COURSE SYLLABUS

BI 541: Coral Reef Resilience and Restoration:  
A Field Research Course on the MesoAmerican Barrier Reef of Belize

Short Title: Coral Reef Resilience

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Required Texts:


Supplemental Text:


Other Readings
http://fragmentsofhope.org/technical-documents/
http://www.reefresilience.org/

OVERVIEW

**Short form:** Caribbean coral reefs have fallen into ruin.  We will learn about the coral reef as one element in a coastal landscape ecology, about methods to restore reef health, and you will help to further develop these methods by integrating across biological scales and disciplines, from molecule to biosphere, and cell biology to systems ecology.  This course runs parallel to Coral Reef Dynamics and is built upon the same background skills and knowledge, but from a more applied, conservation and restoration-oriented perspective.  The heart of the course is natural history study and field work in Belize, as
part of the local coral reef stewardship and restoration activities on the MesoAmerican Reef (MAR).

**Coral Reef Resilience and Restoration** is a field-centered case study of the challenges, triumphs, and travails of restoration ecology in tropical watershed and coastal ocean ecosystems—what in Fijian culture is known as the *vanua*. The pedagogical objective is to understand the processes that sustain the watershed, coastal ocean, and constructed landscape in which the coral reefs of today are embedded, and how these can be capitalized upon to accelerate coral reef recovery. The course begins in Boston with the study of coral reef environments, coupled human and natural system dynamics, and the basics of restoration ecology. Several days are spent in comparative study of framework-building corals and how they interact to assemble—naturally and under directed recovery—the reef fabrics of the Mesoamerican coral reef system. Each student will focus on a specific fabric; for example, the mixture of branching and massive corals typical of a Caribbean fore-reef terrace, the multicolored tapestry of lettuce, fire, and finger corals of Belize’s massive shallow reef buttresses, and the strangely suspended coral communities of mangrove tidal channels. Each student will enumerate the constituent species of a fabric, identify the key species, ecological relationships and processes that determine the fabric’s ability to self-sustain and propagate, and finally propose means of nudging the fabric from a state of disintegration to one of reintegration, maturation, and stability. Grades are based upon one exam, on readings and lecture, and on presentation of a professional seminar based upon the student’s own research.

**NARRATIVE SUMMARY**

The combined effects of anthropogenic climate change and cumulative local human impacts are profoundly altering coastal habitats where the greater part of humanity lives. These effects are pronounced in coral reef and associated habitats, where the loss of value to people is extreme, inspiring Sisyphean attempts at restoration, often on an impractically minute scale and at very great expense. A broader perspective is needed that takes into account the one to two century Great Hiatus during which human impacts, compounded by climate change and overpopulation, could eventually be brought under control. If they are, then we can expect to rehabilitate coral reef ecosystem function using the knowledge acquired and innovative methods to be developed during this course. Can coral reefs survive the harsh transition years of the Great Hiatus? Can we continue to benefit from the many values provided by coral reefs during this rocky interregnum?

Through a mix of organismal, community and forensic ecology we will examine aspects of the biology and socioeconomics of coral reef recovery. We will then develop new knowledge and strategies for rebuilding the quality and resilience of coral reef habitats during the Great Climate Hiatus. Topics range from traditional practices to modern ecosystem-based management, from the monitoring of reef health through a chief’s eye, to advanced molecular diagnostics. The course hinges on theoretical questions that apply to all ecosystems, not just coral reefs. How does biological diversity influence ecosystem function? Is high biodiversity necessary for coral reefs to continue to provide food and
livelihoods for people? Do ecosystems exhibit alternate metastable states? Is the behavior of coupled human and natural systems lawful, and if so, predictable? However, we also recognize that the technological sophistication of coral reef restoration has been expanding rapidly; the idea has progressed from a joke, to a dream, to a practical reality.

