DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2011/107

# East Greenland Ridge 2011 (EAGER) – Cruise Report

Christian Marcussen and the EAGER 2011 Scientific Party

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF CLIMATE AND ENERGY

G E U S

# Contents

# Summary

During the EAGER 2011 (**Ea**st **G**r**e**enland **R**idge) cruise with the Swedish icebreaker *Oden,* multibeam bathymetry, subbottom profiler, seismic reflection and refraction profiles and gravity data were acquired. These mapping activities are all part of the Continental Shelf Project of the Kingdom of Denmark (www.a76.dk). The cruise was a cooperation with the Swedish Polar Secretariat (www.polar.se). However, the cruise was fully funded by the Continental Shelf Project of the Kingdom of Denmark. The EAGER 2011 cruise started in Longyearbyen on Svalbard on August 17, 2011 and ended at the same location on September 10, 2011.

Multibeam bathymetry was collected continuously during EAGER 2011 along the 4000 nautical mile track of *Oden*. Data were acquired with the SIMRAD EM 122 multibeam echo sounder installed on *Oden* in order to study bottom processes and seafloor morphology. In addition, subbottom profiling was carried out continuously to characterise the stratigraphy within the upper 50 to 200 m of the sedimentary column. These data were acquired using the hull-mounted 2-8 kHz chirp sonar system SBP 120. Data acquisition focused on the East Greenland Ridge and the continental slope south-west of the ridge in order to map the position of the foot of the slope and the 2500-meter isobath. Oceanographic measurements, including CTD and water samples, were carried out at 16 dedicated hydrographic stations in order to support the multibeam bathymetric data acquisition and the analysis of the refraction seismic data. The majority of the water column sampling during the EAGER cruise was done using expendable probes of type XCTD-1 and XTB-T5.

Seismic data were acquired to investigate how the East Greenland Ridge is attached to the North-East Greenland Shelf. The seismic data were acquired with the same equipment that was developed for the two LOMROG cruises. However, the size of the source array was increased. Refraction seismic investigations used both ocean bottom seismometers (OBS) and sonobuoys. Reflection seismic data were acquired using a short streamer with an active length of 200 m. The seismic source was either a 2080 cu. inch array consisting of 4 G-guns or a linear array with a volume of 1040 cu. inch consisting of 2 G-guns.

A total of three seismic lines were acquired: for Line 1 (length of 125 km) two runs were accomplished so both dedicated refraction and reflection data were recorded, for Line 2 (163 km) only one run for refraction data was possible due to problems with the large airgun array, and for Line 3 two runs were possible along the 66-km-long ice-free portion of the line. Another 66-km-long segment of Line 3 was located on the ice-covered shelf off North-East Greenland, where one run was completed. Since the streamer was deployed whenever seismic data were acquired, reflection seismic data were collected on all runs, however with a variable shot interval. All 15 OBS deployments and 42 out of 46 sonobuoy deployments were successful.

Gravity data were acquired along the entire track of the EAGER 2011 cruise with a gravimeter installed on *Oden*.

Two Danish science-of-opportunity projects were also on board Oden. One project from DTU-Food focused on the collection of samples to study Roseobacter bacteria populations in the Greenland Sea. Observations of birds and marine mammals were made by an ornithological observer from the National Environmental Research Institute (Aarhus University, Denmark). A Swedish and a Faroese artist participated in the cruise.

Due to the favourable weather conditions all objectives of the cruise were met.

The crew of *Oden* and the EAGER 2011 scientific party.

# 1. Introduction

*By Christian Marcussen, Geological Survey of Denmark and Greenland*

The area northeast of Greenland is one of three potential areas off Greenland where the-continental shelf can be extended beyond 200 nautical miles according to the United Nations Convention on the Law of the Sea (UNCLOS), Article 76 (Marcussen et al. 2004, Marcussen & Heinesen 2010). The technical data needed for a submission to the Commission on the Limits of the Continental Shelf (CLCS) include geodetic, bathymetric, geophysical and geological data. More information on the Continental Shelf Project of the Kingdom of Denmark is available on www.a76.dk.

In 2002, a first expedition was carried out with RV *Håkon Mosby* (GEUS2002NEG) to collect seismic data on the East Greenland Ridge (Døssing et al. 2008). In 2007, further multibeam bathymetric, seismic and gravity data were acquired in the area of the ridge during the LOMROG I expedition (Jakobsson et al. 2008).

The EAGER 2011 (**Ea**st **G**r**e**enland **R**idge) cruise was organized in cooperation with the Swedish Polar Research Secretariat. The cruise started on August 17, 2011 in Longyearbyen, Svalbard, where it also ended on September 10, 2011.

The main objectives of the EAGER 2011 cruise were

UNCLOS related:

1. Acquisition of multibeam bathymetric data covering the East Greenland Ridge and the continental slope of the North-East Greenland Margin south of the ridge
2. Acquisition of seismic data covering the inner parts of the ridge and the shelf area were the ridge is connected to the continental shelf of Northeast Greenland.
3. Acquisition of gravity data along *Oden*'s track.

Add-on science:

4. Oceanography in order to support the acquisition of the multibeam bathymetric data and to aid the analysis of the refraction seismic data.
5. A Danish project on the collection of samples to study *Roseobacter* bacteria populations in the Greenland Sea.
6. Observations of birds and marine mammals by an ornithological observer from the National Environmental Research Institute (Aarhus University, Denmark).

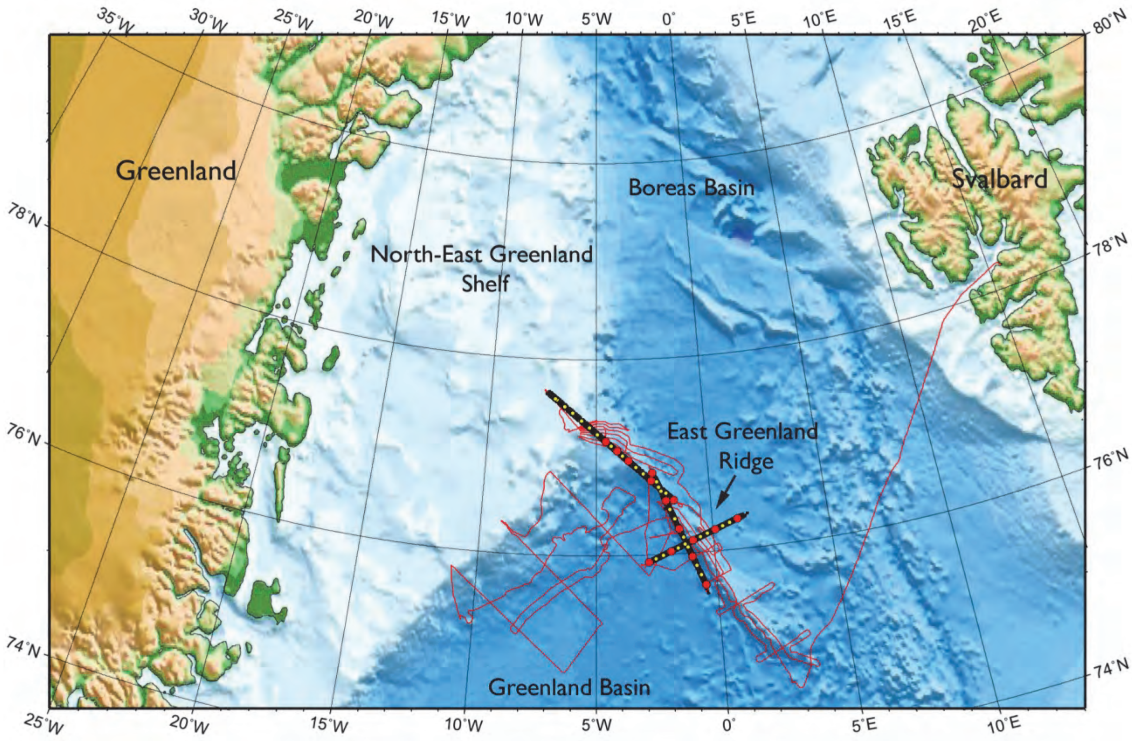



**Figure 1.** *EAGER 2011 ship track. The heavy black lines indicate the position of the seismic lines, where red dots show the position of OBS and the yellow dots the position of the sonobuoys. Multibeam and gravity data were acquired continuously during the EAGER 2011 cruise (thin red line).*

## References:


Døssing, A., Dahl-Jensen, T., Thybo, H., Mjelde, R. & Nishimura, Y. 2008: East Greenland Ridge in the North Atlantic Ocean: An integrated geophysical study of a continental sliver in a boundary transform fault setting. Journal of Geophysical Research **113**, B10107.

Jakobsson, M., Marcussen, C. & LOMROG Scientific Party 2008: Lomonosov Ridge off Greenland 2007 (LOMROG) – cruise report. Special Publication Geological Survey of Denmark and Greenland, Copenhagen, Denmark, 122 pp.

Marcussen, C., Christiansen, F.G., Dahl-Jensen, T., Heinesen, M., Lomholt, S., Møller, J.J. & Sørensen, K. 2004: Exploring for extended continental shelf claims off Greenland and the Faroe Islands – geological perspectives. Geological Survey of Denmark and Greenland Bulletin **4**, 61–64.

Marcussen, C. & Heinesen, M. 2010: The Continental Shelf Project of the Kingdom of Denmark – status at the beginning of 2010. Geological Survey of Denmark and Greenland Bulletin **20**, 51-64.

# 2. Weather and Ice Conditions during EAGER 2011

*By Henrik Braathen, Swedish Polar Research Secretariat; Rasmus Tonsboe & Steffen M. Olsen - Danish Meteorological Institute*

## 2.1 Weather

During the expedition, weather observations (SHIP-obs) were made manually every six hours. They were sent via email to the Swedish Meteorological and Hydrological Institute (SMHI) and then further distributed to the global meteorological community. Various weather data were collected during the expedition and were available through the on-board network on *Oden*. The data can be obtained from the Swedish Polar Research Secretariat (SPRS) and consists of measurements of temperature, humidity, wind direction and speed (both true and relative to the ship), pressure, water temperature, cloud base, NOAA-Satellite images and analysis of mean sea level pressure (MSL) and 10 m-winds.

The expedition started with fair weather and smooth conditions. Upon leaving Isfjorden increasing southeasterly winds (10-13 m/s) and waves (2-3 m) were observed. The waves decreased to approximately 1.5 m late on August 21. Synoptic scale weather systems were in general absent or weak with very little impact. The most significant system was the cyclone formed over the western Norwegian Sea, moving NE while intensifying between September 6 to 7. This low, in combination with a stationary high over Greenland generated increasing NE winds over the Greenland Sea, periodically reaching gale force.

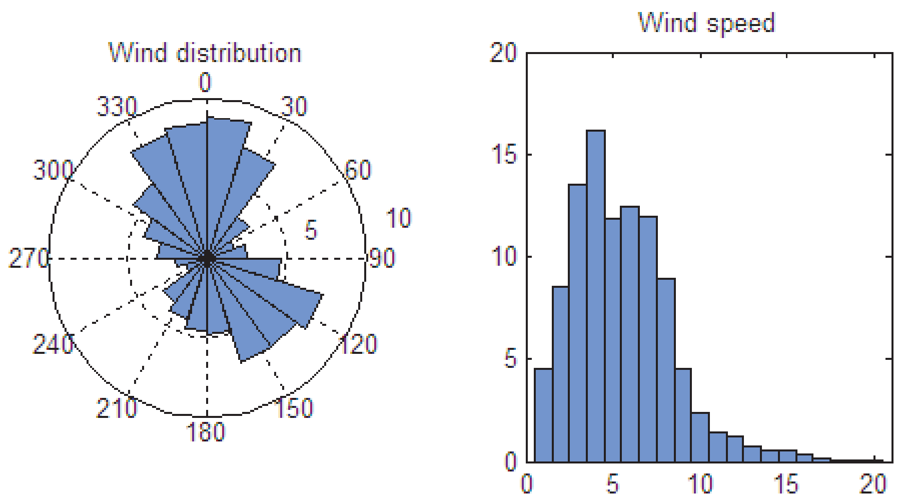



**Figure 2.** *Relative frequency of (true) wind speed and direction during EAGER (16th Aug-8th Sep).*

The dominating wind directions were from SE and around N (see Figure 2) and with most frequent wind speeds between 4-8 m/s. The relative humidity observed was most common around 90-95% (see Figure 3). Fog or low stratus clouds were common during the expedition in general, both on open water and in the ice. The relative frequency of temperature is shown in Figure 2. Over open water it usually varied between +4ºC and +6 ºC, while dropping rapidly when approaching the ice edge to -2ºC to -0,5 ºC.

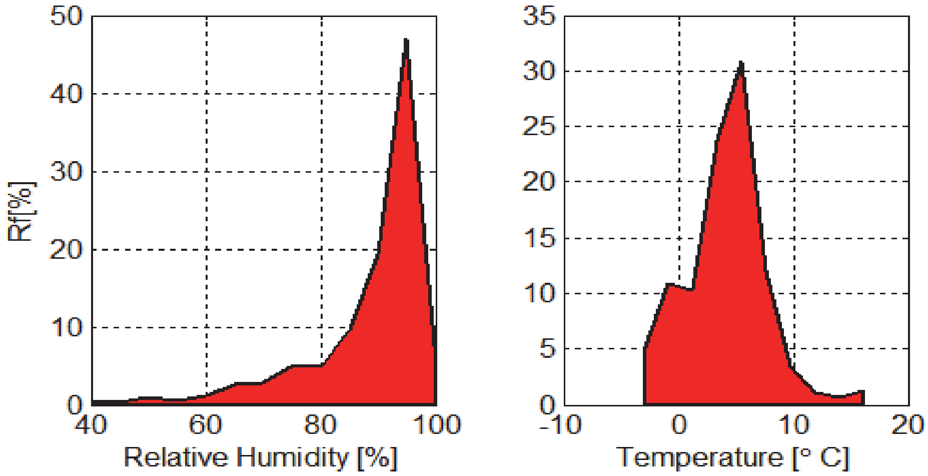



**Figure 3.** *Relative frequency of temperature (right) and relative humidity (left) during EAGER (16th Aug-8th Sep).*

The weather impact on the expedition was fairly low, but had a significant effect in the end of the cruise when the multibeam-measurements had to be aborted on September 7 due to high sea state. On other occasions the sea state prohibited CTD (conductivity, temperature, depth) measurements. Weather had no significant impact on the short-range operation of the on-board helicopter..

## 2.2 Ice Conditions

Using the record of satellite microwave data since 1978 for establishing the sea ice extent normal the August/September 2011 conditions were near normal and extending to the shelf break at 76N. During the last 10 years some years have been much lighter and the area has been virtually ice free during the summer minimum. The overall ice situation is shown in Figure 4 for the beginning and end of the cruise.

The sea ice conditions in the Greenland Sea (GS) are dominated by the Arctic Ocean outflow through Fram Strait. During the winter there is new ice formation in leads, openings and along the ice edge. The oldest and thickest ice has virtually disappeared from the Arctic Ocean in particular since 2002.  During the EAGER 2011 cruise, mainly second-year ice with some fractions of first-year ice was encountered close to the ice edge. The second-year ice had well developed melt-ponds.

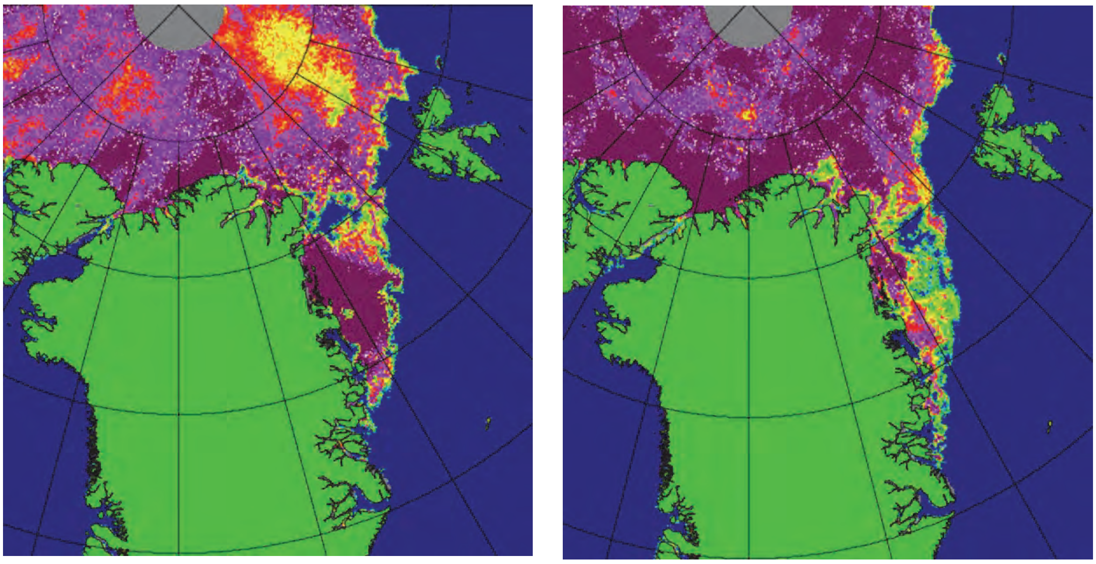


**Figure 4.** *Sea ice concentration at the beginning (left - August 17) and end (right - September 9) of the cruise. Purple colours - near 100% ice cover, dark blue colours - open water. Source: University of Bremen http://www.iup.uni-bremen.de:8084/amsr/amsre.html#Arctic.*

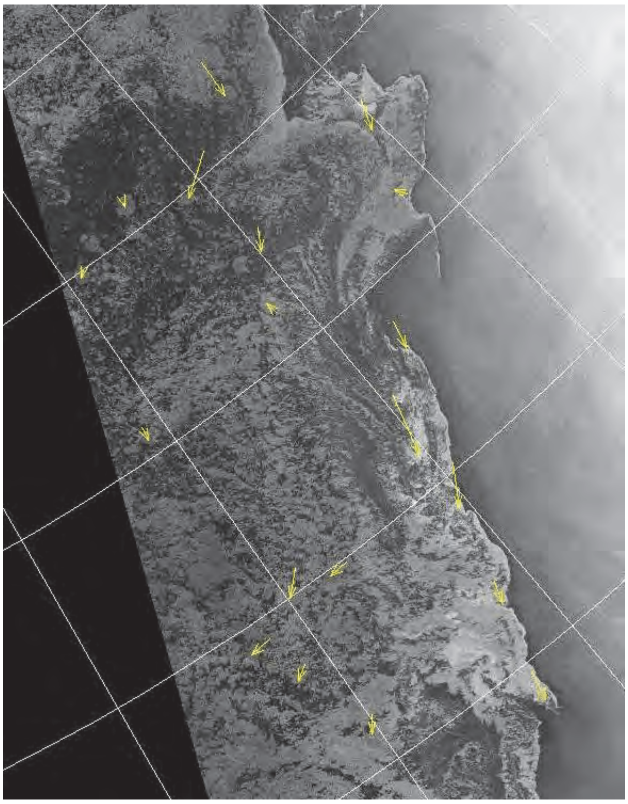


**Figure 5.** *ENVISAT SAR 201108241151. The yellow vectors show ice drift between two scenes 16 hours apart (August 23 (20:43 UTC) to August 24 (11:51 UTC)). The maximum drift in the marginal ice zone is 20 NM.*

The floe size distribution was rather uniform with floes about 10-30m in diameter. There was some dirty ice indicating a possible Siberian shelf origin with a transit time of about 1.5 - 2 years to the GS. Satellite data indicated the presence of km-size floes within the pack ice however, these were not encountered during EAGER in 2011.

The ice conditions encountered were typical for the marginal ice zone near the ice edge. The ice edge is very dynamic with high drift speeds from north to south. During 16 hours on August 23 (20:43) to August 24 (11:51) ice displacement in the marginal ice zone was up to 20NM i.e. 30NM/day. The drift vectors are shown in Figure 5. The edge is undulating and changes position from day to day. The ice drift speed is lower within the pack ice.

| Year month day | Hour:minute | Type |
|---|---|---|
| 2011 08 17 | 21:02 | ENVISAT SAR |
| 2011 08 18 | 12:13 | ENVISAT SAR |
| 2011 08 19 | 11:34 | ENVISAT SAR |
| 2011 08 20 | 20:53 | ENVISAT SAR |
| 2011 08 21 | 12:01 | ENVISAT SAR |
| 2011 08 21 | no time stamp | MODIS |
| 2011 08 22 | 21:19 | ENVISAT SAR |
| 2011 08 24 | 11:51 | ENVISAT SAR |
| 2011 08 26 | 20:33 | ENVISAT SAR |
| 2011 08 29 | no time stamp | MODIS |
| 2011 09 06 | 12:14 | ENVISAT SAR |
| 2011 08 23 | 20:43 | ENVISAT SAR |
| 2011 08 24 | 11:51 | ENVISAT SAR |
| 2011 08 25 | 21:10 | ENVISAT SAR |
| 2011 09 04 | 11:47 | ENVISAT SAR |
| 2011 09 04 | 21:42 | ENVISAT SAR |
| 2011 09 05 | 21:07 | ENVISAT SAR |
| 2011 09 06 | 12:14 | ENVISAT SAR |
| 2011 09 07 | 11:24 | ENVISAT SAR |
| 2011 09 07 | 21:32 | ENVISAT SAR |

**Table 1.** *List of ENVISAT SAR and MODIS images received during EAGER 2011.*

The satellite images were delivered via e-mail by Leif Toudal (Danish Meteorological Institute) during office hours. Because of the dynamic ice edge, a real time access to the data would have helped with the track planning near the ice edge. The Syntehtic Aperture Radar (SAR) scene in Figure 5 shows the bright band with small floes in the marginal ice zone and the darker and larger floes within the pack ice.

The sea ice conditions encountered during EAGER 2011 did not constrain the operations with *Oden* but imposed operational difficulties on the simultaneously commercial seismic activities on the North East Greenland Shelf.

# 3. Multibeam Bathymetry Echo Sounding

*By Benjamin Hell - Stockholm University; Richard Pedersen & Morten Sølvsten - Danish Maritime Safety Administration*

## 3.1 Equipment

### 3.1.1 Hardware - Kongsberg EM122 Multibeam Echosounder

The Swedish Icebreaker *Oden* is equipped with a permanently mounted Kongsberg EM122 1°x1° 12 kHz multibeam echo sounder (MBES) as well as a Kongsberg SBP120 chirp sonar (sub bottom profiler, SBP). The initial installation was carried out in spring 2007, when a Kongsberg EM120 MBES (serial number 205) was installed. This unit was the predecessor of the next generation EM122; with both models utilizing the same transducers. In the spring of 2008, the MBES was upgraded to the current EM122 model (serial number 110) by exchanging the transceiver electronics. It should also be noted that the original ice protection of the hull-mounted transducers has been upgraded twice. The first time was in the spring of 2008 and most recently in the spring of 2009.

The Kongsberg EM122 is a multibeam system featuring a nominal frequency around 12kHz, which is capable of sounding measurements at the full ocean depth of up to 12km. In the 1°x1° configuration installed on *Oden* both the transmit (Tx) and receive (Rx) transducers dimensions are about 8m by 1m. They are separate linear transducers installed in a Mill's cross configuration (Tx in alongship direction) in the ship's hull underneath the ice knife, about 8.1m below the water line and 15cm inside the hull surface. For ice protection, 12 cm thick polyurethane elements reinforced with titanium rods are mounted flush in the hull, leaving a few centimetres (water filled) space between their inside and the transducer elements. The Rx transducer (with ice protection) is further covered with an additional titanium plate (see Figure 6 and 7).


**Figure 6.** *EM122/SBP120 Rx transducer during with titanium plate covering ice protection elements.*

**Figure 7.** *EM122 Tx transducer during installation, with some of the ice protection elements fitted.*

The EM122 MBES provides for a lateral coverage of up to 2x75° under optimal circumstances for installation on regular survey vessels. Initially, it was anticipated that the ice protection would limit the lateral coverage to 2x65° however; the observations made during this expedition suggest that this performance is not to be expected. The current configuration (with existing ice protection) limits the effective coverage to (at best) 2x60° (corresponding to ca. 3.4 times the water depth). However, this performance is only achievable under favourable conditions such as collecting data in open waters or when drifting with the ice. Furthermore, the generally high background noise level of the ship and the effects of ice and air bubbles underneath the ship's hull limit the lateral coverage even more during "high noise" operations such as heavy ice breaking or fast open water transits. Fortunately for this cruise most of the data collection has been carried out in open waters or in areas with very little ice.

The EM122 configuration on the *Oden* has a minimum beam width of 1° in both along ship and athwart ship directions. The beams are transmitted in 3-9 distinct sectors (depending on the water depth), which are distinguished by frequency (11.5 kHz-13 kHz) and in certain cases FM modulation. Each sector is individually compensated for vessel roll, and can be compensated for yaw and pitch. These last two options however, were not used during this expedition IIRC Pitch Compensation was ON until 04 SEP. The system also has a number of different sounding modes. With the "Equi-Angle" and "In-Between" modes there is a maximum of 288 bottom detections per swath, however there is a higher density mode (HD-Equi-Distant) that is capable of increasing the sounding sampling per beam, which makes up to 432 bottom detections possible per swath. The HD equidistant mode was used for all of the science program work. The EM122 also allows for a frequency modulated (FM) chirp-like signal to be used in the deeper sounding modes (enabled for this expedition) and provides the ability to collect the water column information for all beams. The separate water column files (*.wcd) were logged at all times during EAGER 2011. These files have the same naming convention as the sounding files (*.all) but with a different extension, as noted above.

