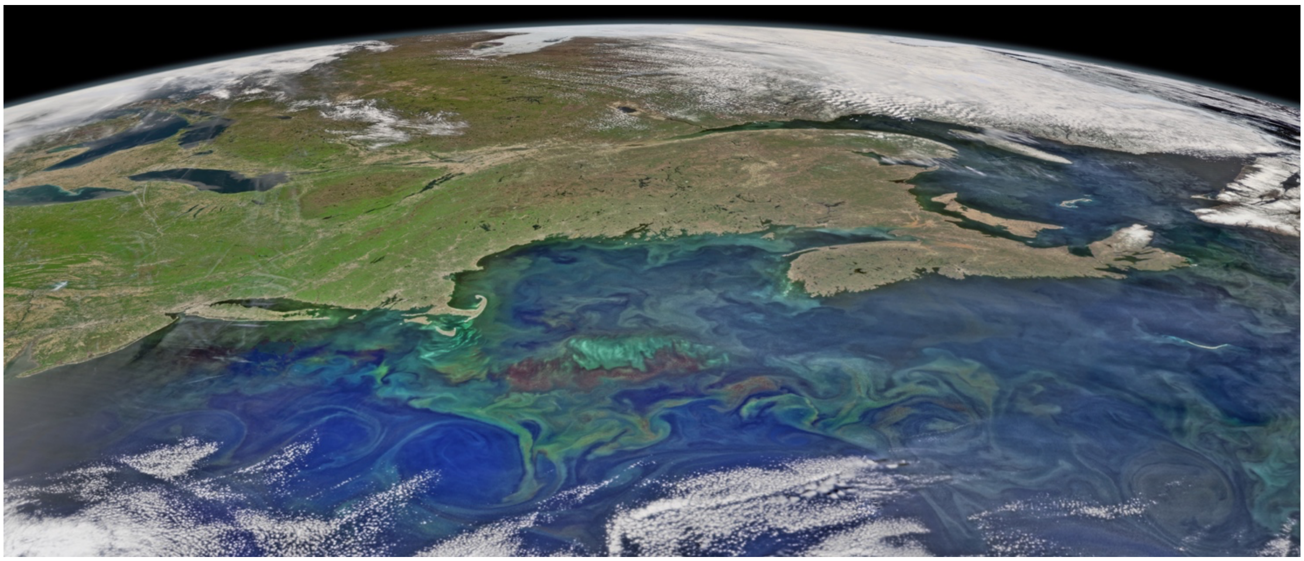
EE/BI 591 Bio-Optical Oceanography

MARINE SEMESTER – Second Block
Fall 2023 (October 2^{nd} – 25^{th})



Professor Information

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Course Overview

Light is crucial to the ecology and biogeochemical cycling of the upper ocean. Characterization of the temporal and spatial variability of light in the sea is fundamental to understanding and quantifying many optical, physical, biological, and chemical oceanographic processes. This course will explore how the various optically active constituents of marine waters (e.g., phytoplankton, suspended particles and sediments, organic matter, etc…) affect the in-water light field and optical properties of the water column. It will also explore how optical measurements made in situ or remotely (ocean color remote sensing) can facilitate the study the biogeochemistry, biology, and water quality of estuarine and marine environments. This research-based course is taught over the course of October as part of the Marine Semester and is heavily based on field and laboratory work. Field work will be carried out onboard the University of New Hampshire research vessel *R/V Gulf Challenger* in the contrasting coastal areas of the Gulf of Maine, and onboard a small boat at the Plum Island Estuary in Northeastern Massachusetts.

The course is intended for upper-level undergraduate and graduate students interested in coastal oceanography and biogeochemistry, optics, and remote sensing.

Through this course, you can expect to gain:

- An understanding of the importance and nature of light in the ocean
- An understanding of the utility of optics to study marine biogeochemistry and biology
- Field experience doing oceanographic work and sampling onboard a research vessel
- Experience carrying out analyses (optical and chemical) and experiments in the laboratory
- Experience with accessing, processing, and utilizing ocean color remote sensing data
- Improve oral and writing communication skills

Prerequisites

- **CH 101**, **CH 102**, **MA 121**, **MA 122**, and **ES 144** (or equivalents) or permission of instructor
- Admission to the Marine Semester

Hub Learning Outcomes

See Hub Appendix at the end of this syllabus.

Course elements

The course includes a balanced combination of lectures, field work, laboratory work (analyses and experiments), data analysis, satellite imagery analysis, oral presentations, and scientific writing.

