Syllabus: SIO 119
Physics and Chemistry of the Ocean

Professor Andreas Andersson
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office hours: Mondays, 2-3:30 pm or by appointment
also in class before or after lecture or via e-mail.
Professor Sarah Gille
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office hours: Thursdays, 8:30-10:30 am or by appointment
also in class before or after lecture or via e-mail.
TAs:
Ben Davis (Wednesday discussion sections)
bddavis@ucsd.edu
office hours: Upstairs bridge of the Sandbox in the Hydraulics Laboratory,
Wednesdays, 5-7 pm
Jimjohn Milan (Tuesday discussion sections)
jmilan@ucsd.edu
office hours: Tuesdays and Wednesdays, 11 am-noon, Eckart 123—Sea Cave

Lectures: Monday/Wednesday/Friday 1:00-1:50, Sumner Auditorium
Discussion times: (attendance required, you can attend a different section if necessary)
Tuesday, 12-12:50 (in Eckart 123—Sea Cave)
Tuesday, 1-1:50 (in Eckart 123—Sea Cave)
Wednesday, 2:00-2:50 (in Eckart Hall 236)
Wednesday, 3:00-3:50 (in Eckart Hall 236)
Final exam: Friday, March 20 2020, 11:30-2:29 pm. (Tentatively Sumner Auditorium).

Grading: Letter or P/NP permitted.
Course public website: http://pordlabs.ucsd.edu/sgille/sio119
Consult Canvas for announcesments and course specific materials.

Objectives: This course will help you master the key elements of physical and chemical oceanography that influence marine ecosystems. The course will draw on your prior background in physics, calculus, and chemistry to help you build specific understanding and skills that are pertinent to marine biology. As much as possible, the course uses an interdisciplinary approach to examine how properties of sea water, ocean currents, air-sea forcing, and chemical processes determine the marine environment, and we examine specific examples relevant to nutrient availability, ocean acidification, and biological productivity.

Lectures, in-class discussion, weekly assignments, term papers and exams will ask you to think and synthesize material.

Specifically, by the end of the course, you should understand, and be able to discuss:

- the basics of the ocean heat and freshwater budgets;
- factors determining the density of sea water;
- locations of major ocean currents and processes driving these currents;

- factors influencing vertical motions in the ocean;
- origin of elements and basics of ocean chemistry;
- the ocean carbon cycle;
- impacts of rising CO_2 concentrations in the atmosphere, as pertaining to ocean climate and ocean acidification.

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 conduct 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.

Reading: Required reading will be made available in electronic form. (This will include book chapters, lecture notes, journal articles or other materials.) This is an upper division class, and reading is an important component of learning and synthesizing the major concepts presented in this class.

Discussion section: Discussion Sections are mandatory. Most weeks (except week 1, and when otherwise noted), you will have an assignment that you must turn in at the beginning of each class.

In many weeks we will ask you to bring to class a *written* and *original* potential short-answer exam question or problem (*and the answer*). Your questions should be derived from the previous week's lecture or reading material. Then, in each session, the TA will select students at random, one after another, and they will present their question to the class, who will then discuss possible answers and critique the question. TAs will continue selecting students until end of the session time period. You will be scored for having turned in your question and attending the *entire* discussion section. By having you come up with questions, we are encouraging you to actively and critically engage with the course material. This will help you get more out of the course. We also may use the top questions in our exams!

Other weeks discussion section will focus on discussion of a journal article, and we will ask you to read the article in advance and come to class with a *written* question that arises in your mind from reading the article.

Grading:

- 20% problem sets, including write ups for case studies in weeks 9 and 10. Homework and discussion are focused on helping you understand material discussed in class. Normally due weekly, on Fridays.
- 25% midterm #1 (physical oceanography) (Friday January 31, wk 4)

- 25% midterm #2 (chemical oceanography) (Friday February 28, wk 8)
- 10% Participation, in class clicker quizzes, attendance in discussion section, discussion session assignments, and other in-class activities.
- 20% group project (poster presentation in final exam time slot, Friday March 20. 1 page individual synopsis due at time of presentation.)
- Exceptional participation can boost your overall grade.
- Late homework assignments lose 10% of points per day and cannot be accepted after we return graded work. Provided that >90% of the class complete CAPE evaluations, the lowest homework grade will be dropped.

Schedule. (See Canvas for updates.)

- **Week 1:** Introduction to the class; physical properties of sea water.
  - 6 January: Introduction to the class. Interdisciplinary thinking
  - 8 January: Physical properties of sea water: Temperature, salinity, density. (Reading: Knauss, Ch. 2; Primer on TEOS-10)
  - 10 January: The ocean energy budget: Measuring changes in ocean heat content (Reading: Knauss, Ch. 4, Rochemmich et al, 2015; Cheng et al, 2019)
- **Week 2:** Warming and moving the ocean
  - 13 January: Air-sea fluxes and water mass transformation (Reading: Knauss, Ch. 3)
  - 15 January: Moving the ocean: Rotation and the Coriolis effect (Reading: Williams and Follows, Ch. 4.1)
  - 17 January: Moving the ocean: Winds and wind-driven circulation (Reading: Williams and Follows, Ch. 4.2; Ebbesmeyer and Ingraham, 1992)
- **Week 3:** More drivers of ocean circulation
  - 20 January: *Holiday*
  - 22 January: Moving the ocean: Geostrophic balance, large-scale circulation (Reading: Williams and Follows, Ch. 4.2)
  - 24 January: Rising and falling seas: Tides and tide pools (Reading: Ocean Networks Canada discussion of tides)
- **Week 4:** Putting together the big picture.
  - 27 January: Vertical motions: Water mass formation and a changing climate
  - 29 January: Southern Ocean or El Niño, the blob, and the California Current + review
  - 31 January: Midterm #1: physical oceanography
- **Week 5:** How to make an Earth-like ocean.
  - 3 February: Origin of universe, earth, oceans and life

  - 5 February: Salinity and the composition of seawater
  - 7 February: Gases in seawater

- **Week 6:** Marine CO_2 system and C cycle.
  - 10 February: Marine carbonic acid system
  - 12 February: Biogeochemical processes effect on marine CO_2 system
  - 14 February: C and $CaCO_3$ cycles

- **Week 7:** Nutrient dynamics (N and P cycle) and metabolic pathways
  - 17 February: *Holiday*
  - 19 February: N and P cycles
  - 21 February: Anaerobic metabolic pathways and deoxygenation

- **Week 8:** Eutrophication, deoxygenation, radioactivity
  - 24 February: Eutrophication, deoxygenation, acidification
  - 26 February: Radioactivity
  - 28 February: Midterm #2

- **Week 9:** Synthesis: Iron fertilization
  - 2 March: Poster presentations: Discussion of expectations and format, begin case study #1
  - 4 March: Case study #1 (Fe fertilization)
  - 6 March: Case study #1: Recommendations. Write-ups due.
  - Discussion section: Poster presentations. Forming groups and selecting topics.

- **Week 10:** Synthesis
  - 9 March: Case study #2 (California Current and Oxygen minimum zones?)
  - 11 March: Case study #2
  - 13 March: Case study #2 write ups due. Class wrap up. Q&A for posters
  - Discussion section: Poster presentations. Collaboration session. Addressing puzzles and challenges for poster presentations.

version date: January 6, 2020