# Course Syllabus Biological Oceanography

## General Information

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| Course Title | **Biological Oceanography** |
| Course Number | BI 458/558 |
| Academic Period | Fall term 2023 |
| Academic credits | 5 |
| Course Meeting time | Mondays (9:00 am-5:00 pm) |
| Course dates | October 2-December 11, 2023 |
| Classroom | TBA |
| Web Site | TBA |

## Instructor

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| Name | Dr. Michael Ahrens |
| E-mail | mahrens@uoregon.edu |
| Office hours | 3-4 pm (Tues, Wed, Thurs) |

I will be a visiting professor at OIMB in Fall 2023. Nevertheless, my home institution is Universidad de Bogota Jorge Tadeo Lozano (Colombia), where I have been a full-time faculty since 2009, teaching undergraduate and graduate (MSc and PhD) courses and directing the Limnology and Marine Biology Lab. My academic formation started at University of Oregon, continued in Germany (BSc Freie Universität Berlin and MSc Christian-Albrechts Universität Kiel in Biology) and culminated with a PhD in Coastal Oceanography (SUNY Stony Brook) and a postdoc and a staff researcher position at the National Institute of Water and Atmospheric Research (NIWA) in Hamilton, New Zealand, before moving to Colombia.

My research interests revolve around understanding the diversity of anthropogenic impacts (chemical pollution, invasive species, land use and climate change) on the composition, structure, and functioning of aquatic ecosystems, both marine and freshwater. My past work has had a focus on animal-sediment interactions (i.e., how animals influence sediment composition and, conversely, how sediment properties, including contamination, affect biochemistry, physiology and the ecology of aquatic organism) as well as monitoring the effects of pollution on marine-coastal ecosystems. I am particularly interested in understanding the mechanisms of contaminant accumulation and toxicity in a multivariate context (i.e., including interactions between pollutants and other environmental and biological variables, such as temperature, salinity, UV radiation, body size, etc.). This endeavor has brought me to work in polar, temperate and tropical coastal environments, where anthropogenic impacts are often the most visible. My latest research in Colombia has explored the effects of chemical and biological contamination (metals and pesticides) on sentinel bivalves, using biochemical and histological markers of exposure. I have also led surveys of non-native marine species in Colombian ports (on the Caribbean and Pacific). Next to research my research group also conducts consulting work, which typically involves chemical and biological monitoring of different aquatic habitats. My most recent research is on understanding the ecoyhdrology of Andean tundra ecosystems (“paramos”) in the context of climate change, examining the role of plants and soils in water budgets. I am also interested in branching out into the mitigation and management of anthropogenic environmental impacts (e.g., pollution remediation, invasive species management, climate change adaptation, and nature-based solutions).

# Biological Oceanography-An Introduction

The oceans cover about 71% of the Earth's surface, making them the biggest biome on our planet. Marine and terrestrial environments provide very different ecological conditions for life, due to their distinct physical, chemical and biological characteristics and interactions. This is reflected in very different evolutionary trajectories. Owing to their vast size and generally lower accessibility compared to terrestrial ecosystems (most of the ocean is remote, deep and dark), marine ecosystems are generally less well studied than their terrestrial counterparts (perhaps with the exception of marine intertidal communities) and continue to harbor many unsolved scientific mysteries: Who lives there? How many species are there (or genera, families, classes, phyla)? How do marine organisms make a living in these often-extreme surroundings? How variable are marine community dynamics over space and time and what are the main drivers of these fluctuations? While we have only begun to answer some of these very basic questions (biological oceanography is a relatively recent science), the rapid intensification of human activities over the last 200 years has already started to shift the ecological baselines in the sea, making it a challenge to state what is "pristine" or "normal".

This course intends to introduce you to the interdisciplinary science of Biological Oceanography, whose aim is to chart the different marine ecosystems of our blue planet and describe their composition, structure and function. For this, you will learn to view marine environments as integrated systems, in which living and non-living components are connected and interact in complex ways. With this holistic perspective, not only will you be able to describe where (and at what moment) different kinds of marine organisms tend to occur (biogeography), but also be able to identify the principal factors that control these spatial-temporal patterns.

As with any natural science, we will attempt to understand the complex systems before us using two concurrent approaches: (1) by breaking them down into manageable chunks, that is, analyzing and classifying the different living and non-living components (=reduction), which will then help us to (2) understand how ocean systems work as a whole (=synthesis). As such, Biological Oceanography will instill in you an appreciation of marine geological processes (geomorphology and plate tectonics), ocean chemistry (composition of sea water and biogeochemical processes), physical oceanography (heat budgets, stratification, currents, waves & tides), next to delivering a big serving of ecology (biodiversity & adaptation, food webs, reproduction and disturbance). Armed with this "systemic" understanding, you will be able to grasp the complex dynamics of life in the ocean, past and present, which will also enable you to analyze current environmental problems facing our seas, as well as venture some reasoned predictions about their likely future trajectories, in light of human-induced changes.