Lectures

A number of lectures will be given throughout the course by the professor in order to familiarize the students with the fundamentals of bio-optical oceanography and ocean color remote sensing. Short lectures will also be given on how to do effective oral presentations and for efficient scientific writing.

Field Work

Field work will be carried out on day-long cruises onboard the R/V *Gulf Challenger* or a small boat will focus on local but contrasting coastal areas (Gulf of Maine, Plum Island Estuary) in terms of their optical and biogeochemical characteristics. It will involve the use of traditional oceanographic equipment (e.g., CTD, rosette), water sampling and onboard processing (e.g., filtering), and the deployment and use of field optical instruments to characterize the in-water light field. Students should expect to go out at sea 3 times during the entire course.

Laboratory work

Samples collected from the boat will be brought back to the Fichot lab and analyzed for optical properties and biological and biogeochemical variables (e.g., particulate and dissolved organic carbon, chlorophyll-a).

Satellite image analysis

Students will be introduced to the use of ocean color satellite imagery analysis and the NASA software SeaDAS (http://seadas.gsfc.nasa.gov). Students will learn how to access, use, and interpret satellite ocean color data and will be able to link these satellite data to the data collected in the field and laboratory.

Research project

The students will work in groups to analyze, compile, and interpret all the data acquired in the field, in laboratory, from remote sensing. Each group will be required to present and discuss the results in a 20-30-min oral presentation. The professor and TF will provide guidance on how to effectively do an oral presentation, in which the students will organize, present and discuss results.

Paper presentation and discussion

During the course, students will be divided in groups. Each group will be required to read a published manuscript (selected by the professor), do a short (10-15 min) oral presentation summarizing the important findings of the paper, and lead a class discussion on the topic. The entire class will be required to read the manuscript and will participate in the discussion.

Course Schedule

The first few days will aim to familiarize students with some fundamentals of marine optics, ocean color remote sensing, coastal oceanography, and with the lab and boat operations that will be carried out the following weeks. The first week will also be used to identify important scientific questions and objectives and to define the field sampling strategy for the coming weeks. The two middle weeks will focus on data collection and analysis. Students should be flexible in their expectations because the field data collection depend strongly on weather. During the last week, the students will spend time working on the data analysis for their research projects and on their presentations.

Week	*Topic*
Week 1	*Introduction to marine optics and ocean color remote sensing* *Define project objectives and design sampling strategy* *Overview of lab and boat operations* *Paper presentation and discussion*
Week 2-3	*Field work and sampling onboard the R/V Gulf Challenger* *Laboratory work in Fichot Lab* *Data compilation and analysis* *Hands-on remote sensing training in computer lab*
Week 4	*Project Data Analysis* *Project wrap-up and presentations*

Grading

Students will be evaluated based on their performance in the field and in the laboratory, on the quality of the data produced, and on the content and quality of their oral presentation and poster. *No late work will be accepted.*

Summary

- Field work performance: 20%
- Laboratory work performance: 20%
- Paper presentation and discussion: 10%
- Final research project
  - Data analysis, content, and effort: 30%
  - Oral presentation and poster: 20%

Percentage	Letter	GPA
93-100	*A*	*4.0*
90-93	*A-*	*3.7*
87-90	*B+*	*3.3*
83-87	*B*	*3.0*
80-83	*B-*	*2.7*
77-80	*C+*	*2.3*
73-77	*C*	*2.0*
70-73	*C-*	*1.7*
60-70	*D*	*1*
<60	*F*	*0*

Reading Material

Hand-outs will be distributed throughout the course. Published manuscripts will be chosen by the professor and presented and discussed in class by students. Below are some optional resources you might want to use.

Optional textbooks:

1. *Light and Photosynthesis in Aquatic Ecosystems (3rd edition*) by J. T. O Kirk, Cambridge University Press 2011.
2. *Light in Water* by Curtis Mobley (electronic version freely available)
3. *IOCCG reports* (all freely available at http://www.ioccg.org/reports_ioccg.html)

Safety and gear

Details will be provided before the course starts. Safety training will be provided by the University of New Hampshire staff as part of the course orientation. The University of New Hampshire will also require documents about your contact information.

Required gear to work on the boat:

Steel-toed, waterproof boots are required to work on the boat.

Recommended gear:

Waterproof and warm clothes:

- Rain gear overalls are a great way to stay dry while on deck
- Use layers so you can rapidly adapt to the weather conditions.

Software

Hands-on computer class activities will require the use of either *SeaDAS* or *Matlab®* and will be carried out in Room 435 (4th floor) in the Earth and Environment Department. Although the hands-on activities are aimed to familiarize students with using these tools, you are also strongly encouraged to get the software on your personal computers and to practice using them individually or in groups. *SeaDAS* is freely available from the NASA website (http://seadas.gsfc.nasa.gov), and university licenses for *Matlab®* are available for your personal computer by contacting CAS IT.

