UM5MRM08	MAJOR CHALLENGES IN POLAR OCEANS: FROM BIOGEOCHEMISTRY TO ECOSYSTEMS	
6 ECTS	*Keywords*	ongoing and past global changes, biodiversity loss, sea ice, carbon, macro and micronutrients cycles, polar marine resources and fisheries, bioregionalization.
M2	*Managers*	Damien CARDINAL, Philippe KOUBBI (LOCEAN, Paris)
Paris	*Professors*	Céline RIDAME, Sandrine CAQUINEAU, Mercedes MENDEZ, Martin VANCOPPENOLE, Sara LABROUSSE (LOCEAN, Paris)
	Tracks	Marine ecosystems functioning and global change AND Biodiversity and conservation of marine ecosystems

Description

Format

Teaching

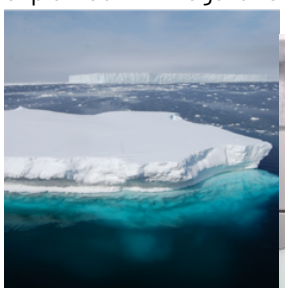
This course will use a variety of teaching methods with preference for active pedagogy. More particularly the Problem-Based Learning (PBL) which "is a student-centred pedagogy in which students learn about a subject through the experience of solving an open-ended problem (Wikipedia)" based on real case-studies. Several practical labs with hand-on will be associated to PBL using advanced analytical techniques (e.g. Scanning Electron Microscope, isotopic labelling and mass spectrometers, cultures of polar phytoplankton strains). Some traditional courses will also be given to provide basic knowledge on polar oceans. For each student there will be 15h of practical lab work, ~ 35h of tutorial / group work and ~ 5h of lectures

Evaluation

Oral or written presentation of projects (80%), written examination (20%).

Summary

This course will focus on polar ecosystems and biogeochemical cycles, which are currently facing major changes with potential impacts at global scale on sea-level, climate, biodiversity and marine resources. It will describe the main characteristics features of the Arctic and Southern Oceans with highlights on both their common and different modes of functioning. Their importance for the carbon cycle at geological and human time scales will be particularly shown and how polar oceans are highly impacted by acidification. Their different responses to global warming will also be described with the potential impacts on ecosystems and macro and micro nutrient cycles. The role of sea ice on circulation, biogeochemistry and ecosystems will be discussed. Finally, the challenging issues of conservation of polar marine ecosystems will be explained with regard to international and national policy framework.



Learning objectives

At the end of this course, the students will be able to:

1. describe the main physical and biogeochemical characteristics of the Southern and Arctic Oceans,

and their ongoing changes;

2. explain the role of the high latitude oceans on the carbon cycle and climate nowadays and during the Last Glacial Maximum;
3. identify and compare the main types of particles and planktonic organisms in the Subantarctic, Polar Front and Sea Ice Zones of the Southern Ocean using Scanning Electron Microscope observations and explain their fate during settling into sediment;
4. design and implement a lab experiment based on polar diatom cultures to discuss the impact of global changes on the primary and new production (N and C isotopic labelling);
5. examine marine conservation policies in the Southern Ocean according to whether they are in areas of national jurisdictions or on the high seas;
6. describe the main characteristics of sea ice environments in both polar oceans (physics, ecology, biogeochemistry) and their ongoing and future changes.

Prerequisites

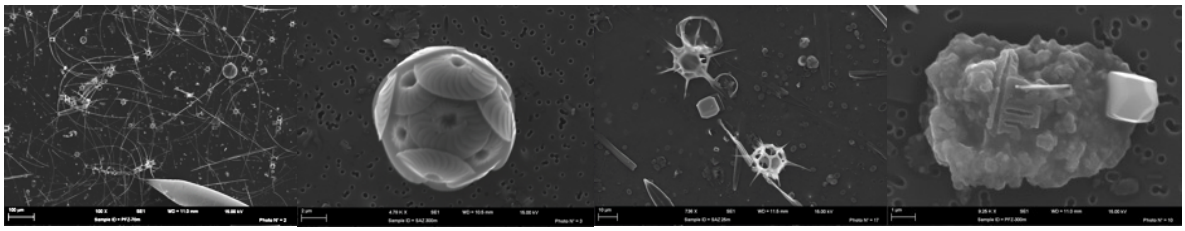
The students should have acquired a good knowledge of oceanography and marine ecology during their curriculum.

