Swedish Abstracts Oden Southern Ocean 2010/11

Oden:

Inter-Related Biogeochemical Cycles of Halocarbons and Mercury in the Southern Ocean

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The project aims to determine the importance of some greenhouse gases (halocarbons), as well as mercury, for chemical and biological exchange processes in the cryosphere (snow and ice) and the marine environment with focus on polar regions and their feedback mechanisms in the context of a changing climate. More specifically, the project aims to quantitatively investigate the mechanisms controlling the temporal and spatial variability in the processes driving the fluxes of halocarbons and mercury in the climatically sensitive polar ocean. The exchange of species (volatile halogenated organic compounds and mercury) between sea–atmosphere–sea ice–snow, as well as the control mechanisms, will be studied in field studies, with emphasis on the impact of changes in sea ice cover, precipitation, temperature, UV radiation, and a high carbon dioxide scenario. The major elements are:

- Flux measurements in different ice regimes in the Antarctica. These measurements include determination of chemical species in seawater, atmosphere, sea ice and snow during sea ice formation and melt.
- Chamber experiments will be performed in order to establish sea ice–atmosphere as well as snow–atmosphere fluxes. These measurements will be combined with incubation experiments on board, where ice and snow samples will be placed in a controlled temperature environment in air tight canisters, and the release of biogenically produced gases will be measured.
- Controlled mesocosm experiments simulating ozone depletion events, ocean acidification and temperature increase.
- Underway measurements of halocarbons and mercury in air and water.

Circulation of Warm Oceanic Water and Glacier Melt Water in the Amundsen Sea – Ross Sea shelf Region

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The mass balance of the large ice sheets bounded on the Antarctic continent is of global significance since they have the potential to alter the sea level. Only the West Antarctic ice sheet, which makes up 10% of the continental area, has a volume that corresponds to a sea level rise of 5–6 meters. The West Antarctic ice shelves are vulnerable to melting by the heat contained in the relatively warm Circumpolar Deep Water (CDW) that crosses the shelf and circulates below the ice shelves (floating tongues of glacier ice). The offshore movements of glaciers which drain into the Amundsen Sea area are accelerating rapidly, presumably due to melting and thinning of the ice shelves. The low salinity melt water eventually leaves the shelf and becomes an important ingredient in the freshwater budget of the Southern Ocean. In the present project we will study cross shelf flow of dense CDW and buoyant melt water by hydrographical sampling along several sections and mooring work in the Amundsen Sea region. The specific objectives are:

- Trace and characterize the inflow of warm CDW across and along several deep channels at the Amundsen Shelf.

- Trace the flow of glacier and sea ice meltwater along the Amundsen Sea and Ross Sea shelf region and off the shelf break.
- Characterize the time variability of the temperature, vertical extent and flow of CDW from moorings.

Dynamics and Evolution of Epidemic Diseases in Antarctic and Arctic Seals

Tero Härkönen, The Department of Contaminant Research, Swedish Museum of Natural History

Since Antarctic seal species have not been exposed to exploitation for more than 50 years, most populations are expected to have reached their asymptotic population sizes, often termed carrying capacity (K). Fluctuations in population numbers are in such cases often linked to food limitation, predation, disease, or catastrophic events leading to mass mortality. Such events have been documented in the 1950s, when a majority of Crabeater seals in investigated areas died. Serum samples collected during the SWEDARP expedition in 1989 showed that the likely cause for the mass mortality was a canine distemper epidemic, that seems to have circulated among Crabeater seals and Leopard seals ever since. We run a program focusing on the potential role of infectious diseases for the population dynamics of Antarctic seals. A general core issue is to explore processes involved in the evolution of disease resistance, where the epidemiology and immunogenetics of canine distemper in Antarctic seals will be investigated in parallel with phocine distemper in Arctic and North Sea seals. Samples secured during the 2008–2009 expedition are now being analyzed together with earlier collected material from seals in the northern hemisphere.