## Learning Objectives

1. Explore the principal marine ecosystems and communities (biogeography)

2. Understand the physicochemical, atmospheric and geological factors that structure the different marine realms

3. Identify the biological components of the main marine ecosystems of the world and understand their diversity and general structure (ecological scaling and food webs)

4. Describe the principal controls of ecological processes (“bottom-up” and “top-down”)

5. Appreciate the patterns of spatiotemporal variability of different physical and biological processes (migration, productivity, growth & reproduction, respiration & decomposition)

5. Highlight the role that the biosphere plays in biogeochemical cycles

6. Examine the different human activities and uses of marine recourses and their past, present and future impacts

7. Evaluate different management options for the sea (protected areas, ecosystem-based management, sustainability)

## Course Topics

**I. Introduction to Biological Oceanography**

- Definition and scope of the field
- Historical background
- Key concepts and terminology
- Methods of oceanographic research

**II. The Abiotic Environment: Geological, Chemical and Physical Oceanography**

- Ocean geomorphology and marine geological processes shaping the ocean basins
- Marine Chemistry and chemical oceanographic processes
- Physical oceanographic processes (vertical stratification and ocean circulation)
- Interactions among physical, chemical and biological components

**III. Marine Pelagic Communities**

- Phytoplankton: the producers
- Zooplankton & Nekton: the consumers
- Marine Microbes: the decomposers
- Dynamics of pelagic communities

**IV. Marine Trophic Relationships and Food Webs**

- Food Webs, Energy Flow and Mineral Cycling
- Ecological and evolutionary interactions among marine organisms
- Ecological Models

**V. Coastal and Benthic Communities**

- Benthic habitats and communities
- Benthic-pelagic coupling
- Benthic dynamics

**VI. Global Change and Human Exploitation of Marine Resources**

- Fisheries & Aquaculture
- Marine Traffic
- Marine Pollution
- Geological Resources from the Sea
- Climate Change and Ocean Biochemistry
- Energy from the Sea
- Marine Conservation & Management

## Course Dynamics

This whole-day course (8 am-5 pm) uses a diverse mix of learning approaches, including frontal lectures (to introduce general concepts), hands-on activities (labs and field work, to hone practical and research skills) and non-synchronous assignments (at-home readings and problem sets, to deepen and consolidate learning). The following teaching resources will be employed:

1. **Lectures** (incl. white board and PowerPoint slides)
2. **Field Trips** (to build first-hand experience of different ecosystems and to strengthen field research skills)
3. **Laboratory exercises** (to strengthen technical/methodological skills and complement theoretical concepts: physical-chemical properties of water, primary production, respiration, decomposition, analysis of field-collected samples)
4. **Problem Sets** (to hone capacity to search & find solutions to specific questions)
5. **Assigned Readings** (to broaden or deepen concepts and expand horizon)
6. **Videos** (to illustrate marine organisms and habitats that cannot be explored first-hand)
7. **Oral presentations** (to strengthen individual presentation skills and confidence)

## Grading

Your learning progress will be assessed using a variety of indicators, including formal exams & quizzes, practical exercises, field/project reports and an oral presentation. Each student's performance will be scored independently (no curve), relative to a master key with pre-defined objectives or criteria.

| Indicator | Weight |
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| **Quizzes** | 10% |
| **Oral presentation** | 10% |
| **Midterm (1)** | 20% |
| **Final (1)** | 20% |
| **Exercises** | 20% |
| **Reports** | 20% |
| **TOTAL** | **100%** |

- **Quizzes:** Weekly classes will typically begin with a short quiz (10 min), to reinforce key concepts or definitions from the week before
- **Oral presentations:** succinct presentation (15-20 min) on an assigned research topic
- **Midterm & Final:** One mid-term and one final, to review learning progress on topics covered since last exam (combination of multiple-choice, fill-in blank and open question)
- **Exercises:** Homework or problem sets in class
- **Reports:** Descriptions of field trips

***Absences:*** While class attendance is not mandatory, it is highly recommended to accomplish the course learning objectives as well as participate in quizzes and exams. As a general rule, there are no make-ups for quizzes, exams or class-activities missed, unless accompanied by a valid excuse (e.g., medical or beyond your control). In case you are unable to attend a class for a pressing reason, please inform me in advance, in writing (e-mail).

***Special needs:*** Please advise me of any learning difficulties that might require special attention or modifications of the course content.

## Recommended Course Materials

1. Rite-in-the-Rain Notebook—(recommended size: Journal No. 393—fits in pocket)
2. Rubber boots (water-proof) or hip waders
3. Second set of dry clothes (you will probably get wet and muddy!)
4. Dissecting Kit (optional, but useful to have at hand)
5. water-proof camera and/or camera/phone bag
6. snorkel gear and wetsuit (optional, but recommended for the brave-at-heart, for exploring fouling communities at their own leisure)

