Shoals Marine Laboratory
Investigative Marine Biological Laboratory (BIOSM 1780/MEFB 530)
July 15-29 2024

Course Syllabus and Schedule

Schedule (and log)

	low tide times, heights (ft)		sunrise	sunset
Mon July 15	12:25 (1.6)	12:29 (1.7)	5:17	8:19

1345 Hagfish trap set
1600 Arrive on R/V Kingsbury
1700 Welcome to Shoals and move into dorms
1800 Dinner
1900 Intro to Course, Introductions
1930 Introduction to Scientific Method (DF)
2100 Done

Tue July 16	1:20 (1.5)	1:21 (1.8)	5:18	8:19

0730 Breakfast
0815 Depart dock for hagfishing
0930 Hagfish trap retrieval, oceanographic sampling on R/V Kingsbury
1230 Lunch
1430 Animal care
1600 More Scientific Method (DF)
1700 Discuss hagfish project
1800 Dinner
1900 The Role of Observation in Science (prep for mudflat visit)
2000 Rock Talk: **Douglas Fudge**, Weird and Wonderful Hagfishes
2100 Done

Wed July 17	2:17 (1.2)	2:14 (1.8)	5:19	8:18

0730 Breakfast
0830 Discuss Assignment 1, tidy up lab, hagfish maintenance
0900 Mudflat ecology, physiology, and biomechanics (KG)
1030 Prep for Creek Farm trip
1230 Lunch
1400 Trip to Creek Farm, invertebrate, sediment sampling
1600 Food Run
1800 Dinner
1900 Assignment 1 in class with feedback

2000 Discuss project ideas
2100 Done

Thu July 18 3:10 (0.9) 3:06 (1.6) 5:20 8:17
0730 Breakfast
0830 Hagfish experiments
1230 Lunch
1330 Worm experiments
1800 Dinner
1900 Hagfish update, mudflat debrief and project planning
2000 Install R-Studio
2100 Done

Fri July 19 3:59 (0.5) 3:56 (1.3) 5:21 8:16
0730 Breakfast
0830 Assignment 2 in class with feedback
0930 Mudflat project planning
1230 Lunch
1330 Experimental design, setup, data collection
1800 Dinner
1900 Continue experiment setup, data collection
2100 Done

Sat July 20 4:47 (0.1) 4:45 (0.9) 5:22 8:16
0730 Breakfast
0830 More Hagfish & Mudflat project planning & data collection
1230 Lunch
1330 Project planning and data collection
1800 Dinner
1900 Project planning and data collection
2000 Project updates from project leaders
2100 Done

Sun July 21 5:34 (-0.2) 5:34 (0.6) 5:23 8:15
1000 Brunch
1100 Set up experiments, collect data
1600 How to write an Introduction (DF), outline Assignment 3
1700 Dinner
1800 Work on Assignment 3
2100 Done

Mon July 22 6:20 (-0.6) 6:24 (0.3) 5:24 8:14

0730 Breakfast (Denny arrives)
0830 Run experiments and collect data
1230 Lunch
1330 Data collection, Assignment 3
1800 Dinner
1900 Data collection, Assignment 3
2100 Done

Tue July 23 7:07 (-0.9) 7:15 (0) 5:25 8:13
0730 Breakfast
0830 Assignment 3 due
0830 Run experiments and collect data
1130 How to write a Results section (DF, KG), outline Assignment 4
1200 What do p-values mean? (DF)
1230 Lunch
1330 Data collection
1530 Intro to R Studio (KG)
1800 Dinner
2000 Rock Talk: TBD
2110 Done

Wed July 24 7:52 (-1.0) 8:07 (-0.1) 5:26 8:12
0730 Breakfast
0830 Collect data
1230 Lunch
1330 Data visualization in R (KG)
1500 Data analysis, Assignment 4
1630 Food run
1800 Dinner
1900 Data analysis, Assignment 4
2100 Done

Thu July 25 8:40 (-0.9) 9:01 (-0.2) 5:27 8:11
0730 Breakfast
0830 Work on assignment 4
1230 Assignment 4 due
1230 Lunch
1330 How to write a Discussion section (DF, KG), outline assignment 5
1430 Literature reading
1630 Assignment 5
1800 Dinner
2000 Time for Assignment 5, reading literature

2100 Done

Fri July 26 9:30 (-0.7) 9:59 (-0.1) 5:28 8:10
0730 Breakfast
0830 Work on Assignment 5
1230 Lunch
1330 Assignment 5 due
1330 How to give a slide presentation (DF, KG)
1430 Work on presentations
1800 Dinner
1930 Work on presentations
2100 Done

Sat July 27 10:22 (-0.3) 10:59 (0.1) 5:29 8:09
0730 Breakfast
0830 Work on presentations
1230 Lunch
1430 Peer review presentations
1330 Work on presentations
1530 Presentation dry runs
1800 Dinner
1930 Finalize presentations

Sun July 28 10:59 (0) 12:02 (0) 5:30 8:08
1000 Brunch
1200 Student Symposium (Commons)
1330 Course evaluations
1400 Lab & equipment cleanup and packing, Google Drive cleanup, SD card cleanup
1500 Island Tour
1700 Dinner

Mon July 29 5:31 8:07
0730 Luggage for dock on porch of dorms
0730 Breakfast
1000 Dock for Departure

Faculty:

DF Douglas Fudge, PhD (he/him) fudge@chapman.edu
KG Kara Gadeken, PhD (she/her) kara.gadeken@stonybrook.edu
DT Denny Taylor, PhD (he/him) dennis.taylor@gmail.com (week 2 only)

TA:

Barbara Orozco

Prerequisites: none

Class enrollment limit: 12 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 2024.

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 practicing 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.* -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:

<u>Module 1: Eco-mechanics</u>
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 introductory lectures on biomechanics, students will be given the opportunity to observe marine 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. Past project topics have included: attachment of intertidal organisms (mussels, gastropods, algae, etc.), mechanics of suspension feeding (in mussels, barnacles, tunicates, bryozoans, etc.), predator-prey mechanics (crabs feeding on armored prey such as bivalves, gastropods, etc.), terrestrial locomotion of intertidal fishes, and burrowing in hagfishes. Students will tackle their question

by systematically and iteratively 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, thermal biology of intertidal animals and algae, and the ecology and physiology of mud flat inhabitants.

Course Materials:

Required readings (provided as pdf files)

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. *J. Exp. Biol.* 223(19).

Martini FH (1998) The ecology of hagfishes. In *The Biology of Hagfishes* 57-77.

Meysman FJ, Middelburg JJ, Heip CH (2006) Bioturbation: a fresh look at Darwin's last idea. *Trends in Ecology & Evolution*. 21:688-95.

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

Recommended readings (provided as pdf files)

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

Freedman CR and Fudge DS (2017) Hagfish Houdinis: biomechanics and behavior of squeezing through small openings. *J. Exp. Biol.*. 220:822-7.

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	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 Services https://www.unh.edu/diversity-inclusion/student-accessibility) 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.