GE-3xx: Oceans and Global Change

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Course Description
We are entering an era of accelerated change in Earth's systems, and many profound effects are occurring or are predicted to occur in the oceans. In this course students will explore topics such as the impacts of ice melt and increasing temperatures on ocean circulation; the spread of low-oxygen conditions and ocean acidification; shifts in marine species distributions and the loss of biodiversity; the implications of ocean-related geoengineering; and the effects of human resource extraction from the sea. Discussion and writing assignments will center around readings taken from the primary oceanographic literature, and will emphasize the role of Earth system models in predictions of future change. Prerequisites are: GE-112, GE-211, or permission of the instructor.

Class Meetings
[Day, time], 4 hours per week, [Classroom]

Learning Goals
Students completing this course will be able to:

- Understand the different timescales of change in the modern and future ocean;
- Discuss the direct and indirect effects on the ocean of planetary warming, anthropogenic carbon dioxide uptake, and release of pollutants.
- Understand the geologic and anthropogenic processes that have altered the functioning of ocean systems in the recent past, and are predicted to do so in the future;
- Efficiently search for, access, and synthesize the primary scientific literature on the topic of global change in the oceans

Geoscience Writing in the Major Learning Goals
Students should be able to:

- synthesize and cite information from a variety of sources in their writing;
- articulate clearly hypotheses and methods for scientific research in their writing;
- develop proficiency in expressing results, including addressing uncertainty in the findings;
- convey the implications of findings for the geosciences community and/or the public through their writing; and
- write effective independent and collaborative pieces.

Course format
The assessment and prediction of change in the modern, global ocean – particularly changes that are due to anthropogenic causes – is a relatively new and rapidly-expanding field of science. As

such, there are few comprehensive textbooks on the topic. In this course, we will rely primarily on peer-reviewed research papers and review articles (the "primary" and "secondary" literature) to build our understanding of this important topic. We will divide class time between 1) lecture, computer modeling and analytical activities, and discussion of assigned readings on a topic, and 2) in-class literature research, discussion, and short writing assignments based on supporting articles that deepen our understanding of that topic. Early in the semester I will help guide the class as we learn to locate, understand, and summarize the relevant papers on each topic; as the term continues students will take on more of the responsibility for directing readings and discussion. A mid-term written exam will assess your understanding of the scientific concepts covered in the first half of the course. The final assignment for the course will be an individual literature research paper on an aspect of global change in the ocean.

Class Policies

Attendance: As with any class, attendance and active participation are key. When you are absent or unprepared, it not only impacts your own learning experience, but also that of your classmates. I will strive to be on time and prepared for every class, and I expect the same from all students. If you are late once or twice it's OK, but please enter quietly and find a seat quickly. If you are sick, please rest and recover – but also inform me ahead of your absence. Unless you have a true emergency (for which I will expect documentation), a quick email ahead of class is all it takes. If I excuse your absence, I will still expect you to turn in any written assignment that was due, and make up any missed in-class work. Each *unexcused* absence from class will result in a 2% penalty to your final grade, plus a zero for any work due that day. Legitimate conflicts must be cleared with me well in advance.

Electronic Devices: Electronic devices and cell phones are allowed in class as long as they *do not distract you or those around you.* This means, for example, that cell phones must be silenced, and laptops used only for activities immediately relevant to this class (e.g., note-taking, data analysis, or when the class is actively researching a topic online). This policy, in which electronic devices are present but silent and unobtrusive, reflects the norms of the professional world that you will enter after you graduate. However, if I notice that you or your neighbors are distracted by your device(s), I reserve the right to restrict their use by everyone, for the remainder of the semester. Electronic devices and cell phones are not allowed during quizzes or exams.

A note on laptop computers and notetaking – While many of us can type faster than we write by hand, research shows that we don't learn as well when we take notes on laptop computers. There are two reasons. The first is obvious: an internet-connected computer offers distractions that take enormous willpower to ignore! The second reason is that your slower handwriting speed forces you to digest, paraphrase, and organize the ideas in the class. These are the first steps of knowledge retention. Therefore, while laptop notetaking is not prohibited, I urge you to consider taking notes the old-fashioned way, then revisiting your notes as necessary during your out-of-class study time to fill in any missing details.