Processes Driving the CO_2 System in Sea Ice and Water in the Climatically Sensitive Amundsen and Ross Seas

Melissa Chierici, Department of Chemistry, University of Gothenburg

The aim for the proposed project is to investigate the carbon dioxide (CO_2) system, the sea–ice–air CO_2 fluxes and the fate of atmospheric CO_2 in the water column and sea ice in areas of varying ice conditions in the Amundsen and Ross Seas in the Southern Ocean. The project takes advantage of the reported decreased sea ice cover in the Amundsen Sea and the observed growth in the Ross Sea to investigate the effect on the carbon system to assess the consequences of a changing environment. The project will use ship-based measurements of the CO_2 system and ancillary parameters (chlorophyll a sensor, oxygen sensor) to provide new insights on the interannual variability of the biogeochemical processes driving the CO_2 system. We will use measurements of total alkalinity and pH to calculate the full oceanic carbonate system. Measurements will be performed in the sea ice, and water column (in sea ice area). CO_2 fluxes will be measured at the ice–air interface using flux chambers. Data will also be used to investigate the calcium carbonate saturation state in the two areas thus increase understanding of the role of sea ice in the fate of oceanic CO_2 and contribute to the study of ocean acidification. Data from this study and previously collected CO_2 data will be used to calculate CO_2 sea–ice–air fluxes and in models to quantify the strength of the processes affecting CO_2, and the vertical transport of carbon in a sensitive area of a changing Southern Ocean.

Moreover, studies will continue from previous Oden Southern Ocean expeditions regarding the possibility of using satellite data to evaluate surface CO_2 algorithms, and facilitate future monitoring of oceanic partial pressure of CO_2 (pCO_2) and remotely sensed sea–air CO_2 fluxes in addition to ship based in-situ observations. Annually repeated studies in these contrasting

areas are comparable to investigate climatically driven conditions and provide an excellent opportunity to obtain information about the feedbacks, and how a change in environmental conditions affects the sea–air CO_2 flux.

Nathaniel B. Palmer:

Iodine Isotopes (^{129}I and ^{127}I) and Species (I^- and IO_3^-) as Ultra Sensitive Tracers of Ocean Circulation

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The objective of this project is to establish data sets for the radioactive isotope ^{129}I and stable isotope ^{127}I as well as their speciation in seawater along a transect across the Atlantic Ocean and into the Ross Sea (Antarctica) which can serve as:

1) Basic information (temporal and spatial) about pattern, sources and processes of water mass exchange roots and rates between the North and South Atlantic Oceans.
2) First data set on the distribution of iodine isotopes and their speciation in the waters of the Southern Ocean, particularly the along the cruise track which cross the convergence zone, the marginal ice and the Ross Sea.
3) A tool for estimating magnitude of the different vertical water parcels dominance that will eventually contribute to improve predictions of ocean circulation in this region of the world.
4) Revealing dominant chemical speciation of ^{129}I in ocean water and bioavailability for ecological loading. Iodine resides in different speciation forms within the water mass and in the organic and inorganic molecules and will strongly be affected by the redox potential of the water parcels.
5) First time series that will elucidate preservation, dissipation and cycling of radioactive ^{129}I within the Atlantic Ocean and into the Southern Ocean.

Patchiness and Significance of Microbial Communities Controlling the Southern Ocean Carbon Cycle

Stefan Bertilsson, Department of Ecology and Evolution, Uppsala University

For the 2010/11 cruise to the Southern Ocean we plan for a strictly open-water-sampling project in the Amundsen Polynya. We will collaborate with a team of US and Swedish scientists with the aim of investigating carbon fluxes in the extremely productive Amundsen Sea Polynya. Our project complements and is integrated within the American ASPIRE (Amundsen Sea Polynya International Research Expedition) project, and concerns assessment of specific processes within the microbial loop, which are important for the flux of carbon. We will assess the significance of several processes mediated by bacteria and viruses, which are not addressed within ASPIRE, and will significantly strengthen knowledge on the importance of microbes for carbon flux in the Amundsen Polynya.

