

**Marine Larval Ecology
Responses to a Changing Ocean Environment**

Instructors:
Dr. Justin McAlister (College of the Holy Cross)
and Dr. Scott Santagata (Long Island University - Post)

July 5 - July 23, 2021



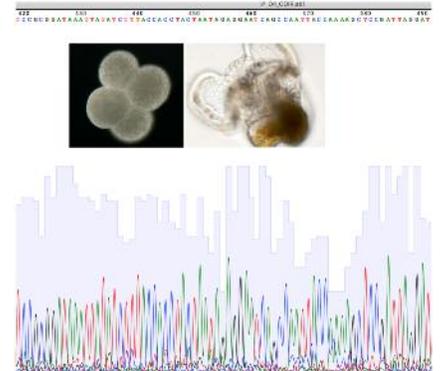


Course work includes student lectures (left); field-trips to visit mangroves and learn about Bermuda's geology and associated specialized plankton communities (center); students in the lab analyze collected samples (right).

Marine Larval Ecology (MLE) Responses to a Changing Ocean Environment

Synopsis of Course Content

The larval developmental stages of many marine invertebrates play important roles in linking benthic ecosystems with pelagic ecosystems and serve to disperse genetic material among populations. Larvae are highly diverse in form, function, and life history and can be particularly sensitive to various kinds of environmental changes. Responses to environmental changes can occur at molecular, physiological, and morphological levels due to elevated ocean temperatures, increased ocean acidity, and patchily distributed phytoplankton food resources, as well as from exposure to pollutants like petroleum, heavy metals, and microplastics. For many organisms, "normal" developmental patterns are not well known, let alone how development may vary in response to single or multiple interacting environmental variables.



DNA barcode identification of unknown larvae (center)

Marine Larval Ecology (MLE) will examine the ecology, evolution, and development of marine invertebrate larvae, their roles as part of the meroplankton, and their responses to environmental stressors at different biological scales. Students will gain hands-on experience collecting various marine invertebrates from local habitats (mangrove, coral reef, pelagic open water) during boat and shore-based excursions. In the laboratory, the focus of the course will be on learning to spawn adults, obtaining and fertilizing gametes, culturing larvae, and conducting empirical studies of larval development under conditions of current and potential future environmental stress. Students will also learn DNA barcoding techniques to classify unidentified zooplankton and more broadly how this information informs on the global dispersal and management of planktonic communities present in ships' ballast water. Lectures and laboratories will cover a broad range of topics and principles relevant to larval biology, zooplankton ecology, and developmental plasticity.



Planktonic animals of varying scales such as these shrimp-like mysid crustaceans and diverse kinds of copepods are known to interact with and ingest micro- and nanoplastics.

Prerequisites

This course is structured for upper level undergraduate and graduate students. Students are expected to have taken at least 2 years of biology coursework including introductory and intermediate courses, e.g. ecology, genetics, or marine biology. Snorkeling and diving opportunities will be available to those students having moderate swimming abilities and training.

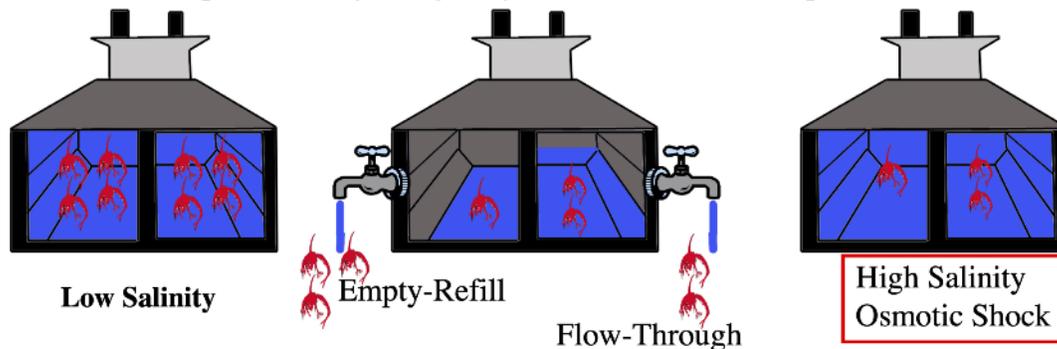
Reading Material

There are no required textbooks for the course, however some material will draw from *Ecological Developmental Biology: The Environmental Regulation of Development, Health, and Evolution* (2nd ed.) by Scott F. Gilbert and David Epel. Students will be assigned readings that include both primary literature and textbook chapters that are pertinent to course modules.

