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The Expedition of the Research Vessel "Polarstern" to the Arctic in 2008 (ARK-XXIII/2)

Edited by
Gerhard Kattner
with contributions of the participants

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4 July 2008 - 10 August 2008

Longyearbyen - Reykjavik

Fahrtleiter / Chief Scientist
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1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Gerhard Kattner, Alfred-Wegener-Institut

Die *Polarstern*-Expedition ARK-XXIII/2 begann am 4. Juli 2008 in Longyearbyen auf Spitzbergen. Ein Schwerpunkt der Forschungsarbeiten war die Untersuchung der Veränderungen der Wassermassen in der Framstraße. Hier fließt wärmeres und salzhaltigeres, Atlantisches Wasser nach Norden, während kaltes, salzärmeres Wasser aus der Arktis nach Süden fließt. Insgesamt wurden 12 Verankerungen ausgewechselt und 2 neue installiert. Die Daten von 74 Messgeräten, die insbesondere Temperatur, Salzgehalt, Strömungen und Druck ein und zum Teil auch zwei Jahre lang gemessen haben, konnten gesichert werden. Damit konnten alle Verankerungsarbeiten bei schwierigen Eisbedingungen erfolgreich abgeschlossen und die Messungen für ein weiteres Jahr gesichert werden. CTD-Messungen wurden parallel zu den Verankerungsarbeiten durchgeführt. Eine erste Auswertung hat gezeigt, dass das Atlantische Wasser im letzten Jahr im Mittel etwas kälter und salzärmer als in den vorherigen Jahren war. Zusätzlich wurde ein „Seaglider" ausgesetzt, der 2 Monate lang selbständig von der Wasseroberfläche bis in 1.000 Meter Tiefe taucht und ozeanografische Messungen durchführt.

Die Arbeiten im AWI-Hausgarten, ein Tiefseeobservatorium westlich von Spitzbergen, konnten ebenfalls erfolgreich durchgeführt werden. In Wassertiefen zwischen 1.000 und 5.500 m wurden in erster Linie biologische Prozesse untersucht, die sich im Einflussbereich der nahe gelegenen Eisrandzone abspielen. Hierzu wurden viele Proben mit CTD, Multicorer und Agassiz-Trawl genommen sowie Fotos vom Meeresboden aufgenommen. Es wurden Lander abgesetzt und Verankerungen ausgetauscht, die mit Sedimentfallen bestückt sind und das gesamte Jahr Messungen in der Wassersäule durchführen.

Die Untersuchungen in der Nordost-Wasser-Polynja vor Grönland sollten zeigen, ob hier wieder pazifische Wassermassen auftreten, so wie es in den Jahren vor 2004 regelmäßig der Fall war, danach jedoch nicht mehr. Ein Teil der Polynja war noch mit Eis bedeckt, so dass die Arbeiten nur im nördlichen Bereich durchgeführt werden konnten. Eine große Ansammlung von Eisbergen vor der Küste hatte möglicherweise das Aufbrechen des Eises verhindert. Das pazifische Wasser kommt durch die Beringstraße in den Arktischen Ozean, fließt entlang der kanadischen Küste und dann durch den kanadischen Archipel und in früheren Jahren auch entlang der ostgrönländischen Küste in den Nordatlantik. Erste Berechnungen anhand der Nährsalzanalysen haben jedoch ergeben, dass der Anteil von pazifischem Wasser auch in diesem Jahr nur sehr gering war. Untersuchungen zum Auftreten von Methan und dessen Umsatz wurden ebenfalls schwerpunktmäßig in der Polynja durchgeführt.

Neun seismische Stationen wurden auf Eisschollen über dem Lenatrog, der zentral zwischen Spitzbergen und Grönland liegt, mit Hilfe der Helikopter abgesetzt, um Mikroerdbeben zu registrieren. Alle Instrumente konnten nach ca. 10 - 12 Tagen Messdauer wieder aufgenommen werden.

Die GPS-Stationen, die vom 24. bis 26. Juli auf Grönland installiert wurden, konnten vom 5. bis 8. August erfolgreich abgebaut und geborgen werden. Siebzehn Stationen wurden aufgebaut, sieben davon bereits während des ersten Fahrtabschnitts. Die GPS-Daten auf den Felspunkten ermöglichen eine präzise Erstbestimmung der Stationskoordinaten. Durch weitere Messungen in den nächsten Jahren wird die Bestimmung von vertikalen Verformungen der Erdkruste möglich, die vor allem aufgrund der Veränderungen nach der letzten Eiszeit zu erwarten sind. Eine Station wurde auf dem 79-Grad-Gletscher aufgebaut, um die Fließgeschwindigkeit und die vertikale Bewegung aufgrund der Ozeangezeiten zu messen.

Während der gesamten Fahrt wurden Vögel und Säugetiere gezählt. Es wurden Ansammlungen von Vögeln in Frontbereichen dort, wo sich polare und atlantische Wassermassen treffen, vorgefunden. Das Vorkommen vom Zooplankton wurde regelmäßig mit einem neuartigen Kamerasystem, das hervorragende Fotos liefert, bestimmt.

Die Fahrt von Nordgrönland nach Reykjavik wurde genutzt, um die GPS-Stationen wieder aufzunehmen, so dass keine zeitlichen Verzögerungen auftraten. Die Expedition endete dann am 10. August 2008 in Reykjavik, Island (Fig. 1.1).

Abb. 1.1: Kurskarte der Polarstern Reise ARK-XXIII/2
Fig. 1.1: Cruise track of Polarstern during the expedition ARK-XXIII/2

ITINERARY AND SUMMARY

On 4 July 2008 the second leg of the Arctic expedition ARK-XXIII started in Longyearbyen, Spitsbergen. One major topic of our research was to investigate changes in Fram Strait waters, both in the warm and salty inflow from the North Atlantic to the Arctic Ocean as well as the cold and fresh outflow from the Arctic. Altogether 12 moorings were exchanged and two new ones deployed. The data, collected by 74 different moored devices (like current meters, temperature and salinity sensors and pressure gauges) were read out from the instruments. Although difficult due to tough ice conditions, all moorings have been successfully recovered and redeployed again to continue measurements until the next year. CTD stations were performed in parallel to the mooring work. A first look at the data shows that the Atlantic water passing through Fram Strait during the last year was colder and less saline than it was on average in previous years. In addition, a Seaglider was deployed, which will measure temperature and salinity in the upper 1,000 m layer of water for about 2 months, travelling across Fram Strait.

The research in the AWI-*Hausgarten*, a deep-sea observatory at high latitudes, was successfully performed. At depths between 1,000 and 5,500 m predominantly biological processes were investigated, which are affected by the nearby marginal ice zone. Numerous samples were taken by CTD, multiple corer and Agassiz trawl, and many photos of the sea floor were made. In addition, we exchanged and deployed landers and moorings with sediment traps that measure many parameters throughout the year.

One of the major interests in the Northeast Water Polynya was to look for water masses of Pacific origin, which were generally observed along the Greenland coast until 2004. Part of the polynya was still ice-covered so that only the northern area could be studied. Numerous icebergs along the coast may have prevented the opening of the ice. Pacific water flows into the Arctic Ocean through Bering Strait, travels along the Canadian coast and exits the Arctic Ocean through the Canadian Archipelago and in former years also along the East Greenland coast. Preliminary calculations using nutrient data show that there is still no increase in water of Pacific origin. In addition, measurements of methane concentrations and turnover were performed in the polynya region.

Nine seismometers were deployed by use of helicopter on ice floes above the Lena Trough, which is situated centrally between Greenland and Spitsbergen to record micro-earthquakes. After measuring about 10 to 12 days all seismometers were successfully recovered.

The GPS stations, which were deployed from 24 to 26 July were successfully recollected from 5 to 8 August. In total, 17 GPS stations were set up, seven already during the first leg. The GPS data recorded at the bedrock stations allow a first precise calculation of the station coordinates. By repetition of the measurements it is possible to infer vertical deformations of the Earth's crust, which are expected to be induced by the postglacial adjustment. One station was deployed at the 79-Degree-Glacier to determine the flow velocity of the glacier as well as its vertical motion caused by the ocean tides.

During the entire cruise birds and mammals were counted. High numbers of birds were found in the frontal zone of the Atlantic and polar waters probably due to a high accumulation of zooplankton. At many stations zooplankton was recorded with a newly developed system producing excellent photos of the individual species.

During the way from North Greenland back to Reykjavik the GPS stations were recovered so that no additional time was necessary. The expedition ended in Reykjavik, Iceland (Fig. 1.1) on 10 August 2008.

2. WEATHER CONDITIONS

Hilger Erdmann, Klaus Buldt (DWD)

Polarstern started from Longyearbyen on the sunny afternoon of 4 July. The dominating high southwest of Svalbvard (1032 hPa) moved into the southern part of the European Polar Sea, and the advection of very mild but wet air towards Svalbard started. Consequently the weather became foggy. On 5 July air temperature increased to 10°C at the 900 hPa level which is unusual even in summer in this area. In the meantime a new low developed east of the north-eastern parts of Greenland. Moving southeast and approaching Svalbard it deepened moderately on 6 July. Wind from south increased to 6 - 7 Bft. Influenced by the hills of Svalbard it temporarily became 8 Bft. At the rear of this low the wind shifted from west to north. Cold and dry air of polar origin moved into the operation area, and therefore visibility improved.

Approaching the AWI-*Hausgarten* in the evening of 8 July first ice flows were observed at 78.8°N 5.5°E. This summer the ice edge in this area was remarkable far in the east which was mainly caused by prevailing north-westerly winds. At the same time a strong low (about 980 hPa in the centre) moved from the western part of the Laptev Sea southwest to Svalbard. Therefore, the weather changed rainy, and wind increased up to 7 Bft from west. However, the swell remained very low because of little fetch. When the cold front passed the wind turned northwest to north force 7 - 8 Bft with incoming squalls. This weather situation persisted for nearly two days. The instable polar air produced snow showers with air temperature down to nearly 0°C and wind-chill close to minus 18°C. The low remained stationary at Svalbard for the following three days where it weakened slowly.

On 12 July the north westerly wind decreased rapidly to only 3 Bft. This indicated a general change in the weather situation. During the following days a new and well developed low moved while deepening below 990 hPa from the south-eastern shores of Greenland to the area just northeast of Iceland. The wind direction in the operation area changed to south, and humid air flowed into the AWI *Hausgarten*. On this day a person had to be flown out to Ny Ålesund, and therefore *Polarstern* steamed about 30 miles east into an area of warmer water. Here the fog lifted so that flight conditions became fair. The next long distant flights were scheduled already one day later. Seismic sensors had to be deployed on a large ice floe about 100 miles off the ship´s position near 81°N 03°W. The flight conditions were not optimal due to fog patches en route. Nevertheless two of three flights were done successfully.

In the meantime a new high formed between Svalbard and central Greenland which caused foggy weather and almost no wind. Although on 17 July the wind turned north and increased to force 4 Bft, visibility remained poor. Reason was the origin of a warm air mass coming in over cold water from North Russia via Barents Sea to Svalbard. This was caused by a steering cyclone over North Scandinavia.

On the next day a depression over northern Europe filled while an anticyclone over the Barents Sea extended west to Svalbard. Because high pressure still dominated over central Greenland the surface pressure gradient remained low in the Fram Strait. Consequently the wind turned southwest and just reached force 1 - 2 Bft. Only on 20 July the wind increased to 4 Bft and turned south to southeast. The visibility increased, and flight activities started again.

During the transit to the polynya near Northeast Greenland the weather situation changed only little. High pressure influence was responsible for calm winds, poor visibilities and sometimes fog. On 22 July the vessel arrived in the new operation area. Here variable weak winds turned west for some time, and dry air came down from the Greenland hills into the research area. This caused clear sky and thus optimal conditions for the helicopter flights to several inland research points.

A weak low, which formed in the lee of the mountains over North Greenland on 24 July, was responsible for increasing southerly wind up to force 6 Bft as well as low level turbulence. However, the visibility persisted very good so that all flight activities could be carried out successfully during day and night. At the end of July (28th), a new low developed over the North of Greenland. It moved slowly east during the following days. Therefore the wind increased up to 5 Bft and turned northwest. Incoming fog and low stratus made all flight operations impossible.

Polarstern reached the most northern position at 82.5°N 10°W on 2 August. The weather situation here was perfect: low wind, very good visibility and clear sky. Because of a strong inversion near the surface several remarkable mirages were observed. A weak cold front crossed the Fram Strait during 4 August southward so that the wind turned northerly with increasing force 5 Bft. The weather changed to overcast but visibility remained good.

Recovering the GPS stations from the coast of Northeast Greenland started on 5 August when the flight weather conditions were sufficient for helicopter operations. All flight activities were finished on 8 August near 75°N. The last part of the expedition from 75°N to Reykjavik was dominated by high pressure influence over Denmark Strait, and thus southerly winds did not exceed 5 Bft, shifting northeast to north force 4 Bft near Iceland. The various weather conditions during the cruise are summarized in Fig. 2.1.

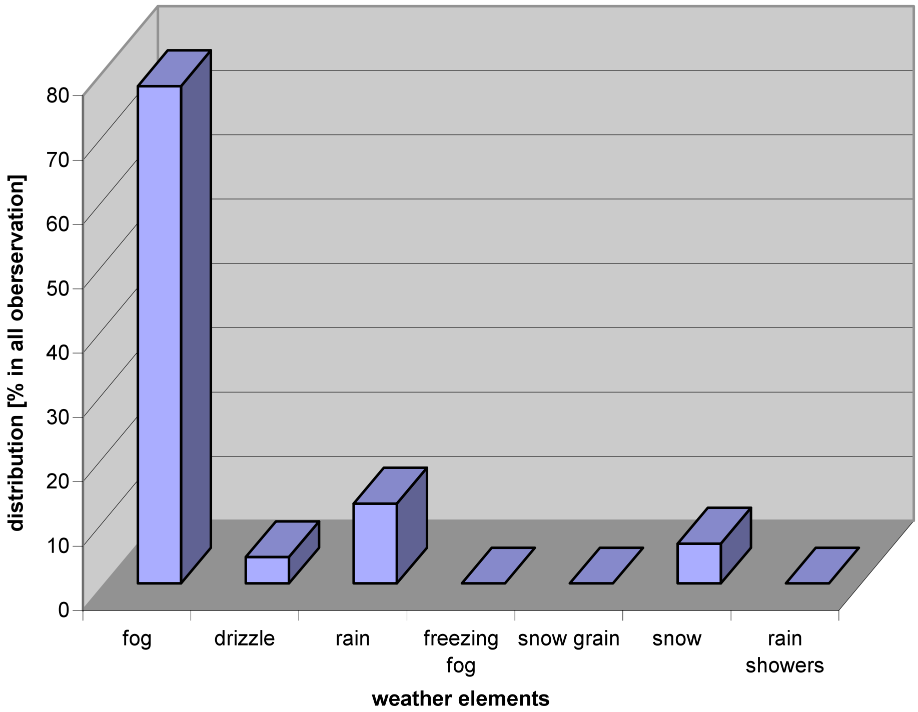

Fig. 2.1 Distribution of weather conditions

3. FLOW THROUGH FRAM STRAIT AND IN THE ENTRANCE TO THE ARCTIC OCEAN

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Objectives

Exchanges between the North Atlantic and the Arctic Ocean result in the most dramatic water mass conversions in the World Ocean: warm and saline Atlantic waters, flowing through the Nordic Seas into the Arctic Ocean, are modified by cooling, freezing and melting to become shallow fresh waters, ice and saline deep waters. The outflow from the Nordic Seas to the south provides the initial driving of the global thermohaline circulation cell. Knowledge of these fluxes and understanding of the modification processes is a major prerequisite for the quantification of the rate of overturning within the large circulation cells of the Arctic and the Atlantic Oceans, and is also a basic requirement for understanding the role of these ocean areas in climate variability on interannual to decadal time scales.

The Fram Strait represents the only deep connection between the Arctic Ocean and the Nordic Seas. Just as the freshwater transport from the Arctic Ocean is of major influence on convection in the Nordic Seas and further south, the transport of warm and saline Atlantic water affects the water mass characteristics in the Arctic Ocean which has consequences for the internal circulation and possibly influences also ice and atmosphere.

The complicated topographic structure of the Fram Strait leads to a splitting of the West Spitsbergen Current carrying Atlantic Water northward into at least three branches. One current branch follows the shelf edge and enters the Arctic Ocean north of Svalbard. This part has to cross the Yermak Plateau, which poses a sill for the flow with a depth of approximately 700 m. A second branch flows northward along the north-western slope of the Yermak Plateau and a third one recirculates immediately in Fram Strait at about 79°N. Evidently, the size and strength of the different branches largely determine the input of oceanic heat to the inner Arctic Ocean. The East Greenland Current, carrying water from the Arctic Ocean southwards, has a concentrated core above the continental slope.