Today, coral reef restoration can mean any one of five different things. First, it could mean the reduction of human impacts so that coral reef systems have an easier time repairing themselves naturally. All the other meanings involve direct ecological manipulations directed toward some goal. The goal could be simply to replace hard coral coverage where it has been lost. It could be to recover one or more species from recognition as threatened or endangered. Many choose to focus on the restoration of ecosystem services; that is, a system is returned to a state where it once again provides well for human needs. Finally, coral reef restoration can mean that a degraded coral reef system has been brought back to a state in which all of its constituent species are secure and the community can maintain and replace itself. Conditions, coverage, species recovery, restitution of immediate value to people, and a total ecosystem recovery. While not mutually exclusive, the paths to any one are somewhat divergent. It matters to have specific goals in mind.

The restoration ecology of coral reefs is in its infancy- we are barely at the stage where we can see the potential value of expanding our efforts… but we also see the pitfalls all the more clearly. One of the most important areas of missing information- and the focus of our class- is the natural history of coral reef framework-building communities. These communities are the tapestries of corals, algae, sponges and other invertebrates, and fishes that together weave the magic of growing and maintaining the coral reef as a physical entity.

The coursework is divided into two parts: ten days in Boston, ten days in Belize, plus two days coming and going from Belize, at the University of Belize’s Calabash Caye Field Station (CCFS), on Turneffe Atoll. Our time in the field will hone skills in natural history, field survey, heuristic modeling, and short-term experimental studies. CCFS sits upon an atoll rim surrounded by a lush mosaic of littoral and mangrove forests, seagrass meadows, and varied coral reef environments. As for much of the world, the ecological health of Turneffe Atoll has plummeted in recent decades, but Belize- whose economy is largely based on tourism and its food security on fisheries- has taken notice. The students will explore how marine science can help in this time of crisis, and prepare their results in a form that can be shared with other scientists as well as the many lay people who care greatly about the future of coral reefs in Belize and elsewhere.

This is an extremely intensive course, and we work straight through the weekends. Time in Belize is also in two parts beside the travel days: an initial two days of exploring the watershed landscape that supports coral reef growth at Calabash Caye, and the remaining eight days during which everybody will conduct their field research, analyze their data, and present their results in a professional manner.

**Grading:** The grade will be calculated as follows:
Project proposal 20
Pre-field quiz 10
Conduct of field research 10
Oral project presentation 20
Written paper 40

**Academic Conduct:**

This class will be taught in compliance with the Boston University Academic Conduct Code. All students are expected to adhere.

The URL for the Code is: [http://www.bu.edu/academics/policies/academic-conduct-code/](http://www.bu.edu/academics/policies/academic-conduct-code/)

**PREPARATION FOR FIELDWORK IN BELIZE:**

1. **INTERNATIONAL TRAVEL**
   
   *Required:* Valid passport (visa not required)

2. **SNORKEL AND SWIM PROFICIENCY**
   
   *Required:* Participation in a BU FitRec snorkel skills analysis (snorkelympics or a "make-up" pool session with instructors); valid BU Swim Card
   
   *Recommended:* Practice both swim and snorkel skills in the FitRec pool prior to departure for the field.
   
   *Provided by BUMP:* Divers Alert Network (DAN) Insurance

3. **SNORKELING GEAR**
   
   *Required:* snorkel, mask, fins and booties (open-heeled fins recommended), waterproof watch, and either a wetsuit or a dive skin (full body or separate top and bottom). Your personal wetsuit choice is based on three important variables: *A. warmth, B. coverage, and C. buoyancy*. Many BUMP students wear full-length 3mm wetsuits, this is an excellent choice if you tend to get cold in the ocean and/or desire a little extra buoyancy during fieldwork. For those with higher body heat, coverage via a dive skin or rashguard is essential. Note: the choice to wear a wetsuit *does not mean that you will forfeit your ability to surface dive*, weights are available at the field station for our use. Regardless of the material, coverage is key given the likelihood that we will be stung by nematocysts when sampling mangrove habitat (additional forms of coverage recommended below).
   
