Subtidal and Deep-Sea Ecology

Biology 457/557

Summer Term, 2018

Course Description:

This course will plunge you into the underwater world to study the ecology of benthic organisms living in the largest habitats on the planet. We will survey habitats and communities found below the intertidal zone, including underwater sand flats, reefs, seagrass meadows, and kelp beds on the shallow continental shelf; coral reefs and mangrove forests in the tropics; and abyssal plains, seamounts, hydrothermal vents, methane seeps, and trenches in the deep ocean. Emphasizing factors that control animal diversity, distribution and abundance, local field work will feature conventional benthic sampling methods as well as OIMB's 600-m Phantom ROV (Remotely Operated Vehicle), a benthic lander, and a video camera sled. The class will have the unusual opportunity to participate in several day trips on a larger oceanographic vessel, the RV *Pacific Storm*, during which we will sample deep-sea benthos on the continental shelf to about 1000 m, at the edge of the Oregon slope. Student projects will contribute to our understanding of subtidal organisms and communities in Europe's first marine reserve, in Ireland. We will also assist the Oregon Department of Fish and Wildlife in analyzing animal diversity using ROV footage taken in one of Oregon's five marine reserves. Class exercises and projects are intended to introduce you not only to these underwater organisms and communities, but also some of the useful technologies and statistical methods by which subtidal and deep-sea systems are studied. Some of the field trips and projects will involve optional snorkeling trips.

Instructors: Dr. Craig M. Young, Dr. Cynthia Trowbridge

Teaching Assistant: Caitlin Plowman, M.S.

Credit Hours: 8

Place: McConnaughey Lab Classroom on the OIMB Campus

Meeting Day and Time: Mondays, Fridays 8:30-5:00; Wednesdays 8:30-3:00. There may be early departures and/or late returns on cruise days or great low-tide days.

Grading: You will have many opportunities to earn points toward your final grade. Grades will be based on 6 criteria:

- ***Weekly quizzes***. Short quizzes will be administered on the first class day of every week, beginning the second week. Each quiz, which will take only 10-15 minutes at the beginning of class, will cover the material learned in lectures, labs, field

trips, cruises, and a literature discussion during the previous week. For the literature discussion, a scientific paper will be assigned each week, and the paper will be discussed by students during the last day (generally Friday) of the week. There will be a total of 6 quizzes and students will be allowed to drop their lowest quiz score. The remaining 5 quizzes are worth 10% of the final grade (2% each).

- ***Cruise Report.*** Each student should keep notes during the *Pacific Storm* cruise and each cruise on the RV *Pluteus*. For each cruise, the notes should include the cruise path, the timing of each sampling activity, the organisms that were collected, the methods used for collection and sampling, and miscellaneous observations and experiences. These notes should be organized into a cruise report that will be handed in during the last week of the class (10% of grade).

- ***Scientific Paper based on the analysis of underwater transects.*** Several lab periods will be devoted to the analysis of underwater image transects from underwater marine reserves. After learning the methods for obtaining data from images and analyzing spatial distributions, abundance patterns and species diversity, each student will select one of the data sets as the topic of a scientific paper. Available data sets include shallow subtidal transects from Lough Hyne, Ireland (Europe's oldest marine reserve) and deeper ROV transects from Cape Perpetua Marine Reserve off Oregon. These papers should follow the "instructions for authors" guidelines for one of the following journals:

  - Ecology
  - Marine Ecology Progress Series
  - Marine Ecology

  Each report should include a brief review of the relevant literature in the **Introduction** (including some classic papers, not just those easily found in Google), a clear **Materials and Methods** section written with enough detail to enable someone else to repeat your study if they wanted to (including a map of study sites produced in Google Earth), a **Results** section that presents your data and observations with graphs, tables, diagrams, photos and text, and a **Discussion** of your findings that should include references to relevant prior studies. **References** at the end should be in the proper journal format. All information and images collected during class will be shared on Canvas. Students may work together but the actual write-ups should be original and unique. The first draft of the written report will be due on the last day of the 5th week of class (July 27) and

will be returned with edits, suggestions, and a provisional grade the following week. Students will then have two weeks to revise the paper (exact due date TBD), which will receive a final grade. In order to write the materials and methods section well, you should take detailed notes of how the sampling was conducted and exactly what you did to analyze it. Two methods documents available on Canvas are intended to help you improve your scientific writing. Feel free to consult these at any time. This major paper will be worth 20% of the final grade.

- ***Oregon Shelf Invertebrates.*** Over more than two decades, various OIMB faculty and students have collaborated on a useful reference work, published by the OIMB library, entitled *Oregon Estuarine Invertebrates*. With this class, we will begin work on a companion volume dealing with animals of the Oregon shelf. Each student will have the opportunity to contribute two pages to this new volume and will receive permanent authorship credit for acceptable contributions. The two species descriptions will each be worth 5% of the final grade, for a total of 10%. Additional descriptions may be contributed to the volume for authorship, but will not count toward the final grade.

