DALHOUSIE UNIVERSITY

Syllabus:

Hacking the blue planet: the scientific and social dimensions of ocean fertilization

MARI/OCEA 4665 BIOL/OCEA 5665
T/Th 16:05-17:25 LSC Common 216

Instructor: *Erin Bertrand* erin.bertrand@dal.c*a* *office: 902- 494-1853* *LSC BIOL 5076B*

Lectures: *Three lecture hours per week*

Office Hours: By appointment; email to arrange anytime

Course Description

This course explores the biology, ecology, biogeochemistry and ethical and legal dimensions of purposeful ocean fertilization. Through lectures, discussion, case studies, and group projects, students consider the biological and oceanographic basis of ocean fertilization and its use as a 1) scientific tool and 2) controversial geoengineering strategy for climate change mitigation.

In the 1980's, the scientific community began discussing the possibility that purposeful ocean fertilization could cause large-scale phytoplankton blooms with the potential to influence climate. Open ocean iron fertilization experiments began in the early 1990's and have continued into the current decade. These iron additions often resulted in large phytoplankton blooms, but the fate of the resulting biomass remained unclear. Ocean fertilization has been surrounded by scientific, ethical and legal controversies. It has received attention as a potential climate change mitigation strategy, a tool for basic oceanography research, and even as a method for revitalizing fish stocks. In this class, ocean fertilization will be used as a starting point from which to teach concepts including ecological stoichiometry, planktonic ecosystem structure and function, as well as order of magnitude calculations. The course will then bridge from biophysical sciences into the social realm, and students will use the knowledge they've gained about relevant biology and oceanography to evaluate various claims about ocean fertilization as a climate and fisheries engineering strategy. Through case study discussions, the class will explore the ethical and legal dimensions of such engineering strategies. This course will expose students to structured reading, discussion and synthesis of primary literature and will provide opportunities for improving cross-disciplinary communication, writing, and critical thinking skills.

Course Prerequisites

For 4665.03: one of the following: BIOL 3101.03, OCEA 2000X/Y.06, ERTH 3601.03, BIOL 3060.03 or Instructor's permission
For 5665: Instructor's permission

Key knowledge or skills expected of students coming into the course
Students will be expected to have a very basic understanding of planktonic marine ecosystems. This class, however, will be suitable for students with a wide range of backgrounds since it explores inherently interdisciplinary topics.

Course Objectives:

Students will come away from this class being able to discuss:

- *The roles of ocean biology in shaping global climate*
- *The concept of ecological stoichiometry and its implications for marine sciences*
  Ecological stoichiometry: the notion that observed patterns in biochemical use of elements at the molecular level may be directly connected with phenomena at the ecosystem or even global level
- *The nature of conflicts that arise at the intersection of basic research and applied science*
- *Ethical, legal, and policy implications of ecosystem and geoengineering schemes*

Students will have gained practical experience in:

- *Synthesizing and interpreting primary literature*
- *Making order of magnitude calculations and estimations to arrive at approximate solutions to complex problems*
- *Writing, peer reviewing, and presenting a formal research proposal*
- *Working in interdisciplinary teams*

Course Materials

All materials will be made available via the course Brightspace page. These include primary literature and perspective pieces from scientific journals as well as select chapters from textbooks including:

- *Sterner and Elser, Ecological Stoichiometry*
- *Harte, Consider a Spherical Cow*
- *Frausto da Silva and Williams, Biological Chemistry of the Elements*
- *Libes, Marine Biogeochemistry*

Readings for each class will be available two weeks ahead of time on the course Brightspace page.
A particularly excellent web-based resource for content on ocean iron fertilization is:
https://web.whoi.edu/ocb-fert/

Course Format: In general, Tuesday and the first half of Thursday classes will be comprised of lecture and group activities led by the Instructor. The second half of Thursday classes will be student-led discussions, with two Peer Discussion Leaders designated. These will focus on 2-3 readings from primary literature, review articles, or opinion pieces from the literature.

Discussion leader responsibilities: Peer discussion leaders should come to class prepared to co-lead discussion on the assigned readings for the week for the last 30 minutes of class on their assigned days. This could consist of preparation of slides to highlight key figures or points, discussion questions, or prepared activities. Leaders for each day should get together to discuss and plan ahead of class such that each co-leader participates. Suggested approaches for discussion leading are provided on the Brightspace page

Course Content and Schedule

(schedule is subject to change; consult Brightspace regularly for updates and details)

Tues Sept 3, Thurs Sept 5: History of ocean fertilization, climate crisis context. Course overview, research proposal and critical literature summary introduction

Tues Sept 10, Thurs Sept 12, Tues Sept 17, Thurs Sept 19 Phytoplankton physiology, ecological stoichiometry, and nutrient acquisition

Tues Sept 24, Thurs Sept 26, Tues Oct 1, Thurs Oct 3: Microbial loop, biological pump, unintended consequences, and the paleo-oceanographic perspective