Course Goals

- Identify and distinguish larvae from major phylogenetic groups of marine invertebrates living in various marine habitats surrounding Bermuda
- Learn small-scale culturing methods for marine invertebrate larvae
- Learn to collect morphometric, biochemical, and energetic data of developing larvae
- Conduct DNA barcoding analyses to classify unidentified wild-caught zooplankton
- Explain the roles that larvae play in invertebrate life histories, connectivity between benthic and pelagic ecosystems, and among populations of marine species
- Examine the effects that human activities have on the development, growth, and dispersal of marine organisms

Open-Ocean Ballast Water Exchange Dispersal of Physiologically-Tolerant Planktonic Species



Assignments and Exams

The course is divided into 3 modules (developmental plasticity, DNA barcoding, and ecotoxicology), ~15 lectures (1.3 hours long), 4 boat trips (2-4 hours duration), 4 on land excursions (2-4 hours duration to visit local sites) and ~12 lab sessions (2-4 hours duration). There will be 3 hands-on assignments, a take home written exam, and a morning of oral presentations.

Grades are Based On

- 3 module assignments (15% per each assignment - 45%)
- Take home exam (20%)
- Oral presentation (student symposium - 15%)
- Participation in lectures and labs (lab notebook - 20%)

Example Lecture Topics

- Marine invertebrate larvae, larval diversity, and classification
- Physics of life at small scales, Reynold's number
- Larval dispersal - ecological and genetic implications
- Larval life histories - direct versus indirect development
- Feeding and food limitation, predation, and mortality
- Developmental plasticity
- Physical environmental stressors - temperature, salinity, ocean acidification
- DNA Barcoding and phylogenetic analyses
- Human-induced environmental stressors, in particular, microplastics
- Ecotoxicology - Ships' ballast water management strategies and the relative physiological tolerances of zooplankton communities

Preliminary List of Trips and Activities

- In- and offshore plankton sampling via nets and snorkeling (coral reef to blue water)
- Night excursion to explore plankton bioluminescence
- Inland trips to visit volcanic caves and mangroves to learn about Bermuda's geology and associated specialized plankton communities



Student Testimonials from Marine Plankton Ecology Course 2019 (MLE course did not run in 2020 due to COVID19)

"I found the course extremely informative, with a broad range of teaching. The lectures, practical labs, data analysis and cruises were very useful tools to open my eyes to the working world of science. Everyone was very accommodating and were made to feel comfortable and supported throughout the course. I thoroughly enjoyed the MPE course." - Emma Busby

"Overall my experience was wonderful. I was surrounded by students and scientists interested in marine biology, oceanography and was able to learn techniques to further my research. I hoped to learn about the connection between plankton and the broader marine food web and what that means for reef and offshore ocean conservation and restoration. I did achieve my goal." - Leigh Fletcher

"I had a great time at BIOS, learning a lot from really good lecturers, having had unique fieldwork opportunities and met amazing people I hope I will be able work with in the future." - Naomi Villiot

"Overall, I loved my time there. I felt the course workload was enough so that it felt you were learning desirable practical skills and knowledge of plankton taxonomy whilst having the spare time to relax and explore Bermuda. Dr Leocadio Blanco-Bercial and Dr Amy Maas were very friendly and interesting people, and both demonstrated a vast knowledge of plankton taxonomy, physiology and methods of sampling. Both were exceptional lecturers, conveying their information clearly, and were receptive to questions and were very patient, especially with me, haha. They appreciated that the MPE course students come from different levels of academic expertise and were careful to ensure that all the students understood the work and no-one was left too far behind. The staff running the facilitates (cooking and cleaning) were also very kind, and it was touching to see how far they went out of their way to help us and ensure we were comfortable. Overall BIOS had a welcoming atmosphere that encouraged students to collaborate with other students/academics on separate courses/ projects and gain a broader understanding of the work being undertaken at BIOS as well as provide new contacts for potential future work." - Dylan Carbone

"I really enjoyed my experience at BIOS. Both Amy and Leo invested a lot of time and effort to make sure everyone understood everything and I gained a lot of field and lab experience." - Maisie Smith

"I hoped to learn more about plankton, a topic which we have merely scratched the surface of in my degree so far. I also hoped to get more confident in my lab skills which have always been a bit poor. What is more, I wanted to get a more realistic experience of what a day in the life of an active researcher is like and see to what extent this is compatible with my idea of a fulfilling career. All of the aforementioned hopes and aims were achieved, since I now feel I know a lot of things about plankton and that I have more experience in lab settings, while I am more sure of what suits me or not professionally." - Danai Antonaki

"In the future I plan to study the gelatinous zooplankton and deep water organisms, it is my interest area. That is why I plan to do a PhD, because I like the research, and my time at BIOS reinforced my thoughts on my future plans." Braulio Fernández

"The experience was amazing, it was great meeting all the people from all different backgrounds and the teachers were just amazing and gave excellent advice...I still believe I will pursue a more molecular/applied biology path and aspects of the MPE course solidified that decision." - Jessica Godfrey