OCES 3202 Chemical Oceanography

1. Instructors

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2. Office hours

By appointment (Zoom)

3. Course Description

Credit points: 3
Pre-requisite: OCES 2001 and OCES 2002
Exclusion: Nil
Brief description:
This course focuses on the major biogeochemical processes in the coastal, benthic, and upper ocean pelagic ecosystems that control the abundances, distribution and transformation of chemical substances. The impacts of human activities and climate change on these processes will be discussed. The use of isotope tracers as a tool to investigate the age and sources of water masses will be illustrated.

4. Intended Learning Outcomes

On successful completion of this course, students are expected to be able to:

1. Demonstrate fundamental understanding of ocean science and technology; and master observational, laboratory, theoretical, and computational techniques in ocean related disciplines.
2. Address challenges in the sustainable management of the ocean by integrating their knowledge, technical skills, and creativity.
3. Employ scientific methods to critically evaluate complex, real-world problems.
4. Communicate effectively in both oral and written formats to convey their scientific knowledge and multi-disciplinary training.
5. Function independently with professionalism and work effectively in teams.

6. Recognize the need for and actively engage in the life-long pursuit of ocean literacy
7. Make informed and responsible decisions regarding the ocean and its resources.

5. Expected Preparation

In addition to having completed the compulsory pre-requisites Introduction to Oceanography (OCES 2001) and Marine Chemistry (OCES 2002), students need to have at least one year of general chemistry at an undergraduate level; organic chemistry, inorganic chemistry and biochemistry would be helpful. Competence in algebra is necessary; introductory calculus and differential equations are useful for some topics but are not required. A basic background in biological and physical oceanography is expected to be obtained from OCES 2001 and OCES 2002 for students that have not had any oceanography training.

6. Assessment Scheme

- Class participation: 15 %
- Assignments: 30 %
- Mid-term Exam: 15 %
- MATLAB Assignment 15 %
- Final Exam: 25 %

Class participation & problem sets

This assessment will consist of be a combination of (1) online questions issued via Canvas due prior to lectures and (2) in class quizzes. In some weeks, potential exam questions will be presented by postgraduate students, with OCES 3202 students expected to join the discussion of possible answers and critique the question. By starting the week's session with questions, we will help everyone to review the previous week's material. Also, by having student - initiated questions, students are encouraged to engage with the course material actively and critically. This will help students get more out of the course and we may also use the top questions in the final exam, so pay attention! Students will be expected to score and provide feedback on postgraduate term paper presentations.

Assignments:

A number of assignments will be delivered covering the course content. One will be a programming assignment to demonstrate the utility of MATLAB® in oceanographic data management and analysis and provide basic experience in its use.

Mid-term Exam:

The Mid-term Exam will consist of multiple-choice questions covering the assigned reading and course content delivered to that point.

Group assignment:

Students will be organized into groups under the management of a postgraduate group Project Manager(s) taking OCES 5300 who will oversee a project exploring a multi-disciplinary aspect of chemical oceanography. Tasks will be assigned by the Project Manager and students will be graded on their ability to complete assigned aspects of a project, be collaborative, and contribute to the overall objective. The overall mark for the assignment will be shared by group members.

Final Exam:

The Final Exam will be open book and delivered online via Canvas. It will consist of multiple-choice and essay style questions covering the entire course content.

7. Student Learning Resources:

Primary reference textbook(s):

- Libes, S.M. (2009) *Introduction to marine biogeochemistry*. Second Edition. Academic Press, Boston, 928 p. [**LIBES**]
    - Library access: https://lbdiscover.ust.hk/bib/991012845169703412
- Hoefs, J. (2018) *Stable Isotope Geochemistry*. Eighth Edition. Springer International Publishing, Switzerland, 437 p. [**HOEFS**]
    - Library access: https://lbdiscover.ust.hk/bib/991012694951003412

Additional textbook(s):

