Syllabus: SIO 143
Ocean Acidification Spring quarter 2022

Lectures: Tuesday & Thursday   11:00-12:20   VH100 or Zoom via Canvas
Discussions: Thursday   12:30-13:20   VH100 or Zoom via Canvas

Instructor: Professor Andreas Andersson
Contact: aandersson@ucsd.edu
Office hours: Tuesday & Thursday after lecture or by appointment

General information

Objectives: The objective of this class is to provide a broad understanding of the problem of ocean acidification (OA) and its potential effects and consequences to the Earth's geobiosphere on timescales ranging from decades to 100,000s of years. To understand the problem of OA it is critical to have a good understanding of seawater CO_2 chemistry and how physical, chemical, geological and biological processes affect and interact with the marine CO_2 system. Thus, the intricacies of this system will be reoccurring topics throughout this class as we explore the effects of OA on biogeochemical processes, organisms, ecosystems, food webs, and human communities. Different experimental approaches, basic chemical measurements, calculations and modeling approaches will also briefly be covered.

Lecture format: Classes will predominantly be taught in person in VH100, but with some occasional remote lectures on Zoom only. Synchronous participation is strongly recommended, but all lectures will be recorded for those that are unable to attend every lecture. Note though that ***the midterm is an in class exam***.

Announcements and Course specific materials: Please consult Canvas

Reading material and computational tools

Textbooks: The lectures will mostly follow the chapters in Gattuso & Hansson (2011) *Ocean Acidification*. The relevant chapters will be available in Canvas. The eBook is also freely available via the UCSD library but you need to use a VPN connection if you are off-campus. Information of how to connect from off-campus can be found here: https://library.ucsd.edu/computing-and-technology/connect-from-off-campus/. In addition, students will be provided relevant material from Zeebe & Wolf-Gladrow (2001). Some material may also be used from Riebesell et al. (2010) and Mackenzie & Andersson (2013), which can be downloaded for free online. Note that there is a scam site that is trying to charge money for the Riebesell book – do not pay for it!

- Gattuso & Hansson, 2011. *Ocean Acidification*. Oxford University Press, 326 p. Access: https://ebookcentral.proquest.com/lib/ucsd/detail.action?docID=1114960

- Zeebe & Wolf-Gladrow, 2001. *CO_2 in seawater: equilibrium, kinetic, isotopes.* Elsevier, 346 p.

- Riebesell et al., 2010. *Guide to best practices for ocean acidification research and data reporting*. European commission, 258 p. Available online at: https://op.europa.eu/en/publication-detail/-/publication/51887496-10b6-4b42-9876-1c2a1346fac5

- Mackenzie & Andersson, 2013. *The marine carbon system and ocean acidification during Phanerozoic time.* Geochemical Perspectives, vol 2, 227 p. Available online at: https://www.geochemicalperspectives.org/online/v2n1

Articles: In addition to readings from the textbooks you will be assigned to read several scientific articles. On occasion we will discuss these articles in class and it is critical that you have read the articles prior to class or at a minimum read the abstract and looked at the figures.

Computer software: As part of the class you will be asked to carry out a number of calculation and modeling exercises using CO2SYS. You are welcome to use any version of this (Excel, Matlab, etc). The Excel version will be available on Canvas and the Matlab version is available at: https://www.nodc.noaa.gov/ocads/oceans/CO2SYS/co2rprt.html. For those students that are using R, you are welcome to use Seacarb for your calculations.

Assignments, Exams and Grading

Assignments: Reading assignments and computational exercises will be given throughout the course. It is expected that each student will complete these. Collaboration is encouraged.

Quizzes: There will be a weekly quiz based on the material covered in class and in the assigned readings for that week. The quizzes will be available on Fridays and due the following Thursday.

Exams: There will be one midterm and one final exam. The midterm will be an in-class exam and the final will be a take-home exam. It is expected that you complete the exams independently.

Term project: A term project will be assigned during the second or third week of class. As part of this project you will have to give a short presentation and submit a final paper.

Discussion section: The discussion section is not mandatory and will mainly focus on addressing general questions, homework, or reviewing material covered in the class.

Expectations: To succeed in the class, students are expected to complete the following:

- Read assigned readings before lectures each week.
- Participate or view recordings of lectures.
- Actively participate in lectures by asking questions, answering questions, and contribute to discussions. If you are unable to participate synchronously, please submit questions via email.
- Complete weekly quizzes on Canvas.
- Complete computational assignments.
- Complete midterm exam.
- Complete final exam (take home, open book).
- Present term project and submit term paper.

Grading: The main objective is that you learn something from this class. You will have the opportunity to demonstrate this by showing your knowledge and understanding during a midterm and final exam, assignments, quizzes, term project, and participation (i.e., ask questions and participate in discussions). Letter grade or P/NP is permitted (note that a P requires a C- or better).

