Nature's Gardens: Coral Reefs

Building a Reef: Symbiosis

Types of Reefs

Life on a Reef

Coral Reefs and the Future

Reading: 12.20-12.22

15.5
16.15, 16.21
17.26

Graphic: Coral reef, courtesy of NOAA.

Cnidaria - Carnivorous Stinging Animals

Jellyfish, anemones, corals

- Simple digestive system (single sac with wastes expelled through mouth)

- Stinging cells (cnidoblasts) shoot upward from tentacles penetrate, entangle or disable prey

-Two forms

- **- free swimming medusa (jellyfish)**
- **- anchored polyp (anemones, coral)**

Graphics: Top left: Anemone.

Collection of Dr. J.P.McVey,

Bottom left Garrison, Fig. 15.6b

NOAA Photo Library. Right:

Garrison 5th Ed., Fig. 15.4.

So What is a Coral Reef?

- Largest animal-built structures on Earth (Great Barrier Reef = 2500 km long)

- Composed of coral animal skeletons, which accumulate, gradually forming a reef

- Reefs grow slowly (1 cm/yr) and are sensitive to changes in sea level and temperature

Graphics: (top) Coral polyps, (middle) colonial coral, (bottom) coral skeleton, all from the collection of Dr.J.P.McVey, courtesy of NOAA.

Coral Reefs and Environmental Conditions

Reefs require:

- abundant light

- warm water temperature

- typical ocean salinity

- sediment-free water

- high oxygen

Graphic: Maldives atolls, images and photographs courtesy Bruce Hatcher and Abdulla Naseer, Dalhousie University, provided by NOAA.

Where are Coral Reefs Found?

Reefs are found in clear, shallow tropical waters with moderate wave action

Graphics: (top) Great Barrier Reef, Australia, Image provided by the SeaWiFS Project, NASA/GSFC and Orbimage, (bottom) Global distribution of coral reefs, courtesy of NOAA.

Coral Reef Communities

Coral reefs are "oases" within the "biological desert" of the tropical oceans

Coral animals- about half of reef biomass

Coralline algae (plants) -form crusts that "cement" the reef together

Most other animal groups inhabit reefs forming a complex food web

Graphic: Garrison, Fig. 16.12.

Biodiversity and Competition on a Reef – Survival of the Fittest

Coral reefs are 0.17% of Earth's surface area but home to 4-5% of all species

Fast-growing coral can overgrow slower-growing species, restricting access to light and food

Long sweeper tentacles can inject venom into adjacent competing coral colonies

Dispersal of toxic water-borne chemicals can deter neighbors

Graphics: (top) Red Sea, M. Al Momany, photographer, courtesy of NOAA, (middle) Gulf of Aqaba, Red Sea, Al Momamy, photographer, courtesy of NOAA. (bottom) Coral reef, photo courtesy of NOAA,

Self-Defense on the Reef

- Toxic venoms and distasteful substances are common among coral, fish and other animals on the reef

- Bright colors serve as warnings to other species – many poisonous species are brightly colored

- Camouflage and confusing coloration helps some species hide from predators

Graphic: Brightly colored coral and fish on a North Carolina reef, C. Liipfert, photographer, courtesy of NOAA/NURP and Univ. N.Carolina at Wilmington.

The Value of Coral Reefs

- 500 million people globally rely on coral reefs for food, coastal protection, resources, etc

- 30 million people depend exclusively on reefs for food

- In the U.S., reefs provide billions of dollars to the economy through tourism, fisheries, and recreation

- Home to 1 million+ species

- "Medicine cabinets" of the

21st century

(treatments for

heart disease, arthritis,

cancer and HIV)

Graphics:

(top) Diver enjoying a reef slope,

courtesy of NOAA, (bottom) A deepwater reef

community that was the focus of a recent

expedition in search of new pharmaceuticals from

the sea, photo courtesy of NOAA. Info from U.S. Coral

Reef Task

Force, NOAA.

