MILLER/SPOOLMAN

LIVING IN THE ENVIRONMENT

17TH

Chapter 11

Sustaining Aquatic Biodiversity

Case Study: Protecting Whales: A Success Story… So Far (1)

- Cetaceans: Toothed whales and baleen whales
- 8 of 11 major species hunted to commercial extinction by 1975
- 1946: International Whaling Commission (IWC)
  - Quotas based on insufficient data
  - Quotas often ignored

Case Study: Protecting Whales: A Success Story… So Far (2)

- 1970: U.S.
  - Stopped all commercial whaling
  - Banned all imports of whale products

- 1986: IWC moratorium on commercial whaling
  - 42,480 whales killed in 1970
  - 1500 killed in 2009
  - Norway, Japan, and Iceland ignore moratorium

Examples of Cetaceans

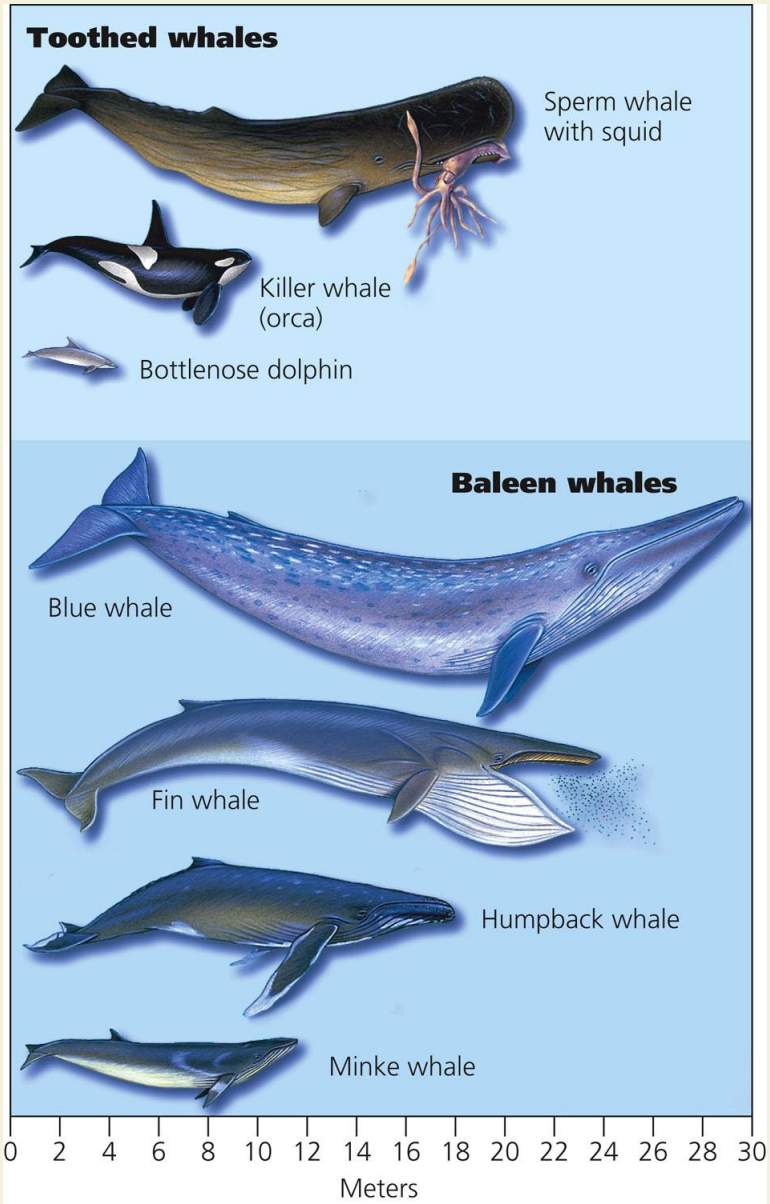


Fig. 11-1, p. 250

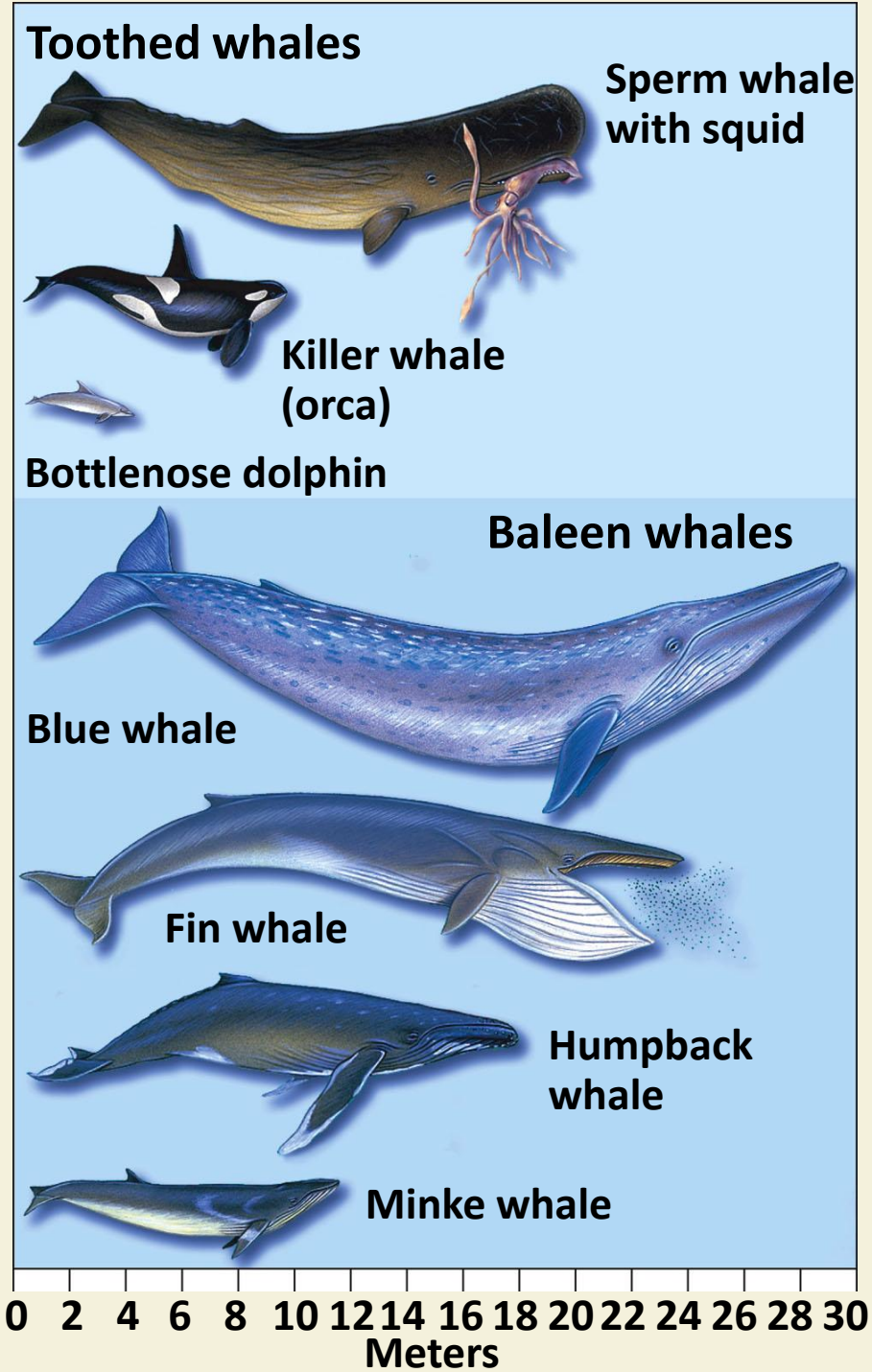
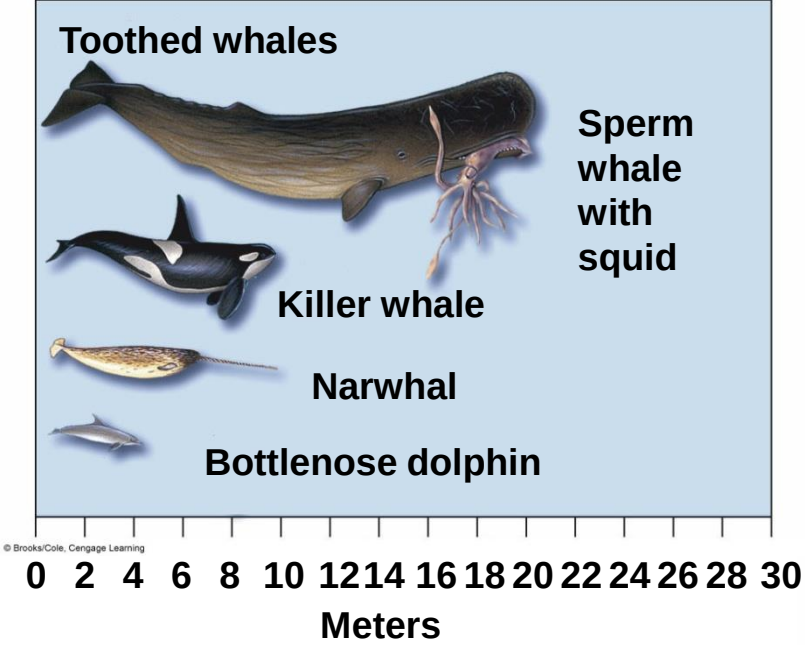
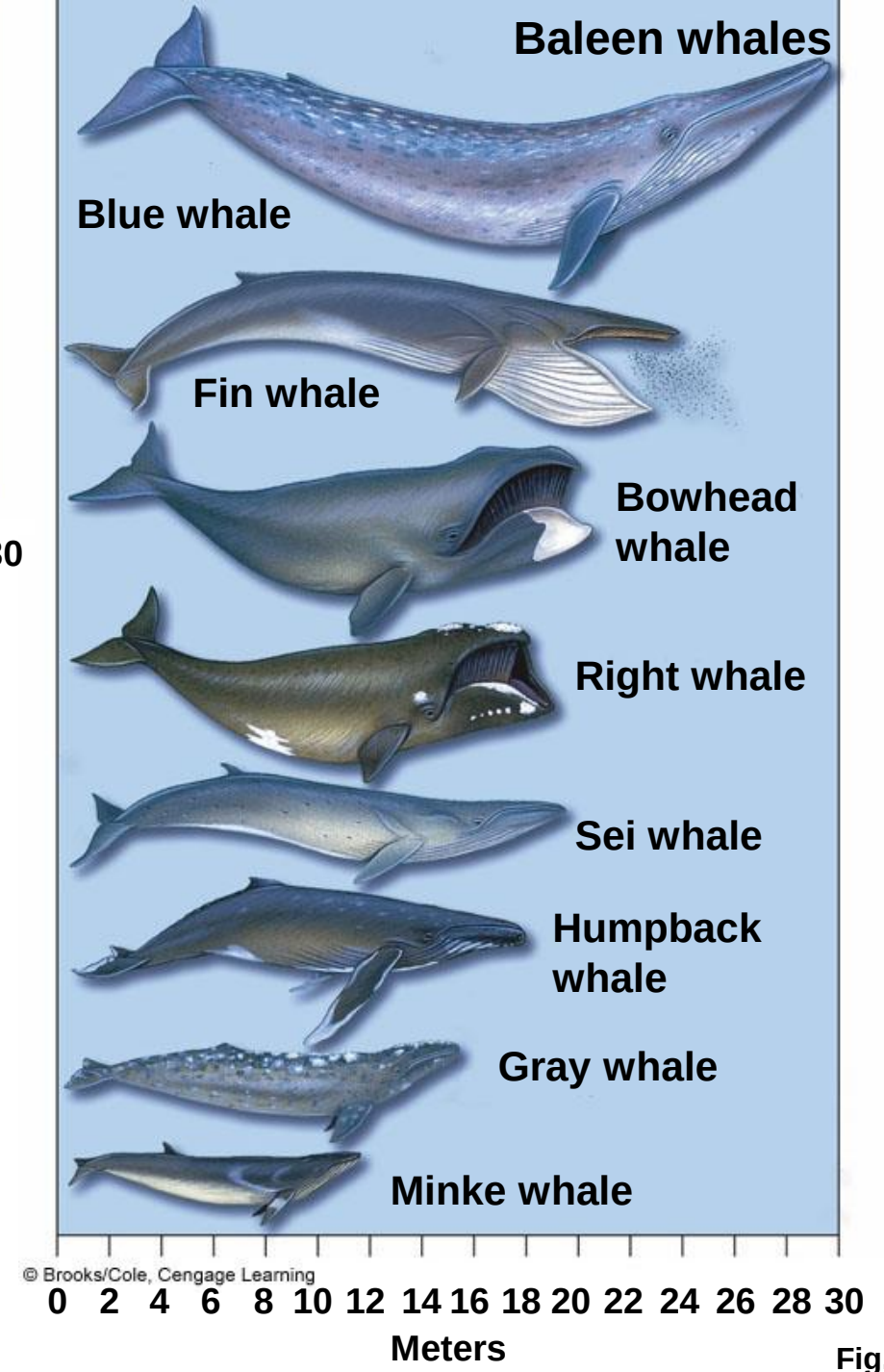

Toothed whales
Sperm whale with squid
Killer whale (orca)
Bottlenose dolphin
Baleen whales
Blue whale
Fin whale
Humpback whale
Minke whale
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Meters

Fig. 11-1, p. 250





Stepped Art

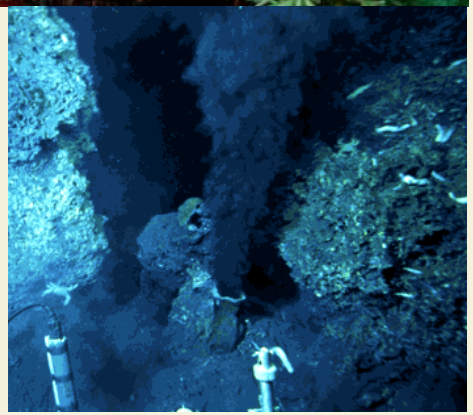
Fig. 11-1, p. 250

11-1 What Are the Major Threats to Aquatic Biodiversity?

