CAS/GRS New Course Proposal Form
This form is to be used when proposing a new CAS or GRS course.

This form should be submitted to Senior Academic Administrator Peter Law (617-353-7243) as a PDF file to pgl@bu.edu. For further information or assistance, contact Associate Dean Joseph Bizup (617-353-2409; jbizup@bu.edu) about CAS courses or Associate Dean Jeffrey Hughes (617-353-2690; hughes@bu.edu) about GRS courses.

DEPARTMENT OR PROGRAM: Biology, Earth & Environment, BU Marine Program (BUMP)

DATE SUBMITTED: November 30, 2016

COURSE NUMBER: CAS BI/ES 593

COURSE TITLE: Marine Physiology and Climate Change

INSTRUCTOR(S): Davies, Sarah W.

TO BE FIRST OFFERED: Sem./Year: Fall 2017

SHORT TITLE: The “short title” appears in the course inventory, on the Link University Class Schedule, and on student transcripts and must be 15 characters maximum including spaces. It should be as clear as possible.

| M | A | R | P | H | Y | S | C | L | I | M | A | T | E |

COURSE DESCRIPTION: This is the description that appears in the CAS and/or GRS Bulletin and The Link. It is the first guide that students have as to what the course is about. The description can contain no more than 40 words.

Explores the range of physiological responses marine organisms exhibit in response to climate change. Investigates the phenotypic plasticity exhibited across different organisms and how this plasticity can influence an organism’s resilience to its changing environment.

PREREQUISITES: Indicate “None” or list all elements of the prerequisites, clearly indicating “AND” or “OR” where appropriate. Here are three examples: “Junior standing or CAS ZN300 or consent of instructor”; “CAS ZN108 and CAS ZN203 and CAS PQ206; or consent of instructor”; “For SED students only.”

1. State the prerequisites:

BI108 (Cell and molecular biology, Mendelian & molecular genetics, physiology, and neurobiology) or permission of the instructor. In addition, admittance to the Marine Semester, which requires the student has taken at least one Marine Breadth class, is required.

2. Explain the need for these prerequisites:
CREDITS: (check one)

☐ Half course: 2 credits  ☐ Variable: Please describe.
☒ Full course: 4 credits  ☐ Other: Please describe.

Provide a rationale for this number of credits, bearing in mind that for a CAS or GRS course to carry 4 credits, 1) it must normally be scheduled to meet at least 150 minutes/week, AND 2) combined instruction and assignments, as detailed in the attached course syllabus, must anticipate at least 12 total hours/week of student effort to achieve course objectives.

The proposed research-based course will be part of the BUMP marine semester and will be taught over the course of 4 weeks during the fourth block of the semester (December). The course will include a balanced combination of lectures, literature review, student-led common garden laboratory, statistical analysis using R, oral presentations, and scientific writing. Students will be fully dedicated to the course during the 4-week period.

DIVISIONAL STUDIES CREDIT: Is this course intended to fulfill Divisional Studies requirements?

☒ No.
☐ Yes. If yes, please indicate which division ______________________ and explain why the course should qualify for Divisional Studies credit. Refer to criteria listed here and specify whether this course is intended for "short" or "expanded" divisional list.

HOW FREQUENTLY WILL THE COURSE BE OFFERED?

☐ Every semester  ☐ Once a year, fall  ☐ Once a year, spring  ☒ Every other year, Fall  ☐ Other: Explain:

NEED FOR THE COURSE: Explain the need for the course and its intended impact. How will it strengthen your overall curriculum? Will it be required or fulfill a requirement for degrees/majors/minors offered by your department/program or for degrees in other departments/school/colleges? Which students are most likely to be served by this course? How will it contribute to program learning outcomes for those students? If you see the course as being of “possible” or “likely” interest to students in another department/program, please consult directly with colleagues in that unit. (You must attach appropriate cognate comments using cognate comment form if this course is intended to serve students in specific other programs. See FURTHER INFORMATION below about cognate comment.)

