Coral Reefs

- Highly diverse – rivals tropical rain forest
- Biogenic habitat – habitat made by living organisms
- Are found in areas of warm clear water – that is also typically nutrient poor
- Are increasingly threatened – mainly by anthropogenic effects

Reef Corals

- Cnidaria – nearly all in class Anthozoa
- Reef building corals are “hermatypic”
  - Have a polyp stage but
  - Lack the Medusa stage
- Ahermatypic corals include: soft corals (Alcyonacea), gorgonians, black corals (Antipatharia)

Coral Nutrition

- Tropical waters where coral reefs found are typically very nutrient limited
- How can such rich communities grow in such an unproductive environment?
- *Zooxanthallae - the answer*

Zooxanthallae

- Single cell dinoflagellates (algae) that live (primarily) within the tissue of corals and other marine animals
- The association is considered symbiotic (mutualistic)
  - Partial obligation - corals require zooxanthellae, zooxanthallae can be free living
Zooxanthallae

• What do Zooxanthallae get?:
  – Place to live
  – Nitrogen
  – Phosphorus
  – Carbon dioxide

• What to corals get?:
  – Organic matter
  – Oxygen
  – Energy

Zooxanthallae

• Used to be believed that there was a single species of zooxanthallae (Symbiodinium microadriaticum)
• Now (based largely on molecular genetics) there are known to be many species. In fact Zooxanthellae species:
  – Are known to be stratified by depth
  – Often vary within a single species by orientation
  – Can be expelled and replaced by the host: adaptive expulsion (bleaching)
Reproduction in hermatypic corals

• All corals can reproduce sexually – two main types:
  – Brooders: sperm is released into the water column taken into the female morph (or hermaphrodite). Fertilization ensues. Planula larvae are brooded then released.
  – Features of Brooded larvae:
    • Competent to settle immediately
    • Planula contain maternally derived zooxanthallae
    • Typically brooded planula larvae are produced year-round
    • 15 percent of species (or less) are brooders
    • Tend to be short-lived

Reproduction in hermatypic corals

• All corals can reproduce sexually – two main types:
  – Broadcast spawners: sperm and egg bundles are released into the water column – typically once per year
    • Bundles float to the water surface, break apart and fertilization ensues
    • In some species there is severe cost to self-fertilization
    • Development to planula stage takes days to weeks
    • Many species take part in mass spawnings that occur once a year – Why?
    • Zooxanthallae are acquired in the larval phase or soon after settlement
    • Tend to be long-lived
Reproduction in hermatypic corals

- All corals can reproduce asexually
  - Chiefly by fragmentation - either accidental or not
  - Polyp bail out
  - Asexual planula
  - Partial death of colony
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Case Study – Fungiid reproduction

• Only free living coral group – almost all are solitary (big question is what counts as an individual)
  – Often occur in very large groups
• Typically have a single large polyp and one mouth – although multiple mouths are found in some species

Case Study – Fungiid reproduction

• Reproduction occurs both sexually and asexually
  – Sexual reproduction by broadcast spawning
    • Planula develops settles and grows as an attached anthocaulus – a stalked mushroom like form that breaks off as a post-juvenile
  – Asexual reproduction:
    • Programmed fragmentation
    • Asexually derived planula that develop into anthocauli on the adult individual
    – Typically arise under conditions of stress (e.g., burial)

Reproduction:

Reproduction can be sexual but is often encountered in the form of asexually produced daughter colonies, called anthocauli. These asexual bits grow and break off a parent, making their lives on the bottom separately. Fragmentation is another way Fungiids may be reproduced. This requires at most the breaking of a donor into six pieces.

Acanthocauli attached on a rock in captivity
**Dispersal and settlement**

- Dispersal distances for hermatypic coral larvae are unknown
  - Brooded larvae are immediately competent so may not disperse far
    - However these larvae have zooxanthallae and can stay in the plankton indefinitely
  - Larvae resulting from broadcast spawning take days to weeks to become competent
    - Many of these species do not acquire zooxanthallae until settlement and therefore rely on lipid stores – may not be able to spend prolonged periods in the plankton

- Settlement stage is planula larvae
  - Most species studied to date indicate importance of settlement cues
    - Some species will not settle without a cue
  - Typical cue is coralline red algae
  - Metamorphosis follows settlement and individual cements itself to the surface

**Fundamental niche for hermatypic corals**

- Temperature
  - Typically 20 – 30 degrees C
  - Higher temperatures induce expulsion of Zooxanthellae: causing bleaching
  - Temperature range varies geographically – local adaptation
- Light
  - Species specific
  - Depends on zooxanthallae and coral species
  - Typically hermatypic species are not found below 50 meters
- Wave action
  - Determines the growth form or species distribution
  - Episodic events (hurricanes, cyclones) can have very long lasting effects on species distributions
- Sedimentation
  - Fines can interfere with coral respiration and feeding
  - Nutrients coming along with sediment can cause local algal blooms
  - Turbidity can affect photosynthesis and coral distributions
- Tidal range – can fundamentally alter reef community – more tidal range more domination by coralline algae in the reef flats
Basic Coral Morphology

