

Syllabus

Department of Chemistry
FCH 796 – Graduate Studies
Oceanography

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OCEANOGRAPHY (FCH 796)

Course Syllabus

Spring 2010 Jahn 122 W and Th 5:00-6:20 pm
Dr. David Kieber (ext. 6951, Room 417 Jahn Laboratory)

General description:

This course will provide to the student a detailed, general description of oceanography including physical, chemical, biological and geological oceanography. Through my lectures and group discussions, this course will highlight the interdisciplinary nature of oceanography and its importance in earth system dynamics such as energy and climate.

Assignments and Expectations:

Class attendance and participation are mandatory. There is no course book that will be used in this class. Rather the student will learn oceanography through reading research articles and reviews from the literature that the instructor will assign. Therefore, during this course, you will be expected to read several scientific papers. I will make available in as much as possible electronic copies of required readings on blackboard.

There will be four exams in this course: three exams during the semester and a final (TBD). For the graduate students, you will all be responsible to present one 1 hr lecture to the class on one topic in Geological Oceanography that I assign to you. Grading will be based on your participation in class, the four exams and for the graduate students your oral presentations. This means that you are required to ask questions and be informed of the topics for the week.

Grading:

Undergraduates: 20% participation, 15% each exam, 20% attendance

Graduate students: 15% presentation, 15% participation, 15% each exam, 10% attendance

Electronic Handouts (to be updated on blackboard during the semester):

- Baum, S.K. 2004. Texas A & M University. Glossary of Physical Oceanography and Related Disciplines.
- Lectures after they are presented to the class
- Selected readings

Office Hours:

Tuesday 1:00-4:00 pm and Thursday 10:00-11:30 pm, Room 417 Jahn

Please email me at djkieber@esf.edu to set up a time to meet rather than simply showing up at my office.

Course Lecture Areas

1. **Physical Oceanography** — Atmospheric circulation, major global wind patterns, wind-driven and thermohaline circulation, major currents including the Gulf Stream, temperature, salinity, density, potential density, equation of state for seawater, Ekman spiral and transport, Coriolis force, surface gravity and inertial waves, Rossby waves, Kelvin waves, Langmuir circulation, upwelling, internal waves, solar transmission of radiation in seawater, absorption and scattering, El Niño-Southern Oscillation (ENSO), La Niña
2. **Chemical Oceanography** – air sea exchange, soluble gases, sea surface microlayer, carbonate chemistry, lysocline, atmospheric imprint, major cation and anion cycling, isotope geochemistry, radiocarbon dating, trace metals, carbon, nitrogen, phosphorous, iron, silica, photochemistry, estuaries, hydrothermal vents
3. **Biological Oceanography** – biological provinces in the oceans, Biology and ecology or coastal vs pelagic environments, hydrothermal vents, nutrient limitation, oceanic time series, anammox bacteria, food web dynamics, light inhibition, net heterotrophy vs net autotrophy, Redfield ratio, molecular biology
4. **Geological Oceanography** – Plate tectonics, marine sediments, hydrothermal vents

Selected Book and Journal References, and Web Links

Books:

- Knauss, J.A. *Introduction to Physical Oceanography*. 1978. Prentice-Hall, Englewood Cliffs, N.J.
- Pinet, P.R. *Invitation to Oceanography*. 3rd Ed. 2003. Jones and Bartlett, Sudbury, MA.
- Broecker, W.S. and T.-H. Peng. *Tracers in the Sea*. 1982. Lamont-Doherty Geological Observatory. Columbia University, Palisades, NY.
- Miller, C. B. *Biological Oceanography*. 2004. Blackwell Publishing, Oxford.
- Mobley, C.D. *Light and Water: Radiative Transfer in Natural Waters*. 1994. Academic Press, San Diego, CA.
- Kirk, J.T.O. *Light and Photosynthesis in Aquatic Ecosystems*. 2nd Ed. 1994. Cambridge University Press, Cambridge, UK.
- Jerlov, N., 1976. *Marine Optics*. Elsevier Oceanography Series, Elsevier Sci. Publ. Co., New York. 231 pp.
- Van Dover, C.L. 2000. *The Ecology of Deep-Sea Hydrothermal Vents*. Princeton University Press, Princeton, New Jersey. 352 pp.
- Charette, M. and J.C. Scholten (Eds.). 2008. *Mar. Chem.* Measurement of Radium and Actinium Isotopes in the marine environment. 109 (3-3). (Entire issue dedicated to isotope measurements)

Other References:

1. Arrigo, K.R. 2005. Marine microorganisms and global nutrient cycles. *Nature*. 437: 349-355.
2. Bates, N.R., A.F. Michaels and A.H. Knap. 1996. Seasonal and interannual variability of the oceanic carbon dioxide species at the U.S. JGOFS Bermuda Atlantic Times-series Study (BATS) site. *Deep-Sea Res.* 43: 347-383.
3. Charria, G., I. Dadou, P. Cipollini, M. DrŽvillon, P. De Mey, and V. Garcon. 2006. Understanding the influence of Rossby waves on surface chlorophyll concentrations in the North Atlantic Ocean. *J. Mar. Res.*, 64: 43-71.
4. Challenor, P.G., P. Cipollini, D. Cromwell, K. L. Hill, G. D. Quartly, I. S. Robinson. 2004. Global characteristics of Rossby wave propagation from multiple satellite datasets. *International J. Remote Sensing*. 25: 1297-1302.
5. Benitez-Nelson, C. R. 2000. The biogeochemical cycling of phosphorus in marine systems. *Earth Sci. Rev.* 51: 109-135.
6. D'Asaro, E.A., and C.L. McNeil. 2007. Air-sea gas exchange at extreme wind speeds measured by autonomous oceanographic floats, *J. Mar. Sys.* 66: 92-109.
7. Donelan, M.A., W.M. Drennan, E.S. Saltzman and R. Wanninkhof (Eds.). *Gas Transfer at Water Surfaces*. Geophysical Monograph Series, Vol. 127, American Geophysical Union. Washington, DC, 2002.
8. Ducklow, H.W, D.K. Steinberg and K.O. Buesseler. 2001. Upper ocean carbon export and biological pump. *Oceanography*. 14: 50-58.
9. Dugdale, R.C., and J. J. Goering. 1967. Uptake of New and Regenerated Forms of Nitrogen in Primary Productivity. *Limnol. Oceanogr.* 12: 196-206.
10. Falkowski, P. G. and A. D. Woodhead. 1992. *Primary Productivity and Biogeochemical Cycles in the Sea*. Plenum Press. New York, NY.
11. Falkowski, P.G., R.T. Barber and V. Smetacek. 1998. Biogeochemical controls and feedbacks on ocean primary production. *Science*. 281: 200-206.
12. Kettle, H. and C. Merchant. 2005. Systematic errors in global air-sea carbon fluxes caused by temporal averaging of sea-level pressure. *Atmos. Chem. Phys.* 5: 1459-1466.
13. Quartly, G.D., P. Cipollini, D. Cromwell, P. G. Challenor. 2003. Rossby waves: synergy in action. *Phil. Trans. R. Soc. London A*, 10.1098/rsta.2002.1108, 1-8.
14. Lalli, C. M. & Parsons, T. R. (2001). *Biological Oceanography - An Introduction* (2nd ed.). Oxford, Butterworth-Heinemann.
15. Liss, P.S. and P.G. Slater. 1974. Fluxes of gases across the air-sea interface. *Nature*. 247: 181-184.
16. Liss, P.S. and L. Merlivat. 1986. The role of sea-air exchange in geochemical cycling, In: *Air-sea Gas Exchange Rates: Introduction and Synthesis*, Ed. P. Menard (Ed.). Reidel, Dordrecht. pg. 113-127.
17. Matthews, B.J.H. 1999. *The rate of air-sea CO₂ exchange: chemical enhancement and catalysis by marine microalgae*. Ph.D. Thesis, University of East Anglia, Norwich, U.K.
18. Nash, J.D. and J.N. Moum. 2005. River plumes as a source of large-amplitude internal waves in the coastal ocean. *Nature*. 437: 400-403.
19. Nightingale, P., G. Malin, C. Law, A. Watson, P.S. Liss, M. Liddicoat, J Boutin and R. Upstill-Goddard. 2000. In situ evaluation of air-sea exchange