- ***Concept 11-1*** *Aquatic species are threatened by habitat loss, invasive species, pollution, climate change, and overexploitation, all made worse by the growth of the human population.*

We Have Much to Learn about Aquatic Biodiversity

- Greatest marine biodiversity
  - Coral reefs
  - Estuaries
  - Deep-ocean floor



- Biodiversity is higher
  - Near the coast than in the open sea
  - In the bottom region of the ocean than the surface region

Human Activities Are Destroying and Degrading Aquatic Habitats

- Marine
  - Coral reefs
  - Mangrove forests
  - Seagrass beds
  - Sea-level rise from global warming will harm coral reefs and low-lying islands with mangrove forests
  - Ocean floor: effect of trawlers

- Freshwater
  - Dams
  - Excessive water withdrawal

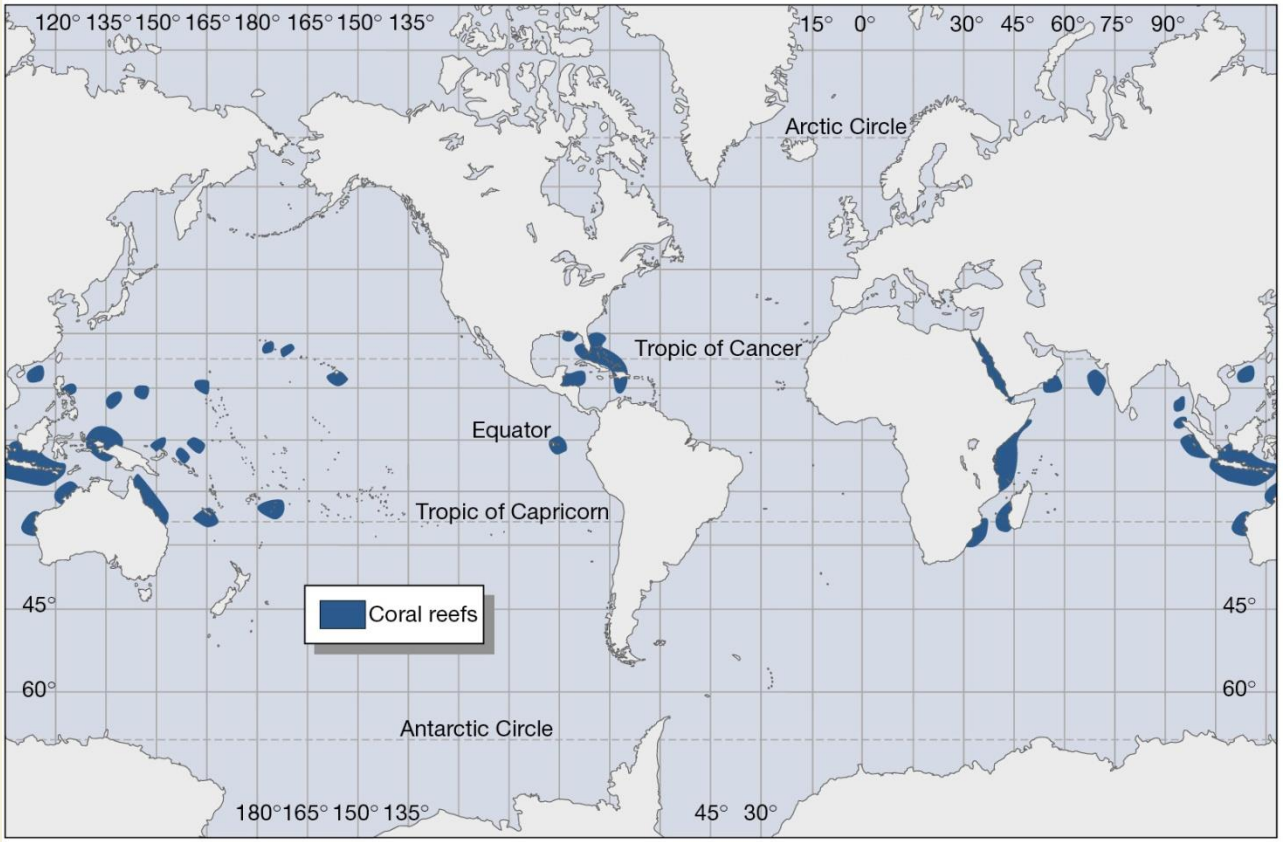
Coral Reefs

- Coral is an animal found in shallow tropical seas
- most productive and diverse ocean ecosystem
- dynamic, fragile, vulnerable, yet often recovers quickly
- structures made of calcium carbonate, built from calcium and carbonate ions in the ocean water
- symbiotic relationship to algae necessary to survive

www.chbr.noaa.gov

Coral Reefs

- tolerate temperatures ~21C – 29C (~70F – 85F)
- require sunlight, so grows in the euphotic zone (several meters to 200 m)
- believed to contain at least 25% (33%?) of all marine species, including 700 coral species and >4000 fish species



How are Coral Reefs Made?

- Corals (tiny animals, called polyps) secrete stony cup of limestone around themselves as a skeleton

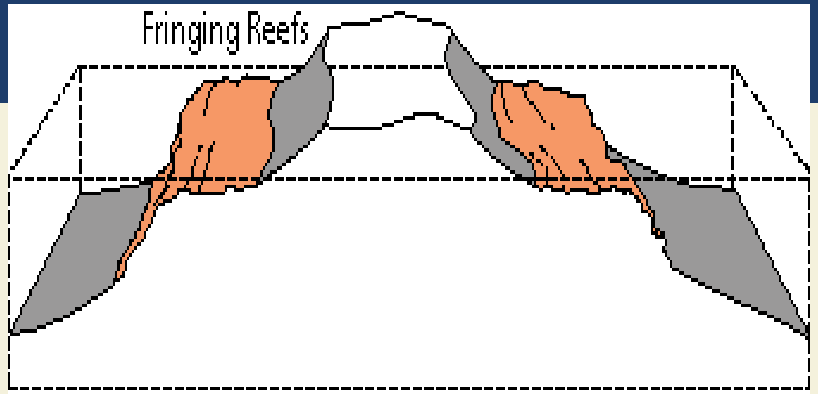
Polyps

- The polyps divide as they grow and form coral colonies - As the coral colonies build up on top of each other, they gradually form a coral reef
- Individual colonies may be up to 1000 years old & Coral reefs may be many thousands of years old

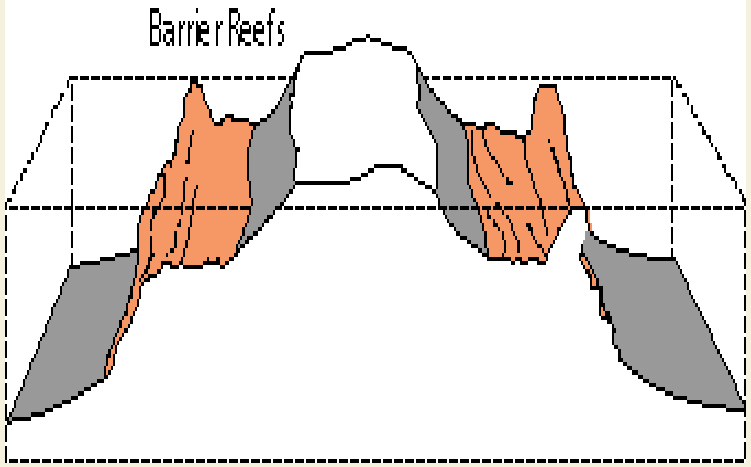
Types of Reefs

- Fringing Reef – lie around islands & continents & are separated from the shorelines by lagoons
- Barrier Reef – grow on the edge of continental shelves and also are separated from shorelines by lagoons
- Atolls – a central lagoon and are circular or sub-circular. There are two types of atolls: deep sea atolls that rise from deep sea and those found on the continental shelf.

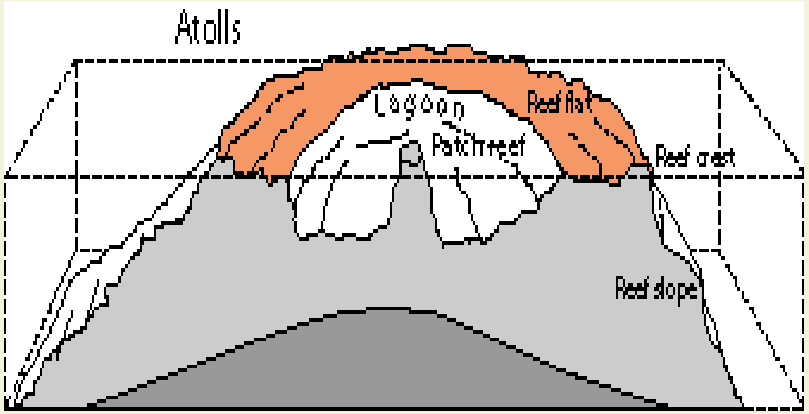
Types of Reefs



Fringing Reef



Barrier Reef



Atolls

Why Reefs Are Important…

- Biodiversity importance
- As a Food Resource
- Source of Economic Wealth
- Medicinal Use

Coral reefs are often called the "Rainforests of the Sea"

- About 4,000 species of fish and 800 species of reef-building coral have been identified

As a vital food source

- Globally, one-fifth of all animal protein consumed by humans comes from marine environments
- Coral reefs provide food for one billion people in Asia alone

Economic importance due to tourism …

- Florida's reefs contribute $1.6 billion to the economy from tourism alone

- Caribbean countries derive half of their GDP from tourism ($8.9 billion in 1990)

Coral reefs can save human lives...

- Treat infections, viruses, and other diseases
- Prevent and treat skin cancer
- Provide bone grafts

Threats to Coral Reefs From…

- Coastal development
- Pollution
  - Marine
  - inland
- Overfishing/ Destructive fishing
- Overexploitation of Resources
- Natural Disturbances

Coastal development ...

