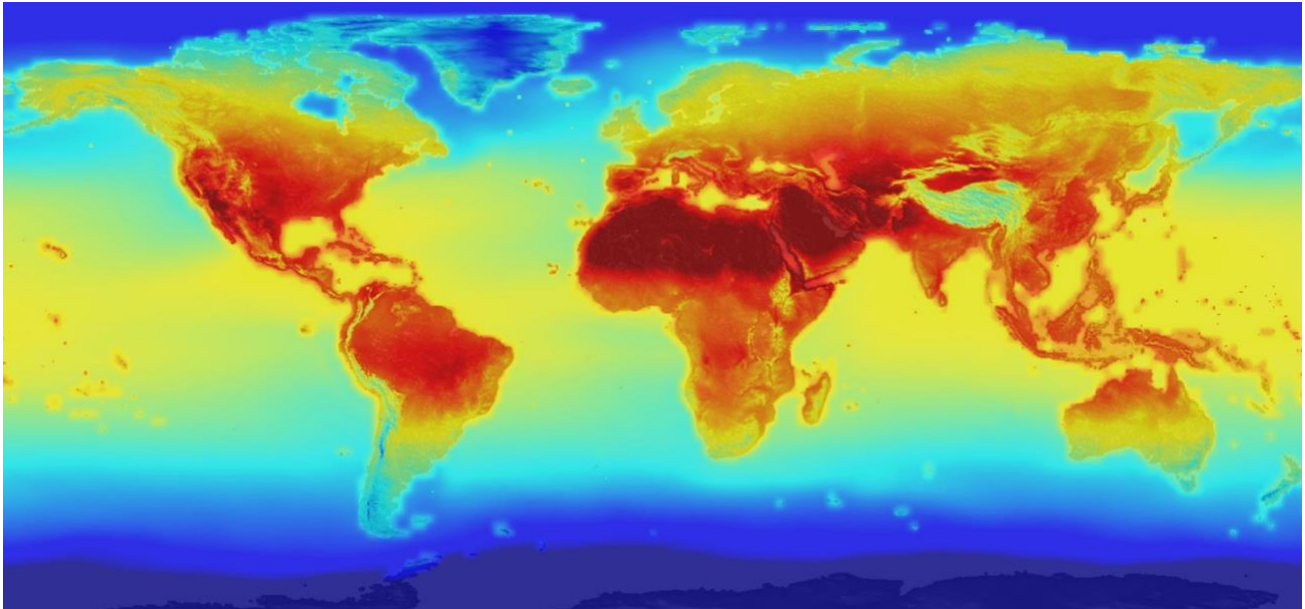


# BI/ES 593 Marine Physiology and Climate Change

MARINE SEMESTER - Fourth Block  
Fall 2021 (November 19-December 16)



## Professor Information

Professor	Email	Office phone	Cell phone	Office Location
Sarah W. Davies	daviessw@gmail.com	617-383-8980	512-609-9134	BRB 215

**Teaching Fellow:** James Fifer email: [jfifer@bu.edu](mailto:jfifer@bu.edu)

Office Hours: Please email, but I am generally available from 9-4pm 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 1° 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-December 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<sub>2</sub> 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 scientific literature in 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: are i) ES144 Intro to Oceanography, ii) BI260 Intro to Marine Biology, iii) MA115 Statistics, and iv) one Marine Breadth course from list on advising worksheet.
    - 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.

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### *Small group independent research project*

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Students will work in small groups (2-4 students) to independently design, implement and carry out their own research project to test the effects of stressors 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 20-min presentation. Each student will also be required to present and discuss their results in a short scientific 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*

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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*

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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*

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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*

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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.

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### *Specific expectations*

**Attendance:** Attendance throughout the block is mandatory and if you miss class/experimental time your grade will suffer. In addition, because of the unique nature of the Marine Semester where each day represents about one week in a traditional semester, students who miss three or more days of class will miss significant course content and will be encouraged to consider withdrawing from the course

**Late Work:** All assignments will be handed in electronically on time unless otherwise discussed with instructor.

**Conduct:** The Code is available online at <https://www.bu.edu/academics/policies/academic-conduct-code/> 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.