All of the raw files were organized by UTC day. UTC time was used for all sounding data collection. If a logged line starts before midnight but ends after the start of the next day it is stored in the day the line started. The convention used to number the lines was as follows:

LineNumber_yyyymmdd_hhmmss_Oden.all (and .wcd)

Where:

*LineNumber* − the number of the line. The system was set to increment the line each three hours, but it was often earlier due to survey requirements

*yyyymmdd* − yyyy is four digit year; mm is two digit month and dd is two digit date

*hhmmss* − the time using 24 hour clock (UTC)

e.g. 2025_20090830_195325_Oden.all and 2025_20090830_195325_Oden.wcd

The lines were named by starting the numbering (with linenumber 0000) at midnight. There was no need to separate the data collected like it was done on LOMROG II cruise in

2009. All raw data were collected and stored in separate folders (named YYYYMMDD) locally. When it were time to process using CARIS HIPS and SIPS the data was copied to the server and the individual lines were then imported to individual folders with the corresponding Julian date under the project.

### 3.1.2 Calibration

The MBES transducer offsets were last calibrated in a patch test in the period between 19 May 2007 and 24 May 2007 by Christian Smith (Kongsberg Maritime). Calibrations of the transmitted energy of the different swath sectors in order to achieve an even distribution of backscatter energy over the entire swath (so-called backscatter calibration) was done by Christian Smith (echo sounder mode “**Deep**” and “**Shallow single swath**”, 04 June 2009) and Benjamin Hell (echo sounder modes "**Deep single swath**", "**Deep dual swath 2**" and "**Very Deep single swath**", 09 August 2009).

#### 3.1.2.1 Kongsberg Seapath 200 Motion Sensor

The Seapath 200 provides a real-time heading, attitude, position and velocity solution by integrating the best signal characteristics of two technologies, Inertial Measurement Units (IMUs) and the Global Positioning System (GPS). The Seapath utilizes the SeaTex MRU5 inertial sensor and two GPS carrier phase receivers as raw data providers. It is critical to have good motion sensor, gyro and GPS data in order to achieve optimal surveying capability. The Seapath replaces three sensors; gyro compass heading reference, the motion sensor for roll, pitch and heave and GPS for positioning and velocity determination. By using one instrument to provide this critical data, potential timing and synchronization problems are virtually eliminated.

### 3.1.3 Acquisition Software

The Seafloor Information System (SIS) is the software that controls the multibeam system and logs the data. The most recent version was used during EAGER 2011 (see details below).

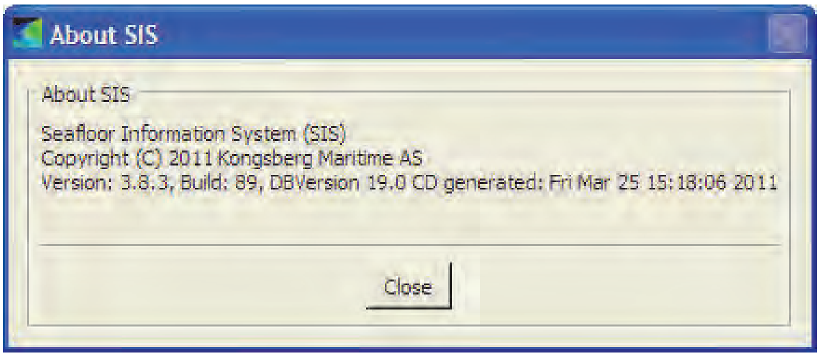



**Figure 8.** *Seafloor Information System (SIS)*

During normal operations we observed at least two different issues with the collected data. Something causes the detected seabed to drop down in the outer most sectors even though it is totally flat. This seems to happen more on the outer sector on port side but isn't restricted to this side. The other issue is best described as something that resembles a "Herring Skillet" (see Figure 9). It seems to be isolated to the number two sector counted from port. A report has been sent to Martin Jakobsson for further communication with Kongsberg. The suggested testing settings from Kongsberg have all been tried without any success. More details about the communication may be found in appendix II. Part of the communication is in Danish, Swedish and English.

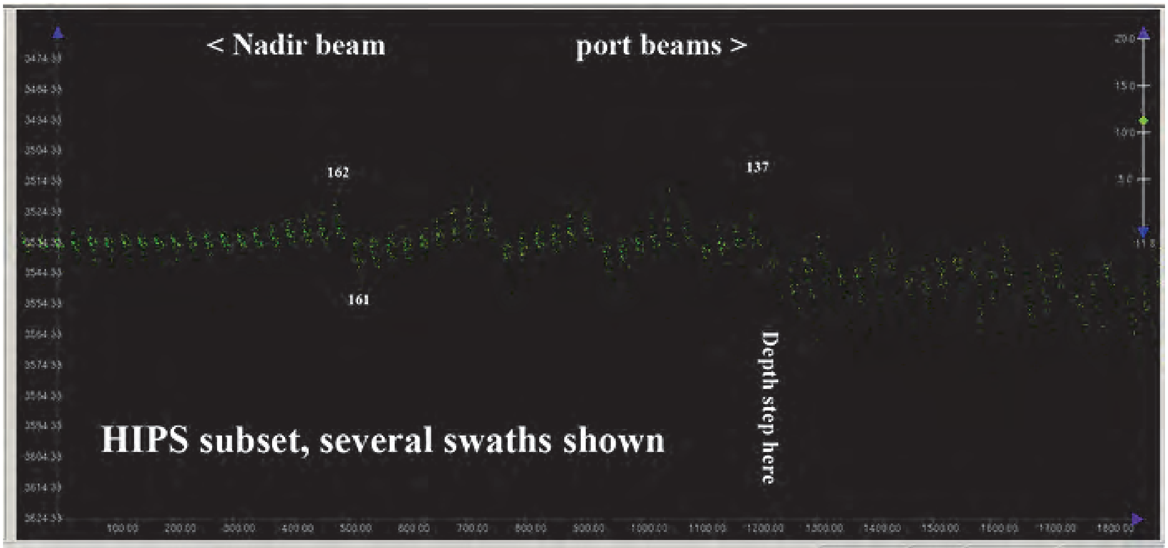



**Figure 9.** *CARIS screen shot describing the problem on port side.*

## 3.2 System Settings: Working Set of Parameters for SIS

### 3.2.1 Installation Parameters

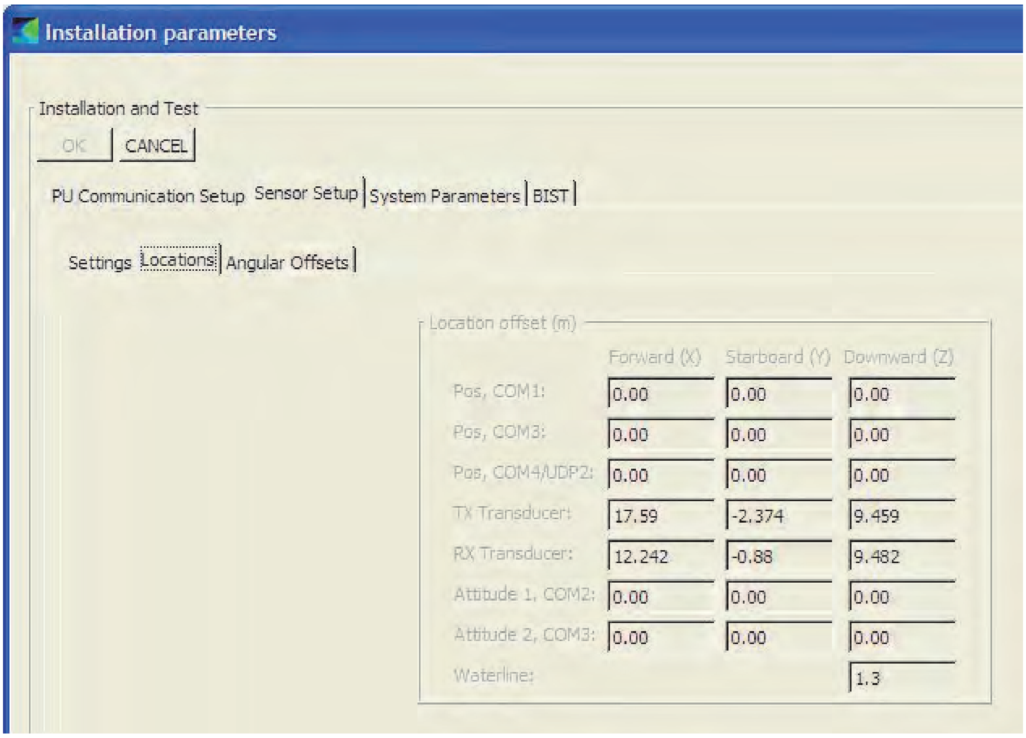



**Figure 10.** *Installation parameters*

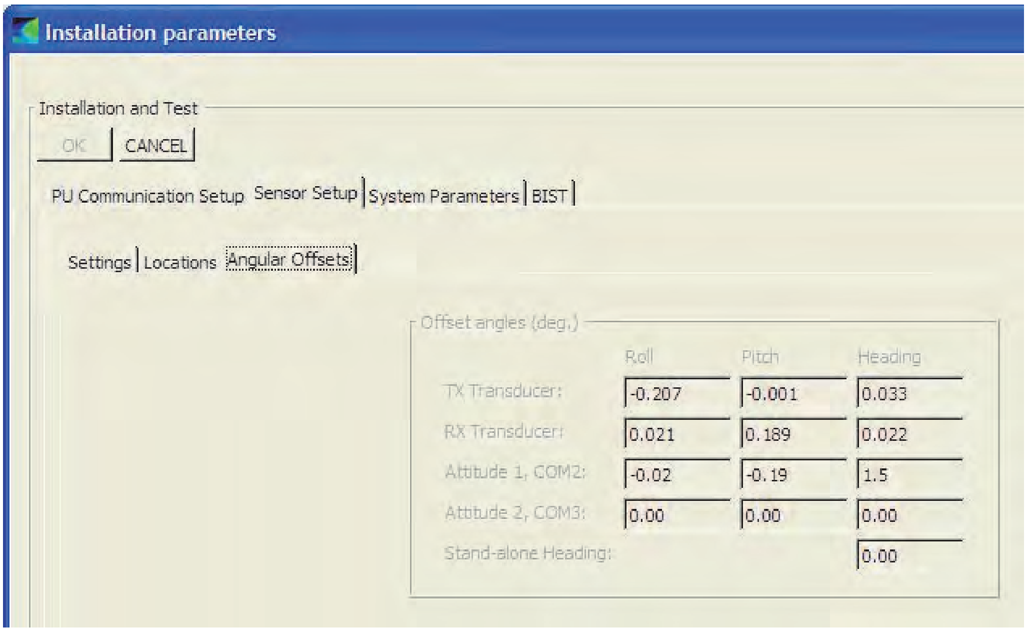



**Figure 11.** *Installation parameters (cont.)*

### 3.2.2 Runtime Parameters

Actual settings are shown with comments to settings that were changed during the survey period.

#### 3.2.2.1 Sounder Main

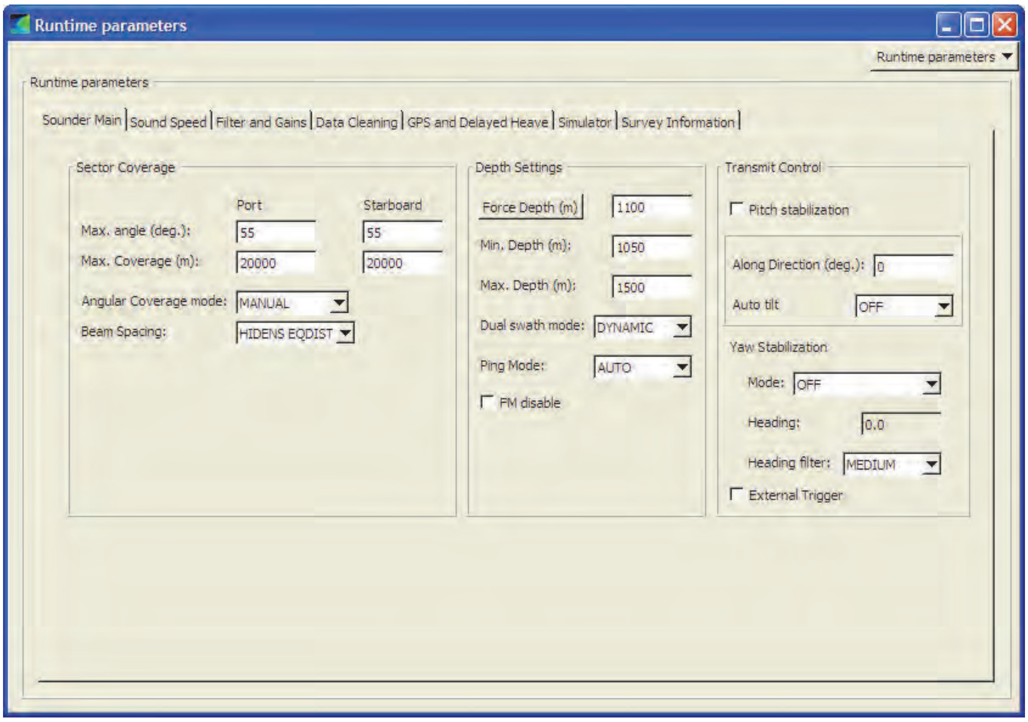



**Figure 12.** *Runtime parameters - sounder main*

| | |
|---|---|
| Max/Min angle: | Normally 60°, adjusted to actual survey conditions.<br>In some occasions as little as 45° (see log sheets). |
| Min/Max depth: | As close around the seafloor as necessary and possible |
| Ping Mode: | Auto. Manual mode used during heavier icebreaking |
| Pitch stabilization: | On (off from 04 Sep 2011 line 0007) |

### 3.2.2.2 Sound Speed

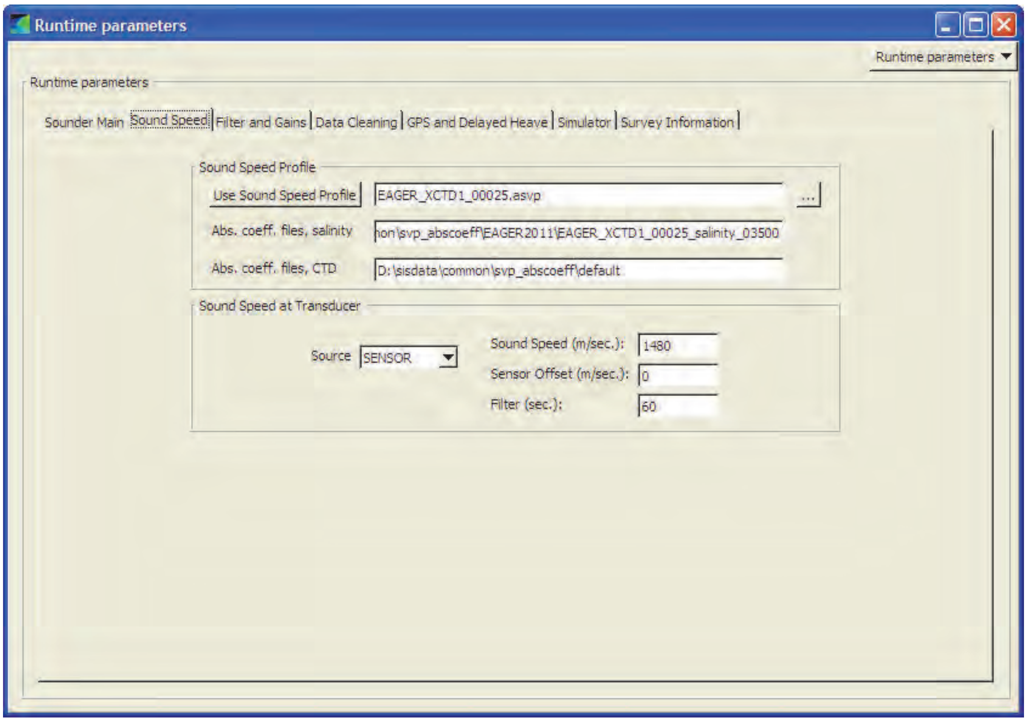



**Figure 13.** *Runtime parameters - sound speed*

### 3.2.2.3 Filters and Gains

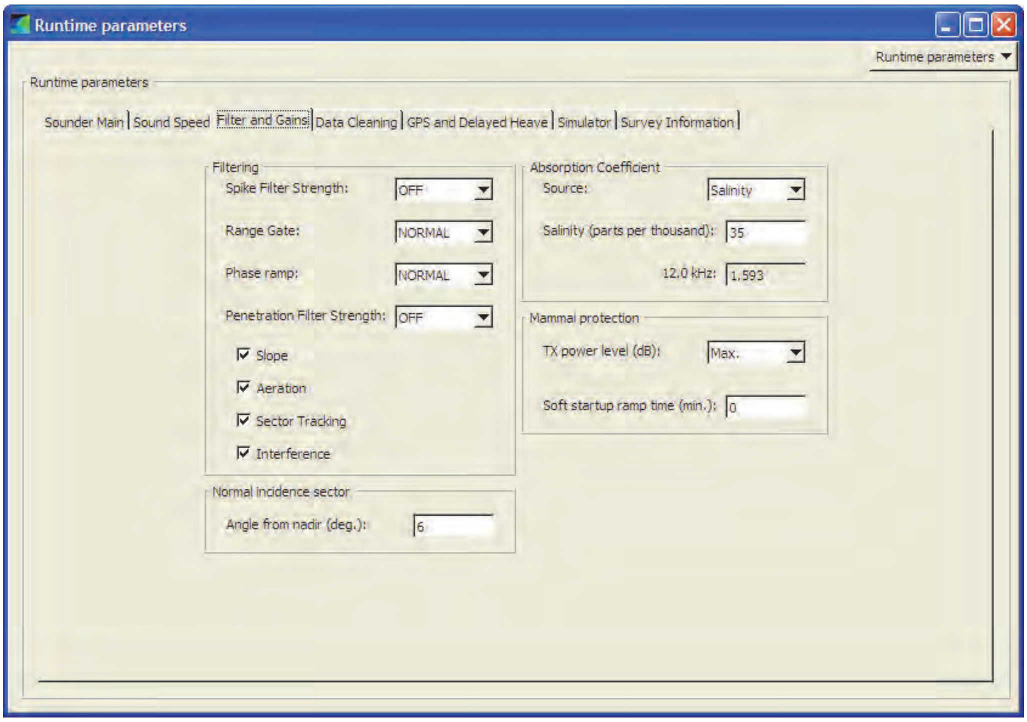



**Figure 14.** *Runtime parameters - filter and gains*

#### 3.2.2.4 Data Cleaning

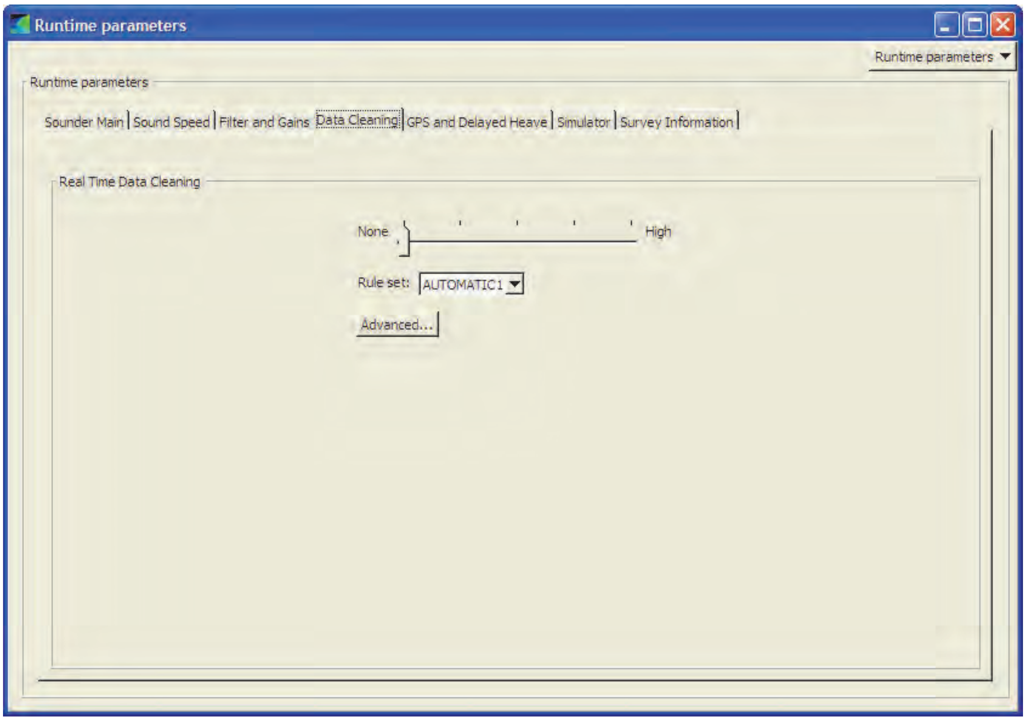



**Figure 15.** *Runtime parameters - data cleaning*

## 3.3 Sound Speed Control

Every time a sound velocity profile (SVP) was obtained, either by CTD cast or by dropping an XBT/XCTD, the data was controlled by operators from Danish Meteorological Institute (DMI). If accepted the data was copied to a common directory on the ship's RAID system. It was then sub-sampled and converted to depth and sound velocity pairs (max 999 lines). The SIS software requires the profile to be extended to 12 km so that was done at the same time. It should be noted that the profiles were very stable and changed little over the duration of the survey. There were however, some differences between the deep and the shallow parts of the area.

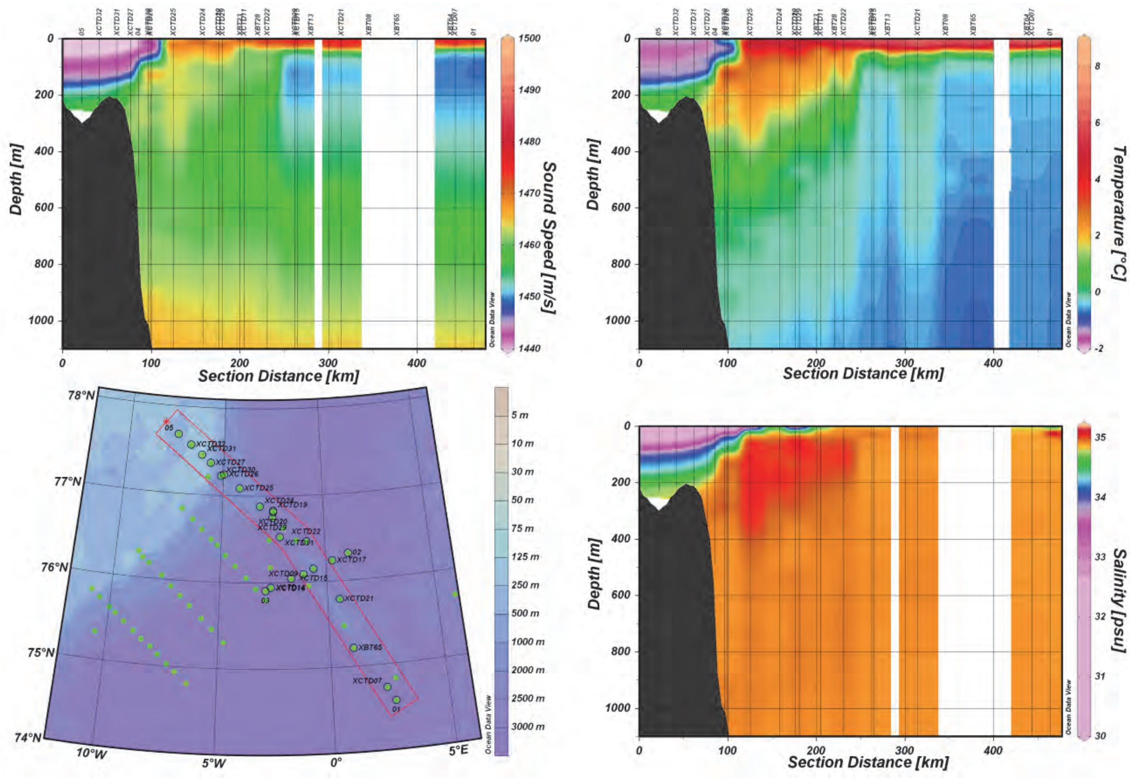



**Figure 16.** *The oceanography group provided a map with an overview of where the different sound velocity profiles were taken.*

The sound speed from the Td sensor was used for sound speed at the transducer throughout the survey.

## 3.4 Depth Modes Used

Below is a list of modes and the suggested depth range that they are designed to support. This is also the depth intervals used by the automatic mode selection.

- Shallow (< 350m)
- Medium (350m-1000m)
- Deep (1000m-9000m)
- Very Deep (> 9000m)

It should be noted that the ping mode was set to run automatically unless the system was tested in order to see if it was possible to fine tune the data quality.

## 3.5 Known Problems with the MBES System

### 3.5.1 Echo Sounder Limitations

- Like on LOMROG II the multibeam is prone to Erik's horns
- In general good lateral coverage even in the ice. The ice coverage and ice thickness on the shelf west of the East Greenland Ridge did not cause too much loss of data.