The proposed BI/ES 593 course will be a new elective course available to undergraduate students enrolled in the BU Marine Semester, and to any interested graduate students in Biology or Earth and Environment. This course will focus on 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. This research-based course will therefore attract upper level undergraduate students interested in inquiry-based science and early career graduate students interested in designing their own physiological experiments in their dissertation research. This course will increase the multi-disciplinary nature of the BU Marine Program and will serve to expand the choices of currently available courses in the BU Marine Semester. The new course is also expected to benefit the curriculum in the following ways:
1. By providing experiential training in marine physiology and additional experience for students to design and implement their own research project, which is essential to a well-rounded education in marine science and science in general.

2. By reinforcing the research-based component of the BU marine program.

3. By helping recruit undergraduate students from other disciplines into the BU marine semester.

4. By helping increase the enrollment of graduate students, primarily from Biology and Earth and Environment and those interested in marine physiology and experimental design.

5. By developing students’ abilities to design and implement lab-based inquiries in small groups.

6. By helping students acquire important transferrable skills such as formulating research questions, data analysis, critical thinking, and written and oral communication.

ENROLLMENT: How many undergraduate and/or graduate students do you expect to enroll in the initial offering of this course?

A total of 8-12 students. At least 6 students are expected to be upper-level undergraduates enrolled in the BU Marine Semester, and the rest of the class is expected to be made up of Ph.D. students from Biology or Earth & Environment.

CROSS-LISTING: Is this course to be cross-listed or taught with another course? If so, specify. Chairs/directors of all cross-listing units must co-sign this proposal on the signature line below.

N/A

OVERLAP:

1. Are there courses in the UIS Course Inventory (CC00) with the same number and/or title as this course?
   - X No.
   - □ Yes. If yes, any active course(s) with the same number or title as the proposed course will be phased out upon approval of this proposal.
   
   NOTE: A course number cannot be reused if a different course by that number has been offered in the past five years.

2. Relationship to other courses in your program or others: Is there any significant overlap between this course and others offered by your department/program or by others? (You must attach appropriate cognate comments using cognate comment form if this course might be perceived as overlapping with courses in another department/program. See FURTHER INFORMATION below.)

   There is no overlap in the content of this course with other courses currently offered in Biology, Earth and Environment, or other departments.

   FACILITIES AND EQUIPMENT: What, if any, are the new or special facilities or equipment needs of the course (e.g., laboratory, library, instructional technology, consumables)? Are currently available facilities, equipment, and other resources adequate for the proposed course? (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

   This course will make use of resources from the BU marine program and the BU Department of Biology.

   BU Marine Program:
• BUMP will provide seawater facilities for a portion animal husbandry, controlled thermal experiments and analyses associated with the course.

**Department of Biology:**

• The Aquarium Research Facility and associated molecular biology laboratory (Dr. Davies) will be used for a portion animal husbandry, controlled thermal experiments and analyses associated with the course.

• Conference room will be used for lectures, presentations, and paper discussions.

**STAFFING:** How will the staffing of this course, in terms of faculty and, where relevant, teaching fellows, affect staffing support for other courses? For example, are there other courses that will not be taught as often as now? Is the staffing of this course the result of recent or expected expansion of faculty? (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

*This course will be taught by a new hire in the Biology department (Davies) and will not adversely affect net departmental course staffing. The course will be taught every other year (commencing in 2017).*

**BUDGET AND COST:** What, if any, are the other new budgetary needs or implications related to the start-up or continued offering of this course? If start-up or continuation of the course will entail costs not already discussed, identify them and how you expect to cover them. (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

**Experimental and laboratory work:** Equipment and facilities from the Aquarium Research Facility and associated molecular biology laboratory (The Davies Lab) will be used for running independent experiments, sample preparation and analysis. The equipment present in the lab will be purchased using Dr. Davies’ start-up funds and research grants, but some money will be required for equipment maintenance/calibration and for purchasing supplies. Details regarding budget are provided in the table below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Supplies</td>
<td>Organism shipment/ physiological measurement equipment</td>
<td>3,500</td>
</tr>
<tr>
<td></td>
<td>Laboratory-based physiological quantification (protein, carbohydrate, etc)</td>
<td>1,500</td>
</tr>
<tr>
<td>Equipment Maintenance/seawater lab maintenance</td>
<td>Seawater and Molecular lab equipment maintenance</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td><strong>6,000</strong></td>
</tr>
</tbody>
</table>

**EXTERNAL PROGRAMS:** If this course is being offered at an external program/campus, please provide a brief description of that program and attach a CV for the proposed instructor.