Tues Oct 8, Thurs Oct 10: Writing and reviewing research proposals; Proposal Topic Workshop; results of iron fertilization experiments to date

Tues Oct 15, Thurs Oct 17: Related geoengineering schemes

Tues Oct 22, Thurs Oct 24: **Case Study 1**: LOHAFEX and international governance

Tues Oct 29: NO CLASS - watch and reflect on video content in your critical summary

Thurs Oct 31: In-class proposal workshopping

Tues Nov 5, Thurs Nov 7: Ethics and Ocean Fertilization

Tues Nov 12, Thurs Nov 14: Fall Study Break

Tues Nov 19, Thurs Nov 21: **Case Study 2**: Haida Salmon Restoration Corporation, Oceaneos and planned 'experiments'

Tues Nov 26 and Thurs Nov 28: **Proposal Presentations**

Course Assessment

Component	Weight (% of final grade)	Due Date
Problem Set 1	15%	Thurs Oct 10 (Assigned Sept 26)
Problem Set 2	15%	Tues Nov 19 (Assigned Oct 31)
Weekly Critical Summaries	35%	Sept 12, 19, 26; Oct 3, 10, 17, 24, 31; Nov 7, 21
Discussion-leading and class participation	10%	
Research proposal	25%	Dec 10- see below for additional deadlines

Problem Sets (30%) Two equally weighted take-home problem sets including calculations and short answer questions on the following topics:

1. Phytoplankton stoichiometry, microbial loop, biological pump
2. Synthesis: where natural science meets policy, legal, and ethical dimensions of eco- and geoengineering schemes

Problem set policies: Students are free to work together and to use any lecture, course or other resources to work on these problems. If you work with another student or receive help from some other living resource, *include their name at the top of your problem set*. Problem sets will be assigned two full weeks before they are due but should not take you more than 8h total to complete.
Show all your work in submitted documents. Problem sets must be uploaded to Brightspace by the due date and time and must ALSO be handed in, on paper, during the next class period

Weekly Critical Summaries (35%) 300-500 word critical summaries of the week's reading assignments. Examples of critical summaries will be discussed in the first week of class. Each of the eleven critical summaries is equally weighted and the one lowest mark will be discarded. Critical summaries will be submitted via upload to Brightspace by 4 pm on the due date and are not required to be submitted on paper.

Weekly Summary marking scheme for UNDERGRADUATES

Criteria For	**Indicators**
Undergraduates	The student demonstrates that they: • have completed the assigned reading (60%) • have developed an understanding of how these readings relate to broad themes in the course (30%) • identify key weaknesses or raise insightful questions when readings include primary scientific literature (10%)
Graduate Students	The student demonstrates that they: • have completed the assigned reading (40%) • have developed an understanding of how these readings relate to broad themes in the course (30%) • identify key weaknesses or raise insightful questions when readings include primary scientific literature (30%)

Discussion Leading and Class Participation (10%) Students are expected to attend and participate in all classes and to effectively lead discussion on their assigned day.

Discussion leading and participation evaluation rubric:

Criteria	**Indicators**
Discussion leading (40%)	The student came well-prepared to lead discussion at the allotted time and effectively facilitated an active discussion
Frequency of participation in discussions (25%)	The student is actively engaged in class discussion at all times.
Quality of contributions (35%)	The student's comments are constructive and relevant; comments reflect a considered understanding of the week's reading materials and course aims.

Research Proposal (25%) Undergraduates in groups of 2-3 students, or graduate students as individuals: propose a research project to answer what you perceive to be a remaining key question about ocean fertilization, another aspect of ecological stoichiometry, or geoengineering more generally. The question can be a basic science question or one that bridges the social and biophysical sciences. Proposals will be 7-10 pages single spaced including figures and tables, and excluding references. Each student will individually review one other draft proposal. Each proposal will also be presented and defended in a 15-minute oral presentation with 5 minutes for questions. Principles of peer review and proposal writing will be discussed in class. Each component will be submitted via Brightspace; paper copies are not required but will be accepted in addition to Brightspace uploads.

Proposal Due Dates and Marking Scheme:

5% Proposal topic and one-paragraph summary due Oct 21
15% 1st draft of proposal due Nov 4
20% Peer review of other group's proposals due Nov 18
20% Presentation- Nov 26 or 28
40% Final proposal due Dec 10

Draft Proposal Marking Rubric

Criteria	**Indicators**
Format (20%)	Follows page length, spacing guidelines. Citations are properly formatted and consistent. Students may choose any citation format employed by a journal they cite in their proposal.
Clarity (30 %)	The proposal should be written for a scientifically- literate but non-specialist audience. The writing style is clear, focused and does not employ large amounts of technical jargon.
Innovation (30%)	The proposal identifies an outstanding problem or question and articulates a useful and innovative approach to solving that problem or answering that question.
Support (20%)	The proposal cites and synthesizes appropriate literature to support the topic choice and effectively places the proposal topic in context with current knowns and unknowns while avoiding plagiarism.