Briefly, our project contains three main parts: 1) The importance of "the viral shunt" where viral cell lysis transforms biomass to dissolved detritus, increase pelagic respiration, and decrease the vertical carbon export, 2) bacterial uptake and turn-over of key carbon substrates, 3) chemoautotrophic carbon fixation, which may complement photosynthesis, particularly in low-light conditions. For selected stations we will examine how these processes relate to microbial community composition. We have extensive experience with the methodology required within the three project parts. The acquired data will be valuable for the carbon budgets established within the ASPIRE project, but in addition these data report on processes not hitherto examined in this oceanic region.

The Amundsen Sea Polynya is a high-productivity region, which was confirmed by the high local chlorophyll values and high viral and bacterial abundances that we measured in December 2007. The region is therefore of particular interest if carbon fluxes in the Antarctic are to be addressed. Consequently, it is a main emphasis within the ASPIRE project to examine the spatial and temporal (e.g., diel) variability of biomasses and processes regulating carbon flux in this productive region. Our examination of important microbe-driven biogeochemical processes is integrated in this program.

Climate Change and Predatory Invasion of the Antarctic Marine Environment

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The marine fauna of Antarctica currently lacks the durophagous predators that structure benthic food webs in nearshore habitats elsewhere. Sea temperatures are now rising rapidly and the physiological barriers to predatory reinvasion are coming down. Adult and juvenile anomuran king (lithodid) crabs have been discovered recently on the continental slope off the Antarctic Peninsula, where water temperatures are slightly warmer than on the shelf. In addition, larvae of brachyuran and anomuran crabs are entering Antarctic waters entrained in warm-core rings (mesoscale eddies) from the Antarctic Circumpolar Current.
We will assess the extent and consequences of the ongoing invasion by: (1) sampling the water column for larvae; and (2) sampling bottom water for demersal larvae and surveying the benthos for juveniles and adults, and for localized changes in community structure.

Iron Speciation and Lead in Amundsen Sea: Study of the Relative Importance of Sea and Glacial Ice Sources

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Primary productivity and the associated uptake of carbon over large areas of the Southern Ocean including coastal Antarctica, is thought to be co-limited by the micro nutrient iron (Fe) and light. The main aim of the proposed project will be to study the source(s) of Fe and other trace metals in the virtually unexplored Amundsen Sea and how its Fe chemical speciation affects biogeochemical processes and phytoplankton dynamics in the region. We will accomplish this by determining Fe speciation and lead (Pb) isotope signatures on sea and glacial ice meltwater to help understand the sources of atmospheric metals to sea ice and, via seasonal melting, to the Amundsen Sea Polynya. The study will be based on two major hypothesis:

(i) That Aeolian deposition is a significant source of Fe that fuels the high productivity observed at ASP and that organic complexation dominates Fe speciation in sea-ice and glacial-ice melt water helping keep Fe in solution. This plays a major role on its (Fe) cycling and bioavailability.
(ii) Lead in the Amundsen surface sea-ice and glacial-ice and Amundsen Sea Polynya water will have a South American industrial aerosol signature. Thus Pb isotope data can be used as a tracer to elucidate if South America is a source of Aeolian transport of other trace metals including Fe to the Amundsen Sea. The information obtained from the study will help us understand trace metal input into the Amundsen Sea and to derive potential impacts of climate change on the biogeochemistry of this region. The project will be carried out in close collaboration with the ASPIRE (Amundsen Sea Polynya International Research Expedition). Polynyas are foci for both energy and material transfer between the atmosphere and the polar ocean. The broader aim of ASPIRE is therefore to investigate why and how the coastal Antarctic Polynya in the Amundsen Sea is so much more productive than other polynyas, and

whether interannual variability can provide insight to climate-sensitive mechanisms driving carbon fluxes there. Thus the source of nutrients, especially Fe, that fuel the high productivity in ASP is a key biogeochemical question of this project and the multidisciplinary ASPIRE study.