Access and Office Hours: I am available for drop-in meetings during my posted office hours. If you are unable to meet during those times, you are welcome to make an appointment with me at a mutually convenient time. The best ways to set a meeting are to catch me in class or email me.

You can also reach me by calling my office. I respond to student messages as quickly as possible, and you can expect a response to e-mail requests typically within 48 hours and often much sooner.

Academic Integrity: Plagiarism, cheating, and other violations of academic integrity will not be tolerated, and will result in consequences in accordance with the Skidmore College Student Handbook, https://www.skidmore.edu/student_handbook/honor-code.php. When writing any kind of academic document, sources of information, including internet sources, must be properly cited, in accordance with the Skidmore College Honor Code. Detailed instructions regarding citation conventions are available from the Library.

Group work: You will be working closely with your classmates to read and present papers, and to complete in-class activities. However, *individual written assignments* must be your own. For each group presentation, I will ask each group member for a brief evaluation of their own and their team members' contributions to the total effort.

Students with disabilities. If you are a student with a disability and believe you need academic accommodations in this or any class you must make requests for such accommodation to Meg Hegener, the Coordinator for Students with Disabilities. You will also need to provide documentation which verifies the existence of a disability in support of your request. Accommodations must be approved in advance of exams to allow time to make any supporting arrangements. For further information and assistance with this process, call 580-8150, or stop by Student Academic Services in Starbuck.

Title IX: Skidmore College considers sexual and gender-based misconduct to be one of the most serious violations of the values and standards of the College. Unwelcome sexual contact of any form is a violation of students' personal integrity and their right to a safe environment and therefore violates Skidmore's values. Sexual and gender-based misconduct is also prohibited by federal regulations. Skidmore College faculty are committed to supporting our students and upholding gender equity laws as outlined by Title IX. If a student chooses to confide in a member of Skidmore's faculty or staff regarding an issue of sexual or gender-based misconduct, that faculty or staff member is obligated to tell Skidmore's Title IX Coordinator or Title IX Deputy Coordinator. The Title IX Coordinator or Deputy Coordinator will assist the student in connecting with all possible resources for support and reporting both on and off campus. Identities and details will be shared only with those who need to know to support the student and to address the situation through the college's processes. If the student wishes to confide in a confidential resource, The Counseling Center Staff, Health Services, and Victim Advocates are all options available.

More information can be found at https://www.skidmore.edu/sgbm/ or by contacting the Title IX Coordinator or Deputy Coordinator.

Grading breakdown and major due dates

Assignment	Percentage of final grade	Due date (subject to change)
Participation and written reading responses	20	Every class
Peer review essay	5	
Reading presentations and discussion leadership	10	Throughout semester
Midterm exam	20	In class
Ecosystem modeling report	5	
Outline and annotated bibliography for final paper	5	
Draft of final paper	10	
Revised final paper	20	Last day of class
Presentation of final paper	5	Final exam period (attendance is required)

Tentative Schedule (continued on next page, and subject to change!)

Note that primary readings and follow-up questions are due on most Thursdays. Additional, supporting readings will be selected in class on Thursdays and presented and discussed the following Tuesday.

Class dates	Tuesday	Thursday
1:	No class	Syllabus, overview, and timescales of change
2:	Reading and researching the scientific literature. Introduction to reference management systems. *Reading: Doney, 2010*	Lecture/group research: Measuring change *Reading: Church et al. 2013*
3:	Discussion: Timeseries measurements and models **Peer review essay due**	Lecture/group research: Planetary warming *Reading: Roemmich et al, 2015*
4:	Discussion: Planetary warming	Lecture/group research: Sea ice loss and sea level rise *Reading: Cazanave and Llovel 2010*
5:	Discussion: Sea ice loss and sea level rise	Lecture/group research: CO_2 and acidification *Reading: Feely et al. 2009*
6:	Discussion: CO_2 and acidification	Exam review and and discussion of final paper assignments
7:	**Midterm exam (in class)**	Lecture/group research: Deoxygenation *Reading: Keeling et al., 2010*
8:	Discussion: Deoxygenation	Lecture/group research: Ecosystem shifts *Reading: Doney et al. 2012*
9:	Discussion: Ecosystem shifts **Final paper outline/annotated bibliography due**	In-class activity: Ecosystem modeling *Reading: Dutkiewicz et al. 2013*
10:	In-class activity: Ecosystem measurements.	Lecture/group research: Mercury pollution *Reading: Lamborg et al. 2014*