## Course Schedule (Fall Term 2023)

| Date | Topics | Assignment due | Recommended Reading |
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| Week 1 (Oct 2) | Introduction to Biological Oceanography. Definitions & Key Concepts. History of Oceanography, Methods of Oceanographic Research. Ocean Geomorphology and Marine Geology (bathymetry, plate tectonics, seafloor spreading, active & passive margins). | n/a | Kaiser (Cap. 1)<br>Lalli & Parsons (Cap. 1)<br>Garrison (Cap. 2, 3, 4) |
| Week 2 (Oct 9) | Marine Chemistry & Physics (salinity, dissolved gases, contaminants, sediments, acidification). **Lab 1 (Sea water properties), Field Trip 1 (Cape Arago or close)** | Exercise 1: Coordinates | Lalli & Parsons (Cap. 2)<br>Garrison (Cap. 5, 6, 7) |
| Week 3 (Oct 16) | Ocean Dynamics: Water Cycle, Earth's heat budget, key parameters (solar radiation, temperature, salinity, density). Atmospheric circulation and seasonality. Ocean circulation (surface currents, stratification & thermohaline circulation). Regional phenomena (upwelling, downwelling, El Niño) **Field Trip 2 (Charleston Marina & Plankton)** | Exercise 2: Water Chemistry | Garrison (Cap. 8, 9) |
| Week 4 (Oct 23) | Photosynthesis and Primary Production, Phytoplankton and Microbial Loop. **Lab 2 (Primary Productivity and Respiration)** | Exercise 3 : Sea Water Charleston Bay | Kaiser (Cap. 2, 3)<br>Lalli & Parsons (Cap. 3) |
| Week 5 (Oct 30) | Secondary Production: Zooplankton & Nekton. Distribution, Pelagic Food Webs, Energy Flow and Mineral Cycling, Marine Fisheries. **Field Trip 3 (Charleston Bay Oceanographic Cruise)** | Exercise 4: Primary Productivity | Kaiser (Cap. 4)<br>Lalli & Parsons (Cap. 4, 5, 6)<br>Garrison (Cap. 13, 14, 15) |
| Week 6 (Nov 6) | Benthos classification (plants and animals, size), Factors structuring benthic environments: substrate, waves, tides, biological interactions (competition, predation, disturbance) | Exercise 5: Charleston Bay<br>**Midterm** | Lalli & Parsons (Cap. 7)<br>Garrison (Cap. 11, 12, 13) |

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| Week 7 (Nov 13) | Nearshore benthic communities (Estuaries, Rocky and Sandy Shores) **Field Trip 4 (Rocky Intertidal, Beach, Estuary)** | | Kaiser (Cap. 5, 6)<br>Lalli & Parsons (Cap. 8) |
| Week 8 (Nov 20) | Offshore communities: pelagic, continental shelf, deep sea. **Lab 3: Benthos** | Exercise 6: Coastal Field Trip Notes | Kaiser (Cap. 7, 8, 9)<br>Garrison (Cap. 16) |
| Week 9 (Nov 27) | Regional benthic communities: seagrass meadows, marshes and mangroves. **Field Trip 5 (Fishery/Aquaculture Facility)** | Exercise 7. Bentos Lab | Kaiser (Cap. 10) |
| Week 10 (Dec 4) | Regional benthic communities: coral reefs, polar seas. **Field Trip 6 (Tidal Marsh)** | Exercise 8: Field Trip Aquaculture | Kaiser (Cap. 11, 12) |
| Week 11 (Dec 11) | Human Impacts and Management: Fisheries & Aquaculture, Marine Pollution, Climate Change, Conservation. **Final Exam** | Exercise 9: Field Trip Tidal Marsh<br>**Final Exam** | Kaiser (Cap. 13, 14, 15, 16) |

## Recommended Literature

- **Principal Textbook**

Michel J. Kaiser, Martin J Attrill, Simon Jennings, and David Thomas (eds) Marine Ecology. Processes, Systems, and Impacts. 2020 Third (or Second) Edition. ISBN: 9780198717850. Oxford University Press. 608 p.

- **Complementary Texts (in bold: recommended)**

Barnes, R.S.K. and Mann, K.H. 1991. Fundamentals of aquatic ecology. Blackwell, Oxford.

Dobson, M & Frid, C. 2009. Ecology of Aquatic Systems. 2nd Edition Oxford University Press.

**Garrison, T. 2016. Oceanography-An Invitation to Marine Science. 3rd Edition. Wadsworth Publishing Company.** *(a classic, very comprehensive)*

**Lalli, C.M & Parsons, T.R 1993: Biological Oceanography: An introduction. 2nd Edition. Pergamon Press** *(old but good!)*

Levinton, J.S. 2001. Marine Biology. Function, Biodiversity, Ecology. Oxford University Press.

Morrissey, J, Sumich, J.L 2012. Introduction to the Biology of Marine Life. 10th Edition. Jones & Bartlett Publishers.

Parsons, T.R., Takahashi, M. y Hargrave, B. 1993. Biological Oceanographic Processes. 3rd Edition. Pergamon Press.

**Roberts, C. 2012. The Ocean of Life. The Fate of Man and the Sea. Penguin Books. 405 p.** *(passionately and beautifully written)*

- **Videos**

BBC. 2002. The Blue Planet--A Natural History of the Oceans. Narrated by David Attenborough. DVD.

BBC. 2018. The Blue Planet II-Take a Deep Breath. Narrated by David Attenborough. DVD