- Dredging
- Construction materials
- Building on reefs
- Unregulated tourism

Tourism/ Recreation

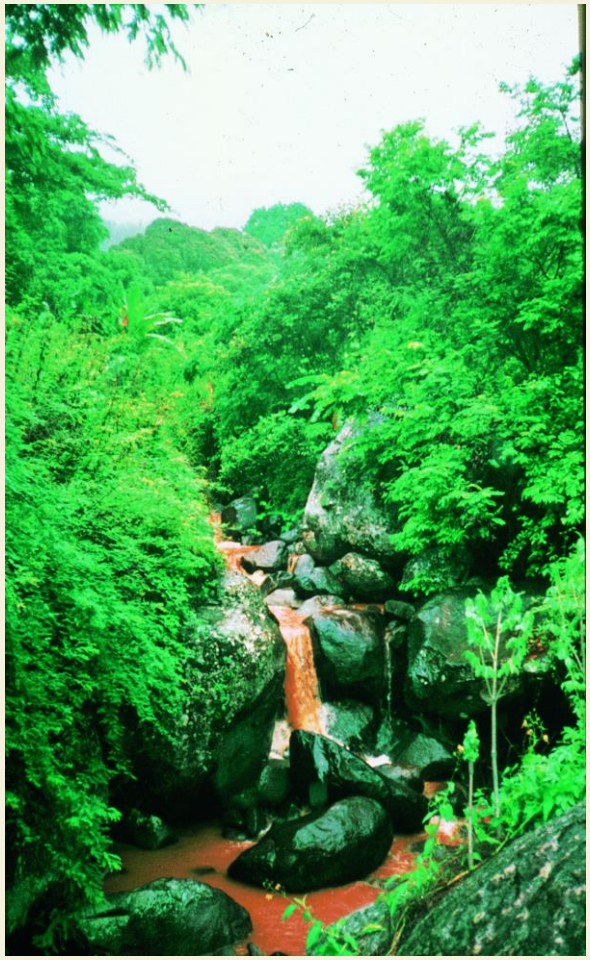
- corals easily broken by trampling when people walk out to the reef;
- snorkelers and divers may kill polyps simply by touching coral colonies

Marine Pollution

- Oil spills
- Discharge of oily ballast water
- Large power plants change water temperatures by discharging extremely hot water into the coastal water

Inland Pollution

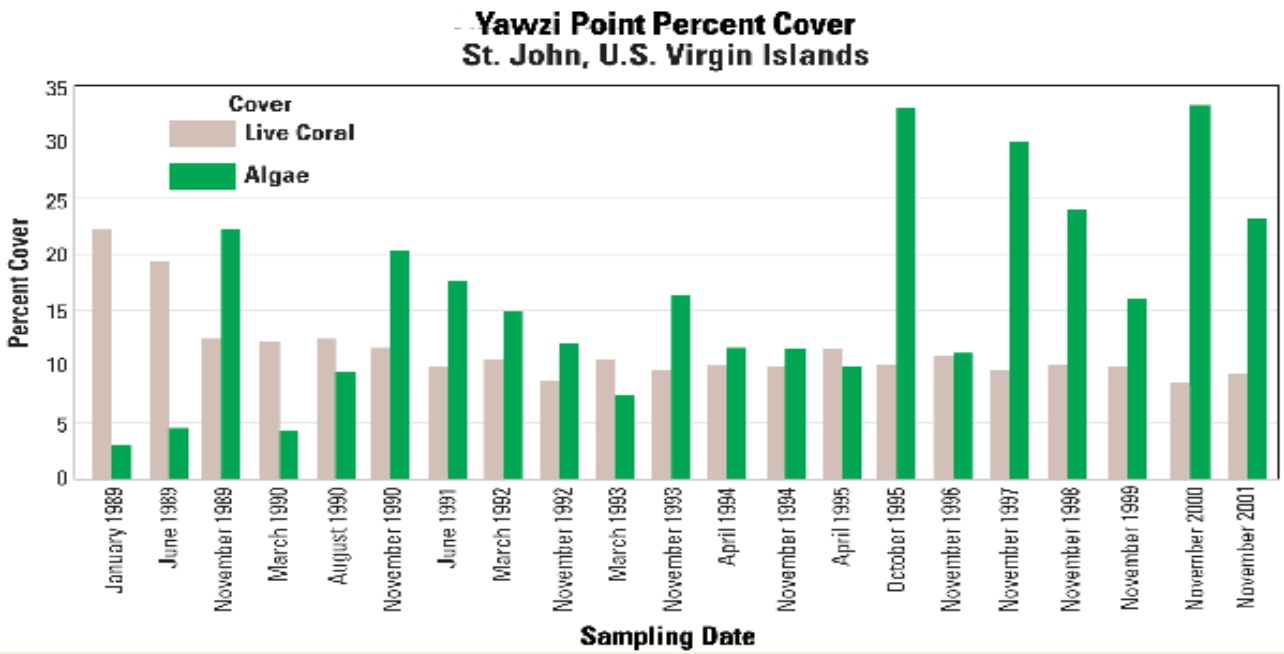
- Erosion from increased forest clearing & intense agriculture causes silt to wash into water, clouding it, and suffocating the coral
- Sewage & agricultural fertilizer runoff increases nutrients in ocean, which produces more seaweed that hurts the coral
- Lack of sunlight from eutrophication/turbidity can cause bleaching



River flow from the land can carry fertilizers, pesticides and sediment - stopping coral growth but encouraging algae

Overfishing

- removal of reef fish causes ecosystems to be unbalanced
- allows more competitive organisms, such as algae, to become dominant



Destructive fishing damages reefs

- Due to decreased yields, fishermen forced to change methods to catch enough fish to sustain needs:
  - Fishing with cyanide
  - Blast Fishing
- Not only do these practices kill all fish in the affected areas but also severely damage the corals

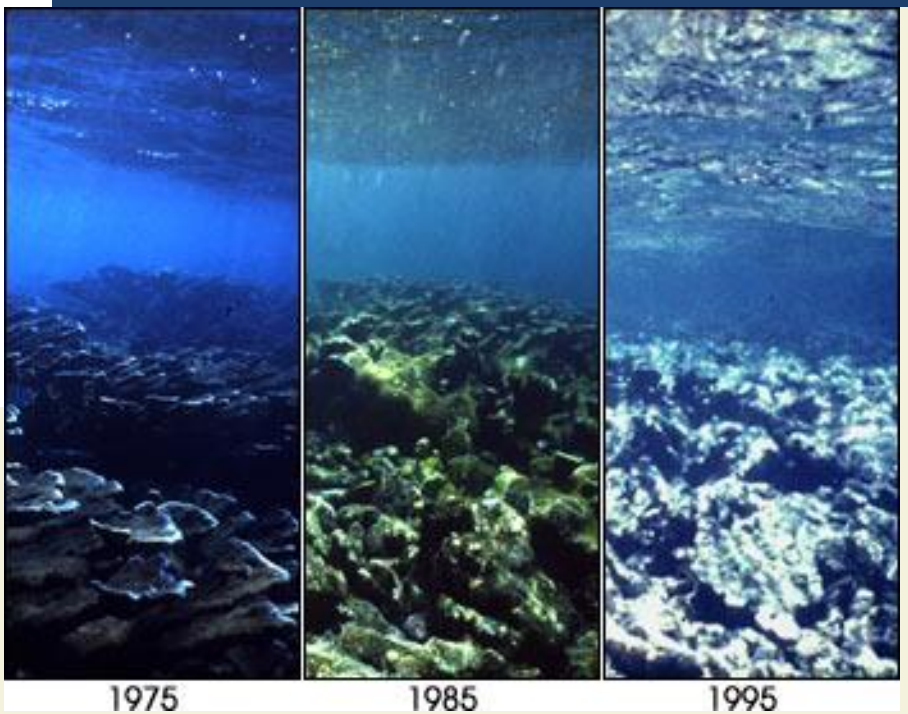
Coral Reef Bleaching

•corals expel the zooxanthellae, single celled organisms

• symbiotic relationship – corals can not live without their nutrients

• corals loose their colors and die

• changes in temperature cause bleaching



http://earthobservatory.nasa.gov/Study/Coral/coral2.html

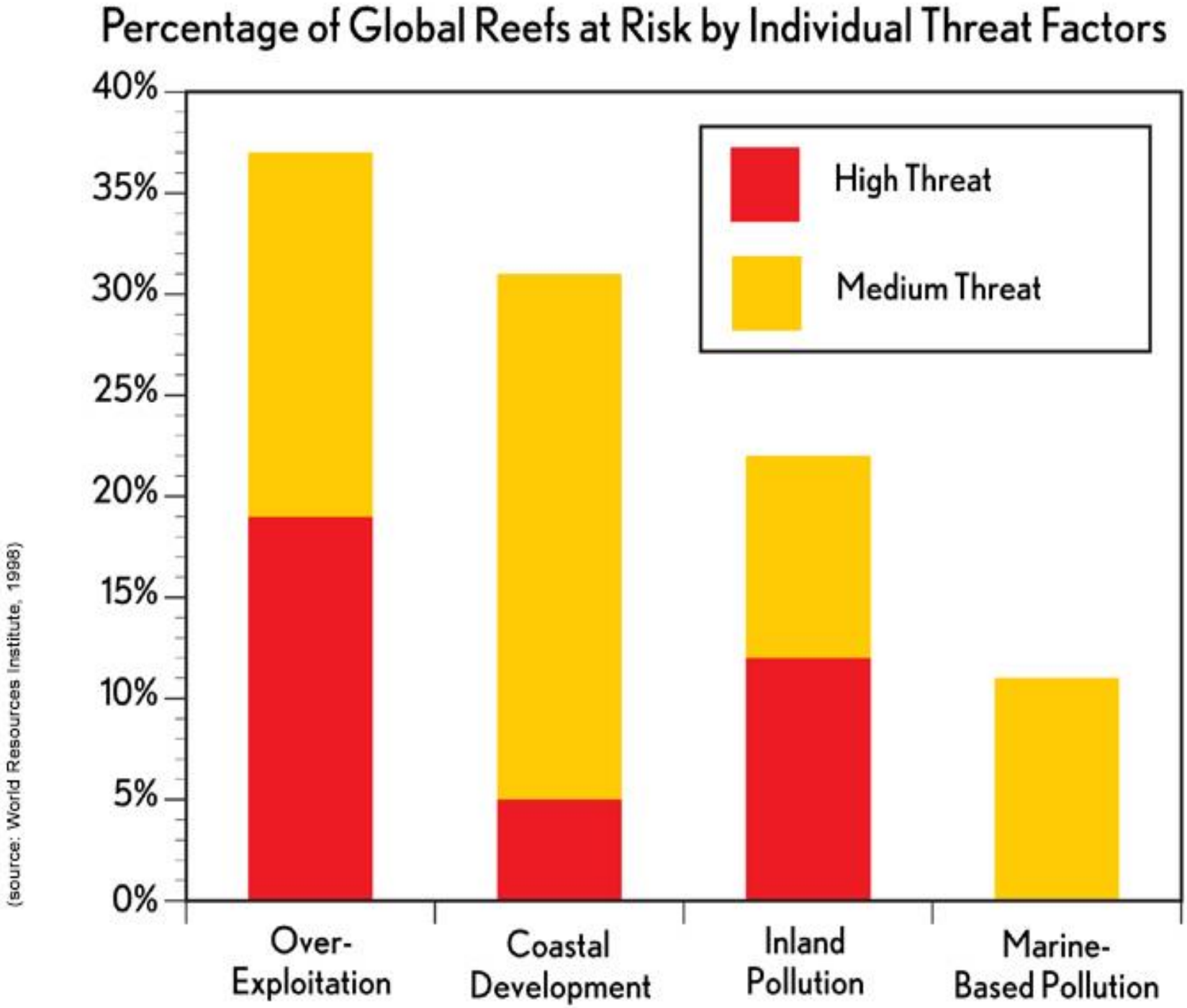
Science, May 4 2007, Vol 316, p. 678-681

Threats to Coral Reefs

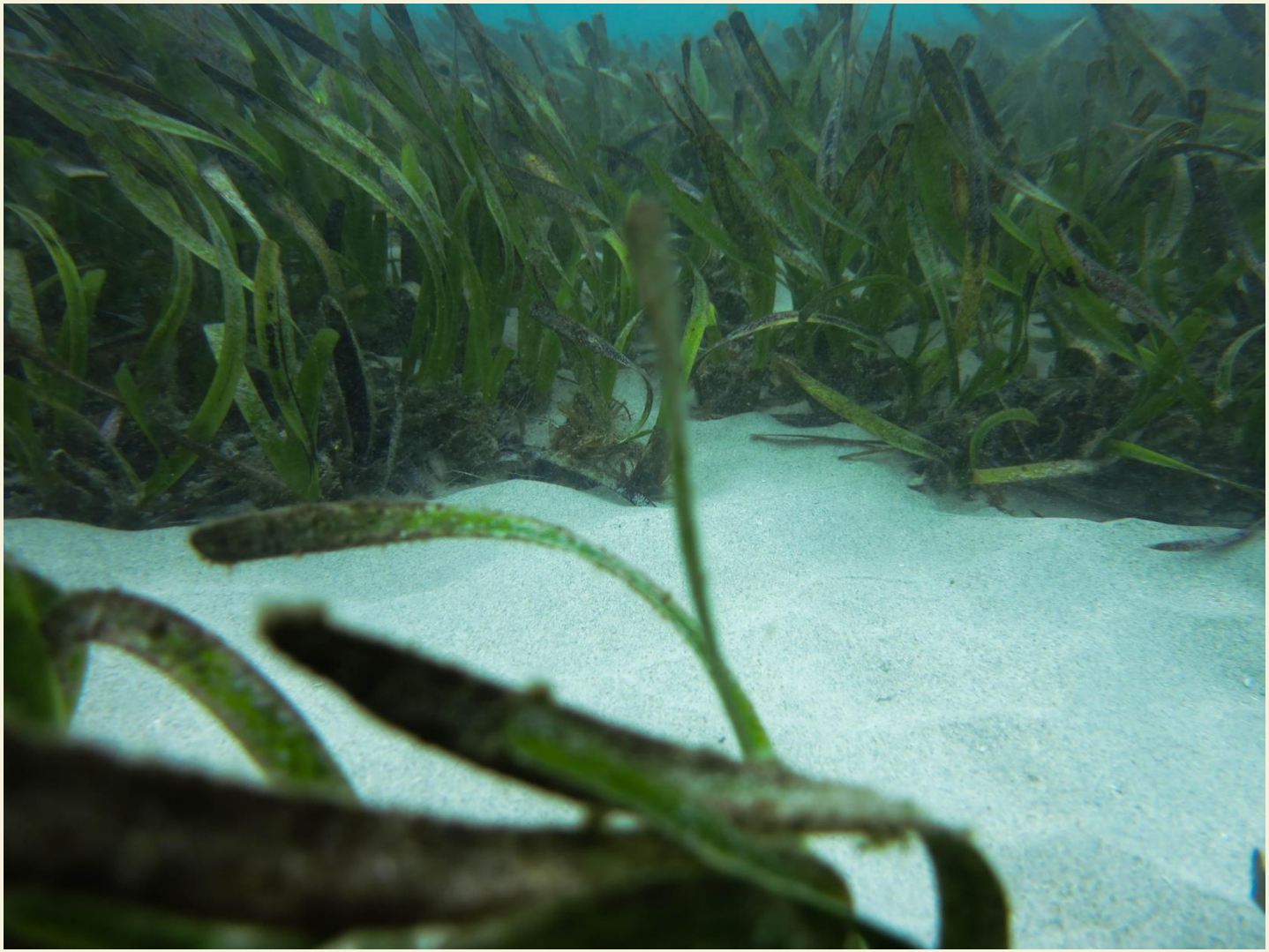
"besieged by pathogens, predators, and people, the 'rainforests of the sea' may soon face their ultimate foe: rising ocean acidity driven by CO2 emissions