Class dates	Tuesday	Thursday
	Reading: Steinberg et al., 2012. **Ecosystem modeling report due**	
11:	Discussion: Mercury pollution	Lecture/group research: Plastic pollution *Reading: Cozar et al., 2014*
12:	Discussion: Plastic pollution **Draft of final paper due**	No class (Thanksgiving)
13:	Lecture/group research: Geoengineering *Reading: Boyd et al., 2000*	In-class activity: Iron fertilization of the oceans
14:	Lecture/group research: The Oceans in the Anthropocene? *Reading: Waters et al., 2016*	Wrap up. Final papers due.
Final exam: Presentation of your paper to your classmates. Attendance required.		

Primary readings. You will supplement these with additional readings from the scientific literature each week.

Boyd, P. W., A. J. Watson, C. S. Law, and others. 2000. A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization. Nature **407**: 695–702.

Cazenave, A., and W. Llovel. 2010. Contemporary Sea Level Rise. Annual Review of Marine Science **2**: 145–173. doi:10.1146/annurev-marine-120308-081105

Church, M. J., M. W. Lomas, and F. Muller-Karger. 2013. Sea change: Charting the course for biogeochemical ocean time-series research in a new millennium. Deep Sea Research Part II: Topical Studies in Oceanography **93**: 2–15. doi:10.1016/j.dsr2.2013.01.035

Cozar, A., F. Echevarria, J. I. Gonzalez-Gordillo, and others. 2014. Plastic debris in the open ocean. Proceedings of the National Academy of Sciences **111**: 10239–10244. doi:10.1073/pnas.1314705111

Doney, S. C. 2010. The Growing Human Footprint on Coastal and Open-Ocean Biogeochemistry. Science **328**: 1512. doi:10.1126/science.1185198

Doney, S. C., M. Ruckelshaus, J. Emmett Duffy, and others. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science **4**: 11–37. doi:10.1146/annurev-marine-041911-111611

Dutkiewicz, S., J. R. Scott, and M. J. Follows. 2013. Winners and losers: Ecological and biogeochemical changes in a warming ocean. Global Biogeochemical Cycles **27**: 463–477. doi:10.1002/gbc.20042

Feely, R. A., S. C. Doney, and S. R. Cooley. 2009. Ocean acidification: present conditions and future changes in a high-CO2 world.

Keeling, R. F., A. Körtzinger, and N. Gruber. 2010. Ocean Deoxygenation in a Warming World. Annual Review of Marine Science **2**: 199–229.

Lamborg, C. H., C. R. Hammerschmidt, K. L. Bowman, and others. 2014. A global ocean inventory of anthropogenic mercury based on water column measurements. Nature **512**: 65–68.

Roemmich, D., J. Church, J. Gilson, D. Monselesan, P. Sutton, and S. Wijffels. 2015. Unabated planetary warming and its ocean structure since 2006. Nature Clim. Change **5**: 240–245.

Steinberg, D. K., M. W. Lomas, and J. S. Cope. 2012. Long-term increase in mesozooplankton biomass in the Sargasso Sea: Linkage to climate and implications for food web dynamics and biogeochemical cycling. Global Biogeochemical Cycles **26**. doi:doi:10.1029/2010GB004026

Waters, C. N., J. Zalasiewicz, C. Summerhayes, and others. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. Science **351**: aad2622-aad2622. doi:10.1126/science.aad2622