It is our aim to measure the oceanic fluxes through Fram Strait and to determine their variability on seasonal to decadal time scales. Since 1997, year-round velocity, temperature and salinity measurements have been carried out in Fram Strait with moored instruments. Hydrographic sections exist since 1980. The estimates of mass and heat fluxes through the strait are provided through a combination of both data sets. From 1997 to 2000 intensive fieldwork occurred in the framework of the European Union project VEINS (Variability of Exchanges in Northern Seas). After the end of VEINS it was maintained under national programmes. From 2003 to 2005, the work was carried out as part of the international Program ASOF (Arctic-Subarctic Ocean Flux Study) and was partly funded in the EU ASOF-N project. Since 2006 measurements in Fram Strait have been continued in the frame of the EU DAMOCLES (Developing Arctic Modelling and Observing Capabilities for Long-term Environment Studies) integrated Project. The mooring line is maintained in close co-operation with the Norwegian Polar Institute. The results of the measurements will be used in combination with regional models, to investigate the nature and origin of the transport fluctuations on seasonal to decadal time scales.

Work at Sea

The oceanographic work at sea during ARK-XXIII/2 embraced two main activities: the recovery and redeployment of the array of moorings and measurements of CTD (Conductivity, Temperature, Depth) profiles (Fig. 3.1). The standard section in Fram Strait at 78°50'N, which has been occupied regularly since 1997, was measured with the high resolution coverage by 59 CTD stations, extending westward to 11°W. Additionally, 16 CTD stations were performed in the AWI-*Hausgarten* area during the first part of the cruise. During activities in the western part of Fram Strait, in the Northeast Water Polynya, CTD profiles and water samples were also obtained on 76 stations.

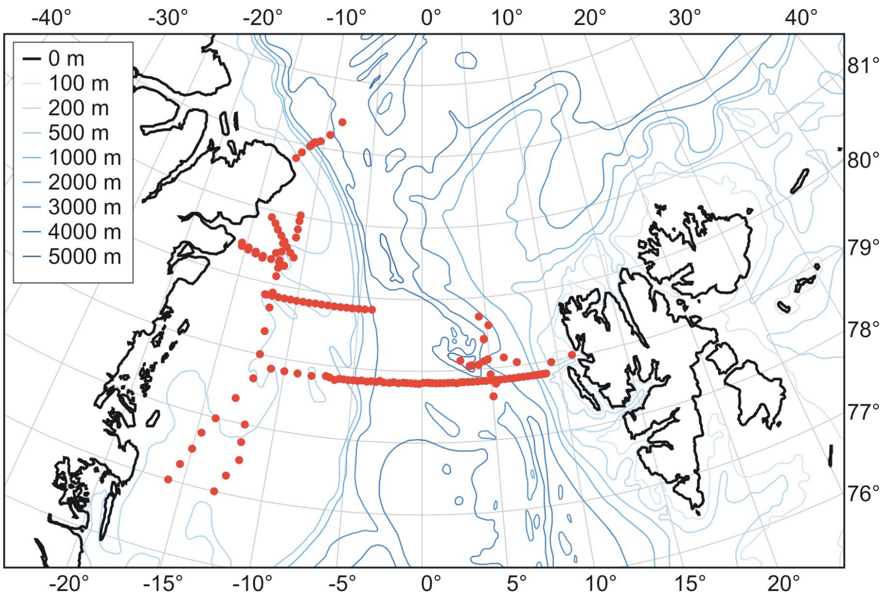


Fig. 3.1: Map with the position of CTD station, moorings and PIES

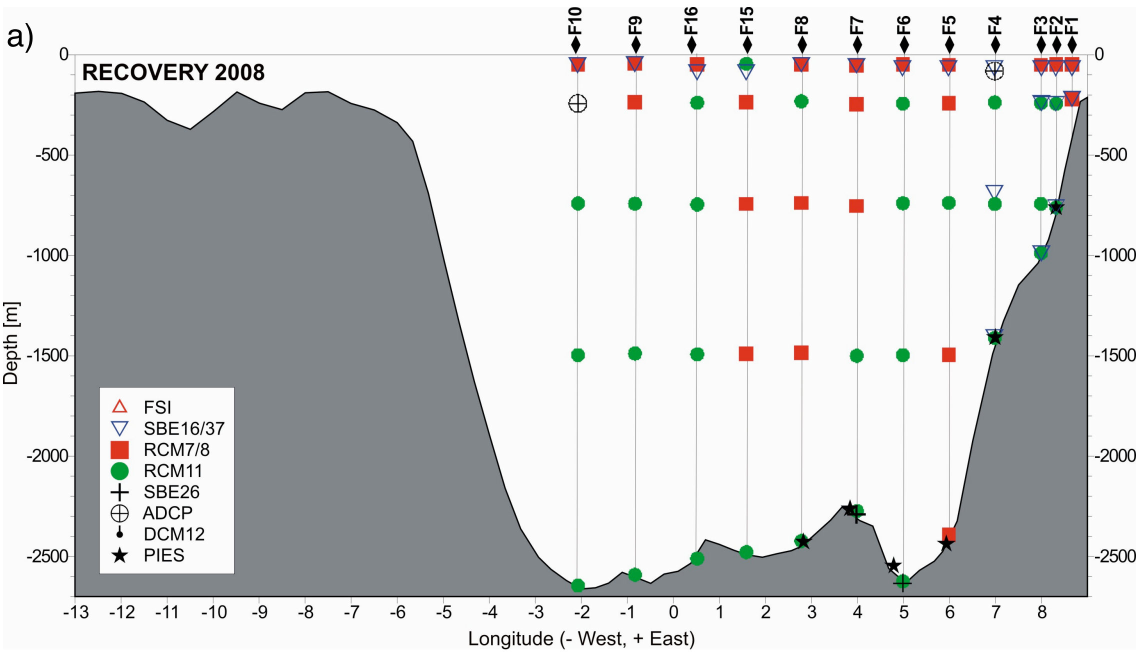
The mooring array passes through the deep part of the Fram Strait from the eastern to the western shelf edge and was extended on the East Greenland shelf in 2003. In July 2008 *Polarstern* recovered 12 moorings east of 3°W, four of which had stayed in water since autumn 2006 and remaining eight were exchanged in autumn 2007 from *Lance*. Each tall subsurface mooring carried 3 to 7 instruments including rotor and acoustic current meters from Aanderaa Instruments (RCM7, RCM8 and RCM11), acoustic current profilers from RD Instruments (WH ADCP), temperature and salinity sensors from Sea-Bird Electronics Inc. (SBE37 and SBE16) and bottom pressure recorders from Sea-Bird (SBE26). The whale recorder (AURAL M2) was also included in the mooring located in the central, deepest part of Fram Strait. The recovery of western moorings (west of 3°W), operated by NPI is planned for September 2008 from board of RV *Lance*. The important task during ARK-XXIII/2 was to recover four moorings, deployed in 2006, which could not be recovered as planned in 2007 due to the cancelled cruise of RV *Maria S. Merian*. Recovery of these rigs was successful, and all instruments were regained in a good shape and with the recorded data. However, all mooring work was extremely difficult due to the exceptional sea ice extent. All moorings west of F5 (6°E) had to be recovered and redeployed in the sea ice covered area, which increases the risk and, in most cases, requires additional time for breaking the ice.

In addition to the long-term array, two new moorings were deployed during ARK-XXIII/2. The mooring F20, located in the eastern part of Fram Strait, has been equipped in the underwater profiling winch and originally instrumented with the CTD profiler capable of the satellite data transfer. However, due to the failure of the CTD profiler immediately before deployment, it has to be replaced with a set of four temperature/salinity sensors (SBE37), programmed to record the data with high frequency, successively during a 20 days' period. The underwater winch has to be reprogrammed to profile 4 times per day until the end of October. The mooring F21, deployed at 1°E was instrumented with the 260 Hz sound source and will serve for testing the feasibility of an underwater acoustic navigation of the Seaglider.

Six pressure inverted echo sounders (PIES Model 6.1E and 6.2E), manufactured by the University of Rhode Island were recovered during ARK-XXIII/2. They were located next to moorings in the eastern and central Fram Strait and have been measuring since autumn 2006. By combining historical hydrography with the acoustic travel time measurements it is possible to obtain time series of the temperature and specific volume anomaly profiles. Due to that they can be used to estimate the baroclinic flow and heat transport. Each echo sounder is also equipped with the accurate pressure gauge, which provides the sea surface slope and resulting barotropic current. Three of the recovered PIES (C-PIES) were additionally instrumented with Doppler Current Sensors from Aanderaa, located 50 m above the PIES frame. All recovered instruments provided full data sets although bottom temperature records seem to be out of the correct range and need calibration against the temperature record from neighboring moorings. All PIES were equipped with the POSIDONIA transponders ET861G what made recovery much easier as compared to the standard procedure. The use of the POSIDONIA transponders allowed also obtaining the accurate positions and depths of deployed instruments. Moreover, while receiving the responses from PIES ASC (Acoustic Command System) is inefficient due to the ship's acoustic noise, the POSIDONIA transponders provide information about a successful release of the instrument and a foreseen position of the instrument's surfacing. During ARK-XXIII/2 two PIES had to be recovered from under the ice and only due to POSIDONIA transponders and radio beacons these recoveries were completed.

The mooring recovery rate was 100 %. 79 of 82 prior deployed instruments including PIES delivered the data what makes obtained data rate of 96 %. Two Seabird TS sensors SBE37 have not recorded any data due to the battery problem. One RCM8 was flooded and data were lost. Most of the instruments, which remained deployed for two years, provided the full time data, with an exception of two TS sensors which stopped two months earlier. The recovered and deployed instruments and the data are summarized in Table 3.1 and 3.2. The distribution of the instruments at the moorings is displayed in Fig. 3.2.

During ARK-XXIII/2 the first operational mission of the Seaglider in Fram Strait was launched. The underwater glider is a buoyancy-driven device, which can alternately reduce and expand displaced volume to dive and climb through the ocean, just as do profiling floats. Unlike floats, a glider additionally carries wings and controls its pitch attitude to effectuate a horizontal speed component through the ocean. The principal glider measurement package is a CTD and also additional packages can be added (dissolved oxygen, fluorescence, scattering). The Seaglider SN127 deployed in Fram Strait for a 2 months' mission in the West Spitsbergen Current, was developed by APL group at the University of Washington (UW) in Seattle and manufactured by the Seaglider Fabrication Center in Seattle, cooperating with UW. The vehicle is capable to profile between surface and 1,000 m with the horizontal speed 0.1-0.45 m/s and minimum vertical speed of 0.06 m/s. The Seaglider SN127 is equipped with SBE Temperature/Conductivity Sensors, SBE43 dissolved oxygen sensor, Wetlabs BB2SF chlorophyll a, fluorescence and optical backscatter sensors.



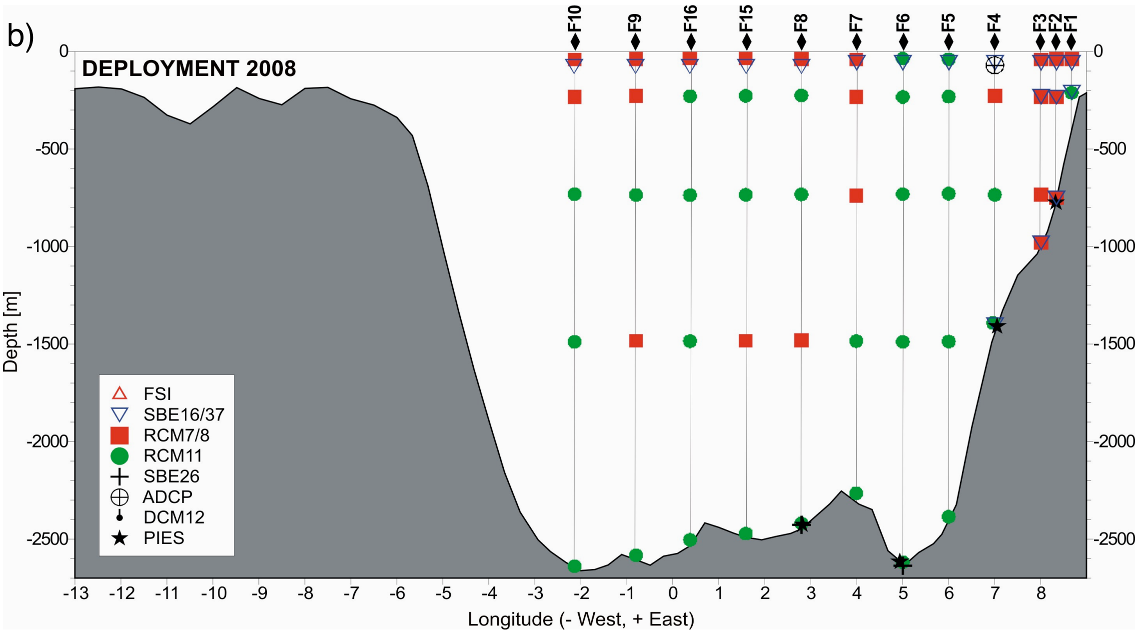


Fig. 3.2: Transect across Fram Strait with the moored instruments recovered (a) and deployed (b)

In addition, the RAFOS hardware was installed to test the possibility of the underwater acoustic navigation of the glider with the main aim to profile also in the sea-ice covered areas. After each dive, the Seaglider reaches the surface and uses the Iridium communication; it obtains new commands and transfers collected data to the Glider Base Station in Bremerhaven. The Seaglider was launched on 19 July after series of tests performed onboard and will profile in the eastern Fram Strait until late September. The Seaglider track during the first week of measurements as well as the vertically averaged currents measured during selected dives are shown in Fig. 3.3.

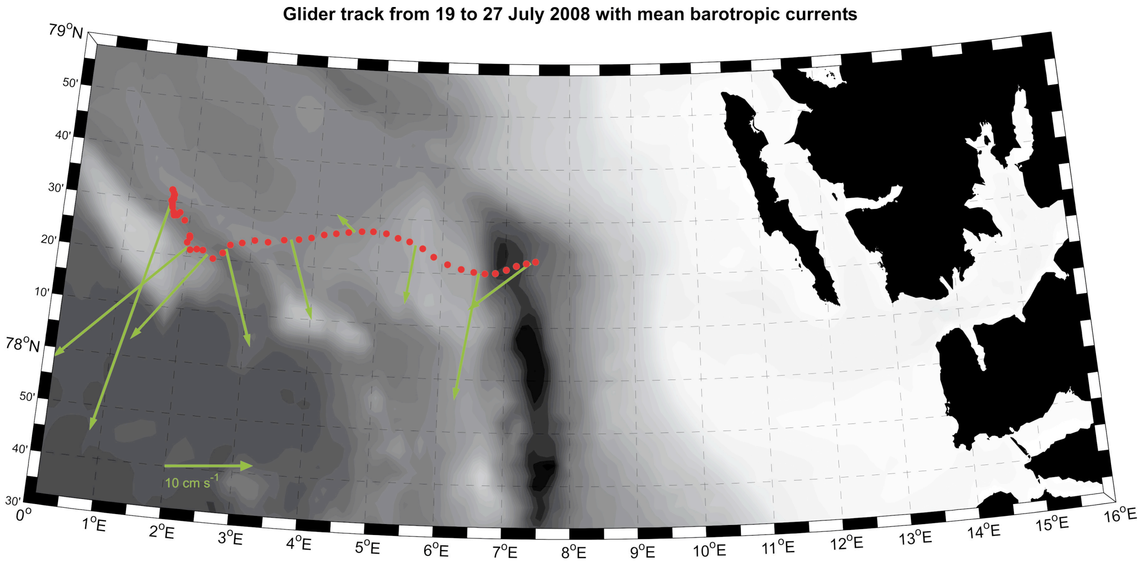


Fig. 3.3: Locations of the Seaglider surfacing positions between successive dives performed in the first week of measurements and vertically averaged currents measured during selected dives

The CTD measurements at the Fram Strait section occurred mostly during the nights between mooring work and in between activities in *Hausgarten* and were also split into two periods (the westernmost part of the section completed one week later). Therefore, the sequence of stations is rather irregular. Altogether 154 CTD profiles were taken at 154 stations, and water samples were collected during all casts (Fig. 3.1, Table 3.3). The CTD system from Sea-Bird Electronics Inc SBE911+ was used. Mainly CTD probe SN 287 with duplicate T and C sensors (temperature sensors SBE3, SN 1373 and 2929, conductivity sensors SBE4, SN 2470 and 3290 and pressure sensor Digiquartz 410K-105 SN 51197) was in service. The CTD was connected to a SBE32 Carousel Water Sampler, SN 55 (24 12-liter bottles). Additionally Benthos Altimeter Model PSA-916 SN 1228 and Wetlabs C-Star Transmissiometer SN 814 were mounted on the carousels. The SBE 43 dissolved oxygen sensor SN 743 was used. The algorithm to compute oxygen concentration requires also measurements of temperature, salinity and pressure. When the oxygen sensor is interfaced with a Sea-Bird CTD, all of these parameters are measured by the system. The oxygen in water samples was also measured onboard with Winkler titration for a calibration of the oxygen sensor. The continuous profiles of the chlorophyll a concentration and yellow substances were obtained with two Dr. Haardt fluorometers. Salinity of 98 water samples was measured using the Guideline salinometer with Standard Water Batch P149.

Underway measurements with a vessel-mounted narrow band 150 kHz ADCP from RD Instruments and a Sea-Bird SBE45 thermosalinograph measurements were conducted along the transect to supply temperature, salinity and current data at a much higher spatial resolution than given through the moorings. Two thermosalinographs were in use, one at 6 m depth in the bow thruster tunnel and one at 11 m depth in the keel. Both instruments were controlled by taking water samples, which were measured on board.