Academic integrity

- Students must adhere to the Boston University Academic Conduct Code: http://www.bu.edu/academics/policies/academic-conduct-code/

- Graduate students must adhere to the Graduate Code: *http://www.bu.edu/cas/students/graduate/grs-forms-policies-procedures/academic-discipline-procedures/*

- For written assignments, any information presented from an outside source (books, newspapers, online sources) must be cited appropriately. Paraphrasing without citation will be considered plagiarism.

- Infractions will be handled in accordance with university policy, and can result in a zero for the assignment, or reduction in course grade.

Student with disabilities

Accommodations for students with disabilities will be provided in accordance with the policies of Boston University.

MARINE SEMESTER HUB SYLLABUS

Upon completion of four courses in the Marine Semester, you will gain one Hub unit in each of the following areas:

- *Scientific Inquiry II*
- *Oral & Signed Communication*
- *Creativity and Innovation*
- *Teamwork and Collaboration*

Individual Hub units are not attached to each course, but are instead assigned to a zero-credit course that all Marine Semester undergraduates will be registered for.

SCIENTIFIC INQUIRY II

General Goal: Scientific Inquiry II

While all courses in scientific inquiry involve the application of major concepts, learning experiences in Scientific Inquiry II require more advanced application of concepts and methods, including the analysis of data, to frame and address complex problems.

Courses in this area must have <u>at least one of the following outcomes</u>.

1. *Students will apply principles and methods from the natural sciences based on collecting new or analyzing existing data in order to answer questions and/or solve problems. They will understand the nature of evidence employed in the natural sciences and will demonstrate a capacity to differentiate competing claims in such fields. This includes reflecting on and critically evaluating how natural scientists formulate hypotheses, gather empirical evidence of multiple sorts, and analyze and interpret this evidence.*
2. *Using their knowledge of the natural and social sciences, students will engage with issues of public policy, such as climate change, inequality, and health, that involve the intersection of perspectives from different disciplines. This would entail an ability to identify the evidentiary basis for scientific claims, the challenges to it, and the connections among the economic, social, and scientific factors that shape the creation and adoption of effective public policy.*

Marine Semester Goal: Original Research and the Scientific Method

In at least three of their four Marine Semester classes, students will conduct original scientific research. To answer an original question, they will formulate a hypothesis, collect data, analyze data, and place their findings in context. Students will learn the approaches that scientists use to form hypotheses about marine science. Through reading scientific articles, learning about studies in lecture, and collecting their own data, students will learn and practice the methods used by scientists for a vast range of marine science topics. Students will be asked to critically evaluate these studies including their own findings.

- *As students progress through the Marine Semester, they will continue to receive feedback on their hypothesis formulation, experimental design, data collection techniques, and data analysis methods. Feedback will come primarily from instructors and Teaching Fellows.*
- *Students will be assessed not on the outcome of their experiments, but their ability to apply the scientific methods that they learn in class. This will be done through multiple contact points in each class. Final papers and/or presentations will provide instructors further insight into student understanding.*

ORAL & SIGNED COMMUNICATION

General Goal: Oral & Signed Communication

BU students should be able to communicate information in a clear and coherent formal oral and/or signed presentation, to engage responsibly with others, and to make use of a range of disciplinary-appropriate informal oratory. As with writing, effective oral/signing communicators should prepare remarks with an awareness of their purpose and their audience. Because oral and/or signed communication is generally interactive, students should be able to attend and respond thoughtfully to others. They should also understand that public presentation serves an essentially civic function as a means of participating in collective debate and decision-making.

Courses and cocurricular activities in this area must have all outcomes.

1. *Students will be able to craft and deliver responsible, considered, and well-structured oral arguments using media and modes of expression appropriate to the situation.*
2. *Students will demonstrate an understanding that oral/signed communication is generally interactive, and they should be able to attend and respond thoughtfully to others.*
3. *Students will be able to speak/sign effectively in situations ranging from the formal to the extemporaneous and interact comfortably with diverse audiences.*

Marine Semester Goal: Scientific Conference Presentations

In at least three of their four marine semester classes, students will give mock scientific conference presentations. Students will improve their ability to give these presentations, by giving at least 3 conference presentations each over the semester. Scientific conference presentations are limited in scope, but all of the skills students learn in this context are transferable to other contexts.

