DALHOUSIE UNIVERSITY

Faculty of Science Course Syllabus
Department of Oceanography
OCEA 4130/5130
Chemical Oceanography
Fall 2024

Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.
Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

Instructor:	Prof. *Doug Wallace*		*dwallace@dal.ca*	*SOSB 2-35*
Lectures:	*Mon*	*16.05-17.25*	*In person*	*LSC C202*
	Wed	*16.05-17.25*	*In person*	*LSC C202*

Tutorials: *We may, in addition, schedule occasional tutorials for discussion of various topics and to answer questions.*

Office hours: *By appointment only; ask in class or E-mail to Makena Njambi: mk839992@dal.ca*

Course Description

This course covers the major and minor constituents of sea water, controls on the ocean's chemical composition, nutrient cycling, gas exchange and the cycling of dissolved gases, the carbon cycle and the influence of the oceans on atmospheric composition including CO_2 levels. Other topics introduced are chemical tracers (including isotopes), chemical speciation and chemical models of sea water as well as current ideas about ocean-based climate interventions based on manipulation of ocean chemistry.

Course Prerequisites

OCEA4130: OCEA 2001.03 and OCEA 2002.03 (or 2000.06) and OCEA 3002.03 or instructor's consent.
OCEA5130: must be enrolled in graduate program.

Course Objectives/Learning Outcomes

At the end of this course students should be able to:

- *Identify the processes at ocean boundaries and within the ocean interior that control the chemical composition of seawater*

- *Understand the role of circulation and source/sinks on controlling the spatial and temporal distributions of chemical species within the world's oceans*
- *Integrate concepts of physical, biological and chemical processes to describe nutrient, dissolved gas and chemical cycling in the ocean, particularly the carbon cycle*
- *Use chemical distributions to infer information about physical and biological processes within the oceans*
- *Understand the key chemical processes and factors that influence the ocean's role with respect to ongoing global environmental change*
- *Be able to assess the basis of proposals to address climate change through manipulation of the ocean chemistry*

Course Delivery

The course will be delivered by in-person lectures. Lecture slides will be available in advance for annotation/ markup. Participation and discussion during the classes will be encouraged. In exceptional circumstances (and upon request) lectures can be recorded.

Lectures
Mondays: 4.05 pm to 5.25 pm
Wednesdays: 4.05 pm to 5.25 pm
Room: LSC C202

Course Materials

- *Recommended textbooks are:*
  - *The main text is "**Chemical Oceanography: Element Fluxes in the Sea**" by Emerson and Hamme. This newer text is recommended, but the older Emerson and Hedges textbook (see below) also contains most of the required material.*
  - *Emerson and Hedges: **Chemical Oceanography and the Marine Carbon Cycle**. Cambridge University Press.*
  - *Pilson: **An Introduction to the Chemistry of the Sea**. Cambridge University Press.*
  - *Berner and Berner: **Global Environment: Water, Air and Geochemical Cycles**. Prentice-Hall.*
  - *Sarmiento and Gruber: **Ocean Biogeochemical Dynamics (for more in-depth information)***
- *Additional literature and out of print required reading materials will be provided and will also be available on the OCEA 4130/5130 Brightspace site.*

Course Assessment

Students will be evaluated on quizzes, problem sets, exams and class participation. Students should be prepared to work both independently and in groups, especially on the problem sets. The problem sets include short answer questions, calculations, and word problems. Generally, problem sets will be

assigned on a Wednesday (after the lecture) and will be due on the Friday of the following week. Students will have just over a week to complete the problem sets. Short, in-class quizzes on the lecture and reading materials will be given weekly (usually at the beginning of the Monday class) and are designed to ensure that lecture notes from the previous week as well as assigned papers/ chapters have been read. The format for exams and exercises will be explained during the course. As both graduate and undergraduate students are completing the same assignments, undergraduates' final marks will be scaled by 5%.

