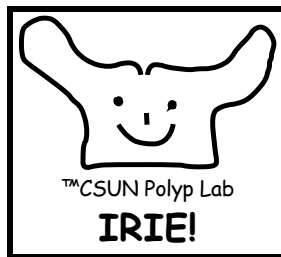


Biology of corals and coral reefs



Part I: Coral Biology -- Pete Edmunds

Course content and tentative schedule

Lectures

1. *Coral Species, Systematics, Anatomy I*: overview of Cnidaria and scleractinians; *brief* intro to types of reefs, spatial distribution of reefs globally, factors limiting global distribution; taxonomy; cell types; coral structure – tissue; coral structure – skeleton.
2. *Coral Species, Systematics, Anatomy II*: host pigment types; zooxanthella biology; zooxanthellae taxonomy; zooxanthellae regulation; new findings in coral taxonomy; new developments in zooxanthella biology.
3. *Coral Metabolism I*: Respiration/Autotrophy/Heterotrophy: overview of respiratory physiology and autotrophy; transport of carbon within coral tissues; effect of UV; carbon translocation; microenvironment within coral tissue; intro to autotrophy versus heterotrophy - Porter 1976; energy budgets; CZAR; use of PAM.
4. *Coral Metabolism II*: Autotrophy/Heterotrophy: nutritional strategies; roles of zooxanthellae; feeding types; DOM; role of mucus; polyp expansion; early plankton research; feeding in turbid locations; heterotrophic plasticity.
5. *Coral Metabolism III*: Heterotrophy/Nutrient recycling: factors affecting uptake; mechanisms; transfer to host and back-translocation; nitrogen budgets; nutrient limitation.
6. *Coral calcification*: mechanisms; transport of calcium; calcification and light; role of temperature; zooxanthellae versus azooxanthellate corals; growth of the colony; polyp age; environmental effects on colony shape.
7. *Coral Reproduction I*: Asexual reproduction: types; polyp bail out; parthenogenetic larvae; bud regeneration; fragmentation; fragmentation and size.
8. *Coral Reproduction II*: Sexual reproduction: life history strategies; hermaphroditic versus gonochoric; brooding versus broadcasting; sexuality; larval development; allocation to sex; spatial and temporal variation in fecundity; gametogenesis and breeding; mass spawning; avoidance of self fertilization.

9. *Coral Reproduction III*: biology of coral larvae – physiology, nutrition, metamorphosis, response to stimuli, effect of elevated temperatures, settlement choice and settlement patterns
10. *Coral Population biology*: modularity and individuality; genet versus ramet; age versus size; Leslie Matrix models; case histories: Hughes, Done, Fong and Glynn.
11. *Biology of bleaching I*: sequence of events in bleaching; evidence of causes; oxygen radicals; role of algal taxa; mechanisms of expulsion; effect of heat on algae; interaction with algal mitosis; host factor; adaptation or acclimation?
12. *Biology of bleaching II*: getting at mechanisms; role of PAM techniques; Warner et al. findings; Jones and Hoegh-Guldberg findings; integration – where are we?

Labs

- 1) Coral ID
- 2) Coral larvae – collection from *Porites astreoides*, behavior and physiology.
- 3) Photophysiology (PAM) and distribution of corals at Columbus Park.
- 4) *Montastraea* morphotypes (*M. annularis* versus *M. faveolata*, etc.) across the reef, potential for gamete mixing assayed with oranges and surface tracking.
- 5) Coral population biology.
- 6) Coral ID underwater exam

Schedule (this may change due to weather etc.)

- | | |
|--------------|---|
| Day 1 | <ol style="list-style-type: none"> 1. Coral Species, Systematics and Anatomy I 2. Coral Species, Systematics and Anatomy II <p>Lab. #1: Identification skills: field, lab. and slides (snorkel)
 Read discussion paper for next day!!</p> |
| Day 2 | <ol style="list-style-type: none"> 3. Coral Metabolism I: Respiration/Autotrophy/Heterotrophy 4. Coral Metabolism II: Autotrophy/Heterotrophy <p>One dive to start two labs:
 Lab. #2: Coral larvae – placement of traps
 Lab. #4: Current tracking with grapefruit
 5:15 pm: What's up with that?! Fine M, Loya Y (2002). Endolithic algae: an alternative source of photoassimilate during coral bleaching. Proc Roy Soc
 Read discussion paper for next day!!</p> |
| Day 3 | <p>07:30 snorkel to view zonation!</p> <ol style="list-style-type: none"> 5. Coral Metabolism III: Heterotrophy/Nutrient recycling 6. Coral Calcification <p>Lab. #3 (dive): Photophysiology & distribution of coral at Columbus Park
 5:15 pm: What's up with that?! Goulet TL, Coffroth MA (2003). Stability of an octocoral-algal symbiosis over time. Mar Ecol Prog Ser 250: 117-124.</p> |
| Day 4 | <ol style="list-style-type: none"> 7. Coral Reproduction I: Asexual reproduction 8. Coral Reproduction II: Sexual reproduction <p>Lab. #4 (dive): <i>Montastraea</i> sibling species and gamete mixing?</p> |

