trawler fishing boats which drive huge and heavy nets over the seafloor.
- 6 The amount of water held behind dams is 3-6 times the amount that flows in natural rivers.

B. Harmful invasive species increasingly threaten marine biodiversity.

C. About 45% of the human population lives along coastal zones and 80% of ocean pollution come from land-based human activities and similar pressures are growing in freshwater systems and more people seek homes and recreation areas around rivers and lakes.

D. About 75% of the world’s commercially valuable fisheries have been over fished and many have surpassed their sustainable limits.

1. Modern industrial fishing can deplete 80% of target fish species in just 10-15 years.
2. Over fishing can lead to commercial extinction, which occurs when it is no longer profitable to continue fishing the affected species.
3. Ninety percent of the large, open-ocean fish like tuna, swordfish, and marlin have disappeared since 1950.
4. More than 1/4th of annual fish catch consists of bycatch—non-target species that are thrown overboard dead or dying

E. Rapidly increasing human impact, invisibility of problems, citizen unawareness, and lack of legal jurisdiction hinder protection of aquatic biodiversity.

Protecting and Sustaining Marine Biodiversity

A. Protecting marine species involves both legal and economic approaches using science and education to inform decision-makers and the general population.

B. National and international laws and treaties help protect marines species, e.g.:

1. 1975 Convention on International Trade in Endangered Species (CITES)
2. 1979 Global Treaty on Migratory Species

Chapter 12 Sustaining Aquatic Biodiversity

“It’s A Small World After All”

3. U.S. Endangered Species Act of 1973
4. U.S. Whale Conservation and Protection Act of 1976
5. 1995 International Convention on Biological Diversity
- C. Six of the seven major sea turtles species are threatened or endangered due to human activities
 1. Since 1989 turtle exclusion devices have been required in the U.S. to prevent turtles from being caught in fishing nets
 2. Sea turtles bring in more tourist dollars than sale for meat, leather, and eggs.
- D. Reconciliation ecology involves restaurants or other commercial establishments, working with conservation programs to both protect species and provide tourist revenue.
- E. Commercial whaling was banned in 1970, but there are efforts to overturn the ban.
 1. Cetaceans are marine mammals, classified into two major groups: toothed whales and baleen whales.
 2. Whales are air breathing and must come to the surface to breathe, this makes them easy targets since they are large mammals and equipment for hunting them is so sophisticated.
 3. Eight of the 11 major species of whale have been driven to the point of commercial extinction, and the blue whale to the edge of biological extinction.
 4. The International Whaling Commission (IWCC) was established in 1946. It set quotas to prevent over harvesting.
 5. This did not work well for two reasons:
 - a. Quotas were based on inadequate data or ignored
 - b. There were no powers of enforcement.
 6. The U.S. banned all whaling in 1970 and banned all imports of whale products. A moratorium on whaling was imposed by governments of many nonwhaling countries in 1986. This has dropped the number of whales killed from 42,480 in 1970 to about 1,200 in 2004.
 7. Japan, Norway, Iceland, Russia and some small island countries continue to work to overthrow the IWC ban on commercial whaling and reverse the ban on purchase and sale of whale products.
 8. Conservationists feel that whaling should not be resumed since estimates of recovery may be too high and these mammals should be protected for ethical reasons. This could also lead to widespread harvests of most whale species and weaken international sanctions. The controversy continues.
 9. The blue whale has fewer than 10,000 in its present population and may never recover due to slow sexual maturation (25 years), low birth rate (1 calf every 2-5 years) and despite protection and nonhunting since 1964 biologists fear there are too few whales remaining for them to recover.
- F. Nations have established marine sanctuaries, but many are only partially protected.
 1. Nations have sovereignty over waters and seabed up to 12 miles offshore. The Exclusive Economic Zone (EEZ) extends out 200 mile from shore, but too often these areas have not been regulated to sustain fish harvest, rather, they have been over fished.
 2. The World Conservation Union helped establish a global system of marine protected areas (MPAs).
 3. There are about 1,300 MPAs, almost 200 in U.S. waters; however, most MPAs allow ecologically harmful activities like trawling, dredging, and resource extraction.
 4. Studies show that within as few as two years after establishing a reserve the fish are larger, reproduce more often and are in greater variety than previously.
 5. According to a 2005 Millennium Ecosystem Assessment, less than 0.3% of the world’s ocean area has fully protected marine reserves waters.
 6. In 2006, U.S. president George W. Bush created the world’s largest protect marine area—140,000 square miles (360,000 square kilometers)—the Northwest Hawaiian Marine National Monument.
- G. Integrated coastal management is a community-based effort to develop and use coastal resources more sustainably.
 1. The idea is to find cost-effective, adaptable solutions to preserve biodiversity while meeting economic and social needs. This uses the principles of adaptive ecosystem management.
 2. The U.S. has 90 coastal counties working to establish management systems, but less than 20 have been implemented.