Component	**Weight (% of final grade)**	**Date**
Quizzes	*20%*	*Weekly (Tuesdays)*
Participation	***5%***	***(assessed continuously)***
Mid-term exam	*20%*	*October 25-27 (tentative)*
Final-term exam	*25%*	*Week of December 9 (tentative)*
Assignments	*30%*	*(mark based on best 3 of 4)*
Problem Set 1		***Assigned:*** *20 September*
Problem Set 2		***Assigned:*** *11 October*
Problem Set 3		***Assigned:*** *1 November*
Problem Set 4		***Assigned:*** *22 November*

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D	(50-54)
A (85-89)	B (73-76)	C (60-64)	F	(<50)
A- (80-84)	B- (70-72)	C- (55-59)		

Course Policies

Health and *Safety:*

Students and lecturer will follow Dalhousie health and safety policy with respect to COVID-19 vaccination and testing requirements, wearing of masks, etc.. The instructor will attempt to ensure that there is adequate ventilation of the classroom and reserves the right to stop teaching if conditions in the classroom are judged unsafe.

Collaboration:

Students are encouraged to discuss problem sets in groups. However, each student must write and submit their own independent answers, rationale, and solutions to problem sets. Essays and quizzes must be exclusively the student's own work.

Late assignments-

Students will lose 5% of the total mark for the assignment per day if an assignment is handed in late. An assignment is considered late if it is not submitted by the time that it is due, which will be clearly marked (including specification of time zone) with every assignment.

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Course Content

The following is an approximate chronological flow of the course. Material not covered in one lecture session will be continued in the following session. Typically lectures will be offered in-person. Lecture slides will be made available online before the lecture.

Exact timing of the assignments and mid-term may change and will be discussed/ explained in class.

Note: Reading suggestions will be updated throughout the course. Reading suggestions from Emerson and Hedges will be updated with reading from Emerson and Hamme.

Week	Date	Lesson Topic(s)	Assessment
1	4 Sep	Lecture 1: Introduction. Informal Quiz (not graded). What is Chemical Oceanography? Seawater composition and basic concepts- water structure; ions in seawater; units; steady-state vs. equilibrium; 1-box model; residence time Reading: Emerson and Hedges, Chapter 3.1; or Pilson Chapter 2.1	
2	9, 11 Sep	Lecture 2: Salinity: definitions; measurement history and principles; accuracy and precision: certified methods and reference materials; practical salinity and absolute salinity. Reading: R. Pawlowicz; Key Physical Variables in the Ocean: Temperature, Salinity, and Density Lecture 3: Why is the Sea Salty? A: rain to river; rainfall composition; B: sea salt aerosol and cyclic salt; C: chemical weathering of crustal rocks; dissolved vs. particulate partitioning; river chemical composition and major ion sources. Reading: Berner and Berner Chapters 2, 3 and 4	Quiz
3	16, 18 Sep	Lecture 4: Why is the Sea Salty? D: Coastal processes. Estuaries; clay minerals and ion exchange; evaporite formation. Reading: Berner and Berner Chapter 7. Lecture 5: Why is the Sea Salty E. Hydrothermal sources and sinks at the sea floor boundary; Reading: Berner and Berner, Chapter 8. Emerson and Hedges, Chapter 2.3	Quiz Problem Set #1 assigned
4	23, 25 Sep	Lecture 6: Why is the Sea Salty? F. biogenic processes I- biogeochemical reactions, rain ratio, carbonate precipitation and dissolution; carbonate sedimentation.	Quiz