### 3.5.2 Software Bugs

- As reported on LOMROG II - when working in projection, COG - Projection rotation at present position = DTK (Desired Track) (western LON negative). This means that the DTK must be corrected for latitude in order to work with the auto pilot. This bug affects in the Helmsman displays and the COG arrow in the geographical window. How to reproduce this bug: Set geographic window to projection. Plan line at some high longitude. The Helmsman DTK will then show the line course offset by the longitude.
- Probably related to the previous bug – still a problem: The ship heading arrow points into the wrong direction when working in a projection with True North not equal Map North. Even working in UTM projection it is offset depending on where the ship is presented on the screen.
- Depth scale of water column display does not match the depth scale in the e.g. cross track display because the water column data is not SVP corrected. It would be very useful to have a function for "locking" the digitizing of the sea floor from within the water column display, as it is often possible to "see" the seafloor and it appears that no bottom detections are logged. Also reported on LOMROG II.
- The display of detections in the Cross track/Beam intensity, Water column and Geographical windows is not always synchronized.

## 3.6 Personnel

MBES measurements were carried out almost continuously during the entire expedition, with a team of seven working according to the following watch scheme. Only during third and fourth time on seismic lines the data collection of both bathymetry and subbottom profiler was stopped. The multibeam was switched of when retrieving the OBS boys.

| Time | Name | Affiliation | Log sheet initials |
|---|---|---|---|
| 0-4 and 12-16 | Morten Sølvsten | Danish Maritime Safety Administration | MS |
| | Rasmus Pedersen | GEUS, student from University of Copenhagen | RAP |
| | Carlos Castro | GEUS, student from University of Copenhagen | CC |
| 4-8 and 16-20 | Benjamin Hell | Stockholm University, Sweden | BH |
| | Jonas Johansen | GEUS, student from University of Copenhagen | JZJ |
| 8-12 and 20-24 | Richard Pedersen | Danish Maritime Safety Administration | RIP |
| | Rezwan Mohammad | Stockholm University, Sweden | RM |

**Table 2.** *Multibeam personnel.*

The watch times are ship time and UTC, which was also used as data time. The time was adjusted by two hours during transit back and forth to Longyearbyen.

**Figure 17.** *The multibeam team - from the left – Rasmus Pedersen, Morten Sølvsten, Jonas Johansen, Carlos Castro, Benjamin Hell, Rezwan Mohammed and Richard Pedersen.*

## 3.7 Ship Board Data Processing

All ship board processing of echo sounding data was carried out using CARIS HIPS and SIPS (version 7.1, SP2). A log sheet was kept and filled out using an Excel spreadsheet in order to get an overview of the actions taken regarding the processing of the data.

For visualization and additional control of the bathymetric data cleaned and gridded in CARIS, we also used Fledermaus (version 7) from IVS 3D where old data could be combined with the new.

During the cruise an inventory of all collected data was built in an Intergraph GeoMedia Professional (version 6.1) geographical information system.

### 3.7.1 Caris HIPS and SIPS Data Processing

**Data conversion:** The echo sounder in ALL format were converted into Caris HDCS data using the Caris HIPS and SIPS conversion wizard.

**Apply tide:** Zero tide was applied to all data.

**Compute TPE:** The total propagated error was computed. The surface sound speed was assumed to be within ±5m/s and sound speed profile were assumed to be within ±10m/s, all other values set to zero (see below for VCF (CARIS's, Vessel Config File) settings).

**Merge:** The data was merged (this process assigns geographic positions to all soundings and reduces them for tide and any other specified corrections such as new sound velocity profile).

**Create field sheet:** Field sheets were generated to the most appropriate resolution based on depth. The cube surfaces varied between 12.5m and 50m. An overall field sheet with a 100m cube surface was used for quality check.

**Data cleaning and gridding:** Manual data cleaning was performed throughout the survey using the subset editor (after data was merged). The data cleaning and gridding was often an iterative process. Deciding about the quality of specific soundings can be hard based on a single coverage of an area. Often, earlier edits were changed after revisiting the same area again. During icebreaking or in particularly bad weather the overall data quality was poor.

**Quality control, final field sheets and bathymetry grids:** Fledermaus was used on a daily basis for quality control and any spikes found using Fledermaus were then cleaned in CARIS – and a new surface was exported. The field sheets set up were used as both working sheets as well as the final product.

## 3.8 Summary

During EAGER 2011 *Oden* travelled a total of approx. 4000 nautical miles. Multibeam data were acquired during the entire cruise.

4 field sheets were created over the Northeast Greenlandic Ridge and 4 field sheets were created for the transit to/from Longyearbyen (Figure 18).

It should be noted that the bathymetric data acquired during the EAGER 2011 cruise will be incorporated in the IBCAO database.

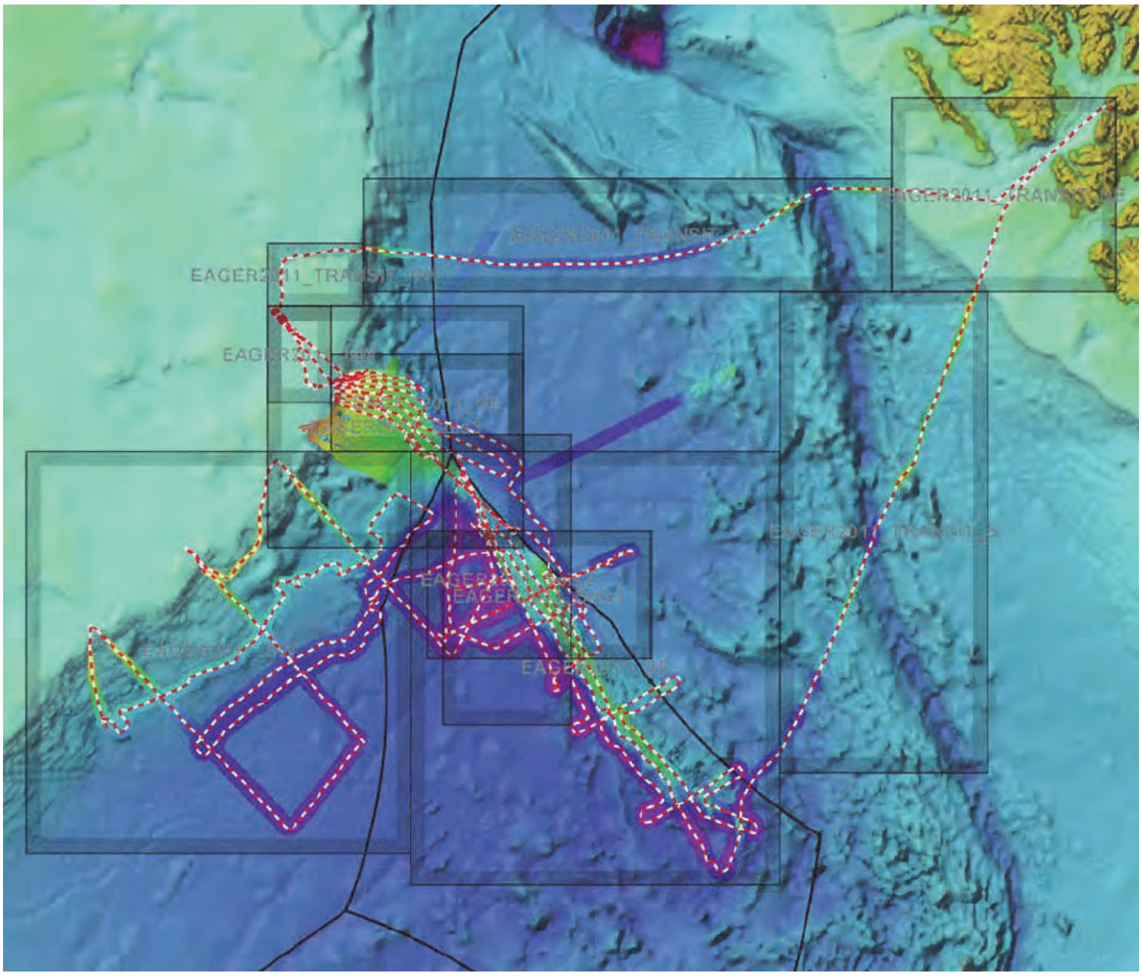


**Figure 18.** *Regional map showing all field sheets created during the EAGER 2011 cruise.*

Data acquisition was focused on the East Greenland Ridge (EGR) and the Continental Slope south-west of the Ridge in order to map the position of the Foot of the Slope (FOS) and the 2500 meter isobath. 100% coverage was achieved at the innermost part of the EGR and along the south-western flank of the EGR. The Continental Slope south-west of the EGR was covered by three profiles across the slope. The 2500m isobath was then followed by one profile and finally two adjacent lines were surveyed around the 3300m contour in order to define the base of slope region and the FOS. A complete 100% coverage of this area was not possible within the time available.

# 4. Chirp Sonar Profiling

*By Benjamin Hell - Stockholm University*

## 4.1 Equipment

Icebreaker *Oden* is equipped with a Kongsberg SBP120 3°x3° subbottom profiler primarily used for the acoustic imaging of the topmost sediment layers underneath the sea floor with a frequency range of 2.5 kHz to 7 kHz. The SBP120 subbottom profiler is an add-on to the EM122 multibeam echo sounder installed. It uses an extra transmit transducer unit, whereas one single broadband receiver transducer is used for both the EM122 multibeam echo sounder and the SBP120 systems. A frequency splitter directly after the receiver staves separates the ca. 12 kHz multibeam signal from the lower frequency (2.5…7 kHz) chirp sonar signal.

The normal transmit waveform is a chirp signal (which is an FM pulse where the frequency is swept linearly or hyperbolically). The outer limits for the start and stop frequencies of the chirp are 2.5 kHz and 7 kHz, providing a maximum vertical resolution of approximately 0.3 milliseconds. In addition to linear chirps, the system offers CW pulses, hyperbolic chirps and Ricker pulses. The system is capable of providing beam opening angles down to 3°, and up to 11 beams in a transect across the ship’s keel direction with a spacing of usually 3°. The system is fully compensated for roll, pitch and heave movements of the ship by means of the Seatex Seapath 200 motion sensor used for the Multibeam echo sounder.

### 4.1.1 System Settings

At most times the SBP120 chirp sonar was run with the following system settings:

| | |
|---|---|
| **Transmit mode:** | Normal |
| **Synchronization:** | Fixed rate until 28 August 2011. From then on EM trigger. |
| **Ping interval:** | Usually controlled by trigger from EM122. |
| **Acquisition delay:** | Depending on water depth, seafloor reflection preferably in upper 100 ms of collected data. |
| **Acquisition window:** | 300ms at most times; 400 ms on some lines with steep terrain. |
| **Pulse form:** | Hyperbolic chirp up (this pulse provides the best trade-off between energy/penetration and resolution). |
| **Sweep frequencies:** | 2500…7000Hz |

**Pulse shape:** 10% tapering most of the time; 1% when a 10ms pulse length was used.

**Pulse length:** 100ms (this is a relatively long signal, which provides the energy needed to record more than noise in ice breaking situations). On some occasions only 10 ms pulse length was used.

**Source power:** -1dB (0dB can harm the electronics)

**Beam width Tx/Rx:** 3° ("Normal")

**Number of beams:** 5 - when going along-slope the off-center beams often contain better information than the center beam.

**Beam spacing:** 3°

**Calculate delay from depth:** Usually off. As this functionality is still not working properly in all but the very best echo sounding conditions, it should only be used when the MBES provides very stable center beam depths.

**Automatic slope correction:** Off, heavily relies on very good Multibeam data, which never is the case in ice.

**Slope along/across:** Usually 0.0° but can be changed when going along/across steep slopes (> 3°) constantly. This was done on some SBP lines (see log sheets).

**Remark:** On a couple of occasions around ca. 1000m the SBP interfered with the EM122 multibeam echosounder. Triggering the SBP from the EM122 solved the problem.

## 4.2 Ship Board Processing

Ship board processing of the acquired SBP120 chirp sonar data was not carried out during the EAGER 2011 cruise. Data will be processed by GEUS afterwards.

# 5. Refraction and Reflection Seismic Survey

*By Thomas Vangkilde-Pedersen, Thomas Funck, John Hopper & Christian Marcussen, Geological Survey of Denmark and Greenland; and Per Trinhammer, Department of Earth Sciences, University of Aarhus*

## 5.1 Results

Seismic data were acquired to investigate how the East Greenland Ridge is attached to the North-East Greenland Shelf. The seismic data were acquired with the same equipment that was developed for the two LOMROG cruises. However, the size of the source array was increased. Refraction seismic investigations used both ocean bottom seismometers (OBS) and sonobuoys for the recording of the signals. Reflection seismic data were acquired using a short streamer with an active length of 200 m. The seismic source was either a 2080 cu. inch array consisting of 4 G-guns or a linear array with a volume of 1040 cu. inch consisting of 2 G-guns.

A total of three seismic lines were acquired: for Line 1 (length of 125 km) two runs were accomplished so both dedicated refraction and reflection data were recorded, for Line 2 (163 km) only one run for refraction data was possible due to problems with the large airgun array, and for Line 3 two runs were possible along the 66-km-long ice-free portion of the line. Another 66-km-long segment of Line 3 was located on the ice-covered shelf off North-East Greenland, where one run was completed. Since the streamer was deployed whenever seismic data were acquired, reflection seismic data were collected on all runs, however with a variable shot interval. All 15 OBS deployments and 42 out of 46 sonobuoy deployments were successful. A full account on the seismic operations is given in the EAGER 2011 Seismic Data Acquisition Report (Vangkilde-Pedersen et al. 2011)

## 5.2 Seismic Equipment

The seismic equipment onboard Oden was more or less identical with the equipment used on the two previous LOMROG cruises with the following exceptions. In order to increase the signal strength, a larger airgun array consisting of four 520 cu. inch G-guns with a total volume of 2080 cu. inch was developed. In addition to the two larger Hamworthy compressors, two smaller Bauer compressors were brought along in order to produce the necessary volume of compressed air. The airgun array used in ice-filled has now been changed to a linear array consisting of two 520 cu. inch G-guns.

Since large parts of the EAGER 2011 seismic survey area was located in open water, depth controllers for the streamer (“birds”) could be used. In open water, the airgun array was kept at a constant depth using two large US fenders, whereas only one US fender was used in light ice conditions when the smaller airgun array was used.

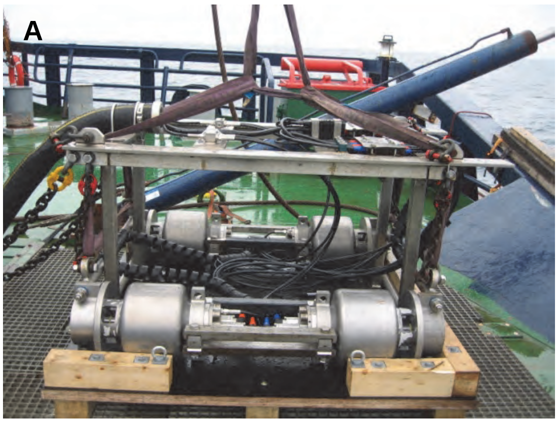




**Fig. 19** A. *Large airgun array of two linear arrays consisting of two 520 cu. inch G-guns each. The total volume of this array is 2080 cu. inch. B. Launch of the streamer. Birds are installed on the streamer for depth control. A US fender used with the airgun array can be seen to the right (grey).*

Prior to the EAGER cruise, the large airgun array could only been tested for a few hours. This was related to bad weather conditions during the test cruise on *M/V Gunnar Thorson* in August 2010. During the EAGER 2011 cruise it soon became obvious that the construction of the array was not as robust as anticipated, which resulted in frequent repairs of the array during the acquisition.

## 5.3 Acquisition and Processing Parameters

| **Source** | Sercel G guns |
|---|---|
| Number of guns in array | 2 / 4 |
| Chamber volume | 520 cu. inch per gun |
| Total volume of array | 1040 / 2080 cu. inch |
| Fire pressure | 180 / 200 bar (2600 / 3000 psi) |
| Mechanical delay | 0 ms (automatically corrected) |
| Nominal tow depth | 9 m / 9.65 m |
| Length of tow cable | 30 m / 32.2 m / 52.2 m |
| | |
| **Streamer** | Geometrics GeoEel |
| Length of tow cable | 30 m |
| Length of vibration section | 53 m / 103 m |
| No. of active sections | 4 |
| Length of active sections | 200 m |
| No. of groups in each section | 8 |
| Total no. of groups | 32 |
| Group interval | 6.25 m |
| No. of hydrophones in each group | 8 |
| Depth sensors | In front of each active section |
| Nominal tow depth | 6 m / 7 m |
| | |
| **Acquisition system** | Geometrics GeoEel controller |
| Sample rate | 1 ms / 2 ms |
| Low-cut filter | Out |
| High-cut filter | Anti-alias (405 Hz / 202.5 Hz) |
| Gain setting | 0 dB |
| No. of recording channels | 32 |
| No. of auxiliary channels | 8 |
| Shot interval | 12 s / 40 s / 60 s |
| Record length | 10 s / 35 s / 55 s |

**Table 3** *Summary of acquisition parameters.*

With limited offsets, the options for processing data are also limited. Except for lines 3C and 3D, data were acquired in deep water where multiple elimination was not an issue. The key steps for producing a reasonable stack primarily involved pre-stack filtering and editing. All data processing was done in ProMAX version 2003.19.1. Complete details regarding setup of the processing computer are provided in Appendix B of the LOMROG 09 processing report (Hopper & Marcussen 2010). The setup for EAGER 2011 was identical except for the following: the operating system on the processing computer was upgraded to Mac OS 10.6; the memory was upgraded to 8 GB, the internal hard disk was upgraded to 750 GB, the backup disk was upgraded to 1 TB, and GMT (Generic Mapping Tools) software was upgraded to version 4.5.3.

Many of the scripts and processing flows used on LOMROG 09 were used on this cruise as well. In particular, the scripts to format data between Navipac, Geometrics and ProMAX were updated for this cruise. Modifications were minor and not reproduced here. Refer to Appendix C of the LOMROG 09 processing report for the key scripts (Hopper & Marcussen 2010).

Because most of the data were acquired in ice-free areas, the towing arrangement was generally better compared to LOMROG I and II (2007 and 2009) as summarised in the acquisition chapters. In particular the shallowing towing depth and better depth control meant that the spectral shaping filter and careful checking of the static corrections was unnecessary.

Finally, the larger gun array resulted in better signal penetration. Clear basement reflections are visible on all the data collected. In addition, on lines 3C and 3D, clear primary energy can still be interpreted in many areas below the first seabed multiple. A notable exception to the good signal penetration is on line 1 where the basement reflection deepens into the southern scarp of the East Greenland Ridge. It is not clear, however, if this is loss of signal penetration, or a geometric problem of imaging the corner near the steep scarp using a short streamer.

The basic processing sequence is as follows:

1. SEG-D read with trace dc bias removal;
2. Geometry assignment including gun and cable statics;
3. Bandpass filtering;
4. Amplitude scaling;
5. Trace equalization;
6. Predictive deconvolution;
7. Trace mixing on shot gathers;
8. Resample to 2 ms (on lines recorded with 1 ms);
9. f-k filtering of shot gathers;
10. Midpoint sort and stack;
11. Post-stack trace mixing (on lines with 40 s or 60 s shot intervals);
12. Merge stacks;
13. Post-stack constant velocity migrations;
14. Seafloor mute;
15. SEG-Y output;
16. GRD conversion and plot.

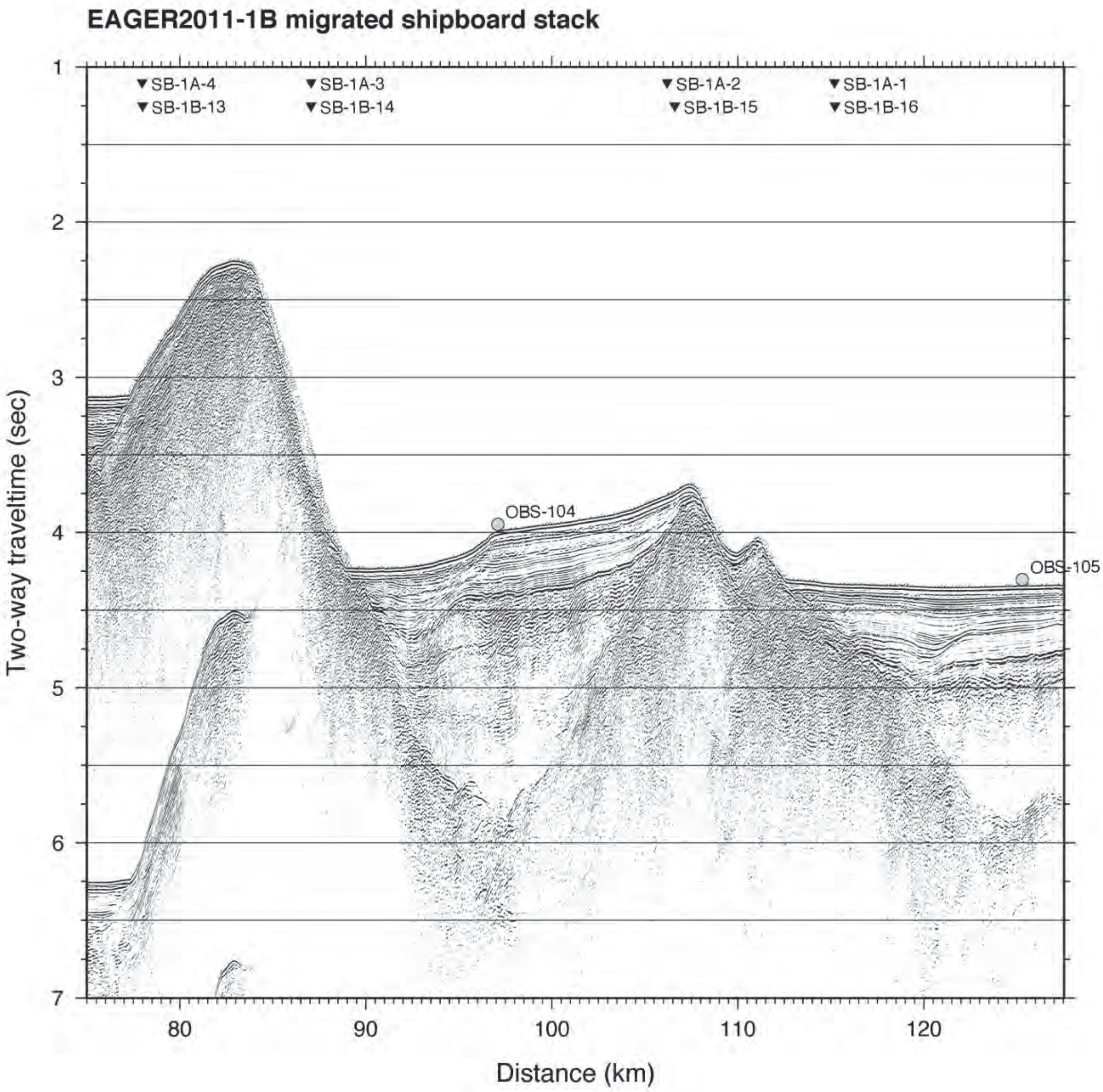



**Figure 20.** *Data example from reflection seismic line EAGER2011-1B.*

## 5.4 Refraction Seismic Data Acquisition

Refraction/wide-angle reflection (R/WAR) seismic data were acquired along three lines (Fig. 1). Both sonobuoys (SB) and ocean bottom seismometers (OBS) were used for the recording of the seismic pulses generated by the airgun array. The objective of the study was to determine the velocity structure of the East Greenland Ridge (EGR) and how the ridge is connected to the continental shelf of Northeast Greenland. In addition, the crustal structure in the Boreas and Greenland basins was analyzed by a seismic line across the EGR. This will provide a proper reference to allow for a better assessment of the crustal character of the EGR.

During the EAGER 2011 expedition, five OBS from the German ocean bottom seismometer instrument pool DEPAS operated by the Alfred Wegener Institute (AWI) in Bremerhaven were used. The OBS were launched by Oden's crane on the aft deck whereas they were retrieved by the on-board helicopter as Oden has difficulties to maintain a fixed position in open waters. The helicopter operations were favoured by the calm weather during the main part of the EAGER 2011 cruise. Sonobuoys were launched from the aft deck of Oden (Fig. 21).