Threats

Under current pressures, 60% of coral reefs could die by 2050

Natural threats:

- hurricanes, storms

- changes in climate

- disease

- predators

Human threats:

- poor fishing practices (e.g., cyanide and "blast" fishing)

- pollution

- overexploitation (for recreation and commerce)

Graphic: (top) Development in coastal Florida, A.Lack, photographer, courtesy of NOAA National Marine Sanctuaries. (bottom) Coral afflicted with fast-spreading yellow-band disease. The left-hand picture was taken several weeks before the right-hand picture, A.Bruckner, photographer, courtesy of NOAA.

What Causes Coral Bleaching?

Large-scale bleaching, across wide swaths of the tropics, is caused by elevated ocean temperatures (1-2 ^{o}C higher than usual)

High temperatures damage the cells of zooxanthellae, interfering with their ability to use light for photosynthesis

Locally, bleaching can also be caused by disease, sediment, cyanide fishing, pollution and changes in salinity

Graphic: Bleached coral, courtesy of NOAA.

Coral Bleaching and Climate Change

Bleaching affects the ecology of the entire reef (if coral die, organisms dependent on them are at risk)

There is concern among scientists for the long-term health of coral reefs due to increasing ocean temperatures due to climate change

Graphic: Global trends in coral bleaching., 1998 (top) vs 2006 (bottom). Graphic from: Schuffenberg, 2006, A reef manager's guide to coral bleaching, Great Barrier Reef Marine Park Authority.

Ocean Acidity (pH) and Reef Health

For many species, the ability of corals to generate the hard parts of a reef depends on the acidity (pH) of the ocean

High acidity (low pH) degrades calcium carbonate skeletons and shells

Low pH puts reef ecosystems at risk of catastrophic structural and ecological failure

About 30% of the anthropogenic CO2 produced since the beginning of industrialization has been absorbed by the oceans, reducing ocean pH by 0.1

As the ocean continues to absorb CO2, pH may fall by an additional 0.14-0.35 units by 2100*

* From Climate Change 2007: The Physical Science Basis, IPCC Working Group I, Summary for Policymakers, 2007.

Graphic: Red Sea coral reef, courtesy of NOAA.

Potential Impacts of Acidification on Coral Reefs

Graphic: Impacts of Ocean Acidification on Coral Reefs and Other Calcifiers, Workshop Report (NSF, NASA, USGS), see http://www.ucar.edu/communications/Final_acidification.pdf, pg 10.

Maintaining Healthy Reefs for the Future

Research and monitoring

- learn more about how reef systems "work" and their potential vulnerabilities

- determine which reefs are most at risk and why

Educational programs

- targeted at both tourists and local populations

Tackle the challenge of climate change

Graphics: (top) Landsat satellite images of reefs are used to map and monitor reefs, French Frigate Shoals, Hawaii, courtesy of NOAA, (bottom) a healthy reef, photo courtesy of NOAA.

Life in Extreme Environments

Hot Vents

Cold Seeps

Brine Pools

Reading: 4.15

13.5

Graphic: Submersible exploring a brine pool. Penn. State Univ.

The Deep Sea

The deep sea is cold and dark

- The food web is weakly supported by organic matter raining from above

- Photosynthetic production of new organic matter is not possible due to lack of light

Most deep sea communities are adapted to

- sparse food availability

- low population density

Graphics (top) Rat-tail, S.Ross photographer, (bottom) octopus, L.Levin, photographer. Both courtesy of NOAA NURP.

Alternative Energy in the Deep Sea

But… Not all ecosystems are fueled by photosynthesis

Methane and sulfur-rich fluids provide energy for <u>chemosynthetic bacteria</u> in some deep sea communities

Graphic: Black smoker at a mid-ocean ridge hydrothermal vent. P.Rona photographer, courtesy of NOAA NURP.

