G.S. Dieckmann, C. Haas, H. Hellmer, and M. Schröder: Project outline for a Polarstern drift station in the Weddell Sea (ISPOL)

Ice Station POLarstern (ISPOL 1)

ANT XXI/2: 18.11.2003 - 8.1.2004 (51 days)
(N.B.: Earlier start and extension of 10 days is highly desirable (70 days duration))

Overall Objective

The main goal of this project is to improve our understanding on the role of the early summer atmosphere-ice-ocean interactions in the western Weddell Sea in global processes. It is an interdisciplinary study involving oceanographers, glaciologists, biologists, and meteorologists.

The western Weddell Sea is unique among Antarctic sea ice regions, as it comprises the largest perennial ice zone of the Southern Ocean and thus exerts a major influence on the oceanography, meteorology and ecology in this region. The results are expected to provide answers to the following questions:

- What controls ice survival during the summer, and how does this affect the perennial ice cover on longer time scales?
- What is the role of the perennial ice region for the fresh water budget of the Weddell Sea?
- What are the hydrological conditions on the western continental shelf (supposed to be the prime site for deep and bottom water formation) after completion of the freezing season?
- How are primary production in sea ice and phytoplankton as well as krill distribution affected by the sea ice regime in the Weddell Sea?

Tasks

- To investigate physical, biogeochemical and biological processes controlling the transformation and interactions in the atmosphere-ice-ocean system from austral spring to summer. Main focus of the project is the sea ice system with emphasis on the study of processes as a function of meteorological and oceanographic boundary conditions. These processes are, from top to bottom:
  - Metamorphism and melt of snow, and related changes in surface albedo.
  - Refreezing of meltwater and formation of superimposed ice at the snow/ice interface.
  - Flooding and near-surface formation of seawater-filled gap layers in the ice.
  - Development of highly productive biological communities within the gap layers.
  - Brine channel development, rotting and bottom melting of sea ice.
  - Exchange of brine/seawater between ice and ocean.
- To provide a comprehensive data set of the entire system, in support of the development of numerical models and as ground-truth information for satellite remote sensing studies.
- To determine the post-freeze hydrographic conditions on the western Weddell Sea continental shelf related to deep and bottom water formation.
G.S. Dieckmann, C. Haas, H. Hellmer, and M. Schröder: Project outline for a Polarstern drift station in the Weddell Sea (ISPOL)

- To complement sea-ice and oceanographic observations and process studies performed during the US/Russian Ice Station Weddell (ISW-1), carried out in the summer-to-fall period 1992.
- To improve our understanding of the seasonal interaction between biota and sea ice.

Framework

The study is a contribution to the following national and international projects or groups:
- BIOPPSI (BIOlogical and Physical Processes in Sea Ice): Interdisciplinary project at AWI involving physical, biological, and biogeochemical studies of sea-ice processes.
- ASPeCt (Antarctic Sea-ice Processes and Climate): International SCAR/GLOCHANT program.
- iAnZone (international Antarctic Zone program): SCOR affiliated program.

Logistics

- The drift station will be performed during the Polarstern cruise ANT 21/2 (Nov. 2003 to Jan. 2004) The ship will be anchored to an ice floe and will serve as a base for field work, while drifting with the floe.
- The ship will depart from Punta Arenas, Chile, and will enter the central Weddell Sea at about 60°S, 40°W, to steam as far to the Southwest as ice conditions allow. The anticipated final destination is 72°S, 50°W (Southwestern Weddell Sea) in mid-November. For that region, model results of drift trajectories have shown a high probability that the ship will still be within closed pack ice at the completion of measurements by mid-January.
- Two helicopters, three divers, and ship-based infrastructure will be available for larger-scale studies around, below, and at the ship.
- A camp consisting of Fibreglass huts will be put up on the floe to house equipment and to provide scientist with a 24 hour possibility to monitor their projects.

Scientific projects

The main goal is to describe the complete system above, within, and below the ice, i.e. the boundary conditions for ice processes. However, this also encourages comprehensive oceanographic and meteorological projects which are linked to the sea-ice studies. Below, we describe the various scientific projects planned by AWI groups as well as those suggested for contribution by other groups. However, as program development is not yet complete, we also welcome contributions by other groups not yet mentioned below. Links showing the interconnection between the project groups are also shown.
Oceanography

1.
Project Title: Deep and bottom water formation along the western Weddell Sea continental shelf / Influence of sea ice melting on water column stability

Links: Provide boundary conditions for physical and biological sea-ice projects. Compare freshwater budget with sea-ice melting.