- parameterizations using novel conservative and volatile tracers. *Glob. Biogeochem. Cycles*, 14: 373-387.
20. Bryden, H.L., H.R. Longworth and S.A. Cunningham. 2005. Slowing of the Atlantic meridional overturning circulation at 25 °N. *Nature*. 438: 655-657.
 21. Barstow, S.F. 1983. The Ecology of Langmuir Circulation: A Review. *Mar. Environ. Res.* 9: 211-236.
 22. Blomquist, B.W, C.W. Fairall, B.J. Huebert, D.J. Kieber and G.R. Westby. 2006. DMS sea-air transfer velocity: direct measurements by eddy covariance and parameterization based on NOAA/COARE gas transfer model. *Geophys. Res. Lett.* 33: L07601-L07604.
 23. Lomas, M.W. and F. Lipschultz. 2006. Forming the primary nitrite maximum: Nitrifiers or phytoplankton? *Limnol. Oceanogr.* 51: 2453–2467.
 24. Feely, R.A., C.L. Sabine, T. Takahashi, and R. Wanninkhof. 2001. Uptake and storage of carbon dioxide in the oceans: The global CO₂ survey. *Oceanogr.* 14: 18–32.
 25. Gargett A.E. 1997. Physics to fish: Interactions between physics and biology on a variety of scales. *Oceanography*. 10: 128-131.
 26. Thompson, A.M. and O.C. Zafiriou. 1983. Air-sea fluxes of transient atmospheric species, *J. Geophys. Res.* 88: 6696-6708.
 27. Thorpe, S.A. 2004. Langmuir circulation. *Annu. Rev. Fluid Mech.* 36:55–79.
 28. Tholosan, O., J. Garcin and A. Bianchi. 1999. Effects of hydrostatic pressure on microbial activity through a 2000 m deep water column in the NW Mediterranean Sea. *Mar. Ecol. Prog. Ser.* 183: 49-57.
 29. Stommel, H. 1948. The western intensification of wind-driven ocean currents. *Trans. Am. Geophys. Union.* 29: 202-206.
 30. Susanto, R.D., Mitnik, L. and Q. Zhaeng. 2006. Ocean internal waves observed in the Lombok Strait. *Oceanogr.* 18: 80-87.
 31. McNeil, C.L., and E.A. D'Asaro. 2007. Parameterization of air-sea gas exchange at extreme wind speeds, *J. Mar. Sys.*, 66: 110-121.
 32. Millero, F. J., C. T. Chen, A. Bradshaw and K. Schleicher. 1980. A new high pressure equation of state for seawater. *Deep-Sea Res.* 27: 255-264.
 33. Kirk, J.T.O. 2003. The vertical attenuation of irradiance as a function of the optical properties of the water. *Limnol. Oceanogr.* 48: 9-17.
 34. Carder, K.L., R.G. Steward, G.R. Harvey and P.B. Ortner. 1989. Marine humic and fulvic acids: Their effects on remote sensing of ocean chlorophyll. *Limnol. Oceanogr.* 34: 68-81.
 35. Riebesell, U., I. Zondervan, B. Rost, et al. 2000. Reduced calcification of marine plankton in response to increased atmospheric CO₂. *Nature*. 407: 364–367.
 36. Walter, S., H. W. Bange, U. Breitenbach, and D. W. R. Wallace. 2006. Nitrous oxide in the North Atlantic Ocean. *Biogeosciences*. 3: 607–619.
 37. Wanninkhof, R. 1992. Relationship between wind speed and gas exchange over the ocean. *J. Geophys. Res.* 97: 7373-7382.
 38. Wanninkhof, R. and W.R. McGillis. 1999. A cubic relationship between air-sea CO₂ exchange and wind speed. *Geophys. Res. Lett.* 26: 1889-1829.
 39. Wu, J., W. Sunda, E. Boyle and D. Karl. 2000. Phosphate depletion in the western North Atlantic Ocean. *Science*. 289: 759-762.

40. Zehr, J.P., J.B. Waterbury, P.J. Turner, J.P. Montoya, E. Omoregie, G.F. Steward, A. Hansen and D.M. Karl. 2001. Unicellular cyanobacteria fix N_2 in the subtropical North Pacific Ocean. *Nature*. 412: 635-638.

Selected Websites:

- <http://www.es.flinders.edu.au/~mattom/IntroOc/> (An online introduction to Physical Oceanography)
- <http://oceancurrents.rsmas.miami.edu/index.html> (Lots of information regarding Ocean Currents)
- http://geography.uoregon.edu/envchange/clim_animations (Global Climate Animations)
- <http://www.phys.ocean.dal.ca/~kelley/seawater/density.html> (calculate ρ given T,S,p)
- <http://www.ioccg.org/biblio.html> (Ocean Optics “color” bibliography)
- <http://amsglossary.allenpress.com/glossary/search?/> (Meteorology glossary of terms but also contains terms used in oceanography)
- <http://www.elnino.noaa.gov/> (NOAA website for El Nino)
- <http://www.oc.nps.navy.mil/webmodules/ENSO/kelvin.html> (Navy site for El Nino and La Nina)
- <http://medias.obs-mip.fr/igac/html/book/chap2/chap2.html> (Good SOLAS overview of ocean-atmosphere interactions and gases)
- <http://www.whoi.edu/sbl/liteSite.do?litesiteid=19977> (Website on 2007 WHOI Ocean Acidification)
- <http://www.chooseclimate.org/benphd/ref.html> (References for Rate of Air-Sea CO_2 Exchange: Chemical Enhancement and Catalysis by Marine Microalgae)
- <http://science.uniserve.edu.au/school/quests/hydrovents.html> (Web resources for creating a Multimedia Scrapbook on Hydrothermal Vents)
- <http://www.divediscover.whoi.edu/vents/chemistry.html> (General website that describes many aspects of hydrothermal vents)

Approximate Schedule

January	20-21	Introduction and Ocean Circulation
	27-28	Temperature, Salinity, Langmuir Circulation
February	3-4	Waves, ocean Optics
	10-11	El Niño and La Niña, Major Cations and Anions
	17-18	Exam 1 (on Feb. 17), Dissolved Gases, Isotope Geochemistry
	24-25	Carbon Cycle 1 and 2
March	3-4	Marine Carbon Cycle 3
	10-11	Sea-Air Fluxes, Marine Phosphorous Cycle
	17-18	No class, spring break
	24-25	Marine Nitrogen Cycle, Hydrothermal Vents
	31	Exam 2
April	1	Introduction to Marine Biology
	7-8	Marine Food Webs, Estuaries, Viruses
	14-15	Lectures TBD
	21-22	Grad. Student Lectures: Plate Tectonics, Mar. Sediments
	28-29	No class on April 28 (I'll be in Germany), Exam 3 on April 29
May		Final (date TBD)