Deep-Sea Ecology

Biology 457/557

Summer Term, 2022

Course Description and Overview:

This course will plunge you into the world of perpetual darkness to study the ecology of benthic organisms living in some of the largest, most dynamic and most extreme ecosystems on the planet. We will survey habitats and communities found beyond SCUBA depths, including underwater sand flats, gravel beds and reefs on the continental shelf; and abyssal plains, seamounts, hydrothermal vents, methane seeps, and trenches in the deep ocean. The course will emphasize: 1) factors that control animal diversity, distribution and abundance, 2) the preservation of deep-sea environments and the conservation of resources, and 3) the adaptations of animals living in extreme environments. We will emphasize bottom-dwelling (benthic) organisms rather than organisms living in the water column (nekton and plankton).

Professor Young has worked in the deep ocean with submersibles for more than 40 years and has offered courses similar to this one since the 1980's. These courses have often been taught on ships during deep-sea submersible cruises. They have also been taught at marine labs in Florida, Oregon and Iceland and the 2020 class was taught by zoom from his Victorian library in Charleston. In every case we strive to give students opportunities to do hands-on work in deep environments, sometimes making dives to the ocean floor and nearly always sampling the benthos with nets, trawls, and old-fashioned dredges. In this day and age, much of real deep-sea biology is done remotely with instruments and submarine camera systems. It is not uncommon for scientists to join cruises remotely through satellite connections that permit virtual dives in real time. Thus, many of the experiences you receive in this class won't be too different from the way deep-sea exploration is actually done in the digital age.

Two class projects are designed to teach you how scientists infer patterns of animal distribution and community structure from deep-sea video footage. You will learn to extract data from transects, to analyze the data using statistical methods, and to present your data in composite figures typical of those found in modern ecological publications. In a third assignment, you will be given the opportunity to write a contribution for Oregon Shelf Invertebrates, an on-line book that will eventually summarize the characteristics and life style of all species found on the Oregon Continental Shelf. Assuming your contribution is accurate and thorough, your name will appear permanently as one of the authors of this book. Thus, you will graduate not only with a degree and a grade, but also with a publication to list on your resume!

Instructors: Professor Craig M. Young

Teaching Assistant: Caitlin Plowman

Credit Hours: 5

Place: OIMB, McConnaughey lab and Boathouse auditorium.

Meeting Day and Time: Mondays & Fridays 9:00-12:00 and 1:00-5:00. Wednesdays 9:00-12:00 and 1:00-3:00 followed by the OIMB seminar. Because of covid restrictions and an exceptionally large class size, the class will be divided into two legs for boat trips. On these days, some students will begin and end their day early and some will begin and end later than usual.

Learning objectives (Knowledge and skills you should acquire)

Knowledge. Students completing this class should:

1. Know the major events, people and discoveries in the history of deep-sea biology.
2. Know and understand some of the key physical and biological factors that determine the distributions and abundances of deep-sea species.
3. Know how food sources and abundances of functional trophic groups change along a depth gradient and understand the underlying mechanisms.
4. Know how suspension-feeding animals adapt to low particle density below the euphotic zone and be able to cite some examples.
5. Know the importance and timing of allochthonous foods such as phytodetritus and macrofaunal falls in the deep ocean.
6. Know the geological processes that facilitate chemosynthesis at deep-sea hot vents and methane seeps.
7. Know the major kinds of organisms that dominate various deep-sea environments, and be able to explain their adaptations for nutrition and reproduction.
8. Know some ways that pressure influences marine animals and their distributions.
9. Know something about the larval development and dispersal of deep-sea animals.

Skills. Students completing the class should be able to:

1. Use Primer software to describe the structure of biological communities with multivariate statistics, rarefaction, and diversity indices.
2. Analyze the spatial distribution of a population by comparing it statistically to a Poisson distribution.
3. Use Excel to make data spreadsheets and create simple graphs depicting organismal distributions.