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

### Land Acknowledgment Statement

We acknowledge that the territory on which Boston University stands is that of The Wampanoag and The Massachusetts People. Our classroom and BU's campus are places to honor and respect the history and continued efforts of the Native and Indigenous community leaders which make up Eastern Massachusetts and the surrounding region. This statement is one small step in acknowledging the history that brought us to reside on the land, and to help us seek understanding of our place within that history. Ownership of land is itself a colonial concept; many tribes had seasonal relationships with the land we currently inhabit. Today, Boston is still home to indigenous peoples, including the Mashpee Wampanoag and Wampanoag Tribe of Gay Head (Aquinnah).

### Diversity Statement

In this class, we are seriously committed to supporting diversity and inclusion among all classroom community members. We proactively strive to construct a safe and inclusive environment by respecting each other's dignity and privacy. We treat one another fairly and honor each member's experiences, beliefs, perspectives, abilities, and backgrounds. Our collective group is stronger because we strive to bring together people of all race, religion, language, immigration status, sexual orientation, gender identification, ability status, socio-economic status, and national identity. Bullying, hateful ideas, violent language, belittling, racial slurs, and other disrespectful or "othering" language or behavior will not be tolerated in the classroom or online.

\*If you ever have any concerns about the classroom climate, please reach out to me.

### Student Protocols for COVID-19

- o Students must stay up to date with testing and attestation and will receive a green-colored badge that will appear on their mobile device.
- o Students arriving to class, lab, or office will be required to show their badges on their mobile devices prior to starting class/meeting.
- o If a student is unable to show a green badge, the student will be asked to leave to rectify any issues with their testing or attestation before their next in-person class, and, if possible, to utilize the remote LfA option for that class session.
- o The student cannot come back to that class session and must resolve any issues they have with testing or attestation before attending in-person again.
- o Refusal to leave will result in the Professor/TF informing the class that we will not proceed with instruction until the student leaves the room.
- o If the student still refuses to leave the room, dismissal of the class will result and the Dean's office will be contacted.
- o For everyone's health and safety, in the unlikely event that you have a contact tracing interview, please remember to communicate the nature and duration of the work that we do together in marine semester courses**

## 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 discussions: 30%
  - 10% Participation
  - 10% Leadership in Discussion Topic
  - 10% 1pg summaries (2.5% each)
- Final research project: 45%
  - 5% Experimental Plan
  - 5% Intro Experiment Presentation
  - 25% Research manuscript
  - 10% Oral presentation

<u>Percentage</u>	<u>Letter</u>	<u>GPA</u>
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 each session will be presented and discussed in class by students. Students are highly encouraged to seek out literature from diverse scientists.

### Reading materials for discussion:

Discussion 1: Experimental Work on Ocean Warming (Led by Davies November 30<sup>th</sup>)

1. Castillo KD, Ries JB, Weiss JM, Lima FP (2012) Decline of forereef corals in response to recent warming linked to history of thermal exposure. *Nature Climate Change* 2: 756-760.
2. EM, Finnerty JR, Kaufman L, Rotjan RD. 2017. Temperature and symbiosis affect lesion recovery in experimentally wounded, facultative symbiotic temperate corals. *Marine Ecology Progress Series* 570: 87-99.

Discussion 2: Experimental Work on Ocean Acidification (Led by Groups 1 and 2 November 30<sup>th</sup>)

1. Groups 1's Decision
  2. Group 2's Decision
- \*\*\*announce papers to the class by 4pm November 23<sup>rd</sup>

Discussion 3: Experimental work on Local Stressors (Led by Groups 3 and 4 December 7<sup>th</sup>)

1. Group 3's Decision
  2. Group 4's Decision
- \*\*\*announce papers to the class by 4pm Wednesday December 1<sup>st</sup>)

Discussion 4: Experimental Work on Multi Stressor Responses (Led by Groups 5 and 6 December 10<sup>th</sup>)

