

Chapter 8

Aquatic Biodiversity

Summary

1. The basic types of aquatic life zones are the surface, middle, and bottom layers. The life in aquatic life zones is influenced by temperature, access to sunlight for photosynthesis, dissolved oxygen content, and availability of nutrients.
2. The major types of saltwater life zones are the coastal zone and the open sea. Coastal ecosystems contain estuaries, wetlands, and mangrove swamps. Because of their close proximity to man's activities, they are under constant strain from water pollution, industrial run-off, construction and soil erosion, agricultural pesticides flowing into rivers and streams, and aquaculture farming. The open sea contains the euphotic zone, which is the lighted upper zone of the ocean. The bathyal zone is in the middle and is dimly lit. The lowest zone, the abyssal zone, is dark and very cold. But all are being affected by human activities: over-harvesting, oil spills, filling-in of wetland areas, agricultural and industrial development and pollution, rising sea levels, and careless fishing/trawling techniques.
3. The major types of freshwater life zones are lakes, wetlands, and rivers. Human activities, such as dams or canals; flood control levees and dikes; and industrial, urban, agricultural pollutants all affect the flow and health of freshwater zones. Much of U.S. wetlands have been drained and filled to farm and/or to construct homes and businesses. These actions increase flood potential and encourage droughts. People overfish the waters; pollute the streams, rivers, and lakes; and dump excessive nutrients from pesticides and waste lots into the fresh water sources.
4. We must protect aquatic life zones from the pollutants, water controls, and deterioration that we press upon them every day.

Key Questions and Concepts

8-1 What is the general nature of aquatic systems?

CORE CASE STUDY: Coral reefs are highly biodiverse, and they provide us with many ecological and economic services. They serve to sequester carbon, buffer coastlines, and provide valuable habitat. Globally, 19% of reefs have been destroyed and another 20% have been degraded. An additional 25–33% could be lost in the coming decades. Degradation and loss of reefs is an indicator that should serve as a warning about threats to the health of oceans.

- A. Saltwater and freshwater aquatic zones cover about 71% of the earth's surface.
- B. Salinity of the water determines the major types of organisms found in an aquatic environment.
- C. There are four major types of organisms in aquatic systems:
 1. Plankton are free-floating, weakly swimming, generally one-celled organisms. There are three major types of plankton: phytoplankton (plant plankton), zooplankton (animal plankton), and ultraplankton, which are no more than two micrometers wide and are photosynthetic bacteria.
 2. Ultraplankton may be responsible for as much as 70% of the primary productivity near the ocean surface.
 3. Nekton is a second group of organisms. These are fish, turtles, and whales.
 4. Benthos are bottom dwellers.
 5. Decomposers are a fourth group. These organisms break down organic matter.
- D. In aquatic systems, the key factors determining the types and numbers of organisms are temperature, dissolved oxygen, sunlight availability, and nutrient availability.
 1. Photosynthesis is largely limited to the upper layers, or photic zone, which can be diminished by turbidity.

8-2 Why are marine aquatic systems important?

- A. Oceans have two major life zones: the coastal zone and the open sea.
- B. The coastal zone interacts with the land, and so is much affected by human activities.
 - 1. Ecosystems in coastal zones have a high net primary productivity per unit area. They constitute 10% of the oceans and contain 90% of all marine species.
 - 2. There is ample sunlight, and nutrients flow from land and wind/currents distribute them.
 - 3. The coastal zone extends from the high-tide mark on land to the edge of the continental shelf.
 - 4. Estuaries and coastal wetlands are subject to tidal rhythms, runoff from land, and seawater that mixes with freshwater and nutrients from rivers and streams.
 - 5. Mangrove forest swamps grow in sheltered regions of tropical coasts.
 - 6. Coastal wetlands/estuaries make nutrients available due to constant stirring of bottom sediment.
 - 7. These areas filter toxic pollutants and excess plant nutrients, reduce storm damage, and provide nursery sites for aquatic species.
- C. Organisms living in the intertidal zone have adapted ways to survive the daily changes in wet/dry conditions and changes in salinity.
- D. Barrier beaches/sandy shores are gently sloping. Organisms tunnel or burrow in the sand to survive daily changes in conditions.
- E. Low, sandy, narrow islands that form offshore from a coastline are barrier islands. They generally run parallel to the shore.
- F. Coral reefs are home to $\frac{1}{4}$ of all marine species.
- G. The open sea is divided into three vertical zones based primarily on penetration of light.
 - 1. The euphotic zone is lighted, has floating phytoplankton carrying on photosynthesis, and has low nutrient levels except at upwellings.
 - a. Dissolved oxygen level is high.
 - 2. The bathyal zone is the dimly lit middle zone; no producers are in this zone. Zooplankton and smaller fish live in this zone.
 - 3. The abyssal zone is dark, very cold with little dissolved oxygen.
 - a. Organisms in this area are deposit feeders, or filter feeders.
 - b. Hydrothermal vents are present in some areas with specialized bacteria that feed on chemical nutrients and are food for other organisms.
 - c. Low average primary productivity and NPP occurs, but oceans are so large they make the largest contribution to NPP overall.