Chapter 12 Sustaining Aquatic Biodiversity

“It’s A Small World After All”

- H. In 2003 and 2004 two studies called for an overall of U.S. ocean policy and management. Both agreed that coastal waters of the U.S. are fundamentally threatened and offer recommendations (p. 260-261).

Managing and Sustaining Marine Fisheries

- A. Over fishing is a serious threat to biodiversity in coastal waters and to some marine species of open-ocean waters.
- B. One way to prevent over fishing is to develop better ways to project fish populations. The maximum sustained yield mathematical model is used, but indications are that it has hastened the collapse of most commercially valuable stocks for several reasons:
 - 1. Populations and growth rates are difficult to measure
 - 2. Sizes of fish stocks are often based on unreliable/underreported catch figures
 - 3. Harvesting a species at maximum sustainable yield can affect other target and nontarget fish species
 - 4. Fishing quotas are difficult to enforce
- C. Optimum sustained yield is a concept that takes into account interactions with other species and allows more room for error. Another approach is multi-species management of a number of interaction species, which accounts for competition and predator-prey interactions.
- D. There has been limited management of several large marine systems, such as the Mediterranean Sea.
- E. Many fisheries scientists and environmentalists are interested in using the precautionary principle for management of fisheries and marine systems.
- F. Some fishing communities regulate fish harvests on their own and others work with the government to regulate them. Influx of large modern fishing boats and fleets has weakened the ability to regulate and sustain local fisheries. Many community management systems are now co-managed, where community and government work together to manage fisheries.
 - 1. Central government sets quotas for various species, divides the quotas among communities
 - 2. Government may also limit fishing seasons and regulate gear to be used.
 - 3. Each community then allocates its quota among members.
- G. Individual transfer quotas (ITQs) are assigned to each fisherman, and these can then be bought, sold or leased, like private property. This has resulted in some reduction of over fishing, but it is hard to enforce, and wasteful bycatch has not been reduced.
- H. Four problems with the ITQ system are:
 - 1. It transfers public ownership to private fishers, but still makes the public responsible for cost of management and enforcement. Remedy this by collecting fees from quota holders to pay costs of enforcement.
 - 2. Small fishing vessels and companies may be squeezed out if they can’t afford to buy ITQs from others
 - 3. Poaching may increase. Remedy this by strict record keeping and observers on all vessels with quotas.
 - 4. Fishing quotas often set too high, so leave 10-50% of the estimated MSY as a buffer to protect the fishery from decline.

Protecting, Sustaining, and Restoring Wetlands

- A. Coastal and inland wetlands are important reservoirs of aquatic biodiversity; they provide ecological and economic services.
- B. Despite their ecological value, the U.S. has lost more than half of its coastal and inland wetlands since 1900
- C. Wetland loss in the U.S. will get worse as global warming leads to rising sea levels which will put many coastal wetlands under water.
- D. In the U.S., a federal permit is required to fill or deposit dredge material into many wetlands
- E. The U.S. federal policy is a zero net loss goal; mitigation banking allows destruction of some wetlands as long as same type of wetland is created elsewhere.
- F. An ambitious restoration project is trying to undo the human damage in South Florida’s Everglades. The natural Everglades is half its original size and is drying out, leaving it vulnerable to fire and invasion by nonnative species

