# "BIOLOGICAL PROCESSES IN ANTARCTIC ECOSYSTEMS"

## AnT-ERA/SCAR Spring Course, Buenos Aires, Argentina,

### 24 - 28 September 2018

**Objectives**

Experienced scientists from the SCAR/AnT-ERA community will give a short course on conducting Antarctic and Southern Ocean biological and ecological research. This opportunity will focus on topics relevant to marine and terrestrial organisms. It is intended to complement formal university courses and encourage the participants of the course to pursue Antarctic research.

**Host institution**

Instituto Antártico Argentino - Dirección Nacional del Antártico. **Venue:** San Martín Palace, https://en.wikipedia.org/wiki/San_Martín_Palace, Buenos Aires, Argentina

**Contact**

Julian Gutt, general organization (julian.gutt@awi.de) and Irene Schloss, local organization (ireschloss@gmail.com), see also: http://www.scar.org/srp/ant-era

**Themes of half-day teaching units**

- **Benthic ecosystem along the shelf and fjords of the West Antarctic Peninsula: Responses to environmental gradients and climate warming.**
  *Craig R. Smith,* Dept. of Oceanography, University of Hawaii at Manoa, Honolulu, USA,

- **Analyses of local/regional biodiversity and species turnover: two biodiversity concepts.**
  *Julian Gutt,* Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

- **Adaptations of Antarctic marine benthic organisms to Southern Ocean environments and how this affects their ability to respond to change.**
  *Lloyd Peck,* British Antarctic Survey, Cambridge, UK

- **Protein structure, function, stability and dynamics in changing environments. Structural constraints and evolution at low temperature.**
  *Cinzia Verde,* National Research Council (CNR), Institute of Biosciences and BioResources (IBBR), Naples, Italy; *Leonardo Boechi, Dario Estrin*

- **Climatic controls on sedimentation and their implications for benthic communities.**
  *Enrique Isla,* Institut de Ciències del Mar-CSIC, Barcelona, Spain

- **Methods for observing change to soil biota in terrestrial ecosystems.**
  *Diana Wall,* Natural Resources Ecology Lab., Colorado State University, Fort Collins, U.S.A.

- **How to Identify the Plants and Animals? DNA barcoding for species' identification and monitoring of plant and animal life in the Antarctic and sub Antarctic**.
  *Ian Hogg,* Polar Knowledge, Canada

- **Ecology of Southern Ocean predators: Approaches to studying their movement and behaviour.**
  *Trevor McIntyre,* University of Pretoria, South Africa

- **Marine plankton and multilayer network modelling**
  *Leonardo Saravia* and *Irene Schloss,* Instituto Antártico Argentino, Buenos Aires and Universidad Nacional de Tierra del Fuego, Ushuaia, Argentina

- **Grant writing: pro tips for crafting compelling proposals.**
  *Byron Adams,* Department of Biology and Monte L. Bean Museum, Brigham Young University, Provo, U.S.A.

- **The commercial fishery in the Antarctic and its regulation by CCAMLR**
  *Esteban Barrera-Oro*, Instituto Antártico Argentino, Buenos Aires, Argentina

SUMMARIES OF THE HALF-DAY TEACHING MODULES

## Benthic Ecosystem along the Shelf and Fjords of the West Antarctic Peninsula: Responses to Environmental Gradients and Climate Warming

*Craig R. Smith*

The West Antarctic Peninsula (WAP) exhibits ecologically important boundaries and gradients that are being altered by regional warming. These include (1) oceanographic boundaries resulting from the Antarctic Circumpolar Current, (2) climate gradients caused by the large latitudinal extent of the peninsula, and (3) down-fjord gradients in productivity, diversity and burial disturbance.