Bibliography

Before the course short videos on general ocean's functioning (mostly circulation and climate) can be watched to gain some of the prerequisites that might be missing on:
https://www.canal-u.tv/chaines/ipsl/videos-courtes-spoc-niveau-licence/oceanographie (French)
https://www.canal-u.tv/chaines/ipsl/short-videos-spoc-undergraduate/oceanography (English)

Biogeographic Atlas of the Southern Ocean. De Broyer, C., Koubbi, P., Griffiths, H.J., Raymond, B., Udekem d'Acoz, C. d', Van de Putte, A.P., Danis, B., David, B., Grant, S., Gutt, J., Held, C., Hosie, G., Huettmann, F., Post, A., Ropert-Coudert, Y. (eds.): 510 pp., 2014. Cambridge, SCAR. ISBN 978-0-948277-28-3

MEASO: Marine Ecosystem Assessment for the Southern Ocean: Meeting the Challenge for Conserving Earth Ecosystems in the Long Term. Frontiers in Ecology and Evolution. https://www.frontiersin.org/research-topics/10606/marine-ecosystem-assessment-for-the-southern-ocean-meeting-the-challenge-for-conserving-earth-ecosys



Organisation details

The course is organised in five blocks.

1 Southern and arctic Oceans

First part: lecture

- main physical and biogeochemical characteristics of the Southern and Arctic Oceans
- the storage of heat and carbon in the Southern Ocean
- what are the consequence of climate change on heat and carbon storage
- what are the consequences on biogeochemistry of Southern Ocean and Arctic Oceans

Second part: climate engineering in the Southern and global ocean.

Work by group on documents.
Discussion/debate on the different facets of this issue.

2 Paleoceanography and Scanning Electron Microscope (D. Cardinal / S. Caquineau)

You will work by group of 2-4 students following the Problem Based Learning Approach. There are two sub-parts in this bloc:

Paleo-oceanography: You will be provided real scientific results based on paleo-proxies that are related to the functioning of the polar oceans during the Last Glacial Maximum.

Scanning Electron Microscope (SEM) and chemical probe: You will observe suspended particles from different zones of the Southern Ocean along the water column.

Accompanied by the teachers during the three weeks, you'll explore the provided resources and synthesize the knowledge gained from these two case studies in an oral presentation. By doing this, you will then be able to:

- Describe the advantages and limits of a SEM coupled to a chemical probe to observe marine suspended particles.
- Recognise the different types of particles and their origins that can be observed in Southern Ocean water column.
- Explain the impacts of sedimentation of particles along the water column and its implications for paleoceanography.
- Differentiate the dominant phytoplankton groups in the Subantarctic, Polar Front and Sea-Ice Zones of the Southern Ocean.
- Explain the causes of the Last Glacial Maximum (LGM) and the periodic succession of glacial-interglacial times.
- Identify some of the impacts of the LGM on the global ocean.
- Explain the different roles and feedbacks of the ocean on atmospheric CO2 during the LGM.
- Assess the importance of high latitude oceans on carbon cycle and climate.
- Explain the principles, advantages and limits of at least two paleo-oceanographic proxies.

3 Marine ecology and Protected Marine Area (P. Koubbi)

The following topics are the subject of lectures and analysis of bibliography. An inverse class is organized on different synthesis that were published by the programme MEASO: Marine Ecosystem Assessment for the Southern Ocean: Meeting the Challenge for Conserving Earth Ecosystems in the Long Term.

- Southern Ocean Benthos focused (1) on microbenthic assemblages with examples on echinoids, demersal fish and underwater observations by Remotely Operated Vehicles, (2) on the consequences of iceberg scouring on the sea floor and (3) on the changes after glacial tongue or iceshelf collapse.
- Southern Ocean Pelagic biodiversity with (1) description of net samples from an oceanographic vessel or from the seaice and a focus on the Continuous Plankton Recorder surveys, (2) details on the Antarctic krill life cycle, ecology and ecological consequences of the fishing industry on it and its predators, (3) changes of the pelagic biodiversity along geographical gradients or because of global change.
- Southern Ocean Marine Mammals and seabirds by presenting regional or global studies issued from biologging of the animals.
- Marine Conservation by explaining (1) the role of CCAMLR (Commission for the Conservation of Antarctic Marine Living Ressources) to manage fisheries and to develop conservation measures to limit impacts on the Southern Ocean ecosystems and (2) how Marine Protected Areas are developed in the Southern Ocean in areas under national jurisdictions by countries and in the high seas by CCAMLR.

4 Phytoplanktonic responses to environmental factor changes in polar and sub-polar regions: a Lab experiment based on cultures and isotopes (C. Ridame / M. Mendez)

Based on your knowledge and literature, you must propose a scientific question on phytoplanktonic responses to changes in environmental conditions in the polar and subpolar regions, related to global change. To answer this question, you will have to design an experiment based on monospecific cultures of (sub)polar diatoms. The parameters you will measure during the experiment, are the growth rate, the primary production and the new production thanks to the use of stable isotopes 13C and 15N. At the end of the experiment, you will write a report in which you will present, interpret and discuss your results. This work will be

done in groups of 3 or 4 students.

5 Sea ice biogeochemistry (M. Vancopenolle)

- State of the art on sea-ice environments
- Plankton in sea ice zone
- Sea ice algae
- Observed changes in sea ice environments
- Future changes predicted
- Impacts on higher trophic levels

Note: This document is for informational purposes. The details of the content and format of the courses and evaluations may change from year to year.