**FURTHER INFORMATION THAT MUST BE ATTACHED IN ORDER FOR THIS PROPOSAL TO BE CONSIDERED:**

• A complete week-by-week SYLLABUS with student learning objectives, readings, and assignments that reflects the specifications of the course described in this proposal; that is, appropriate level, credits, etc. (See guidelines on “Writing a Syllabus” on the Center for Teaching & Learning [website].) Be sure
that syllabus includes your expectations for academic honesty, with URL for pertinent undergraduate or GRS academic conduct code(s).

- Cognate comment from chairs or directors of relevant departments and/or programs. Use the form here under “Curriculum Review & Modification.” You can consult with Joseph Bizup (CAS) or Jeffrey Hughes (GRS) to determine which departments or programs inside and outside of CAS would be appropriate.

DEPARTMENT CONTACT NAME AND POSITION:

DEPARTMENT CONTACT EMAIL AND PHONE:

DEPARTMENT APPROVAL: ____________________________ 12/22/16
Department Chair

__________________________ 12/20/16
Other Department Chair(s) (for cross-listed courses) Date
CAS/GRS CURRICULUM COMMITTEE APPROVAL:

☐ Approved Date:____________________
☐ Tabled Date:____________________
☐ Not Approved Date:____________________

Divisional Studies Credit:

☐ Endorsed

☐ HU
☐ MCS
☐ NS
☐ SS

☐ Not endorsed

______________________________________________________________
Curriculum Committee Chair Signature and Date
Comments:

PROVISIONAL APPROVAL REQUESTED for Semester/Year ___________________

______________________________________________________________
Dean of Arts & Sciences Signature and Date
Comments:

CAS FACULTY: Faculty Meeting Date: ____________________  ☐ Approved  ☐ Not Approved

______________________________________________________________
Curriculum Administrator Signature and Date
Comments:
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 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 intertidal invertebrates native to the coast of New England 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 CO₂ 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 in order to familiarize the 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 (2-3 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. Students 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.

Final Exam

A final exam will be given during the last week that will test your understanding of the fundamentals of physiology and climate change acquired during the course.

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.

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
</table>
| Week 1 | 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 |
| 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  
Final exam |

**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. Students will also be evaluated based on a final exam during the last week of the course that will assess. No late work will be accepted.

**Summary**

- Laboratory work performance: 25%
- Literature discussion: 15%
- Final exam: 20%
- Final research project  
  - Manuscript: 25%
  - Oral presentation: 15%

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Letter</th>
<th>GPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>93-100</td>
<td>A</td>
<td>4.0</td>
</tr>
<tr>
<td>90-93</td>
<td>A-</td>
<td>3.7</td>
</tr>
<tr>
<td>87-90</td>
<td>B+</td>
<td>3.3</td>
</tr>
<tr>
<td>83-87</td>
<td>B</td>
<td>3.0</td>
</tr>
<tr>
<td>80-83</td>
<td>B-</td>
<td>2.7</td>
</tr>
<tr>
<td>77-80</td>
<td>C+</td>
<td>2.3</td>
</tr>
<tr>
<td>73-77</td>
<td>C</td>
<td>2.0</td>
</tr>
<tr>
<td>70-73</td>
<td>C-</td>
<td>1.7</td>
</tr>
<tr>
<td>60-70</td>
<td>D</td>
<td>1</td>
</tr>
<tr>
<td>&lt;60</td>
<td>F</td>
<td>0</td>
</tr>
</tbody>
</table>

**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.
Example discussion publications:

Kenkel et al., 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: 4335-4348.


**Academic Conduct**

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


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.