Topics addressed in this course module will include the following. (A) How the interface between warmer Upper Circumpolar Deep Water and colder Antarctic Shelf Water forms a temperature barrier to the dispersal of predacious king crabs onto the Antarctic shelf, and how recent warming trends suggest that this king-crab temperature barrier to the WAP shelf may soon be lifted, with dire consequences for diverse, evolutionarily novel shelf communities. (B) Insights from the latitudinal climate gradient along the West into the potential effects of warming related sea-ice loss on Antarctic shelf benthos. (C) Down-fjords gradients in glacial meltwater influence, burial disturbance, productivity, diversity and ecosystem function; the potential consequences of climate warming.

The goals of this module will be to (a) provide basic understanding of the structure, function, and climate-sensitivity of WAP shelf and fjord benthic (b) introduce state-of-the-art methods and tools for their study, (c) highlight the influence of climate warming (and other anthropogenic impacts) on Antarctic coastal ecosystems, and (d) foster critical thinking about environmental issues related to coastal ecosystems and climate change.

## Local/Regional Diversity and Species Turnover: Two Different Biodiversity Concepts

*Julian Gutt*

Biodiversity can be measured as the number and abundance of species. Similarly, genetic and ecosystem diversity are important components of biodiversity. Estimates of biodiversity can be calculated for local, regional and even global scales. Especially at larger spatial scales, detailed studies can be important in the context of natural and anthropogenic environmental changes. Beta-diversity, or species turnover, is a measure of community heterogeneity and is independent of the size of the area under investigation. Such heterogeneity can be the result of patchy environmental conditions that arise from abiotic factors, like iceberg scouring, biological factors, such as grazing effects, or anthropogenic factors, including trawling.

- Analytical methods for the different approaches to working with biodiversity measures will be presented.
- Basic data for analyses of the above-mentioned biodiversity measures will be collected from photographs of the Southern Ocean sea-bed.
- Data will be analysed and discussed by the participants.

## Adaptations of Antarctic Marine Benthic Organisms to Southern Ocean Environments and how this Affects their Ability to Respond to Change

*Lloyd Peck*

This module covers the physiological adaptations of Antarctic marine benthic species, including the possession of antifreeze and the loss of haemoglobin in some fish; the widespread loss of the heat shock response; large size in some clades; the slow growth and very slow development rates, well beyond the expected limitations of low temperature; the slowed responses to feeding, again beyond the expected effects of low temperature; slowed metabolic rates and low levels of activity. It will then show how these differences in scale of adaptation might be explained by limitations to the ability to make proteins and also frame the question as to whether protein synthesis adapted to low temperature in these species or is merely limited by the conditions. A second part of the lecture course would be to look at what animals can do physiologically to respond to change and how the specific adaptations of Antarctic benthic animals affect these basic response mechanisms.

## Protein Structure, Function, Stability and Dynamics in Changing Environments: Structural Constraints and Evolution at Low Temperature

*Cinzia Verde*

An important question associated with climate change is whether species will be able to adapt fast enough to keep up with the rapid pace of environmental changed. Whatever the type of adaptive responses, underlying mechanisms are either due to evolution or plasticity. Empirical evidence suggests that physiological plasticity is often more important than genetic contribution in complex, long-living species. The biological effects of increasing temperature on marine ecosystems are already evident. Temperature governs the rate of chemical reactions and pathways regulating the development and decline of life. Sensitivity to temperature influences the success of organisms in all habitats. All biochemical and physiological processes are influenced by temperature and a temperature term enters in all equations describing the ecosystem. Therefore, the thermal stability of proteins is a unifying property in the evolution and adaptation of life on Earth. However, despite many advances in our understanding of structure–function relationships, we cannot still predict how a particular amino acid change can impact temperature sensitivity of protein function. Recent studies indicate that only minor structural modifications are needed to change the intrinsic stability of cold-adapted proteins, and that local rather than global flexibility may play an important role.

In this module, we first summarise how temperature affects the physiology and then focus on the molecular mechanisms of cold adaptation revealed by recent biophysical, biochemical and genetic studies in some proteins. Next, we also discuss the structural and functional features of the cold-adapted proteins in an attempt to put into perspective what has been learnt about these proteins and their role in the biology of cold-adapted marine species. The methods and tools for proteins study will be introduced and explained.

