MARI 431: Antarctic and Southern Ocean Marine Ecosystems (Past and present responses to environmental change)

Marine Science Department
Semester 2 2015

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Course assessment and key dates associated with grading schedule

30%	Review article	7 August 2015
20%	Antarctic fish experiments and poster presentation	14 August 2015
15%	Sea Ice physics laboratory and report	28 August 2015
10%	Seminar presentation, Emperor Penguins	15 Sept 2015
10%	Seminar presentation, Antarctic Seals	22 Sept 2015
15%	Diatom core analysis and report	25 Sept2015

For all written reports please use the departmental coversheet and submit to Miles Lamare by email as a **pdf**

1. Course Overview

New Zealand is closely linked with Antarctica and the Southern Ocean, both physically and biologically. This course is an opportunity to explore Antarctica and the Southern Ocean marine ecosystem at the physical and biological level, and inhabitants adapted to some of the most challenging marine environments on the planet. A central theme of this course is to examine the response (via adaptation) of Antarctic and Southern Ocean marine ecosystems and organisms to past and future climate change, and to direct human impacts. Key to this theme is understanding the interaction between physical and biological processes at these high latitudes. The University of Otago has extensive research expertise in the region, and this course will taught by scientists at the forefront of current research on Antarctica and the Southern Ocean.

Seminar Sessions (Tuesday 9:00 AM 12:00 PM)

This 12-week course will introduce 400-level students to the Antarctic and Southern Ocean marine ecosystem, starting with the key physical and biological features of the region. How the Antarctic and surrounding oceans have responded to climate change over the longer (65 million years) and more recent periods (last glacial maxima, 14,000 years) will give students an understanding of the dynamic nature of the marine ecosystem over time, the magnitude of changes that have occurred, and how the region responds to climate changes (and how the Antarctica and surrounding oceans can drive global change).

To illustrate, the course will first examine Antarctic fish, the best studied marine group in terms of physiological adaptations to the changing Antarctic environment. There is an experimental laboratory on Antarctic fish enzymes, to illustrate key principles of cold adaptation, with the results presented in the form of a conference quality conference poster. We will next examine specific adaptations in the marine invertebrate fauna, focusing on life-histories and reproductive strategies at high latitudes.

Sea ice will be introduced in the second half of the semester, arguable the most important feature of the Antarctic and Southern ocean marine environment. This will start with a consideration of the physical sea ice environment (through the literature and work in a sea ice laboratory), namely its formation, structure, distribution and variability, and how sea ice formation affects the underlying and surrounding water masses. Next, we examine the complex microbial community associated with the sea ice, and the role of these key microbes in the broader Southern Ocean and Antarctic ecosystem. Sea ice extent is variable over geological time, and we will reconstruct sea ice extent (through the literature and examinations of recent sea floor cores) by quantifying changes in diatom communities that reflect sea ice variation.

The Sub-Antarctic Islands are biological hotspots, and we will consider their role in ecology of the Southern Ocean. The islands are also key to the recovery of marine mammals decimated through hunting in the 19th and 20th century. We

will look at the mammals associated with the islands, their habitat use and discuss their conservation and recovery in modern times.

Students are expected to run two colloquia on: (i) adaptations in Emperor Penguins to the physical environment (possibly the most fascinating of all Antarctic animals), and; (ii) Antarctic seals as top-predator sentinels of climate change. These colloquia will be a series of 20-minute presentations in conference format (15 min talk, 5 min questions) and will be graded.

The course finishes with an examination of contemporary climate and environmental change (ice loss, ozone loss, warming, ocean acidification), with students provided with an opportunity to explore and discuss how these issues are being addressed in the latest research at Otago University.

Practical Sessions

1. Physiological adaptations in polar ectotherms and cold-adapted proteins

This lab will start with a discussion of the types of physiological adaptations required by polar ectotherms for living at near-zero or sub-zero sea temperatures. This will include considering the effects of the cold on proteins and this will be practically examined by comparing the biological properties of the enzyme LDH purified from the Antarctic Cod, *Dissostichus mawsoni* and two temperate fish. The results will be analysed, interpreted and later presented in the form of a 'conference quality' scientific poster.
This lab will be held at the Portobello Marine Laboratory on Friday 24 July (all day). Posters to be presented on 14 August.