- Emerson, S. and Hedges, J. (2008) *Chemical oceanography and the marine carbon cycle*. Cambridge University Press, Cambridge, 475 p. [**E&H**]
    - Library access: https://lbdiscover.ust.hk/bib/991012846066003412

      This is an excellent text, but it is more advanced (has some maths) and is terse (heavy reading). We recommend this as primary textbook for all graduate students with a chemical focus and offer it as extra reading material below.
- Sarmiento, J.L. and Gruber, N. (2006) *Ocean biogeochemical dynamics*. Princeton University Press, Princeton, New Jersey, 528 p.
    - Library access: https://lbdiscover.ust.hk/bib/991012830921203412

      This is an advanced text (lots of math) but selected chapters are very useful (Si cycle, C cycle). In our experience physics students find this very helpful. It is also an excellent reference text.
- Chester, R. and Jickells, T.D. (2012) *Marine geochemistry*. Third Edition. Wiley-Blackwell, Chichester, UK, 411 p.
    - Library access: https://lbdiscover.ust.hk/bib/991006198239703412

      This textbook treats the oceans as a unified system, with detailed descriptions of material transport (sources and sinks) in the oceans. Students interested in global (bio)geochemical cycles will find its integrated treatment of the ocean chemistry very useful.
- Fry, B.J. (2006) *Stable isotope ecology*. Springer Verlag, New York, 308 p. [**FRY**]

- Library access: https://lbdiscover.ust.hk/bib/991012692305603412

  Excellent primer on the application of stable isotopes to studying ecology.

Supplementary materials

- A range of reading and web resources will be made available on Canvas (canvas.ust.hk) prior to each lecture.

8. Learning Activities

Three contact hours per week consisting of discussion/review sessions, lectures, and student-led presentations.

9. Course Schedule

Wk	Topic	Key Text	Instructor
1	Course introduction – what is chemical oceanography?	LIBES Ch.1	AW
	Chemical properties of seawater	LIBES Ch.2-3.3	
2	Major elements and mass balance	LIBES 3.4-4, E&H Ch.2	
	Chemical transformations in the ocean	LIBES Ch.5, E&H Ch.9	
3	Air/sea gas exchange and dissolved gases	LIBES Ch.6, E&H Ch.10	
	Carbonate chemistry: Calcite, alkalinity and pH	LIBES Ch.15, E&H Ch.4	
4	Stable isotopes as biogeochemical tracers	HOEFS Ch.1-2, E&H Ch.5	
	Compound-specific and radioisotope tracers	E&H Ch.5, handouts	
5	Isotope ecology – a chemical approach to ecology	HOEFS Ch.3, FRY	
	Thermodynamics, chemical equilibrium, and ion speciation	LIBES Ch. 5, E&H Ch.3.3	JL
6	Redox chemistry	LIBES Ch.7, E&H Ch.3.5	
	Nutrients and productivity in the ocean	LIBES Ch.9-10, E&H Ch.6	
7	Marine biogeochemical cycles – Nitrogen	LIBES Ch.24	
	MID-TERM EXAM	-	
8	Marine biogeochemical cycles – Phosphorous	LIBES Ch.24	
	Marine biogeochemical cycles – Silica and trace elements	LIBES Ch.11 & Ch.16	
9	**HOLIDAY**	-	
	Marine sediments and diagenetic processes	LIBES Ch.12, E&H Ch.12.1	
10	Paleoceanography: chronology and reconstruction of past ocean chemistry	E&H Ch.7	
	MID-TERM BREAK	-	-
11	Organic Matter: Production and Destruction	LIBES Ch.8	DH
	Dissolved and particulate organic matter cycling	LIBES Ch.23	
12	The marine carbon cycle and global climate change	LIBES Ch.25	
	Chemical extraction and pollution of the ocean	LIBES Ch.26, Ch.28	
13	Advanced techniques in chemical oceanography	-	
	Postgraduate Term Paper presentations	-	AW
14	Postgraduate Term Paper presentations Revision	-	