Preliminary Results

The data from the moored instruments were read out from the memories, and preliminarily processed onboard but the final processing including the pressure correction needs to be performed in Bremerhaven. The preliminary evaluation of the raw data is promising, especially with the very good obtained data rate. The analysis of the hydrographic data occurred on the basis of preliminary data available on board. The post-cruise calibration might result in minor changes.

The temperature and salinity sections across the Fram Strait are shown in Fig. 3.4. The main core of northward flowing warm and saline Atlantic Water (AW) is found at the eastern side of the transect in the shallow to intermediate layers. The West Spitsbergen Current (WSC) is visible at the eastern slope by downward sloping isolines. The AW layer in the West Spitsbergen Current above the slope was shallower and the amount of AW in the recirculation area has decreased as compared to previous years. In summer 2008 the temperature of the Atlantic Water in the WSC core was lower and the offshore branch of the WSC was significantly colder than last year. The outer branch of WSC is less pronounced and much shallower than in 2006. The recirculating

AW westward extent was similar as in previous years but its temperature and particularly its salinity were significantly lower (temperature by 1-2°C at some locations, salinity by 0.04-0.06). The cold and low saline Polar Waters of the East Greenland Current can be found down to 300 m in the western part of Fram Strait, above the shelf and continental slope. The Polar Water overlies the Atlantic Water layer also through the central Fram Strait with the only exception due to the warm mesoscale eddy, passing across the section.

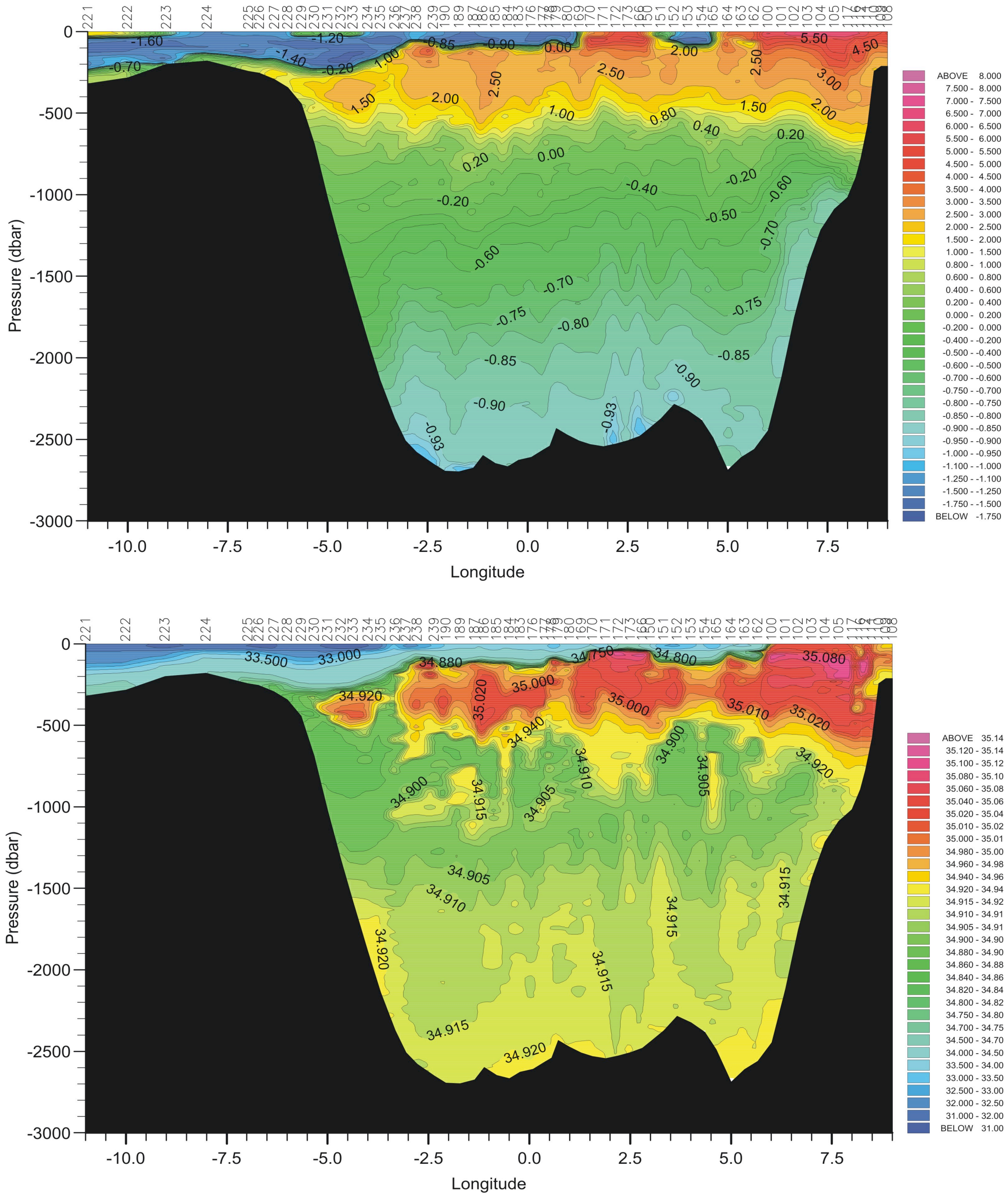


Fig. 3.4: Vertical distribution of potential temperature (top) and salinity (bottom) across Fram Strait measured

The differences in temperature observed between 2008 and 2005 are shown in Fig. 3.5. While in summer 2007 the Atlantic Water in Fram Strait was already colder than in the extremely warm summer 2006, in summer 2008 significant cooling was found in all areas occupied by the inflowing as well as by the recirculating Atlantic Water. Areas of the slight warming were observed in deep waters, however, this finding has to be confirmed after the post-cruise calibration.

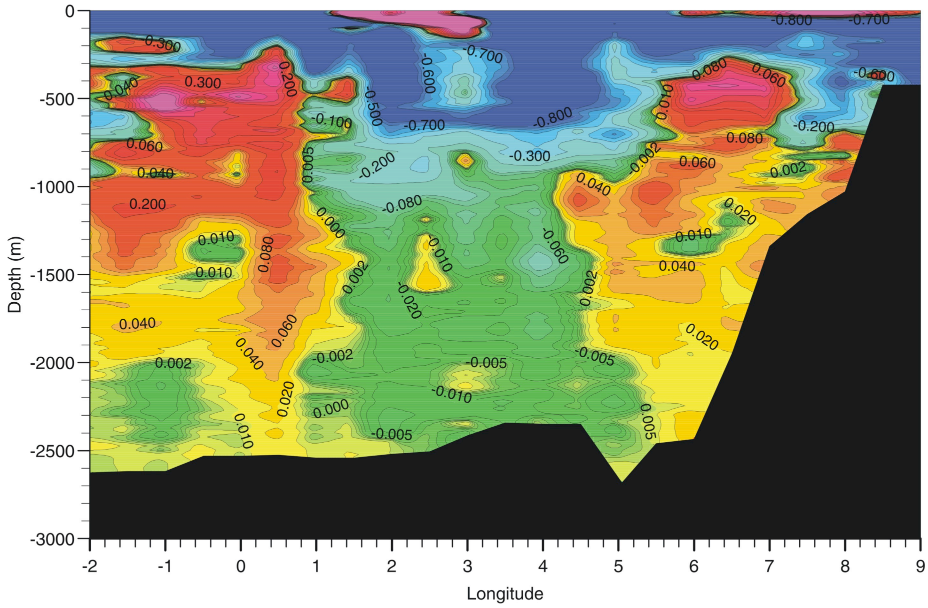


Fig. 3.5: Difference of potential temperature in Fram Strait between 2008 and 2007.

To identify the longer-term variability, time series of mean temperatures and salinities for typical water masses were derived for the depth interval from 50 to 500 m (Fig. 3.6). Three characteristic areas were distinguished in relation to the main flows: the West Spitsbergen Current (WSC) between the shelf edge and 5°E, the Return Atlantic Current (RAC) between 3°W and 5°E, and Polar Water in the East Greenland Current (EGC) between 3°W and the Greenland Shelf. In all three domains, spatially averaged (in boxes defined by the longitude and depth ranges) temperatures and salinities were lower than in 2007. This strong decrease was found across the whole Fram Strait where both temperature and salinity dropped below the long-term average (11-year mean). In the EGC the significantly colder water was observed after the period of 6 consecutively warmer years. This cooling was also accompanied by the strong freshening of the Polar Water outflow. The mean values of temperature and salinity might be biased by the seasonal variability, facing the fact that the Fram Strait section in the last 6 years was occupied in the late summer/early autumn as compared to July in 2008. However, the observed decreases in temperature and salinity are clearly larger than those, possibly induced by seasonal differences.

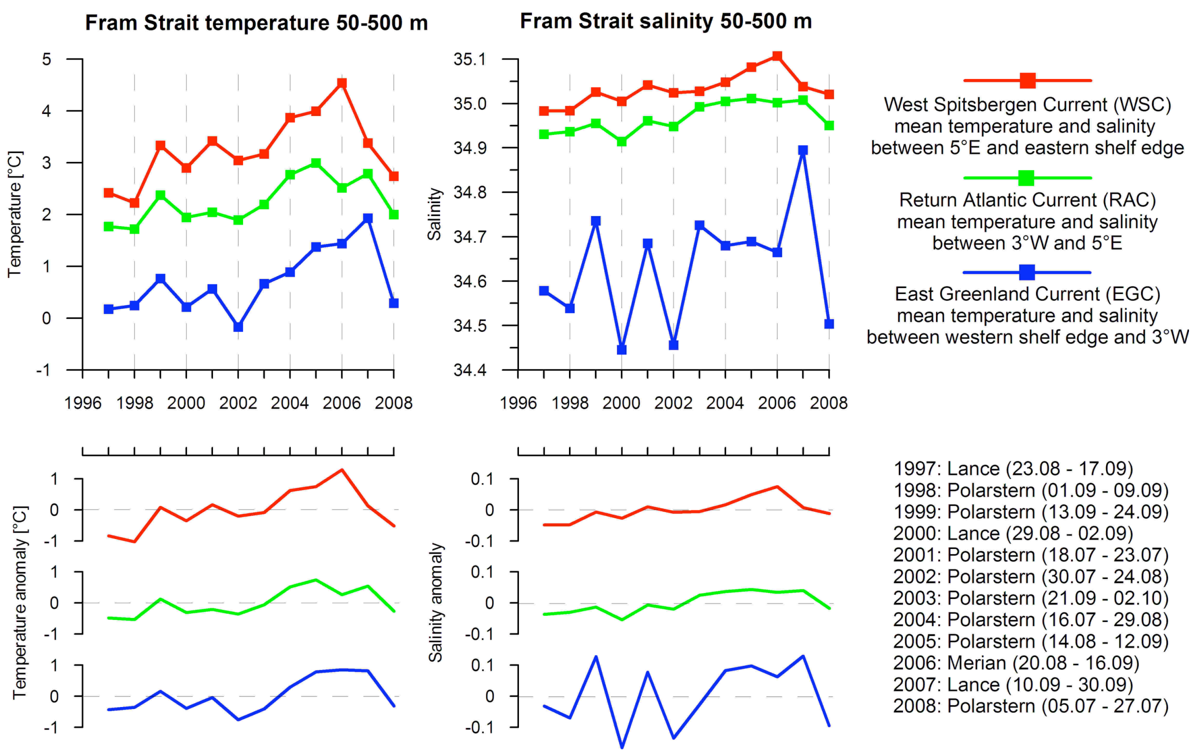


Fig. 3.6: The variations of the mean temperatures and salinities in the Fram Strait in the West Spitsbergen

The preliminary results obtained by the moored array confirm findings from the hydrographic snapshot. Variability of temperature and cross-section current speed in the Atlantic Water (at the depth of ca. 250 m) is presented in Fig. 3.7 as the time-space diagram, based on monthly averaged values. Since 2007 lower temperatures have been observed in the eastern and central Fram Strait and the westward extent of the isotherm 3°C has been significantly shortened. Also the late autumn/winter temperatures in 2007/2008 were much below those observed during the warm period. The northward flow in the WSC core was slightly weaker than in the previous years, although a strength and variability of the offshore WSC branch was comparable in last 5 years. Data from the western part of Fram Strait are still missing, but the relatively strong southward flow at the westernmost recovered mooring suggests the intensive outflow in the East Greenland Current.

The preliminary time series of the volume transport, separately in the WSC and RAW domains, are presented in Fig. 3.8. In particular, the volume flux of the RAW in the central part of Fram Strait was characterized by a strong month-to-month variability. The total volume flux through the whole Fram Strait can be obtained only after including the data of the western moorings.

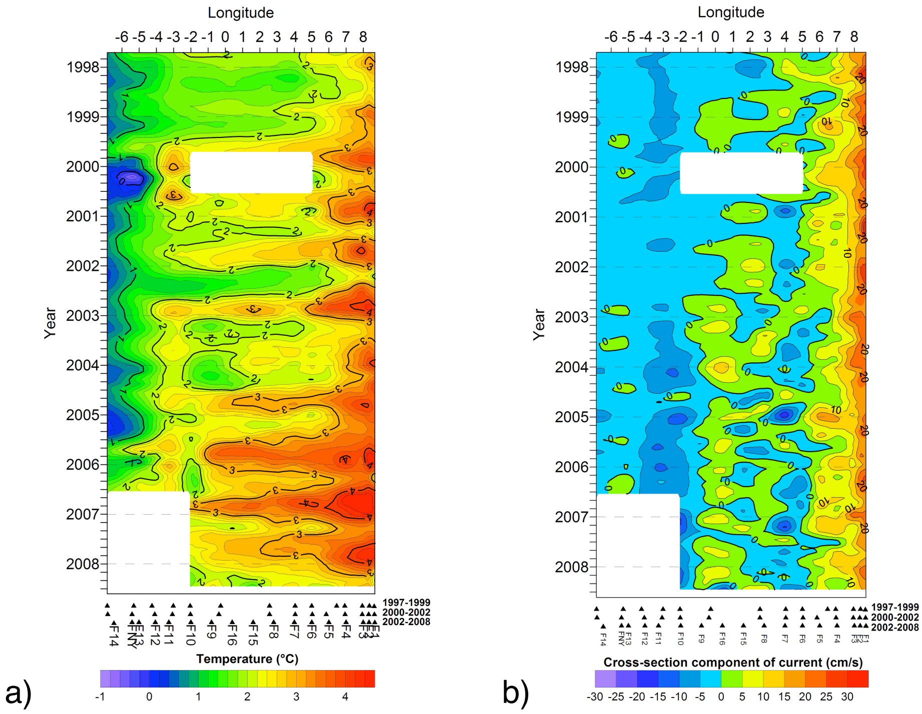


Fig. 3.7: Variability of (a) temperature and (b) cross-section current in the Atlantic Water layer (ca. 250 m) in Fram Strait, based on monthly averaged measurements by the moored array in 1997-2008

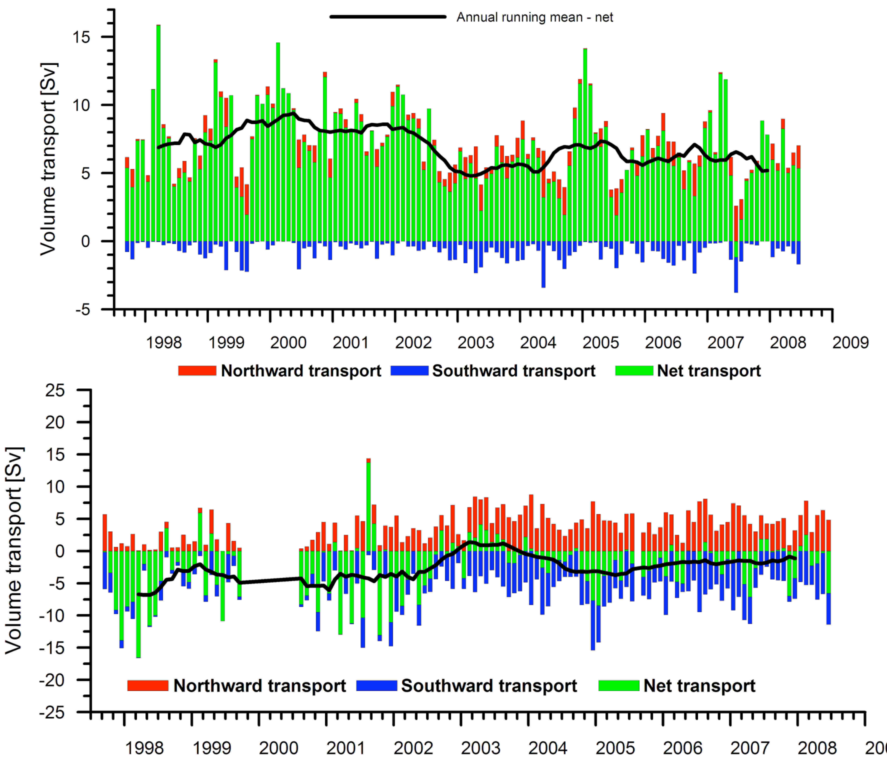


Fig. 3.8: Variability of volume transport in (top) West Spitsbergen Current and of (bottom) Return Atlantic Water in Fram Strait, based on monthly averaged measurements by the moored array in 1997-2008