Lab. #5 (**dive**): Practice for population biology lab
****Read discussion paper for next day!!****

- Day 5**
- 9. Coral Reproduction III: Coral larvae
 - 10. Coral population biology
Lab. #5 (**dive**): Coral population biology lab
5:15 pm: What's up with that?! *Fukami H, et al., (2003). Ecological and genetic aspects of reproductive isolation by different spawning times in Acropora corals. Marine Biology 142: 679-684*
- Day 6**
- 11. Biology of bleaching I
 - 12. Biology of bleaching II
Lab #6 (**dive**): Field identification exam (**Dive**)
- Day 7**
- Exam for Part I: 08:00
 - Lab report due January 16th, 6 pm

Weather disclaimer

Experience has shown that January courses have a high probability of encountering foul weather that will keep us out of the water and may result in murky conditions for days. We will do everything possible to reduce the effects of inclement weather.....but if all else fails you may end up viewing corals in a murky back reef. While this probably is far from your preconceived picture of a coral reef, it is part of tropical life!



Biology of corals and coral reefs

Part II: Coral Reef Ecology – Brian Helmuth

Materials are also available on-line at:

<http://www.biol.sc.edu/~helmuthlab/classes/corals/corals.html>

Your grade for the second portion of the course (50 points total) will be based upon 3 lab reports (5 points each), and a brief (2-3 page) critique of a journal article (10 points) and a written exam at the end of the course (25 points).

Instructions for lab reports will be passed out in class. The first reports will describe the results of Labs 1 and 3, and pre-made lab sheets will be handed out. The second lab report will present the results of a survey (Labs 2 and 4) in which we will compare of the physical characteristics and species compositions of two different habitats: the shallow (30') fore reef and deeper (50-60') fore reef. The format of this lab report should be 5-6 pages long, in the format of a journal article, and should compare the physical environments and species compositions of these two environments.

The critique (of Koehl 1996) should, in 2 double-spaced pages, summarize the major points of the paper, its strengths and weaknesses, and a description of how it altered (or failed to alter) your view of coral reefs. I am more interested in seeing how you synthesize the ideas presented in the paper than I am in seeing how well you can regurgitate material.

The final exam will cover only the second part of the course, but by necessity will rely on concepts and terms that you learned during the first portion of the class. Emphasis will be placed on your ability to explain and synthesize concepts, rather than on rote memorization. You will be responsible for the material covered in the readings, although again emphasis will be placed on concepts rather than details.

Course Content and Tentative Schedule

Lectures:

1. Introduction to boundary layers, mass flux, and trade-offs in reef organism design. The ecology and evolutionary history of organisms are strongly affected by their physical environment. But, how do we measure this environment, and to what extent is the physical environment of any particular creature determined by other organisms, or by the characteristics of the animal or plant itself? What can physics tell us about the biology of reef invertebrates?

2. Physical basis of hydrodynamic forces and damage from waves. Roles of disturbance and organism morphology on reef zonation. What causes physical disturbance, and how does organism morphology affect the probability of dislodgement or damage from moving water?
3. Feeding in flow I: mechanisms of particle capture by reef organisms. Organism shape, size and proximity to neighbors has significant impacts on rates of particle capture. An overview of the different mechanisms that reef invertebrates use for removing particles from the water column.
4. Feeding in flow II: case studies. Examples from field and lab experiments that show how corals, sponges and other reef invertebrates filter-and deposit-feed.
5. Mechanics of gas and nutrient exchange I: diffusional boundary layers, gradients, and the role of gas exchange in photosynthesis and respiration. When is the exchange of gases and nutrients limiting to coral reef organisms, and how do we measure this limitation?
6. Mechanics of gas and nutrient exchange II: Case studies at the level of the organism, and at the scale of entire reefs.
7. Biology and Ecology of Sponges & Soft-corals: functional morphology; nutritional strategies; reproduction.
8. Competition for space, flow and light: theory; modes of action; competition in the field; community implications.
9. Predation: mechanisms & responses; case studies; community effects.
10. Ecosystem engineering, positive interactions and community ecology of reefs

Labs:

1. Measuring the environment.
2. Flow and Coral Reefs 1: Measurement of hydrodynamic regimes and sponge and coral morphology (Dive to shallow (30') fore reef).
3. Laboratory measurements of the effects of water flow on coral photosynthesis and gas exchange
4. Flow and Coral Reefs 2: Dive to deeper fore reef (50-60')
5. Mechanisms of competition for space.