Attempting to regrow reefs that were devastated by the tsunami of Dec 2004 such attemps have been somewhat successful

Science, May 4 2007, Vol 316, p. 678-681


Percentage of Global Reefs at Risk by Individual Threat Factors
40%
35%
30%
25%
20%
15%
10%
5%
0%
High Threat
Medium Threat
Over-Exploitation
Coastal Development
Inland Pollution
Marine-Based Pollution
(source: World Resources Institute, 1998)

Sea Grass



Life in a Florida Seagrass Bed

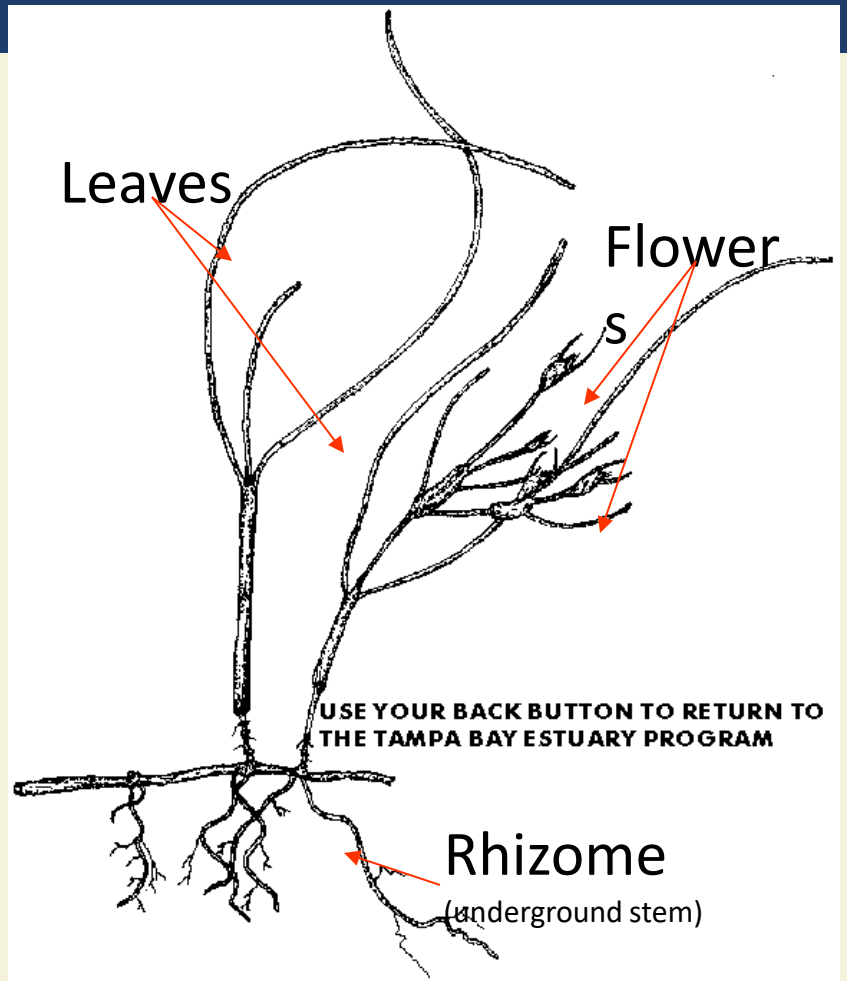
- Bacteria, Fungi
  - Decompose seagrass leaves
- Algae
  - Grows on seagrass leaves, becomes detritus
- Invertebrates
- Fish
- Reptiles
- Birds
- Mammals

Life in a Florida Seagrass Bed

- Bacteria, Fungi
- Algae
- Invertebrates – scallops, crabs
- Fish – snook, sharks
- Reptiles – sea turtles
- Birds – wading birds
- Mammals - manatees

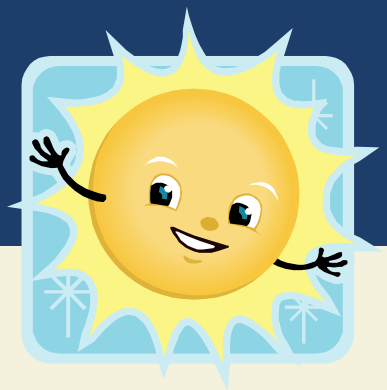
Seagrasses: So What Are They?

- Seagrasses are flowering underwater plants
- Found at shallow depths in estuaries: bays and lagoons with good water quality
- What are some reasons that these plants can grow only in shallow water?



Source: http://tbep.org/portrait/habitats.html

Line drawing of Manatee grass (*Syringodium filiforme*)



They grow in shallow water because…

- Seagrasses require good water clarity and quality to survive.
- They possess structures similar to terrestrial plants like roots, leaves and flowers.
- They need sunlight to penetrate the water in order to perform photosynthesis.

3 Types of Seagrasses in Tampa Bay

- turtle grass
  (yes, sea turtles eat it!)

- shoal grass
  (usually the first species to appear)

- manatee grass
  (yes, manatees love it!)

Pictures from http://www.dep.state.fl.us/coastal/habitats/seagrass/awareness/healthy_images.htm

So, Why are Seagrass Beds Important?

- ★ As a nursery environment, seagrasses support small fish, shrimp, and crabs that hide among the blades and feast on decaying leaves.
- ★ They help stabilize shifting sands on the bottom of the bay.
- ★ They improve water clarity by trapping fine sediments and particles.

The Decline of Seagrass Beds

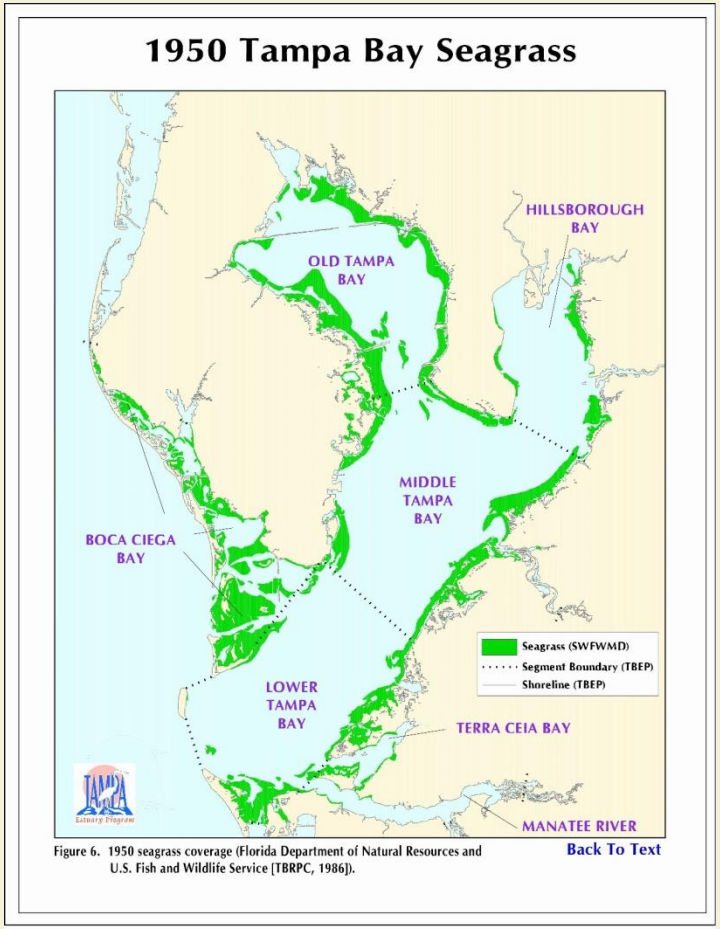
- After 1950, the seagrass beds in Tampa Bay seriously declined.
- The major reason for decline in seagrass beds is probably water pollution.
- As a class, list reasons why water pollution in Tampa Bay would increase after 1950.

Reasons Why Water Pollution Would Increase

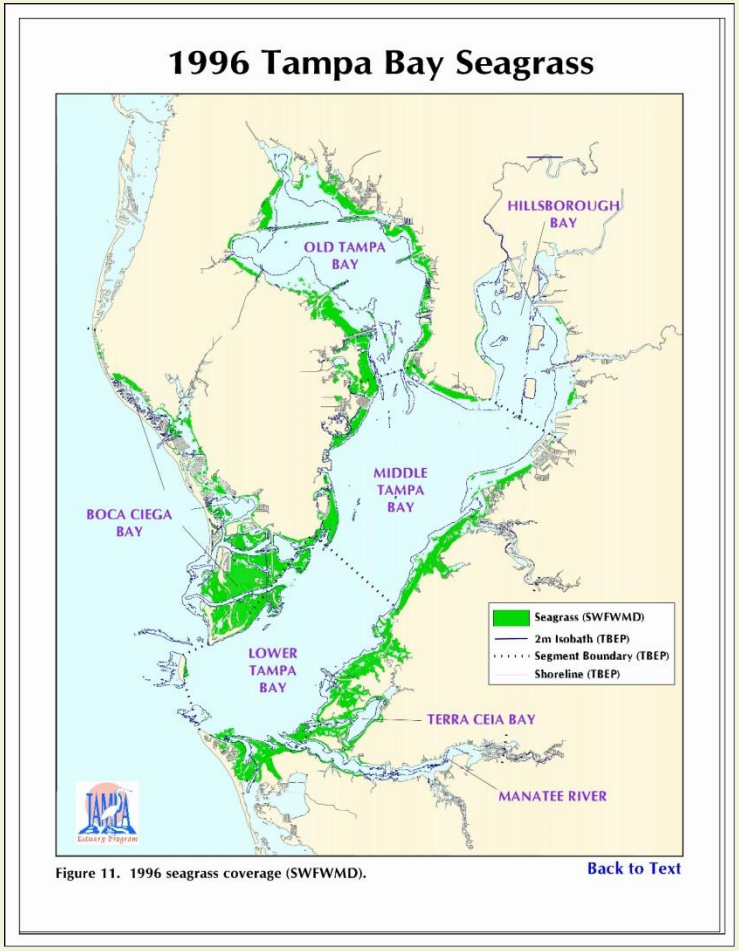
- Population increased; more garbage, sewage dumped into bay
  - More people lived near the Bay; more workplaces built
  - More cars, trucks -- air pollution (mercury, NOx, lead ends up in water)
- Oil, gasoline spills from cargo ships
- Port of Tampa receives more cargo ships (sewage, garbage and fuel spills from ships)
- More nitrogen entered the bay:
  - Sewage treatment plants were not like today (untreated sewage common in bay)
  - Industries dumped chemically polluted waste directly into water
- No real government control of water pollution before 1972