8-3 How have human activities affected marine ecosystems?

- A. Human activities are greatly affecting the ecological and economic services provided by marine ecosystems.
 - 1. Studies suggest 41% of the world's ocean area has been heavily affected by human activities.
 - 2. About 45% of the global population lives along coasts, and that figure is expected to rise.
 - 3. Major threats to marine systems include coastal development, degradation of wetlands and estuaries, over-fishing, non-point and point source pollution, habitat destruction, invasive species, and climate change.

CASE STUDY: Chesapeake Bay is the largest estuary in the United States. Population pressures and pollution have led to severe environmental problems in the region. An integrated program involving diverse groups has been effective in recent years at alleviating the severity of some of these pressures. Nevertheless, a recent decline in funding has slowed progress and environmental problems remain. New efforts to revitalize the project are promising.

8-4 Why are freshwater ecosystems important?

- A. Freshwater life zones include standing (lentic) bodies—such as lakes, ponds, and wetlands—and flowing (lotic) systems such as streams and rivers.
- B. Lakes are large natural bodies of standing water found in depressions.
 - 1. Rainfall, runoff, groundwater seepage and stream drainage feed lakes.
 - 2. Generally consist of four distinct zones depending on depth and distance from shore.
 - a. Littoral zone is open, sunlit surface water away from shore and is the most productive area for food and oxygen production.
 - b. The limnetic zone is the open sunlit surface away from the shore that extends to the depth that sunlight reaches.
 - c. Profundal zone is deep open water too dark for photosynthesis. Oxygen levels are lower.

- d. Benthic zone consists of decomposers and detritus feeders. Fish swim from one zone to another. Sediment washing and dropping detritus feed this area.
 - e. Oligotrophic lakes have small supplies of plant nutrients.
 - f. Eutrophic lakes have large nutrient supplies.
 - i. Human inputs can lead to cultural eutrophication.
 - g. Lakes between these two extremes are called mesotrophic lakes.
- C. Surface water is precipitation that does not infiltrate the ground or evaporate.
- 1. Runoff is surface water that flows into streams and rivers, and the area it drains is called a watershed or drainage basin.
- D. Three aquatic life zones, each with different conditions, can be identified along stream flow.
- 1. The source zone is narrow and fast moving. It dissolves large amounts of oxygen from air, and most plants are attached to rocks. Light is available, but is not very productive.
 - 2. The transition zone forms wider, deeper streams that flow down gentler slopes. The water is warmer, with more nutrients, which supports more producers, but has slightly lower dissolved oxygen.
 - 3. The floodplain zone has wider, deeper rivers. Water temperature is warmer; less dissolved oxygen is present and flow is slower.
- CASE STUDY:** Coastal deltas and wetlands provide protection against flooding. When these areas are degraded, the effects of storm events can be intensified. Many deltas are shrinking rather than being maintained, because the sediments that normally build them are trapped behind dams upstream. Much of the city of New Orleans is now below sea level for this reason. Levees offer a temporary solution but will usually be breached by a strong storm. Climate change also suggests that sea level will be rising further. We now understand these processes, but the question is whether or not we will apply them to the systems that are at risk.
- E. Inland wetlands cover the land for a part of all of each year. Wetlands include swamps, marshes, prairie potholes, floodplains, and arctic tundra in summer.
- 1. Wetlands provide a variety of ecosystem services, including filtering waste, reducing flooding, replenishing stream flows, recharging aquifers, maintaining biodiversity, supplying valuable products, and providing recreation opportunities.

8-5 How have human activities affected freshwater ecosystems?

- A. Human activities have four major impacts on freshwater systems.
- 1. Dams, diversions of canals fragment ~60% of world's large rivers and destroy habitats.
 - 2. Flood control dikes and levees alter rivers and destroy aquatic habitats.
 - 3. Cities and farmlands add pollutants.
 - 4. Many inland wetlands have been drained or altered.

CASE STUDY: More than half of the inland wetlands that existed in the United States in the 1600s no longer exist. About 80% are now used to grow crops and the rest have been lost to mining, forestry, and oil and gas extraction. This has greatly increased the flood and drought damage in the United States.

Explain the ramifications of both scenarios, in terms of flooding, recharging groundwater resources, cleaning the water of toxins and pollutants, etc. It may be valuable if the technology is available in your classroom to project a Google Earth map of the surrounding region. This will help students visualize the extent to which community design dictates the flow of water. Perhaps there is a levee system, a dam, or a reservoir in your area. If not, you might focus on the relative abundance of pavement versus vegetated open space to draw conclusions about what this entails for the hydrologic cycle.

Key Terms

aquatic life zones
benthos
coastal wetland
coastal zone
cultural eutrophication
decomposers
drainage basin
eutrophic lake
freshwater
inland wetlands
intertidal zone
lakes
marine
mesotrophic lake
nekton
oligotrophic lakes
open sea
plankton
runoff
saltwater
surface water
turbidity
watershed