   *Recommended:* dive gloves (1-1.5mm or thin gardening gloves), dive hood (lycra or thin neoprene), underwater flashlight, personal underwater camera
   
   *Provided by BUMP:* underwater dive slate, UW pencil, snorkel vest, and several UW cameras for check-out

4. **FIELD GEAR AND CLOTHING**
   
   *Required:* light rain jacket, polarized sunglasses, sunscreen, insect repellant, light long-sleeved clothes, hat, bathing suit
   
   *Recommended:* headlamp, sandals (chacos or tevas), water bottles(s), and a few cool weather clothing items

5. **BUNKROOM AND BATHROOM**
Required: tropical sleeping bag or sleeping sheet, towel (full-sized towel or REI pack towel), and all personal toiletries (see below)

Recommended: extra string or cord for laundry line and/or use in setting up your mosquito tent, favorite personal snacks and treats (clifbars, probars, chocolate, fancy coffee, favorite tea). We will be making a stop at a local supermarket before heading to the Ferry Dock on arrival in Belize but note that typical Belize City grocery store goods are quite different than those we stock up here in the US.

Provided by CCFS: bunk beds, bug tent, fan, pillow/case, and bed sheets

6. TOILETRIES AND MEDICATIONS

Required: any/all personal toiletries and personal medications (in original bottles)

Recommended: swimmer's ear drops, motion sickness medicine (dramamine or bonine), anti-diarrheal (imodium), cold medicine antihistamine, nasal decongestant, pain medicine (tylenol, ibuprofen, acetaminophine), and personal first aid (disposable bandages, benadryl). Consult your physician and the CDC regarding immunizations.

7. TECH AND ACADEMIC

Required: USB flashdrive/thumbdrive, chargers/batteries/cases for personal devices

Recommended: personal field guides, artist's paper (personal field drawings, plant/algae pressings), binoculars (7x50 to 10x50, suitable for birding)

Provided by BUMP: two online laptop stations (pc and mac) with photo-analysis, stats, and presentation software; four ipad mini's with stats and presentation software; underwater sampling gear, dry and wet lab instrumentation, waterproof field journals (Rite in Rain), and a field library of guides and references.

Optional: personal laptops, tablets, and phones are allowed at CCFS for data entry, ppt building, final presentation, and field camera use. Should you choose to bring your laptop or device please note the following: wifi is not available for personal use (our bandwidth is extremely limited on the Atoll and is reserved for our two BUMP laptops, the CCFS Manager, and emergency medical communication); CCFS buildings can leak in heavy rainstorms (we will provide air tight pelican cases as daily and nightly classroom storage but waterproof cases and/or anti-desiccation packets are recommended); and all associated personal power cords must be brought by you (clearly labeling them is a good idea).

Course Syllabus

Monday, November 28- Coral Reefs in Context: The comparative anatomy of tropical vanua ecosystems and what’s happening to them today.

Readings:
Jackson et al.: scan vigilantly and continually return for the duration of this course
Goldberg: Read and study Chapter 1
Precht: Read and study Chapters 1 and 4
Other: CHI manual

1. Lecture
2. Discussion
3. Field project options discussed
4. ID lab

Tuesday, November 29- **Scleractinian Corals: Major Builders of Modern Coral Reefs**

**Readings:**
Goldberg: Read Chapter 13; read and study Chapter 6; scan Chapters 2-5.
Precht: Read and study Chapter 3 and 7

**Other:**
1. Lecture
2. Discussion
3. Students select projects
4. Organization of field teams, research questions, resources.
5. ID Lab
6. Work in BUMP lab to become familiar with some reef organisms.

Wednesday, November 30- **Cumulative human impacts on coral reefs**

**Readings:**
Goldberg: Read and study Chapter 15
Precht: Read and study Chapter 12
Jackson et al.: Review

**Other:**
1. Lecture
2. Discussion
3. ID Lab
4. Analysis of Caribbean reef assessment data sets (AGGRA-Plus, Healthy Reefs, CHI)
5. Field team break-out groups- compose questions, species lists and references

Thursday, December 1- **Rules of reef fabric assembly and turnover: a theoretical basis for restoration**

**Readings:**
Goldberg: Read and study Chapters 12 and 14
Precht: Read and study Chapters 4 and 6

**Other:**
1. Lecture
2. Field team break-out groups- design experiments, logistics, gear list
3. Reef Fabrics: shallow reef buttresses
4. ID Lab
5. Project Work

Friday, December 2- **Methods in Coral Reef Restoration I: Rapid expansion in sophistication and scale of Caribbean reef restoration**
Readings:
Goldberg Chapters: Read and Study Chapter 16
Precht: Read and study Chapters 15 and 16
MMAS Brochures, NOAA Coral Restoration Symposium

1. Lecture
2. Discussion
3. Field team break-out groups- create statistical designs for field experiments, refine hypotheses.
4. Reef Fabrics: fore-reef terrace/back-reef gardens
5. ID Lab
6. POOL SESSSION: 2PM

Monday, December 5- Restoration technologies II: Inspiration from nature and by necessity.