Compare the Seagrass Beds

40,420 ac in 1950



26,920 ac in 1996



Boat damage to seagrass beds, manatees

Natural Capital

Freshwater Systems

Ecological Services

Climate moderation

Nutrient cycling

Waste treatment

Flood control

Groundwater recharge

Habitats for many species

Genetic resources and biodiversity

Scientific information

Economic Services

Food

Drinking water

Irrigation water

Hydroelectricity

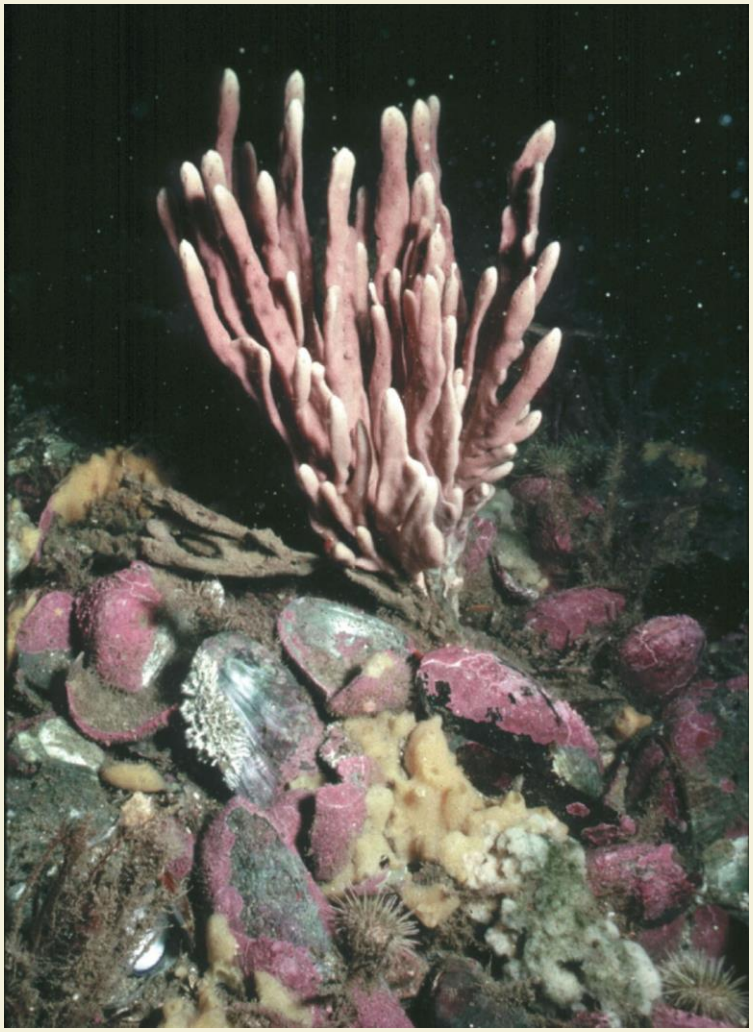
Transportation corridors

Recreation

Employment

Fig. 8-15, p. 181

Natural Capital Degradation: Area of Ocean Bottom Before and After a Trawler



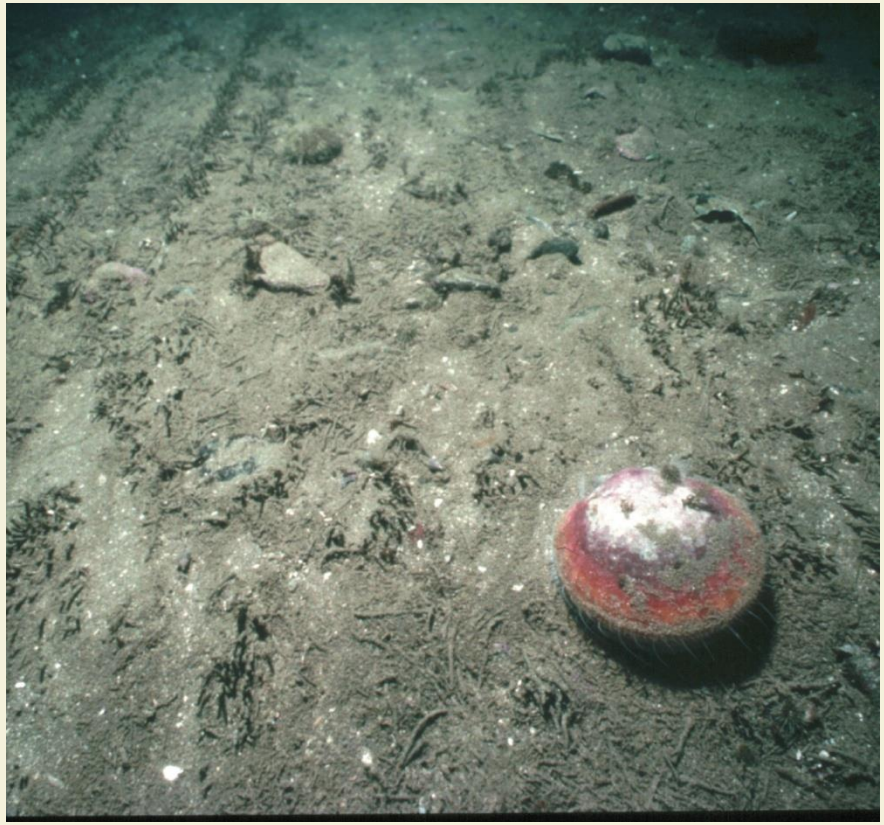


Fig. 11-2, p. 252

Invasive Species Are Degrading Aquatic Biodiversity

- Invasive species
  - Threaten native species
  - Disrupt and degrade whole ecosystems

- Two examples
  - Asian swamp eel: waterways of south Florida
  - Lionfish in the Atlantic

Invasive Lionfish

Fig. 11-3, p. 254

Science Focus: How Carp Have Muddied Some Waters

- Lake Wingra, Wisconsin (U.S.): eutrophic
  - Contains invasive species
    - Purple loosestrife and the common carp

- Dr. Richard Lathrop
  - Removed carp from an area of the lake
    - This area appeared to recover

Lake Wingra in Madison, Wisconsin

Fig. 11-A, p. 255

Case Study: Invaders Have Ravaged Lake Victoria

- Loss of biodiversity and cichlids
- Nile perch: deliberately introduced
- Frequent algal blooms
  - Nutrient runoff
  - Spills of untreated sewage
  - Less algae-eating cichlids
- Water hyacinths

Natural Capital Degradation: The Nile Perch In Lake Victoria

Fig. 11-4a, p. 254

Water Hyacinths in Lake Victoria

Fig. 11-5, p. 255

Population Growth and Pollution Can Reduce Aquatic Biodiversity

- More noise and crowding from humans
- Nitrates and phosphates, mainly from fertilizers, enter water
  - Leads to eutrophication
- Toxic pollutants from industrial and urban areas
- Plastics

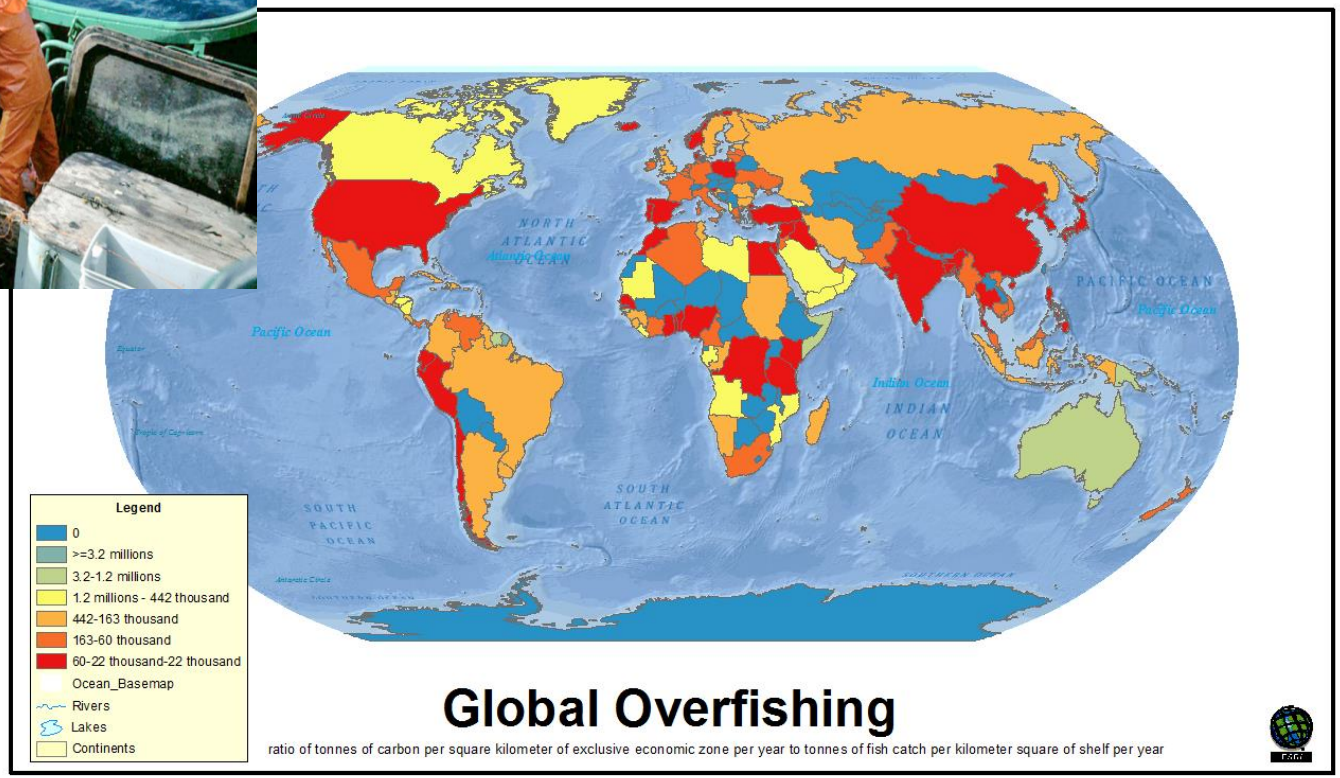
Hawaiian Monk Seal

Fig. 11-6, p. 256

Climate Change Is a Growing Threat

- Global warming: sea levels will rise and aquatic biodiversity is threatened
  - Coral reefs
  - Swamp some low-lying islands
  - Drown many highly productive coastal wetlands
    - New Orleans, Louisiana, and New York City

Overfishing and Extinction: Gone Fishing, Fish Gone (1)



Overfishing and Extinction: Gone Fishing, Fish Gone (1)

- **Fishery**: concentration of a particular wild aquatic species suitable for commercial harvesting in a specific area

- **Fishprint**: area of ocean needed to sustain the fish consumption of a person, country, or the world

- Marine and freshwater fish
  - Threatened with extinction by human activities **more** than any other group of species

Overfishing and Extinction: Gone Fishing, Fish Gone (2)

- **Commercial extinction**: no longer economically feasible to harvest a species
- Collapse of the Atlantic cod fishery and its domino effect
- Fewer larger fish
- More problems with invasive species