2. Sea ice physical properties and super-cooling seawater

This lab will explore two important features of Antarctic oceans; (i) Sea ice will be made in a cold-water wet lab to simulate the process of sea ice formation in the Antarctic. This will then be sampled and key features of the ice structure will be quantified (salinity, temperature, porosity, density), and; (ii) Super-cooled sea water will be produced and its physical behavior examined in the context of sea ice formation and freeze-avoidance in Antarctic ectotherms.
This lab will be held in Dept of Physics on Friday 7 August (9:00 – 12:00 AM).

3. Examination of Ross Sea marine sediment cores: quantifying sea ice extent and productivity changes through changes in diatom flora

Using a series of cores recently recovered from the Ross Sea, this laboratory will give students an opportunity to use the latest techniques to identify changes that have occurred in the Ross Sea water column during and after the last glacial maxima (14,000 years ago). Students will use clues from the cores to reconstruct and better understand how warming and cooling can drive changes in sea ice cover, plankton communities and primary productivity in Antarctic waters.
This lab will be held in Dept of Geology on Friday 11 September (9:00 – 1:00 PM).

2. Timetable

Seminar Sessions (Rm 153, Dept of Marine Science, Tuesdays 9:00 -12 AM)

Tuesday 7 July - Introduction to the Antarctic and Southern Ocean Marine Environments (MDL)

Tuesday 14 July – Adaptation in Antarctic fish – Antifreeze Proteins (MDL)

Tuesday 21 July – Adaptation in Antarctic fish – Divergence of Antarctic fish and Antarctic cooling (CJM)

Friday 24 July: Laboratory learning (MDL and CJM)
Some principals of cold-water physiology and adaptation – Mitochondria and cell membranes**,** and Cold-adapted enzymes

Tuesday 28 July – Climate variability and the Antarctic and Southern Ocean (CH)

Tuesday 4 August – Antarctic Sea Ice – physical features and processes (ISM)

Friday 7 August: Laboratory learning (ISM and MDL)
Frigid oceans: physical features of sea ice and super-cooled water.

Tuesday 11 August Antarctic Sea Ice – biological features and processes (MDL)
AND Fish enzyme poster presentations

Tuesday 18 August – Antarctic marine invertebrates (MDL)

Mid-Semester Break (24 to 30 August)

Tuesday 1 September Recent (LGM) changes in Antarctic climate/ocean productivity (CR)

Tuesday 8 September Sub-Antarctic Island ecosystems and marine mammal population biology (WR)

Friday 11 September - Laboratory learning (CR and MDL)
Processing of Antarctic Deep Sea cores for diatom assemblages as indicators of sea ice change following the last glacial maxima.

Tuesday 15 September – Student seminars, Adaptation in Emperor Penguins

Tuesday 22 September - Student seminars, Antarctic seals as sentinels of climate change

Tuesday 29 September - Responses of Antarctic species to contemporary changes in the Antarctic (ozone loss, ocean warming, ocean acidification) (MDL)

3. Assignment Guidelines

I. 30% Review Article (30%) *7 August 2015*

General outline of essay

Describe the links between sea ice and krill *(Euphausia superba*) populations in Antarctica, and consider how changes in sea ice will affect future the future of the species in the region.

DUE: 7 August 2015

The following are the instructions for writing a review for the journal *Science*.
http://www.sciencemag.org/site/feature/contribinfo/prep/gen_info.xhtml
Please read carefully and follow the instructions exactly:

"Reviews (up to 3500 words including references, notes and captions) describe new developments of interdisciplinary significance and highlight future directions. They include an abstract, an introduction that outlines the main theme, brief subheadings, and an **outline of important unresolved questions**. A maximum of 40 references is suggested. Most Reviews are solicited by the editors, but unsolicited submissions may also be considered."

II. 20% Antarctic fish experiments and poster presentation *14 August 2015*

Elements of poster grading

- Title
- Statement of Aims/Hypotheses
- Methods
- Content and interpretation of the data
- Clear conclusions
- References
- Figures/Table
- Overall presentation

There is lots of good advice on what makes a good and bad science poster. Here is one:

http://www.nature.com/naturejobs/science/articles/10.1038/nj7387-113a

III. Oral Presentations

10%	*Seminar presentation, Emperor Penguins*	*15 Sept 2015*
10%	*Seminar presentation, Antarctic Seals*	*22 Sept 2015*

As a starting point, a paper(s) will be distributed to each student and presented to the class. The subjects addressed are:

Presentation date: 15 September 2015

Emperor Penguin Ecology *(Aptenodytes forsteri)*
- Vocalisation
- Huddling
- Walking
- Diving and energy saving
- Emperor Penguins and climate change

Presentation date: 22 September 2015

Antarctic seals as sentinels of climate change
- Breeding success
- Diving behavior
- Spleen contraction and diving
- Oxygen consumption and muscles during diving
- Energy saving when diving

Talks should emphasis adaptations to the Antarctic environment.

