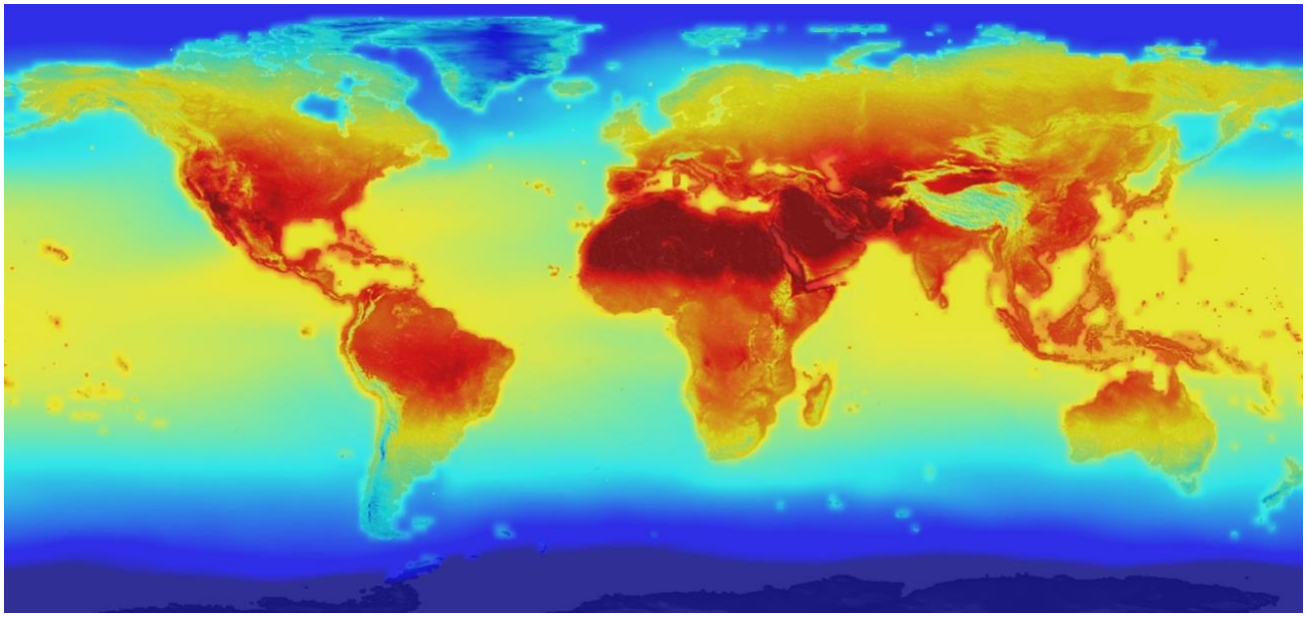
BI/ES 593 Marine Physiology and Climate Change

MARINE SEMESTER – Third Block
Fall 2019 (October 28-November 20)



Professor Information

Professor	Email	Office phone	Cell phone	Office Location
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Teaching Fellow: Nicola Kriefall email: thenicolakriefall@gmail.com

Office Hours: Please email, but I am generally in my office from 9-430pm M-F

Course Overview

Greenhouse gas emissions are warming the planet at unprecedented rates and these rapid environmental changes represent one of the greatest global threats for marine ecosystems. Ocean temperatures are predicted to rise by at least 1º C over the coming century and the consequences of these increased temperatures on marine communities depend upon the organism's physiological response, its genetic background, and its interactions with other individuals in their community. This course will explore the range of physiological responses marine organisms exhibit in response to climate change. We will be exploring the phenotypic

plasticity exhibited across different organisms and investigating how this plasticity can influence an organism's resilience to its changing environment. This research based course will be taught over the course of November as part of the Marine Semester and will be based on lectures, literature review and student-led common garden laboratory experiments. The marine invertebrates that will serve as our research subjects will include previously collected invertebrates native to the east coast of the US and coral populations from Florida, Belize and Panama. This course is intended for upper-level undergraduate and graduate students interested in the physiological responses of marine organisms to climate change with the end goal being to design and implement physiological experiments to better predict how marine organisms will respond to the challenges posed by global change. Students will work in small groups to pursue their own independent research projects.