Tab. 3.1: Moorings recovered during ARK-XXIII/2

Mooring	Latitude Longitude	Water depth (m)	Date and time of first useful record	Instrument type	Serial number	Instr. depth (m)	Time series length (days)
F1-10	78°50.03'N	229	12.09.07 13:00	RCM7 VTP	8367	61	
	008°40.46'E			SBE37 P	242	80	
				SBE37	212	232	
				RCM8 VTP	9215	233	
F2-11	78°50.09'N	779	28.09.07 14:00	RCM7 VTP	8400	60	
	008°19.76'E			SBE16	1973	80	
				RCM11 VTP	455	256	
				SBE37	216	257	
				SBE16	630	771	
				RCM11 VT	134	772	
PIES F2-10	78°50.50'N 008°19.52'E	772	23.08.06 14:00	C-PIES	181	772	683.8
F3-10	78°50.02'N	1010	28.09.07 12:00	RCM7 VTP	8402	62	
	008°00.03'E			SBE16	1975	80	
				RCM11 VTP	569	253	
				SBE16 P	631	254	
				RCM11 VT	133	754	
				RCM11 VT	102	999	
				SBE 16	1167	1001	
F4-10	78°50.18’N	1429	12.09.07 19:00	SBE37 P	248	80	
	07°00.14’E			ADCP	951	93	
				RCM11 VTP	461	249	
				SBE37	229	700	no data
				RCM11 VTP	127	755	no data
				SBE37	223	1415	
				RCM11 VT	145	1421	
PIES F4-10	78°50.31'N 007°00.29'E	1420	27.08.06 08:00	C-PIES	182	1420	680.5
F5-10	78°50.05'N	2415	12.09.07 21:00	RCM7 VTP	8405	62	
	006°00.02'E			SBE37	224	80	no data
				RCM8 VTP	9995	253	
				RCM11 VT	458	749	
				RCM8 VTP	9783	1505	
				RCM8 VT	9768	2401	
PIES F5-10	78°50.02'N 005°56.84'E	2446	28.08.06 14:00	PIES	058	2446	680.1
F6-11	78°50.02'N	2642	13.09.07 09:00	RCM7 VTP1000,tlow	10491	59	
	005°00.14'E			SBE 16 P1000	2420	80	
				RCM11VTCP3500,tlow	469	255	
				SBE37	472	751	
				RCM8 VTP3000	488	1507	
				RCM11 VTP3500	135	2633	
				RCM11 VT	258	2642	

Moor-ing	Latitude Longitude	Water depth (m)	Date and time of first useful record	Instrument type	Serial number	Instr. depth (m)	Time series length (days)
PIES F6-11	78°49.98'N 004°54.13'E	2538	28.08.05 18:00	C-PIES	183	2538	679.9
F7-8	78°50.02'N 04°00.02'E	2298	29.08.06 11:00	RCM7 VTP SBE 16 P2000 RCM8 VT RCM8 VT RCM11 VTP RCM11 VT	8403 1253 9769 9770 312 297	66 68 258 764 1510 2286	
PIES F7-8	78°49.98'N 003°56.74'E	2283	29.08.06 09:00	PIES	071	2283	681.6
F8-9	78°49.98'N 02°48.04'E	2445		RCM7 VTP SBE 16 RCM11 VT RCM7 VTP RCM8 VT RCM11 VT	8048 1976 314 10927 6854 315	60 62 244 750 1496 2432	
PIES F8-9	78°49.98'N 002°50.87'E	2437	29.08.06 18:00	PIES	074	2437	685.9
F15-6	78°49.96'N 001°36.27'E	2454	24.09.07 14:00	RCM11 VTP SBE37 RCM7 VTP RCM8 VT RCM8 VT RCM11 VT	568 231 8417 10531 9391 313	57 100 249 755 1501 2487	
F16-6	78°49.94'N 000°32.40'E	2481	14.09.07 00:00	RCM8 VTP SBE37 RCM11 VTP RCM11 VTP RCM11 VTP RCM11 VT	11892 227 462 506 509 311	59 100 251 757 1503 2519	
F9-8	78°50.34'N 00°48.64'W	2614	08.09.06 01:00	RCM7 VTP1000 SBE 37P RCM8 VTP RCM11 VTP RCM11 VTP RCM11 VT	8050 2087 9207 570 513 294	58 60 247 753 1499 2600	
F10-9	78°49.26'N 02°02.99'W	2669	09.09.06 01:00	RCM8 VTP1000 SBE 37 ADCP-UP RCM11 VTCP RCM11 VTP RCM11 VT	9195 448 1561 452 501 212	63 65 255 752 1507 2654	

Abbreviations:

ADCP RDI Inc. Self-Contained Acoustic Doppler Current Profiler
VTCP Aanderaa current meter with temperature, conductivity and pressure sensor
VTP Aanderaa current meter with temperature and pressure sensor
VT Aanderaa current meter with temperature sensor
RCM7 Aanderaa current meter type RCM7
RCM8 Aanderaa current meter type RCM8

RCM 11	Aanderaa Doppler current meter with temperature sensor
SBE 16	Seabird Electronics SBE16 recording temperature, conductivity, and pressure
SBE 26	Seabird Electronics SBE26 bottom pressure recorder
SBE 37	Seabird Electronics SBE37 recording temperature and conductivity (optionally pressure SBE 37P)
PIES	Pressure Inverted Echo Sounder
C-PIES	Pressure Inverted Echo Sounder with Aanderaa Doppler Current Sensor

Tab. 3.2: Moorings deployed during ARK-XXIII/2

Mooring	Latitude Longitude	Water depth (m)	Date and time of first useful record	Instrument type	Serial number	Instr. depth (m)
F1-11	78°50.00'N	248	07.07.08	RCM7 VTP	8395	61
	008°40.03'E	(DWS)	06:00	SBE 37P	225	80
		247		SBE 37	226	232
		(corr. CTD)		RCM11VT	20	233
F2-12	78°50.40'N	796	07.07.08	RCM7 VTP	10002	60
	08°20.00'E	(DWS)	11:00	SBE 16P	1973	80
		777		RCM8VTP	10004	256
		(corr. CTD)		SBE 37	232	257
				SBE 16 Trans.	2418	771
				RCM8VT	11613	772
PIES-F2-11	78°50.49' N	793	07.07.08	C-PIES	141	793
	08°19.45' E		14:00			
F3-11	78°50.00'N	1033	07.07.08	RCM8 VTP	11889	62
	07°59.99'E	(DWS)	15:00	SBE 37	239	80
		1011		RCM8 VTP	9213	253
		(corr. CTD)		SBE 37	2723	254
				RCM8 VT	9786	754
				RCM8 VT	10498	999
				SBE 16 Trans.	2419	1001
F4-9	78°50.00'N	1462	07.07.08	SBE 37P	236	80
	07°00.00'E	(DWS)	18:00	ADCP WH	1368	93
		1428		RCM8 VTP	11888	249
		(corr. CTD)		RCM11 VT	215	755
				RCM11 VT	26	1421
				SBE 16 Trans.	2421	1421
PIES-F4-9	78°50.21'N	1428	08.07.08	C-PIES	181	1428
	07°02.94'E		16:00			
F5-11	78°50.00'N	2470	12.07.08	RCM11 VT	474	62
	06°00.00'E	(DWS)	14:00	SBE 37P	2395	80
		2415		RCM11 VTP	500	253
		(corr. CTD)		RCM11 VT	512	749
				RCM11 VT	217	1505
				RCM11 VT	214	2401
F6-12	78°50.02'N	2705	12.07.08	RCM11 VTP	475	59
	05°00.25'E	(DWS)	17:00	SBE 37	243	80
		2652		RCM11VTP	491	255
		(corr. CTD)		RCM11 VTP	469	751
				RCM11 VT	488	1507
				RCM11 VT	135	2633
				SBE 26	227	bottom

Mooring	Latitude Longitude	Water depth (m)	Date and time of first useful record	Instrument type	Serial number	Instr. depth (m)
PIES-F6-12	78°50.046'N 04°56.324'E	2632	11.07.08 18:00	C-PIES	182	2632
F7-9	78°50.00'N 03°59.80'E	2341 (DWS) 2295 (corr. CTD)	15.07.08 12:00	RCM8 VT SBE 16P RCM8 VTP RCM8 VTP RCM11 VTP RCM11 VT	10532 630 11887 9211 455 134	62 80 253 759 1503 2281
F8-10	78°50.0'N 02°48.30'E	2483 (DWS) 2445 (corr. CTD)	18.07.08 09:00	RCM8 VTP SBE 37 RCM11 VTP RCM11 VTP RCM8 VT RCM11 VT SBE26	9215 2097 569 133 9783 102 228	60 100 247 753 1499 2435 bottom
PIES-F8-9	78°49.979'N 02°49.902'E	2442	18.07.80 10:00	PIES	183	2442
F15-7	78°50.06'N 01°35.97'E	2503 (HSW) 2497 (corr. CTD)	18.07.08 17:00	RCM8 VTP SBE 37 RCM11 VTP RCM11 VTP RCM8 VT RCM11 VT	9995 2719 461 145 9768 297	57 100 249 755 1501 2487
F16-7	78°49.60'N 00°23.41'E	2542 (HSW) 2530 (corr. CTD)	20.07.08 12:00	RCM8 VTP SBE 37 RCM11VTP RCM11 VTP RCM11 VTP RCM11 VT	8405 2720 312 9770 568 313	59 100 251 757 1503 2519
F9-9	78°50.24'N 00°46.93'W	2618 (HSW) 2611 (corr. CTD)	21.07.08 10:00	Aural M2 RCM7 VTP SBE 37 RCM7 VT RCM11 VT RCM8 VTP RCM11 VT	 8402 2722 8417 311 10531 294	58 60 100 250 756 1502 2598
F10-10	78°49.65'N 02°06.90'W	2663 (HSW) 2655 (corr. CTD)	21.07.08 20:00	RCM8 VTP SBE 37 RCM8 VTP RCM11 VTP RCM11 VTP RCM11 VT	11892 227 9219 462 506 509	63 100 255 752 1507 2654
F20-1	78°49.01'N 06°00.04'E	2426 (HSW) 2415 (corr. CTD)	17.07.08 17:00	SBE37 SBE37 SBE37 SBE37 Profiling winch	248 212 242 223	0-80 0-80 0-80 0-80 80
F-21	78°49.74'N 01°03.70'E	2480 (HSW) 2506 (corr. CTD)	20.07.08 08:00	Sound source	24	ca. 800

For abbreviations refer to Table 3.1

Tab. 3.3: CTD stations carried out during ARK-XXIII/2

File	Station	Cast	Lat	Lon	Depth	PMax	Date			Time	
					(m)						
09802.dat	098	2	78.833	7.005	1442	204	5	7	2008	12	6
10001.dat	100	1	78.832	6.012	2415	2446	5	7	2008	16	5
10101.dat	101	1	78.833	6.349	2094	2119	5	7	2008	18	57
10201.dat	102	1	78.833	6.664	1739	1755	5	7	2008	21	34
10301.dat	103	1	78.833	7.003	1428	1438	5	7	2008	23	35
10401.dat	104	1	78.834	7.332	1209	1217	6	7	2008	1	28
10501.dat	105	1	78.833	7.667	1084	1091	6	7	2008	3	6
10601.dat	106	1	79.028	11.088	281	275	6	7	2008	8	25
10702.dat	107	2	78.980	9.499	225	219	6	7	2008	20	14
10801.dat	108	1	78.834	9.009	218	213	7	7	2008	3	15
10901.dat	109	1	78.833	8.834	218	213	7	7	2008	4	10
11001.dat	110	1	78.833	8.663	247	244	7	7	2008	4	42
11101.dat	111	1	78.833	8.497	579	577	7	7	2008	6	17
11201.dat	112	1	78.833	8.332	777	778	7	7	2008	7	14
11601.dat	116	1	78.835	8.207	893	895	7	7	2008	20	49
11701.dat	117	1	78.834	8.001	1011	1016	7	7	2008	22	33
11801.dat	118	1	79.050	6.998	1314	1323	8	7	2008	1	8
12201.dat	122	1	79.063	4.181	2426	1016	8	7	2008	23	23
12501.dat	125	1	78.917	4.995	2586	2622	9	7	2008	22	47
12601.dat	126	1	78.781	5.337	2418	2450	10	7	2008	3	17
12701.dat	127	1	78.608	5.066	2292	1014	10	7	2008	7	49
12904.dat	129	4	78.609	5.064	2291	2320	10	7	2008	14	32
13002.dat	130	2	79.066	4.176	2416	2446	10	7	2008	20	40
13101.dat	131	1	79.109	4.605	1889	1908	11	7	2008	1	10
13601.dat	136	1	79.130	4.895	1523	1537	11	7	2008	19	1
13701.dat	137	1	79.134	6.090	1251	1260	11	7	2008	22	56
14101.dat	141	1	79.062	3.658	3029	3075	12	7	2008	2	35
14201.dat	142	1	79.055	3.568	3441	3498	13	7	2008	7	17
14401.dat	144	1	79.603	5.153	2744	2784	14	7	2008	2	57
14502.dat	145	2	79.734	4.472	2613	2650	14	7	2008	10	19
14701.dat	147	1	79.412	4.716	2528	823	15	7	2008	1	55
14702.dat	147	2	79.418	4.708	2528	2563	15	7	2008	2	46
15001.dat	150	1	78.834	2.998	2411	2443	15	7	2008	18	0
15101.dat	151	1	78.834	3.331	2343	2374	15	7	2008	20	35
15201.dat	152	1	78.833	3.662	2255	2285	15	7	2008	23	6
15301.dat	153	1	78.833	4.008	2295	2325	16	7	2008	1	22
15401.dat	154	1	78.835	4.353	2350	2382	16	7	2008	4	5
15901.dat	159	1	79.135	2.845	5556	5682	16	7	2008	20	43
16001.dat	160	1	79.056	3.507	3910	3982	17	7	2008	6	8
16201.dat	162	1	78.833	5.663	2524	2560	17	7	2008	17	15
16301.dat	163	1	78.833	5.335	2577	2613	17	7	2008	19	46
16401.dat	164	1	78.833	5.001	2652	2691	17	7	2008	22	22
16501.dat	165	1	78.832	4.638	2457	2491	18	7	2008	1	2
16601.dat	166	1	78.836	2.799	2445	2480	18	7	2008	5	2
16901.dat	169	1	78.833	1.287	2475	2510	18	7	2008	17	12
17001.dat	170	1	78.830	1.565	2497	2532	18	7	2008	19	47
17101.dat	171	1	78.834	1.893	2509	2545	18	7	2008	22	31
17201.dat	172	1	78.834	2.205	2494	2528	19	7	2008	1	4
17301.dat	173	1	78.825	2.505	2475	2509	19	7	2008	3	30
17601.dat	176	1	78.840	0.092	2575	2610	19	7	2008	19	5
17701.dat	177	1	78.842	0.394	2530	2565	19	7	2008	21	59

File	Station	Cast	Lat	Lon	Depth	PMax	Date			Time	
17801.dat	178	1	78.836	0.554	2506	2541	20	7	2008	0	11
17901.dat	179	1	78.836	0.715	2402	2435	20	7	2008	2	32
18001.dat	180	1	78.831	0.996	2441	2475	20	7	2008	4	50
18301.dat	183	1	78.825	-0.230	2591	2628	20	7	2008	17	20
18401.dat	184	1	78.829	-0.493	2632	2669	20	7	2008	19	45
18501.dat	185	1	78.833	-0.811	2611	2649	20	7	2008	22	43
18601.dat	186	1	78.834	-1.119	2563	2599	21	7	2008	1	29
18701.dat	187	1	78.839	-1.355	2637	2675	21	7	2008	4	36
18901.dat	189	1	78.830	-1.715	2660	2699	21	7	2008	13	8
19003.dat	190	3	78.844	-2.069	2655	2694	21	7	2008	19	41
19101.dat	191	1	80.411	-15.361	189	184	23	7	2008	5	51
19201.dat	192	1	80.386	-14.766	277	272	23	7	2008	11	51
19301.dat	193	1	80.357	-14.094	300	295	23	7	2008	13	14
19401.dat	194	1	80.324	-13.451	271	268	23	7	2008	15	59
19501.dat	195	1	80.316	-12.001	172	168	23	7	2008	17	54
19601.dat	196	1	81.017	-10.989	60	53	23	7	2008	22	36
19701.dat	197	1	80.934	-10.997	81	75	24	7	2008	0	0
19801.dat	198	1	80.816	-10.990	213	209	24	7	2008	1	10
19901.dat	199	1	80.701	-11.005	126	122	24	7	2008	2	40
20001.dat	200	1	80.584	-12.010	262	258	24	7	2008	4	30
20101.dat	201	1	80.466	-11.994	260	255	24	7	2008	5	47
20201.dat	202	1	80.345	-11.996	244	239	24	7	2008	7	8
20301.dat	203	1	80.233	-11.998	203	199	24	7	2008	8	30
20401.dat	204	1	80.115	-11.998	160	155	24	7	2008	9	50
20501.dat	205	1	79.882	-11.995	142	137	24	7	2008	12	13
20601.dat	206	1	79.666	-12.007	258	255	24	7	2008	14	2
20701.dat	207	1	79.331	-11.998	192	186	24	7	2008	16	40
20801.dat	208	1	79.002	-11.990	198	192	24	7	2008	19	16
20901.dat	209	1	78.653	-12.086	212	207	24	7	2008	23	11
21001.dat	210	1	78.332	-13.001	184	180	25	7	2008	2	14
21101.dat	211	1	77.992	-14.002	106	99	25	7	2008	5	30
21201.dat	212	1	77.748	-14.682	379	377	25	7	2008	8	4
21301.dat	213	1	77.500	-15.006	310	307	25	7	2008	11	45
21401.dat	214	1	77.251	-15.494	236	229	25	7	2008	16	0
21501.dat	215	1	77.000	-15.941	207	201	25	7	2008	18	13
21601.dat	216	1	77.001	-13.002	257	254	25	7	2008	23	37
21701.dat	217	1	77.249	-12.497	277	274	26	7	2008	1	58
21801.dat	218	1	77.497	-11.884	453	450	26	7	2008	5	0
21901.dat	219	1	77.750	-11.993	210	204	26	7	2008	7	21
22001.dat	220	1	77.999	-12.001	162	157	26	7	2008	9	51
22101.dat	221	1	78.833	-10.993	326	321	26	7	2008	16	45
22201.dat	222	1	78.833	-9.998	290	284	26	7	2008	18	55
22301.dat	223	1	78.833	-9.028	204	200	26	7	2008	21	3
22401.dat	224	1	78.830	-8.015	185	181	27	7	2008	1	5
22501.dat	225	1	78.852	-6.980	248	244	27	7	2008	4	36
22601.dat	226	1	78.840	-6.710	260	254	27	7	2008	6	22
22701.dat	227	1	78.813	-6.333	295	293	27	7	2008	9	2
22801.dat	228	1	78.836	-5.998	346	344	27	7	2008	10	33
22901.dat	229	1	78.835	-5.656	446	445	27	7	2008	12	53
23001.dat	230	1	78.830	-5.332	686	688	27	7	2008	13	59
23101.dat	231	1	78.833	-4.995	1019	1027	27	7	2008	15	27
23201.dat	232	1	78.831	-4.665	1319	1330	27	7	2008	17	15
23301.dat	233	1	78.840	-4.365	1573	1589	27	7	2008	19	12
23401.dat	234	1	78.832	-4.001	1866	1888	27	7	2008	21	23
23501.dat	235	1	78.840	-3.685	2111	2138	27	7	2008	23	55
23601.dat	236	1	78.833	-3.322	2340	2372	28	7	2008	3	38

