Three Seas Program
EAST WEST MARINE BIOLOGY

Ocean and Coastal Processes

Winter 2011
Isla Coiba / Bocas del Toro
Panama

Instructors:

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Ocean and Coastal Processes (‘OCP’) is a multidisciplinary introduction to the mechanisms that shape coral reefs through space and time. The unifying theme of this diverse course is the coupling between physical and biological processes on coral reefs and in adjacent habitats. The course will span spatial scales from organisms to entire ecosystems Specific topics will include oceanographic forcing mechanisms, organismal biomechanics, biogeochemistry and nutrient dynamics. The course will be taught in two integrated modules, with each module composed of lectures, field/lab activities and experiments, and discussion of primary scientific literature. Required assignments and exams for each module will count toward an overall course grade.

Module I: The Physical and Biological Oceanography of Coral Reefs

James Leichter
Scripps Institute of Oceanography

Course Content and Tentative Schedule
The first portion of OCP will focus on oceanography of coral reefs and the factors that influence nutrient dynamics on oceanic islands such as Isla Coiba. The lectures will focus on large-scale concepts relevant to coral reefs in a wide variety of settings, with specific examples drawn from the particular context of Isla Coiba. Lectures topics will include basin scale currents and mechanisms of interannual variation, island and reef scale mechanisms of delivery and connectivity, island wakes, internal waves, and nutrient dynamics.

Required Readings:

Andrews JC, and P. Gentien. 1982. Upwelling as a source of nutrients for the Great Barrier Reef ecosystem: A solution to Darwin's question? Mar. Ecol Prog Ser 8:257-269

Glynn, PW and JL Mate. 1997. Field guide to the Pacific coral reefs of Panama. Proc. 8th Int Coral Reef Symp. 1: 145-166.

Wolanski E. and W.M. Hamner 1988. Topographically controlled fronts in the ocean and their biological influence. Science 241:177-181.

Wolanski, E., and B. Delesalle. 1995. Upwelling by internal waves, Tahiti, French Polynesia. Continental Shelf Research 15: 357-368.

Additional suggested reading:

Leichter, J. 2007. Waves, Internal. In M.W. Denny and S.G. Gaines ed. Encyclopedia of Rocky Shores.

Monismith, S. 2007. Hydrodynamics of coral reefs. Ann. Rev. Fluid Mech. 39: 37-55.

Andrews and Pickard 1990. The physical oceanography of Coral Reef Ecosystems. In: Dubinsky Z (ed) Ecosystems of the World, Vol 25: Coral Reefs, Vol 25. Elsevier, Amsterdam, p 11-48

Module II: Interactions of Organisms and their environment at small scales

Brian Helmuth
University of South Carolina, Columbia

Course Content and Tentative Schedule

The second portion of OCP will focus on the interaction of organisms with their physical environment, and will explore, in depth, biomechanical and hydrodynamical methods for defining these interactions. Specifically, we will ask how interactions between small-scale environmental variation and organism physiology can drive ecological patterns at larger scales. Note that the material is highly integrative, so that if you slip behind in the readings or lectures you will likely be lost in later lectures. By all means if you have any questions as we work through these techniques please don't be afraid to stop and ask: chances are pretty good that if you are confused about something, so are other people in the class.

Lectures:

1. How do we measure the environment? 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. Introduction to boundary layers, mass flux, and trade-offs in design. What causes physical disturbance, and how does organism morphology affect the probablility of dislodgement or damage from moving water?

3. 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? Case studies at the level of the organism, and at the scale of entire reefs.

4. Feeding in flow: 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 for removing particles from the water column. Examples from field and lab experiments that show how corals, sponges and other reef invertebrates filter-and deposit-feed.

5. Wrap-up. Using quantitative methods to forecast patterns of ecological and physiological responses; links between science and policy.

Labs:

1. Measuring the environment. Lab report: Fill out questions *thoughtfully and in detail* on lab report.

2. Flow and Coral Reefs: Measurement of hydrodynamic regimes and coral morphology. Dive/snorkel to low and high flow regions of the back reef. Write a 4-5 page paper, complete with Abstract, Introduction, Methods, Results, Discussion, and References, discussing the results of the pooled class data. See instructions in lab directions.

Schedule:

21 Feb AM: Lecture 1: How do we measure the environment?
Lecture 2: Introduction to boundary layers, mass flux, and trade-offs in design.
PM: Lab 1: Measuring the environment *(Lab reports due Feb 24 at beginning of class)*

Readings:

Kearney, M. 2006. Habitat, environment and niche: what are we modelling? *Oikos* 115: 186-191.

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.

22 Feb

AM: Lab 2, part I: Dive to high flow region of fore reef
PM: Lecture 3: Mechanics of gas and nutrient exchange
Collate results from morning dive; analyze video tapes; download ibuttons from Lab 1
Discussion and collation of results; analysis of video tapes

Readings:

Finelli, C.M., B.S. Helmuth, N.D. Pentcheff, D. Wethey. 2006. Water flow influences oxygen transport and photosynthetic efficiency in corals. *Coral Reefs* 25: 47-57.

Lenihan, H.S., Mehdi, Adjeroud, M., Kotchen, M.K., Hench, J.L., Nakamura, T. (2008) Reef structure regulates small-scale spatial variation in coral bleaching *Marine Ecology Progress Series* 370:127-141

23 Feb Research and reading day

Readings:

Carpenter, L.W., and M.R. Patterson. 2007. Water flow influences the distribution of photosynthetic efficiency within the scleractinian *Montastrea annularis* (Ellis and Solander, 1786). Can water flow modulate coral reef bleaching? Journal of Experimental Marine Biology and Ecology 351: 10-26

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.

24 Feb AM: Lab 2, Part II: Flow and coral reefs 2

PM:

Collate results from morning dive; analyze video tapes

** Lab 2 reports will be due Feb 26 by 9AM (e-mail to Brian)

Readings:

Jimenez, I. M., Kühl, M., Larkum, A. W. D. and Ralph, P. J. (2008). Heat budget and thermal microenvironment of shallow-water corals: Do massive corals get warmer than branching corals? *Limnology and Oceanography* 53, 1548-1561.

Leichter, J. J., Helmuth, B. and Fischer, A. M. (2006). Variation beneath the surface: Quantifying complex thermal environments on coral reefs in the Caribbean, Bahamas and Florida. *Journal of Marine Research* 64, 563-588.