Shoals Marine Laboratory
Investigative Marine Biological Laboratory (BIOSM 1500/MEFB 530)
30 June - 14 July 2021

Course Syllabus and Schedule

Faculty: Douglas Fudge, PhD (fudge@chapman.edu)
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Prerequisites: none

Class enrollment limit: 16 who are: a) matriculated students at Cornell, UNH or at any 4-year college or university; or b) incoming freshmen who will arrive at Cornell or UNH in fall 2021.

Credit hours: 3

Course Overview: This course is an intensive, marine-based introduction to scientific method and experimental biology taught at the Shoals Marine Laboratory. The course takes advantage of the unique learning opportunities afforded by the pristine marine environment (especially the intertidal zone) around Appledore Island. The overall course philosophy is to allow students to learn the scientific method by doing it themselves under the guidance of veteran marine biologists. The course is structured around two class projects that are designed to expose students to concepts and techniques in marine ecophysiology and biomechanics.

> *The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth'. But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is imagination to create from these hints the great generalizations - to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we have made the right guess.*
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>
> Richard Feynman

Course Objectives/Goals:

1. Scientific method. Students will:
    - appreciate the power and limitations of science as a way of knowing.
    - understand and apply the structure of the scientific method.
    - understand and apply principles of good experimental design and data collection.
    - learn how to carry out statistical testing, analysis, and graphing using R software.

2. Scientific information literacy. Students will:
    - learn how to use online research tools for scholarly literature.
    - learn how to cite sources using proper format.

3. Scientific communication. Students will:
    - demonstrate understanding of the structure of scientific papers and their relationship to the scientific method via five writing assignments.
    - demonstrate principles of data analysis, slide design, and oral communication via participation in a scientific symposium at the end of the course.

4. Knowledge of and ability to use equipment in the lab and field. Students will:
    - understand the importance of measurement to the scientific process
    - demonstrate proper use of equipment such as pipets, calipers, micrometers, force transducers, and dissolved oxygen probes.
    - demonstrate proficiency with the use of remote sensing devices such as CTD probes, and other data loggers.
    - demonstrate proficiency with biological imaging using microscopes and cameras.
    - demonstrate proficiency with image processing using ImageJ software.

5. Conceptual knowledge pertaining to two laboratory modules. Students will master introductory concepts in two main areas:
    - Marine Eco-mechanics
    - Marine Eco-physiology

6. Additional goals. Students will
    - be empowered to undertake their own scientific investigations.
    - practice critical thinking skills as background for MCAT and GRE.
    - take ownership of the material.
    - learn how to work cooperatively with others toward a common goal.

Course Content:

The course objectives will be met in the context of two modules that will engage students in active learning and research. These modules are as follows:

Module 1: Eco-mechanics

Organisms are routinely subjected to mechanical forces, both from other organisms, and from physical phenomena such as water flow, buoyancy, and gravity. Ecomechanics explores the roles that these forces play in determining the form, function, and ecological roles of organisms in their environment. In this module, students will be exposed to background information on how organisms are adapted to physical forces in their environment as well as general principles of biomechanics. Students will carry out a research project whose goal will be to answer an “ecomechanical” question that emerges from their explorations of the marine environment around Appledore Island. After a lecture on biomechanics, students will be given the opportunity to observe intertidal organisms in their natural habitats and generate ecomechanical questions about their distribution, behavior, or function. These questions will be discussed as a group until the class agrees on a question that they think they can answer in the time available in the course. Possible project topics include attachment of intertidal organisms (mussels, gastropods, algae, etc.), mechanics of suspension feeding (in mussels, barnacles, tunicates, bryozoans, etc.), and predator-prey mechanics (crabs feeding on armored prey such as bivalves, gastropods, etc.). Students will tackle the question posed by systematically applying the steps of the scientific method that they will learn at the beginning of the course.

Module 2: Eco-physiology

In addition to mechanical forces, marine organisms are also subjected to physical stressors such as fluctuations of temperature, salinity, and oxygen content, and these factors can play important roles in determining their function and distribution. While much of the marine environment is known for its stability, the intertidal environment is one of the most challenging habitats on the planet. Intertidal organisms must be able to endure crashing waves, desiccation, and extremes of temperature, salinity, and dissolved oxygen that would kill most other organisms. In this module, students will be exposed to some of the physiological adaptations that intertidal organisms possess that allow them to survive and reproduce in such a stressful environment. The hands-on portion of the module will consist of students carrying out a research project whose goal will be to answer an “ecophysiological” question that emerges from observations they make in the field. As in the second module, students will engage in observation and question finding in addition to all the other steps of the scientific method. While the exact research project topic will be up to the class to decide, possible areas of inquiry include desiccation resistance, hypoxia tolerance, and thermal biology of intertidal animals and algae.

