

# **Biology of Coral Reefs (BIOL 619)**

## **Syllabus Spring 2016**

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Among the most spectacular of all ecosystems, coral reefs form in the world's tropical oceans through the action of animals and plants. They are the largest and most complex biological structures on earth. Although they cover less than one percent of the earth's surface, they are reservoirs for much of the ocean's biodiversity, housing some of nature's most intricate ecological secrets and treasures.

Coral reefs are also the most productive ecosystems in the sea and provide significant ecological goods and services, estimated at about \$375 billion annually (1997 dollars) with more recent estimates topping 9 trillion dollars in 2015. Their physical structures protect thousands of miles of coastline from the fury of tropical storms, tsunamis, and many low-lying islands threatened by rising seas.

The intricate adaptations for survival that have evolved over an immense span of time make reefs vulnerable to human activities. For example, excess nutrients support algal overgrowth, while over-fishing alters the food web. The extent to which reefs in remote locations are now showing signs of stress, especially bleaching and disease, points to the critical role that coral reefs play as indicators of declining ocean health.

This course will be an introduction to tropical coral reefs and the organisms and processes responsible for their formation. We will begin with an overview of reefs and their tropical marine environment. The course will then move into the evolution, systematics, and physiology, ecology and symbiosis of reef-building corals. These subjects will set the stage for learning about coral reef community structure and ecological dynamics. The course will close by taking a critical look at natural and human disturbances to reefs with an emphasis on current models of management and conservation.

There will be an optional Laboratory (1 credit) one-week field trip to explore the reefs of Glover's Atoll, Belize during March Spring Break. We will stay at the Isla Marisol Resort (<http://islamarisolresort.com/>) on Southwest Caye, Glovers Atoll Belize. Glover's is one of the few offshore atolls in the Caribbean and is an excellent location to introduce you to the ecology and conservation of Caribbean reefs. The cost of the trip will be approximately \$2400-2700, including all accommodations, diving, and travel from the US. You must be a certified SCUBA diver to participate. If you are a foreign student you must secure the appropriate visa documentation if necessary.

### **The learning goals of this class include gaining an appreciation and understanding of:**

1. How abiotic forcing functions control the ecology of coral reefs including reef morphology and coral distribution.
2. The principles of carbonate biogeochemistry; the reef as a biogenic structure.
3. The flow of energy and molecules through coral reef ecosystems, reef trophodynamics.
4. The role density dependent vs. density independent control in the growth and regulation of coral reef populations.
5. The impact of natural and anthropogenic forcing functions on coral reef ecology.
6. The open-source peer reviewed literature.
7. Experimental design, data analysis, and limitations of underwater ecological experiments

### **Critical Thinking:**

Critical thinking is the common denominator between all forms of analysis. As a graduate student, there is no more important goal than that of developing your mind, as everything you do in your life will be affected by your mind and how it operates. The quality of your learning is affected by the quality of your thinking about learning. The quality of your personal relationships is affected by the quality of your thinking about those relationships. To take command of the thinking that controls your life, you must cultivate your intellect". (**Refer to [www.criticalthinking.org](http://www.criticalthinking.org)**)

**Prerequisites:** Open to MBGP graduate students with general knowledge background of an undergraduate biology major (General Biology, Ecology, Chemistry and Physics). Supplemental materials will be provided to students without such a background.

### **Requirements:**

Midterm and Final exams = 50%

Term paper, presentations and participation. = 50%

### **Graduate Student higher-level learning outcomes and additional workload:**

The Biology of Coral Reefs is a combined undergraduate and graduate course to provide a synthetic capstone-type course at the ecosystem level. Graduate students will have additional educational requirements placed on them in the form of a more in-depth research paper culminating in a class presentation as well as a written document. They will be expected to lead group discussions of assigned peer-reviewed literature to improve their critical learning skills and understanding of experimental design and statistical analysis.

**Honor Code:** All class work must be your own original work and must not have been submitted for a grade in any other class while at the College of Charleston or elsewhere. Furthermore, no project done in this class can be submitted for grading in any other future or present course. To do so will be construed as a clear violation of the Honor Code.