- ***Midterm exams.*** The first midterm will cover lecture materials on deep-sea biology presented during the first half of the course. The format will include short answer questions, matching, and definitions. The second midterm will be at the end of the course and will cover only materials on subtidal ecology presented during the second half of the course. (Each midterm is worth 20% of grade).

- ***Group projects on the shallow subtidal zone.*** During the second half of the course, students will be divided into groups of three or four students. Each group will undertake a research project of their own design, using snorkeling or other shallow-water sampling methods. These projects will be presented orally during the final week of the course and will be worth 10% of the grade.

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 subtidal ecology and deep-sea biology.

2. Know and understand some of the key physical and biological factors that determine the distributions and abundances of subtidal and deep-sea species.
3. Know why the competitive exclusion principle does not always seem to apply in subtidal food webs.
4. Know and be able to discuss three major theories of soft-bottom animal distribution: trophic amensalism, adult-larval interactions, and grain-size preference.
5. Know how food sources and abundances of functional trophic groups change along a depth gradient and understand the underlying mechanisms.
6. Know how suspension-feeding animals adapt to low particle density below the euphotic zone and be able to cite some examples.
7. Know the importance and timing of allochthonous foods such as phytodetritus and macrofaunal falls in the deep ocean.
8. Know the life cycle of a typical kelp and be able to explain how sea urchins and their predators influence the densities of seaweeds and animals in kelp beds.
9. Know the geological processes that facilitate chemosynthesis at deep-sea hot vents and methane seeps.

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. Prepare and examine sessile animals such as sponges and bryozoans for identification with a scanning electron microscope.
4. Participate in an ROV crew by launching, navigating and piloting a small Remotely Operated Vehicle.
5. Deploy and recover over-the-side benthic sampling gear including box dredge, Agassiz trawl, otter trawl, CTD, lander, and camera sled.
6. Identify several kinds of benthic animals and seaweeds, using dichotomous keys.
7. Write an original research project in the standard form of a scientific paper.
8. Take careful notes and data on a scientific cruise and prepare a cruise report based on these notes.

Tentative Course Schedule

Monday, June 25.

A.M. Lecture: (Young): Expectations, safety, grading, syllabus, cruise details.

A.M. Lecture: (Young): Some fundamentals of ecology; ocean bathymetry and a brief overview of underwater ecosystems.

A.M. Lab: (Young): Seamanship, over-the-side sampling skills, line handling, and safety at sea.

P.M. Lecture (Young): Sampling and exploration in the deep ocean: HOVs, ROVs and AUVs.

P.M. Lab: (Young, Plowman): Launching and recovering an ROV. Pre-dive checklist, handling the umbilical and control box, capturing images and video.

Wednesday, June 27.

Day Cruise on RV Pacific Storm: Sampling with Agassiz Trawl on the outer shelf and slope. Deployment of amphipod traps and baited camera. Recovery of living echinoderms for experiments on reproductive seasonality. Box core samples for microplastics.

Thursday, June 28.

Day Cruise on RV Pacific Storm: Sampling with Agassiz Trawl on the shelf. ROV work at several depths. Box core sampling for microplastics. Deployment of amphipod traps at shallower depths.

Friday, June 29.

Day cruise on RV Pacific Storm: Continue ROV work on the shelf. Box core sampling. Deployment of shallow amphipod traps. Recovery of baited camera.

Saturday, June 30.

Day cruise on RV Pacific Storm: Optional participation strongly encouraged. Recovery of all deployments. Sampling with Agassiz trawl at shallower depths.

Monday, July 1.

No class. (Fish Biology & Birds and Mammals classes will meet).

Wednesday, July 4.

No class. Independence Day holiday; OIMB picnic at Sunset Bay)

Friday, July 6.

Literature Discussion 1.

A.M. Lecture (Young): Historical context of subtidal and deep-sea biology (with field trips to the OIMB library and to Craig's house, with a visit to his Victorian library and microscope collection).

P.M. Lecture (Young): Detrital based ecosystems in the deep sea

P.M. Lecture (Plowman): Ecology of the Hadal Trenches

P.M. Lab: Begin identification of invertebrates from cruises.

Monday, July 9.

RV Pluteus Cruise: Nested sampling of bottom communities using photo landers. Vertical zonation on the shelf. Dredge sample on a rocky reef at Cape Arago.

Quiz 1. (P.M.: Covering weeks 1 and 2)

P.M. Lab: Continue taxonomic identification of subtidal animals from shelf and slope. Analysis of photo lander data. Preparation of sponges, hydroids and bryozoans for SEM. Select species for *Oregon Shelf Invertebrates* project.

Wednesday, July 11.

A.M. Lecture (Young): Hard-bottom communities on the shelf and slope. Ecology of fjords and rock walls. Submarine canyons, deep coral reefs & seamounts. Filter- feeding adaptations to flow.

A.M. Lab: Continue taxonomic work. Begin work on *Oregon Shelf Invertebrates.*

P.M. Lab: Scanning electron microscopy (small groups). Library research for *Oregon Shelf Invertebrates*.