File	Station	Cast	Lat	Lon	Depth	PMax	Date			Time	
23701.dat	237	1	78.852	-3.055	2473	2509	28	7	2008	9	34
23801.dat	238	1	78.831	-2.779	2542	2579	28	7	2008	14	24
23901.dat	239	1	78.830	-2.357	2617	2653	28	7	2008	18	10
24001.dat	240	1	79.836	-3.983	1957	1981	29	7	2008	8	40
24101.dat	241	1	79.834	-4.533	1606	1623	29	7	2008	12	30
24201.dat	242	1	79.834	-5.048	1146	1153	29	7	2008	16	15
24301.dat	243	1	79.831	-5.545	498	503	29	7	2008	17	59
24401.dat	244	1	79.833	-6.005	296	291	29	7	2008	19	18
24501.dat	245	1	79.833	-6.490	270	267	29	7	2008	20	41
24601.dat	246	1	79.833	-6.991	237	234	29	7	2008	22	5
24701.dat	247	1	79.833	-7.493	210	206	29	7	2008	23	18
24801.dat	248	1	79.835	-8.003	187	183	30	7	2008	0	36
24901.dat	249	1	79.837	-8.502	221	218	30	7	2008	2	29
25001.dat	250	1	79.833	-9.000	199	193	30	7	2008	3	46
25101.dat	251	1	79.833	-9.498	256	250	30	7	2008	4	59
25201.dat	252	1	79.832	-10.006	190	184	30	7	2008	6	14
25301.dat	253	1	79.834	-10.495	205	201	30	7	2008	8	20
25401.dat	254	1	79.833	-10.997	246	243	30	7	2008	9	33
25501.dat	255	1	79.833	-11.489	172	168	30	7	2008	11	32
25601.dat	256	1	79.835	-11.999	149	145	30	7	2008	12	48
25701.dat	257	1	79.834	-12.451	193	189	30	7	2008	14	32
25801.dat	258	1	79.835	-12.564	185	181	31	7	2008	0	58
25901.dat	259	1	80.282	-11.544	185	179	31	7	2008	7	17
26001.dat	260	1	80.316	-11.997	176	172	31	7	2008	8	46
26101.dat	261	1	80.334	-12.708	215	212	31	7	2008	10	24
26201.dat	262	1	80.351	-13.435	299	296	31	7	2008	12	0
26301.dat	263	1	80.384	-14.099	330	327	31	7	2008	13	30
26401.dat	264	1	80.418	-14.767	251	248	31	7	2008	15	5
26501.dat	265	1	80.457	-15.420	197	190	31	7	2008	16	50
26601.dat	266	1	80.432	-12.416	276	273	31	7	2008	23	0
26701.dat	267	1	81.790	-12.500	208	203	2	8	2008	5	7
26801.dat	268	1	81.885	-12.043	195	190	2	8	2008	6	38
26901.dat	269	1	81.992	-11.383	228	225	2	8	2008	9	5
27001.dat	270	1	82.034	-11.138	360	358	2	8	2008	10	30
27101.dat	271	1	82.062	-10.952	882	887	2	8	2008	11	41
27201.dat	272	1	82.063	-10.794	1722	1739	2	8	2008	13	9
27301.dat	273	1	82.088	-10.404	2452	2485	2	8	2008	15	14
27401.dat	274	1	82.199	-9.539	2843	2886	2	8	2008	18	3
27501.dat	275	1	82.402	-8.502	3151	3203	2	8	2008	23	4
27601.dat	276	1	80.418	-10.879	315	313	5	8	2008	14	6
27701.dat	277	1	80.475	-11.230	299	296	5	8	2008	15	20
27801.dat	278	1	80.544	-11.621	270	265	5	8	2008	16	54
27901.dat	279	1	80.613	-11.914	262	259	5	8	2008	18	0
28001.dat	280	1	80.683	-12.294	233	228	5	8	2008	20	17
28101.dat	281	1	80.757	-12.702	121	116	5	8	2008	21	40
28201.dat	282	1	80.834	-13.029	59	51	5	8	2008	22	57
28301.dat	283	1	80.907	-13.469	48	42	5	8	2008	23	59

4. CHEMICAL OCEANOGRAPHY

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Objectives

Nutrients and oxygen measurements performed during the entire cruise will be compared with historical data to determine interannual variability, and to see if there are modifications of the water masses exiting or entering the Arctic Ocean.

The distribution of nutrients and oxygen are well suited as tracers for the identification of water masses. Especially the nitrate to phosphate ratio is a good tracer to follow the outflow of Pacific Water along the Greenland continental shelf and slope. Although the Pacific Water is originally less saline than the Atlantic Water, it is not always possible to separate these water masses in the Arctic Ocean by use of salinity and temperature. The Polar Water ($T < 0$ºC, $S < 34.5$), which exits the Arctic through the Fram Strait, actually consists of several distinct water masses, which might be of either Pacific or Atlantic origin, including the surface waters as well as the halocline waters. Different halocline types can be identified in the Arctic Ocean. Upper Halocline Water (UHW) of Pacific origin formed in the Canadian Basin is associated with a nutrient maximum and a corresponding salinity of about 33.1. UHW from the Canadian Basin is especially rich in silicate compared to other water masses.

The relationship between nitrate and phosphate is appropriate to distinguish between water of Pacific and Atlantic origin in the Arctic. The amount of the two water masses in the upper layer of the Arctic Ocean can be estimated from this relationship, and it has been shown that Pacific Water was dominant in the Canadian Basin, but significant amounts were also present in the area north of Greenland, which might exit through Fram Strait. This has been confirmed with data from summer 1993, which showed that the shelf off northeast Greenland was covered by nearly undiluted Pacific Water from the surface down to the depth of the winter mixed layer. Pacific Water extending from the coast of Greenland to nearly halfway across the Fram Strait along 79ºN was reported for the years 1997-1999.

Nutrient and hydrographic data from four *Polarstern* cruises to the area north of the Fram Strait in 1984, 1990, 1997, and 2004 show that substantial changes have occurred lately in the amount of Pacific Waters delivered to Fram Strait and hence further to the Atlantic Ocean. While the data from 1984, 1990, and 1997 all showed considerable amounts of Pacific Water above the shelf and slope northeast of Greenland, this strong signal had completely vanished in 2004.

Of special interest is the distribution of water masses in the Northeast Water (NEW) Polynya area. The NEW Polynya has been intensively studied as part of the International Arctic Polynya Program. The polynya is located on the continental shelf off northeast Greenland and covers the area between the Norske Øer Ice Shelf in the south and the Ob Bank Ice Shelf in the north; the eastern boundary is given by the slope of the East Greenland Shelf. The hydrography of the NEWP shows a two layered water structure of relative fresh and cold water in the upper 50 to 150 m, denominated as East Greenland Shelf Water because of its local character and an anticyclonic circulation. Below this layer warmer and saltier waters influenced by Atlantic Water are located.

Polynyas are assumed to be areas of high production. The productivity, however, is basically limited by the nutrients available for the primary producers when environmental conditions are favourable for phytoplankton growth. Polynyas are ice-free before the usual opening of the ice coverage and receive therefore light earlier so that primary production can start earlier in the year than in other polar regions. The supply of nutrients together with the low ice coverage and a stabilization of the surface layer widely determine the primary production. Data on nutrient concentrations and distributions are a major basis for the interpretation of the ecological system of the NEW Polynya.

In addition, nutrient and oxygen data will be used for the interpretation of the biological studies in the AWI-*Hausgarten*.

Work at sea

At each station water samples taken with the rosette sampler at different depth were determined immediately on board for nutrients - nitrate, nitrite, phosphate and silicate – and for oxygen. Nutrients were determined with an Autoanalyser-system according to standard seawater methods, and oxygen was measured by the Winkler method. In addition, samples for the determination of dissolved organic carbon and nitrogen (DOC, TN) were taken, stored in glass ampoules and frozen at -20°C.

Preliminary results

During the transect across the Fram Strait nutrient and oxygen measurements (Fig. 4.1) were performed at all CTD stations which gives a very good special resolution.

One major objective was to trace water masses of Pacific origin which are known to exit the Arctic Ocean through the Canadian Archipelago and with the East Greenland Current through Fram Strait. The preliminary results show that unmodified Pacific Water has not returned to the East Greenland shelf, only some diluted remnants of this water mass could still be seen circulating around the Belgica Bank (Fig. 4.2).

At about 90 stations samples were taken over the East Greenland Shelf. Although most parts of the former NEW Polynya study area were covered with ice, measurements in the northern part were performed and will be compared with the 1993 data.

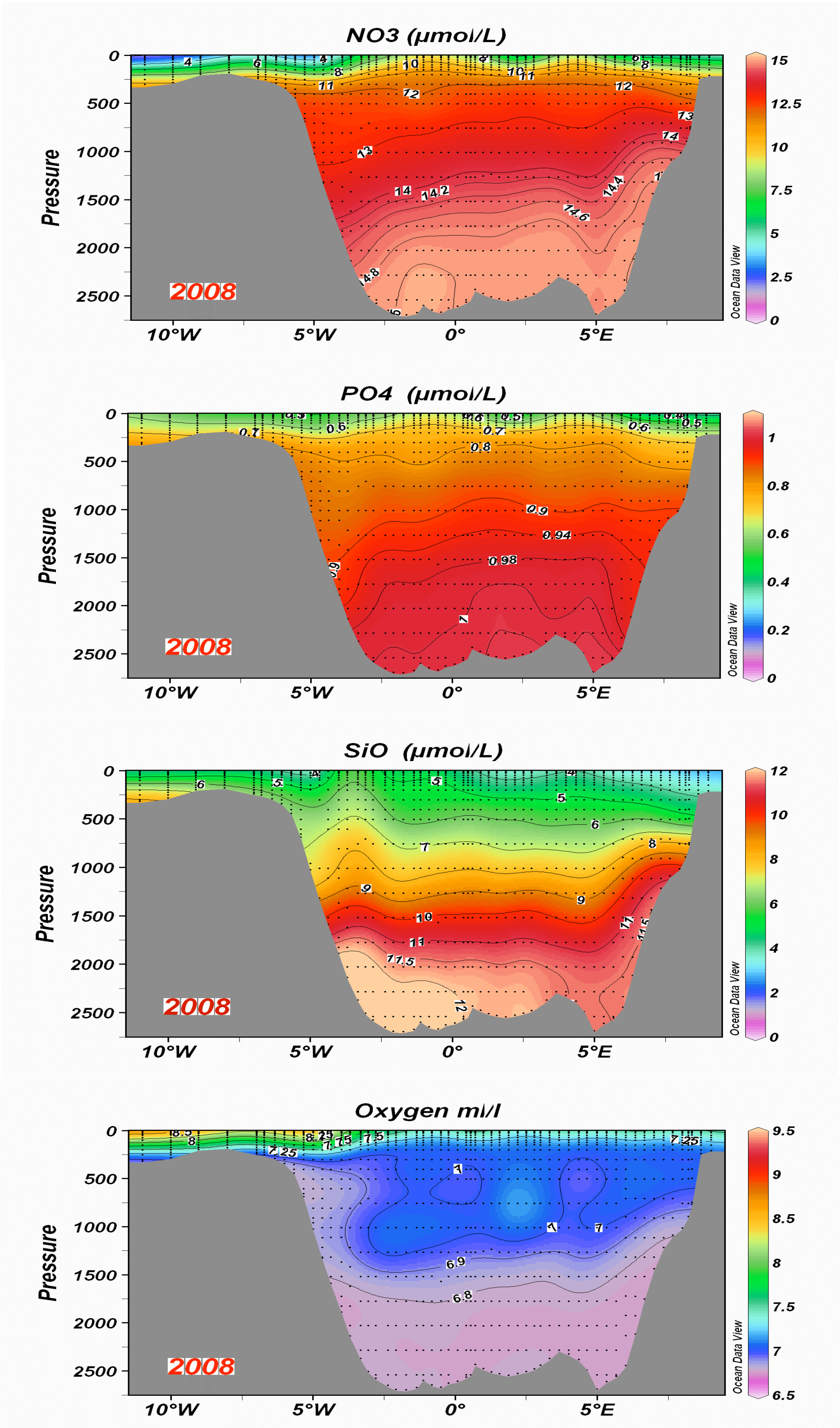

Fig. 4.1: Distribution of nutrients and oxygen along the transect (78.5°N) in the Fram Strait

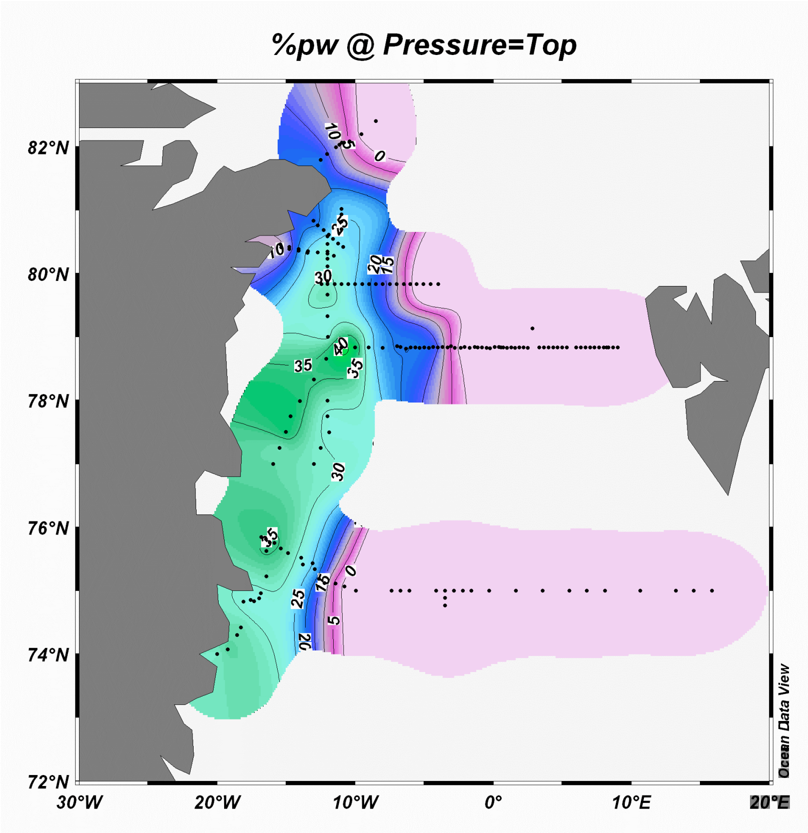

Fig. 4.2: Preliminary results of the distribution of waters of Pacific origin (in %)

5. IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE COMMUNITY STRUCTURES AND FOOD WEBS

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Objectives

The deep oceans have received disproportionately little attention, particularly those in polar regions, despite their importance both in terms of area covered and their role in heat distribution around the globe. Thus, long time series of marine fauna and flora in the Arctic are rare. This is not surprising since the area is only accessible by means of expensive modern infrastructure and instrumentation. However, since almost ten years the Deep-Sea Research Group of the Alfred Wegener Institute monitors this first and - to date - only deep-sea observatory at high latitudes. In a deep-sea area of almost 8,000 m^2 with depths between 1,000 and 5,500 m predominantly biological processes are investigated. This so called AWI-*Hausgarten* is located westerly off Spitsbergen in a region which is distinctly affected by the adjacent marginal ice zone.