- Corallites
- Costae
- Septa
- Oral Disk
- Body Cavity
- Mouth
- Pharynx
- Gonads

- Ectodermis
- Mesoglea
- Gastrodermis
- Stinging cells
- Zooxanthellae

- Tentacle
Colony Formation

• Colony formation is by asexual reproduction
  – **Intratentacular** budding – parent polyp divides into two or more polyps
  – **Extratentacular** budding – daughter polyps form on the side of the parent polyp

Colony Formation

• Colony growth form
  – **Plocoid** - corallites have own walls
  – **Phaceloid** – corallites have own walls and are elongate
  – **Meandroid** – corallites share walls and have valleys
  – **Ceroid** – corallites share walls but have no valleys
  – **Flabello-meandroid** – valleys without common walls
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Reef Coral Morphologies

- Massive and encrusting corals – tend to be found on tops of reef crests where wave splash is most intense
- Branching or columnar corals – tend to be found in the fore and back of crests, typically in shallow to moderate depth of water
- Flat or leafy corals – tend to be found at deeper depths – flat shape is thought to aid uptake of light
- Free living corals – the fungids – can be found anywhere

Coral Practical

1. Pocillopora damicornis
2. Pocillopora verrucosa
3. Acropora spp.
4. Montipora tuberculosa
5. Montipora faveolata
6. Porites rus
7. Pavona cactus
8. Pavona minuta
9. Pachyseris speciosa
10. Fungia concinna
11. Herpolitha limax
12. Lobophyllia hemprichii
13. Stylocenella armata
14. Acanthastrea echinata
15. Psammacora profundacella

Reef Building
Accomplished by:
1. Living and dead corals
2. Other colonial organisms
   1. Eg. bryozoans
3. Coralline algae, which cements the reef together
Coral Reef Formation

Darwin’s original drawing

Coral Reef Formation

Bora Bora

Fringing Reefs
Barrier Reefs

Great Barrier Reef

Atolls in the Maldives
Coral Reef Community Types

- Lower Slope, Upper Reef Slope, Reef Front
- Outer Reef Flats, Inner Reef Flats, Lagoon

**Lower Slope**
1. Depth: to 50-60 meters
2. Coral form: plate-like (laminar) and typically flat or thin and brittle
3. Coral cover: may be very dense and monospecific
4. Wave action: Normally very low
5. Light: Often very Limited

**Upper Reef Slope**
1. Depth: to 20 meters
2. Coral form: varied forms including plate-like, branching and columnar
3. Coral cover: may be very dense, very mixed and diverse community
4. Wave action: Moderate
5. Light: Not limiting

**Reef Fronts**
1. Depth: narrow zone to 5 meters
2. Coral form: massive, sometimes branching or columnar with appearance of being mowed down
3. Coral cover: often low cover, with spurs and grooves
4. Wave action: High
5. Light: Not limiting
Outer Reef Flats

1. Depth: Intertidal
2. Coral form: Only massive, but substrate is consolidated
3. Coral cover: lowest cover of all reef zones – sometimes covered with coralline algae
4. Wave action: Extremely High
5. Light: Not limiting

Inner Reef Flats

1. Depth: Intertidal
2. Coral form: Only massive, substrate is often unconsolidated – rubble intermixed with solid rock
3. Coral cover: Good cover of corals
4. Wave action: High, but not as high as Outer Reef Flats
5. Light: Not limiting

Lagoon

1. Depth: Shallow – often to 10 meters or less (except in channels)
2. Coral form: Mixtures of branching, columnar and some plate-like corals
3. Coral cover: Very patchy, sandy flats intermixed with patches of corals
4. Wave action: Typically low, but susceptible to hurricanes
5. Light: Not limiting
Coral Reef Ecosystem

- Primary producers
  - Zooxanthellae
  - Calcareaeous algae
  - Algae
  - Microscopic phytoplankton

- Primary consumers
  - Starfish
  - Fish and other large animals

- Secondary consumers
  - Reef fish, wrasse, parrotfish

- Tertiary consumers
  - Butterfly fish, large carnivores

Input from land:
- Coral / algae
- Sea urchins
- Large Mobile Animals

Living Habitat Structure

Coral Bleaching
- The loss of the zooxanthellae in the polyps
- Corals appear “bleached”
- Cuts off oxygen supply and kills them
- Caused by:
  - Oversedimentation
  - Environmental stresses: T.S, UV light
  - Cyanide fishing
Worldwide Bleaching, 1997-98

- 95% mortality in shallow waters around Maldives, Bahrain, Sri Lanka, Singapore, Tanzania
- Typically in depths <15m
- Mainly fast growing species
- Attributed to El Nino and subsequent La Nina