Through this course, you can expect to gain:

- *An understanding of how increased CO_2 emissions are affecting the world's oceans*
- *An understanding of how marine populations can respond to their changing environments*
- *Experience designing statistically robust common garden experiments*
- *Experience carrying out temperature controlled experiments in the laboratory*
- *Experience in measuring a myriad of physiological responses in marine invertebrates*
- *Experience carrying out statistical analyses of physiological data using R software*
- *Experience generating scientific figures using R software*
- *Improved comprehension of the scientific literature in the field of Marine Physiology and Climate Change*
- *Improved oral and writing communications*

Prerequisites

- BI108 (Cell and molecular biology, Mendelian & molecular genetics, physiology, and neurobiology) or permission of the instructor
- Admission to the Marine Semester
    - Acceptance to partake in the marine semester requires the following:
        - Undergraduates: Completion of at least one intermediate-level course in one of the following areas: (1) marine biology; (2) marine biogeochemistry; (3) physical oceanography; (4) marine geology. Any one of the following CAS courses will satisfy this requirement: BI 260; BI/ES 423; ES 331; ES 440; ES 541; GE 507.
        - Graduate, junior or senior standing (although sophomores may be considered if they have completed the required marine breadth course).

Course elements

The course includes a combination of lectures, primary literature reading assignments and discussions, laboratory work (analyses and experiments), data analysis, programming and statistics using the R language, oral presentations, and scientific writing.

Lectures

A number of lectures will be given during the first week of the course and sporadically throughout the rest of the course by the professor and other guest lecturers in order to familiarize students with the fundamentals of climate change and its effects on marine physiology. Short lectures will also be given on how to effectively

design ecological experiments, how to analyze and visualize data using R, how to give strong oral presentations and tips for efficient scientific writing.

Small group independent research project

Students will work in small groups (3-4 students) to independently design, implement and carry out their own research project to test the effects on temperature or temperature variation on a suite of physiological measurements. Students will work together to collect, analyze, and interpret their data acquired during their experiments. Each group will be required to present and discuss their results in a 30-min presentation. Each student will also be required to present and discuss their results in a short science manuscript using primary literature to put their research in greater scientific context. The professor and TF will provide guidance on how to effectively do an oral presentation, and organize, present and discuss results in a concise manuscript.

Laboratory work

All experimental subjects will be maintained in the BUMP research facility until independent research projects commence. Once student groups decide on their organism and physiological trait(s) of interest, laboratory work will largely be dependent on the group's interest but could range from measuring photosynthetic efficiency, growth, calcification, fecundity, behavioral changes, or protein content. Daily tasks will involve the maintenance of experiments and data collection.

Data analysis and statistics

Students will be introduced to R statistical environment, which is a free software environment for statistical computing and graphics (https://www.r-project.org/). Students will learn a variety of statistical tests and packages, which will be largely dependent on their data. Students will work closely with myself and the TF during data analysis and discussions on how to best present data.

Primary literature readings and discussion

Once a week students will be required to read two published manuscripts, which will be selected by the professor. The class will get together to discuss these papers during a short 1-hour weekly meeting. Student will be expected to participate actively in the discussions, ask questions and critically analyze the research. The entire class will be required to read the manuscripts and participate in discussions. Each student will be required to speak at least once per paper discussion. A one-page report on the readings will be required.

Final project paper and presentation

Students will be required to submit a final scientific paper on their research that follows traditional scientific manuscript style. In addition, each group will present their research projects in conference style presentations.

Specific expectations

All assignments will be handed in electronically on time- no late work accepted.

Attendance throughout the block is mandatory and if you miss class/experimental time your grade will suffer.

Cell phones should be put away during lectures/discussion/presentations. Cell phones can be used during experiments, however each of your group members will be assessing your contribution so be sure not to be using cell phone for extraneous purposes (social media/personal phone calls etc).

Cleanliness in the BUMP research area is mandatory and will be graded accordingly.

Grading

Students will be evaluated based on their performance in the saltwater laboratory and during lectures/discussions, on the quality of the data produced, and on the content and quality of their manuscript and oral presentation. No late work will be accepted. Attendance throughout the block is required.

Summary

- Laboratory work performance: 25%
  - 10% TF/Instructor grade
  - 10% group grade
  - 5% Seawater lab cleanliness
- Literature discussion: 20%
  - 10% participation
  - 10% 1pg summaries (2% each)
- Research Proposal: 20%
  - 10% Written proposal
  - 10% Proposal Presentation
- Final research project: 35%
  - 25% Research manuscript
  - 10% Oral presentation

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

Two published manuscripts a week will be presented and discussed in class by students.

Reading materials for discussion:

Week 1: Ocean Warming

1. Kenkel C, Goodbody-Gringley G, Caillaud D, Davies SW, Bartels E and MV Matz. 2013 Evidence for a host role in thermotolerance divergence between populations of the mustard hill coral (*Porites astreoides*) from different reef environments. Molecular Ecology. 22(16): 4335-48.
2. Coles SL, Bahr KD, Rodgers KS, May SL, McGowan AE, Tsang A, Bumgarner J, Han JH. (2018) Evidence of acclimatization or adaptation in Hawaiian corals to higher ocean temperatures. PeerJ 6:e5347

Week 2: Ocean Acidification

1. Ries JB, Cohen AL and DC McCorkle (2009) Marine calcifiers exhibit mixed responses to Co2-induced ocean acidification. Geology 37(12):1131-1134.
2. Kriefall NG, Pires A, Pechenik JA and SW Davies (2018) Resilience of the Atlantic slippersnail *Crepidula fornicata* larvae in the face of coastal acidification. Frontiers in Marine Science 5:312.

