Coral Reefs & Seagrasses
NREM 301
Dr. Greg Bruland
(Mitsch & Gosselink 2000)
Phylum CNIDARIA

Class Hydrozoa
- Portuguese man-of-war
- Hydroids
- Upside-down Jellies
- Sea Jellies
- Anemones
- Soft Corals

Class Scyphozoa
- Sea Fans
- Zoanthids

Class Cubozoa
- Box Jellies
- Stony Corals
- Precious Corals

Class Anthozoa

(Gulko 1998)
Coral polyps
Microscopic view of zooxanthella
CORAL - ALGAL SYMBIOSIS

What does each of them get out of the relationship?

Light Energy
(Visible & UV)

Light is necessary for photosynthesis to occur; but certain wavelengths of light (such as UV) can be harmful.

Visible Light Energy

Harmful UV light can be filtered by coral pigments or special UV-absorbing chemicals (Meso- or plumboporin-like Amino Acids or MAAs).

Some corals have pigments which absorb UV light exciting certain molecules which in turn emit lower frequencies of visible light. Such fluorescence might be used for photosynthesis; in addition to protecting both coral and zooxanthellae from the harmful effects of UV.

Coral provide protection for their endosymbionts through their hard skeletons and stinging cells.

The excess organic energy translocated to the coral host is rich in carbohydrate but low in nitrogen compounds (important building blocks for proteins); most corals supplement this food source by actively feeding on zooplankton or dissolved organic nitrogen (DON).

Zooxanthellae

Photosynthesis

Respiration

Coral

Protection

Excess "Food"

Nitrogen-rich

Nitrogen-poor

H$_2$O

CO$_2$

CO$_2$

CaCO$_3$

H$_2$O

Waste Products

Skeleton Formation

Ca + CO$_3$

The symbiotic algae also act like a "kidney" for the coral, removing waste materials which are then used to assist the algae in conducting photosynthesis.
Subsidence Theory
Reef Succession
Case Study:
Hawai‘i

A. Three month old lava flow. No visible coral colonies present, primarily diatomaceous slime.

B. Ten year old lava flow supporting a coral colony roughly ten years old.

C. Fifteen year old lava flow. Coral cover is almost entirely Pocillopora meandrina; a fugitive species often found colonizing such flows.

D. Twenty year old lava flow. Reef is made up of 12 species of corals, almost 100% coral cover.

E. Forty-four year old lava flow. At this point coverage is primarily Porites compressa and Porites lobata.

F. A hundred year old lava flow in a relatively undisturbed area. This very developed reef is almost 100% Porites compressa (finger coral).
Global Coral Reef Distribution

(Spalding et al. 2001)
Figure 6.3 Diagrammatic section of a typical atoll showing the major subdivisions of the reef complex.
Figure 16.3 A three-dimensional representation of One Tree Reef, part of the Great Barrier Reef. Note that One Tree Island is a very small part of the reef complex. For discussion of the features, see text. Reproduced from Borowitzka and Larkum (1986) by permission.
Coral Reef Zonation in Hawaiʻi

(Gulko 1998)
Herbivorous reef fish

Damselfish
Family: Pomacentridae

Fiercely protective

Redlip parrotfish, pālukaluka,
*Scarus rubroviolaceus*

Surgeonfish
Acanthuridae

Sexually dimorphic

Achilles tang, pākuʻikuʻi
*Acanthurus achilles*

Rabbitfish
Siganidae

Active, aggressive seaweed grazer
Direct coral grazers

butterflyfish, lauhau
Chaetodon

Spotted puffer, ‘o’opu hue
Arothron meleagris

Triggerfish
Balistidae

Lagoon triggerfish

Reef triggerfish,
humuhumunukunukuāpua‘ā,
Rhinecanthus rectangulus

Spectacled Parrotfish
Chlorurus perspicillatus
Hawaiian cleaner wrasse, *Labroides phthirophagus*

Moorish idol, kihikihi, *Zanclus cornutus*

Old woman wrasse, hīnālea luahine, *Thalassoma ballieui*

Cornetfish, nūnū peke, *Fistularia commersonii*
Seabirds, such as these Brown noddy terns and Brown booby at P&H (left photo), rely on the NWHI for nesting, feeding and breeding. The critically endangered Hawaiian monk seal (right photo) is an integral component of the NWHI ecosystem. Photos: J. Watt.

(Waddell 2005)
Apex Predators NWHI

Figure 10.27. Large apex predators, such as sharks (left panel) and jacks (right panel), are abundant in the NWHI and dominate the ecosystem in terms of biomass. Large predators are conspicuously absent from most of the other jurisdictions in this report.

