Coral Reefs

Primary Production

- Along with seagrass beds, coral reefs have highest levels of primary productivity - 1,000 gC/m^2/yr (up to 5000)
  - Foundation for substantial diversity and biomass
- Not due to phytoplankton, not due to seaweed
- Not due to corals, but what's within coral
  - Zooxanthellae

Zooxanthellae

- Photosyn. variety of dynoflagellate (single-celled protists) as symbionts
  - Symbiotic form without flagella and cell wall
  - Up to 1million cells/cm^2
    - Give color to coral, the darker the coral, the more pigment in zooxanthellae
    - Bleached coral without zooxanthellae
    - Foundation for very large group of associated organisms
- Mutualistic relationship
  - Zooxanthellae provide organic molecules and O_2
    - 90-99% available to corals
    - Carbon production several times greater than phytoplankton contribution above
  - Corals provide nutrients (wastes), CO_2, and protection (hard skeleton and nematocyts)
    - Means corals don't have to unload wastes
- Hermatypic corals are considered reef building corals – ↑ light; ↑ calcification
  - Ahermatypic corals (without zooxanthellae) deposit $CaCO_3$ as fast but are not as successful (no continuous source of nutrition?)
- Zooxanthellae in other animals too
  - Sponges, some jellyfishes, giant clams, nudibranchs, worms
- Other photosynthetic symbionts too
  - Cyanobacteria in sponges

Bleached, Dead or Alive? (graphic)

Coral Polyp & Zooxanthellae (graphic)

Reef Building

- Largely dependent on species within Class Anthozoa, Subclass Zoantharia
  - Group includes anemones, false corals, black corals and stony corals
  - Order Scleractinia - stony corals
  - Carnivorous with six tentacles and nematocysts, gastrovacular cavity, colonial
    - Form corallites with interior septa by secretion from bottom-most structure

    - Periodically move up and seal region below
    - Colony interconnected by overlying cenosarc (for protection against pathogens?) - can easily be damaged
- Growth rate dependent on many factors
  - Water motion, depth, turbidity, sedimentation, day length, water temperature, plankton concentrations, predation, competition from other corals
- Several growth forms
  - Encrusting, massive, branching, foliaceous
  - Some species “polymorphic”
  - Growth rate dependent on above factors and growth forms
    - Branching tends to grow faster
    - Estimated rate 1mm/yr vertically, 8mm/yr horizontally
- Geographical distribution
  - Restricted to tropical and subtropical (<30 degrees N/S latitude)
  - Typically located on eastern seaboards of continents (less upwelling)
  - Away from freshwater intrusion
  - Within 25-70 m of surface
- Not all reefs are created by corals
  - encrusting red algae, oysters, tube worms

Coral Structure (graphic)
Interaction of Individual Polyps (graphic)
Growth Forms of Single Species
Coral Reef Distribution (graphic)
Reef Formation

- Growth of corals in water surrounding land mass
- Probable geologic succession of reefs - first postulated by Darwin (founded originally on volcanic islands)
  - Fringing reef - coral growing adjacent to land
  - Barrier reef - body of water separating land and growing coral reef
    - Sinking or eroding land mass, freshwater/sedimentation affects on nearshore corals
    - Mana reef on Kauai, K-Bay on Oahu (formed by landslides of Koolau volcano)
  - Atoll - subsidence of land mass with remaining reef
    - NW Hawaiian Islands - Kure, Midway, Pearl & Hermes, Lisianski, Laysan, French Frigate Shoals
  - Guyot - continuing growth of reef insufficient to keep up with subsidence

Island Aging (graphic)
Reef Zonation

- Diversity of corals much reduced in Hawaii
- Zonation dependent on some of the previous characteristics that affect growth

  - Light, wave action, temperature, salinity, sedimentation
- Zonation can vary between islands and leeward/windward sides
- Below 25m: very low light, primarily downwelling, no wave energy
  - Sand zone, coral rubble (may be thin or absent), plate coral (*Porites rus*)(often absent)
- 13-25m: low light, low wave energy
  - Finger coral (*Porites compressa*)
- 6-13m: moderate light, occasional storm wave energy
  - Lobe coral zone (*Porites lobata*)
- 0-6m: high light, moderate wave energy
  - Cauliflower coral zone (*Pocillopora meandrina*)

Zonation on Atoll (graphic)
Zonation on a Barrier Reef (graphic)
Human Effects

- Divers - collecting, direct contact, Clorox/dynamite use for fish
- Ships/boats - anchor damage, grounding
- Land development - sedimentation, dredging, use of fertilizers (increased algae growth)
- Environmental changes that cause bleaching - Increased UV (less ozone), global warming, thermal pollution, chemical/oil spills
  - Recent increase visualized using satellites