**Internet Materials:** Any information you quote for a paper or presentation must come from the peer-reviewed scientific literature and not a website. Use search engines such as the Web of Science or Google Scholar. Search journals such as Coral Reefs, Limnology and Oceanography, Marine Biology, Marine Ecology Progress series, etc.

### **Grading Policy:**

|                                   |                                       |           |
|-----------------------------------|---------------------------------------|-----------|
| A : 92-100 excellent and creative | A-: 89-92                             |           |
| B+: 86-89 very good               | B: 82-86 good                         | B-: 79-82 |
| C+: 76-79 fair                    | C: 72-76 acceptable                   | C-: 69-72 |
| D+: 68-69 passing                 | D: 65-68                              | D-: 63-65 |
| F :> 63                           | XF Failure due to Academic Dishonesty |           |

Final grades are supposed to reflect how much you have progressed and/or learned in the time span of a course. With this in mind, one could suggest that an average student receives an average grade, a very good student a higher grade, and an excellent and creative student the highest grade.

### **Sidebar Knowledge**

This course will focus on the corals and the coral reef ecosystem. Within the context of the course students will be required to draw on knowledge from earlier classes. Since this course will be taught at the undergraduate and graduate levels it is expected that students will have varied educational backgrounds. I will help you with sidebar information (selected readings, lectures, websites, etc.) on selected topics to help students will become knowledgeable in areas that are important framework fundamentals to the study of coral reefs. A partial list follows:

- Geological time line of Earth history and the fossil record
- Principles of general oceanographic circulation
- Theories on the origin of life and biodiversity
- Theory of Evolution by Natural Selection
- Photosynthesis and the pathways of carbon
- Density dependence and the growth and regulation of populations

### **Reference Texts:**

Text: The biology of reefs and reef organisms. Goldberg, Walter M. 2013. The University of Chicago Press, Chicago, Illinois. vii þ 401 p. \$145.00 (cloth), ISBN: 978-0-226-30167-9 (alk.paper); \$55.00 (paper), ISBN: 978-0-226-30168-6 (alk. paper); \$7.00-44.00 (ebook), ISBN: 978-0-226-92537-0.

Reference suitable for keeping: *A Field Guide to Coral Reefs*, Eugene Kaplan. *Peterson Field Guide Series*. This is an excellent pocket field guide to Caribbean coral reefs.

Supplemental texts include:

*Life and death of coral reefs*, Charles Birkland. (out of print and expensive but very good)

*Aquarium Corals* by Eric Borneman, T.E.H Publications 2004

*The Great Barrier Reef Expedition* <https://archive.org/details/GreatBarrierReef1Yong>

*Coral reefs in the microbial seas*. Forest Rohwer, with M Youle and D. Vosten. 2010. Plaid Press.

### **Office Hours:**

9-10 Tues/Thurs or by appointment.

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**Biology of Coral Reefs (BIOL 619)**  
**Course Syllabus Spring 2016 P. Dustan**