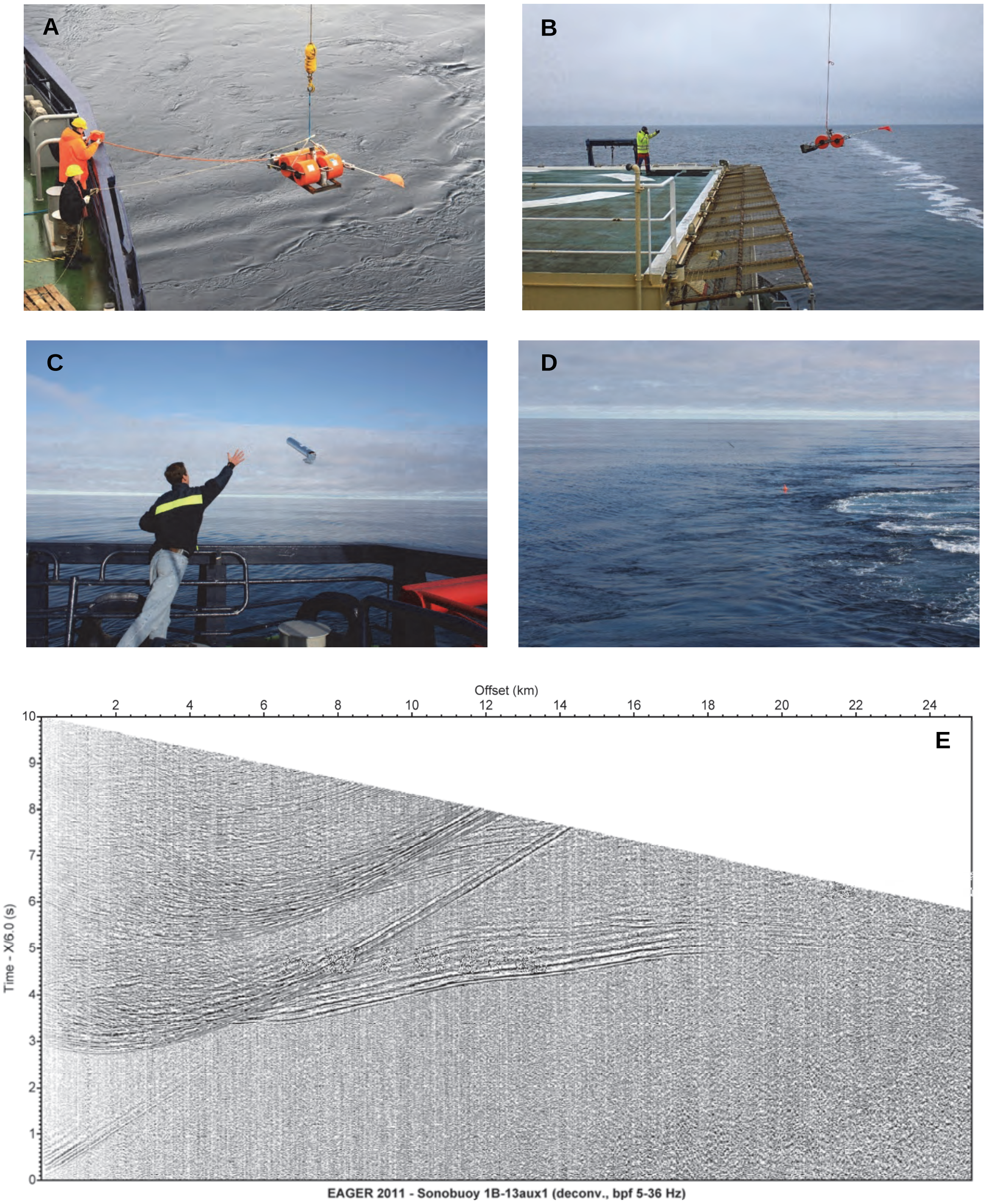



**Figure 21.** *A. OBS launch (by crane) and B. retrieval (by helicopter) C. and D. Sonobuoy deployment from the aft deck of Oden. E. Data example from Sonobuoy 13 on line 1B.*

## 5.5 Staffing

The reflection seismic operation was carried out by eight members of the scientific crew on-board *Oden* as listed in Table 4.

| Name | Affiliation | Function |
|---|---|---|
| Thomas Vangkilde-Pedersen | GEUS | Geophysicist |
| Lars Georg Rödel | GEUS | Technician |
| John R. Hopper | GEUS | Processing geophysicist |
| Emil Kousted Mauritzen | GEUS, Aarhus University | Watch keeper and deck hand |
| Jens Andreas Rasmussen | GEUS, Aarhus University | Watch keeper and deck hand |
| Knud Karkov | GEUS, Aarhus University | Watch keeper and deck hand |
| Erik Labahn | KUM GmbH | Gun and compressor technician |
| Tom Oliva | TTSurvey, UK | Gun and compressor technician |

**Table 4.** *Staffing of the reflection seismic group.*

The sonobuoy and OBS operation was carried out by six members of the scientific crew on-board *Oden* as listed in Table 5. Additional support for the recording of the data and the airgun operation was obtained from the technical staff of the seismic crew.

| Name | Affiliation | Function |
|---|---|---|
| Thomas Funck | GEUS | Head of R/WAR program |
| Emil Kousted Mauritzen | Aarhus University | Sonobuoy deployment |
| Jens Andreas Rasmussen | Aarhus University | Sonobuoy deployment |
| Knud Karkov | Aarhus University | Sonobuoy deployment |
| Jürgen Gossler | KUM GmbH | OBS technician |
| Tobias Hermann | AWI | Support OBS operation |

**Table 5.** *Staffing of the R/WAR seismic group.*

## 5.6 References

Hopper, J.R. & Marcussen, C. 2010: Seismic Processing Report - LOMROG II in 2009: Acquisition of reflection and refraction seismic data during Oden's Lomonosov Ridge Off Greenland (LOMROG II) cruise in 2009. Confidential report, Danmarks og Grønlands Geologiske Undersøgelse Rapport **2010/36**, 99pp + 3 DVD's.

Lykke-Andersen, H., Funck, T., Hopper, J.R., Trinhammer, P., Marcussen, C., Gunvald, A.K. & Jørgensen, E.V. 2010: Seismic Acquisition Report – LOMROG II in 2009, Danmarks og Grønlands Geologiske Undersøgelse Rapport 2010/53, 73 pp + 5 appendices + 1 CD.

Vangkilde-Pedersen, T., Funck, T., Hopper, J.R., Karkov, K., Mauritzen, E.K., Rasmussen, J.A., Hermann, T., Gossler, J., Trinhammer, P. & Marcussen, C. 2011: Seismic Acquisition Report – EAGER in 2011, Danmarks og Grønlands Geologiske Undersøgelse Rapport 2011/108, 85 pp + 5 appendices + 1 CD.

# 6. Gravity Measurements during the EAGER 2011 Cruise

*By Arne Vestergaard Olesen, DTU Space*

## 6.1 Background

Variations in the gravity field at sea reflect density variations beneath the sea surface. Both changes in bathymetry and lateral variations in rock densities will affect the observed gravity field. The strongest signal will in most cases arise from bathymetric features such as seamounts and submarine canyons. A reduction of the gravity observations for the effect of seafloor topography, i.e. forming the so-called Bouguer anomaly, will highlight signals originating from rock density variations e.g. faults, intrusions and sediment/bedrock interfaces.
Gravity information in the form of Bouguer anomalies has in many cases proven helpful in the interpretation of seismic data. Gravity data were therefore collected during the EAGER 2011 cruise by a LaCoste & Romberg marine gravimeter provided by DTU Space.

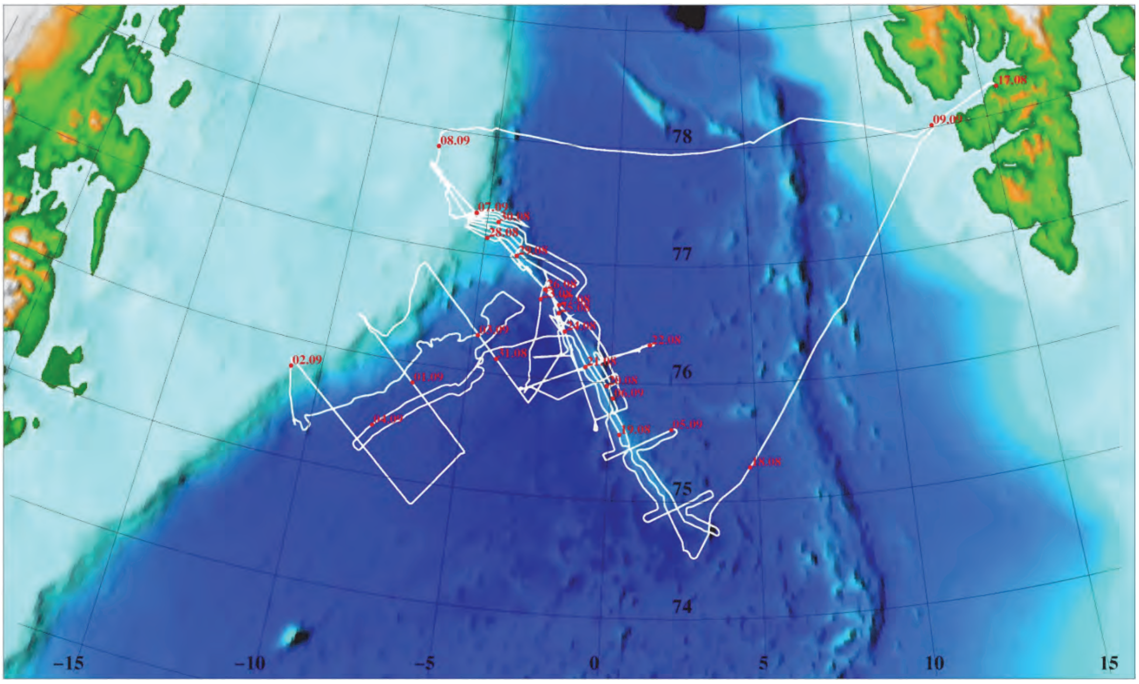



**Figure 22.** *The EAGER 2011 cruise. Oden's midday positions are marked with red labels.*

## 6.2 Equipment, Installation and Operation

The gravimeter, LaCoste & Romberg S-38, was installed in the engine room near the center-of-mass of the ship (the same location as during LOMROG I and II) to minimize the effect of the ship's movements (Figure 23). The instrument is in principle an ultra-precise spring balance with a "proof mass", which is mounted on a two-axis gyro stabilized platform. Levelling is maintained by a feedback mechanism consisting of gyros, accelerometers and torque motors. The accuracy of the marine gravimeter is about 1 mGal at 200-500 m horizontal resolution, somewhat dependent on ice conditions and the speed of *Oden*.

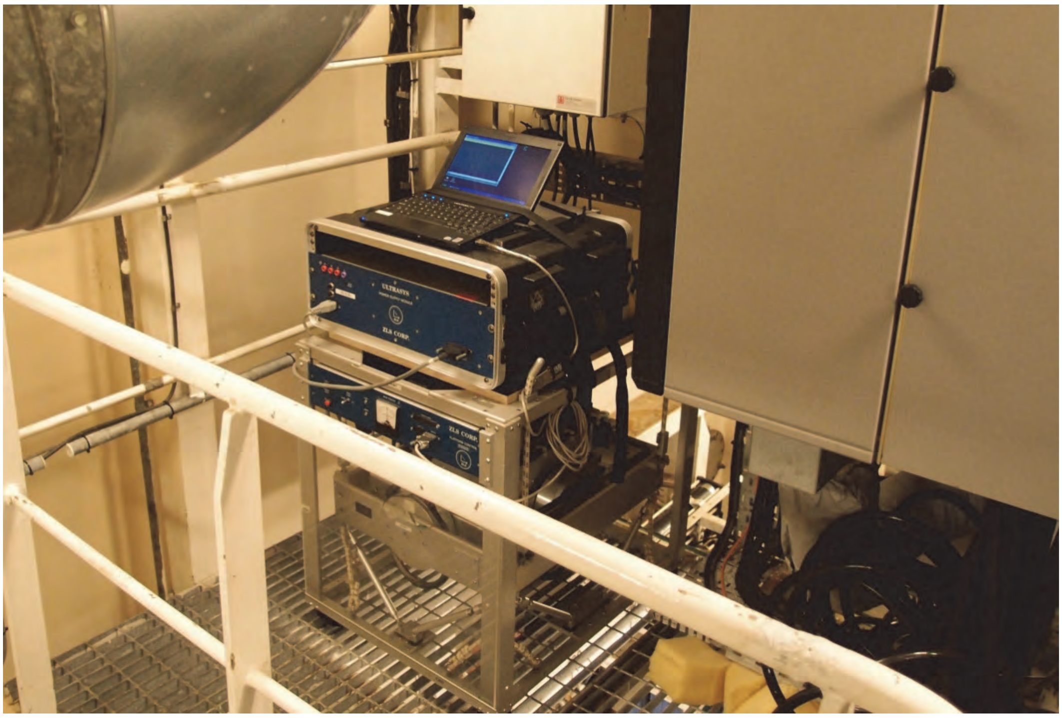


**Figure 23.** *S-38 gravimeter installed in the engine room.*

The installation was done in Landskrona on July 11 by Henriette Skourup and Emil Nielsen, DTU Space. The system was checked and prepared for survey on August 15 by Emil Nielsen while *Oden* anchored in Adventsfjorden near Longyearbyen.

Steffen M. Olsen and Rasmus Tonboe from DMI serviced the instrument during the cruise. Final check of instrument and securing of data were done by the author when *Oden* arrived in Longyearbyen at the end of the cruise. The instrument also recorded data en route from Svalbard to Helsingborg on request from Statens Kartverk, Norway. The instrument was finally removed from *Oden* in Helsingborg on September 22 by Arne Døssing Andreasen, DTU Space.

**Figure 24.** *Oden arriving in Longyearbyen in the evening of September 9.*

## 6.3 Gravity Ties and Data Reduction

The LaCoste & Romberg gravimeter is a relative instrument and the marine measurements have to be tied to places with known gravity values. This is normally done as harbor ties before and after a cruise. But since *Oden* did not call at the pier in Longyearbyen we may use the well known gravity field in the Adventsfjord as reference values instead. Exact gravity values for the anchoring positions have been established in connection with LOMROG I and LOMROG II cruises (see Figure 25).

Processing of the gravity data is not finalized at the time of writing but an initial screening of the data indicates that the instrument has been in a healthy state during the cruise and collected useful data.

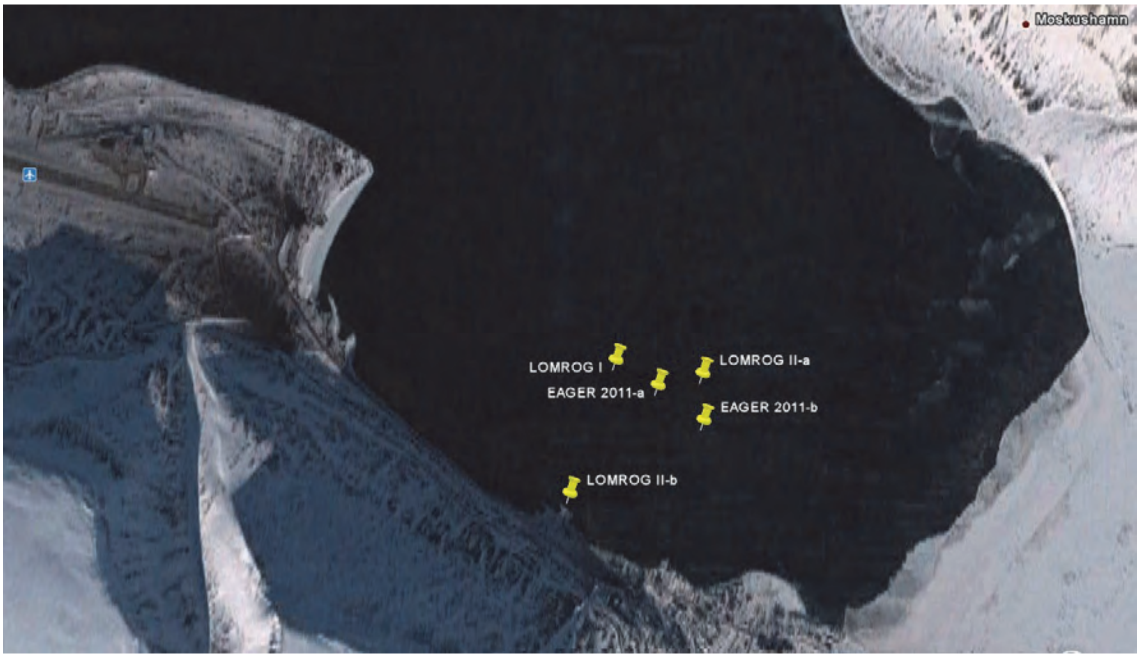



**Figure 25.** *Oden's anchoring positions in Adventsfjord.*

# 7. Oceanography

*By Steffen M. Olsen and Rasmus Tonsboe - Danish Meteorological Institute (DMI)*

## 7.1 Oceanographic Measurements

The oceanographic field work program of the EAGER 2011 cruise is designed as a coarse resolution regional survey to support the core activities of the cruise. Knowledge of water mass distribution and in particular the water column sound-velocity profile is required for proper interpretation of the seismic data and is essential for the sonar mapping of the sea-floor bathymetry. The primary purpose of the oceanographic work is thus regionally to supply representative, near real time vertical profiles of sound velocity derived from CTD (Conductivity, Temperature and Depth) measurements. Data are collected either from the ship during station work or by making use of expendable probes capable of measuring while steaming but offering no direct means of verification.

The area of interest spans transitions from open ocean oceanic conditions in the Greenland Sea and Boreas Basin to the stratified shelf waters by crossing the continental shelf break. It is a challenge to map in detail the transition zone in particular since it is characterized by sharp frontal structures and eddy features. On the basis of this knowledge, a sampling strategy has been designed seeking to make optimal use of resources. Data has mainly been retrieved on four lines (Panels 1-4) perpendicular to the shelf and spanning the dimensions of the study area.

A science-of-opportunity project to study the population of *Roseobacter* bacteria depends on oceanographic CTD measurements and accompanied collection of water samples. This project is led by María Jesús Prol García, DTU-Food. A synergy has been developed during the cruise between the two activities in order to make optimal use of resources and personnel. During station work, the oceanographic team onboard from DMI also collected water samples from the water column for a Danish science group not onboard the *Oden*. These samples are catalogued and stored for post cruise analysis. Dr. Colin Stedmon, NERI, is the contact point for this initiative which is linked to the Danish Strategic Research Project NAACOS (2011-2014) coordinated by Prof. Andre W. Visser, DTU-Aqua. Furthermore, the team launched a drifting float of ARGO type equipped with additional chemical sensor packages and optimized for operating in partly ice covered regions. Also here, water samples and profile data have been collected for verification for the group led by Prof. Mike Steele, Univ. Washington.

Oceanographic data acquired during the cruise are expected to contribute to the understanding of the processes leading to mixing of fresh and cold polar water masses on the shelf with the off-shelf Atlantic Water derivatives found along the continental shelf break. Of particular interest to the science group onboard is the role of cross slope topography - the East Greenland Ridge - on the leakage of freshwater from the east Greenland Shelf. This may occur by way of eddy formation and eddy shedding or directly by topographically steered surface currents. Data obtained will also yield an updated view of the stratification and renewal of dense water masse in the central Greenland Sea.

## 7.2 Along-track Surface Ship Data

Data from the along track logging of surface salinity and temperature in the SBE 'Ferry Box' unit installed by Polar on *Oden* have been monitored during the cruise in order to identify in particular crossings from the open ocean to shelf water conditions. Maps have been produced daily including the derived sound velocity. Before August 21, 2011, the quality of the logged data was not satisfactory and only data from the period August 21 to September 5, 2011 have been considered. Poor data quality here was partly due to a reduced flow rate in the scientific sea water system supplying the main laboratory and partly due to air bobbles continuously being trapped in the SBE unit. A simple fix was performed by attaching a hose to the air vent allowing water and air to flush out. Data processing of the logged measurements includes removal of spikes and outlier values. For this, a conservative error estimate has been applied using a one standard deviation cutoff estimated from a 5 minute running mean value. In addition, outliers have been removed by applying simple cut-off criteria on temperature and salinity, respectively. Noise in the salinity measurements is largely one-sided which may tend to bias the averaged reading towards lower salinities also after processing.

## 7.3 Calibration Data, Surface Ship Data

Individual five seconds readings under stable conditions with little noise have been compared with bottle samples drawn from the outlet of the 'Ferry-Box'. In total 18 samples were analyzed using a Portasal Salinometer following the procedure described under the CTD calibration. A large negative offset in salinity of -0.171 ±0.059 (median value and standard deviation) could be identified. This significant correction should be seen in the context since the sensor calibration date is only one year old (summer 2010). The uncertainty in the error estimate of ±0.059 stems mainly from the noise in the system and the accuracy of processed data will be superior to this estimate. Daily, processed but not bias corrected data files have been produced and are available in a geo-referenced format at roughly five seconds intervals.

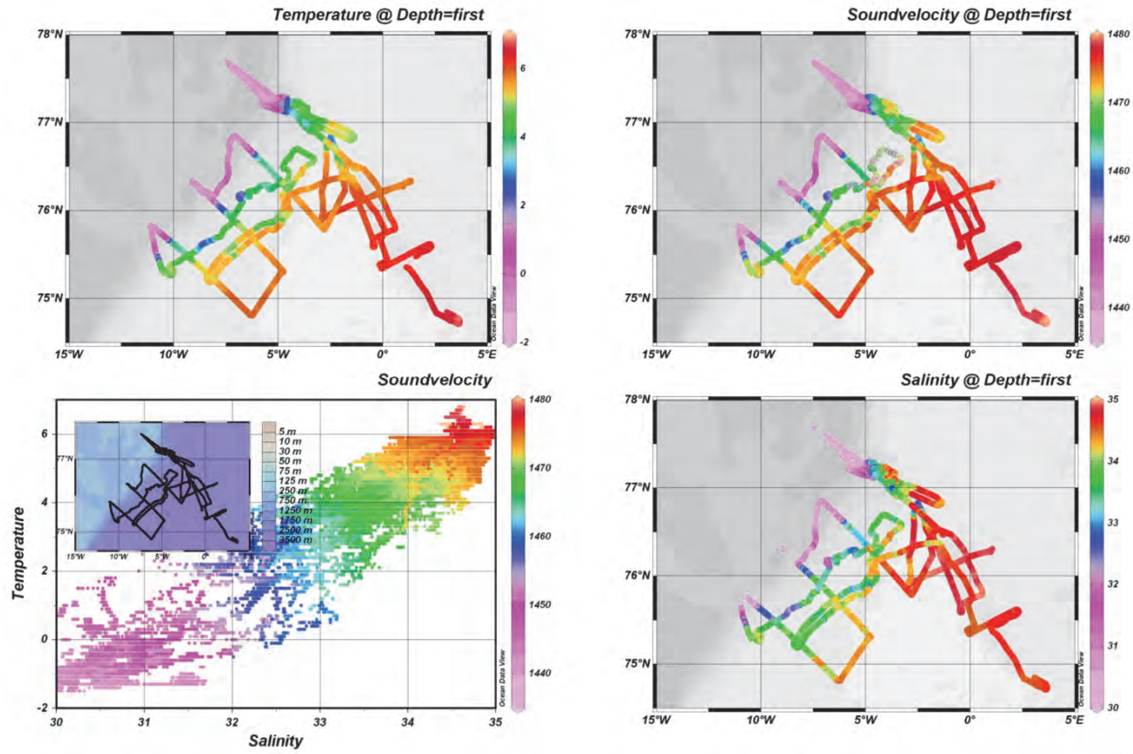



**Figure 26.** *Ship track surface data collected in the period 21082011 to 04092011.*

Compiled ship track surface data (Figure 26) illustrates the transition zones along the continental shelf break with polar surface water reaching just beyond the 1500m isobaths. In the transition zone approximate 20-30 nm wide and above the core of the Atlantic return flow (see Figures 27 to 30), properties are very variable and show signatures of a number of cold-core mesoscale eddy features spinning off the baroclinic slope current. Anomalies encountered in the surface have a horizontal extent of 15-25 nm with accompanying negative anomalies in temperature and salinity of $2^oC$ and 1-2 psu, respectively.

| Station ID | Cast # | Date and time yyyy-mm-ddThh:mm:ss.sss | Longitude [East] | Latitude [North] | File name |
|---|---|---|---|---|---|
| 1 | 3 | 2011-08-18T23:12:00.000 | 2,6893 | 74,5720 | GOT03.cnv |
| 2 | 4 | 2011-08-22T13:42:00.000 | 1,0664 | 76,3140 | GOT04.cnv |
| 3 | 5 | 2011-08-23T03:46:00.000 | 357,1240 | 75,9060 | GOT05.cnv |
| 4 | 6 | 2011-08-28T14:34:00.000 | 354,2146 | 77,2130 | GOT06.cnv |
| 5 | 7 | 2011-08-30T03:44:00.000 | 352,5573 | 77,6790 | GOT07.cnv |
| 6 | 8 | 2011-09-01T04:39:00.000 | 351,0759 | 76,3050 | GOT08.cnv |
| 7 | 9 | 2011-09-01T12:16:00.000 | 353,1698 | 75,8270 | GOT09.cnv |
| 8 | 10 | 2011-11-02T17:03:00.000 | 349,4946 | 75,3230 | GOT10.cnv |

**Table 6.** *CTD station list.*

## 7.4 Water Column Sampling with CTD and Water Sampler

Measurements of water mass distribution were done at full depth at key points in the study area making use of the onboard CTD rosette system owned by the University of Gothenburg and made available for the Continental Shelf Project by Prof. Göran Björk. This system consists of a 24-bottle rosette sampler equipped with 12 liter Niskin type bottles, a

SBE9plus CTD with a SBE11plus Deck Unit. Sensors include a single pumped SBE Temperature-Conductivity package and a Benthos altimeter. In total 8 profiles were obtained during the cruise (Table 6). After deployment, the CTD rested in the surface layer (10 m) for approximately 5 minutes until the pump turned on and sensor readings equilibrated. Hereafter the CTD and water sampler were raised to 4-5m where data acquisition was started. Profiles were retrieved with a descent rate of approximately 30 m/min in the upper 200m, roughly across the strong upper ocean stratification. Away from strong gradients, a descent rate of 60m/min was used. Water samples were taken at predefined depths during the upcast waiting not more than 2m at each depth before closing of bottles. On deck, samples were drawn from the bottles for salinity (S), isotopic composition (d18O), nutrient (N) and bacterial filtration (Roso), see Table 7 for a complete list of the water column sampling distribution at individual stations. Apart from salinity analyzed onboard, all samples are stored for post cruise analysis.

