Requirements for the Colby at Bigelow Semester: Oceans Track

Students in the Bigelow Ocean semester take three, intensive, four-week courses in series and a research course that extends over the entire semester.

A) ES383: The Ocean Environment: Setting the Scene

The intersection of marine physical sciences and policy requires an understanding of the systems bounding the oceans, be it the solid container below it (sea floor) or the gaseous layer above it (atmosphere), and the physical, chemical, and geological processes controlling and modifying the aqueous environment for the life dwelling within. This course will set the stage to cover the sea floor, plate tectonics, sediments, beaches, and estuaries. We will address physico-chemical properties of seawater (salinity, density, sound, light) as a link to understanding how marine organisms cope with saltwater, photosynthesis, planetary greenhouse gases, etc., all of which will be addressed later in the semester. We will explore where and why water flows, as a link to organisms' dispersal and migration to be discussed later in the semester. The course will introduce modern methods in ocean observing, including remote sensing, ocean and ice-tethered observing platforms, autonomous sampling, and time- series stations. Readings will also link oceanic processes to human processes, whether policy, geoengineering, sustainability, or other.

B) BI384: Biological Oceanography: Diversity and Function of Life in Marine Ecosystems

The ocean engine is comprised of many connected biological cogwheels, from viruses and microorganisms to whales. Chemical and physical processes fuel this engine and interactions between biotic and abiotic components ensure its smooth functioning. The course will explore the diversity and biological activities of oceanic life, with emphasis on microbial aspects, across contrasting ecosystems (open/coastal oceans, deep-sea, coral reefs). We will address current topics that drive biological oceanography research, including: the role of diversity and organismal interactions in sustaining healthy ecosystems, climate change, and human impacts. Students will gain a working knowledge of the role biological processes play in global ocean cycles.

C) CH385: Ocean Biogeochemistry on a Changing Planet

The cycles of carbon, nitrogen, phosphorus, silicon, sulfur, and trace metals in the ocean are intimately linked to dynamic physical, chemical and biological processes. These elements are the building blocks of life and their availability can control ocean biology and ecology at numerous scales. At the same time, elemental cycling in the ocean impacts global climate, mainly through controls on climate-active gases. These connections are at the heart of ocean biogeochemistry, and they are changing in response to human activities on regional and global scales. In this course, students will explore the biological, chemical and physical processes that affect the cycling of elements in the ocean, including photosynthesis and respiration, redox reactions, calcification, ocean upwelling, air-sea exchange and ocean- sediment interactions. Particular emphasis will be placed on processes that directly affect global climate such as cycling of CO_2, CH_4, N_2O and DMS, and on the response of ocean biogeochemistry to changing climate variables. The role of humans in these cycles will also be addressed, including current topics in marine pollution (e.g. microplastics and mercury toxicity), ocean acidification, coastal eutrophication and oxygen minimum zones, and geoengineering. Laboratory activities will investigate carbonate chemistry in the ocean, redox reactions and metabolic energy transfer, and climate active trace gas exchange.

Research Course: BI386: Life on the Ocean Wave

The field research course is designed to provide students the opportunity to collect, process and interpret oceanographic data. The field component of the semester program runs the entire duration of the semester and includes 6 research cruises. Students will collect physical (temperature, salinity, light penetration), chemical (macro-nutrient) and biological (bacterial, phytoplankton and zooplankton) data at 4 stations from within the Damariscotta River Estuary to the open ocean. This course is split into two practical elements: 1) field work in the Gulf of Maine, 2) a lab-based independent research project at Bigelow Laboratory in collaboration with a Senior Research Scientist. The Field Course will include a Final presentation (1 hour total), during which students will discuss the field sampling and the data they collected and analyzed during the 6 research cruise dates. Students are responsible for analyzing and compiling all the data from the field work. The Independent research will be mentored. The students will have 4 "Roundtable on Research" (ROR) meetings that will be led by Field Course instructors.

Requirements for the Colby at Bigelow Semester: Marine Omics

Students in the Bigelow Marine Omics semester take three, intensive, four-week courses in series and a molecular research course that extends over the entire semester.