| <b>Week</b> | <b>Topic</b>   |
|-------------|--|
| 1. Jan 13   | Introduction to Biology of Coral Reefs   |
| 2 Jan 20    | The tropical marine environment and climate: sun, sea, waves<br>Fundamentals of oceanography, global ecology.<br>Depth gradients of sunlight and wave action<br>Reef morphology, distribution of reef systems<br>Coral Reefs, John Wells, GSA Memoir 67<br><i>Climates on a Rotating Earth, Robert MacArthur</i><br><i>The biological control of chemical factors in the environment, American Scientist, A.C. Redfield 1958</i><br><i>Adjustment of Bikini Atoll to Ocean Waves, Munk and Sargent 1948</i><br><i>Transactions AGU, 29:6 pp855-860.</i><br><b>Goldberg Chapter 1</b>   |
| 3. Jan 27   | Coral Reef Zonation and geological reef constructional processes.<br>The Ecology of Jamaican Coral Reefs I. Species Composition and Zonation Thomas F. Goreau,<br><i>Ecology</i> , Vol. 40, No. 1 (Jan., 1959), pp. 67-90<br>The Zonation of West Indian Gorgonians, Robert A. Kinzie, Bull Mar Sci 28(1)<br>Deep Fore reef slope depositional processes, Goreau and Land,<br>Reefs in Time and Space, SEPM 1974 Special Pub #18.<br>Deep Forereef and Upper Island Slope, Lynton Land and Clyde More,<br>Marine Geology 1977 29:pp53-65.<br>Sclerosponges primary framework constructors on the Jamaican deep fore reef Judith Lang, Willard<br>Hartman and Lynton Land, Journal of Marine Research 33(2), 1975<br>Biological zonation at the base of the reef. Judith Lang,<br>American Scientist Vol 62, May-June, 1974.<br><b>Goldberg Chapters 1 and 2.</b> |
| 4. Feb 3    | The Evolution of Coral Reefs through the Phanerozoic<br>Clonal Growth, Algal Symbiosis, and Reef Formation by Corals, Coates, A.G. and Jackson, J.B.C.<br>Paleobiology, 13(4)363-378. 1987<br>The Ecological Evolution of Reefs, Wood, R. Ann Rev Ecol and Syst. 29(179-206) 1998<br>Nutrients, Predation and the History of Reef-Building. Rachel Wood: Palios, 8(6)526-543, 1993<br><b>Goldberg Chapter 13</b>   |
| 5. Feb 10   | <b>Exam first hour of class.</b><br>Limiting factors and concept of polytropy.<br>Reef Corals: Mutualistic symbiosis, Muscatine and Porter, 1977 Bioscience, 27:7  |
| 6. Feb 17   | Anthozoan corals: morphology, evolution, systematics, and identification Hermatypic corals I: Coral-<br>algal symbiosis: nutrition, calcification, photobiology<br>Henretta Hyman, The Invertebrates.  |
| 7. Feb 24   | Film and/or guest lecture. Dr. Dustan at Ocean Science 2016 meeting  |
| 8. Mar 2    | Hermatypic corals II: reproduction and settling<br>The coral holobiont and genomics  |
| 9. Mar 5-12 | <b>Study Abroad Spring Break Excursion to Glovers Atoll, Belize</b>  |
| 10. Mar 16  | Biodiversity: invertebrates and vertebrates<br><b>Goldberg Ch 14</b>   |

11. Mar 23 Trophodynamics: Biomass, primary production and metabolism  
Ecological dynamics: competition, predation, grazing  
**Goldberg Chapter 12, HSS and Charles Birkland on fish**
12. Mar 30 Natural and human disturbances weather, climate, and global change  
Overharvesting and mass mortalities  
**Goldberg Chapter 15**  
*Future of Coral Reefs, Knowlton, 2001 PNAS 98:10 pp 5419-5425*
13. Apr 6 Natural and human impacts:, physical damage, pollution, disease  
**Term papers due**
14. Apr 13 Management of Coral Reefs  
**Goldberg Ch 16**
15. Apr 20 Last Day of Class  
**Apr 27 Final Exam (4-7pm)**

### **Term paper assignment:**

**You may not write a term paper on global warming, coral bleaching, ocean acidification, lionfish or any other topic dealing with pollution or man's impact on reefs.** Start your project by finding a paper in the recent peer-reviewed scientific literature that is central to your interest. Then research the topic using other papers from the literature. After you have done some reading on your chosen topic make an appointment to discuss it me. The paper should be at least 2500 words of text, cite a minimum of 15 peer-reviewed papers from 2000 or later plus any other references you choose to use, and must be typed (Times Roman font, 11 or 12 pica, double spaced). Submit both paper copy and email electronic copy.

**Filename = YOUR LAST NAME\_PAPER\_BIOL619\_S2016.DOC).**

### **Term Paper Topic:**

#### **1. Research themes in coral reef science**

Coral biologists have tended to use a selection of coral species for experimental purposes to develop and examine themes in coral reef biology. Examples of this are calcification, endosymbiosis, reproduction, systematics and the species problem, and life history strategies. The reasons for this usually focus around the availability of specimens, habitat distribution, or some peculiar aspect of a species' biology. For example, *Stylophora pistillata* has become the experimental organism of choice for Red Sea biologists, the *Montastrea annularis* species complex in the Caribbean, and *Pocillopora damicornis* in the Hawaiian Islands. Your assignment is to select a well-used species of fish, coral or other invertebrate from the literature and report on how research centered on your selected species has contributed to a particular "niche of understanding" of coral reef ecology.