Chapter 12 Sustaining Aquatic Biodiversity

“It’s A Small World After All”

1. Everglades National Park was set up in the lower part of the Everglades, but water didn’t flow into it and human activity caused disturbances.
2. Ninety percent of the wading birds are gone and other vertebrates are reduced in number 75-95%.
3. Florida Bay has become saltier and warmer due to lack of water flow from the Everglades and the Kissimmee River.
4. Loss of water flow and input from crop fields and cities has caused large algal blooms on the bay. These blooms threaten coral reefs, hinder diving, fishing and the tourist industry of the bay and the Florida Keys.
5. The U.S. Army Corp of Engineers has begun a restoration project funded by the state and the federal government to restore the meandering river and flow of water to the Everglades. It has several ambitious goals:
 - a. Restore curving flow of more than half of the Kissimmee River.
 - b. Remove 250 miles of canals and levees south of Lake Okeechobee.
 - c. Buy 93 square miles of farmland and allow it to flood to create artificial marshes.
 - d. Create a network of artificial marshes.
 - e. Create 18 large reservoirs to ensure water for south Florida’s present and future population and the lower Everglades.
 - f. Build new canals, reservoirs, and pumping stations to capture and return to the Everglades 80% of the water flowing out to sea.

Protecting, Sustaining and Restoring Lakes and Rivers

- A. Invasions by nonnative species have upset the ecological functioning of the Great Lakes for decades with more invaders coming.
 1. At least 162 nonnative species have invaded the Great Lakes since the 1920’s.
 2. Measures have been taken to control a number of these species.
 - a. Sea lampreys are one of the biggest threats and have depleted a number of the sport fish species in the lakes.
 - b. Zebra mussels were brought into the lakes in ballast and have become very aggressive pests since they have no known natural enemies. They have displaced native mussel species, clogged pipes, piers, and fouled beaches and have spread to other parts of the U.S.
 - c. Quagga mussels invaded the Great Lakes in 1991 and Asian Carp may be the next invader.
- B. Rivers/streams are important ecological and economic resources, but they can be degraded by over fishing, pollution, dams and water withdrawal.
- C. The Columbia River has been altered by 119 dams and withdrawal of water for agriculture.
- D. Sustainable management of freshwater fish involves encouraging populations of commercial/sport fish species, prevents over fishing, and reduces or eliminated less desirable fish populations.
 1. Regulate fishing seasons and the number and size of fish taken.
 2. Improve habitats, breed genetically resistant fish varieties, and judicious use of antibiotics and disinfectants to control predators, parasites and diseases are methods suggested.
 3. Some individuals have worked to restore degraded streams.
- E. The national Wild and Scenic Rivers Act was passed in 1968 to protect rivers and river segments with outstanding scenic, recreational, geological, wildlife, historical or cultural values.
- F. Congress established a three-tiered classification scheme:
 1. Wild rivers are relatively inaccessible; they are not permitted to be widened, straightened, dredges, filled or dammed.
 2. Scenic rivers are free from dams, mostly undeveloped, of great scenic value, and accessible in some places by roads.
 3. Recreational rivers are readily accessible by roads and may have some dams or development along their shores.
 4. Only 0.2% of the 3.5 million miles of rivers are protected under the Act, and 17% of the total river length has dams and reservoirs on them.
 5. Environmentalists want to add 1,500 additional river segments for a total of 2% of the total river systems. There is opposition from several groups.
- G. Threats to aquatic biodiversity are real and growing. We must greatly increase research and

Chapter 12

Sustaining Aquatic Biodiversity

“It’s A Small World After All”

expand

efforts to protect and restore aquatic biodiversity and promote integrated ecological management.

