# *Ecology and Biogeochemistry of the Southern Ocean*

Name of Institute: **Institut Universitaire Européen de la Mer**
Faculty: **Université de Bretagne Occidentale**
Unit title (unit code of home institute): **LCEM 803**
Semester/Year: **1st Semester/2009 (March-May)**

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## Unit description

This unit is designed for 1st year Master's students in Marine Biology and Marine Chemistry. It is based on the multidisciplinary expertise in marine sciences of the European Institute of Marine Studies (IUEM) and it aims to give a comprehensive understanding of Antarctica and the Southern Ocean, with a focus on the ecology and biogeochemistry of regions around the subantarctic islands.

A multidisciplinary introduction (~32 hours of lectures) provides a broad overview of general topics of Law (SubUnit 1, ~8 hours), Geosciences (SU 2, ~8 hours), Physical Oceanography (SU 3, ~8 hours), and Ecology/Biogeochemistry (SU 4 and SU5, ~8 hours) See below for more details on the subunits. Subantarctic islands will be used as an example to illustrate the strong links that exist between the different subunits: Law/Geosciences (continental shelf and Exclusive Economic Zone for fisheries), Geosciences/Physical Oceanography (topography/bathymetry and their origin/evolution, and the oceanic currents), Physical Oceanography/Biogeochemistry (oceanic circulation and nutrient supply/primary production), Biogeochemistry/Ecology (nutrient supply/primary production and food webs), Ecology/Law (food webs/fisheries).

Special tutorials will then be held on Southern Ocean Ecology for students in Marine Biology (SU 4, ~16 hours) and on Southern Ocean Biogeochemistry for students in Marine Biogeochemistry (SU 5, ~40 hours). During these tutorials:

(i) short seminars will be given on specific topics (eg biology of benthic organisms, Fe fertilization experiments…)

(ii) students will work on predefined topics, using scientific publications and finally present their work during an oral or poster session.

## Teaching arrangements and contact hours

### *Lectures/Intensive sessions and Tutorials*

The unit includes ~32 hours of lectures and ~16 hours (Marine Biology) or ~40 hours (Marine Chemistry) of practical work or tutorials over 9 weeks (March-May) at IUEM.

**Or** videoconference activities (see below)

***Videoconference activities***

Lectures will be recorded and loaded on the internet with PowerPoint presentations, and made accessible to the IAI students. Videoconferences will be organized regularly for students/teachers meetings.

***Practical/laboratory sessions***

None

***Field trips***

None

## Assessment

| **Assessment task** | **Date due** | **Percent weighting** |
|---|---|---|
| Assignment 1: report (10-20 pages) on literature review/ analysis of papers | End of April | 20% |
| Assignment 2: Oral/Poster presentation of the report | End of April | 30% |
| End of semester exam | | 50% |

Expected number of students: ~ 20
Number of places available for IAI students: 10
Instruction language: French and/or English
Extra costs associated with this unit that students will have to cover: None

## Description of the Subunits:

### *Subunit 1: International law in polar regions (~8 hours)*

Contact: Dr Anne Choquet
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Web link: http://www.umr-amure.fr/

This subunit covers the legal regimes applicable to the Arctic and Antarctica. Each region is managed by a particular legal regime. In this unit, differents ideas will be developped:

Antarctica:

- The Antarctic Treaty and the development of international legal regulation instruments that regulate activities in the area south of 60° South latitude.
- Protecting the environment of Antarctica through international cooperation
- Conflict of use in Antarctica (e.g., between scientific activities and tourist activities)

Arctic:

- International law in the Arctic
- Sovereignty and boundary disputes in the Arctic area (Northwest Passage: Arctic Strait, extension of the continental shelf…)
- An Arctic regional cooperation (i.e., for environmental protection)
- The rights of Arctic indigenous people

**Prior knowledge and/or skills**

None. This unit is open to lawyers and non lawyers

**Learning resources required**

***Requisite texts and recommended reading***

- The United Nations Law of the Sea Convention (1982)
- The Antarctic Treaty (1959)
- The Convention for the Conservation of Antarctic Seals (1972)
- The Convention for the Conservation of Antarctic Marine Living Resources (1980)
- The Convention on the Regulation of Antarctic Mineral Resource Activities (1988)
- The Protocol on Environmental Protection to the Antarctic Treaty (1991)

***-E- (electronic) resources***

Secretariat of the Antarctic Treaty: http://www.ats.aq/index_e.htm
United Nations: http://www.un.org/
Arctic Council: http://www.arctic-council.org/

## Subunit 2: *Evolution of the Southern Ocean and Remote sensing applied to Polar areas (~8 hours)*

Contact: Dr Jean Yves Royer
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This course provides a geodynamic background on the break-up of Gondwana and opening of the Southern Ocean, which led to the individualization of the Antarctic continent. In this framework, the course will address some outstanding questions about continental break-up and Large Igneous Provinces. The course also includes a short training in remote sensing in polar areas.