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		Lecture 7: Why is the Sea Salty? G. biogenic processes II-redox reactions and sulfate removal; reactions and transport in sediments; I: summary of sources/sinks. Recommended reading: Berner and Berner Chapters 8;	
5	30 Sep, 2 Oct	Lecture 8: Major nutrients; I- nitrogen in the ocean; chemical forms; nitrogen cycle; vertical and temporal nutrient distributions; transformations Reading: Pilson Chapters 8 Lecture 9: Major nutrients; II-Phosphorus- speciation and temporal distribution in surface water; remineralization; 2-box model of nutrient cycling; nutrient limitation concept; sources and sinks Reading: Redfield Revisited; Weber and Deutsch 2012 Redfield 1934; Redfield 1958; Emerson and Hedges Chapter 5.	Quiz
6	7, 9 Oct	Lecture 10: Major Nutrients III-Silicon- speciation, solubility, dissolution; vertical and horizontal distribution; remineralization; sources and sinks; Importance of micronutrients. Reading: Redfield Revisited; Tregueir et al., 2021 Lecture 11: Major Nutrients (catch-up).	Quiz Problem Set #2 assigned
7	16 Oct	(Monday= Thanksgiving) Lecture 12: Gases. Introduction– - concentrations; partial pressures and mole fraction; composition of the atmosphere; circulation of the atmosphere; gas solubility and Henry‘s Law Reading: Emerson and Hedges Chapter 10; Broecker and Peng Chapter 3 pg. 110-161	Quiz
8	21, 23 Oct	Lecture 13: Gases: seawater dissolved gas composition; simple gases; sources and sinks of simple dissolved gases; exchanges at the boundaries; air-sea gas exchange kinetics Reading: Pilson, Chapter 5;	Quiz
9	28, 30 Oct	Lecture 14: Oxygen- internal sources/ sinks; processes creating non-equilibrium conditions; photosynthesis / respiration; AOU; ocean de-oxygenation? Recommended Reading: Emerson and Hedges Lecture 15: Dissolved gases/ oxygen (continued). Ocean de-oxygenation and re-oxygenation? Reading: Emerson and Hedges, Chapter 6.2-6.4	Quiz Mid-Term Exam; Problem Set #3 assigned
10	4, 6 Nov	Lecture 16 and 17: Carbon cycle and the Anthropocene. Role of ocean chemistry in climate change. Intro to CO2- Keeling Curve; temporal	Quiz

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		variations of atmospheric CO2; latitudinal distributions; sources and sinks (global carbon budget). Reading:	
11	Reading Week		
12	18, 20 Nov	Lecture 18 and 19: CO2 Systems I- reactions in seawater; measuring the CO2 system; processes affecting CO2 speciation; buffering; CO2 Systems II- pCO2, global cycling of carbon species, concept of anthropogenic CO2, effects of anthropogenic CO2; including ocean acidification. Reading: Emerson and Hedges Chapter 4; Pilson Chapter 7.	Quiz Problem Set #4 assigned
13	25, 27 Nov	Lecture 20 and 21: Introduction to chemical tracers including use of isotopes. Stable and radioactive isotopes as tracers of physical, chemical and biological processes. Chlorofluorocarbons as tracers. Reading: Emerson & Hedges: Chapter 5; TBA	Quiz
14	2, 4 Dec	Lecture 22: Use of tracers to estimate anthropogenic CO2 or other carbon-cycle topics. Lecture 23: Negative Emission Technologies and natural climate solutions. Reading: TBA	Quiz
	6-17 Dec	Exam period	Final Exam

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University Policies and Statements

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding the Indigenous Student Centre can be found at: https://www.dal.ca/campus_life/communities/indigenous.html

Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about-dal/internationalization.html

Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/about-dal/agricultural-campus/student-success-centre.html)

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

Diversity and Inclusion – Culture of Respect

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Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: http://www.dal.ca/cultureofrespect.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner - perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. The full Code of Student Conduct can be found at: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Fair Dealing Policy

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/dept/university_secretariat/policies/academic/fair-dealing-policy-.html

Originality Checking Software

The course instructor may use Dalhousie's approved originality checking software and Google to check the originality of any work submitted for credit, in accordance with the Student Submission of Assignments and Use of Originality Checking Software Policy. Students are free, without penalty of grade, to choose an alternative method of attesting to the authenticity of their work and must inform the instructor no later than the last day to add/drop classes of their intent to choose an alternate method. Additional information regarding Originality Checking Software can be found at: https://www.dal.ca/about/leadership-governance/academic-integrity/faculty-resources/ouriginal-plagiarism-detection.html

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.


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