**Climatic Controls on Sedimentation and their Implications for Benthic Communities.**

*Enrique Isla*

Analyzing the magnitude and composition of particle flux exports towards the seabed is important to assess how the pelagic and benthic environments are related. The conditions at the sea surface determine to a large extent the quality of the food that the benthos may ingest. Also, the environmental characteristics near the sea floor determine the availability of organic matter for benthos and consequently the spatial distribution of the animals. This module attempts to explain some of the mechanisms driving pelagic-benthic coupling in Antarctic continental shelves, including climatic and meteorological forcing. The lectures will also provide information on sampling tools and strategies to analyze particle fluxes.

**Methods for Observing Change to Soil Biota in Terrestrial Ecosystems**

*Diana Wall*

The goal of this module is to learn about standardized protocols available for testing hypotheses, characterizing landscapes and observing change of soil biota. Some of the methods facilitate comparison of biota across polar and temperate ecosystems. Topics include:

- Preparation for Antarctic field work, timing, soil sampling, quality control
- Site and soil characterization for ecosystem studies
- Types of soil, geological history, physical and chemical analyses (water, temperature, pH, soil cation, salinity) that may inform ecology measures
- Soil ecosystem processes, including C02, nitrogen availability, soil carbon, decomposition
- Soil biodiversity measures, including microbial biomass, soil invertebrate ecology, survival and measuring biomass
- Testing hypotheses and measuring change: Manipulative experiments, transects, landscape features; sites of high and low biodiversity, models
- Archiving soil samples
- The importance and how-to of good data collection, including metadata and field records, and consistency across methods, sites, collaborations and long term studies

**How to Identify the Plants and Animals? DNA Barcoding for Species' Identification and Monitoring of Plant and Animal Life in the Antarctic and sub Antarctic**

*Ian Hogg*

DNA barcoding refers to the use of short (<700bp) strands of DNA for species identification. A variety of DNA regions can be used to identify taxa and specific markers often vary between groups of taxa. For example, the 16S region is usually used for microbial diversity whereas plants require a variety of markers including rbcL, ITS and matK. For animal life, the COI (cytochrome *c* oxidase subunit 1) gene is by far the most common marker with over 5M records currently available in public databases.

This module of the AnT-ERA 2018 Spring Course will introduce participants to: 1) relevant background for DNA barcoding; 2) a hands-on session using the Barcode of Life Datasystems (BOLD) database, including data mining; 3) workflows for processing Antarctic samples for DNA barcoding; and 4) applications for the use of barcode data including examples of ecological and evolutionary studies. This latter component will also include information on Next-Generation-Sequencing approaches and how DNA-based methods can be included in proposed Antarctic monitoring initiatives (e.g. ANTOS). The basic principles are not necessarily restricted to terrestrial habitats (e.g. sample design, barcoding), but we will focus on terrestrial habitats in our examples for this workshop.

**Ecology of Southern Ocean Predators: Approaches to Studying their Movement and Behaviour.**

*Trevor McIntyre*

Understanding where top predators go, when they go there and what they do provides insight not only into the behaviour of the study species, but also the underlying qualities of the ecosystems they exploit. To study such aspects in Antarctic predators, researchers have used animal-borne telemetry devices and other technologies for nearly 80 years, generating substantial amounts of data and numerous publications. The development of biologging technologies and other complementary techniques, as well as the development of statistical approaches, is still ongoing and the last two decades has seen a rapid increase in publications emanating from such approaches, particularly in the Antarctic and sub-Antarctic.

This module will aim to introduce students to the fast-developing world of biologging sciences and other related high-tech tools used currently by researchers to gain insights into the movements and behaviour of top predators in the Southern Ocean. It will include (a) a background information session on the available tools and current uses of data obtained from biologging tools; (b) a practical session where students can access and explore freely available telemetry data; and (c) an introductory practical session where students will learn and apply some basic coding (in the R environment) to filter, visualise and analyse telemetry data.