Natural Capital Degradation: Collapse of the Cod Fishery Off the Canadian Coast

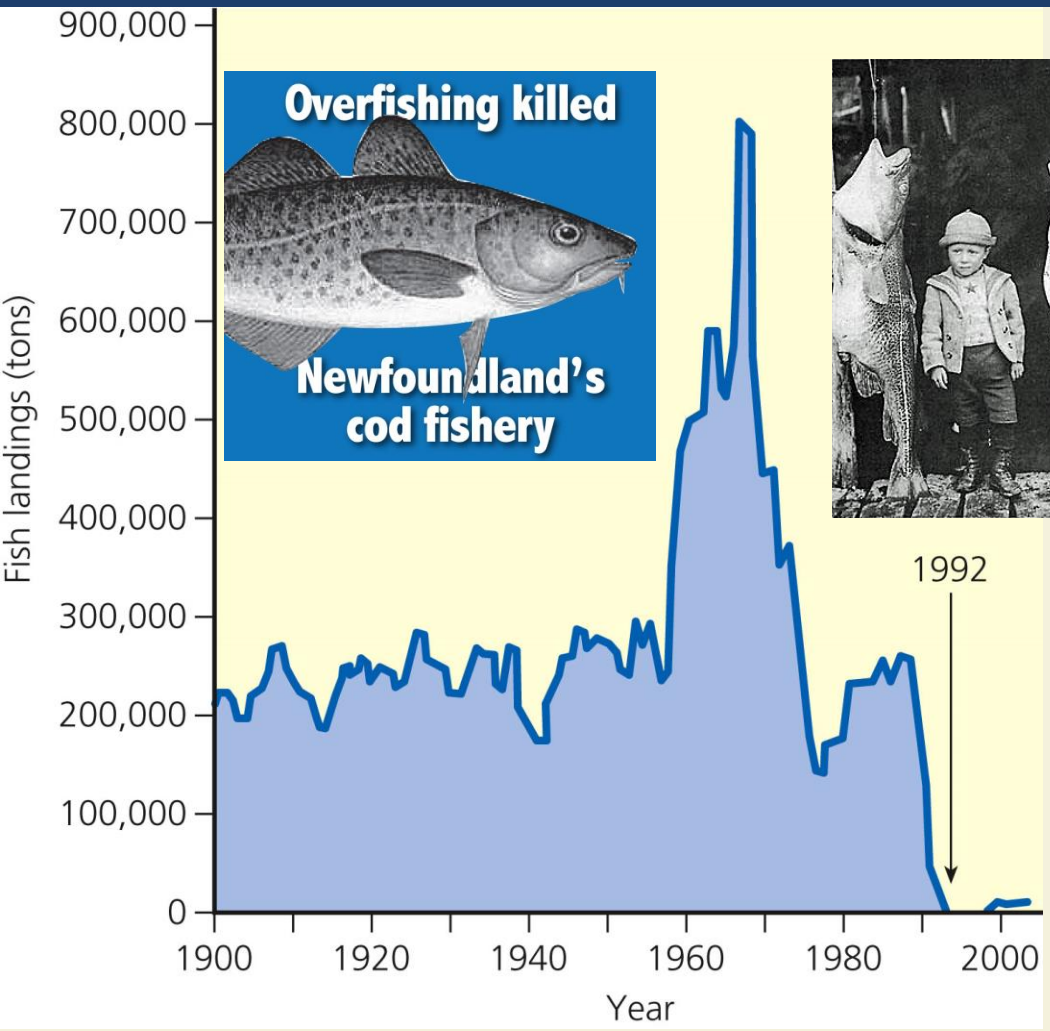


Fig. 11-7, p. 257

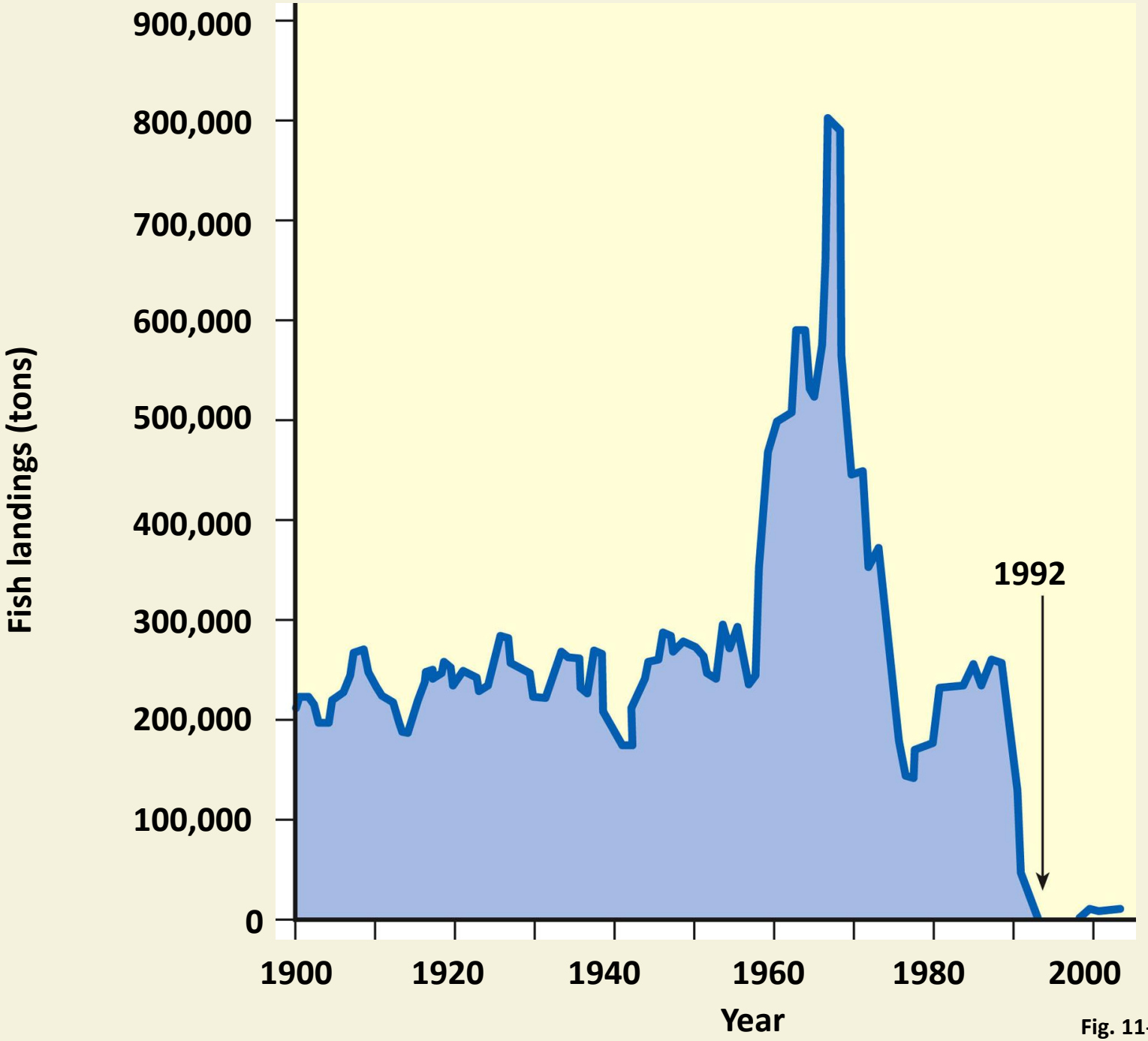

900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Fish landings (tons)
1992
1900
1920
1940
1960
1980
2000
Year

Fig. 11-7, p. 257

Science Focus: Clashing Scientific Views Can Lead to Cooperation and Progress

- Ray Hilborn disagreed Boris Worm with about the long-term prognosis for the world's fisheries

- The two agreed to work together
  - Developed new research methods and standards
  - Examined maximum sustained yield
  - Reported findings and prognosis in 2009

Case Study: Industrial Fish Harvesting Methods

- Trawler fishing
- Purse-seine fishing
- Longlining
- Drift-net fishing
- Bycatch problem

Major Commercial Fishing Methods Used to Harvest Various Marine Species

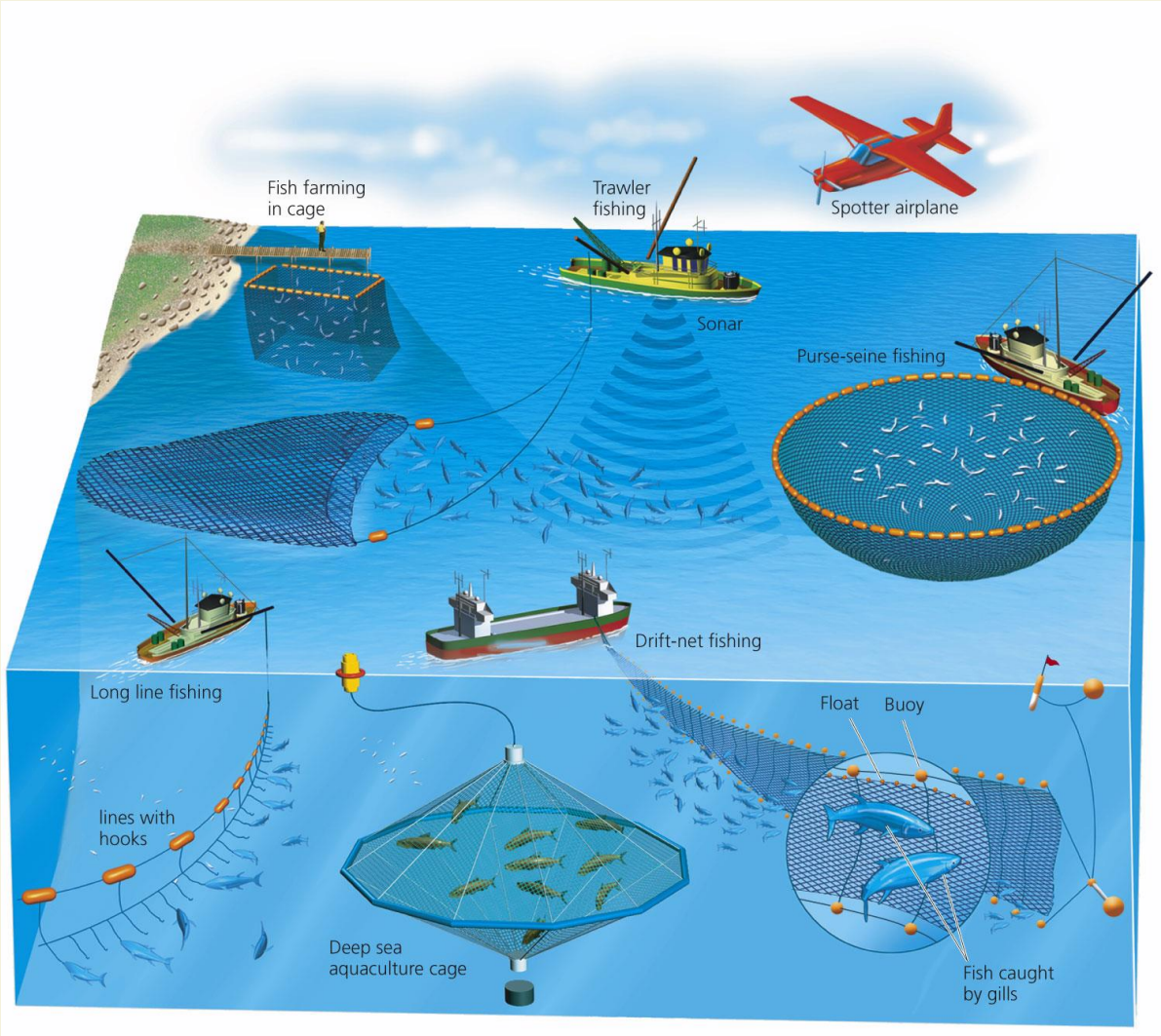


Fig. 11-8, p. 259

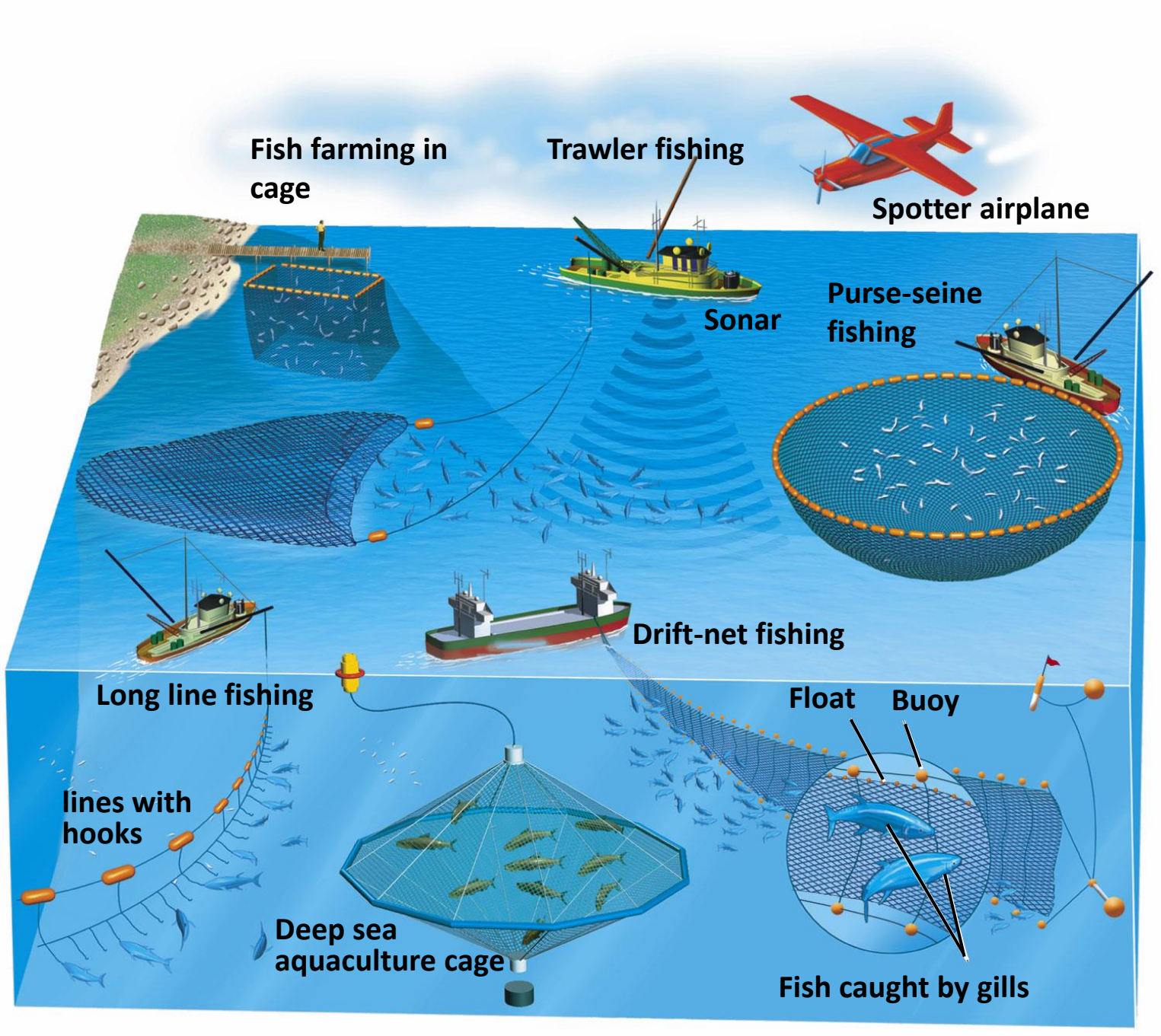

Fish farming in cage
Trawler fishing
Spotter airplane
Sonar
Purse-seine fishing
Drift-net fishing
Long line fishing
Float
Buoy
lines with hooks
Deep sea aquaculture cage
Fish caught by gills