1. Group 5's Decision
  2. Group 6's Decision
- \*\*\*let the group know by 4pm Friday Dec 3<sup>rd</sup>)

## 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.

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

Specific Schedule 2021 \*\*\*Tentative- subject to change  
ALL STUDENTS SHOULD PLAN TO BE ON CAMPUS M-F 10-4 daily

### Friday November 19<sup>th</sup>

10-10:45am: Introductions, syllabus, expectations, and introduction to Slack

1045-1130: Lecture 1: Introduction to Climate Change and the Marine Environment (Davies)

1130-1pm: Lunch Break

1-1:45: Lecture 2: Coral Biology and Climate Change (Davies)

1:45-2: Break

2-2:45: Lecture 3: MPCC 2017: Effects of temperature stress on *Astrangia poculata* (Davies)

Optional Homework: Watch Chasing Corals on Netflix

### Saturday November 20<sup>th</sup> & Sunday November 21<sup>st</sup>

N/A

Monday November 22<sup>nd</sup>

10-10:30: Lecture 4: Experimental design and Peer Grading (Davies)  
10:30-11: Lecture 5: MPCC 2018 Hot and Cold V2 and intro of FGB experiments (Davies)  
11-1145: Lecture 6: Population-specific thermal performance and Astrangia 2021 (Aichelman+Fifer)  
1145-1: Lunch break  
11-145: Lecture 7: Experimental Best Practices & data collection format (Fifer)  
1-2: Introduction to potential projects & deciding on groups  
2-4pm: Work in groups on experimental design and experimental plan

Tuesday November 23<sup>rd</sup>

10-10:30: Lecture 8: Water Quality (Isa Trumble)  
10:30-12: Work in groups on experimental design - confirm with Sarah and James  
12-1: Lunch  
1-130: Lecture 9: Guests Maria Valadez Ingersoll and Joshua Aguirre Carrión: Cnidarian responses to heterotrophy  
130-4: Tank room orientation and water quality tutorials with James, Sarah, Isa and Justin Scace  
\*\*\*\* Discussion Groups 1&2 announce their papers

Wednesday November 24<sup>th</sup>– Sunday November 28<sup>th</sup>: Thanksgiving Break

Monday November 29<sup>th</sup>: EXPERIMENTAL DAY 1

**10am: Finalized experimental design contract due to Sarah electronically**  
10am: Bagel Breakfast 10-12 BRB 219 2nd Floor Conference Room  
10-10:30: Background on Introductions and manuscript rubric  
9-4pm: Experimental set-up and physiological measurements for time zero  
\*\*this may be a long day for some groups

Tuesday November 30<sup>th</sup>: EXPERIMENTAL DAY 2

**Please download [MatLab](#) before coming to class**  
**<https://www.bu.edu/tech/services/cccs/desktop/distribution/mathsci/matlab/>**  
10-12: Experiments  
12-1:15pm: lunch  
1:15-2:30: Discussion 1: Ocean Warming: Kenkel et al., 2013 and Castillo et al 2013 (Davies)  
230-4: Learn to do Photo Analysis (Kimberly)  
230-4pm: Experiments

Wednesday December 1<sup>st</sup>: EXPERIMENTAL DAY 3

10-11: Lecture 10: Guest Dr. Marie Strader: Impacts of Ocean Acidification on marine calcifiers (Zoom)

11-11:45: Lecture 11: Effective powerpoint presentations and scientific manuscripts (Davies)  
1145-130: lunch break and experiments  
12:20-1:20pm: lunch + EBE Chalk Talks  
130-230pm: Introduction to R and data manipulation ½ class (Fifer and Davies)  
230-330pm: Introduction to R and data manipulation ½ class (Fifer and Davies)  
130-4pm: Experiments  
\*\*\*\* Discussion Groups 3&4 announce their papers

Thursday December 2<sup>nd</sup>: EXPERIMENTAL DAY 4

10-1015: Presentation: Team 1 organism biology + experimental design  
1015-1030: Presentation: Team 2 organism biology + experimental design  
1030-1045: Presentation: Team 3 organism biology + experimental design  
1045-11: Presentation: Team 4 organism biology + experimental design  
11-11:15: Presentation: Team 5 organism biology + experimental design  
1115-12pm: Experiments  
12-1: Lunch break  
1-4: Experiments