A) ES383: The Ocean Environment: Setting the Scene

The intersection of marine physical sciences and policy requires an understanding of the systems bounding the oceans, be it the solid container below it (sea floor) or the gaseous layer above it (atmosphere), and the physical, chemical, and geological processes controlling and modifying the aqueous environment for the life dwelling within. This course will set the stage to cover the sea floor, plate tectonics, sediments, beaches, and estuaries. We will address physico-chemical properties of seawater (salinity, density, sound, light) as a link to understanding how marine organisms cope with saltwater, photosynthesis, planetary greenhouse gases, etc., all of which will be addressed later in the semester. We will explore where and why water flows, as a link to organisms' dispersal and migration to be discussed later in the semester. The course will introduce modern methods in ocean observing, including remote sensing, ocean and ice-tethered observing platforms, autonomous sampling, and time- series stations. Readings will also link oceanic processes to human processes, whether policy, geoengineering, sustainability, or other.

B) BI384: Biological Oceanography: Diversity and Function of Life in Marine Ecosystems

The ocean engine is comprised of many connected biological cogwheels, from viruses and microorganisms to whales. Chemical and physical processes fuel this engine and interactions between biotic and abiotic components ensure its smooth functioning. The course will explore the diversity and biological activities of oceanic life, with emphasis on microbial aspects, across contrasting ecosystems (open/coastal oceans, deep-sea, coral reefs). We will address current topics that drive biological oceanography research, including: the role of diversity and organismal interactions in sustaining healthy ecosystems, climate change, and human impacts. Students will gain a working knowledge of the role biological processes play in global ocean cycles.

C) BI385: Marine 'Omics: Deciphering the genetic code of the ocean

Molecular and genomic techniques have revolutionized ocean sciences over the past two decades. Detecting DNA, RNA, and macromolecules (eg, proteins and metabolites) in the marine environment has opened new doors to studying harmful, protected, and/or ecologically-important species, understanding the processes of adaptation and evolution, and understanding links between genomes and ecosystem processes. In this course, students will learn basic principles and theory behind the various ’omic-based approaches (genomics, transcriptomics, proteomics, and metabolomics) and how they have led to major discoveries and new paradigms. Particular focus will be given to the most up-to-date technologies for studying these problems and developing a working knowledge for how to approach ’omics-based questions. Practically, students will learn how to design and use species-specific genetic assays to both investigate ocean ecology and enhance management decisions for living marine resources. Lab work will include processing field samples for extraction of DNA, RNA, and proteins, as well as downstream applications such as PCR, qPCR, and DNA sequencing. Investigation will focus on ecological research questions as well as species-focused questions that can be enhanced by the investigation of environmental DNA (eDNA). The course will cover how the methods and principles tie into bigger ecological questions such as those dealing with ecosystem and human health, climate change, invasive species, and conservation.

Prerequisites: BI163, BI164, BI279

Molecular Research Course: BI 387: Molecular Tools to Understand the Environment

This course will be offered in parallel to the field research course (BI386). As with that course, participants will be involved in field collection, but samples will be processed for eDNA, qPCR, and metagenomic analyses rather than focusing on oceanographic and biogeochemical parameters. Additionally, students will engage in lab exercises focused on the alteration of genetic material, including building gene expression vectors, gene transfection, and genome editing with CRISPR/CAS9. As with the field research course, students will also undertake independent, mentored research. But students in this course will be involved in bioinformatic projects mining the eDNA samples for genes of interest. The genes will be either PCR amplified or synthetized for cloning in plasmid vectors, with either prokaryotic or eukaryotic systems used for heterologous expression depending on the gene chosen. Students will meet regularly to get help from instructor and peers about techniques, discuss ethics and societal issues surrounding genetics (gene editing, GMO, synthetic biology and bioremediation, and synthetic biology and aquaculture), and prepare individual final presentations as well as a group presentation on the eDNA data.

Prerequisites: BI163, BI164, BI279

Course Mappings: Oceans Track

- Chemistry: CH385 = CH217
- Biology: BI384 = field-based biology credits
- Environmental Science: BI383, BI384 = two focus areas courses; BI386 = ES Capstone

Course Mappings: Omics Track

- Biology and Chemistry: BI385 and BI387 = BC378 requirement of the CMBB major
- Environmental Science: BI383, BI384 = two focus areas courses; BI387 = ES Capstone