Course Materials:

Required readings (provided as pdf files)

Platt JR (1963) Strong Inference. *Science* 164: 347-53.

Deutsch D (2011) *Beginning of Infinity*, Ch 1 “The Reach of Explanations” pp 1-31.

Fudge DS and Turko AJ (2020). The best predictions in experimental biology are critical and persuasive. *Journal of Experimental Biology* 223(19).

Bressman NR, Farina S, Gibb A (2016) Look before you leap: Visual navigation and terrestrial locomotion of the intertidal killifish *Fundulus heteroclitus*. *J. Exp. Zool*. 325A:57–64.

Leigh KL, Sparks JP, Bemis WE (2016) Food preferences of Atlantic hagfish, *Myxine glutinosa*, assessed by experimental baiting of traps. *Copeia* 104:623-7.

Recommended readings (provided as pdf files)

Diamond J (1983) Laboratory, field and natural experiments. *Nature* 304: 586-7.

Fudge DS (2014) Fifty years of J. R. Platt's strong inference. *J Exp Biol* 217, 1202-4.

Assignments & Grading:

Required Assignments

Assignment 1 (Sci Method - Observations & Questions)	5%
Assignment 2 (Sci Method - Hypotheses & Predictions)	15%
Assignment 3 (Sci Writing - Introduction)	15%
Assignment 4 (Sci Writing - Results)	15%
Assignment 5 (Sci Writing – Discussion)	15%
Peer Reviews	5%
Oral Presentation (Research Proposal)	15%
Participation	15%

Expectations and Conduct:

Students are responsible for fully understanding all of the information presented in this syllabus. If there are any questions regarding this information, it is the student’s responsibility to bring it to the instructor’s attention. In addition, students are responsible for attending all activities associated with this course and completing all assignments. Students are responsible for asking questions anytime they need clarification (remember, there is no such thing as a bad question).

Every student is responsible for their own behavior- specifically in being respectful and collegial to other students and with instructors. Students are responsible for fully understanding and adhering all of the information presented in the SML Appledore Handbook (http://www.sml.cornell.edu/sml_forms.html)

1. *Personal Technology.* Do not use cell phones, smart phones, iPads, mp3 players, headphones, or similar devices in the classroom or during course

activities. If you take notes with your computer, disable wireless access during lecture.

2. The lab has a modest computer facility in Laighton Library; please treat this shared facility with respect. Printers are available, but please limit printing to your FINAL document (if required).
3. *Transmission of Course Materials*. Students are not authorized to replicate, reproduce, copy or transmit lectures and course materials presented, or derivative materials including class notes, for sale or free distribution to others without written consent of the instructors who are the original source of the materials.
4. *Academic Integrity***.** Any work submitted must be your own. Uncredited use of another person's words, data or images is considered plagiarism, a serious violation of the Code, whether the material comes from another student, a web site, or a published paper. Students must adhere to Cornell's and UNH's Policy for Academic Honesty/Plagiarism and Discrimination
    A. Cornell: http://cuinfo.cornell.edu/aic.cfm
    B. UNH: http://www.unh.edu/vpsas/handbook/welcome-university-new-hampshire
5. *Disabilities & ADA Accommodation*: Students with a disability must contact Cornell's (420 CCC building; 607-254-4545) or UNH's Student Disability Serviceshttp://www.unh.edu/disabilityservices) four weeks prior to start of class for confidential discussion of needs and for registration to verify eligibility for academic accommodations. No retroactive accommodations can be made.
6. *Mental Health:* Shoals Marine Laboratory cares about you and your well-being. If you experience unusual personal or academic stress during the course or need to talk with someone about a personal problem, seek support from your instructors as soon as possible. In addition, any SML staff is available for consultation 24/7. Find staff in the office in the Hamilton House between 8am – 7pm or knock on the door of Bartell House after hours

Schedule (subject to change!)

	low tide times, heights			sunrise	sunset
Wed June 30	10:24	0.0	22:47 +1.0	05:01	20:28

0800 (island staff: set hagfish traps)
15:15 Arrive on R/V Kingsbury
1600 Welcome to Shoals and move into dorms

1615 Intro to Course, introductions
1700 Food Run
1730 Intro to Course, Introductions
1800 Dinner
1900 Visit *Fundulus* tidepools, observations
1945 Discuss observations from tidepools