Friday, July 13

Literature Discussion 2.

A.M. Lecture (Trowbridge, Young): Subtidal marine reserves in two oceans (Oregon and Ireland).

A.M. Lecture (Young): Characterizing spatial patterns, abundance patterns, community associations and species diversity.

A.M. Lab (Young, Trowbridge): Extracting data from underwater transects; begin analysis of transect images from marine reserves (Oregon and Ireland).

P.M. Lab (Young, Plowman, Trowbridge): Continue analyzing transect data.

Monday, July 16.

Quiz 2. (covering week 3)

A.M. Lecture (Young): The geological setting of chemosynthetic ecosystems.

A.M. Field trip (sack lunches): Pillow lavas at an ancient underwater volcano.

P.M. Lecture (Young): Ecology of Methane Seeps

P.M. Lecture (Young): Ecology of Hydrothermal Vents

Wednesday, July 18.

A.M. Lab (Plowman, Trowbridge, Young): Multivariate statistics with Primer software.

A.M. Lecture (Young): Sex under pressure: how babies are made in the deep sea.

P.M. Lab. (Plowman): Measuring gametogenic patterns with gonad histology.

P.M. Lab. (Plowman): Analysis of gamete size distributions using image analysis software.

Friday, July 20.

A.M. Midterm I.

A.M. Free time for writing and analysis.

P.M. Discussion and Lecture (Young, Trowbridge): Scientific writing and publication: advice from journal editors.

Monday, July 23

Quiz 3. (Covering week 4).

AM Lecture (Trowbridge): Habitats vs Processes/Interactions

A.M. Lab (Trowbridge, Plowman): Identifying seagrasses, pressing, etc.

A.M. Lecture (Trowbridge): Seagrasses

P.M. Field Trip: Lighthouse Beach & Point Adams: drift seagrass and kelp collection

P.M. Lecture (Trowbridge): Mangroves

P.M. Lab (Trowbridge and Plowman): Identify and press drift seaweed

Wednesday, July 25

AM: RV Pluteus trip: Cape Arago rocky reefs

PM Lecture (Trowbridge): Coral Reefs

PM Lab: Process animals, select group project

Friday, July 27

Literature discussion 3.

A.M. Field Trip: Seagrass beds & epiphytes: Sunset Bay & Lighthouse (deploy settlement plates & flow blocks center vs edge)

A.M. Lecture (Trowbridge): Subtidal of rocky shores

P.M. Lab: Process animals, select groups

P.M. Lecture (Trowbridge): Kelp beds I

Monday, July 30

Quiz 4: (Covering week 5)

A.M. Field Trip: Lighthouse kelp beds

A.M. Lecture (Trowbridge): Kelp beds II and Fucalean beds

A.M. RV Pluteus trip: North Spit vs South Jetty

P.M. Lab: Process animals

P.M. Lecture (Trowbridge): Soft-bottom shores

Wednesday, August 1

A.M. Field Trip: Middle Cove beds (snorkel kelp beds and fucalean beds)

A.M. Lecture (Trowbridge): Soft-bottom shores (Trowbridge)

P.M.: work on group projects

Friday, August 3

Literature Discussion 4.

A.M. Field Trip: South Cove kelp beds (snorkel kelp beds and fucalean beds)

P.M R/V Pluteus trip: Soft sediment in Coos Bay

P.M. Lab: Process animals

P.M.: Lecture (Trowbridge): Mutualism vs commensalism; direct vs indirect interactions

Monday, August 6

Quiz 5 (Covering week 6)

A.M.: Lecture (Trowbridge): Herbivory

P.M.: Field Trip: Boat House to Adam's Point kelp beds (snorkel & sample zooplankton)

P.M.: Lab: collate data and work up results

Wednesday, August 8

A.M. RV Pluteus trip: Coos Bay

A.M. Lab: Process animals and seaweeds

P.M.: Lecture (Trowbridge): Herbivory and Predation

P.M.: Group projects

Friday, August 10

Literature Discussion 5.

A.M. Field Trip: Outer Boat Basin kelp

A.M. Lab: collate data and work up results

P.M. Lecture (Young): Interference competition and the use of space in hard-bottom communities.

P.M.: **Group projects** (Plowman)

Monday, August 13

Quiz 6 (Covering week 7)

A.M. Group projects (Plowman)

P.M. Lecture (Trowbridge): Predation

P.M. Lecture (Young): Predator-prey interactions on subtidal soft bottoms. *Ptilosarcus* feeding guild as a case study

Wednesday, August 15

A.M. Oral group presentations (15-20 min/group)

A.M. Lecture (Trowbridge): Recruitment

P.M.: Field Trip: Tabulating overgrowth on Charleston docks

P.M. Lab: Examining settlement plates from kelp beds and seagrass meadows

Friday, August 17

A.M. Midterm II (Lectures, labs, & field trips)

P.*M.:* Lab clean-up and grading