4. Prepare simple and composite figures suitable for publication in the scientific literature.
5. Prepare and examine sessile animals such as sponges and bryozoans for identification with a scanning electron microscope.
6. Understand how to participate in an ROV crew by launching, navigating, and piloting a small Remotely Operated Vehicle.
7. Understand how to safely deploy and recover over-the-side benthic sampling gear such as box dredge, Agassiz trawl, and camera sled.
8. Identify benthic animals using dichotomous keys.
9. Research and write an original chapter on an invertebrate animal using correct zoological terminology with language and grammar suitable for educated readers of diverse backgrounds.
10. Be able to tie (preferably with your eyes closed) several of the most useful knots (bowline, square knot, sheet bend) and hitches (half hitches, cleat hitch, clove hitch, trucker's hitch) used on ships.

Grading

Grades will be based on: 1) three short quizzes taken in weeks 2-4. 2) two assignments presenting the results of underwater transect analyses from ROV footage, 3) a small chapter written for the on-line publication *Oregon Shelf Invertebrates*, and 4) oral delivery of a brief Powerpoint presentation on the *Oregon Shelf Invertebrates* chapter.

Quizzes (30% of grade). Each quiz will be administered at the beginning of class on the second, third and fourth Monday of the term. The quiz will cover only the information taught during lectures, labs and field trips during the preceding week of the course. Each student may prepare a one-sided 8.5x11 "cheat sheet" for use in the exam. Although you are encouraged to read as broadly as you wish, the exam is based on what you learned in class. Thus, for grading purposes, the lecture is regarded as the final authority, even if it disagrees with Wikipedia or some other source. The exam will be made available on line at 9:00 a.m. on the exam day, and must be completed in 30 minutes or less. The quiz format may include short answer questions, matching, and definitions of terms.

Animal Distribution Assignment (15% of grade). This assignment, which will be based on lab work during week 1, consists of two parts: a one-page composite figure made up of photos and graphs depicting patterns of distribution on an ROV transect in the Southern Ocean, and a figure caption describing the components of the figure, in the

appropriate format for a scientific journal. The data will be generated by teams of students, but the final products must represent your own individual work. Your graphic depiction must be absolutely unique to you.

Animal Diversity and Community Structure Assignment (25% of grade). Like the previous assignment, this one will be submitted in two parts: a single-page composite figure showing a rarefaction curve and one or more comparisons of community structure in three transects, and a written document (no more than 2 pages) describing the methods and the interpretation of results. The raw data will be generated by teams of students from three ROV transects at the base of the Florida Escarpment. This assignment will be based on Primer (multivariate) statistics we will learn as a class in week 2.

Oregon Shelf Invertebrates Assignment (25% of grade): Oregon Shelf Invertebrates is an ongoing project documenting the identity, classification and natural history of benthic invertebrates found on the Oregon shelf, from the top of the circumlittoral zone at about 60m to the shelf break at about 500m. Each student will select an animal in week 3 and write an illustrated page about that species, following a standard format, for inclusion in the on-line book.

Oregon Shelf Invertebrates Oral Presentation (5% of grade). On the last afternoon of the final class day, each student will present a Powerpoint talk of no more than 5 minutes and with no more than 4 slides to share what they wrote for *Oregon Shelf Invertebrates.*

Course Schedule: see next page

Color Coding for Schedule:

Lectures and other activities in Boat House Auditorium

Labs and other activities in McConnaughey Laboratory

Boat trips and other learning activities at OIMB docks

Pre-recorded lecture to view outside class

Assignments and quizzes to be handed in

Week 1	***Monday, June 20***		***Wednesday, June 22***		***Friday, June 24***
Pre-recorded lectures to view outside class: ***Abyssal plains and the impact of deep-sea mining (Dr. Diva Amon, Scientific Associate, Natural History Museum, London, U.K, pre-recorded.)*** ***DSV Alvin: History, Operations and Future Plans (Bruce Strickrott, Chief Alvin Pilot, Woods Hole Oceanographic Institution, pre-recorded video)***	***Juneteenth Holiday (no class)***		***Introductions, Course Expectations, and Story Telling*** ***Lecture 1: Review of Ecology and overview of the Deep Ocean (Craig Young)*** ***Lecture 2 The heroic age of deep-sea exploration, part 1: Europe*** ***Lunch*** ***Field trip to OIMB library to examine early expedition reports.*** ***Lecture 3. The heroic age of deep-sea exploration, part 2: North America.*** 16:00 OIMB Seminar		***Lecture 4. A human presence below the waves (Craig Young)*** ***An abyssal transect from the Southern Ocean*** ***Analysis of ROV transects 1.*** *Using Image J to count organisms on photos* *Classifying organisms by morphotype.* *Correlating animal distributions with habitat (geology and chemistry)* ***Lunch*** ***Lecture 5: Detrital-based ecosystems in the deep sea*** ***Analysis of ROV transects 2.*** *Spatial distributions of species* *Association analysis* *Split into two groups, each counting species along half of transect.* *Share data and discuss how to plot them*