Station work in open sea using the frame and winch system on the fore deck was only possible in calm conditions with winds less than 7-8 m/s and without significant swell causing heave. Engines were stopped and *Oden* typically drifted 0.5-1.0kn over ground. In cases, thrusters were used to keep *Oden* from spinning round which would mean that the wire would go under the hull. Due to a long period of settled weather, CTD work could be performed safely also in open sea. The same procedure was used in ice where operations were even simpler due to the lack of swell. However, while recovering the CTD on the last station in open sea, the system was dropped on deck with some material damage. This accident was caused by unintended activation of the winch during crane operations. Water samples from this station were lost.

## 7.5 Data Processing

After calibration, raw data from the CTD (HEX format) are converted to engineering units including pressure, in situ temperature and conductivity. Pressure readings are initially high pass filtered two ways in order to smooth high frequency data and to obtain a uniform descent history of the cast. The applied cut-off period for the SBE9plus is 0.15 seconds. Inherent misalignment time delay in sensor responses and transit time delay in the pumped pluming line are corrected by advancing conductivity 0.073 sec relative to pressure for the SBE9plus. By this alignment, measurements refer to same parcel of water and the procedure eliminated artificial spikes in the calculated salinity which is dependent on temperature, pressure and conductivity. A recursive filter was hereafter applied to remove cell thermal mass effects from the measured conductivity according to the specifications for the individual sensors of the CTD system. This correction of salinity is significant in the upper layers with steep temperature gradients, but otherwise negligible. The last modification of the data removes scans with slow descent rate or reversals in pressure. Post processed data is averaged into 1m bins and includes a number of derived parameters including salinity and sound velocity.

| Station | Depth [m] | Pressure [db] | T [oC] | S [psu] | Pot [°C] | Sigma [k/m³] | S | d18O | N | Roseo |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2011-08-18T23:12:00.000 | | | | | | | | | |
| | 2999,611 | 3052,989 | -0,7881 | 34,9099 | -0,9592 | 28,0788 | xx | | | x |
| | 2003,45 | 2034,282 | -0,6962 | 34,9064 | -0,794 | 28,0691 | xx | | | x |
| | 1002,342 | 1015,32 | -0,6186 | 34,9005 | -0,6589 | 28,0584 | xx | | | x |
| | 497,545 | 503,369 | -0,6088 | 34,8969 | -0,6265 | 28,054 | | x | x | x |
| | 301,388 | 304,77 | -0,5467 | 34,896 | -0,557 | 28,0502 | | x | x | |
| | 199,699 | 201,89 | -0,4401 | 34,897 | -0,4469 | 28,0458 | | x | x | x |
| | 148,561 | 150,172 | -0,4588 | 34,8881 | -0,4637 | 28,0394 | | x | x | |
| | 98,896 | 99,957 | -0,3305 | 34,888 | -0,3339 | 28,033 | | x | x | |
| | 50,121 | 50,653 | 0,095 | 34,8801 | 0,0932 | 28,0044 | | x | x | x |
| | 24,984 | 25,247 | 2,9801 | 34,8525 | 2,9786 | 27,7693 | | x | x | |
| | 10,271 | 10,379 | 6,5061 | 34,8538 | 6,5052 | 27,3711 | | x | x | x |
| 2 | 2011-08-22T13:42:00.000 | | | | | | | | | |
| | 2997,864 | 3051,435 | -0,7701 | 34,9109 | -0,9415 | 28,0789 | xx | | | x |
| | 2004,504 | 2035,515 | -0,7441 | 34,9083 | -0,8413 | 28,0727 | xx | | | x |
| | 1011,139 | 1024,331 | -0,499 | 34,9045 | -0,5408 | 28,0563 | xx | | | x |
| | 504,309 | 510,261 | -0,1558 | 34,9248 | -0,1757 | 28,0548 | | x | x | x |
| | 305,136 | 308,587 | -0,0642 | 34,9174 | -0,0759 | 28,0437 | | x | x | |
| | 203,876 | 206,131 | 0,389 | 34,9378 | 0,3806 | 28,0346 | | x | x | x |
| | 152,033 | 153,695 | 0,7767 | 34,9531 | 0,77 | 28,023 | | x | x | |
| | 102,407 | 103,514 | 1,5316 | 34,9962 | 1,5264 | 28,0053 | | x | x | |
| | 48,606 | 49,124 | 1,9779 | 34,9726 | 1,9753 | 27,9518 | | x | x | x |
| | 25,809 | 26,083 | 4,849 | 34,8689 | 4,847 | 27,589 | | x | x | |
| | 9,769 | 9,872 | 5,8547 | 34,8634 | 5,8538 | 27,4633 | | x | x | x |
| 3 | 2011-08-23T03:46:00.000 | | | | | | | | | |
| | 1996,15 | 2026,956 | -0,6825 | 34,9057 | -0,78 | 28,068 | xx | x | x | x |
| | 1505,696 | 1527,136 | -0,6202 | 34,9017 | -0,6878 | 28,0607 | | x | x | x |
| | 1011,402 | 1024,58 | -0,6141 | 34,9011 | -0,6549 | 28,0587 | xx | x | x | x |
| | 515,524 | 521,613 | -0,5093 | 34,9046 | -0,5281 | 28,0558 | | x | x | x |
| | 305,026 | 308,471 | -0,3798 | 34,9093 | -0,3907 | 28,053 | | x | x | |
| | 200,129 | 202,337 | -0,4143 | 34,8992 | -0,4212 | 28,0463 | | x | x | x |
| | 155,92 | 157,624 | -0,2611 | 34,9031 | -0,2666 | 28,0419 | | x | x | |
| | 108,356 | 109,527 | -0,1198 | 34,9014 | -0,1237 | 28,0333 | | x | x | |
| | 50,73 | 51,27 | 0,8729 | 34,9128 | 0,8707 | 27,984 | | x | x | x |
| | 26,115 | 26,392 | 5,9752 | 34,9069 | 5,973 | 27,4826 | | x | x | |
| | 10,172 | 10,279 | 6,1176 | 34,8634 | 6,1167 | 27,4298 | | x | x | x |
| 4 | 2011-08-28T14:34:00.000 | | | | | | | | | |
| | 489,781 | 495,563 | 0,4409 | 34,8849 | 0,4193 | 27,9897 | x | x | x | x |
| | 401,057 | 405,703 | 1,5991 | 34,9588 | 1,5777 | 27,9714 | x | x | x | x |
| | 349,285 | 353,286 | 1,6665 | 34,9606 | 1,6479 | 27,9676 | | x | x | |
| | 300,012 | 303,413 | 1,9434 | 34,9351 | 1,9268 | 27,9256 | | x | x | |
| | 250,103 | 252,907 | 2,7797 | 34,9988 | 2,7643 | 27,9057 | | x | x | |
| | 200,113 | 202,332 | 2,7227 | 34,9484 | 2,7106 | 27,8702 | | x | x | x |
| | 150,016 | 151,661 | 0,5722 | 34,5945 | 0,5659 | 27,7469 | | x | x | |
| | 99,447 | 100,525 | -1,2961 | 34,2389 | -1,2985 | 27,5472 | | x | x | x |
| | 49,624 | 50,155 | -1,5394 | 33,6792 | -1,5404 | 27,1002 | | x | x | x |
| | 24,582 | 24,844 | -1,587 | 32,6587 | -1,5875 | 26,2725 | | x | x | |
| | 9,651 | 9,754 | -1,4779 | 31,7103 | -1,478 | 25,4999 | | x | x | x |
| 5 | 2011-08-30T03:44:00.000 | | | | | | | | | |
| | 233,044 | 235,652 | 0,7382 | 34,7312 | 0,728 | 27,847 | xxx | x | x | x |
| | 199,812 | 202,031 | 0,3095 | 34,594 | 0,3016 | 27,762 | | x | x | x |
| | 150,004 | 151,652 | -1,1662 | 34,2697 | -1,1701 | 27,5678 | | x | x | |
| | 100,393 | 101,483 | -1,5226 | 33,8844 | -1,5248 | 27,2664 | | x | x | x |
| | 49,646 | 50,179 | -1,5459 | 32,3136 | -1,5468 | 25,9913 | | x | x | x |
| | 24,509 | 24,771 | -1,4378 | 31,3861 | -1,4383 | 25,2359 | | x | x | |
| | 10,238 | 10,347 | -1,2912 | 30,0499 | -1,2914 | 24,1491 | | x | x | x |

**Table 7.** *Bottle samples.*

| Station | Depth [m] | Pressure [db] | T [oC] | S [psu] | Pot [°C] | Sigma [k/m³] | S | d18O | N | Roseo |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 2011-09-01T04:39:00.000 | | | | | | | | | |
| | 278,014 | 281,139 | 1,5823 | 34,9255 | 1,5678 | 27,9455 | | x | x | x |
| | 251,053 | 253,859 | 1,4525 | 34,883 | 1,4398 | 27,9208 | | x | x | x |
| | 200,89 | 203,11 | 0,818 | 34,71 | 0,809 | 27,8248 | | x | x | x |
| | 150,391 | 152,034 | -0,3793 | 34,4223 | -0,3843 | 27,6589 | | x | x | |
| | 101,059 | 102,151 | -1,556 | 34,1455 | -1,5582 | 27,4795 | | x | x | x |
| | 50,473 | 51,012 | -1,5645 | 33,4783 | -1,5655 | 26,9377 | | x | x | x |
| | 24,438 | 24,698 | 0,3906 | 32,0911 | 0,3897 | 25,7399 | | x | x | |
| | 10,828 | 10,943 | -1,1778 | 30,8696 | -1,178 | 24,8111 | | x | x | x |
| 7 | 2011-09-01T12:16:00.000 | | | | | | | | | |
| | 2753,744 | 2801,282 | -0,7882 | 34,9102 | -0,9393 | 28,0783 | xx | | | x |
| | 2000,138 | 2031,016 | -0,7673 | 34,908 | -0,8638 | 28,0734 | xx | | | x |
| | 999,94 | 1012,903 | -0,5766 | 34,9006 | -0,6172 | 28,0566 | xx | x | x | x |
| | 499,224 | 505,100 | -0,1693 | 34,9217 | -0,1889 | 28,0531 | | x | x | x |
| | 299,314 | 302,692 | 0,0394 | 34,9176 | 0,0277 | 28,0383 | | x | x | |
| | 199,25 | 201,404 | 0,4423 | 34,9296 | 0,434 | 28,0248 | | x | x | x |
| | 149,286 | 150,915 | 1,0774 | 34,9662 | 1,0704 | 28,0136 | | x | x | |
| | 100,241 | 101,322 | 1,7275 | 35,001 | 1,7223 | 27,9944 | | x | x | |
| | 49,887 | 50,419 | 2,646 | 34,955 | 2,6431 | 27,8815 | | x | x | x |
| | 23,819 | 24,071 | 5,2767 | 34,8618 | 5,2748 | 27,5333 | | x | x | |
| | 10,261 | 10,37 | 5,4201 | 34,4085 | 5,4192 | 27,157 | | x | x | x |

**Table 7 (cont.)** *Bottle samples.*

## 7.6 Calibration Data, CTD

From each CTD station, at least two samples were taken for on-board bottle salinity reference measurements. With replicates, 21 individual samples have been measured onboard yielding satisfactory statistics for performing post cruise corrections of the raw data files. Bottle salinities were measured using an Autosal Guildline 8410 portable lab salinometer with a nominal precision of 0.003 PSU. IAPSO standard seawater references were used purchased prior to the cruise from OSIL (www.oscil.co.uk): Batch: P153, $K_{15}$=0.99979, Practical Salinity 34.992 and to be used by 8th March 2014. The Autosal salinometer was placed in stable temperature environment of 20 $^{o}$C and left to warm up 24 hours prior to standardization, zero calibration and analysis. Bath temperature was set to two degrees above ambient temperature, 22$^{o}$C. The bottle samples were analyzed in one series near the end of the cruise and negligible drift (0.001 or less) could be identified during the sequence of analysis. Three readings were performed for each bottle and the mean error between CTD salinity and bottle salinities could be estimated with at precision of 0.001 disregarding one obvious outlier. Reference readings are primarily but not exclusively based on deep samples representing the weekly stratified abyssal water column where the CTD reading is well determined during closing of water samplers. A small but significant mean offset of **-0.0050 +/-0.0013** (CTD measuring too low salinities) could be determined for the SBE911 system based on the bottle data statistics. Since this is close to the nominal error of the Portasal salinometer, it has not been considered to correct the CTD data during the cruise.

## 7.7 Water Column Sampling with XBT's and XCTD's

The majority of the water column sampling during the EAGER cruise was done using expendable probes (see Table 8). Two types of probes have been used, both manufactured by Sippican Inc, the expendable bathythermograph XTB-T5 capable of reaching 1830m and the Conductivity-Temperature-Depth probe XCTD-1 reaching 1100m. The probes also differ in the maximum speed by which they may be launched and reach their target depth. XBT-T5's require less than 6kn while the XCTD-1 will reach target depth at speed up to 12.5kn. Probes were launched in the lee side on the after deck using a hand launcher and taking care that the line did not interact with the side of the ship. Data acquisition was done using the MK21 deck-unit system and Sippican MK21 acquisition software with NMEA string logging the launch position, date and time. The raw data files were processed according to the recommendations by the manufacturer as part of the acquisition. This includes removal of noise and averaging of bins. Export data files (.edf) with derived parameters (salinity and sound velocity) have been produced for each profile. For the XBT-T5's, a fixed salinity profile is assumed for estimating the sound velocity. A salinity of 34.90 was used resembling well the vast interior of the Greenland Sea with the exception of the slightly fresher shallow mixed-layer.

Of the 36 XCTD-1 probes launched, all 36 were successfully detected by the acquisition system and started logging after impact with the water. Three did however terminate before reaching termination depth or the sea floor. Of these, two were launched within the pack ice and most likely the thin copper wire got caught in the ice and snapped premature. The third early termination may be due to the wire being trapped by the ship. The overall evaluation of the functioning of these probes is good and data are consistent with the CTD measurements considering the nominal precision of the probes of ±0.03psu and ±0.02$^{o}$C for salinity and temperature, respectively. This, however, is not sufficient to resolve satisfactory the interior horizontal gradients across the Greenland Sea gyre below intermediate levels of oceanographic interest.

In addition to the XCTD-1 launches, three XCTD-2 were launched which had past their expiry date. XCTD-2 probes are capable of reaching 1850m at a speed of 3.5kn but otherwise an identical sensor system. All of these failed in the sense that data retrieved were filled with spikes and/or data retrieval cancelled unexpectedly.

BT-T5 probes were primarily used in the weakly stratified waters off the shelf slope where salinity plays a minor role for the sound velocity profile. The success rate with these simpler probes was also good, only one could not be recognized by the acquisition system and was discarded.

Nominal temperature accuracy of the XBT-T5's is ± 0.1$^{o}$C or an order of magnitude less than the XCTD-1 probes. System depth accuracy is 4.6m or 2% of depths whichever is larger. Preliminary comparison of deep ocean temperatures across ships CTD profiles, XCTD-1 and XBT's reveals inconsistencies only to be explained by relatively large errors in individual XBT-T5 measurements. These errors may exceed 0.2 degree which is more than

| Station ID XBT/XCTD## | Date and time yyyy-mm-ddThh:mm:ss.sss | Longitude [ East] | Latitude [North] | Filename [ascii] |
|---|---|---|---|---|
| XBT05 | 2011-08-18T09:23:00.000 | 5,8223 | 75,7020 | EAGER_[Station ID].edf |
| XCTD06 | Failed | | | |
| XCTD07 | 2011-08-19T04:11:00.000 | 2,3624 | 74,7310 | EAGER_[Station ID].edf |
| XBT08 | 2011-08-19T11:08:00.000 | 0,6649 | 75,4780 | EAGER_[Station ID].edf |
| XCTD09 | 2011-08-19T17:19:00.000 | 358,9121 | 76,0940 | EAGER_[Station ID].edf |
| XBT10 | 2011-08-19T23:11:00.000 | 357,3624 | 76,1790 | EAGER_[Station ID].edf |
| XCTD11 | 2011-08-20T05:30:00.000 | 357,8304 | 76,5270 | EAGER_[Station ID].edf |
| XCTD12 | Failed | | | |
| XBT13 | 2011-08-20T16:09:00.000 | 359,1424 | 75,9570 | EAGER_[Station ID].edf |
| XCTD14 | 2011-08-20T20:12:00.000 | 357,3852 | 75,9440 | EAGER_[Station ID].edf |
| XCTD15 | 2011-08-20T23:28:00.000 | 359,3918 | 76,1530 | EAGER_[Station ID].edf |
| XCTD16 | 2011-08-21T14:58:00.000 | 358,3380 | 76,0470 | EAGER_[Station ID].edf |
| XCTD17 | 2011-08-22T08:30:00.000 | 0,2929 | 76,2390 | EAGER_[Station ID].edf |
| XBT18 | 2011-08-23T10:57:00.000 | 357,2983 | 76,4940 | EAGER_[Station ID].edf |
| XCTD19 | 2011-08-23T13:48:00.000 | 357,5207 | 76,8290 | EAGER_[Station ID].edf |
| XCTD20 | 2011-08-23T14:08:00.000 | 357,5246 | 76,8150 | EAGER_[Station ID].edf |
| XCTD21 | 2011-08-26T01:02:00.000 | 0,5540 | 75,7880 | EAGER_[Station ID].edf |
| XCTD22 | 2011-08-26T07:28:00.000 | 359,1148 | 76,4720 | EAGER_[Station ID].edf |
| XBT23 | 2011-08-26T10:17:00.000 | 358,0183 | 76,6310 | EAGER_[Station ID].edf |
| XCTD24 | 2011-08-26T13:51:00.000 | 356,8686 | 76,8800 | EAGER_[Station ID].edf |
| XCTD25 | 2011-08-26T15:46:55.000 | 355,8286 | 77,0880 | EAGER_[Station ID].edf |
| XCTD26 | 2011-08-26T17:20:53.000 | 355,0276 | 77,2430 | EAGER_[Station ID].edf |
| XCTD27 | 2011-08-26T19:53:37.000 | 354,3239 | 77,3710 | EAGER_[Station ID].edf |
| XBT28 | 2011-08-27T15:24:00.000 | 358,6100 | 76,4900 | EAGER_[Station ID].edf |
| XCTD29 | 2011-08-27T21:36:00.000 | 357,4776 | 76,7480 | EAGER_[Station ID].edf |
| XCTD30 | 2011-08-29T06:52:00.000 | 354,8850 | 77,2270 | EAGER_[Station ID].edf |
| XCTD31 | 2011-08-29T22:26:00.000 | 353,8636 | 77,4570 | EAGER_[Station ID].edf |
| XCTD32 | 2011-08-30T00:46:00.000 | 353,2584 | 77,5650 | EAGER_[Station ID].edf |
| XBT33 | 2011-08-31T09:50:00.000 | 357,1293 | 75,8040 | EAGER_[Station ID].edf |
| XBT34 | 2011-08-31T11:09:00.000 | 356,6682 | 75,9310 | EAGER_[Station ID].edf |
| XCTD35 | 2011-08-31T12:26:00.000 | 356,2061 | 76,0550 | EAGER_[Station ID].edf |
| XBT36 | 2011-08-31T13:52:00.000 | 355,6878 | 76,1910 | EAGER_[Station ID].edf |
| XCTD37 | 2011-08-31T15:10:00.000 | 355,2076 | 76,3140 | EAGER_[Station ID].edf |
| XBT38 | 2011-08-31T16:17:00.000 | 354,8029 | 76,4300 | EAGER_[Station ID].edf |
| XCTD39 | 2011-08-31T17:08:00.000 | 354,4955 | 76,4950 | EAGER_[Station ID].edf |
| XCTD40 | 2011-08-31T18:19:00.000 | 354,0200 | 76,6040 | EAGER_[Station ID].edf |
| XCTD41 | 2011-08-31T19:29:00.000 | 353,5501 | 76,7140 | EAGER_[Station ID].edf |
| XCTD42 | 2011-08-31T20:50:00.000 | 352,9880 | 76,8330 | EAGER_[Station ID].edf |
| XCTD43 | 2011-09-01T07:17:00.000 | 351,2935 | 76,2330 | EAGER_[Station ID].edf |
| XCTD44 | 2011-09-01T08:10:00.000 | 351,6146 | 76,1790 | EAGER_[Station ID].edf |
| XCTD45 | 2011-09-01T09:50:00.000 | 352,2583 | 76,0450 | EAGER_[Station ID].edf |
| XBT46 | 2011-09-01T10:56:00.000 | 352,7171 | 75,9310 | EAGER_[Station ID].edf |
| XBT47 | 2011-09-01T15:32:00.000 | 353,6344 | 75,7160 | EAGER_[Station ID].edf |
| XCTD48 | 2011-09-01T17:04:00.000 | 354,2085 | 75,5740 | EAGER_[Station ID].edf |
| XBT49 | 2011-09-01T18:21:00.000 | 354,6948 | 75,4560 | EAGER_[Station ID].edf |
| XCTD50 | 2011-09-01T19:54:00.000 | 355,2466 | 75,3040 | EAGER_[Station ID].edf |
| XCTD51 | 2011-09-02T00:45:00.000 | 353,6790 | 74,8120 | EAGER_[Station ID].edf |
| XBT52 | 2011-09-02T02:06:00.000 | 353,1418 | 74,9400 | EAGER_[Station ID].edf |
| XBT53 | 2011-09-02T03:03:00.000 | 352,7766 | 75,0250 | EAGER_[Station ID].edf |
| XBT54 | 2011-09-02T04:11:00.000 | 352,3337 | 75,1270 | EAGER_[Station ID].edf |
| XCTD55 | 2011-09-02T05:02:00.000 | 351,9969 | 75,2140 | EAGER_[Station ID].edf |
| XBT56 | 2011-09-02T06:05:00.000 | 351,5742 | 75,2940 | EAGER_[Station ID].edf |
| XBT57 | 2011-09-02T07:05:00.000 | 351,1668 | 75,3800 | EAGER_[Station ID].edf |
| XCTD58 | 2011-09-02T08:08:00.000 | 350,7124 | 75,4770 | EAGER_[Station ID].edf |
| XBT59 | 2011-09-02T09:11:00.000 | 350,2956 | 75,5630 | EAGER_[Station ID].edf |
| XCTD60 | 2011-09-02T09:52:00.000 | 350,0083 | 75,6210 | EAGER_[Station ID].edf |
| XCTD61 | 2011-09-02T11:03:00.000 | 349,5011 | 75,7210 | EAGER_[Station ID].edf |
| XCTD62 | 2011-09-02T12:08:00.000 | 349,1078 | 75,8050 | EAGER_[Station ID].edf |
| XCTD63 | Failed | | | |
| XBT64 | 2011-09-05T20:23:00.000 | 2,7395 | 74,8320 | EAGER_[Station ID].edf |
| XBT65 | 2011-09-06T09:12:00.000 | 1,0320 | 75,2120 | EAGER_[Station ID].edf |

**Table 8:** List of probes.

twice the nominal precision guarantied. An offset of this size varying in sign from probe to probe makes these of little use in mapping the thermal structure below 200m. XBT-T5 temperature errors can be identified in Figures 23 to 26 showing the compiled cross slope hydrography for the four individual sections covered based on CTD station data, XCTD-1 and XBT-T5 probe data.

In summary, XCTD-1 to be used at speeds up to 12kn reaching 1100m has proven very efficient for the hydrographic program. Measuring accuracies of the XBT-T5 probes have not been satisfactory but the probes have been a cost efficient alternative to the XCTD-1 probes in open and predominantly thermally stratified waters of the central Greenland Sea. Probe loss in ice has been significant and the use in ice cannot be recommended unless the ship halts or major leads can be identified.

## 7.8 Watermass Characteristics in the Study Area

Data from the oceanographic surveys are compiled to show the water mass distribution along the four main sections defining the study area. Figures 23 to 26 show the in-situ temperature, salinity and derived sound velocity synthesizing station CTD data, XCTD-1 and XBT-T5 data. Confined to the shelf and extending roughly to the 1500m isobaths near the steepest topography is the polar water with salinities below 34.7psu. This cold outflow from the arctic is highly stratified in salinity with upper layer values reaching 30-31psu already a few miles inshore of the shelf break reflecting the influence of melting sea-ice. Temperatures are relatively constant and near -1$^{o}$C in this layer which reaches down to 120-160m on the sections covered. The interface depth with the warmer intruding Atlantic Water below is deepening moving onto the shelf approaching Greenland but a bottom layer of warmer, saltier water exists below the Polar Water mass on all sections. This in turn result in a complex vertical structure in both water mass properties and sound velocities which reach their minimum values in the upper, fresh layers on the shelf.

The warm and saline Atlantic return flow forming the intermediate water mass flanks the polar water in the surface and extends to depths of 300-400m. The width of this boundary flow is on the order of 60nm whereby this is the dominating water mass in this depth interval towards the foot of the shelf. Below the Atlantic Return flow the water mass characteristics are more homogeneous. The intermediate water mass centered around 500-600m have in-situ temperatures near zero, slightly warmer than the Greenland Sea deep water below with in-situ temperatures of -0.7 to -0.8$^{o}$C.

