CH385: Ocean Biogeochemistry on a Changing Planet

4 credit hours

Required Text: Introduction to Marine Biogeochemistry, 2nd Edition by Susan M. Libes, Elsevier, 2009.

Additional resources that you will need to use
Course wiki: https://wiki.bigelow.org (go to 'Organizational Units', 'Education', 'Ocean Biogeochemistry 'Twining')

Meeting times: variable
Location: Bigelow Laboratory for Ocean Sciences, OBCC Classroom and Teaching modular Lab

Instructors:
Dr. Benjamin Twining, Bigelow Laboratory for Ocean Sciences, btwining@bigelow.org
Dr. Jochen Nuester, Bigelow Laboratory for Ocean Sciences, jnuester@bigelow.org

office hours: after lectures, or by appointment
Ben's office phone: 207-315-2567 x309
Ben's cell phone: 207-449-7822
Ben's home phone: 207-725-2649

Course Description:

The cycles of carbon, nitrogen, phosphorus, silicon and trace metals in the ocean are intimately linked to dynamic biological and physical processes. These elements are the building blocks of life and their availability can control ocean biology and ecology at numerous scales. At the same time, biological processes in the ocean impact element distributions and global climate, mainly through controls on climatically-active gases. These connections are at the heart of ocean biogeochemistry, and they are changing in response to human activities on regional and global scales. In this course, students will explore the biological and chemical processes that affect the cycling of elements in the ocean, including photosynthesis and respiration, calcification and silicification, nitrogen fixation and denitrification, and redox cycling of sulfur and metals. Particular emphasis will be placed on processes that directly affect global climate such as cycling of CO_2, N_2O and DMS, and on the response of ocean biogeochemistry to changing climate variables. The role of humans in these cycles will also be addressed, including current topics in marine pollution (oil spills, mercury toxicity, radioisotope releases), coastal eutrophication/hypoxia, and proposals to fertilize the ocean. The course will cover chemical equilibrium modeling of acids-bases and metal-ligand complexes. Laboratory activities will include titrations, spectrophotometry and electrochemistry.

Course Outline:

The course will incorporate lectures, laboratory activities, problem sets, and reading of the primary literature. Lectures on each meeting day will generally break out into two one-hour lecture topics with a 10 minute break after the first hour. The second hour of some sessions will also be used for discussions of current literature topics. See table below for lecture topics and assigned readings based on the specific lecture number (following table). Schedule and topics are subject to change; however this will be announced in class prior to any revisions to the course calendar below.

Course Calendar:

Date	Lecture Topics	Lecture/Lab #
Wed. Oct. 30	9 – 10 am: Intro to ocean biogeochemistry	1
	10 – 11 am: Ocean carbon cycle	2
Fri. Nov. 1	9 am – Noon: Calcification I: measuring pH and alkalinity of seawater	Lab 1
Mon. Nov. 4	9 – 10 am: Production and destruction of organic matter (redox reactions)	3
	10 – 11 am: Eutrophication and the productivity balance	4
Tue. Nov. 5	9 – 10 am: Nutrient distributions and the biological pump	5
	10 – 11 am: Marine carbon cycle and global climate change	6
Thurs. Nov. 7	9 am – Noon: Calcification II: effects of photosynthesis and calcification on carbonate chemistry	Lab 2
Fri. Nov. 8	9 am – Noon: Silicification I: effect of iron on diatoms	Lab 3
Thurs. Nov 14	9 am – Noon: Silicification II: effect of iron on diatoms	Lab 4
Fri. Nov. 15	9 – 10 am: Marine carbon cycle and global climate Change continued	7
	10 – 11 am: Trace metals in the ocean	8
	11 am – noon: Jim Fleming seminar	
Mon. Nov 18	9 am – Noon: Silicification III: effect of iron on diatoms	Lab 5
Tues. Nov. 19	9 – 10 am: Trace metals in the ocean continued	9
	10 – 11 am: Diagenesis in ocean sediments (Jochen)	10
Thurs. Nov. 21	9 – 10 am: Ocean nitrogen cycle	11
	10 – 11 am: Ocean phosphorus cycle	12
Fri. Nov. 22	9 am – Noon: Electrochemistry	Lab 6
Mon. Nov. 25	9 – 10 am: Oil pollution in the marine environment	13
	10 – 11 am: Plastics and persistent organic pollutants	14
Tues. Nov 26	9 – 10 am: Ocean fertilization: past and future	15
	10 – 11 am: Radionuclide and metal pollution	16
Mon. Dec. 2	9 pm: Take-home final exam due	

Planned reading assignments for Ocean Biogeochemistry

Lecture 1: Intro to Ocean Biogeochemistry
Libes: Chapter 1, 5.1-5.6, 5.8.3
Lecture 2: Ocean carbon(ate) cycle
Libes: Chapter 6.1-6.3, 6.5, 15
Papers: Doney. 2010. The growing human footprint on coastal and open-ocean biogeochemistry. *Science*. 328: 1512-1516.
Schlosser & Pfirman. 2012. Earth science for sustainability. *Nature Geoscience*. 5: 587-588.