Final Proposal Marking Rubric

Criteria	Indicators
Format (15%)	Follows page length, spacing guidelines. Citations are properly formatted and consistent. Students may choose any citation format employed by a journal they cite in their proposal.
Clarity (25 %)	The proposal should be written for a scientifically- literate but non-specialist audience. The writing style is clear, focused and does not employ large amounts of technical jargon.
Innovation (25%)	The proposal identifies an outstanding problem or question and articulates a useful and innovative approach to solving that problem or answering that question.
Support (15%)	The proposal cites and synthesizes appropriate literature to support the topic choice and effectively places the proposal topic in context with current knowns and unknowns while avoiding plagiarism.
Revision (20%)	Productively incorporates constructive criticism given by instructor and peer reviewer into an improved final proposal submission.

Peer Review Marking Rubric

Criteria	Indicators
Format (25%)	Adheres to the guidelines and evaluation criteria provided.
Constructive feedback (75%)	Clearly and constructively identifies areas in which the proposal can be improved, either in content or in presentation.

Presentation Marking Rubric

Criteria	Indicators
Format (25%)	Adheres to time limit guidelines for both presentation and question and answer period.
Clarity of oral presentation (25%)	Presents the problem/ question, its significance, the approach taken and the expected outcomes clearly for a scientifically literate but non-specialist audience.
Clarity of slides (25%)	Effectively uses figures, images, and minimal text on slides for the purpose of enhancing the clarity of the presentation.
Responses to questions (25%)	Demonstrates a clear understanding of the topic of discussion in responses to questions.

Conversion of numerical grades (%) to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (<50)
A- (80-84)	B- (70-72)	C- (55-59)	

NOTE THAT GRADUATE STUDENTS REQUIRE A B- (70%) OR BETTER TO PASS

Evaluation Definitions and Schema: In addition to the rubrics provided above, which articulate the criteria evaluated in each assignment, students should be aware of the definitions and evaluation schema that will be used for assigning numerical grades to written assignments and presentations:

Grade	Point	%	Definition	Notes
A+	4.3	90-100	Exceptional	Exceptional work- exceeds expectations; high order, original thinking, research, critical evaluation skills; extraordinary analysis and synthesis skills; excellent grasp of subject matter and command of relevant literature
A	4.0	85-89	Excellent	High order, original thinking, research and critical evaluations skills; excellent analysis and synthesis skills; excellent grasp of subject matter and command of relevant literature
A-	3.7	80-84	Very Good	Evidence of strong original thinking, research and critical evaluations skills; very good analysis and synthesis skills; very good grasp of subject matter and command of relevant literature
B+	3.3	77-79		
B	3.0	73-76	Good	Evidence of some original thinking, research and critical evaluations skills; sufficient analysis and synthesis skills; good grasp of subject matter and command of relevant literature
B-	2.7	70-72		
F	0	0-69	Failure	Insufficient evidence of original thinking, research and critical evaluations skills; poor grasp of subject matter and command of relevant literature or failure to complete assignments on time or according to course specification
INC			Incomplete	Extensions available only in exceptional circumstances
ILL			Illness, compassionate reasons	Documentation must be submitted to instructor within one week of due date
W			Withdrew after deadline	Registrar assigns this

Course Policies

Complete attendance of all lectures is highly recommended, and class participation is key.

Late assignments: 10% reduction in grade for every day an assignment is late. Extenuating circumstances will be considered; contact the instructor as soon as possible, within one week of the assignment due date.

Assignment submission: Assignments should be submitted via Brightspace with the following file naming format: Jane Doe, problem set 1, submission date Sept 27th 2016: File name: JDoe_PS1_20160927

Brightspace will be used for regular updates and announcements; students are responsible for regularly monitoring this space.

Plagiarism detection software may be used at any time during evaluations in this course.

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.
Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).
Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.
Code: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness
Statement: http://www.dal.ca/cultureofrespect.html

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates)
https://www.dal.ca/academics/important_dates.html

University Grading Practices
https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Missed or Late Academic Requirements due to Student Absence (policy)
https://www.dal.ca/dept/university_secretariat/policies/academic/missed-or-late-academic-requirements-due-to-student-absence.html

Student Resources and Support

Advising

General Advising https://www.dal.ca/campus_life/academic-support/advising.html

Science Program Advisors: https://www.dal.ca/faculty/science/current-students/academic-advising.html

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Black Students Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports

Library: https://libraries.dal.ca/

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Studying for Success: https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Copyright Office: https://libraries.dal.ca/services/copyright-office.html

Fair Dealing Guidelines https://libraries.dal.ca/services/copyright-office/fair-dealing.html

Other supports and services

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html

Student Advocacy: https://dsu.ca/dsas

Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Safety

Biosafety: https://www.dal.ca/dept/safety/programs-services/biosafety.html

Chemical Safety: https://www.dal.ca/dept/safety/programs-services/chemical-safety.html

Radiation Safety: https://www.dal.ca/dept/safety/programs-services/radiation-safety.html

Scent-Free Program: https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html