Week 3: Multi Stressor Responses

1. Castillo KD, Ries JB, Bruno JF and IT Westfield. 2014 The reef-building coral *Siderastrea siderea* exhibits parabolic responses to ocean acidification and warming. Proc. R. Soc. B 281: 20141856.
2. Gaitán-Espitia JD, Hancock JR, Padilla-Gamiño JL, Rivest EB, Blanchette CA, Reed DC and GE Hofmann (2014) Interactive effects of elevated temperature and pCO2 on early-life-history stages of the giant kelp *Macrocystis pyrifera*. Journal of Experimental Marine Biology and Ecology. 457: 51-58.

Week 4: Environmental Variability

1. Ainsworth TD, Heron SF, Ortiz JC, Mumby PJ, Grech A, Ogawa D, Eakin MC and Leggat (2016) Climate change disables coral bleaching protection on the Great Barrier Reef. 352 (6283): 338-342.
2. Cornwall CE, Comeau S, DeCarlo TM, Moore B, D'Alexis Q, McCulloch MT. 2018 Resistance of corals and coralline algae to ocean acidification: physiological control of calcification under natural pH variability. Proc. R. Soc. B 285: 20181168

Course Schedule

The first few days will aim to familiarize students with some fundamentals of climate change and its effects on marine organisms. The first few days will also be used to identify important scientific questions and objectives and to design the independent research projects for the coming weeks. Students will be introduced to the saltwater lab and the APEX control system and animal husbandry will be emphasized. The middle three weeks will focus on data collection and analysis of independent research projects. Weekly reading discussions will take place and students will be expected to use their spare time to research background information on their projects. During the last week, students will spend time working on their research presentations and manuscript and will be take the final exam.

General Schedule

****Students should plan to be on campus working on course material from 10am-4pm daily. Like all science, situations come up and the times of lectures/workshops/discussions can change. Students should not book anything during class time without first checking with the instructor and TF.

Week	Topic
Week 1	Introduction to climate change and marine physiology Overview of saltwater lab and husbandry expectations Define project objectives and design research projects Propose and defend Independent research projects Start independent research projects Read and discuss primary literature
Week 2-3	Independent research projects Data compilation and analysis Read and discuss primary literature
Week 4	Complete independent research projects Project wrap-up and presentations

Academic Conduct

It is each student's responsibility to know and understand the provisions of the Academic Conduct Code at Boston University.

The Code is available online at http://www.bu.edu/academics/ files/2011/08/AcademicConductCode.pdf.

Cases of suspected misconduct will be referred to the Dean of the College. If the Dean's office comes to the conclusion that cheating or plagiarism have occurred, a grade of zero will be awarded for the assignment in question.

Specific Schedule ***Tentative- subject to change
ALL STUDENTS SHOULD PLAN TO BE ON CAMPUS M-F 10-4 at MINIMUM

Monday October 29th

10-10:45am: Introductions, syllabus, expectations
10:45-11:00am: Break
11-1130pm: Lecture 1: Introduction to Climate Change and the Marine Environment (Davies) (Jen-Wei present)
1130-1145: Lecture 2: Effects of high and low temperature stress on *Astrangia poculata* (Davies) (Jen-Wei present)
1145-12: Lecture 3: Effects of thermal stress of *P. damicornis* (Kriefall)
12-1pm: lunch
1-2pm: Introduction to potential projects & decide on groups
2-2:30: Lecture 4: Experimental design (Davies)
2:30-3pm Lecture 5: Experimental Best Practices (Guest: Brooke Benson)
3-4pm: Workshop: How to write a research proposal & grading of proposals (Davies and Kriefall)

Tuesday October 30th

10-1030am: Workshop: Effective powerpoint presentations (Kriefall)
10:30am-12pm: Work in groups on experimental design
12-1230pm: lunch
1230-230pm: Individual group meetings with Sarah and Nicola to discuss experimental plans (30 mins each)
3pm: Tank room orientation with Brooke Benson and Justin Scace
1230-4pm: Work on research proposal as a groups

Wednesday October 31st

Halloween- Please come in costume!!!