Summary

1. Aquatic biodiversity refers to the composition of plants and animals in the fresh and salt waters of the planet. Its economic importance of aquatic diversity lies in the conservative estimate of the value of their ecological services which is \$21 trillion a year, as well, at least 3.5 billion people depend on the seas for their primary source of food and this number could double to 7 billion in 2025. Many medicines have been developed from sea organisms: sponges, anemones, puffer fish, porcupine fish, seaweeds, etc. The waters are used for extensive recreational activities, not to mention commercial transportation.
2. Human activities are undermining aquatic biodiversity by destroying and degrading coastal wetlands, coral reefs, seagrass beds, kelp beds, mangroves and the ocean bottom.
3. We can protect and sustain marine biodiversity by using laws, international treaties, and education. We must identify and protect species that are endangered and/or threatened. This entails cleaning up aquatic environments, as well as inventing fishing methods which do not destroy animals and birds inadvertently caught in fishing nets. Poaching and illegal harvesting of marine creatures must also be eliminated. Public aquariums can, also, educate the public about protecting marine animals and birds. Marine sanctuaries and coastal management can protect aquatic environments as well as their creatures.
4. The world’s marine fisheries can be managed by setting catch limits below the maximum sustained yield limits, by reducing/eliminating fishing subsidies and by charging fees for fishing in publicly owned offshore waters. Some areas can be protected from any kind of fishing; there should be more marine protected areas and more integration of coastal management practices. Develop net-escape devices for fishing boats. Restriction of coastal locations for fish farm, control of pollution, and decreasing the pollution of ship ballast water into the sea will all protect marine fisheries. Multispecies management of large marine systems offers hope for conserving marine resources and for renewing those resources.
5. Wetlands can be protected, sustained, and restored by government regulations which prevent wetland loss. Destroyed wetlands can, also, be restored and adequately monitored for their protection. Development can be kept away from wetland areas and control of nonnative species needs to be instituted to prevent invasion into wetlands.
6. Freshwater fisheries, lakes and rivers can be protected, sustained, and even restored by building and protecting populations of desirable species, by prevention of over fishing, and by decreasing populations of less desirable species. Laws must be enacted and enforcers of these laws must be funded to protect scenic rivers; they must be protected from development and dam construction projects.

Objectives

1. Discuss the importance of aquatic systems research and its potential environmental and economic benefits. Describe the ecological services provided by aquatic systems.
2. Discuss how humans have impacted aquatic systems, and how these actions have affected aquatic resource availability.
3. Describe the problems associated with marine environment protection. Discuss the roles of legislation, regulation, and economic pressures.

Chapter 12 Sustaining Aquatic Biodiversity

“It’s A Small World After All”

4. Describe freshwater and marine fishery management and how it can be improved. Analyze the lessons to be learned from the decline of the whaling industry.
5. Distinguish between coastal and inland wetlands. Describe the ecological functions performed by wetlands. Describe environmental problems associated with coastal and inland wetlands.
6. Discuss the problems caused by human development of lake and river resources, including eutrophication, introduction of alien species, and management for flood control and power generation. Describe how some rivers are being protected from development.

Key Terms (**Terms are listed in the same font style as they appear in the text.**)

<i>Asian carp</i> (p. 266)	<i>mitigation banking</i> (p. 263)
<i>Asian swamp eel</i> (p. 252)	<i>multispecies management</i> (p. 262)
<i>baleen whales</i> (p. 257)	<i>optimum sustained yield (OSY)</i> (p. 262)
<i>bycatch</i> (p.253)	<i>precautionary principle</i> (p. 262)
<i>cetaceans</i> (p. 257)	<i>purple loosestrife</i> (p. 252)
<i>comanagement</i> (p. 262)	<i>quagga mussel</i> (p. 266)
<i>commercial extinction</i> (p. 253)	<i>reconciliation ecology</i> (p. 256)
<i>exclusive economic zones</i> (p. 259)	<i>recreational rivers</i> (p. 268)
<i>high seas</i> (p. 259)	<i>research frontier</i> (p. 250)
<i>integrated coastal management</i> (p. 260)	<i>scenic rivers</i> (p. 268)
<i>large marine systems</i> (p. 262)	<i>sea lampreys</i> (p. 266)
<i>marine protected areas</i> (p. 259)	<i>toothed whales</i> (p. 257)
<i>marine reserves</i> (p. 259)	<i>wild rivers</i> (p. 268)
<i>maximum sustained yield (MSY)</i> (p.261)	<i>zebra mussel</i> (p. 266)