Concurrent with the efforts made by AWI the research groups of ARCTOS have access to the best available data to assess past changes in shallow Arctic pelagic and benthic ecosystems. In particular, this long-term co-operation has provided good baseline data from Kongsfjorden (site of large-scale Norwegian and EU research facilities). In 1996, a transect of ten stations (by the North Polar Institute, Tromsø) was established from the inner part of the Kongsfjorden to outside the shelf break at five discrete depth strata and has been sampled several times a year. The data have been continuously processed until summer 2006. Additionally, a large data set has been gathered on fatty acid trophic markers and stable isotopes of zooplankton, fish and marine birds. The state of the Kongsfjorden ecosystem has been reviewed by several authors and the potential effect of climate swings.

To assess how changes at one level impinge on other compartments of the ecosystem, we began to optimize the scientific outcome of the two sampling programmes by combining the Kongsfjorden and AWI-*Hausgarten* transects. By chance, the shallowest AWI sampling station lies only some 25 nautical miles northwest of the deepest station of the Kongsfjorden transect. This collaboration between AWI and ARCTOS yields a more complete data set spanning from shallow to deep water stations and rises in the KONGHAU project (Fig. 5.1). This recently started project is sponsored by the Norwegian oil company StatoilHydro and was realized as a HERMES sub-project.

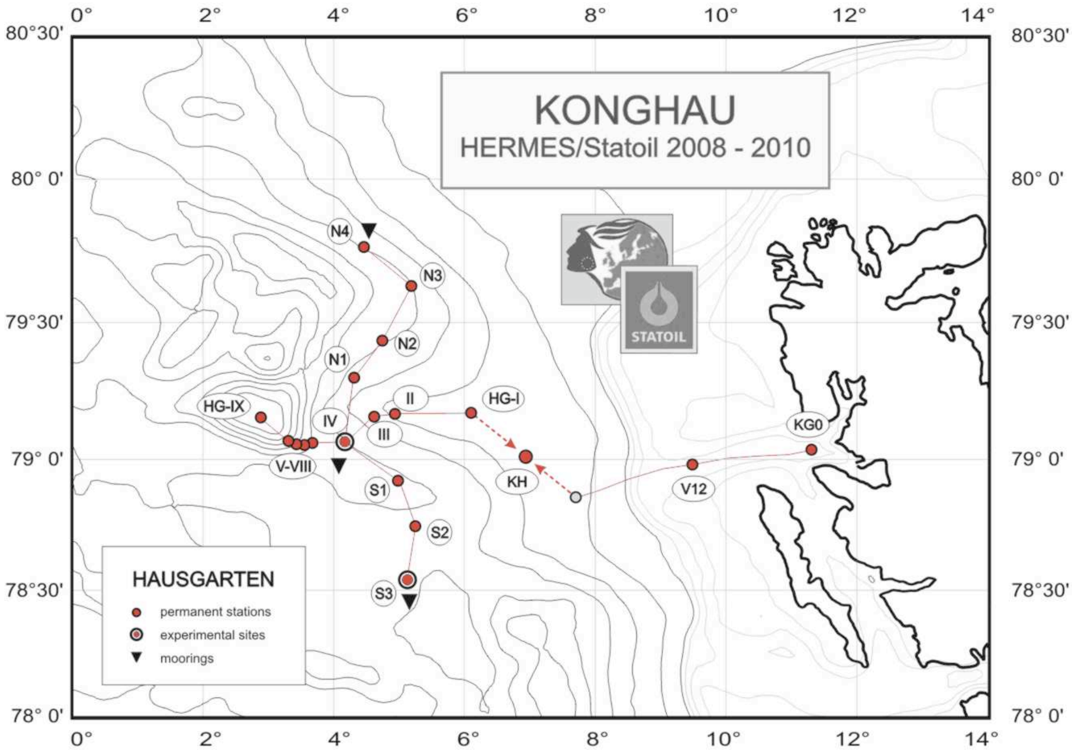

*Fig. 5.1: Overview map of the AWI-*Hausgarten *and connected KONGHAU stations*

The benthic studies in the KONGHAU area are directed towards describing and explaining spatial differences in diversity and community patterns at different scales from bacteria to megafauna and fish on the West Spitsbergen slope and its adjacent shelf in relation to water depth, ice cover and productivity. The main aim is to assess the benthic response (microorganisms to fish) to different qualities and quantities of organic input in terms of abundance, diversity, trophodynamics and metabolic processes and to relate these findings to the productivity and sediment fluxes of the overlying waters. This allows to compile budgets of energy transfer within the benthic sub-system from experimental and field data and, thus, to contribute to models of energy flow between the pelagic and benthic subsystems.

Work at sea

During ARK-XXIII/2 we were able to accomplish an almost complete set of benthic stations (Table 5.1). Sixteen stations were sampled by a video guided multiple corer and supplemented with oceanographic information by CTD casts. Agassiz trawl hauls were taken at 4 stations, whereas 2 shallow shelf stations were trawled for the first time as a contribution to the KONGHAU project. These hauls are additionally applied for ground-truthing the OFOS transects, which have been performed at the same stations. The OFOS (Ocean Floor Observation System) was towed with distance of one meter above the seafloor at 5 stations in total. We successfully recovered three moorings equipped with sediment traps and current meters. But due to limited budget we were constrained to skip the southernmost station for redeployment. Thus, only two moorings, one at central *Hausgarten* and one at the northernmost station N4, were redeployed for an additional year. At the central *Hausgarten* station we were able to recover and redeploy our long-term lander-system equipped with a bottom near sediment trap, current meter and oxygen-optodes.

In preparation for several *in-situ* experiments during the next years we additionally deployed one disturber lander, as well as four huge cages for a starvation experiment at the experimental site of the central *Hausgarten*.

Tab. 5.1: Casts accomplished in the AWI-*Hausgarten* during ARK-XXIII/2

HG-Station	Station	Date	Time	PositionLat	PositionLon	Depth [m]
Multicorer						
Kb0	PS72/106-2	06.07.08	09:15	79° 1.71' N	11° 5.25' E	-288
KH	PS72/118-3	08.07.08	02:51	79° 1.80' N	6° 59.99' E	-1307
HG I	PS72/137-2	12.07.08	00:17	79° 8.07' N	6° 5.52' E	-1281
HG II	PS72/136-2	11.07.08	20:39	79° 7.82' N	4° 53.99' E	-1554
HG III	PS72/131-2	11.07.08	03:10	79° 6.48' N	4° 36.27' E	-1924
HG IV	PS72/122-2	09.07.08	01:23	79° 3.93' N	4° 11.04' E	-2462
HG V	PS72/141-3	13.07.08	05:34	79° 3.21' N	3° 44.61' E	-2822
HG VI	PS72/142-2	13.07.08	10:46	79° 2.78' N	3° 35.94' E	-3440
HG VII	PS72/160-2	17.07.08	09:58	79° 3.51' N	3° 28.60' E	-4023
HG IX	PS72/159-2	17.07.08	02:11	79° 8.62' N	2° 45.16' E	-5577
N4	PS72/145-3	14.07.08	13:04	79° 44.17' N	4° 29.37' E	-2670
N3	PS72/146-1	14.07.08	19:43	79° 35.68' N	5° 12.48' E	-2768
N2	PS72/147-3	15.07.08	05:12	79° 25.55' N	4° 45.59' E	-2587
S1	PS72/125-2	10.07.08	01:23	78° 55.03' N	5° 0.13' E	-2637
S2	PS72/126-2	10.07.08	05:40	78° 46.82' N	5° 19.99' E	-2465
S3	PS72/129-3	10.07.08	13:39	78° 36.46' N	5° 3.80' E	-2343
GKG						
Kb0	PS72/106-3	06.07.08	09:59	79° 1.64' N	11° 4.85' E	-287
AGT (start/ stop)						
V12	PS72/107-1	06.07.08	18:41	78° 59.07' N	9° 31.11' E	-242
V12	PS72/107-1	06.07.08	19:16	78° 58.63' N	9° 27.52' E	-225
KH	PS72/118-7	08.07.08	11:53	79° 2.55' N	7° 0.34' E	-1332
KH	PS72/118-7	08.07.08	12:34	79° 1.76' N	7° 1.46' E	-1309
HG I	PS72/137-5	12.07.08	08:29	79° 7.75' N	6° 7.46' E	-1273
HG I	PS72/137-5	12.07.08	08:58	79° 7.46' N	6° 9.55' E	-1272
HG V	PS72/156-1	16.07.08	13:55	79° 3.39' N	3° 50.54' E	-2732
HG V	PS72/156-1	16.07.08	14:25	79° 3.83' N	3° 48.96' E	-2736
OFOS (start/ stop)						
Kb0	PS72/106-4	06.07.08	12:13	79° 3.48' N	11° 4.27' E	-259
Kb0	PS72/106-4	06.07.08	16:16	79° 1.56' N	11° 5.79' E	-281
V12	PS72/107-4	06.07.08	22:00	78° 58.73' N	9° 29.80' E	-230

HG-Station	Station	Date	Time	PositionLat	PositionLon	Depth [m]
V12	PS72/107-4	07.07.08	02:03	78° 57.25' N	9° 22.82' E	-223
KH	PS72/118-6	08.07.08	06:10	79° 1.82' N	7° 0.01' E	-1308
KH	PS72/118-6	08.07.08	10:12	79° 3.44' N	7° 3.18' E	-1356
HG I	PS72/137-4	12.07.08	02:41	79° 7.98' N	6° 5.66' E	-1280
HG I	PS72/137-4	12.07.08	06:33	79° 7.93' N	6° 15.29' E	-1320
HG IV	PS72/122-3	09.07.08	03:46	79° 2.02' N	4° 10.11' E	-2628
HG IV	PS72/122-3	09.07.08	04:04	79° 2.13' N	4° 10.55' E	-2621
HG IV	PS72/140-1	12.07.08	19:38	79° 4.62' N	4° 16.47' E	-2357
HG IV	PS72/140-1	12.07.08	23:40	79° 2.36' N	4° 26.60' E	-2442
Moored equipment						
HG IV	PS72/123-1	09.07.08	07:04	79° 5.16' N	4° 9.86' E	-2434
HG IV	PS72/157-1	16.07.08	17:14	79° 4.83' N	4° 5.41' E	-2467
HG IV	PS72/158-1	16.07.08	17:37	79° 4.96' N	4° 8.22' E	-2465
HG IV	PS72/124-1	09.07.08	08:15	79° 4.97' N	4° 8.10' E	-2466
HG IV	PS72/124-2	09.07.08	13:28	79° 4.88' N	4° 8.60' E	-2462
HG IV	PS72/124-3	09.07.08	15:28	79° 4.94' N	4° 8.13' E	-2467
HG IV	PS72/124-5	09.07.08	20:27	79° 5.04' N	4° 7.47' E	-2472
HG IV	PS72/143-1	13.07.08	14:41	79° 0.88' N	4° 20.58' E	-2590
HG IV	PS72/155-1	16.07.08	09:51	79° 0.42' N	4° 19.97' E	-2606
N4	PS72/145-1	14.07.08	08:38	79° 43.93' N	4° 27.81' E	-2695
N4	PS72/145-4	14.07.08	15:20	79° 44.35' N	4° 30.55' E	-2721
S3	PS72/128-1	10.07.08	09:09	78° 34.70' N	5° 2.43' E	-2347
CTD						
Kb0	PS72/106-1	06.07.08	08:36	79° 1.68' N	11° 5.50' E	-287
V12	PS72/107-2	06.07.08	20:24	78° 58.82' N	9° 30.19' E	-230
KH	PS72/118-1	08.07.08	01:34	79° 3.02' N	7° 0.14' E	-1347
HG I	PS72/137-1	11.07.08	23:22	79° 8.03' N	6° 5.43' E	-1280
HG II	PS72/136-1	11.07.08	19:33	79° 7.81' N	4° 53.80' E	-1557
HG III	PS72/131-1	11.07.08	01:49	79° 6.47' N	4° 36.10' E	-1917
HG IV	PS72/122-1	08.07.08	23:45	79° 3.74' N	4° 10.86' E	-2477
HG V	PS72/141-1	13.07.08	03:39	79° 3.63' N	3° 41.35' E	-3004
HG VI	PS72/142-1	13.07.08	08:26	79° 3.08' N	3° 35.63' E	-3436
HG VII	PS72/160-1	17.07.08	07:24	79° 3.44' N	3° 29.13' E	-4001
HG IX	PS72/159-1	16.07.08	22:34	79° 8.25' N	2° 48.97' E	-5581
N4	PS72/145-2	14.07.08	11:12	79° 44.08' N	4° 28.48' E	-2663
N2	PS72/147-2	15.07.08	03:37	79° 25.21' N	4° 43.64' E	-2577
S1	PS72/125-1	09.07.08	23:41	78° 55.02' N	4° 59.98' E	-2638
S2	PS72/126-1	10.07.08	04:06	78° 46.79' N	5° 19.94' E	-2465
S3	PS72/127-1	10.07.08	08:13	78° 36.50' N	5° 3.98' E	-2342

5.1 Sedimentary processes and interactions: Particle flux and phytoplankton

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Objectives

The transfer of organic material, which is formed in the upper water column, to the deep waters and finally to the sediments of the deep sea is a crucial process, as this organic matter is the major food source for deep sea organisms. To get insights into the amount and composition of the sedimenting material measurements have been performed by means of moored sediment traps since 1999/2000.

Work at sea

During the cruise ARK-XXIII/2 three deep sea moorings each equipped with sediment traps and current meters were successfully recovered. These instruments were deployed at the *Polarstern* cruise (ARK-XXII) in 2007. The mooring positions at water depth of ~2,500 to 2,700 m are indicated in the map (Fig. 5.1). Seasonally resolved samples during the period July 2007 to July 2008 from 3 depths (~300 m, 900 m and 150 m above the seafloor were obtained at the central *Hausgarten* position. At the same location a benthic lander also equipped with a sediment trap, that sampled successfully, was recovered. At the southern and northern mooring position, which were equipped with 2 sediment traps (~300 m, 150 m above the seafloor) only 1 trap at each mooring sampled over the entire mooring period, whereas the others miss functioned.

At the northern and central *Hausgarten* position moorings with sediment traps and current meters were redeployed at 79°44.24' N, 4°29.95' E and 79°01.76' N, 4°18.98' E, respectively. However, the mooring work at the southern *Hausgarten* location was cancelled. At all stations in the *Hausgarten* a CTD profile from the surface to the seafloor was carried out. At the mooring positions and at selected other stations water samples were taken for the analysis of chlorophyll a, seston, particulate organic carbon and nitrogen (POC/PON), biogenic silicon (bPSi), stable isotopes ($^{15}N/^{13}C$) as well as species composition of the phytoplankton. All this analyses will be carried out after the return to the land based laboratory.

Along the section across Fram Strait at 78° 50' N water samples were taken from the upper water layer (200 m) for the analyses of chlorophyll a and phytoplankton. This work was also continued at sections in the Polynya area. In this region water samples were also filtered for the analyses POC/PON and of stable isotope at selected positions.

Preliminary results

A first impression of sedimentation during 2007/8 can be obtained from the visual inspection of the material collected in the sampling bottles (Fig. 5.2). It shows the sampling jars of the sediment traps obtained in the central *Hausgarten* in 1000 m and the trap in 150 m above the seafloor. A seasonal sedimentation pattern can be deduced with larger amounts of material collected shortly after the deployment at the end of July and August 2007 at both depths. The amount of material collected remained at an elevated level until October, decreased afterwards and remained at a low amount until May/June 2008. An exception was a sedimentation pulse during March 2008, when in both depths larger quantities of material were visible. In the beginning of June 2008, increasing fluxes until the end of the mooring period in July can be noted at both depths. More detailed information on the sedimentation and composition of the sedimented matter will be obtained after biochemical and microscopic analyses in the laboratory.

