Deep-Sea Biology

Biology 457/557

Summer Term, 2020

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 40 years and has offered courses similar to this one since the late 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. They have never before been taught by Zoom! In every case previously, students have had opportunities to do hands-on work and boat trips, sometimes making dives to the ocean floor and nearly always sampling the deep-sea benthos and plankton with nets, trawls, and old-fashioned dredges. Thanks to the current Pandemic shut-down, our experiential components will be limited to a series of live or pre-recorded broadcasts designed to teach you some of what you would normally have learned in the field and lab. Fortuitously, much of real deep-sea biology is done remotely with instruments and submarine camera systems. Some scientists even join cruises through satellite connections that permit virtual dives in real time. Thus, the experience you receive in this class won't be too different from the way deep-sea exploration is actually done in the digital age.

The Covid-19 viral shutdown also has a wonderful silver lining! Virtually all deep-sea scientists worldwide are currently stuck at home rather than sailing in exotic distant seas. We reached out to many of these colleagues and invited them to speak to our class here at OIMB. Every person we invited was delighted to offer a Zoom lecture in her or his area of expertise. You will therefore be treated to an incredible opportunity to be taught by some of the most dynamic and famous deep-sea biologists of our era. We have 4 lecturers from elsewhere in the United States, including one originally from England; one from Trinidad living in England, two others from England, one Spaniard living in Norway, one from Portugal, one from New Zealand, and one from Hong Kong living in Japan. You will enjoy rubbing shoulders with this truly international assemblage of professors.

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: At your home, via Zoom.

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. Three of the seminars are by speakers invited by the deep-sea class and are therefore required.

Joining the Zoom Meetings: You must have access to a computer with reliable internet connectivity, a microphone and a camera in order to participate in this class. Zoom links will be provided through the course Canvas site. We will open a 3-hour zoom session at 9:00 each morning, then a second 4-hour zoom session at 1:00, following a one-hour lunch break. Portions of the Zoom meetings will involve breakout sessions with subsets of the class. Because the course is intended to be interactive, and as a matter of courtesy to our speakers, please do not turn off your video during active zoom sessions. Turning off your video is akin to walking out of the room in the middle of a lecture!

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 including box dredge, Agassiz trawl, and camera sled.
8. Identify benthic animals using dichotomous keys.
9. Write an original research project with language and grammar suitable for educated readers of diverse backgrounds.
10. Be able to tie (preferably with your eyes closed) to tie 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) two exams (Midterm and Final), 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.

Midterm exam (20% of grade). The midterm will cover information taught during lectures and virtual field trips during the first two weeks of the course. Each student may prepare a one-sided 8.5x11 "cheat sheet" for use in the exam; no other notes or resources may be consulted. The exam will be made available on line at 9:00 a.m. on the exam day, and must be completed in 1.5 hours. The exam format will include short answer questions, matching, and definitions of terms.

Final Exam (20% of grade). The final will be administered at 9:00 a.m. on the last day of class, following the same protocols and policies as the midterm. The exam will not be comprehensive; it will cover only information from the third and fourth weeks of the course.

Animal Distribution Assignment (20% 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 written description, no more than two pages in length, describing your methods and results. The data will be generated by teams of students, but the final products must represent your own individual work.

Animal Diversity and Community Structure Assignment (20% 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 results. The raw data from these ROV transects will be provided. This assignment will be based on Primer (multivariate) statistics we will learn as a class in week 3.

Oregon Shelf Invertebrates Assignment (15% 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 2 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.*