Participation	10%
Problem sets	10%
Quizzes	10%
Midterm exam	25%
Take-home final exam	20%
Term project	25%

Extra credit, late submissions etc.: No extra credit is given as part of this class. I also understand that life sometimes get in the way of submitting things on time. That is OK and there is some flexibility within reasonable bounds. Once the correct answers are posted I cannot accept any late submissions and there is no way for making up for any missed opportunities unless you have a documented emergency.

Maintaining academic integrity:
Students agree that by taking this course all required papers will be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the terms of use agreement posted on the Turnitin.com site. This course will also adhere to the standard UCSD policy on academic integrity: "Students are expected to do their own work, as outlined in the UCSD Policy on Integrity of Scholarship. Cheating will not be tolerated, and any student who engages in forbidden con- duct will be subjected to the disciplinary process. Cheaters will receive a failing grade on the assignment or the exam and/or in the entire course. They may also be suspended from UCSD." See http://www-senate.ucsd.edu/manual/Appendices/app2.htm for details.

Discrimination and harassment
The University of California, in accordance with applicable federal and state laws and university policies, does not discriminate on the basis of race, color, national origin, religion, sex, gender, gender identity, gender expression, pregnancy (including pregnancy, childbirth, and medical conditions related to pregnancy or childbirth), physical or mental disability, medical condition, genetic information, ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services (including membership, application for membership, performance of service, application for service, or obligation for service in the uniformed services). The university also prohibits harassment based on these protected categories, including sexual harassment, as well as sexual assault, domestic violence, dating violence, and stalking. The nondiscrimination policy covers admission, access, and treatment in university programs and activities.

If students have questions about student-related nondiscrimination policies or concerns about possible discrimination or harassment, they should contact the Office for the

Prevention of Harassment & Discrimination (OPHD) at (858) 534- 8298, ophd@ucsd.edu, or reportbias.ucsd.edu.

Campus policies provide for a prompt and effective response to student complaints. This response may include alternative resolution procedures or formal investigation. Students will be informed about complaint resolution options.

A student who chooses not to report may still contact CARE at the Sexual Assault Resource Center for more information, emotional support, individual and group counseling, and/or assistance with obtaining a medical exam. For off-campus support services, a student may contact the Center for Community Solutions. Other confidential resources on campus include Counseling and Psychological Services, Office of the Ombuds, and Student Health Services.

CARE at the Sexual Assault Resource Center - 858.534.5793 or sarc@ucsd.edu Counseling and Psychological Services (CAPS) - 858.534.3755

Preliminary schedule (please check lecture slides for most up to date schedule):

Dates highlighted in yellow are only taught remotely via Zoom <join via link in Canvas>

Week	Month	Day	WeekDay	Overarching topic	Readings Textbook:	Articles:
				SEAWATER CO2 CHEMISTRY		
1	March	29	T	Introduction to Ocean Acidification	OA book Ch.1	Doney et al. 2020
	March	31	Th	Marine CO2 system	Zeebe p. 1-27	
2	April	5	T	Marine CO2 system cont.	Zeebe p. 27-53	
		7	Th	Marine CO2 system cont.	Zeebe p. 53-67	
				PAST, PRESENT AND FUTURE OCEAN ACIDIFICATION		
3	April	12	T	Past changes in ocean carbonate chemistry & past OA events	OA book Ch. 2	Honisch et al. 2012
		14	Th	Past changes in ocean carbonate chemistry & past OA events		Kump et al. 2009
4	April	19	T	Recent and future changes in ocean carbonate chemistry	OA book Ch. 3	Bates et al. 2014; Feely et al. 2004; Gruber et al. 2019
		21	Th	Recent and future changes in ocean carbonate chemistry		Duarte et al. 2013; Cai et al. 2011
				EFFECTS ON BIOGEOCHEMICAL PROCESSES		
5	April	26	T	Recent and future changes in ocean carbonate chemistry/Biogeochemical consequences		
		28	Th	Biogeochemical consequences	OA book Ch 12	Hutchins et al. 2009
6	May	3	T	Biogeochemical consequences		
		5	Th	Biogeochemical consequences/Midterm review		
				EFFECTS ON ORGANISMS ECOSYSTEMS AND FOODWEBS		
7	May	10	T	Midterm		
		12	Th	Effect on organisms/ecosystems	OA book Ch 7	Andersson et al. 2015; Gattuso & Lavigne, 2009
8	May	17	T	Effect on organisms/ecosystems	OA book Ch 7	
		19	Th	Effect on organisms/ecosystems	OA book Ch 6 & 5	Riebesell et al. 2000; Iglesias-Rodriguez et al. 2008
9	May	24	T	Effect on organisms/ecosystems	OA book Ch. 8	Clark et al. 2020; Munday et al. 2020; Williamson et al., 2021
		26	Th	Effect on organisms/ecosystems/OA and society	OA book Ch. 9 & 10	
				OA CHALLENGES FACING SCIENCE & SOCIETY		
10	May	31	T	Solutions, mitigation scenarios	OA book Ch. 13 & 15	
		2	Th	Presentations and discussion Term project		
11	June	4-11	S-S	FINALS WEEK: Take home exam		