Friday December 3<sup>rd</sup>: EXPERIMENTAL DAY 5

**10am: Paper Discussion Summaries #2 Due to James electronically via email**  
10-1130: Discussion 2: Ocean Acidification: TBD and TBD (led by Group 1 and Group 2)  
1130-1230: Experiments  
1230-130pm: lunch  
130-4: Experiments  
\*\*\*\* Discussion Groups 5&6 announce their papers

Saturday December 4<sup>th</sup>: EXPERIMENTAL DAY 6

Experiments as needed - Isa available if seawater emergency comes up

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Sunday December 5<sup>th</sup>: EXPERIMENTAL DAY 7: James Fifer's Birthday!

Experiments as needed - Isa available if seawater emergency comes up

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Monday December 6<sup>th</sup>: EXPERIMENTAL DAY 8

**10am: Manuscript Introductions due electronically to Sarah via email!**  
10-11: Workshop: How to write an effective abstract (Davies)  
11-12: Lecture 12: Adaptation vs Plasticity (Davies)  
12-1pm: lunch  
1-4: Individual group check-ins for data structure  
1-4pm: Experiments

Tuesday December 7<sup>th</sup>: EXPERIMENTAL DAY 9

**10am: Paper Discussion Summaries #3 Due to James electronically via email**



10-11: Workshop: Basic statistics and visualization in R ½ class (Fifer and Davies)  
11-12: Workshop: Basic statistics and visualization in R ½ class (Fifer and Davies)  
10-12pm: Experiments  
12-1pm: lunch  
1-230: Discussion 3: Local stressors: TBD and TBD (Led by Groups 3 and 4)  
230-4 Experiments

Wednesday December 8<sup>th</sup>: EXPERIMENTAL DAY 10

10-1130pm: Experiments final measurements and preservation  
1130-1220: Lunch break  
1220-120pm: Lecture 13: Chalk Talk: Nicola Kriefall BRB 113  
3-4pm: Experiments final measurements and preservation

Thursday December 9<sup>th</sup>: EXPERIMENTAL Breakdown

11-12: Breakdown of experiments  
12-1pm: lunch  
1-4pm: Breakdown of experiments  
1-4pm: Touch base with James and Sarah about plan for data analysis- make individual meetings

Friday December 10<sup>th</sup>

**10am: Final grade on station cleanliness (James, Isa, and Justin)**  
**10am: Paper Discussion Summaries #4 Due to James electronically via email**  
10-1130: Discussion 4: Multistressors: TBD and TBD (Led by 3 people + 2 people)  
1130-1: lunch break  
1-3pm: Data analysis: open office hours  
3pm onwards: James and Sarah unavailable (Biology Department Holiday party)

Saturday December 11<sup>th</sup>

Sunday December 12<sup>th</sup>

Monday December 13<sup>th</sup>

**10am Manuscript methods due electronically to Sarah via email**  
10-11: Making Maps in R ½ class: Taught by Sarah and James  
11-12: Making Maps in R ½ class: Taught by Sarah and James  
12-1: lunch  
1-2: Workshop: How to write effective figure legends (Davies)  
2-4pm: Data analysis

Tuesday December 14<sup>th</sup>

10-11: Lecture 14: Dr. Colleen Bove: The influence of multiple stressors on corals

11-12pm: work on data analysis, visualization and writing  
12-1pm: lunch  
1-4pm: work on data analysis, visualization and writing

Wednesday December 15<sup>th</sup>

10-12pm: work on data analysis, visualization and writing  
12-1: lunch  
1:30-4pm: work on presentation

Thursday December 16<sup>th</sup>: LAST DAY OF CLASS

**Final Manuscript due 10am to Sarah via email**

10-12pm: Final Presentations BRB 113 20 mins/group (17 minute presentation + 3 minutes for questions)  
10am: Introduction to the symposium  
10:10-1030am: Group 1  
1030-1050: Group 2  
1050-1110: Group 3  
1110-1140: Group 4  
1140-12: Group 5  
12pm: Lunch as a team!