Having passed the transition zone and the core of the Atlantic return flow moving into the central Greenland Sea, the water mass structure is simpler. The late summer mixed layer reaches 25-35m with temperatures between 5 and 6 $^{o}$C and typical salinities of 34.5psu. Below is a sharp transition associated with a strong gradient in temperature to the intermediate and deeper water masses of the Greenland Sea Gyre.

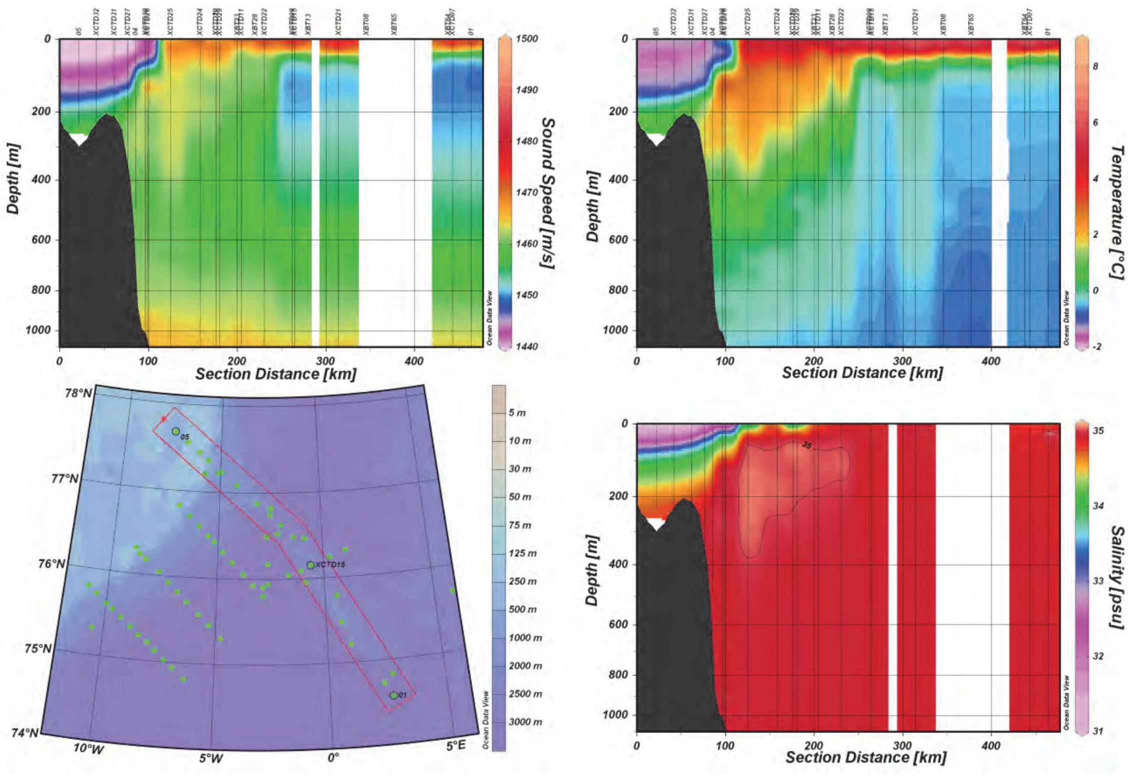


**Figure 27.** *East Greenland Ridge hydrographic section.*

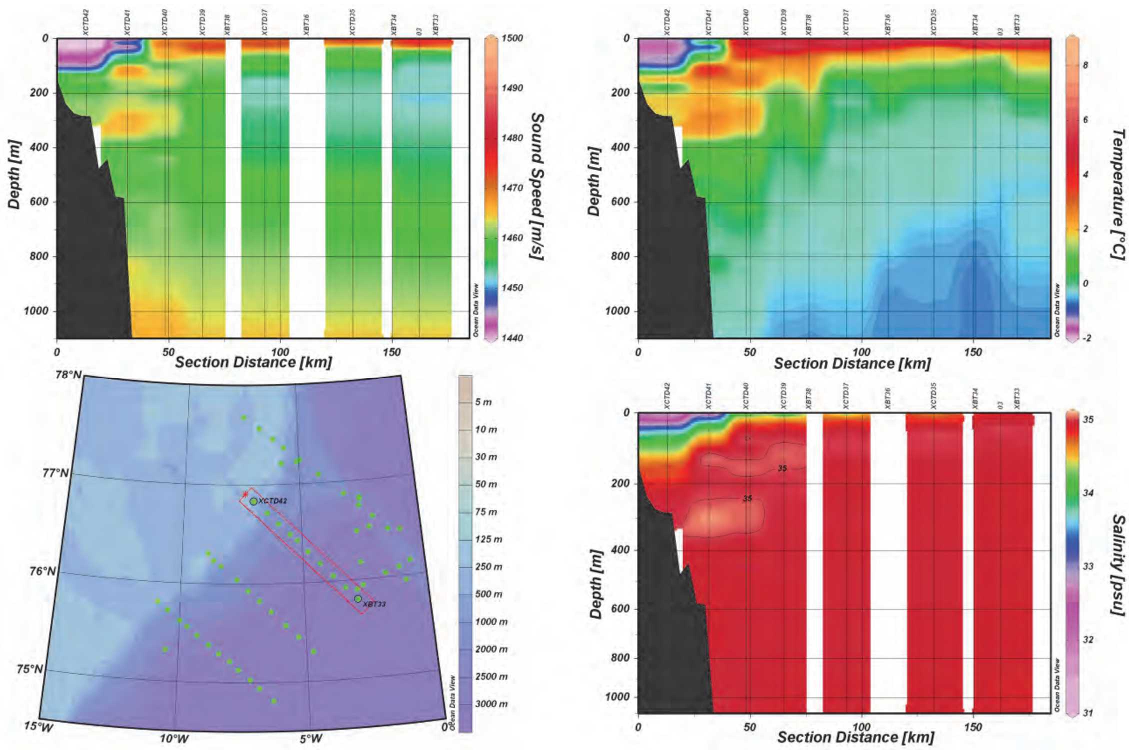


**Figure 28.** *Hydrography across the shelf break, section C.*

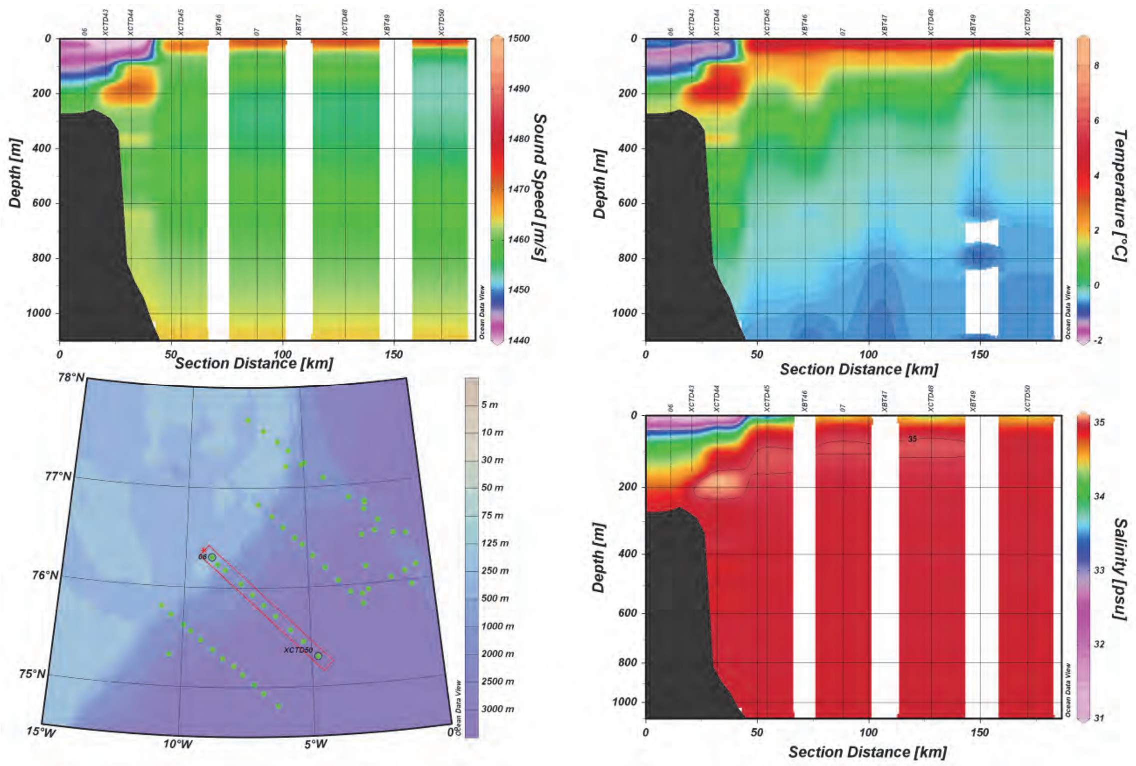



**Figure 29.** *Hydrography across the shelf break, section B.*

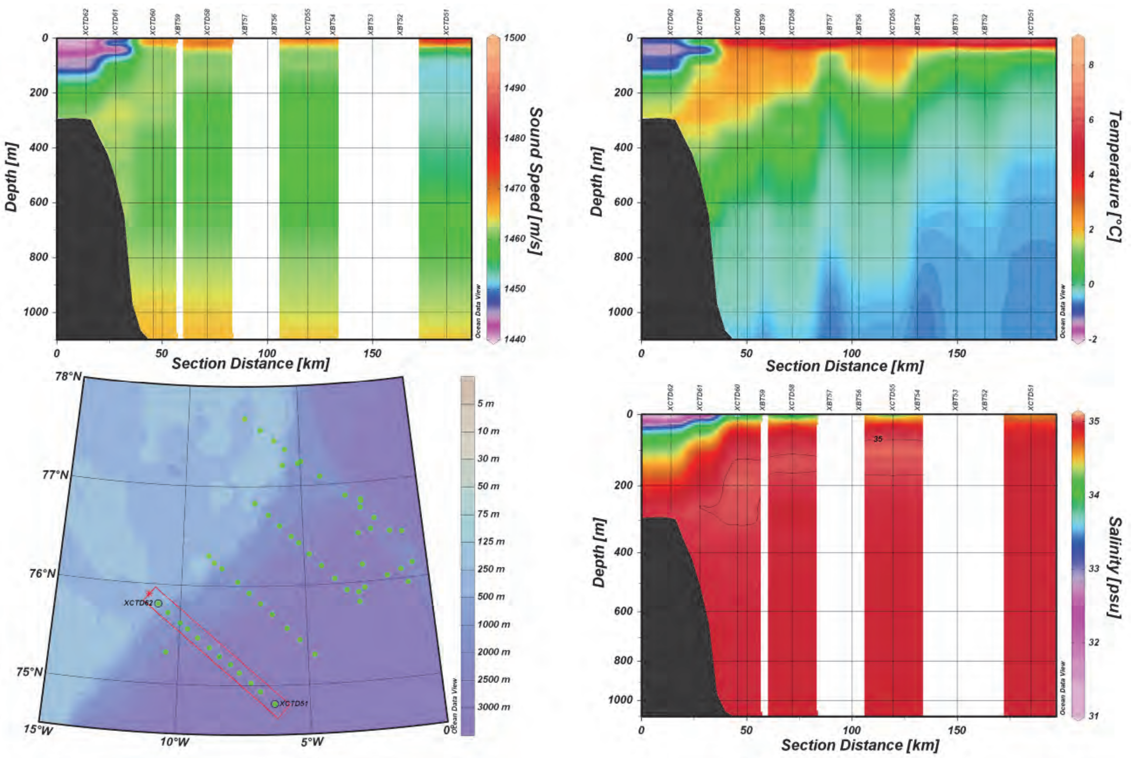



**Figure 30.** *Hydrography across the shelf break, section A.*

# 8. Collection of Samples to Study *Roseobacter* Bacteria Populations in the Greenland Sea

*By María Jesús Prol García - Technical University of Denmark - National Food Institute (DTU Food)*

## 8.1 Introduction

*Roseobacter* bacteria are some of the most common bacteria in the ocean and have been found in both coastal regions and open waters, as well as in aquaculture environments. *Roseobacter* are usually associated with algae and are capable of metabolising the algal sulphur compound, dimethylsulphonioproprionate (DMSP) by using two pathways: demethylation and/or cleavage. The latter leads to the production of dimethyl sulphide (DMS) which is the main sulphur form transferred from sea to air. Oxidised DMS acts as condensation nuclei that initiates cloud formation and hence increasing clouds albedo and leading to a greater reflexion of the sunlight. Hence, in the ocean, *Roseobacter* are mainly studied due to their role in the sulphur biochemical cycle and their potential impact on global climate.

Some members of the *Roseobacter* clade are able to produce a sulphur compound, the tropodithietic acid (TDA), which inhibits and kills both Gram positive and Gram negative bacteria. TDA, differently to the classic antibiotics, does not induce resistance in the target bacteria. This makes TDA producing *Roseobacter* important for aquaculture industry, where they can be applied as probiotics.

The purpose of this project was the collection of seawater, ice and phytoplankton samples for the analysis of *Roseobacter* populations in the Greenland Sea. Samples taken during EAGER 2011 expedition will be used for isolation and identification of *Roseobacter* bacteria and analysis of expression of genes involved in DMSP metabolism and TDA production, once in our laboratory at DTU National Food Institute (Kongens Lyngby, Denmark). EAGER samples will complement results obtained from previous expeditions (Galathea 3 and LOMROG II) and will contribute to understand the role of *Roseobacter* bacteria in sulphur cycle and therefore in global climate.

## 8.2 Scientific Methods

### 8.2.1 Collection and Preparation of Samples

#### 8.2.1.1 Seawater

Different depth seawater samples (10-3000 m) were collected at seven stations by using a CTD rosette equipped with 12 l bottles. CTD was performed by Steffen M. Olsen and Rasmus Tonboe. Surface water samples (8 m depth) were also taken almost daily at different positions from *Oden* seawater inflow located in the main laboratory (Table 9).

All seawater samples (500 ml) were filtered over 5 μm and the resultant solutions subsequently filtered over 0.2 μm (Figure 31). Additionally, a larger volume (20 l) of 10 m seawater was filtered over 2 μm and subsequently over 0.2 μm. The 5 and 2 μm fractions contain bacteria associated with live and inert particles (e.g. algae and organic matter) and the 0.2 μm fraction includes the free living bacteria. All filters are preserved at -80 ºC until analysed.

From all seawater samples a small volume (100 μl) was used to inoculate 5 ml 50 % Marine Broth (MB, Difco) in order to grow the bacteria present in those seawater samples. All cultures are incubated at room temperature (20-25 ºC) in the main lab. At the end of the cruise the bacterial cultures are transferred to 4 ºC.

#### 8.2.1.2 Phytoplankton

Collection of phytoplankton was done in four of the seven CTD stations by using a small plankton net (20 µm pore size). The net was submerged slowly to a depth of around 3-5 m and then quickly pulled up, concentrating the phytoplankton in the flask attached to the bottom of the net (Figure 32). Resultant solution was subsequently filtered over 5 µm in order to concentrate both algae and their associated bacteria. Filters are preserved at – 80 ºC.

#### 8.2.1.3 Ice

Although the original idea of the project was also getting ice samples, it was not possible during this cruise, as the conditions of the ice were not favourable for work on ice.

**Figure 31.** *Filtration of seawater samples (Photo by Jonas Zilmer Johansen).*

| Sample | Position | | Depth | Analysis | | |
|---|---|---|---|---|---|---|
| | | | | DNA | Gene expression | Bacterial growth |
| CTDSt01-1 | 74.3422 N | 02.4171 E | 10 m | x | x | |
| CTDSt01-2 | | | 50 m | x | | |
| CTDSt01-3 | | | 200 m | x | | |
| CTDSt01-4 | | | 500 m | x | | |
| CTDSt01-5 | | | 1000 m | x | | |
| CTDSt02-1 | 76.1866 N | 01.0350 E | 10 m | x | x | x |
| CTDSt02-2 | | | 50 m | x | | x |
| CTDSt02-3 | | | 200 m | x | | x |
| CTDSt02-4 | | | 500 m | x | | x |
| CTDSt02-5 | | | 1000 m | x | | x |
| CTDSt02-6 | | | 2000 m | x | | x |
| CTDSt02-7 | | | 3000 m | x | | x |
| CTDSt03-1 | 76.5309 N | 02.5577 W | 10 m | x | x | x |
| CTDSt03-2 | | | 50 m | x | | x |
| CTDSt03-3 | | | 200 m | x | | x |
| CTDSt03-4 | | | 500 m | x | | x |
| CTDSt03-5 | | | 1000 m | x | | x |
| CTDSt03-6 | | | 1500 m | x | | x |
| CTDSt03-7 | | | 2000 m | x | | x |
| CTDSt04-1 | 77.1280 N | 05.4745 W | 10 m | x | x | x |
| CTDSt04-2 | | | 50 m | x | | x |
| CTDSt04-3 | | | 100 m | x | | x |
| CTDSt04-4 | | | 200 m | x | | x |
| CTDSt04-5 | | | 300 m | x | | x |
| CTDSt04-6 | | | 400 m | x | | x |
| CTDSt04-7 | | | 489 m | x | | x |
| CTDSt05-1 | 77.4092 N | 07.2679 W | 10 m | x | x | x |
| CTDSt05-2 | | | 50 m | x | | x |
| CTDSt05-3 | | | 100 m | x | | x |
| CTDSt05-4 | | | 200 m | x | | x |
| CTDSt05-5 | | | 230 m | x | | x |
| CTDSt06-1 | 76.1961 N | 09.0564 W | 10 m | x | x | x |
| CTDSt06-2 | | | 50 m | x | | x |
| CTDSt06-3 | | | 200 m | x | | x |
| CTDSt06-4 | | | 277 m | x | | x |
| CTDSt07-1 | 75.4964 N | 06.4984 W | 10 m | x | x | x |
| CTDSt07-2 | | | 50 m | x | | x |
| CTDSt07-3 | | | 200 m | x | | x |
| CTDSt07-4 | | | 500 m | x | | x |
| CTDSt07-5 | | | 1000 m | x | | x |
| CTDSt07-6 | | | 2000 m | x | | x |
| CTDSt07-7 | | | 2754 m | x | | X |

**Table 9.** *Samples collected during EAGER 2011 and indication of planned subsequent analyses at DTU Food (Identification, gene expression and isolation of Roseobacter bacteria). CTD: CTD seawater samples, LabSW: seawater from Oden inflow, Phyto: phytoplankton samples.*

| Sample | Position | | Depth | Analysis | | |
|---|---|---|---|---|---|---|
| | | | | DNA | Gene expression | Bacterial growth |
| LabSW01 | 76.1540 N | 00.2940 E | 8 m | x | | x |
| LabSW02 | 76.1866 N | 01.0350 E | 8 m | x | | x |
| LabSW03 | 76.5309 N | 02.5577 W | 8 m | x | | x |
| LabSW04 | 76.0632 N | 01.1133 W | 8 m | x | | x |
| LabSW05 | 76.3617 N | 02.0369 W | 8 m | x | | x |
| LabSW06 | 76.5012 N | 02.2914 W | 8 m | x | | x |
| LabSW07 | 76.1709 N | 00.5810 W | 8 m | x | | x |
| LabSW08 | 77.0415 N | 04.0497 W | 8 m | x | | x |
| LabSW09 | 76.5079 N | 02.5914 W | 8 m | x | | x |
| LabSW10 | 76.5812 N | 03.3466 W | 8 m | x | | x |
| LabSW11 | 77.1280 N | 05.4745 W | 8 m | x | | x |
| LabSW12 | 77.0089 N | 03.4400 W | 8 m | x | | x |
| LabSW13 | 77.4092 N | 07.2679 W | 8 m | x | | x |
| LabSW14a | 77.2151 N | 06.0375 W | 8 m | x | | |
| LabSW14b | 77.1714 N | 05.4308 W | 8 m | | | x |
| LabSW15 | 75.5584 N | 02.2720 W | 8 m | x | | x |
| LabSW16 | 76.0429 N | 03.5118 W | 8 m | x | | x |
| LabSW17 | 76.2342 N | 05.0617 W | 8 m | x | | x |
| LabSW18 | 76.5018 N | 06.5909 W | 8 m | x | | x |
| LabSW19 | 75.4964 N | 06.4984 W | 8 m | x | | x |
| LabSW20 | 75.2978 N | 09.2294 W | 8 m | x | | x |
| LabSW21 | 75.4918 N | 11.0067 W | 8 m | x | | x |
| LabSW22 | 75.1942 N | 10.3039 W | 8 m | x | | x |
| LabSW23 | 76.1102 N | 06.4414 W | 8 m | x | | x |
| LabSW24 | 76.3025 N | 04.4435 W | 8 m | x | | x |
| LabSW25 | 75.2699 N | 07.1916 W | 8 m | x | | x |
| LabSW26 | 75.2124 N | 08.0837 W | 8 m | x | | x |
| PhytoSt01 | 74.3422 N | 02.4171 E | 3-5 m | x | | |
| PhytoSt02 | 76.1866 N | 01.0350 E | 3-5 m | x | | |
| PhytoSt04 | 77.1280 N | 05.4745 W | 3-5 m | x | | |
| PhytoSt07 | 75.4964 N | 06.4984 W | 3-5 m | x | | |

**Table 9. (cont.)** *Samples collected during EAGER 2011 and indication of planned subsequent analyses at DTU Food (Identification, gene expression and isolation of Roseobacter bacteria). CTD: CTD seawater samples, LabSW: seawater from Oden inflow, Phyto: phytoplankton samples.*

## 8.2.2 Work at DTU National Food Institute (Denmark)

### 8.2.2.1 Bacterial Isolation and Analysis of Bioactivity

MB cultures showing a brown colour will be spread on Marine Agar (MA, Difco) plates and incubated for 3-5 days at 25 ºC. Brown colonies will be subsequently isolated for further analysis. The resultant MA plates will be also replicated on a plate containing the fish pathogen *V. anguillarum* 90-11-287 and those colonies able to inhibit growth of the fish pathogen will be also isolated for further analysis (e.g. identification and physiological analyses).

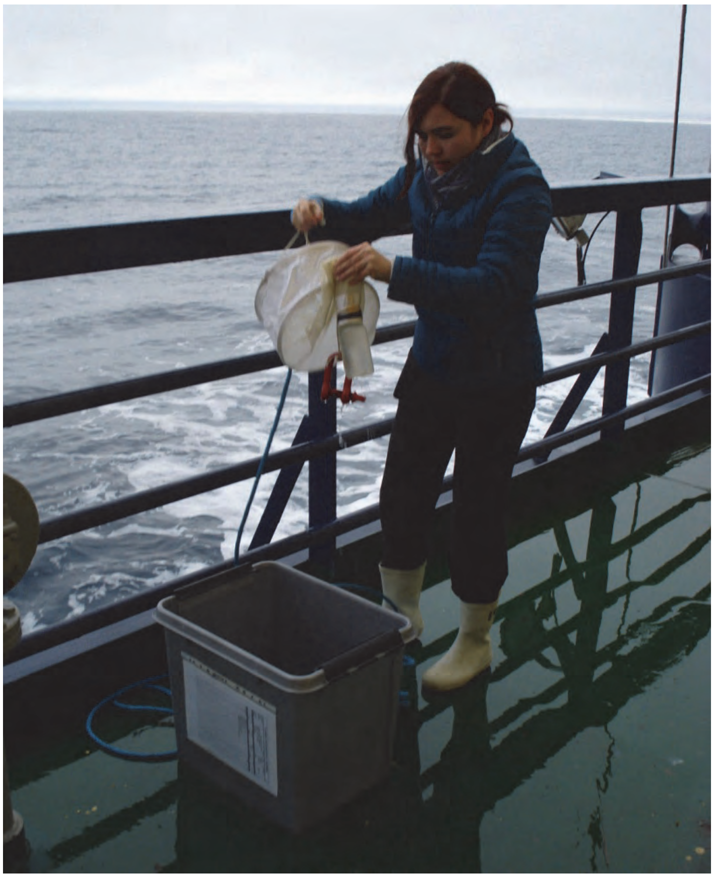


**Figure 32.** *Plankton net recovery (Photo by Linda Karlsson).*

#### 8.2.2.2 Analysis of Roseobacter Populations

Bacterial DNA or RNA will be extracted. Probes specific for *Roseobacter* DNA will be used for identification of the different *Roseobacter* species-genera and analyse their distribution along Greenland Sea. Expression of genes involved in DMSP and TDA production will be analysed by using transcriptomic analysis.

The latter will be done in collaboration with the German Collaborative Research Centre Transregio 51 in Germany (http://roseobacter.de/en). Resultant data will complement data from Galthea 3 and LOMROG II cruises.

## 8.3 Results

To grow bacteria on MA requires very sterile conditions, which is not possible on board *Oden*. Furthermore, the analysis of bioactivity requires growing of fish pathogens. On the other hand molecular biology analysis of the different samples collected during EAGER 2011 requires several hazardous chemicals. For these reasons, all bacteriological cultures and molecular biology analyses will be performed at DTU National Food Institute (Denmark) and thus no results are so far reportable.