10am: Group research proposal due to Sarah! Bagel Breakfast 10-12 BRB 113
10-12pm: Work in groups on proposal defense
12:20-1:20pm: Robin's chalk talk
1:20-4pm: Proposal defense Presentations (15 minute presentation + 15 minutes questions/ group)
Each student grades and provides feedback to all groups on presentations

Thursday November 1st: EXPERIMENTAL DAY 1

10-4pm: Experimental set-up and physiological measurements for time zero
Students should expect this to be a long day

Friday November 2nd: EXPERIMENTAL DAY 2

10am: Paper Discussion Summaries #1 Due to Nicola! Electronically, must be emailed by 10am
10-11:30: Discussion: Week 1 papers (Kenkel and Coles)
11:30-12: Experiments
12-1:00pm: lunch
1:00-4pm: Experiments

Saturday November 3rd: EXPERIMENTAL DAY 3

Experiments as needed- Sarah Available

Sunday November 4th: EXPERIMENTAL DAY 4

Experiments as needed- Sarah Available

Monday November 5th: EXPERIMENTAL DAY 5

10-11am: Groups 1-2: Introduction to R and good data management: Taught by Matt Kanke
11-12pm: Groups 3-5: Introduction to R and good data management: Taught by Matt Kanke
10-12pm: Experiments
12-1:30pm: lunch
1:30-2:30: Lecture 6: Corals and climate change (Davies) (BRB 113)
2:30-4pm: Experiments (no access to classroom)

Tuesday November 6th: EXPERIMENTAL DAY 6 VOTE!!!

10am: Manuscript Introductions due!
10-11am: Groups 1-2: Introduction to R and data visualization
11-12pm: Groups 3-5: Introduction to R and data visualization
12-2pm: lunch and VOTE!!! Extended lunch offered
2-4pm: Experiments

Wednesday November 7th: EXPERIMENTAL DAY 7

10am: Paper Discussion Summaries #2 Due to Nicola!
10-11am: Discussion: Ries and Kriefall
11-12pm: Experiments
12-1pm: lunch
1-2pm: Workshop: Groups 1-2: Basic statistics in R
2-3pm: Workshop: Groups 3-5: Basic statistics in R
3-4: Experiments

Thursday November 8th: EXPERIMENTAL DAY 8

10-12pm: Experiments
12-1pm: lunch
1-2pm: Lecture 7: Adaptation vs Plasticity (Davies)
2-4pm: Experiments

Friday November 9th: EXPERIMENTAL DAY 9

10-10:30am: Experiments
10:30-12: Workshop: How to write an effective abstract
12-1pm: lunch
1-4pm: Experiments

Saturday November 10th: EXPERIMENTAL DAY 10

Experiments as needed- Nicola available

Sunday November 11th: EXPERIMENTAL DAY 11

Experiments as needed- Nicola available

Monday November 12th: EXPERIMENTAL DAY 12

Veteran's Day Observed- no formal classwork, Experiments as needed- Nicola available

Tuesday November 13th: EXPERIMENTAL DAY 13

10am: Paper Discussion Summaries #3 Due to Nicola!
10-11am: Discussion: Castillo and Rivest
11-12pm: Experiments
12-1pm: lunch
1-2pm: Experiments
2-3pm: Guest Lecture Colleen Bove
3-4pm: Experiments

Wednesday November 14th: EXPERIMENTAL DAY 14

10am Manuscript methods due
10-11am: Groups 1-2: Making Maps in R: Taught by Nicola
11-12pm: Groups 3-5: Making Maps in R: Taught by Nicola
12-1pm: lunch
1-2pm: Guest Lecture 8: Thermal variability and its effect on corals (Brooke Benson)
2-4pm: Experiments
4-7pm: Free time
7-9pm: 2018 University Lecture

Thursday November 15th: EXPERIMENTAL DAY 15

12-430pm: Nicola at Genomics Conference

Experimental break-down and final physiological measurements
Students should expect this to be a long day

10am: Paper Discussion Summaries #4 Due to Nicola!
10-11am: Paper Discussion: Ainsworth and pH variability
11-1pm: Experimental Breakdown
1-2pm: Workshop: How to write effective figure legends (Davies and Kriefall)
2-4pm Experimental Breakdown

Friday November 16th

10am: Final grade on station cleanliness (Brooke and Justin)
10-12pm: Data analysis, visualization and writing
12-1pm: lunch
1-4pm: Data analysis, visualization and writing
**Sarah and Nicola are available all day for consult

Saturday November 17th
Sunday November 18th

Monday November 19th

10am: Final manuscripts due electronically to Sarah
10-12pm: Presentation preparation

12-1pm: lunch
1-4pm: Presentation preparation

Tuesday November 20th

10-1:30pm: Final Presentations BRB 113
Lunch provided!