Laboratory 1: Calcification I: Measuring pH and alkalinity of seawater
Libes: Chapter 15.4

Lecture 3: Production and destruction of organic matter (redox reactions)
Libes: Chapter 7.1-7.3.2, 8
Lecture 4: Eutrophication and the productivity balance
Libes: Chapter 8, 28.6.2-28.6.3
Papers: Ducklow & Doney. 2013. What is the metabolic state of the oligotrophic ocean? A debate. *Annual Review of Marine Science*. 5: 1-9.
Cai et al. 2011. Acidification of subsurface coastal waters enhanced by eutrophication. *Nature Geoscience*. 4: 766-770.

Lecture 5: Nutrient distributions and the biological pump
Libes: Chapter 9, 10
Paper: Weber & Deutsch. 2010. Ocean nutrient ratios governed by plankton biogeography. *Nature*. 467: 550-554.

Lectures 6-7: Marine carbon cycle and global climate change
Libes: Chapter 25
Papers: Stramma et al. 2011. Expansion of oxygen minimum zones may reduce available habitat for tropical pelagic fishes. *Nature Climate Change*. 2: 33-37.
Gruber et al. 2012. Rapid progression of ocean acidification in the California Current system. *Science*. 337: 220-223.

Laboratory 3: Silicification of diatoms as a function of iron availability
Libes: Chapter 16.1-16.3

Lecture 8-9: Trace metals in the ocean
Libes: Chapter 5.7, 11
Paper: Shi et al. 2010. Effect of ocean acidification on iron availability to marine phytoplankton. *Science*. 327: 676-679.

Lecture 10: Diagenesis in ocean sediments
Libes: Chapter 12
Paper: TBD

Lecture 11: Ocean nitrogen cycle
Libes: Chapter 24
Lecture 12: Ocean phosphorus cycle
Libes: Chapter 24
Paper: TBD

Laboratory 6: Electrochemistry
Readings: TBD

Lecture 13: Oil pollution in the marine environment
Libes: Chapter 26, 28.6.6
Lecture 14: Plastics and persistent organic pollutants
Libes: Chapter 28.7-28.8
Papers: Kessler et al. 2011. A persistent oxygen anomaly reveals the fate of spilled methane in the deep Gulf of Mexico. *Science*. 331: 312-315.
Camilli et al. 2012. When scientific research and legal practice collide. *Science*. 337: 1608-1609.
Law et al. 2010. Plastic accumulation in the North Atlantic subtropical gyre. *Science*. 329: 1185-1188.

Lecture 15: Ocean fertilization: past and future
Libes: Chapter 25.6
Lecture 16: Radionuclide and metal pollution
Libes: Chapter 28.6.7-28.6.8
Papers: Boyd et al. 2000. A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization. *Nature*. 407: 695-702.
Strong et al. 2009. Ocean fertilization: time to move on. *Nature*. 461: 347-348.
Madigan et al. 2012. Pacific Bluefin tuna transport Fukushima-derived radionuclides from Japan to California. *Proceedings of the National Academy of Sciences*. 1-4.

Grading Policy:

Class participation	**10%**
Homework/Problem sets	**25%**
Lab Reports	**30%**
Literature Discussions	**10%**
Final Exam	**25%**
Total	**100%**

Evaluations:

Participation will be evaluated through your contributions to class discussions and engagement with the course materials. You're encouraged to ask questions during lectures and to be an active participant.
Lab Reports/Problem sets will be assigned following each lab session. The lab sessions are organized into 3 topics, 2 of which will span multiple lab sessions. The first lab for each topic will be followed by a

series of questions (some discussion, some quantitative) which will be due prior to the second lab. Following the second lab for each topic, students should prepare a 2-3 page report outlining the techniques, presenting data in graphic format, and including a brief discussion of the results, data analysis, and interpretation.

Literature Discussions will be conducted on a paper during the second half of most lecture days. One students will be chosen to summarize the paper and lead the discussion. Other students are responsible for asking **at least one** question to the group or the discussion leader. Come prepared!

Final Exam will include material covered in the lectures and laboratory exercises.

Academic Honesty:

Academic dishonesty will not be tolerated. Exams, question sets, abstract and presentation must be your own work and thought. Use of other people's work without acknowledging their contribution is plagiarism and is a serious offense. Plagiarism includes verbatim copying, paraphrasing (changing a few words here and there), and structural plagiarism (borrowing the structure or outline of somebody else's work without acknowledgement). Students cheating on exams or submitting question sets containing plagiarized materials will receive an F in the assignment and may receive a failing grade for the course. Any case will be reported to Department Chair and the Dean of Students, possibly resulting in academic probation or suspension from the college, as noted in both the student handbook and college catalog.

Attendance:

Attendance is required at all classes. Please contact the professor if you must miss a class. Unexcused absences will be reflected in the Class Participation portion of your grade.

Mobile device policy:

The use of cell phones or other personal electronic communication devices during class is discouraged. Please silence your device before class. All such devices must be put away during exams.