Week 2	***Monday, June 27***		***Wednesday, June 29 – Friday, July 1***
Pre-recorded lecture to view outside class: ***The five deeps Expedition. Alan Jamieson, University of Newcastle Upon Tyne, U.K. (pre-recorded video).***	**9:00 am - Quiz 1** ***Mobilize and test the Phantom ROV (OIMB dock)*** ***Nautical knots*** ***Lunch*** ***Lecture 6. Hard-bottom communities, filter feeding, and adaptations to water flow (Craig Young).*** ***Analysis of Deep-Sea Communities (Caitlin Plowman).*** *Organizing transect data for community analysis.* *Introduction to Primer* *Begin analysis of seep transects*		***Class splits into three groups for the following activities:*** ***ROV cruise to Baltimore Rock or Cape Arago (8:00 departure):*** *Group A: Wednesday, Group B: Thursday, Group C: Friday* ***Scanning Electron Microscopy (class begins at 9:00)*** *Group B: Wednesday, Group C: Thursday, Group A: Friday* ***Generate and organize data for seep transect project (3 transects, each group responsible for one; class begins at 9:00)*** *Group C: Wednesday, Group A: Thursday, Group B: Friday* ***Lunch: (ROV group will take sack lunches)*** ***ROV cruise returns to dock by 2:00 p.m.*** ***Wednesday p.m.: Introduction to the Oregon Shelf Invertebrates assignment. Selection of species.*** ***Thursday Lecture 7. Adaptations to depth: pressure and temperature (Craig Young)*** ***Friday Lecture 8. The Hadal Zone (Caitlin Plowman)***

Week 3	***Monday, July 4***		***Wednesday, July 6***		***Friday, July 8***
(Quiz 2 will be take-home and must be handed in no later than Wednesday a.m.) *(Hand in hard copy of Animal Distribution assignment any time this week.)*	***Independence Day Holiday***		***Dredging cruise to Cape Arago (8:00 departure, return 2:00 p.m.) First half of Class.*** ***Free time to work on assignments (second half of Class)*** ***Lunch (sack lunches for first half)*** ***Free time to work on assignments*** 4:00 OIMB Seminar (zoom)		***Dredging cruise to Cape Arago (8:00 departure, return 2:00 p.m.) Second half of Class.*** ***Free time to work on assignments (second half of Class)*** ***Lunch (sack lunches for first half)*** ***Lecture 9. Methanotrophic ecosystems (Craig Young)*** ***Free time to work on assignments***

Week 4	***Monday, July 11***		***Wednesday July 13***		***Friday, July 15***
(Hand in Primer graphs and interpretations for the Animal Diversity and Community Structure Assignment any time this week) *(Hand in hard copy of Oregon Shelf Invertebrates assignment any time this week)*	***Lecture10: Hydrothermal Vent Ecosystems (Craig Young)*** ***Field trip to CMLC to examine chemosynthetic organisms.*** ***Lunch*** ***Lecture 11. Zonation and physiological tolerances.*** ***Demonstration of pressure vessels, temperature gradient block.*** ***Class experiment on pressure tolerances of shallow-water animals.*** ***Free time to work on projects including Powerpoint slides for Friday oral presentations.***		**9:00 am - Quiz 3** ***Lecture 12. Sex under pressure: gametogenesis, fertilization, reproductive timing and spawning (Craig Young)*** ***Lunch*** ***field trip in groups:*** *histology lab (demonstration of methods for evaluating reproductive seasons)* ***Free time to work on projects including Powerpoint slides for Friday oral presentations.***		***Lecture 13. Larval Dispersal and Genetic Connectivity in the deep sea*** ***Lunch*** ***Individual oral reports (maximum 3 Powerpoint sides) on Oregon Shelf Invertebrates.***