Readings:
Goldberg Chapters: Study Chapter 4 and 5
Precht: Read and study Chapters 17 and 18.

1. Lecture
2. Discussion
3. Project Proposals DUE
4. ID Lab
5. Discussion of projects
6. Project Work

Tuesday, December 6- Belizean Reef Crest Fabrics: acroporid, agariciid, and faviid framework dominants and their motile associates

Readings:
Goldberg Chapters: Study Chapter 11
Other:

1. Lecture
2. Discussion
3. Pre-field QUIZ
4. Field team break-out groups- group work on project proposals
5. Project Work

Wednesday, December 7- Natural Reefs, No-Analog Reefs, Non-Reefal Coral communities, and Reiteratively Restored Reefs
1. Lecture
2. Discussion of Reef Fabrics: adding Mangrove root coral communities
3. Project Discussion
4. Project Work

Thursday, December 8 – **DEPARTURE FOR BELIZE**

Friday, December 9– Sunday December 18- **Project Work, Calabash Caye Field Station, Belize**

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<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
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<tbody>
<tr>
<td>27</td>
<td>28:Class Begins</td>
<td>29</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>Post Session (9-11)</td>
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<td>4</td>
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<td>Travel Day</td>
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<tr>
<td>AM: Ecosystem Tour 4 Blockhead: Genetics and ARMS</td>
<td>Am: Snorkel Checkout / Ecosystem Tour 1</td>
<td>PM: Fragments of Hope Community Consultation (Scopes out Fabrics Sites)</td>
<td>PM: Ecosystem Tour 2 More CCFS Table Rhizophora or Pelicanus</td>
<td>PM: Ecosystem Tour 3 Build and place Blackbird Table Rhizophora or Pelicanus</td>
<td>Evening: ARMS introduction and construction</td>
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<td>AM: Fabrics Data Collection 1 (B) FOH Site 1 (A) Rhizophora or Pelicanus</td>
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<td>PM: Fabrics Data Collection 3</td>
<td>PM: Fabrics Data Collection 4</td>
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<td>Evening: ARMS retrieval and breakdown</td>
<td>AM: Fabrics Data Collection 3 (B) FOH Sta 3 (B) Rhizophora or Pelicanus</td>
<td>PM: Fabrics Data Collection 4 (B) FOH Site 4 (A) Rhizophora or Pelicanus</td>
<td>Evening: Group Discussion: Observations and Importance of Fabrics in Conservation</td>
<td>Exploration Day</td>
<td>Evening: Data analysis</td>
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<td>AM: Optional: Day 0 Nursery Coral Measurements (Install ARMS)</td>
<td>AM: Ecosystem Tour 5 AM: Ecosystem Tour 5</td>
<td>PM: Data analysis/ presentation prep (Install ARMS)</td>
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<td>AM: Fabrics Data Collection 5 (B)</td>
<td>AM: Fabrics Data Collection 6 (B)</td>
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<td>PM: Data analysis/ presentation prep (Install ARMS)</td>
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<td>Evening: Presentation Practice</td>
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<td>PM: Fabrics Data Collection 5 (B)</td>
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<td>PM: Lab Clean Up (Fun Snorkel?)</td>
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<td>PM: Data analysis/ presentation prep (Install ARMS)</td>
<td>PM: Lab Clean Up (Fun Snorkel?)</td>
<td>Evening: Bonfire</td>
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Monday, December 19: **Class Project Presentations in Belize**

Early AM, Tuesday December 20: **DEPART BELIZE FOR HOME**

Wednesday afternoon, December 21: **LAST DAY OF CLASS**
1. Papers due.
2. Post-trip clean-up