Fig. 11-8, p. 259

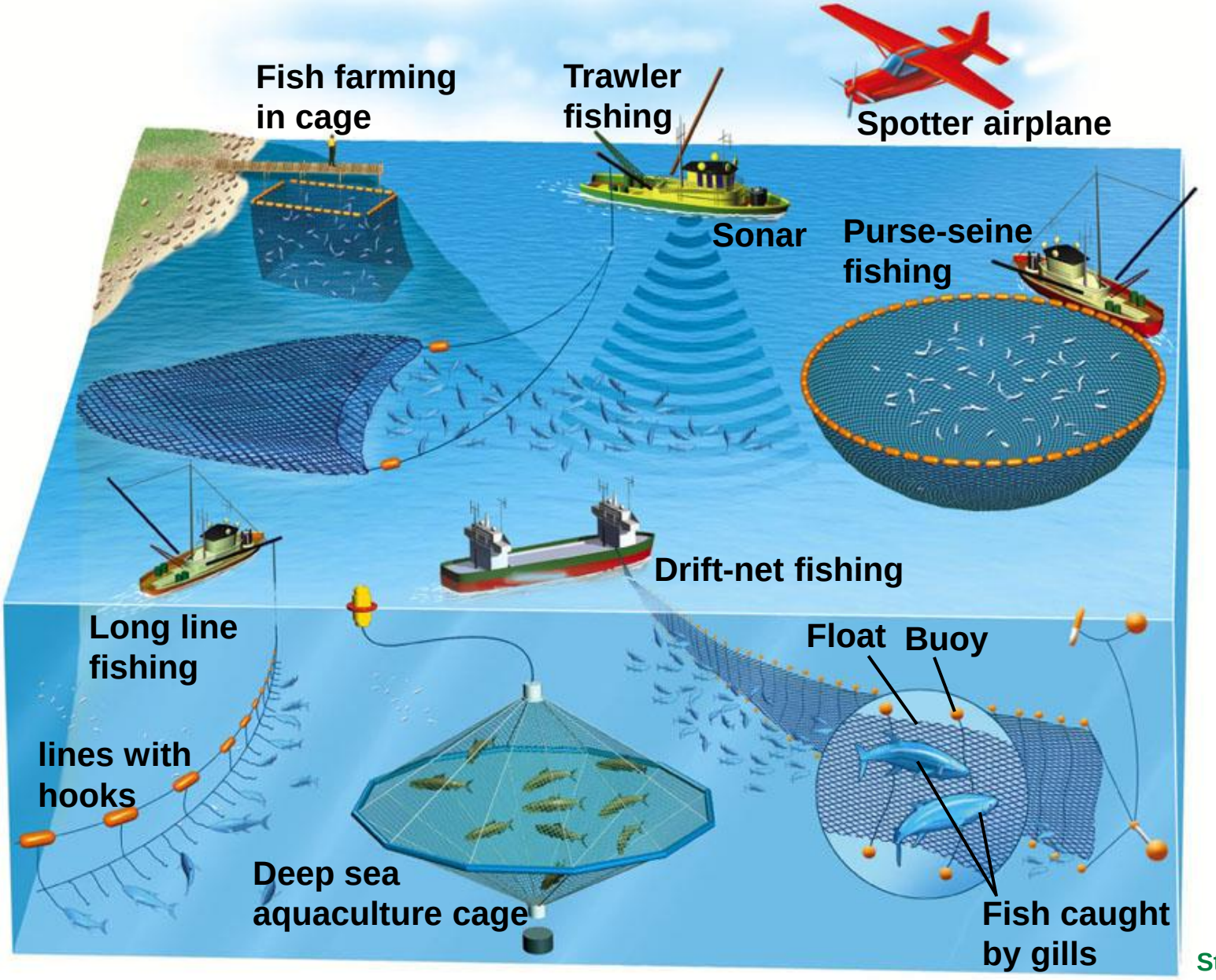


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Fig. 11-8, p. 259

11-2 How Can We Protect and Sustain Marine Biodiversity?

- ***Concept 11-2*** *We can help to sustain marine biodiversity by using laws and economic incentives to protect species, setting aside marine reserves to protect ecosystems, and using community-based integrated coastal management.*

Legal Protection of Some Endangered and Threatened Marine Species (1)

- Why is it hard to protect marine biodiversity?
  1. Human ecological footprint and fishprint are expanding
  2. Much of the damage in the ocean is not visible
  3. The oceans are incorrectly viewed as an inexhaustible resource
  4. Most of the ocean lies outside the legal jurisdiction of any country

Legal Protection of Some Endangered and Threatened Marine Species (2)

- 1975 Convention on International Trade in Endangered Species
- 1979 Global Treaty on Migratory Species
- U.S. Marine Mammal Protection Act of 1972
- U.S. Endangered Species Act of 1973
- U.S. Whale Conservation and Protection Act of 1976
- 1995 International Convention on Biological Diversity

Economic Incentives Can Be Used to Sustain Aquatic Biodiversity

- Tourism
  - Sea turtles
  - Whales

- Economic rewards

Case Study: Holding Out Hope for Marine Turtles

- Threats to the leatherback turtle
  - Trawlers and drowning in fishing nets
  - Hunting
  - Eggs used as food
  - Pollution
  - Climate change
- Fishing boats using turtle excluder devices
- Communities protecting the turtles

Sea Turtle Species

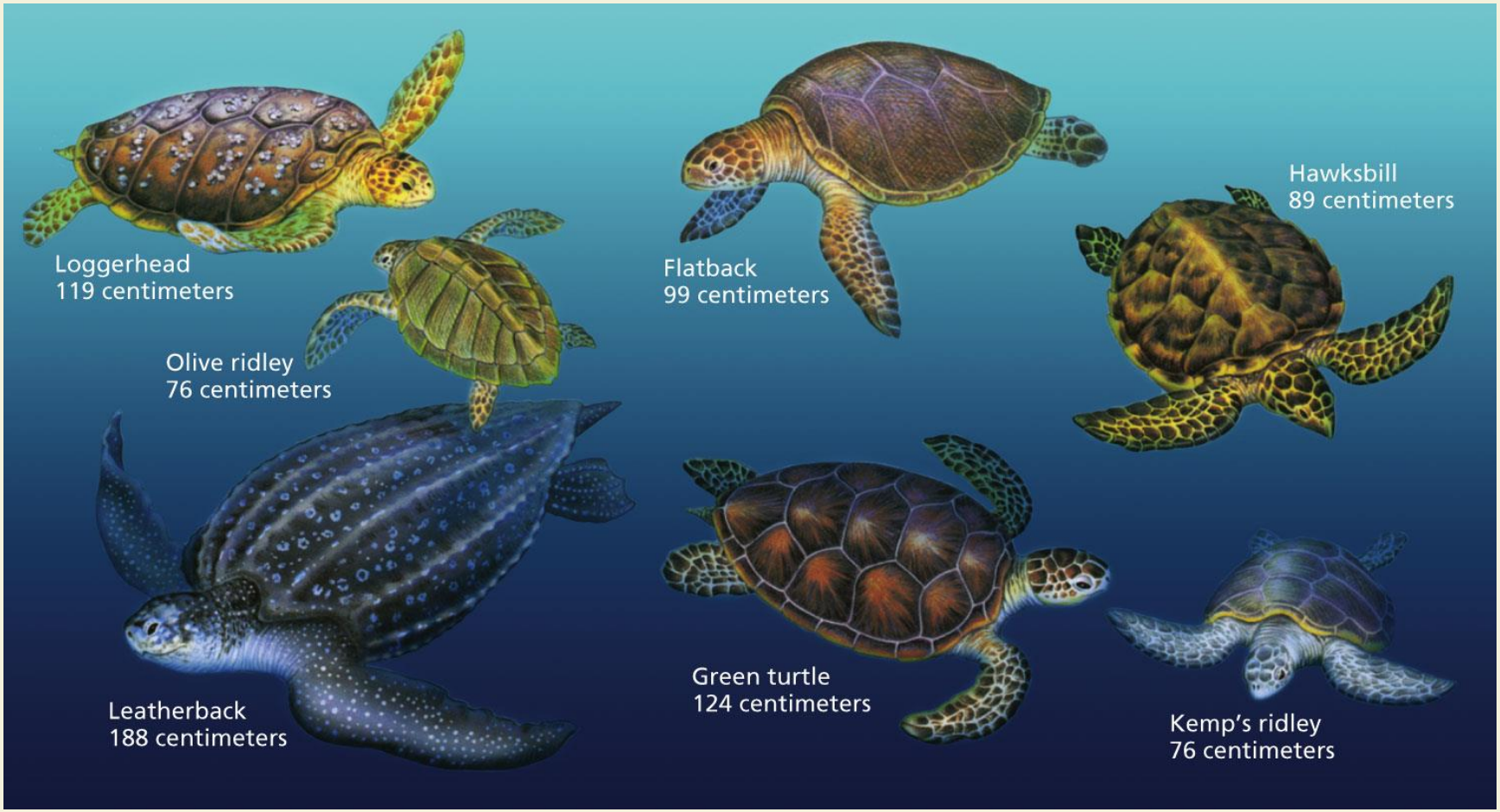


Fig. 11-9, p. 262

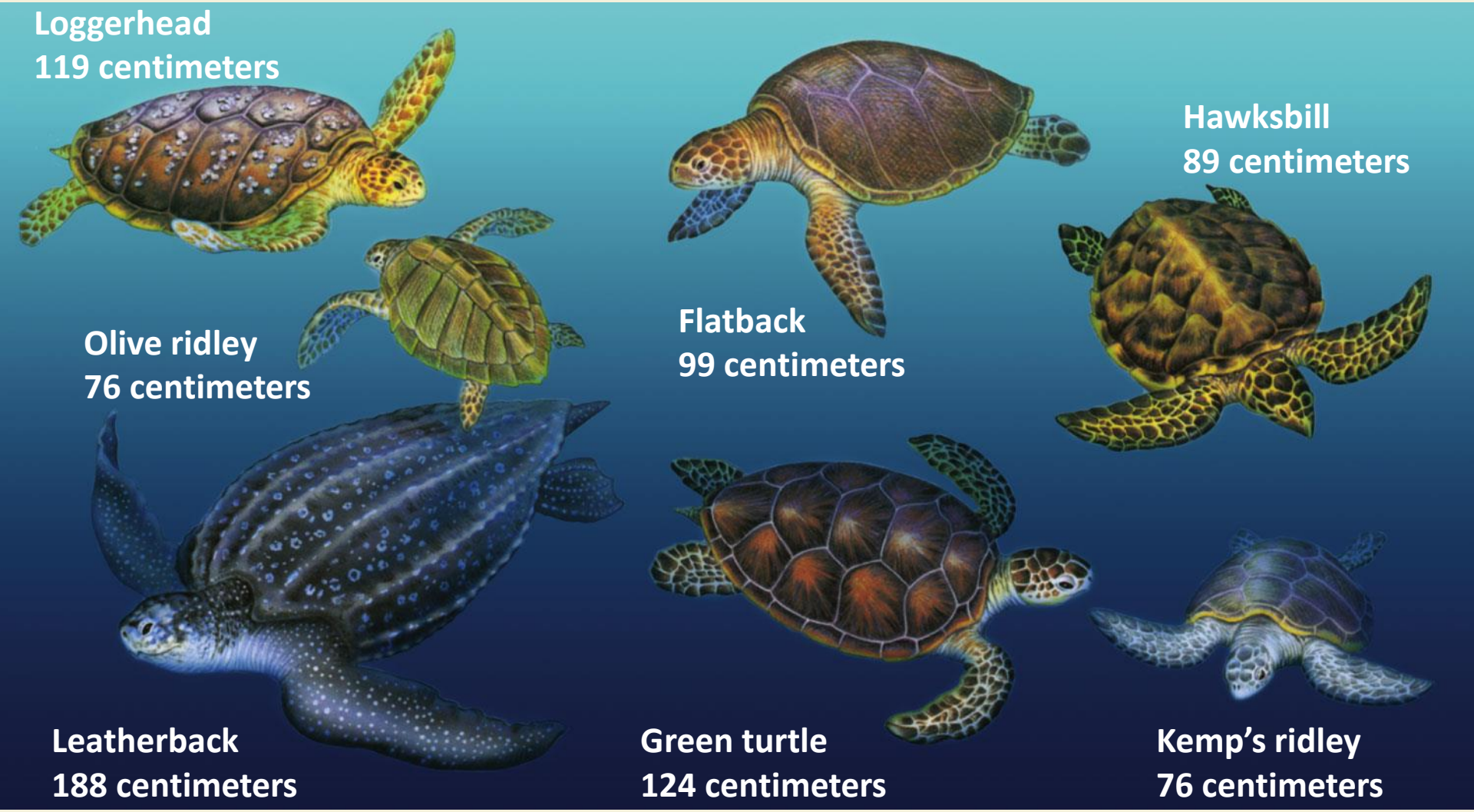

Loggerhead
119 centimeters
Hawksbill
89 centimeters
Olive ridley
76 centimeters
Flatback
99 centimeters
Leatherback
188 centimeters
Green turtle
124 centimeters
Kemp's ridley
76 centimeters