**Or**

**2. Reef Processes:** Our understanding of coral reefs has come from curious individuals. Your assignment is to report on the current state of knowledge of an ecological or evolutionary reef process of your choosing, NOT a thing or an organism, but an actual Ecological or Evolutionary Process.

**Presentations and class reports:** Materials other than simple introductory information should be gleaned from the peer-reviewed literature, **NOT** website information.

### **Underwater Photography Research Techniques:**

Underwater photography is essential to coral reef studies. Interested students will be exposed to a wide variety of underwater cameras and techniques including film and digital still photography and underwater video.

**Honor Code:** All class work must be your own original work and must not have been submitted for a grade in any other class while at the College of Charleston or elsewhere. Furthermore, no project done in this class may be submitted for grading in any other present or future course. To do so will be construed as a clear violation of the Honor Code. More information is available in the *Student Handbook* at <http://www.cofc.edu/generaldocuments/handbook.pdf>.

## Grading Rubric:

|   | <b>Excellent<br/>4</b>   | <b>Above Average<br/>3</b>   | <b>Average<br/>2</b>  | <b>Below Average<br/>1</b>  |
|---|--|--|---|---|
| <b>Question selection</b>                         | Identifies a creative, focused, and manageable topic that addresses potentially significant yet previously less explored aspects of the topic. | Identifies a focused and manageable/doable topic that appropriately addresses relevant aspects of the topic.   | Identifies a topic that while manageable/doable, is too narrowly focused and leaves out relevant aspects of the topic.  | Identifies a topic that is far too general and wide-ranging as to be manageable and doable.                           |
| <b>Existing knowledge, research, and/or views</b> | Synthesizes in depth information from relevant sources representing various points of view/approaches.   | Presents in depth information from relevant sources representing various points of view/approaches.  | Presents information from relevant sources representing limited points of view/approaches.  | Presents information from irrelevant sources representing limited points of view/approaches.                          |
| <b>Methods</b>                                    | All elements of the methodology or theoretical framework are skillfully developed.   | Critical elements of the methodology or theoretical framework are appropriately developed however more subtle elements are ignored or unaccounted for. | Critical elements of the methodology or theoretical framework are missing, incorrectly developed or unfocused.  | Inquiry design demonstrates a misunderstanding of the methodology or theoretical framework.                           |
| <b>Analysis</b>                                   | Organizes and synthesizes evidence to reveal insightful patterns, differences, or similarities related to focus.                               | Organizes evidence to reveal important patterns, differences, or similarities related to focus.  | Organizes evidence but the organization is not effective in revealing important patterns, differences or similarities.  | No apparent organization. Evidence is not used to support assertions.   |
| <b>Organization</b>                               | The presentation is carefully organized and provides convincing evidence to support conclusions.   | The presentation has a focus and provides some reasonable evidence to support conclusions.   | There is some organization, but the speaker occasionally goes off topic. Evidence used to support conclusions is weak.  | No apparent organization. Evidence is not used to support assertions.   |
| <b>Content</b>                                    | The content is accurate and comprehensive. Listeners are likely to gain new insights about the topic. Clear and creative graphics              | The content is generally accurate and reasonably complete. Listeners may develop a few insights about the topic. Interesting graphics                  | The content is sometimes inaccurate or incomplete. Listeners may learn some isolated facts, but they are unlikely to gain new insights about the topic. Acceptable graphics | The content is inaccurate or overly general. Listeners are unlikely to learn anything or may be misled. Poor graphics |
| <b>Delivery</b>                                   | The speaker is professional, relaxed, and comfortable and interacts effectively with listeners.  | The speaker is generally relaxed and comfortable. Listeners are generally recognized and understood.   | The speaker occasionally appears anxious or uncomfortable, and may occasionally read notes, rather than speak. Listeners are often ignored or misunderstood.                | The speaker appears anxious and uncomfortable and reads notes, rather than speaks. Listeners are ignored.             |