**Prior knowledge and/or skills**

Basic understanding of plate tectonics.

**Learning resources required**

***Requisite texts and recommended reading***

Plate tectonics: How it works. Cox & Hart, ISBN: 978-0-86542-313-8
Fundamentals in Geophysics. Lowrie

## Subunit 3: *The Antarctic Circumpolar Current dynamics and variability - Impacts on biogeochemical fluxes (~8 hours)*

Contact: Dr Pascal Rivière
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Web link: http://www-iuem.univ-brest.fr/UMR6539/recherche/equipe-1/equipe-1
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The Antarctic Circumpolar Current system is one of the most particular systems in the world ocean. Indeed, the quasi-absence of continent in a large band of latitudes, the thermal distribution and the strong atmospheric forcing induce a circulation with a marked zonal symmetry. This region, highly variable at every scale of time and space, plays a major role in the context of global change because of its connection with all other major ocean basins in the context of the "conveyor belt", and the high $CO_2$ exchanges linked to a high biological productivity.

In this unit the main characteristics of the Antarctic Circumpolar Current will be described in terms of its dynamics, frontal distribution and mass transport and biogeochemical fluxes. The dynamics of the system will be described at different time scales: the mean equilibrium (What forces the ACC ?), the interannual and seasonal variability and mesoscale variability, with a focus on the effects on primary and export production.

**Prior knowledge and/or skills**

Basic understanding of general ocean circulation and climate

**Learning resources required**

***Requisite texts and recommended reading***

Pickard, G. L., and W. J. Emery, 1990: *Descriptive physical oceanography, An introduction.* Permagon Press, 5th Edition, 173-76.
Deacon, G., 1984: *The Anarctic circumpolar ocean*. Cambridge University Press, 180 pp.
Nowlin, W. D., Jr., and J. M. Klinck, 1986: The physics of the Antarctic Circumpolar Current. *Rev. Geophys*., 24, 469-491.
Florindo, F. and Siegert, M (eds), 2009: *Antarctic climate evolution.* Elsevier.
Marshall, J. and Plumb, R.A., 2008: *Atmosphere, ocean, and climate dynamics : An introductory text.* Elsevier.

## Subunit 4: *Ecology and biogeochemistry of Polar ecosystems (~24 hours)*

Contact: Dr Philippe Pondaven
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Web links: http://www-iuem.univ-brest.fr/recherche/equipes/lemar
http://www.univ-brest.fr/IUEM/MACARBI2/
http://www.ipev.fr/pages/bonus/AccueilBonusGoodhope.html

This subunit will focus on the structure and functioning of polar ecosystems, from phytoplankton to top predators (mammals and sea birds). Courses will be organised as follow: ***Lectures (~14 hours)***: in the form of short seminars on specific topics: ecology of coastal ecosystems (biology of benthic organisms, metabolism etc.), controlling factors of primary production in polar oceans, impact of climate changes on marine ecosystems, ongoing scientific programmes in the Southern Ocean, etc.

***Practical works (TP/TD ~10 hours)***: Students will work individually or in pairs on a project (which will require a literature review on a specific topic). The lecturer will meet with the students regularly to follow their work (and help de refine or reorientate the work if

necessary). At the end, the students will produce a short report and will defend their work through an oral presentation at which both lecturers and students will be present.

**Prior knowledge and/or skills**

Basic knowledge of marine ecology and biogeochemistry

**Learning resources required**

***Requisite texts and recommended reading***

Journals in Marine Ecology: *Marine Ecology Progress Series*, *Marine Biology* etc.
Journals (with a focus on polar ecosystems): *Polar Biology, Antarctic Sciences, Polar Research*

## Subunit 5: *Southern Ocean Biogeochemistry and Relation to Climate (~48 hours)*

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This subunit will build on the information given earlier in the course on the legal issues, geology and geologic history, physical oceanography, and ecology of the Southern Ocean. The basic details of biogeochemical cycling in the Southern Ocean will be presented in a short set of lectures. The biogeochemistry and resulting ecology of the Southern Ocean islands areas (e.g., the Kerguelen and Crozet Plateaus) in the context of local physical conditions will be explored in a series of student-led presentations and discussions of published papers. This will be followed by a similar exploration of the considerable number of mesoscale Fe fertilization experiments carried out in the Southern Ocean. The course will finish with the students reporting on the legal, climatic, and environmental aspects of Southern Ocean Fe fertilization and holding a debate over whether it should be used as a method for removing $CO_2$ from the atmosphere and sequestering it in the deep ocean.

**Prior knowledge and/or skills**

Students should have attended the introductory lectures on polar law and Southern Ocean geology, physical oceanography, and ecology.

**Learning resources required**

Will be announced as the course progresses