Fig. 11-9, p. 262

An Endangered Leatherback Turtle is Entangled in a Fishing Net

Fig. 11-10, p. 262

Marine Sanctuaries Protect Ecosystems and Species

- **Offshore fishing** extends to 370 kilometers
- **Exclusive economic zones**-can take certain quotas of fish
- **High seas-**beyond legal jurisdiction of any country

- **Law of the Sea Treaty –** world's coastal nations have jurisdiction over 36% of the ocean surface and 90% of the world's fish stocks

- **Marine Protected Areas (MPAs) –** 4000 world wide, 200 in US waters

Establishing a Global Network of Marine Reserves: An Ecosystem Approach (1)

- Marine reserves (remember Exuma Cays)
  - Closed to
    - Commercial fishing
    - Dredging
    - Mining and waste disposal
  - Core zone
    - No human activity allowed
  - Less harmful activities allowed
    - recreational boating and shipping

Establishing a Global Network of Marine Reserves: An Ecosystem Approach (2)

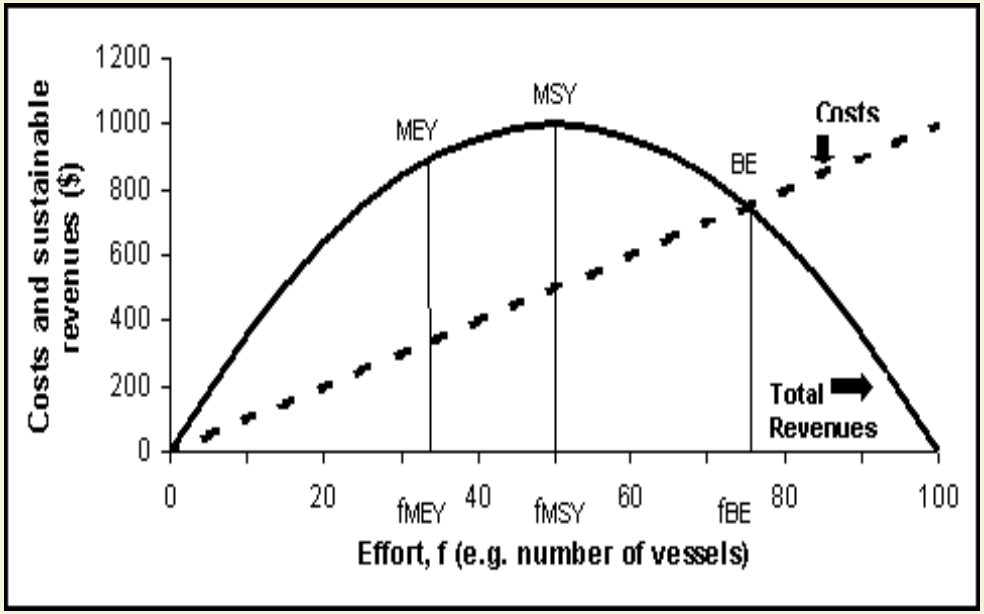
- Fully protected marine reserves work fast
  - Fish populations double
  - Fish size grows
  - Reproduction triples
  - Species diversity increase by almost one-fourth

11-3 How Should We Manage and Sustain Marine Fisheries?

- ***Concept 11-3*** *Sustaining marine fisheries will require improved monitoring of fish populations, cooperative fisheries management among communities and nations, reduction of fishing subsidies, and careful consumer choices in seafood markets.*

Estimating and Monitoring Fishery Populations Is the First Step

- **Maximum sustained yield (MSY)**: traditional approach
- **Optimum sustained yield (OSY)**
- **Multispecies management**
- **Large marine systems**: using large complex computer models
- **Precautionary principle**



Government Subsidies Can Encourage Overfishing

- 2007: World Trade Organization, U.S.
  - Proposed a ban on fishing subsidies

- Reduce illegal fishing on the high seas and in coastal waters
  - Close ports and markets to such fishers
  - Check authenticity of ship flags
  - Prosecution of offenders

Consumer Choices Can Help to Sustain Fisheries and Aquatic Biodiversity

- 1997: Marine Stewardship Council (MSC), London
  - Supports sustainable fishing
  - Certifies sustainably produced seafood

See http://www.seafoodwatch.org for info

- Manage global fisheries more sustainably
  - Individuals
  - Organizations
  - Governments

Solutions: Managing Fisheries

Solutions

Managing Fisheries

Fishery Regulations

Set low catch limits

Improve monitoring and enforcement

Economic Approaches

Reduce or eliminate fishing subsidies

Certify sustainable fisheries

Protect Areas

Establish no-fishing areas

Establish more marine protected areas

Consumer Information

Label sustainably harvested fish

Publicize overfished and threatened species

Bycatch

Use nets that allow escape of smaller fish

Use net escape devices for seabirds and sea turtles

Aquaculture

Restrict coastal locations of fish farms

Improve pollution control

Nonnative Invasions

Kill or filter organisms from ship ballast water

Dump ballast water at sea and replace with deep-sea water

Fig. 11-11, p. 267

Solutions

Managing Fisheries

Fishery Regulations

Set low catch limits

Improve monitoring and enforcement

Economic Approaches

Reduce or eliminate fishing subsidies

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Fig. 11-11, p. 267

11-4 How Should We Protect and Sustain Wetlands?

- ***Concept 11-4*** *To maintain the ecological and economic services of wetlands, we must maximize preservation of remaining wetlands and restoration of degraded and destroyed wetlands.*

Coastal and Inland Wetlands Are Disappearing around the World

- Highly productive wetlands
- Provide natural flood and erosion control
- Maintain high water quality; natural filters
- Effect of rising sea levels

We Can Preserve and Restore Wetlands

- Laws for protection
  - Zoning laws steer development away from wetlands
  - In U.S., need federal permit to fill wetlands greater than 3 acres

- Mitigation banking
  - Can destroy wetland if create one of equal area
  - Ecologists argue this as a last resort

Human-Created Wetland in Florida

Fig. 11-12, p. 268

Case Study: Can We Restore the Florida Everglades? (1)

- “River of Grass”: south Florida, U.S.

- Damage in the 20th century
  - Drained
  - Diverted
  - Paved over
  - Nutrient pollution from agriculture
  - Invasive plant species

- 1947: Everglades National Park unsuccessful protection project

Case Study: Can We Restore the Florida Everglades? (2)

- 1990: Comprehensive Everglades Restoration Plan (CERP)
  1. Restore curving flow of ½ of Kissimmee River
  2. Remove canals and levees in strategic locations
  3. Flood farmland to create artificial marshes
  4. Create 18 reservoirs to create water supply for lower Everglades and humans
  5. Recapture Everglades water flowing to sea and return it to Everglades

- Already weakened by Florida legislature

The World's Largest Restoration Project

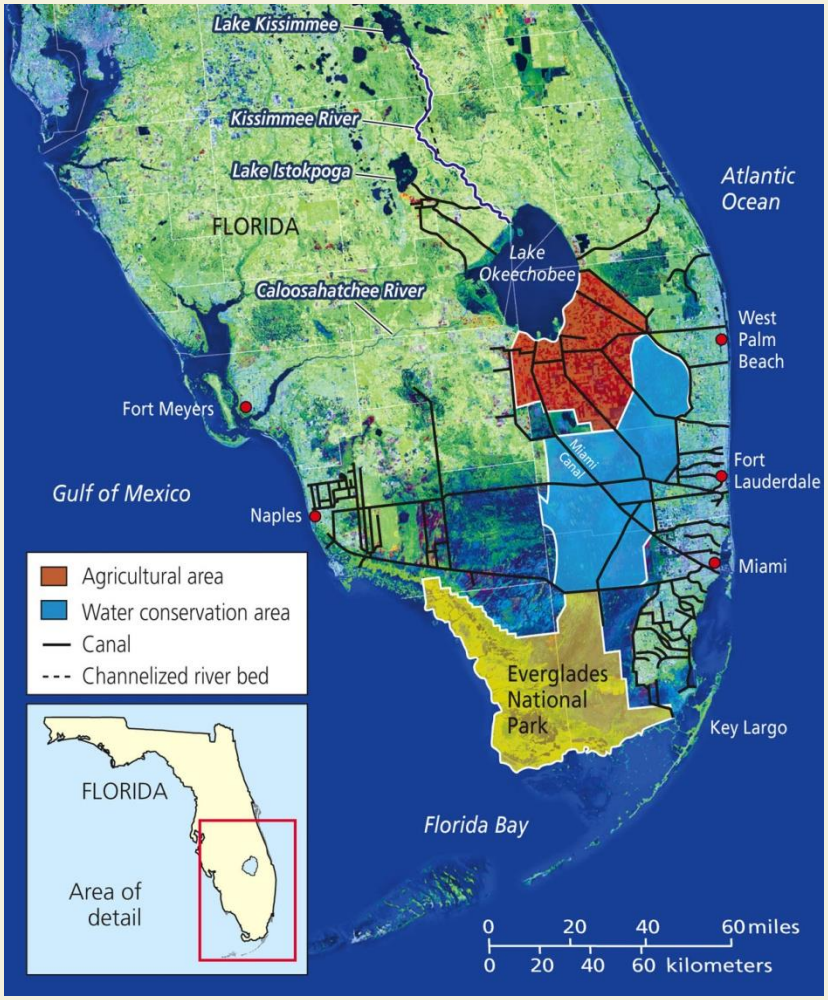

Fig. 11-13, p. 269

11-5 How Should We Protect and Sustain Freshwater Lakes, Rivers, and Fisheries?

- ***Concept 11-5*** *Freshwater ecosystems are strongly affected by human activities on adjacent lands, and protecting these ecosystems must include protection of their watersheds.*

Freshwater Ecosystems Are under Major Threats

- Think: **HIPPCO**
- 40% of world's rivers are dammed
- Many freshwater wetlands destroyed
- Invasive species
- Threatened species
- Overfishing
- Human population pressures

Case Study: Can the Great Lakes Survive Repeated Invasions by Alien Species?

- Collectively, world's largest body of freshwater

- Invaded by at least 162 nonnative species
  - Sea lamprey
  - Zebra mussel
  - Quagga mussel
  - Asian carp

Zebra Mussels Attached to a Water Current Meter in Lake Michigan

Fig. 11-14, p. 271

Asian Carp from Lake Michigan

Fig. 11-15, p. 271

Managing River Basins Is Complex and Controversial

- Columbia River: U.S. and Canada
- Snake River: Washington state, U.S.
- Dams
  - Provide hydroelectric power
  - Provide irrigation water
  - Hurt salmon

Natural Capital: Ecological Services of Rivers

Natural Capital

Ecological Services of Rivers

- Deliver nutrients to sea to help sustain coastal fisheries
- Deposit silt that maintains deltas
- Purify water
- Renew and renourish wetlands
- Provide habitats for wildlife

Fig. 11-16, p. 272

We Can Protect Freshwater Ecosystems by Protecting Watersheds

- Freshwater ecosystems protected through
  - Laws
  - Economic incentives
  - Restoration efforts

- Wild rivers and scenic rivers
  - 1968 National Wild and Scenic Rivers Act

11-6 What Are the Priorities for Sustained Biodiversity, Ecosystem Services?

- ***Concept 11-6*** *Sustaining the world's aquatic biodiversity requires mapping it, protecting aquatic hotspots, creating large, fully protected marine reserves, protecting freshwater ecosystems, and carrying out ecological restoration of degraded coastal and inland wetlands.*

Using an Ecosystem Approach to Sustaining Aquatic Biodiversity

- Edward O. Wilson
  - Complete the mapping of the world's aquatic biodiversity
  - Identify and preserve aquatic diversity hotspots
  - Create large and fully protected marine reserves
  - Protect and restore the world's lakes and rivers
  - Ecological restoration projects worldwide
  - Make conservation financially rewarding

Three Big Ideas

1. The world's aquatic systems provide important ecological and economic services, and scientific investigation of these poorly understood ecosystems could lead to immense ecological and economic benefits.

2. Aquatic ecosystems and fisheries are being severely degraded by human activities that lead to aquatic habitat disruption and loss of biodiversity.

Three Big Ideas

3. We can sustain aquatic biodiversity by establishing protected sanctuaries, managing coastal development, reducing water pollution, and preventing overfishing.