Presentations should be **20 mins duration**, including a maximum of 5 minutes for questions. Powerpoint, overhead projector, slide projector and video is available.

Oral Presentation Grading Schedule

	Scale
Introduction of the subject and concepts	0 to 5
Content (Identifying problems faced by the species and mitigating strategies)	0 to 10
Presentation (Overheads, Oratory Skills)	0 to 5
Timekeeping	0 to 5
	Total 25

IV. (15%) Diatoms and climate change report (15%) 25 Sept 2015

Report should include (1000 words excluding references, captions, tables)

Hypothesis: *The distribution of summer sea ice on the East Antarctic margin changed during the Holocene, and these changes can be reconstructed using diatom assemblages from marine sediments.*

Address the following statement: *The proportion of sea-ice vs. open ocean fossil diatoms in "summer" (dark-coloured) layers of a laminated sediment core from Adélie Drift (IODP Site U1357B) is consistent with regional patterns of Holocene sea ice reconstructed from nearby locations.*
The report should include the following elements:

1. Title
2. Abstract (100-word limit) – state hypothesis
3. Introduction
4. Methods including metadata (depth, core depth, location, age)
5. Results - presented in the appropriate figures/tables)
6. Discussion
7. Key conclusion
8. References

Delphine Denis, Xavier Crosta, Sabine Schmidt, et al (2009) Holocene glarier and deep water dynamics, Adélie Land region, East Antarctica. Quaternary Science Reviews 28, 1291-1303.

Leanne K. Armand,T, Xavier Crosta, Oscar Romero, Jean-Jacques Pichon (2005) The biogeography of major diatom taxa in Southern Ocean sediments: 1. Sea ice related species. Palaeogeography, Palaeoclimatology, Palaeoecology 223: 93–126.

Xavier Crosta,T, Oscar Romero, Leanne K. Armand, Jean-Jacques Pichon (2005) The biogeography of major diatom taxa in Southern Ocean sediments: 2. Open ocean related species. Palaeogeogr, Palaeoclimatology, Palaeoecol 223, 66– 92.

Xavier Crosta, Nalan Koc. (2007) Diatoms: From Micropaleontology to Isotope Geochemistry Developments in Marine Geology, Volume 1. Elsevier B.V. ISSN 1572-5480, DOI 10.1016/S1572-5480(07)01013-5

Xavier Crosta, Delphine Denis, and O. Ther (2008) Sea ice seasonality during the Holocene, Adélie Land, East Antarctica. Marine Micropaleontology 66, 222-232.

Integrated Ocean Drilling Program (IODP) Expedition 318, Site U1357 expedition report: http://publications.iodp.org/proceedings/318/318toc.htm

V. 15% Sea Ice physics laboratory and report *28 August 2015*

This laboratory will be held in the Department of Physics cold laboratories (meet 9 am at Physics Reception, 1st floor of the Science III Building) and will be an opportunity to experimentally examine the growth characteristics of sea ice and its key physical characteristics.

You are required to bring the following:

- Very warm clothing such as jackets, hats, polyprops/thermal underwear (you could be -20°C for a couple of hours) – polypropylene gloves will be loaned to you in the lab, but you might also want to bring your own if you have some
- A notebook/exercise book (1B8 size recommended) that is to be handed in at the end of the morning
- A memory stick
- Pencil and pens (a pencil is needed in the coldroom, as the ink in pens will freeze)

The laboratory will involve a series experiments and measurements of which you will be required to make detailed records on the methods, results, observations, and interpretations. Data will also be generated that you can store for later reporting.

At the end of the morning your notebook will be collected, graded and returned within the week. You will also then be required to submit a 1000-word report relating your laboratory experiments and measurement to sea ice properties as they are observed and measured in polar regions. The report should include figures and tables were appropriate, and primary literature should be referenced. The report should use experimental results to explain observed physical processes occurring in Antarctica.

Laboratory Book Records (7.5%)
Laboratory Report (7.5%) Due: 26 September 2014

Supercooling

The laboratory will also be an opportunity to see a demonstration of supercooling (and to consider the implications of supercooling for ice formation in Antarctic waters and for the organisms living in shallow coastal waters).