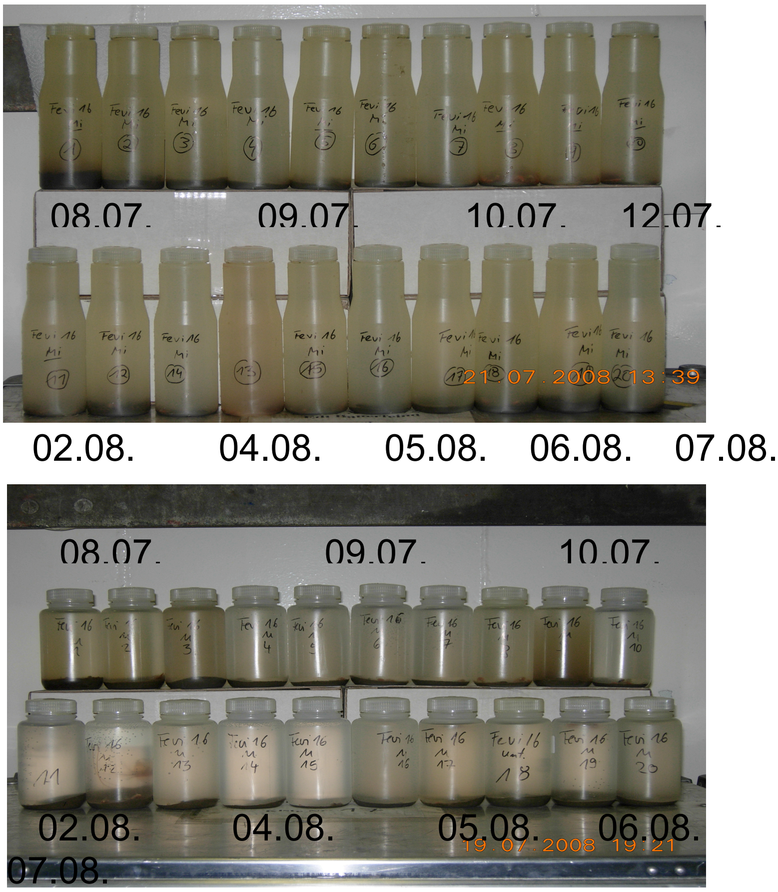

Fig. 5.2: Sampling bottles from sediment traps at the central Hausgarten *station, moored in 1,000 m and 2,400 m during July 2007 to July 2008*

Chlorophyll a concentrations in the *Hausgarten* area ranged between 1 and 3 μg Chl a dm^{-3} in the upper 30 m of the water column, with slightly higher concentrations in the southern and eastern region, whereas at the northern stations the Chl a concentrations were ~1 μg dm^{-3} or less. At most stations in the *Hausgarten* the concentrations of inorganic nutrients in the upper water layer were not exhausted which was mirrored in dense phytoplankton abundances. In the eastern and southern area phytoplankton composition was dominated by the prymnesiophyte *Phaeocystis* sp., the colony forming chrysophyte *Dinobrium* sp. and small diatoms of the genus *Chaetoceros* (*Chaetoceros socialis*, *C. teres*, *C. debilis*, *C.* spp.). In the northern region only very few diatoms species were observed. The phytoplankton was dominated by various species of dinoflagellates and small flagellates.

5.2. Structure and functioning of meio- and microfauna communities

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Objectives

The benthic standard long-term investigations in the KONGHAU area are dedicated to large-scale ecological investigations on the deep-sea community. The stations for these investigations are spread over a wide range in water depth and in latitudinal space (Fig. 5.1), so they cover a wide variety of different habitats. Sampling of virtually undisturbed sediments was done with a video guided multiple corer.

Work at sea

During ARK-XXIII/2, we were able to absolve a programme of 16 multicorer-operations in total. With the sampled sediments, we will be able to cover the full set of aspired biochemical analyses and investigations on the benthic organisms itself. Sediment related biochemical analyses comprise estimations for the input of organic matter from phytodetritus sedimentation and analyses of activity and biomass of the small sediment-inhabiting biota as well as assessments of distribution and diversity patterns of benthic organisms (covering all size classes from bacteria to meiofauna) and their temporal development.

Preliminary results

Immediately on board we measured the concentrations of sediment bound plant pigments as well as the potential hydrolytical activity of sediment inhabiting bacteria. Both sediment-related parameters showed a nice gradient of decreasing values with increasing water depth (Figs. 5.3 and 5.4) with expected very high concentrations on the shallow shelf station Kb0.

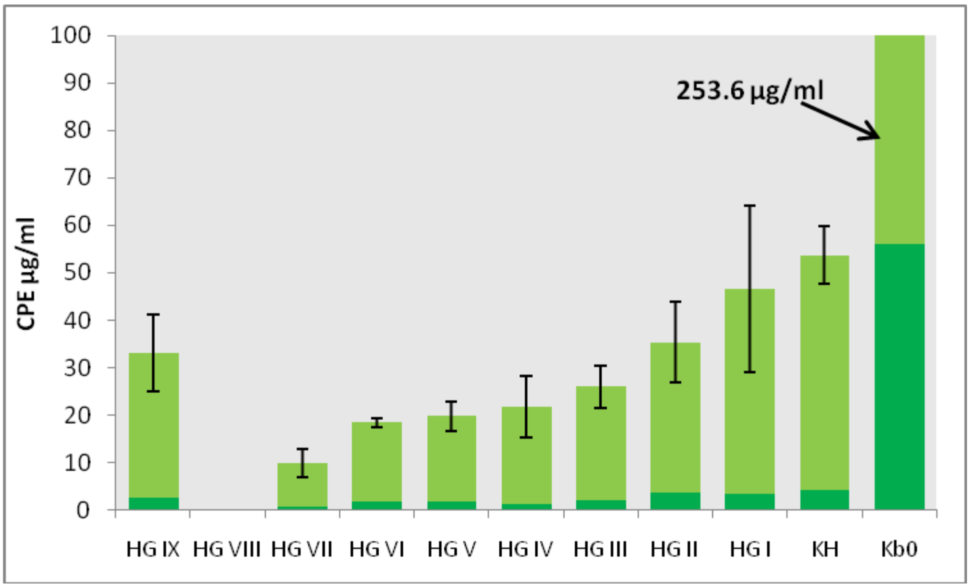

Fig. 5.3: Chloroplastic pigments bound in the first sediment centimetre (light green: phaeopigment; dark green: Chl a)

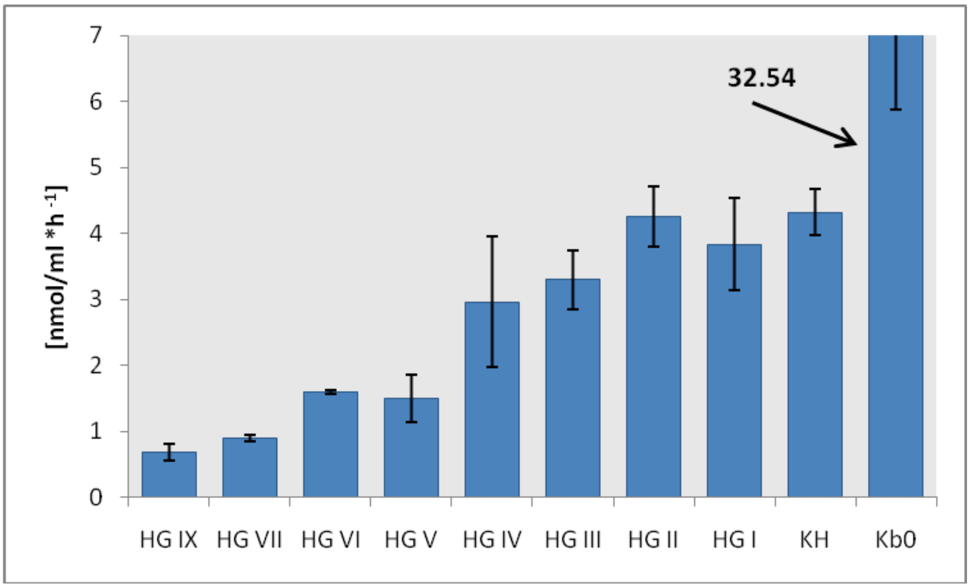

Fig. 5.4: Hydrolytical activity of bacteria within the first sediment centimeter

Fig. 5.5 shows exemplarily the long-term results from 1999 to 2008 of pigment concentrations in the uppermost sediment layer at the central *Hausgarten* station at 2,500 m. These results let suppose a continuous increase in phytodetritus availability during the years with a concurrent decrease of detritus quality. This is mirrored by a decreasing proportion of fresh chlorophyll a of the total plant pigment concentration.

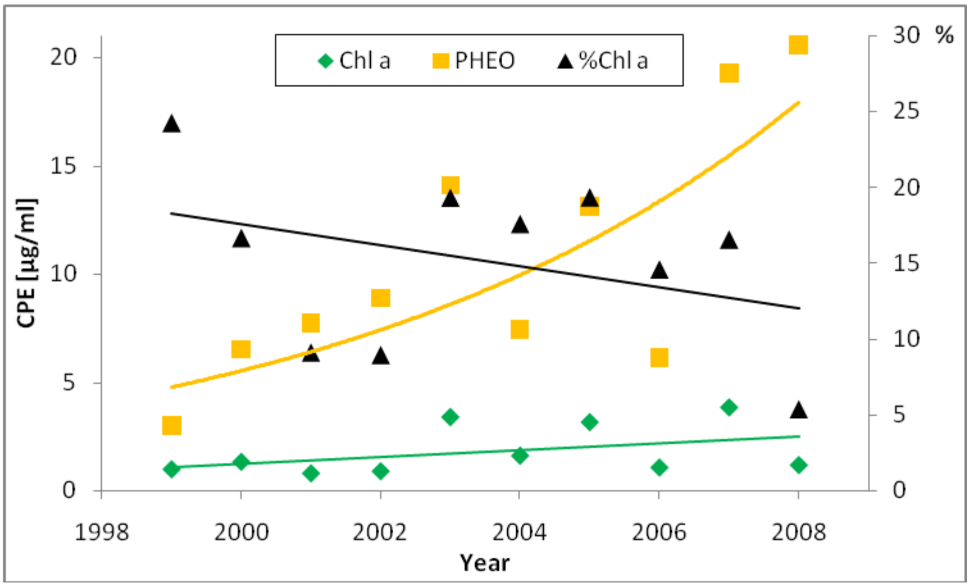

Fig. 5.5: Sediment bound pigments in the first cm of station HG VI from 1999 until 2008

Future analyses in Bremerhaven of the sediments will show, how far these preliminary results are confirmed by the remaining parameters. This will help to answer the question if already observed long-term trends in the AWI-*Hausgarten* are continuing, and to which extend climate change induced processes might be responsible for these changes within the deep-sea ecosystem.

5.3. Oxygen micro-profile variability on *Hausgarten* transects based on shipboard measurements

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Objectives

Performing on board oxygen profile on sediment cores allowed us to study the oxygen distribution and the organic matter remineralisation in the sediment along a North-South transect at a constant depth of ca. 2,500 m and on a bathymetric transect from 1,300 to 5,500 m in the *Hausgarten* area. In addition, we explored the effect of small scale features (burrows, crinoids, hydrozoans and foraminifera colonies) on oxygen dynamics in the sediment.

Work at sea

Twelve different stations from the *Hausgarten* area (central Arctic) were investigated (Table 5.2). Cores were collected using the AWI Multicorer (MUC). Profiles were acquired in a cold room maintained at 0°C within a few hours after core recovery without air bubbling or stirring. The profiles were performed in duplicate or triplicate using a 100 *µ*m tip oxygen microelectrode (Clark, with a guard cathode) and monitored by a PA2000 (Unisense). The electrode was moved using a motorized micromanipulator with a maximum resolution of

100 μm. Several small-scale biological features were studied in these cores: Crinoid, agglutinated hydrozoans or foraminifera, large burrows, and sponges.

Tab. 5.2: Stations for oxygen micro-profiles

Label	Station	Date	Long	Lat	Depth (m)
PS72/106-2	KG 0	06.07.08	79° 1,71' N	11° 5,25' E	284
PS72/118-2	KH	08.07.08	79° 1,80' N	6° 59,99' E	1269
PS72/122-2	HGIV	09.07.08	79° 3,93' N	4° 11,04' E	2414
PS72/125-2	S1	10.07.08	78° 55,03' N	5° 0,13' E	2577
PS72/126-2	S2	10.07.08	78° 46,82' N	5° 19,99' E	2416
PS72/129-2	S3	10.07.08	78° 36,46' N	5° 3,80' E	2288
PS72/131-2	HGIII	11.07.08	79° 6,48' N	4° 36,05' E	1897
PS72/136-2	HGII	11.07.08	79° 7,82' N	4° 53,99' E	1519
PS72/137-2	HGI	12.07.08	79° 8,07' N	6° 5,52' E	1243
PS72/141-2	HGV	13.07.08	79° 3,21' N	3° 44,61' E	2816
PS72/142-2	HGVI	13.07.08	79° 2,78' N	3° 35,94' E	3363
PS72/146-2	N3	14.07.08	79° 35,68' N	5° 12,48' E	2721

Preliminary results

The replicate profiles performed on sediment cores were very reproducible. They all showed a large decrease in the uppermost layers, but at most stations the penetration depth of oxygen was not reached at 10 cm. There appeared to be little variation along the North-South transect at 2,500 m, whereas a decreasing trend was clearly visible in oxygen gradient and asymptotic concentration along the bathymetric transect from 280 m to 4,000 m. At this depth range, the only core with an anoxic zone was the core at 284 m with an oxygen penetration of 6 mm. The situation below 4,000 m reversed to an oxygen-limited system. The depth pattern of oxygen uptake observed along the bathymetric transect reflects the decreasing input of organic matter from 1,300 m to 4,000 m.

5.4 Benthic food web structure and megafaunal diversity at *Hausgarten*

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Objectives

Deep seafloor communities, especially those from the ice-covered Arctic, are subject to severe food limitation as the amount of particulate organic matter (POM) from the surface is attenuated with increasing water depth (Wassmann et al. 2003). This should be reflected in the structure of assemblages found at different depths. To date, however, little is known about the trophic interactions between benthic organisms and ecosystem function of such assemblages. One of the big questions is, how are such food-limited ecosystems sustained and who eats whom.

Stable isotope analysis has been increasingly used to characterize food webs. This method relies on the fact that the heavy isotopes of nitrogen and carbon (^{15}N, ^{13}C) are enriched throughout the food web from primary producers via consumers to top predators and scavengers. Previous research has shown that the *Hausgarten* food web encompasses five trophic levels (Bergmann et al. accepted) and therefore belongs to the longest food webs. This indicates continuous recycling of organic material, which is typical of food-limited ecosystems such as the deep sea. Although the $\delta^{15}N$ signatures ranged from 3 ‰ (Foraminifera) to 21 ‰ (starfish *Poraniomorpha tumida*) the majority of organisms occupied the second and third trophic level. Surprisingly, depth-increasing food limitation affected the different feeding types in different ways: While the isotopic signatures of predators/scavengers did not change, the $\delta^{15}N$ of suspension feeders increased with depth, and the reverse was found for deposit feeders. In contrast to other studies, the $\delta^{15}N$ of POM samples obtained below 800 m at different depths was not significantly different indicating that changes in $\delta^{15}N$ could not be held responsible for the depth-related $\delta^{15}N$ changes observed for benthic consumers. However, the $\delta^{15}N$ of sediments decreased with increasing depth which explains the trend found for deposit feeders.

Within the framework of a new project, KONGHAU, we aim to merge selected *Hausgarten* stations with those from the shallower Norwegian long-term transect off the Kongsfjorden. The aim of this work is to contribute benthic (food web) data to selected Kongsfjorden stations while the Norwegian partners from the ARCTOS network add pelagic data to selected *Hausgarten* stations which will be integrated in an ecosystem model.

Work at Sea

One giant box corer was taken at Kongsfjorden station KB0. Unfortunately, the subsequent 3 deployments only yielded empty cores so that this part of the programme was abandoned. Four 0.5 h trawls were taken by a large Agassiz trawl (stations V12, KH, HGI and IV). The volume of the catch was estimated by transferring it into counted buckets. It was washed on a sieving table. One haphazardly chosen (reference-) bucket was sieved over a 0.5-mm mesh sieve and sorted into broad taxonomic groups using a binocular for taxonomic identification/diversity analyses. The remainder of the catch was washed over a 1-mm mesh, and a minimum of six individuals per taxon was taken for stable isotope analysis. Macrofaunal organisms were sampled by use of a binocular. All fish from the catch were weighed and measured before sampling the tissues and otoliths. All tissue samples were shock-frozen and freeze-dried in a lyophilisator. After grinding, the samples were decalcified by addition of HCl and ground again after drying. From megafaunal organisms and demersal fish 334 and 35 tissue samples were taken, respectively. Additional specimens were taken for ground-truthing of the OFOS footage and for genetic bar-coding purposes.

Bottom and surface water samples were taken by the CTD water sampler at selected stations (see Bauerfeind). The water was filtered to obtain phytoplankton and particulate organic matter for stable isotope analysis to obtain a baseline value for the food web. Fifteen surficial sediment samples were gained from multiple cores (see Schewe et al.) for stable isotope analysis as an estimate for the trophic level of bacteria. All (384) samples will be analyzed by isotope-ratio mass spectrometry at the Natural History Museum in Berlin.

Preliminary results

Description of the box core and Agassiz trawl catches (Fig. 5.6; see Janussen for a description of the sponge fauna).

KB0 (PS72/106-3): The giant box corer was only half-full. One half was preserved for taxonomic identification, the other was sorted immediately on sea ice to obtain specimen for stable isotope analysis. Unfortunately, the sample contained only few organisms.

V12 (PS72/137-5): The (31 bucket) catch contained many small and large stones. The catch was very diverse. It was dominated by at least four different species of brittlestars (*Ophiura* spp., *Ophiothrix* sp.). The catch also contained many whelks (*Neptunea antiqua*?), ophistobranchs (*Philine* sp.), cockles, limpets, chitons, sea urchins, shrimps (*Pandalus* sp.?, *Pontophilus* sp.), tube worms, scale worms, priapulids, sipunculids, and anthozoans. There was a minimum of six different species of starfish. This site appeared to constitute a nursery ground as it harboured many small fish (*Myoxocephalus scorpius*?, Lumpenidae, *Hippoglossoides cf. platessoides*, Lycodes sp., rays).

KH (PS72/118-7): The (47 bucket) catch was characterized by brittlestars (*Ophiocten cf. gracilis*), small bivalves, tube worms, a smaller-sized pycnogonid species and *Colossendeis proboscidea*. Only two fish (*Lycodes squamiventer, Gaidropsarus argentatus*) were caught. The catch also contained the jaw bone of a whale, some shrimps (Bythocaris spp.), echiurans (*Hamingia arctica*), *scaphopods (Siphonodentalium laubieri?)* and starfish (*Bathybiaster vexillifer*).