# 9. Ornithological Work

*By Henrik Haaning Nielsen, National Environmental Research Institute at Aarhus University and ornit.dk*

## 9.1 Introduction

An ornithological observer from Aarhus University, Denmark, participated in the EAGER 2011 survey in the Greenland Sea. His task was to count seabirds and marine mammals at sea following the 'Distance Sampling'-methods (Webb & Durinck 1992, Buckland et al. 2001) along the sailed transects between the research stations. This observation method makes it possible to calculate densities of seabirds and the results can be compared to other results sampled in the same way.

Sampling takes place in a 300 m (or occasionally 500 m, when observation conditions are optimal) wide strip along the transect. The sampling is divided into 2 min. observation periods, and the distance all birds observed on the water within the strip is estimated.

To avoid an overestimate of flying birds, these are counted only by means of the snapshot technique (Webb & Durinck 1992). That is, if the ship travels 600 m in two minutes, then once every minute (at snapshot time) the birds flying over the transect strip within a distance of 300 m ahead of the ship are counted and designated with a special snapshot distance code. Flying birds occurring within this zone between two consecutive snapshots are not counted.

As sightings of marine mammals are comparatively rare, they are treated in a different way than birds. No matter where a marine mammal is sighted, whether inside or outside the transect strip, it is always recorded by the observer. If a marine mammal is observed perpendicular to the track line of the ship within the transect strip width, the sighting is recorded with a distance code in exactly the same way as birds on water. If a marine mammal is spotted outside the transect strip, it is designated with the distance code corresponding to "outside transect". However, the angle relative to the ships direction, and the distance in meters to the marine mammal are always estimated.

## 9.2 Results

High densities of Little Auks were observed both along the East Greenland Ridge and the investigation area further to the south. A total of 15,784 Little Auks were counted during the survey. These were most likely foraging birds from the huge breeding colonies on the coasts of Liverpool Land between Carlsberg Fjord and Scoresby Sound. In comparison other seabird densities were quite low and e.g. the Brünnich Guillemots were only noted with 451 ex. in total. Investigations were also carried out in the sea-ice, which resulted in interesting observations of a total of 130 Ivory Gulls and 5 Polar Bears.

| Species | 17-08-2011 | 18-08-2011 | 19-08-2011 | 20-08-2011 | 21-08-2011 | 22-08-2011 | 23-08-2011 | 26-08-2011 | 28-08-2011 | 29-08-2011 | 30-08-2011 | 31-08-2011 | 01-09-2011 | 02-09-2011 | 03-09-2011 | 04-09-2011 | 05-09-2011 | 06-09-2011 | 07-09-2011 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eider | | | | | | | | 2 | | | | | | | | | | | | 2 |
| Fulmar | 1209 | 19 | 3 | 13 | 6 | 1 | 2 | 4 | 6 | 23 | | 9 | 13 | 4 | | 7 | 1 | | 38 | 1358 |
| Gannet | | | | | | | | | | | | | | | | 1 | | | | 1 |
| Ringed plover | | | | | | | | | | | | | 4 | 1 | | | | | | 5 |
| Sanderling | | | | | | | | | | | | | | 1 | | | | | | 1 |
| Turnstone | | | | | 1 | | | | | | | | | | | | | | | 1 |
| Great skua | | | 1 | 2 | | 1 | | | | 1 | | | 2 | | | | | | | 7 |
| Pomarine skua | | 4 | | 1 | | | | 6 | 2 | 3 | | 1 | | | | | | 3 | 1 | 21 |
| Long-tailed skua | | 3 | | 1 | | 1 | 1 | 1 | | 1 | | | 1 | 1 | | | | | | 10 |
| Glacous gull | 2 | | | | | | | | | 3 | 1 | | | | | | | | 2 | 8 |
| Kittiwake | 505 | | 1 | 4 | 3 | 1 | 11 | 2 | 1 | 43 | 2 | 4 | 2 | 16 | 3 | 2 | | | 43 | 643 |
| Sabines gull | | | | | | | | | 2 | | | | | | | | | | | 2 |
| Ivory gull | | | | | | | | 2 | 3 | 12 | 35 | | 2 | 6 | | | | | 12 | 72 |
| Arctic tern | 3 | 1 | | 27 | 5 | 15 | 4 | 74 | 20 | 28 | | 3 | | 4 | 4 | 1 | | 1 | 3 | 193 |
| Little auk | 6 | | 39 | 375 | 1114 | 773 | 1290 | 1698 | 622 | 2508 | 126 | 526 | 1222 | 2476 | 870 | 1543 | 162 | 360 | 71 | 15781 |
| Puffin | 51 | | | | 3 | 1 | 6 | 3 | | | | | | | | | | | | 64 |
| Black guillemot | 13 | | | | | | | | | | | | | 2 | | | | | 6 | 22 |
| Brünnich guillemot | 5 | | 101 | 22 | 23 | 20 | 13 | 40 | | 1 | | 17 | 41 | 98 | 4 | 51 | 1 | 13 | | 450 |
| Minke whale | 2 | | | | | | 2 | | | 7 | | | 1 | | | | | | | 12 |
| Harp seal | | | | | | | | 1 | 2 | 3 | | | | 27 | | | | | 1 | 34 |
| Ringed seal | 1 | | | | | | | | | | | | | | | | | | | 1 |
| Unidentified seal | 1 | | | | | | | 1 | | | | | | | | | | | | 2 |
| | 1798 | 27 | 145 | 445 | 1155 | 813 | 1329 | 1834 | 658 | 2633 | 164 | 560 | 1288 | 2636 | 881 | 1605 | 164 | 377 | 177 | 18690 |

**Tabel 10.** *Observations on transect. All birds and mammals observed within 300 m (or 500 m) wide transects at one side of the ship. The 500 m wide transect is only used at calm sea-state.*

| Species | 17-08-2011 | 19-08-2011 | 20-08-2011 | 21-08-2011 | 22-08-2011 | 23-08-2011 | 25-08-2011 | 26-08-2011 | 27-08-2011 | 29-08-2011 | 30-08-2011 | 31-08-2011 | 01-09-2011 | 02-09-2011 | 04-09-2011 | 05-09-2011 | 06-09-2011 | 07-09-2011 | 08-09-2011 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| King eider | | | | | | | | | 1 | | | | | | | | | | | 1 |
| Fulmar | 40 | | 22 | 17 | 13 | 4 | 30 | 20 | | 6 | 1 | | 12 | 21 | 8 | 12 | 8 | 12 | 40 | 266 |
| Ringed plover | | | | | | | | | | | | | | 1 | | | | | | 1 |
| Knot | | | | | | | 7 | | | | | | | | | | | | | 7 |
| Grey Phalarope | | | | | | | | | | | | | | 1 | | | | | | 1 |
| Pomarine skua | | | | | | | 2 | 3 | | | | | | | | | | | | 5 |
| Long-tailed skua | | | | | | 1 | 6 | | | | | | | | | | | | | 7 |
| Great black-backed gull | 2 | | | | | | | | | | | | | | | | | | | 2 |
| Glacous gull | | | | | | | | | | | | | | | | | | 2 | 26 | 28 |
| Kittiwake | | 1 | 1 | | | 1 | | | | | | | | | 2 | | 3 | | 24 | 32 |
| Ivory gull | | | | | | | | 8 | | 2 | 16 | | | 3 | | | | 2 | 27 | 58 |
| Little auk | | | | | | | | | | | | | | | | | | | 3 | 3 |
| Puffin | | | | | | | 1 | 1 | | | | | | | | | | | | 2 |
| Black guillemot | | | | | | | | | | | | | | | | | | | 1 | 1 |
| Brünnich guillemot | | | | | | | | | | | | | | | | | 1 | | | 1 |
| Snow bunting | | | | | | | | | | | | | | | | 1 | | | | 1 |
| Blue whale | | | | | | | | 1 | | | | | | | | | | | | 1 |
| Fin whale | 1 | | | 2 | | | | 1 | 1 | | | | | | | | 1 | | | 6 |
| Minke whale | 2 | | | 5 | | 2 | 2 | 3 | 2 | 14 | | | 6 | 9 | | 7 | 2 | 1 | | 55 |
| Humpback whale | 2 | | | | | | | | | | | | | | | | | | | 2 |
| Unidentified baleen whale | | | | 1 | | | | | | | | 1 | | | | | | | | 2 |
| Long-finned pilot whale | | | | | | | | | | 2 | | | | | | | | | | 2 |
| Hooded seal | | | | | | | 1 | | | | 1 | | | | | | | | | 2 |
| Harp seal | | | | | | | | 40 | | | | | | | | | | | | 40 |
| Polar bear | | | | | | | | 1 | | 2 | 2 | | | | | | | | | 5 |
| | 47 | 1 | 23 | 25 | 13 | 8 | 49 | 78 | 4 | 26 | 20 | 1 | 18 | 35 | 10 | 20 | 15 | 17 | 121 | 532 |

**Tabel 11.** *Observations off transect. All mammals observed outside the transects, flying birds noted during snapshot sequences, birds noted as "ship-followers" and birds noted outside standard observations.*

Quite impressive numbers of whales were observed and 61 Minke Whales constitute a high total. Best day total was 16 individuals. Also an observation of one Blue Whale is very interesting, as are the total of 6 Fin Whales.

The results will be included in the AU database of seabirds-at-sea in Greenland waters. This database provides data for research and background data for future environmental impact assessments of primarily off-shore oil exploration activities. Such are expected to be initiated within a few years in the Greenland part of the Greenland Sea.

**Figure 33**. *Ivory Gull.*

## 9.3 Species List

***Birds:***

Fulmar (Fulmarus glacialis)

Common Eider (Somateria mollissima)

King Eider (Somateria spectabilis)

Long-tailed Duck (Clangula hyemalis)

Ringed Plover (Charadrius hiaticula)

Sanderling (Calidris alba)

Purple Sandpiper (Calidris maritima)

Ruddy Turnstone (Arenaria interpres)

Grey Phalarope (Phalaropes fulicarius)

Arctic Skua (Stercorarius parasiticus)

Great Skua (Stercorarius skua)

Sabines Gull (Xema sabini)

Glacous Gull (Larus hyperboreus)

Great Black-backed Gull (Larus marinus)

Kittiwake (Rissa tridactyla)

Ivory Gull (Pagophila eburnea)

Arctic Tern (Sterna paradisaea)

Brünnich Guillemot (Uria lomvia)

Black Guillemot (Cepphus grylle)

Little Auk (Alle alle)

Long-tailed Skua (Stercorarius longicaudus)

Pomarine Skua (Stercorarius pomarina)

Puffin (Fratercula arctica)

Snow Bunting (Plectrophenax nivalis)

***Mammals:***

Polar Bear (Ursus maritimus)

Ringed Seal (Phoca hispida)

Harp Seal (Phoca groenlandica)

Hooded Seal (Cystophora cristata)

Long-finned Pilot Whale (Glopicephala melas)

Minke Whale (Balaenoptera acutorostrata)

Fin Whale (Balaenoptera physalus)

Blue Whale (Balaenoptera musculus)

Humpback Whale (Megaptera novaeangliae)

## 9.4 Reference

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L. & Thomas, L. 2001: Introduction to Distance Sampling. Estimating abundance of biological populations. Oxford University Press, 448 pp.

Webb, A. & Durinck, J. 1992: Counting birds from ship. In J. Komdeur, J. Bertelsen & G. Cracknell (eds): Manual for aeroplane and ship surveys of waterfowl and seabirds, IWRB Special Publication **19**, 24-37.

**Figure 34.** *Polar Bear.*

# 10. Art Projects

## 10.1 “ICE IN DISGUISE” by Linda Karlsson

I came here without knowing anything about how I would react on board the icebreaker or what I would see, but with the intension of making two unique cups or objects in porcelain every day, inspired from the environment.

**Figure 36.** *Cup nr. 1, Sun over Svalbard.*

My work on board is very different from how I usually work. Here I have time to make things that takes a lot of time. I use an old technique called "thumbing" when I make my cups, and it brings me to a meditative mood.  The only tool I need is my hands. After a while when the cups have dried it is time to make the pattern. The knife cuts the clay surface and the colour drips into the marks in the clay. Now is the last revealing moment almost there, just wait some more and then scratch away the unwanted colour and reveal the pattern, my image of what is out there.

Last but not least I write down the time, day and position under each object, with that info anyone can look up where and when on the open sea it is made.

### 10.1.1 Working Conditions

There have been different working conditions in my container. Some days just calm and steady and in other days I have been shaken up and down and struggled just to stay on the chair.

Every day I have seen new stunning views from the small window in the container. To hear the wind and see the wave’s splash on the window and at the same time feel the container shake is an experience hard to explain.

I learned a lot about colour. For example grey, there are so many different varieties and a new scale of thousands of grey tones has appeared in front of my eyes: Water and sky is not blue and ice is not white.

**Figure 37.** Interior *of workshop container.*

To be surrounded by ice is in some sense equal to being in love. One day in the ice I tried to find a polar bear looking through the binoculars until my eyes hurt and I was shaking from the cold, but I didn't care and just kept on looking. Also the open sea has the same effect on me, the horizon lures my eyes to look at it while the sea rocks and within seconds time disappears.

Exiting things appear and people say: "oh now you got inspired, didn't you?" it happened several times throughout the weeks on board and it has made me think. The inspiration comes from within and from the input mixed together. It is more the way the ice, the wind or just the open sea clears my head. It swipes everything away and my soul kind of reboots itself and saves a lot of energy. It has been as important just to be out on the deck as in my studio/container.

**Figure 38.** Self-portrait of Linda Karlsson.

**Figure 39.** Cups, bowls and jars manufactured during the cruise.

### 10.1.2 Results

I made at least two unique objects every day, some days up to 27 pieces. For this I used in total 38 kg of porcelain. I have not counted the objects but I think that I have made a total of 120 pieces. Mostly cups, but also some bowls and jars. In the beginning of the trip I thought that I had to make patters of what I saw, but as time went and I got more at home in my container things changed.

As a side project I have started to think about possible sculptures that I am going to make when I come home again. It will be lots of animals and things. At one time after the happiness of seeing both a blue whale and a polar bear the same day, my imagination started and new animals appeared. The “snow hare” will be the main object as it is the biggest animal in the arctic. It eats polar bears and has two big sharp and pointy teeth. If you are lucky you can see it jump from ice flake to ice flake looking for food.

**Figure 40.** *Ice in four different looks and with the horizon going around the cup.*

On my webpage www.lindakarlsson.se you can follow what will happen with “ice in disguise” when I am back in my studio in Stockholm.

The expedition “EAGER” on board of *Oden* has given me so much and it is hard to explain in words. I think that it will sink in and appear in my coming to be sculptures.

**Figure 41.** *The last days I made bowls with lines in grey/blue/black/brown. They shall represent the feeling of going back and forth again and again without the feeling of repetition or being bored.*

## 10.2 Rannva Kunoy - Paintings

Whilst on the expedition EAGER 2011 I have worked on a project, which was decided prior to departure. The aim was not to produce finished works but to come here with a few ideas and to see how far they could be pushed whilst on board.

The "abstractness" of the landscape, light in extreme pure form, were perfect backdrops upon which to push the concepts further and the results have been very fruitful. Possible solutions for various structures of colour, breaking down decisions and concepts for compositions in order to restructure and question each component making up the whole, hence getting a stronger base upon which to conceptually decide future compositions.

I am very grateful for the time on board, both on a personal and especially professional level. I would like to say my sincere thanks for this opportunity and hope GEUS will be working with other artists in the future.

# 11. Acknowledgements

The successful outcome of the EAGER 2011 cruise could not have been achieved without the excellent cooperation between the crew of *Oden*, the helicopter crew and the science party.

We especially acknowledge the technical support from the Swedish Polar Research Secretariat and the last minute technical support from KUM (Kiel, Germany) and TTSurveys (Cornwall, UK). Coordination and time sharing of the seismic work with GX Technology and TGS-Nopec was accomplished without any problems due to the good communication between the different parties.

The EAGER 2011 cruise is part of the Continental Shelf Project of the Kingdom of Denmark which is founded by the Ministry for Science, Technology and Higher Education.

# 12. Appendices

## 12.1 Appendix I: List of Participants

| Profession | Name | Affiliation |
|---|---|---|
| Master | Mattias Peterson | *Oden* Crew |
| Ch. Officer | Mats Wisén | *Oden* Crew |
| 2:nd Officer | Linda Svenson | *Oden* Crew |
| 2:nd Officer | Joakim Boström | *Oden* Crew |
| Bosun | Mats Hansson | *Oden* Crew |
| Able Seaman | Ingemar Johansson | *Oden* Crew |
| Able Seaman | Mattias Karlsson | *Oden* Crew |
| Able Seaman | Jan Nilsson | *Oden* Crew |
| Ch. Engineer | Per Salo | *Oden* Crew |
| 1:st Engineer | Jonas Brorsson | *Oden* Crew |
| 2:nd Engineer | Daniel Ernhill | *Oden* Crew |
| 2:nd Engineer | Martin Hahne | *Oden* Crew |
| Oiler | Fredrik Nordahl | *Oden* Crew |
| Oiler | Kristian Petersén | *Oden* Crew |
| Oiler | Mathias Stark | *Oden* Crew |
| Ch. Cook | Bo Cederberg | *Oden* Crew |
| Messman | Lise Rempling | *Oden* Crew |
| Cook | Ranjit Roy | *Oden* Crew |
| Fitter | Per Blad | *Oden* Crew |
| Ice Officer | Mikael Sandström | *Oden* Crew |
| 2:nd Officer | Björn Hjelmer | *Oden* Crew |
| IT/Log | Chris Buckley | *Oden* Crew |
| MD | Agnetha Folestad | *Oden* Crew |
| Meteorologist | Henrik Braathen | *Oden* Crew |
| Hkp Pilot | Sven Stenvall | *Oden* Crew |
| Hkp. Tech | Nils Eriksson | *Oden* Crew |
| Chief Scientist | Christian Marcussen | GEUS |
| Polar Representative | Cecilia Dahlberg | SPRS |
| Logistics | Axel Meiton | SPRS |
| Scientist | Carlos Castro | GEUS/Copenhagen University |
| Scientist | Henrik Haaning Nielsen | DMU/Aarhus University & ornit.dk |
| Scientist | Jens Andreas Rasmussen | GEUS/Aarhus University |
| Scientist | John Hopper | GEUS |
| Scientist | Jonas Zilmer Johansen | GEUS/Copenhagen University |
| Scientist | Jürgen Gossler | KUM |
| Scientist | Knud Karkov | GEUS/Aarhus University |

| Profession | Name | Affiliation |
|---|---|---|
| Scientist | Lars Rödel | GEUS |
| Scientist | Maria Prol García | DTU/Food |
| Scientist | Morten Sølvsten | DAMSA |
| Scientist | Thomas Vangkilde-Pedersen | GEUS |
| Scientist | Rasmus Anker Pedersen | GEUS/Copenhagen University |
| Scientist | Rasmus Tonboe | DMI |
| Scientist | Rezwan Mohammad | Stockholm University |
| Scientist | Steffen Olsen | DMI |
| Scientist | Thomas Funck | GEUS |
| Scientist | Tobias Hermann | AWI |
| Scientist | Richard Pedersen | DAMSA |
| Scientist | Emil Kousted Mauritzen | GEUS/Aarhus University |
| Scientist | Benjamin Hell | Stockholm University |
| Artist | Linda Karlsson | Stockholm |
| Scientist | Rannva Kunoy | London |
| Radar Tech. | Arnfin Kjelsrud | Norway |
| Scientist | Erik Labahn | KUM |
| Scientist | Tom Oliva | TTSurvey |

## 12.2 Appendix II: Multibeam Acquisition: TPE (Total Propagated Error) Background Information

The convention for the Cartesian coordinate system for the EM122 is as follows:

X = Positive Forward
Y = Positive Starboard
Z = Positive Down

The convention for the Cartesian coordinate system for CARIS HIPS/SIPS is as follows:

X = Positive Starboard
Y = Positive Forward
Z = Positive Up

The settings in the rest of this section are just a documentation of the values that were entered into the system during EAGER 2011. A quick examination of these values shows inconsistencies with these numbers. There is also not an obvious way to enter the ship's physical draught (which was 8.1 meters at the start of the trip). It is a fact that as some of the 4,500 tonnes of fuel is used the draft will decrease significantly. It is reported that the range in draught values due to fuel usage is 6.7 to 8.7 meters.

It also appears that the X & Y values of the MRU to Transducer in the HIPS VCF file have been transposed. This will not affect any sounding positions unless a different sound velocity is re-applied in HIPS.

*SIS Installation Settings:*

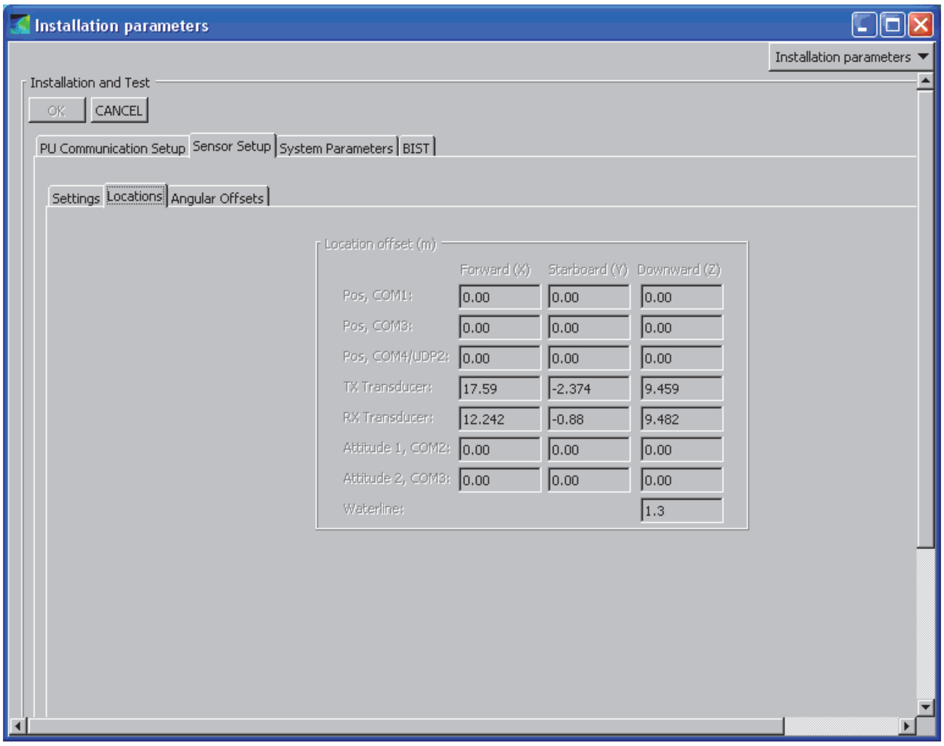



**Figure 1.** *Installation parameters: Locations*

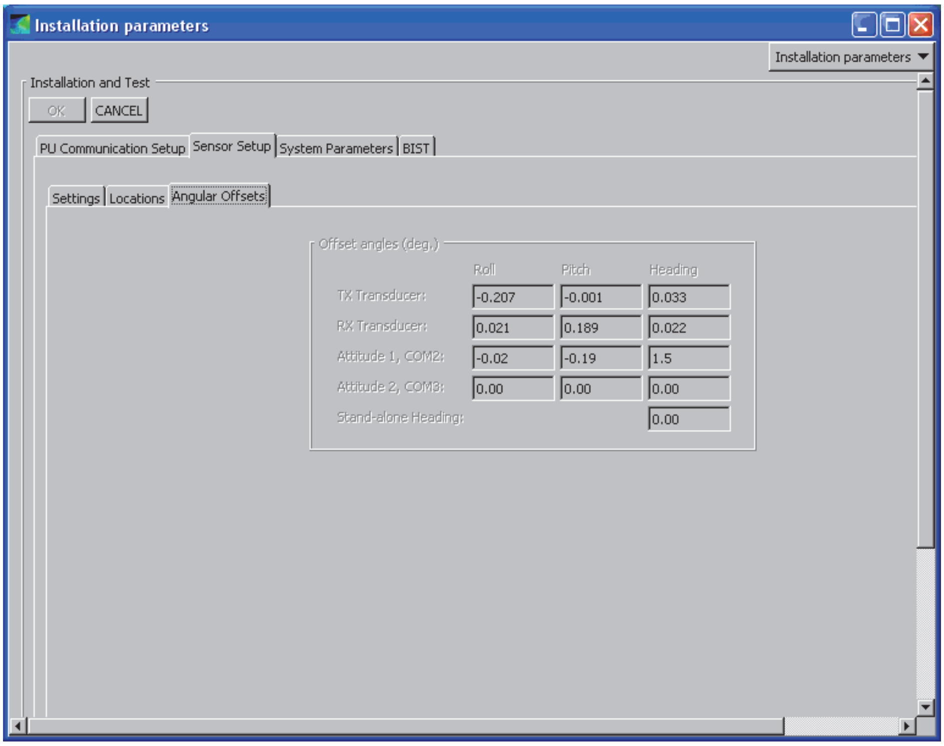



**Figure 2.** *Installation parameters: Angular Offset*

*SeaPath settings:*
Extracted from Configuration Report

# Vessel

### Geometry

Vessel dimensions:

Length: 107.00 Width: 30.00 Height: 30.00 [m]

Center Of Gravity (CG) location:

CG-X: -60.00 CG-Y: 0.00 CG-Z: 8.00 [m]

### Description

Vessel data:

Type: Ice Breaker Owner: Sjöfartsverket

Name: *Oden* Country of origin: Sweden

# Sensor

### GPS Geometry

Antenna Lever Arm

From CG to antenna #1:

X: 3.973 Y: -3.050 Z: -33.152 [m]

### GPS Antenna Configuration

Baseline length: 2.500[m] Heading offset: -1.68[deg] Height difference: 0.099[m]

**Attitude Processing**

Max pitch and roll angles: 15.00
Max average pitch and roll angles: 7.00

**MRU Geometry**

MRU Lever Arm
From CG to MRU:
X: 0.000 Y: 0.000 Z: 0.000 [m]
MRU Mounting Angles:
Roll: -179.77 Pitch: -0.15 Yaw: 0.30 [deg]

================================

**CARIS/HIPS 7.1**
**From the VCF (Vessel Configuration File), settings for TPE:**

Time Stamp: 2007-140 01:00

Comments Estimated after installation

Offsets

Motion sensing unit to the transducer 1
X Head 1 17.590
Y Head 1 -2.370
Z Head 1 -9.460

Motion sensing unit to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

Navigation antenna to the transducer 1
X Head 1 14.860
Y Head 1 -1.500
Z Head 1 -42.600

Navigation antenna to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000
Heave Error: 0.050 or 0.100'' of heave amplitude.
Measurement errors: 0.000

Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 10.000
Transducer timing error: 0.000
Navigation timing error: 0.000
Gyro timing error: 0.000
Heave timing error: 0.000
PitchTimingStdDev: 0.000
Roll timing error: 0.000
Sound Velocity speed measurement error: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.000
Dynamic loading measurement error: 0.500
Static draft measurement error: 0.000
Delta draft measurement error: 0.500
StDev Comment:
=================================

## 12.3 Appendix III: Communication - Error report to Kongsberg

The following text is written in Danish, Swedish and English.