Tentative Schedule:

- 23 Feb** AM: Lecture 1: Introduction to boundary layers, mass flux, and trade-offs in design.
Lecture 2: Physical basis of hydrodynamic forces and damage from waves
PM: Lab 1: Measuring the environment (*Lab reports due tomorrow morning*)
Discussion and collation of results

Readings:

- * Shashar, N., S. Kinane, P.L. Jokiel and M.R. Patterson, 1996. Hydromechanical boundary layers over a coral reef . J. Exp. Mar. Biol. Ecol. 199:17-28.
- *Rubenstein, D. I. and M.A.R. Koehl. 1977. The mechanisms of filter feeding: some theoretical considerations . Amer. Nat. 111: 981-994.

24 Feb *Lab 1 reports due*

- AM: Lab 2: Flow and coral reefs 1 (Dive to shallow forereef)
Discussion and collation of results
PM: Lecture 3: Feeding in flow I: mechanisms of particle capture by reef organisms.
Lecture 4: Feeding in flow II: case studies

Readings:

- *Sebens K.P., J. Witting, and B. Helmuth, 1997. Effects of water flow and branch spacing on particle capture by the reef coral *Madracis mirabilis* (Duchassaing and Michelotti) . J. Exp. Mar. Biol. Ecol., 211:1-28.
- *Sebens, K.P. and T.J. Done. 1992. Water flow, growth form and distribution of scleractinian corals: Davies Reef (GBR), Australia . Proc. Seventh Int. Coral Reef Symp., Guam. 1: 557-568.

25 Feb (Research and Reading Day)

Readings:

- **Koehl, M.A.R. 1996. When does morphology matter? Annu. Rev. Ecol. Syst. 27: 501-542.
(Prepare a 2-3 page critique and summary of the Koehl paper, due Feb 10.)

Also read:

- *Helmuth B.S.T., K.P. Sebens and T.L. Daniel. 1997. Morphological variation in coral aggregations: branch spacing and mass flux to coral tissues. J. Exp. Mar. Biol. Ecol. 209: 233-259. (Understanding the concepts in this paper will be important for Lab 3)
- *Read the directions for Lab 3 prior to tomorrow's class

- 26 Feb** AM: Critique of Koehl 1996 due at beginning of class
Lectures 5 and 6: Mechanics of gas and nutrient exchange
PM: Lab 3: Measuring flow effects on photosynthesis and respiration
**Reports from this lab will be due March 1 .

Readings:

- *Patterson, M.R., K.P. Sebens and R.R. Olson, 1991. In situ measurement of flow effects on primary production and dark respiration in reef corals . Limnol. Oceanogr. 36:936-948.

Optional:

*Thomas, F.I.M. and M.J. Atkinson 1997. Ammonium uptake by coral reefs: effects of water velocity and surface roughness on mass transfer *Limnol. Oceanogr.* 42:81-88.

27 Feb AM: Lab 4: Flow and coral reefs 2 (Dive to Deeper (50-60') forereef)
Discussion and collation of results
**Reports combining results of the two dives will be due March 2.
PM: Lecture 7: Biology and Ecology of Sponges & Soft-corals.
Lecture 8: Competition for space, flow and light.

Readings:

- *Jackson, J.B.C. 1979. Overgrowth competition between encrusting cheilostome ectoprocts in a Jamaican cryptic reef environment. *J. Animal Ecol.* 48: 805-823.
- * Kim, K., and H. R. Lasker. 1997. Flow-mediated resource competition in the suspension feeding gorgonian *Plexaura homomalla* (Esper). *Journal of Experimental Marine Biology and Ecology* **215**:49-64.

28-29 Feb (Research and Reading Days)

Note that Lab Report 1 (results of Lab 3) is due March 1, and Lab Report 2 (comparison of 2 physical environments) is due March 2.

**Please note that we have a dive scheduled for the morning of March 1

Reading:

- * Jones, C. G., J. H. Lawton, and M. Shachak. 1997. Positive and negative effects of organisms as physical ecosystem engineers. *Ecology* **78**:1946-1957.

1 March AM: Lab 5: Dive to forereef: mechanisms of competition for space and light.
PM: Lab 3 Report due at beginning of class.
Lecture 9: Predation
Lecture 10: Positive interactions and ecosystem engineering
Question and Answer

2 March AM: Lab Report 2/4 (comparison of 2 forereef environments) due by noon.
PM: Final Exam (covers Part II of course only)