Photosynthesis, Respiration and Chemosynthesis

Photosynthesis binds energy into large organic molecules…

Carbon dioxide + water + sunlight + nutrients → organic matter + oxygen

Respiration converts organic matter to energy…

Organic matter + oxygen →

Carbon dioxide + water + chemical energy

Chemosynthesis (An Old Way of Life)

Chemosynthesis synthesizes organic material from inorganic substances

Carbon Dioxide + Hydrogen Sulfide + Oxygen + Water → Carbohydrates + Sulfuric Acid

Chemosynthesis can sustain vibrant food webs in the complete absence of sunlight

Graphic: Tubeworms and mussels living on a methane hydrate mound (yellowish substance). Courtesy of NOAA Ocean Explorer.

Where Are Chemosynthetic Communities Found?

Chemosynthesis requires high concentrations of chemicals such as hydrogen sulfide or methane

These are found where:

- seawater is in contact with the mantle (hydrothermal vents)

- these materials enter the sea due to other processes (cold seeps and brine pools)

Graphic: Garrison, Fig. 16.20.

Hydrothermal Vent Communities

At hydrothermal vents and cold seeps, chemosynthetic bacteria are at the base of complex food webs

Other organisms:

- tube worms

- giant clams

- mussels

Graphic: Tube worms feeding near the base of a black smoker hydrothermal vent. Courtesy of National Undersea Research Program.

Challenges in a Hydrothermal Vent Community

Most inhabitants must be adapted to life at high temperatures (sometimes over 600 deg F!)

Hydrothermal vents are temporary features – organisms must be able to colonize distant locales

Graphics: (left) See Garrison. 16.21, (right) courtesy of NOAA Ocean Explorer.

Cold Seep Environments

Tectonic motion can force methane-rich fluids out of sediments to form cold seeps along continental margins

Cold seeps emit chemical-rich fluid slowly over long periods of time

Unlike hydrothermal vents, these are relatively stable environments, home to long-lived organisms

Graphic: Tube worms in a Gulf of Mexico cold seep grow to 2 meters long, C.Fisher, photographer, courtesy of NOAA NURP and Penn. State Univ.

Bottom Graphic: Garrison Fig.4.32

Cold Seep Communities

In many cold seeps, the food web is supported by:

- "mat" forming bacteria

- bacteria that are in symbiotic relationships with animals

Clams and worms derive most of their food from the bacteria

Other animals forage at the seeps (crabs, anemones, gastropods)

Graphic: Mussels, worms and a spider crab at a hydrocarbon seep, I.MacDonald, photogapher. Courtesy of NOAA NURP and Texas A&M Univ.

Brine Pools

Along passive margins, salt domes can create brine pools with salinity 4 times greater than seawater

Methane seeping from the edges of the pool creates a diverse community

But.. anything that swims or falls into the hypersaline pool dies

Graphic: (top) Edge of a brine pool, a super salty pond, ringed by mussels. J. Brooks, photographer, courtesy of NOAA NURP and Texas A&M Univ, (bottom) submersible exploring a brine pool, Penn. State. Univ.

The Brine Pool

The brine pool is a crater-like depression filled with water up to four times saltier than seawater

Mussels and other organisms inhabit the region just outside the pool

Graphic: Top Gulf of Mexico brine pool. Image based on mosaic from Dr. I.McDonald, Texas A&M Univ. Bottom Graphic: Garrison Fig.4.32.

Extreme Environments - A Model for Extraterrestrial Life?

Hydrothermal vent communities suggest life could be thriving elsewhere in our solar system

Europa (a moon of Jupiter)

- icy surface

- deep saltwater ocean

- tectonic activity

- hydrothermal vents??

- life???

Graphics: (top) Europa as viewed by Voyager I, (bottom) Europa's icy surface, as viewed by Galileo, both courtesy of NASA/JPL.

Preview of Next Lecture

Charismatic Megafauna (Marine Mammals)

Review for Final Exam

Reading: **6.24-6.25**

15.35-15.38
17.22

Graphic: Humback whale breaching. Cmmdr. J. Bortniak, NOAA Corps, photographer. Courtesy of NOAA.