Measurements: Schröder / Hellmer, AWI:
- Standard Ship-CTD + LADCP (Lowered Acoustic Doppler Current Profiler)
- Helicopter-CTD
- Ship-ADCP
- Submersible floats

Others:
- Tracers (Shelf water modification (including Larsen Ice Shelf))
- Turbulence measurements
- Moorings / Oceanographic buoys (J-CAD from JAMSTEC)

2.
Project Title: Plume dynamics / dense water sinking

Links: Determine intensity and variability of deep and bottom water formation at the end of the freezing season. Continuation of ISW-1.

Measurements: Gordon/Muench:

Bathymetry

Project Title: High resolution shelf brake bathymetry

Links: Physical oceanography

Measurements: Schenke, AWI
- Hydrosweep
- Parasound

Meteorology

Project Title: Energy balance at the ice surface from spring to summer

Links: Provide boundary conditions for transformation of snow and ice properties and biological/chemical activity. Compare with / include ocean heat fluxes.

Measurements: Helbig / Bareiss, Uni Trier:
- Radiation fluxes
- Albedo
- Launiainen, Helsinki:
- Turbulent fluxes
Sea ice physics

1. Project Title: *Formation of superimposed ice and surface gaps, as a function of ocean and atmosphere forcing*

   Links: Meteorological and oceanographic measurements of energy fluxes. Biological dynamics in surface gaps.

   Measurements: Haas, AWI:
   - Ice coring and S, T, porosity, texture analysis
   - Thermistors
   - Drill-hole transects
   - Non-destructive EM monitoring of changes in ice conductivity

   Blümich / Menzel, RWTH Aachen:
   - NMR

   Others:
   - Snow properties
   - δ¹⁸O
   - Microwave properties -> Scatterometer
   - Albedo

2. Project Title: *Evolution of the meso-scale ice thickness distribution – Cal/Val of CryoSat mission*

   Links: Freshwater balance, surface and ocean heat flux. Ice dynamics, atmospheric circulation.

   Measurements: Haas, AWI:
   - Airborne and ground-based EM thickness and laser ridge profiling

   Others:
   - Buoy drift
   - Satellite ice drift

Geodesy

Project Title: *Calibration/Validation of CryoSat and other geodetic missions*

Links: Sea ice thickness, physical oceanography, bathymetry

Measurements: Schenke, AWI:
- Precise DGPS
- Skyfix
- Ship draft monitoring

Sea ice biology and biogeochemistry

1. Project Title: *Growth and development of algal communities at sea ice peripheries and freeboard layer*

   Links: Micro and mesoscale physical sea ice properties; energy balance.

   Measurements: Dieckmann/Thomas, AWI/Bangor:
   - Primary production
   - Nutrient dynamics
   - DOC
2. **Project Title:** Biogenic flux from sea ice  
   **Links:** Copepods, krill, and dynamics at ice water interface  
   **Measurements:** Dieckmann/Thomas, AWI/Bangor:  
   - Deployments of small under-ice sediment traps  
   - Bottom melting rates

3. **Project Title:** Life-cycle strategies of Copepods  
   **Links:** Micro and mesoscale physical sea ice properties/sea ice biota  
   **Measurements:** Schiel, AWI:  
   - Stephos longipes

### Water column biology

1. **Project Title:** Zooplankton ecology  
   **Links:** Micro and mesoscale physical sea ice properties / Sea ice biota / Physical oceanography  
   **Measurements:** Bathmann, AWI  
   - Krill ecology  
   - Copepod  
   - Phytoplankton  
   - Acoustics

2. **Project Title:** Krill physiology and ecology  
   **Links:** Micro and mesoscale physical sea ice properties / Sea ice biota / Physical oceanography  
   **Measurements:** Meyer-Harms, AWI  
   - Feeding strategy of krill under ice  
   - Sea ice algae

3. **Project Title:** Phytoplankton dynamics  
   **Links:** Mesoscale physical sea ice properties / Biogenic flux / Physical oceanography  
   **Measurements:** NN, AWI  
   - Ocean color remote sensing  
   - Optical measurements  
   - CTD  
   - Inorganic nutrients