## Marine Plankton and Multilayer Modelling

*Leonardo Saravia* and *Irene Schloss*

Biological models are widely recognized as a powerful tool to study marine ecosystems' actual dynamics as well as their response to environmental perturbations. By formulating the relation of the different ecosystem compartments among them and with the environment by means of mathematical formulations, they allow the study complex systems from the basic understanding of the underlying processes, integrating different layers of available knowledge. At the ecosystem level species are linked by trophic relationships such that changes in the abundance of species can propagate through intermediaries to affect other species and can have dramatic consequences for the structure and dynamics of whole ecosystem. Besides trophic interactions, species are also linked by competitive and mutualistic interactions. The different types of interactions are described as layers in a multiplex structure. Species have not only different kinds of interactions with other species at the same time, but the structure of each of these layers cannot be analyzed separately: the way these network layers are intertwined with each other influence community dynamics and resilience. In the present module, we will use different modelling approaches to study plankton dynamics in a realistic, turbulent ocean environment and further scale this dynamics to the upper levels of the food web. In the first part, typical NPZD (nitrate, phytoplankton, zooplankton, detritus) models will be explained and their use exemplified in different scenarios where they have been applied. We will additionally show some examples of this kind of multilayer networks, review some new tools to analyze multiplex networks and describe them using a bio-energetic consumer-resource model. During the module, we will propose an exercise for students to apply some of the concepts explained during the course.

## Grant Writing: Pro Tips for Crafting Compelling Proposals

*Byron Adams*

The first, and often most challenging task of conducting polar research is to find adequate funding support for your project. Thus, one of the most critical skills for conducting polar research is to be able to prepare and submit a persuasive, compelling research proposal.

In this workshop students will learn how to:

- Identify funding sources
- Craft key elements common to most requests for proposals
- Craft not just an interesting, but a compelling, research proposal
    - Create catchy (but not annoying) titles
    - Write concise executive summaries, abstracts, and introductions that capture reviewer attention
    - Make the most of preliminary data/proof of concept
    - Demonstrate independence from previous advisors and projects
- Develop Effective Project planning
- Master Tips for telling compelling stories
- Utilize Tech-tips and time saving techniques
- Develop realistic budgets and budget justifications
- Use time-saving organizational techniques
- Effectively collaborate on interdisciplinary proposals

## The commercial fishery in the Antarctic and its regulation by CCAMLR

*Esteban Barrera-Oro*

The Antarctic Ocean is one of the last regions in the world where commercial exploitation of the fishing resources has been carried out. From the conservation point of view, the finfish fishery was the most important one and began at the end of the 1960s, just as decades of sealing and whaling were finishing. It first started in the Atlantic sector/Scotia Sea region in waters around South Georgia in 1969 and in the Indic sector around the Kerguelen Islands in 1971, and later on it expanded to other Antarctic áreas. Since then, krill, and in much less amounts, squid and king crab, have been also exploited. The Antarctic coastal fish, represented by the endemic Suborder Notothenioidei, are characterized by slow growth and low fecundity, which made some of its populations be overexploited in a few years.

Historically, about 20 fish species have been taken by the industry either as target species or as by catch. Nowadays, the commertial fishery of these species is limited or prohibited. Up to the 1990s the main fishing country was the former Soviet Union, but in the last two and a half decades the finfish fishery became multinational and has focused almost exclusively on the *Dissostichus* species patagonian toothfish *D. eleginoides* and Antarctic toothfish *D. mawsoni*. Likewise, the present fishery of the Antarctic krill *Euphausia superba*, also multinational, is regulated mainly to protect the dependent species in the entire Antarctic ecosystem.

Shortly after the inception of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) in 1982, its Commission started the adoption of a series conservation measures – in permanent updating - to protect biodiversity. As a recent, key objective, CCAMLR has been working since 2011 on a development of a representative network of Marine Protected Areas (MPA) in the entire Antarctic ecosystem.