- *Scientific conference presentations commonly reflect the content of a single scientific paper — indeed they are often given before the paper is published, so that people can get feedback on their work. Before each presentation, students will work with their instructors, TFs, and peers to prepare the presentation.*
- *Scientific conference presentations are commonly given using Powerpoint or in a poster format. Powerpoint presentations are commonly 12 minutes long (12-15 slides) with 3 minutes for questions (15 minutes total). Poster presentation are commonly interactive with the presenter explaining text and figures on poster to audience. How colleagues view the presentation depends on many factors, including content, organization of material, effective use of Powerpoint, presentation skills and facility with answering questions.*
- *After presentations, students will receive feedback from instructors, TFs, and peers so that they can continue to improve upon previously learned skills.*
- *To give you an example of what makes a successful presentation, you will see presentations from your instructors and visiting scholars.*

CREATIVITY AND INNOVATION

General Goal: Creativity and Innovation

Creative activity is a source of deep human satisfaction and common good. In addition, the ability to generate and pursue new ideas is quickly becoming a prerequisite for entry into the skilled workforce, which places a premium on applicants' creative skills and potential for contributing to creativity's more applied offspring, innovation. BU graduates should understand how the creative process moves from need or desire to design, to draft, to redesign, to execution; they will have personal experience of taking risks, failing, and trying again; and, in this way, they will have developed the patience and persistence that enables creativity to come ultimately to fruition.

Courses and cocurricular activities in this area must have all outcomes.

1. *Students will demonstrate understanding of creativity as a learnable, iterative process of imagining new possibilities that involves risk-taking, use of multiple strategies, and reconceiving in response to feedback, and will be able to identify individual and institutional factors that promote and inhibit creativity.*
2. *Students will be able to exercise their own potential for engaging in creative activity by conceiving and executing original work either alone or as part of a team.*

Marine Semester Goal: Creativity through Scientific Exploration

In at least three of their four marine semester classes, students will complete a month-long project in which they follow Design Thinking to solve scientific problems. Design Thinking is critical to success in Marine Science and students will follow the same general three steps in each research-based class:

- *Inspiration – Students begin by learning generally about the topic of the class. They learn through readings, lectures, fieldtrips, followed by discussions. These often open-ended learning opportunities help students to come up with original questions of their own.*
- *Ideation – Students work together or in teams to form hypotheses and experimental designs that can answer their original question. Often, these ideas and designs need to be re-worked after trial and error, and feedback from instructors. Through the iterative process of designing and re-designing experiments, students become more comfortable with the creative process.*
- *Implementation – Students work together with peers and instructors to produce a tangible product that can be shared broadly. This can come in many forms, for example, a scientific presentation, scientific paper, fisheries report, or captioned photos that are available publicly.*

TEAMWORK AND COLLABORATION

General Goal: Teamwork/Collaboration

Collaboration defines the 21st-century workplace. Employers rely increasingly on teams—groups of people with different backgrounds and training who tackle projects jointly—and they identify the ability to collaborate with these diverse groups as an essential skill for almost every position. Civic life in an increasingly interdependent world also calls more and more for the ability to collaborate with people from different backgrounds and with different perspectives, build consensus, and compromise for the good of a broader purpose.

Courses and cocurricular activities in this area must have all outcomes:

1. *As a result of explicit training in teamwork and sustained experiences of collaborating with others, students will be able to identify the characteristics of a well-functioning team.*
2. *Students will demonstrate an ability to use the tools and strategies of working successfully with a diverse group, such as assigning roles and responsibilities, giving and receiving feedback, and engaging in meaningful group reflection that inspires collective ownership of results.*

Marine Semester Goal: Working as a scientific team

Conducting scientific research is done as a team. Students must work together with their instructors, TFs, peers, and outside collaborators to be successful. Following the 3-S model, students will gain understanding of what makes a successful scientific team.

- *In at least three of their four Marine Semester classes, student teams will address the "Same" problem. This will be an original research question in the case of all research-based classes, but may also come in the form of working with a dive buddy, or using newly learned quantitative skills to work through a problem set.*
- *Students then make "Specific" choices about the problem. This can take the form of choosing an experimental design, a specific quantitative tool, or method of communication while underwater.*
- *Finally, students "Simultaneously" report their choices to the class. Throughout all Marine Semester classes, students update the larger group with progress being made and challenges they are facing.*
- *Students are assessed and receive feedback – both formally and informally – over the course of each Marine Semester class. Through discussions with their instructors, students will reflect on their own roles within each team, how the team is functioning as a whole, and if any changes need to be made.*
- *Students will be graded on their "performance as a field scientist" which includes working in a collaborative and collegial way with classmates, teaching fellows, instructors, and staff.*