***DTG missing – from Benjamin Hell***

Hej Martin!

Vi upplever problem med outer beams igen, och har känslan att det blev värre över de senaste veckorna. Morten har sammanställt följande problembeskrivning, som vi gärna skulle skicka till Kongsberg. Det är rätt allvarliga artefakter i data, tydliga spår parallelt med tracken.

Är det typ våra standardproblem med outer beams, eller är det värre än "normalfallet"? Jag hoppas att du finner lite tid att titta på det, även med besöket idag - vi skulle gärna börja felsöka innan helgen.

Mvh,

Benjamin

To whom it may concern,
We have experienced some problems with the EM122 multibeam system onboard the Swedish icebreaker *Oden*. The problem has been experienced at various depths from shallow (250m) to deep (3600m). The artifacts are most prominent in deep mode. At least in one occasion they started shortly after passing the 1000m contour (where the EM122 goes from medium to deep mode). The system has been adjusting the modes automatically but we have also been tried to set the system to “very deep” in the area with a water depth of 3600m without any improvement. YAW correction has been switched of at all instances and pitch stabilisation was set to on.

The two outermost sectors on the swaths are very poor (swath width ±60°). Especially on the port side on the outer most sector on port side the data drops down below the real seafloor. As it might be seen from the screen dump from Caris the data in that region almost looks like a harmonica and the medium level of the seafloor is lower than the real seafloor. Detections ca. 162 to 137 look as if the high density detection algorithm locks on a constant phase shift for all detections within one beam. The very prominent step in the detected depth occurs around detection 137. The detections further out are shift to greater depths and more noisy.

The problem is worse at higher speeds and worse sea conditions. We usually survey at 8kn, and the sea state has been very favourable during this cruise. No ice. Slowing down to 6kn or less helps sometimes, but the problem does not disappear then either.

The following has been tried out:
* Restarting both the EM122 and the SBP120 and leaving the SBP120 shut down to check for any interference before starting the SBP120. No difference.
* Setting the mode to “very deep” in water depths that normally only requires “deep mode”. No difference at best, very bad data consisting of almost only amplitude detections at worst.
* The backscatter has been checked for any evidence of the problem. The backscatter looks normal, without any visible sector boundaries even in very clean data collected during drifting with the machines off.
* The “Dual swath mode“ has been set to “off” and “dynamic”. No difference.
* A variety of filters have been systematically turned on and off. No difference.

Please advise us if we can improve the data as we otherwise eventually have to cut off the outer sector on port side. We are in the middle of collecting data at the North East Greenlandic Ridge and would appreciate a solution that solves the problem.

Best regards,

Benjamin Hell and Morten Sølvsten

***Response from Martin Jakobsson:***

Hej,

jag ser direkt och känner igen. Det är ett problem som kommer av och till, de kan hänga ihop med bottnens beskaffenhet, och ljudhastighet.
Men Torgrim hade ideer om detta och de har jobbat på problemen. Jag gör CC till Torgrim som kan komma med förslag på parameterar ni kan testa.
Skicka då en av bilderna till honom.

Problemen tycker jag blir värre då båten rör sig mera, och i områden med mjuka bottnar, så det kan ha med signaldetektionen att göra och penetration, bara några förslag?

Torgim, vad kan de pröva? Hur långt har ni kommit med dessa problem som jag tidigare tagit upp? Det är altså offset ute vid outer beams och flapping därifrån, någonstans vid 45-50 grader brukar det komma.

MVH

Martin

***Fri 02/09/2011 13:23 – from Benjamin Hell***
Hej igen!

Här kommer tre bilder till för att illustrera problemet.

Tacksam för hjälp!

Benjamin

On Sep 2, 2011, at 12:50 , Morten Sølvsten wrote:

Hej Torgrim,
En lille rettelse til vores tidligere korrespondance. Det ses også i backscatter data når skibet gør fart (8knob). Da vi testede det var det mens skibet lå stille og drev rundt, hvorfor det ikke er synligt når vi driver og kun når vi sejler - trigger mig til, at sige at det kan have noget med S/N forholdet at gøre.

Jeg har vedhæftet er par screen-dumps der måske bedre beskriver problemet.

Venlig hilsen

Morten Sølvsten

***Fri 02/09/2011 14:44 From Martin Jakobsson***
Hej Benjamin och Morten,
har precis ringt o pratat med Torgrim. Support case hamnade hos hans kollega. Men här kommer ett par punkter från vårt samtal.
1) Dom har sett detta på många system och det accentueras vid svåra skiktningar i vattnet, och det är samma som jag noterat, man måst,e verkligen ha bra SVP för att hålla flappingen på ett minimum. Dom ser det på EM120, 122 o 710, jag har ju loggat felet fleranggr och även skrivit en rapport om det. De har dock inte låst vad som orsakar flappingen och offseten dock.

2) Prova att slå av pitch och yaw stabilisation, för vid p dessa kan orsaka att problemet bli faktiskt större pga av dessa filter.

Låt höra om punkt 2 ger någon effekt. För om det är något som ör dåligt kalibrerar ger yaw och pitch stabilisering ochså ge synliga problem i övergången mellan sektorerna som dåmär olika vid olika modes,

låte mig få veta så ringer jag KM o ligger på

MVH

Martin

***Fri 02/09/2011 15:31 From Benjamin Hell***

Hej igen!

Tack för er input!

(1) Ljudhastigheten har vi haft bra kontroll på den största delen av tiden. Speciellt lite längre ifrån shelfkanten och på abyssalplan är oceanografin relativt simpel och vi använde väldigt pålitliga ljudhastighetsprofiler. Det är bara ett fåtal tillfällen där vi ser ljudhastighetsproblem i data (och vi körde en del korsande linjer). När problemet var värst igår körde vi faktiskt med en (riktig) CTD som oceanograferna ombord anser som korrekt för ett stort område på abyssalplanen. Ungefär 2/3 av tiden körde vi med XCTD-profiler, men även de passade in i oceanografiska kontext väldigt väl. Jämfört med tidigare *Oden*-expeditioner har vi väldigt bra ljudhastighetskontroll tack våra duktiga oceanografer. Min bedömning är att problemet inte korrelerar med kvaliten på ljudhastighetsprofiler.

(2) Yaw stabilisering var av hela tiden. Pitch kompensering däremot har varit på. Vi ska definitivt testa att slå av den när vi kommer till större vattendjup igen och in i DEEP mode.

Tack för hjälpen!

Benjamin

Hej Martin,

din rapport var tyvärr lite för stor för att tanka hem till båten (max ca. 100 kB just nu).

Vi tror också att problemen är sektor-beroende. Man ser sektorerna tydligt i vattenkolumn-displayen och ±50° är ungefär gränsen till de yttersta sektorerna i deep mode (som vi kör i 95% av tiden). Däremot har jag väldigt svårt att inse varför dessa problem skulle primärt ha med förhållandena i vattenkolumnen och vid bottnen att göra: Asymmetrin mellan styrbord och port finns även där det definitivt inte finns asymmetrier i oceanogra-fin/bottenbeskaffenhet. Hårdvarurelaterade problem behöver ju inte vara konstant samma hela tiden.

Har du hört någonting officiellt från Kongsbergs support ännu? Alla informationer har vi bara fått genom dig och av Torgrim; men inte ett ord på support case hittils.

Nu ska jag sätta mig på presentationen för BSHC-mötet…

Mvh,

Benjamin

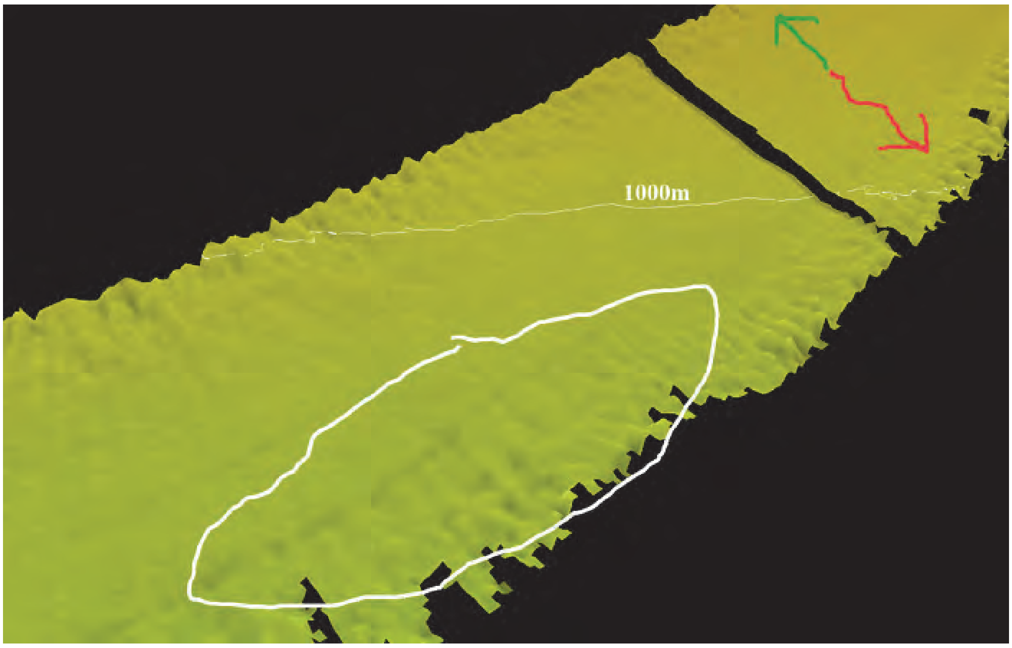
**On Sep 6, 2011, at 09:24 , Martin Jakobsson wrote:**

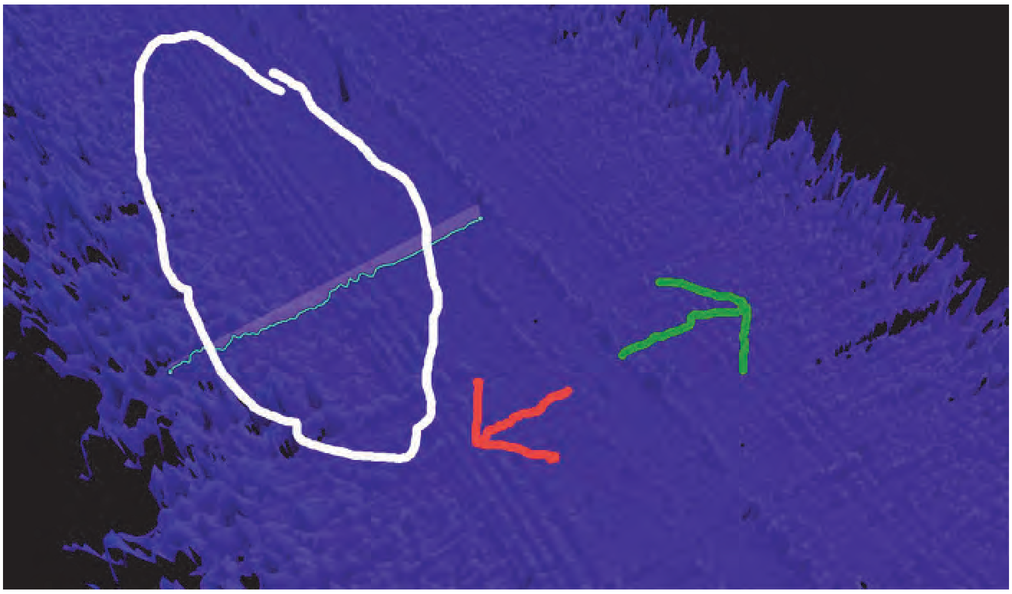
> Hej Benjamin,
> se på bifogad rapport som jag tidigare skickat till Kongsberg för
> EM120, det mesta känns igen!
>
> Men jag skall gräva fram en bild där jag har sett att offset helt
> klart beror på sektor konfiguration, det har jag inte fått bekräftat
> hos Kongsberg, verkar som om dom är lite lost när det gäller dessa problem!
> I princip alla EM120 och 122 har dessa problem mer eller mindre och de

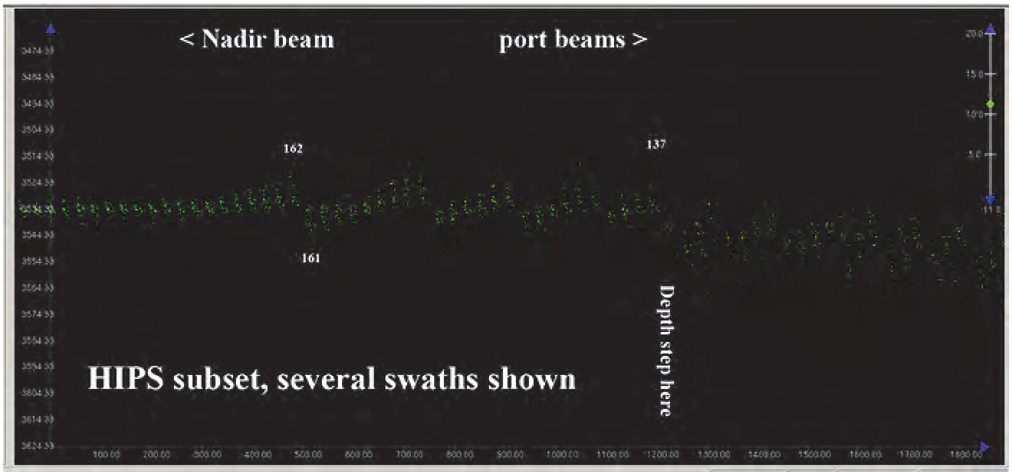
> syns beroende på var de mäter.
>
> Martin
>
>
>
**> On 9/6/2011 10:45 AM, Benjamin Hell wrote:**
>> Hej Martin!
>>
>> Jag tror att vi ser flera olika problem, som kanske men inte nödvändigtvis är relaterade:
>>
>> (1) Det finns ett signalbehandlingsproblem, som har med high density detections att göra. Det kan vi ser på båda sidor av swathen som harmonika-liknande detektioner på omkring 45-55° (se tidigare bild där jag la in beam numbers). Finns på båda sidor, men något värre på port sidan.
>>
>> (2) Vi ser också gamla "flapping", dvs. instabila swaths vid 50°+, på båda sidor. Den blir något bättre eller värre, möjligtvis(!) korrelerad med oceanografin eller vattendjupet.
>>
>> (3) Nytt för mig är offset-problemet med ett tydligt steg av ca. 20m vid 3500m vattendjup på port sidan (också dokumenterad med tidigare screen shots mm.). Steget ligger också vid ca. 50°, direkt utanför high-density detection problemet och på samma plats där flappingen börjar. Men som sagd bara på den ena sidan (eller iaf mycket otydligt på styrbord).
>>
>> I kombination av alla dessa problem är port sidan är alltid betydligt värre än styrbord, om man inte går ned till ±45° swaths. I natt har vi kört två tracks fram och tillbaka på abyssalplanen, och problem 1 och 3 fanns hela tiden mest på port sidan. För mig tyder det på att de är oberoende av oceanografin och bottenbeskaffenket, då dessa i det här fallet inte varierar lateralt. Signalbehandlingen är nog också samma på båda sidor. Därför tyder för mig mycket på att hårdvaran inte fungerar likadant på båda sidor.
>>
>> Det är svårt att hitta var felet ligger, för att det finns förmodligen flera felkällor till de olika problemen, som även kan vara beroende av varandra. Men just nu är vi tillbaka ungefär på EM120-kvaliten av 2007. Det är alltså inte någonting man ska bara leva med.
>>
>> IBCAO 3 kommer att visa Östgrönländska ryggen i en helt ny dimension ändå. Vi har kartlagd den i princip helt (förutom några ytterområden), med nästan 100% täckning. Och griddad på typ 200m upplösning finns inte så mycket kvar av våra artefakter.
>>
>>
>> Mvh,
>>
>> Benjamin
>>
>>
**>> On Sep 6, 2011, at 05:43 , Martin Jakobsson wrote:**
>>
>>> Hej Benjamin och Morten,
>>> hur går det för er? Jag har kollat lite på mina data från Antarktis. Vi har, som vi alltid har hart, "flappingen och offseten" ibland och ibland inte! Eftersom det kommer och går måste det vara förhållandena som framkallar problemet, och jag kan inte annat än att tro att det är knepiga oceanografiska förhållanden i kombination med bottenbekaffenhet. Det är också vad Kongsberg tror. Det är därför något i deras signalbehandling, förslagsvis detektion av signalen som inte blir rätt vi vissa förhållanden.
>>>

>>> Under OSO0910 körde jag därför galet många SVP profiler och fick ibland bort problemet helt, men ibland gick det bara inte utan jag såg klart en mkt ökat störningsnivå utanför en viss beam (omkring 45 grader eller så) samt en offset, precis som ni noterat. Jag såg då till att alltid köra overlapp så detta försvinner i processering. Kör man overlapp som är mer än offset (jag körde 100 % i Pine Island Bay) så går allt detta bort vi processeringen.
>>>
>>> Vi måste ligga på KM angående detta, det är i deras signalbehandling problemet ligger, det är jag helt övertygad om. Man kan nämligen se detta också tydligt i 710 också. Dom mindre systemen med högre frekvens har inte samma fenomen, så det är något med detektionen.
>>>
>>> MVH
>>>
>>> Martin

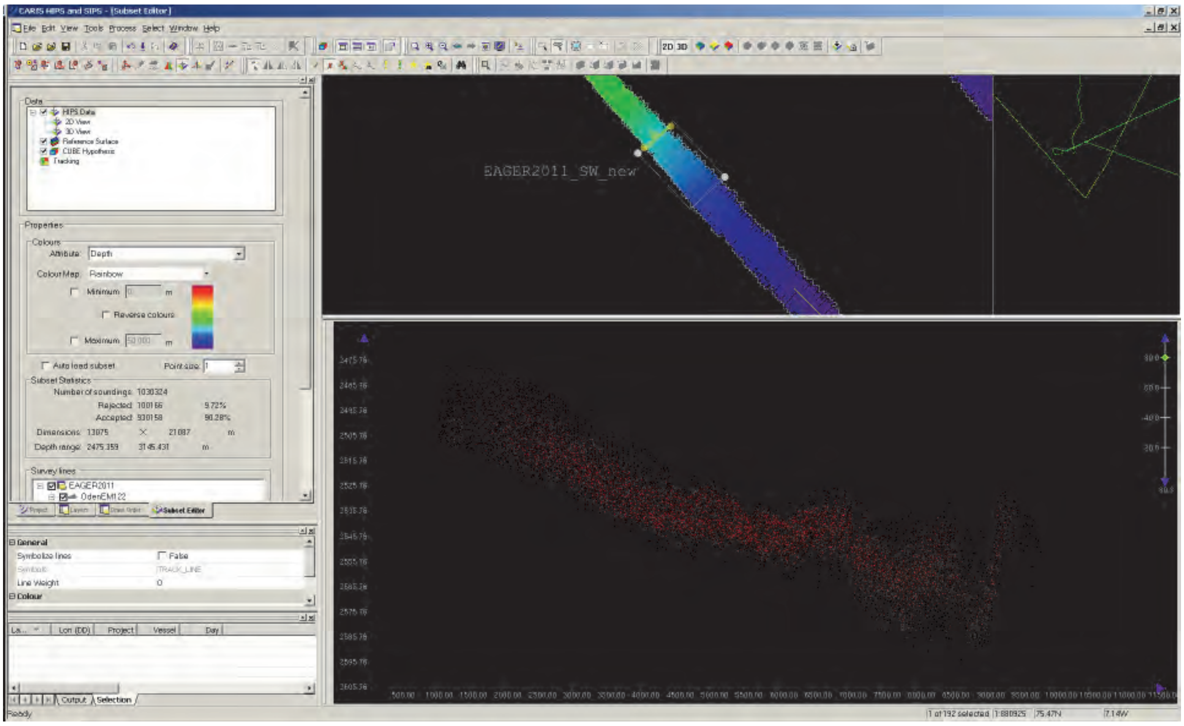
The following screen dumps are discussed in the communication.

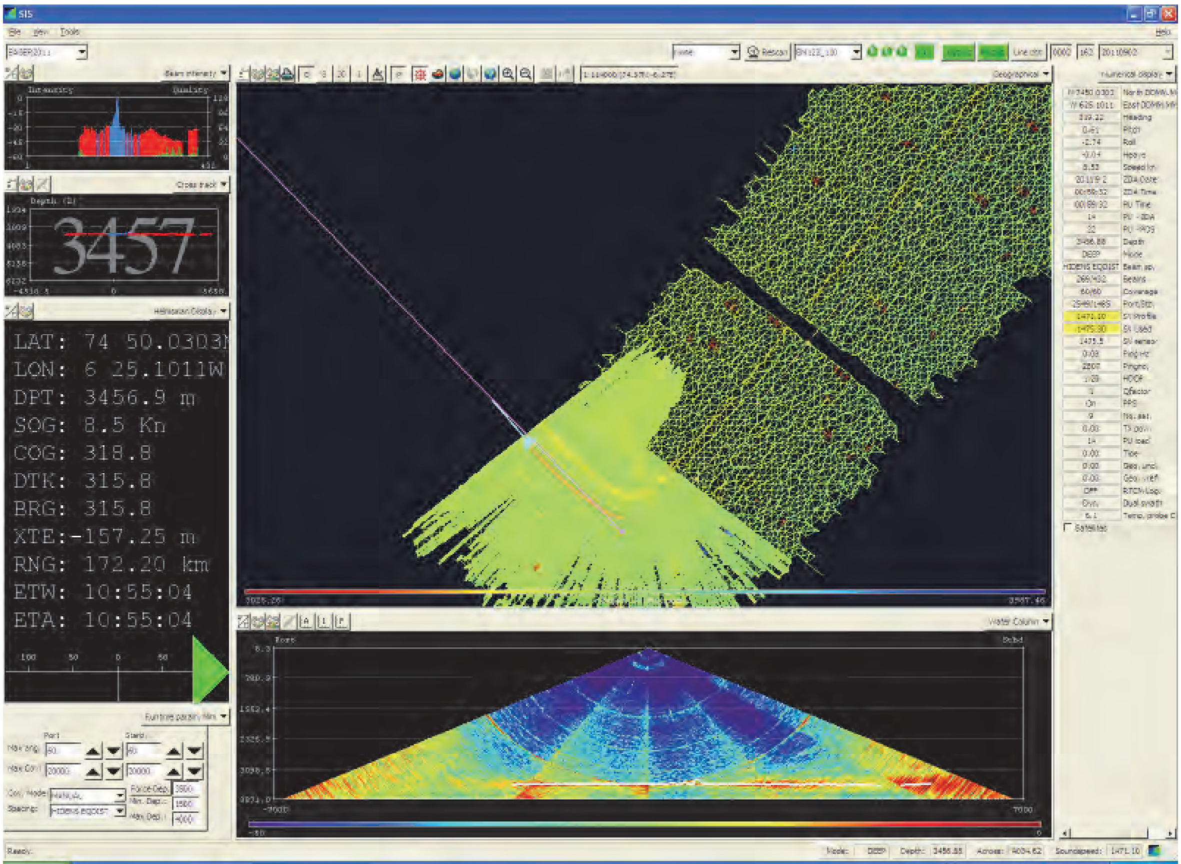






< Nadir beam
port beams >
162
137
161
Depth step here
HIPS subset, several swaths shown


CARIS HIPS and SIPS - [Subset Editor]
EAGER2011_SW_new


SIS
3457
LAT: 74 50.0303N
LON: 6 25.1011W
DPT: 3456.9 m
SOG: 8.5 Kn
COG: 318.8
DTK: 315.8
BRG: 315.8
XTE:-157.25 m
RNG: 172.20 km
ETW: 10:55:04
ETA: 10:55:04