Photos: J. Watt.
The Coral Reef Food Web at French Frigate Shoals (NWHI)

- Sea Birds
- Monk Seals
- Sharks, Jacks & Scrombrids
- Sea Turtles
- Small Pelagics
- Lobsters & Crabs
- Reel Fish
- Bottom Fish
- Zooplankton
- Phytoplankton
- Benthos
- Benthic Algae

(after Polovina, 1984)
NWHI vs MHI biomass

(Maragos & Gulko 2002)
Natural vs human-modified coral reef food web

Before Fishing

After Fishing

Bold font = abundant
Normal font = rare

(Jackson et al. 2001)
Land-based threats to coral reefs

Plume of fine silts & clays discharging into the sea in Indonesia.

(http://www.dfid-kar-water.net/w5outputs/soil_erosion_slides.htm)
Other threats

(Photo: Reefbase/ T. Heeger )

(http://courses.washington.edu/larescu e/projects/devin/index3.htm)
Human Impacts on Coral Reefs

(Gulko 1998)
Sea Grass Beds
Sea Grass Anatomy

- **Blades** - Photosynthesis, Nutrient uptake
- **Short shoot** = stem
- **Rhizomes** - Anchoring, Propagation, Nutrient absorption, Gas exchange
- **Roots** - Nutrient uptake, Anchoring (binding), Gas exchange
Zostera canopy velocity profiles

Fig. 5. Vertical velocity ($U$) profiles (thick solid lines) in seagrass canopies exposed to 5 cm s$^{-1}$ (A), 10 cm s$^{-1}$ (B) and 20 cm s$^{-1}$ (C). $Z$, distance above the sediment interface. Note that, as velocity increases, the angle of bending of the canopy increases and the canopy height (dashed horizontal line) decreases. Based on a flume experiment using a short (16 cm) and dense (1,000 shoots m$^{-2}$) Zostera marina canopy (Gambi et al. 1990).
Blade bending cycle for unidirectional (A, B) & oscillatory (C, D, E) flows

(Koch & Gust 1999, Larkum et al. 2006)
Distribution of Seagrasses

Temperate - Boreal Regions
- 4 genera
- ~ 28 species

Tropical - Subtropical Region
- 7 genera
- ~ 30+ species

Eurythermal
- *Ruppia*
- ~ 2-10 spp.
(Orth et al. 2006)
Habitats

**Soft Sediments**
- Leaves reduce flow
- Particulate matter drops out
- Rhizomes - sediment accumulation

**Rocky Inner Tidal**

*Phyllospadix* spp.
- Late successional species

(K. Peyton 2007)
Zonation

FIGURE 20.4  Diagram of an example of inshore-offshore seagrass zonation on the Florida west coast (data from McNulty et al. 1972).
Grazers

A manatee (Trichechus manatus), teixe-boi in Portuguese, over a Halodule wrightii bed in Recife, Brazil.

(Green & Short 2003)

Dugong feeding on Halophila ovalis, Vanuatu, western Pacific islands.
Seagrasses of Hawai‘i

(K. Peyton 2007)

Halophila decipiens

Halophila hawaiiiana

Ruppia maritima
Seagrasses in Hawaii

- Endemic species
- 2-3 cm canopy height
- 30 m water depth
- Blow-outs

Halophila hawaiiana

(K. Peyton 2007)
Halophila decipiens

(K. Peyton 2007)
Anthropogenic Stressors:

- Sewage discharge
- Non-point pollution
- Algal epiphytes

(K. Peyton 2007)
Invasive Species

Caulerpa taxifolia - cultured strain
Mediterranean Sea; California; Australia

Posidonia oceanica - endemic seagrass
Aquarium dumping

(K. Peyton 2007)
Invasive species & seagrasses of Hawai‘i: Displacement & Smothering

Gracilaria salicornia

Halophila decipiens

Avrainvillea amadelpha

Gracilaria sp. Florida

Halophila hawaiiana

Ruppia maritima

(K. Peyton 2007)
Ruppia outcompeted by Gracilaria

Gracilaria sp. Florida

(K. Peyton 2007)
Pristine vs Degraded Sea Grass Beds

(Duffy et al. 2006)
Key ecosystem services

- High biomass seagrass meadows trap sediments and nutrients.
- Seagrasses and associated algae have high primary production.
- Seagrasses promote trophic transfers and cross-habitat utilization.
- Tropical seagrasses provide food for dugongs, manatees, and turtles.

Major loss mechanisms

- Coastal salinity changes because of altered water flow for irrigation.
- Pulsed turbidity exacerbated by erosion due to poor land management.
- Large urchin grazing events.
- Eutrophication resulting in phytoplankton blooms, reducing light.
- Dredging and boating effects.

Tropical seagrass ecosystems

Temperate seagrass ecosystems

Eutrophication causes growth of macro- and microalgae, reducing light.

High water temperature, combined with low light.

Wasting disease.

Herbivory by waterfowl, urchins, turtles.

Introduced species displacing seagrass.

(Orth et al. 2006)