Thu July 1 11:16 +0.4 23:46 +1.2 05:01 20:28
0730 Breakfast
0830 Scientific Method (DF)
1100 Eco-Physiology of amphibious killifishes (NB)
1230 Lunch
1330 *Fundulus* project planning
1500 Back to *Fundulus* pools for observing
1800 Dinner
1930 Rock Talk
2030 Discuss hagfish project

Fri July 2 12:08 +0.8 05:02 20:27
0730 Breakfast
0830 Hagfish biology (DF)
0930 Prep hagfish tank
1030 Hagfish discussion
1230 Lunch
1330 Hagfishing on R/V J.B. Heiser
1330 Project planning
1630 Personal time to work on Assignment 1
1800 Dinner
1915 Project planning
2000 Assignment 1 due (Observations and Questions)
2030 Project planning and observations

Sat July 3 00:46 +1.3 13:00 +1.2 5:03 20:27
0730 Breakfast
0830 Hagfishing trip #2
1230 Lunch
1330 Work on Assignment 2
1500 Project planning
1800 Dinner
1930 Assignment 2 due (Hypotheses and Predictions)

1945 Project planning

Sun July 4 01:45 +1.2 13:52 +1.4 05:03 20:27
0730 Breakfast
1000 Observations, questions, hypotheses, predictions
1230 Lunch
1330 Observing and sketching with Abby McBride
1530 Project planning and data collection
1800 Dinner
1900 Project planning

Mon July 5 02:41 +1.1 14:43 +1.6 05:04 20:27
0730 Breakfast
0830 Project planning
0930 Prepare for experiments
1230 Lunch
1330 Research Presentation by Kela Bakari
1430 Project data collection
1800 Dinner
1900 Project data collection
2115 View movies, analyze

Tue July 6 03:31 +0.9 15:29 +1.6 05:04 20:26
1000 Brunch
1100 Hagfish slime (DF)
1300 Experiment planning and trials
1530 How to write an introduction (DF & NB)
1600 Project planning
1700 Dinner
1800 Project data collection (*Fundulus*)
1815 Faculty meeting
2100 Break down trials

Wed July 7 04:16 +0.7 16:12 +1.6 05:05 20:26
0730 Breakfast
0830 Course planning
0930 Trials and data collection
1100 Personal time to complete Assignment 3
1230 Lunch
1330 Continue with experiments/Assignment 3

1700 Swim call/Food Run
1800 Dinner
1900 Data collection/Assignment 3

Thu July 8	04:58	+0.9	16:53	+1.5	05:06	20:25

0730 Breakfast
0830 Assignment 3 due
0830 Project data collection
1230 Lunch
1330 Project data collection
1730 Intro to Stats, R (NB)
1800 Dinner
1900 How to write a Results section (DF), more data collection

Fri July 9	05:37	+0.4	17:32	+1.4	05:07	20:25

0730 Breakfast
0830 Analysis of tern video
1100 Data collection and analysis
1230 Lunch
1330 Data analysis of terns, *Fundulus*
1645 Food run
1700 Intro to plotting in R
1800 Dinner
1900 More R training (NB)
2100 Night fishing at the dock

Sat July 10	06:15	+0.2	18:11	+1.3	05:07	20:24

0730 Breakfast
0830 Check-in and planning for day
0900 Data analysis, writing assignment 4
1215 What do p-values mean?
1230 Lunch
1330 Analysis, graphs, results writing
1800 Dinner
1930 Work on Assignment 4
2200 Assignment 4 due (Results section)

Sun July 11	06:52	+0.1	18:51	+1.2	05:08	20:24

0730 Breakfast
0830 How to write a Discussion section (DF, NB)

0900 Work on Assignment 5
1230 Lunch
1330 Continue working on Assignment 5
1800 Dinner

Mon July 12	07:29	+0.0	19:31	+1.1	05:09	20:23

0730 Breakfast
0830 Assignment 5 due (Discussion section)
0830 How to give a slide presentation (DF, NB, KB)
0900 Work on presentations
1230 Lunch
1330 Work on presentations
1600 Peer review presentations
1800 Dinner
1930 Work on presentations

Tue July 13	08:08	-0.1	20:14	+1.0	05:10	20:23

1000 Brunch
1130 Student Symposium (Hamilton)
1530 Lab cleanup, Google Drive cleanup
1700 Dinner
1930 Island cruise

Wed July 14	08:48	-0.1	21:00	+0.8	05:11	20:22

0730 Breakfast
0830 Luggage for dock on porch of dorms
0915 Dock for Departure

DF Douglas Fudge
NB Noah Bressman
KB Kela Bakari

NSF Research Experience for Teachers fellows:
CQ Christian Quinteros
PL Peter Ly