Deep-Sea Biology 2020: Course Schedule

	Mon		Wed		Fri
Week 1 ***Deep Ocean: Past and Future***	*June 22* 9:00 ***Introduction and Course Expectations*** (Craig Young) 10:30 ***Collaboration and context in deep-sea research: a discussion between friends.*** *(*Prof. Paul Tyler, Natl. Oceanographic Center, Southampton, U.K. (retired) and Craig Young) 1:00 ***Species distributions along a deep-sea ROV transect (a collaborative exercise in generating data).***		*June 24* 9:00 ***Environmental Issues in the Deep sea: plastics, pollution, and climate*** (Dr. Eva Ramirez-Llodra (REV Ocean, Oslo, Norway) ***Data analysis of ROV transect data*** 1:00 ***Creating composite figures for scientific papers*** 4:00 **OIMBSeminar:** ***Cool Corals Live Down Deep*** (Dr. Rhian Waller, Darling Marine Center, Univ. of Maine)		*June 26* 9:00 ***Deep-Sea Exploration, part 1: the nineteenth century "heroic age***" (Craig Young , Paul Tyler, Professor Dan McCarthy (Jacksonville Univ., Florida) ***Virtual Tour: Expedition Reports, Historic books & Microscopes*** 1:00 ***Deep-sea Exploration, part 2: 1900-1952*** (Craig Young) ***Individual and collaborative work on transect project***
Week 2 ***Deep Ocean: Mostly Mud*** *(Hand in ROV transect assignment any time this week)*	*June 29* 9:00 ***Deep-sea Exploration, part 3: a human presence below the waves*** *(Craig Young)* 10:00 ***DSV Alvin: History, Operations and Future Plans*** *(*Bruce Strickrott, Chief Alvin Pilot, Woods Hole Oceanographic Institution) 1:00 ***Virtual Tour of OIMB's Phantom ROV*** ***Introduction to Oregon Shelf Invertebrates Project***		*July 1* *9:00* ***Detrital- Based Ecosystems in the deep sea*** *(Craig Young)* ***Virtual dredging and trawling cruise on the Oregon Shelf*** ***Sailor knots and hitches*** 1:00 ***Select and Identify Oregon Shelf Invertebrates*** 4:00 ***OIMB Seminar: Title TBA: wood-fall organisms and /or cephalopods*** *Dr. Janet Voigt (Curator, Field Museum of Natural History, Chicago)*		*July 3* 9:00 ***Abyssal plains and the impact of deep-sea mining*** **(**Dr. Diva Amon, Scientific Associate, Natural History Museum, London, U.K.) ***Virtual session: Scanning Electron Microscopy*** 1:00 ***Prepare figures and text for Oregon Shelf Invertebrates*** ***Midterm Review Session***

Week 3	July 6		July 8		July 10
Deep Ocean: Top to Bottom *(Hand in hard copy of Oregon Shelf Invertebrates assignment any time this week)*	9:00 ***Midterm Exam*** 10:30 ***Hard-bottom communities, filter feeding, and adaptations to water flow.*** (Craig Young). _____ 1:00 ***Introduction to Community Analysis with Primer Multivariate Statistics*** 3:00 ***Ecology and Conservation of New Zealand Seamounts*** (Dr. Ashley Rowden, NIWA: National Institute of Water and Atmosphere, Wellington, New Zealand)		9:00 ***Biology of gutless siboglinid tubeworms (***Dr. Ana Hilario , Assistant Researcher, University of Aveiro, Portugal) 11:00 ***Methane Seeps: Brine pools, Salt Diapirs, , Accretionary Prisms and Mud Volcanos*** (Craig Young) _____ 1:00 ***Virtual Submersible Dives on methane seeps: highlight videos from a recent cruise*** (Young Lab Graduate Students: Avery Calhoun, Lauren Rice, Caitlin Plowman, Matt DePaolis) 4:00 ***OIMB Seminar***		9:00 ***Ecology of the Hadal Zone*** Caitlin Plowman, M.S. (PhD Student, OIMB) 11:00 ***Marine protected areas in the deep ocean*** (Craig Young) _____ 1:00 ***Primer Analysis of Community Patterns and Biodiversity on the Oregon Shelf***
Week 4	July 13		July 15		July 17
Deep Ocean: Adaptations of Bizarre Beasts *(Hand in primer graphs and interpretations any time this week)*	9:00 ***Geology and biology of hydrothermal vents: a global view*** Professor Jon Copley (Associate Professor of Ocean Exploration and Public Engagement, National Oceanographic Centre, Southampton, U.K.) ***Virtual Tour of CMLC Deep-Sea Exhibit & Young Lab Deep-sea Collections*** _____ 1:00 ***Adaptations to depth: pressure and temperature*** (Craig Young). ***Virtual field trip: measuring pressure and temperature tolerances in the lab*** ***Free time to work on Powerpoint slides for Friday oral presentations.***		9:00 ***Sex under pressure: how babies are made in the depths of the sea (gametogenesis, fertilization, reproductive timing and spawning)*** (Craig Young). 11:00 ***Virtual field trip: histology lab (evaluating reproductive seasons) and deep-sea culture lab (experiments on entrainment of reproductive cycles in deep-sea urchins)*** _____ 1:00 ***Larval Dispersal and Genetic Connectivity in the deep sea*** (Craig Young) **OIMB Seminar:** ***Adaptations of deep-sea hot vent snails revealed by cutting-edge techniques in morphology and genomics*** (Dr. Chong Chen, Researcher II: Japan Agency for Marine-Earth Science and Technology, Japan)		9:00 ***Final Exam*** 11:00 ***Current projects, upcoming cruises, and potential student opportunities.*** _____ 1:00 ***Individual oral reports (maximum 3 Powerpoint sides) on Oregon Shelf Invertebrates.*** ***Relaxing deep-sea documentary films (time permitting)***