HGI (PS72/137-5): The (23 bucket) catch resembled that of KH. It contained many tube worms, small bivalves, *O. gracilis*, *B. vexillifer*, *C. proboscidea, H. arctica, S. laubieri*? In terms of fish, four *L. squamiventer* and one *Lycodonus flagellicauda* were caught.

HGIV (PS72/156-1): The (21 bucket) catch was dominated by the sea cucumbers *Kolga hyalina* and *Elpidia heckeri*. There were also large quantities of gastropods (*Mohnia mohni* and *Tacita danielsseni*), small sea spiders (*Ascorhynchus abyssi*?). The catch was also characterized by small anthozoans (*Bathyphellia margaritacea*?), sea lilies (*Bathycrinus cf carpenteri*) and the irregular sea urchin (*Pourtalesia jeffreysi*?). Twelve Arctic eelpouts (*Lycodes frigidus*) and one jumbo octopus were also caught.

Fig. 5.6: Photographs of organisms caught at stations V12, KH and HGI and IV

5.5. Agassiz Trawl deployments: Report of the Porifera (sponges) collected in the Fram Strait and South of Belgica Bank (NE Greenland)

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Objectives

Together with cooperation partners, taxonomic, zoogeographic and phylogenetic investigations are performed on the sponges collected during 4 expeditions to the Antarctic Weddell Sea (2002-2008). As part of a research project on the phylogeny and radiation history of Polar deep-sea sponges, we want to compare Porifera key taxa from the Arctic and Antarctic, to resolve the phylogenetic relationships of sponges in the Polar deep-seas, and to gain a better understanding of their evolutionary ecology in these extreme environments. Purpose of sponge research during this expedition was the collection of fresh material of representative Porifera taxa and its documentation and fixation for molecular biology, and further investigations.

Work at sea

Sampling was done mainly by use of the Agassiz Trawl (AGT). Furthermore, the study of sponges on OFOS videos was important to better understand the ecology and distribution of Porifera taxa in the *Hausgarten* and to select appropriate sites for the employment of benthic sampling gears (MUC, KG, AGT). The AGT was employed to obtain representative samples of animals and sediment from the *Hausgarten* stations and to improve the identification of different taxa on underwater photos.

Preliminary results

During this expedition, we employed the AGT at 5 stations (Table 5.3), and all of the hauls were successful in the sense that we obtained representative biological samples from each station trawled.

Tab. 5.3: Main data from the AGT stations 1-5

AGT No.	Station No.	Position, Area	Date	Depth (m)	Trawling dist. (calc.)	Catch: no. buckets, sediment/ animals
1	72/107-	78:58.0 N 09:85.4 E Kongsfjord-renna	6.07.08	237-225	580 m	30 b., mainly stones/ echinod. (aster., ophior.), fishes, scrimps, ca. 20 sponges
2	72/118-7	79:02.9 N 06:59.9 E E`-border of Hausgarten	8.07.08	1337-1307	966 m	47 b., silty clay/ ophiurides, pentapodes, bivalves, 1 fish, few sponges
3	72/137-5	79:08.9 N 06:08.5 E HG I	12.07.08	1281-1272	1022 m	23 b., silty clay/ echinod. (aster., ophior.), fishes, scrimps, pentapodes
4	72/156-1	79:02.2 N 03:50.7 E HG IV	16.07.08	2741-2738	1539 m	21 b., silty clay/ many holothurians, irregular echinoids, abundant small sponges, fishes,
5	72/213-2	77:30.8 N 14:59.3 W S`of Belgica Bank, NE Greenland	25.07.08	316-320	489 m	13 b., silty clay, many stones/ many fishes, Echinod. (aster., crinoid., ophior.), crustaceans, sponges

Porifera collection: About 250 sponges were collected by the AGT; one complete specimen of Cladorhiza (the only well-preserved cladorhizide, including soft body) was caught by the MUC. The sponges were washed and preliminarily sorted into morpho-types, and each morpho-group was counted and photographed. Depending on the amount of material, samples were taken from each morpho-species and fixated for molecular biology, histology, EM, or frozen (-20 °C) for biochemical investigations. At the *Hausgarten* stations, samples of characteristic sponge groups were taken by M. Bergmann and frozen (–80 °C) for stable isotopes. At a later stage, exchange, comparison of results and further cooperation are planned.

All together, 23 morpho-types were preliminarily distinguished, and from 19 skeletal preparations were made to obtain more detailed taxonomic identifications. A list of still very preliminary identifications of the sponge taxa is given below (Table 5.4). The number of species listed is conservative and will most probably increase.

Tab. 5.4: First preliminary list of sponge taxa

Station/Depth/ Specimens no.	#107- ,AGT1 237-225 m	#145-3, MUC 2670 m	#118-7,AGT2 1337-1307 m	#156-1,AGT4 2741-2738 m	#213-2,AGT5 316-320 m
Demospongiae: Astrophorida:					
Thenea cf. *abyssorum*				ca. 50	
T. valdiviae				ca. 50	
Hadromerida:					
Tentorium spp.			sp.1: 1	sp.2: ca. 10	
Radiella sol				ca. 100	
Polymastia spp.			sp.1: 1, sp.2: 1		sp.3: 1
Stylocordyla sp.				6	
Suberitidae sp.					3
Halichondrida: Axinellidae:					
Phakellia sp.			6		
Poecilosclerida: Myxillina:					
Hymedesmia spp.	sp.1: 1		sp.2: 1		
Crella sp.	1				
Lissodendoryx sp.					1
Mycalina:					
Desmacellidae sp.	1				
Hamacantha sp.	ca. 25				
Cladorhizidae:					
Cladorhiza cf. *tenuisigma*		1	1	1	
Microcionina:					
Artemisina sp.	1				
Demospongiae sp., incrust.					2
Hexactinellida: Rosselliidae:					
Schaudinnia cf. *rosea*					1
Bathydorus sp.					3
Calcarea: Calcinea:	:				
Sycon sp.				5	

According to this collection and to OFOS observations, the distribution of Porifera taxa is very patchy. This is true for both the distribution of species and of higher taxa (genera, families and orders). An example: At 2,500 m depth at HG1 on the OFOS, we observed large fields, densely populated by large specimens of *Caulophacus* and *Cladorhiza*. However, as the AGT was deployed at 2,700 m at HG4 (#156-1) only a few miles away from these fields, we caught a completely different sponge fauna. Here we collected hundreds of small sponges (5 - 10 mm); several species belong to the genera *Radiella* and *Thenea*. During this expedition, we collected mainly Demospongiae. We did not get any Hexactinellida from any of the HG stations (but from the NE Greenland coast), and only a few Calcarea were collected from the HG4 station. Within the Demospongiae we found, that there is hardly any species overlap between the stations sampled. Only of *Cladorhiza* cf. *tenuisigma* there is a questionable record from 3 HG stations, questionable because only the specimen from #145-3 was complete with soft body and microscleres; the other 2 specimens were denuded fragments without microscleres, and therefore do not allow a definite species identification (they look most similar to the denuded *Cladorhiza tenuisigma* figured by Lundbeck 1905). Perhaps some of the *Tentorium* and *Polymastia* spp. are identical between different stations, but this remains to be answered.

Discussion

Whereas the Antarctic shelf, due its relative isolation, is characterized by high specific endemism of the Porifera fauna, this is considered to be much less in the Arctic Ocean (Koltun 1970). In the deep-sea, however, this difference may be much less pronounced than on the shelf, because both of the Polar deep-seas are historically and continuously connected with other deep-sea regions, notably the Atlantic and the Pacific. First results from the ANDEEP I-III expeditions (2002 - 2005) have shown that the Antarctic abyssal sponge fauna possesses a higher affinity to the deep-sea faunas in other oceans than to the Antarctic shelf (Janussen & Tendal 2007). It will be an important part of our present research project (JA-1063/14-1) to investigate the phylogenetic relations between Arctic and Antarctic sponge taxa, such as the allegedly bi-polar species, e. g. *Tentorium semisuberites*.

The extremely patchy distribution of sponge taxa is characteristic for most deep-sea environments, including the Antarctic, but so far the reasons for this phenomenon are not well understood. Mostly local variations in nutrition supply which is in some places higher, e.g. near the ice shelf edge, are discussed as possible a tricker controlling the diversity and abundance of the benthic fauna. Another factor, particularly concerning the sessile animals, is the availability of substrates for larval settlement. In the deep-sea, many sponge groups, such as most of the sponges collected in the *Hausgarten* during this expedition (e.g. *Cladorhiza* and *Thenea* spp., and *Radiella sol*), possess root tufts or radiating basal spicules, which make them independent of hard substrates and enable them to settle and live on the soft sediment. However, for the Porifera sedimentation rates seem to be another, maybe even more severe limiting factor, because heavy load of fine sediment particles such as clay may inhibit their suspension feeding by blocking the aquiferous system of the sponges. It is assumed that generally higher sedimentation rates in the Arctic may be a reason for the lower sponge diversity recorded in the Arctic compared to the Antarctic Ocean (Koltun 1970). Also the bottom currents probably play an important role. In the future, these hypotheses need to be tested by detailed studies of sponge taxa distribution and diversity in comparison with data on sedimentation, currents and water chemistry in the Polar deep-seas. For the Arctic, the AWI-*Hausgarten* seems to be the ideal place for this kind of research, as it is located in the important Fram Strait, and is already well-investigated; data already exist from one decade of monitoring. Unfortunately, a similar deep-sea observatory is missing in the Antarctic. There, we have to rely on comparably sporadic data, e.g. from the ANDEEP/SYSTCO programmes, and to aim for further Antarctic deep-sea expeditions to investigate the biotic response on environmental factors, such as currents, bottom topology and sedimentation rates.

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6. SEISMOLOGY: RECORDING THE SEISMICITY OF LENA TROUGH WITH SEISMOMETERS ON DRIFTING ICE FLOES

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Alfred-Wegener-Institut

Objectives

Lena Trough is the decisive tectonic structure responsible for plate kinematics in the Fram Strait, a key location in the global conveyor belt, which controls the flow of cold Arctic water into all the oceans of planet earth. Up to 2004 even the morphology of the Lena Trough system was poorly known, and its key position in the global mid-ocean ridge system was seriously in doubt. However, dredges and multibeam bathymetry of the *Polarstern* cruise ARK-XX/2 have renewed the interest for the only bathymetric low among thousands of kilometres of bathymetric highs in the world´s mid-ocean ridge system. From the experience at the ultraslow-spreading Gakkel Ridge during the AMORE 2001 and the AGAVE 2007 cruises, it has been shown that the Arctic Ridge system consists of segments with pronounced volcanism and segments lacking any signs of melting. The Lena Trough has been proposed to lack melting nearly on its entire length. Lena Trough as a spreading rift is the youngest element of the Arctic Ridge system and its transition to the Spitsbergen Fracture Zone in the south is in many ways similar to the opening of the East African rift valley with the exception that the process opens a rift between continent and ocean and not in the interior of a continent. We therefore tried to characterize seismicity and tectonic control in this area (Fig. 6.1) of amagmatic spreading in order to compare it to magmatic segments of the Gakkel Ridge as a part of the scientific focus of the DFG-funded Emmy Noether group MOVE (Mid-Ocean Volcanoes and Earthquakes) headed by Vera Schlindwein at the Alfred-Wegener-Institut. Important questions remain unanswered: Which factors control the melting process? When does a rift system shift from amagmatic to magmatic spreading or vice versa? What opened the Fram Strait Gateway? Is there still evidence of former transform activity along the spreading center, which has been proposed before?

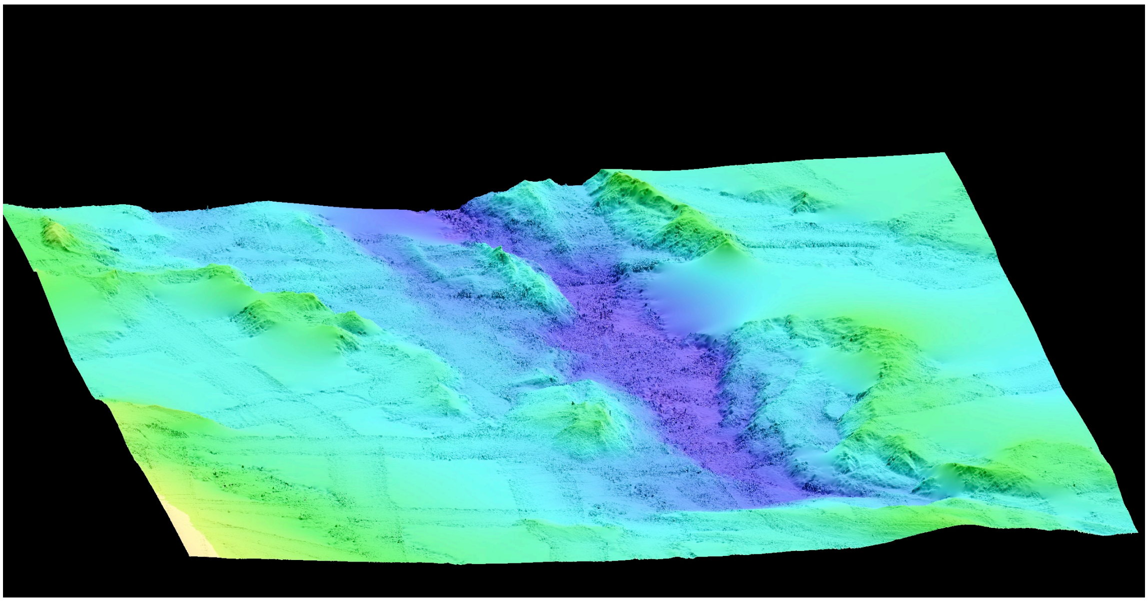

Fig. 6.1: The morphology from the southernmost part of the Lena Trough, with the transition to the Spitsbergen Fracture Zone (recorded during cruise ARK-XX/2 of Polarstern*), which was the target area during this cruise*

Work at sea

We deployed 3 arrays with 3 broadband seismometers each on ice floes in an area covering 20 x 20 km in order to characterize and locate seismicity in the southernmost Lena Ridge. The survey area was situated about 100 nm NNW from the northernmost *Hausgarten* station N4 and the oceanographic transect so that during the deployment phase it was only accessible by helicopter. Only 2 stations from one array could be deployed at the same time. A complete number of 5 flights was necessary to deploy the acquisition setup, and this could only be arranged in 3 different days, so that the coverage of the area is heterogeneous and varies with time (Table 6.1).

Every broadband seismometer station was equipped with a GURALP CMG-3ESPC seismometer, a Reftek data logger, GPS antenna and 2 or 3 batteries. Two of 3 stations on the same ice floe also included an Argos transmitter so that we were informed about the locations of our stations during the entire cruise. The deployment and recovery positions are listed in Table 6.1.

During the deployment phase fog dominated the weather around *Polarstern* so that long distance flights of 100 km were hard work for the pilots, because they constantly had to look for suitable pathways though the fog patches in order to arrive at the target locations. The sea ice coverage, where visible during the flight, consisted mostly of floes not bigger than 50 m in diameter, open sea up to a couple of hundred meters wide and rarely large ice floes of 1 km or more base length. At position, it was almost impossible to determine ice floe sizes from high air positions so that each suitable position had to be verified by a flight around the entire ice floe. No ice floe with a diameter of more than a couple of hundred meters was found. The ice floes were covered with small pools of melt water, but water temperatures below zero let them appear trustworthy to us. We tried to arrange the 3 stations on one floe in a triangle within one wavelength of the dominating frequencies in order to allow array processing methods during the data analysis phase. The scientific equipment was packed in a red box (0.8x0.6x0.4 m), and a red flag was erected next to the station.

After deployment, the Argos transmitters sent a signal containing their position, the status of the Reftek data loggers and the battery every hour. These messages were bundled by Optimare and sent to an e-mail account aboard *Polarstern* so that we were always following the stations. Interdistance measurements between the positions of the transmitters can tell us, whether the entire ice floe field was drifting in an ice pack, and the relative position of the stations remained more or less the same during the experiment. Interdistance measurements between the positions of the transmitters in the same arrays can tell us, whether the ice floes are breaking apart. The drift of the ice floes was later analysed in comparison to the wind situation throughout the monitoring phase.

On 27 July the weather was fine, and we were able to recover 8 of 9 stations. The ice floes appeared to be smaller on average with rare big ice floes in between. With relatively old positions (i.e. a couple of hours old messages from the Argos transmitters) it was hard to detect the ice floes but when the first station on a floe was retrieved the others were easy to find, even when a new flight had to be started because the GPS coordinates could be memorized in the helicopters GPS receiver. Some of the flags had dropped to the floor so that recognition was complicated.

The last station LENA 2-3 was only retrieved 2 days later because fog did not permit recovery the next day and the station was not located on the same ice floe anymore. The ice floe had split and been joined to another floe so that its size had increased, and the station was located in the interior of the floe instead of the rim. The position was only detected after an Iridium telephone call with an update of the Argos position 10 minutes before recovery.

Tab. 6.1: Deployment and recovery data of the seismic station setup (in German)

	LENA 1-1	LENA 1-2	LENA 1-3	LENA 2-1	LENA 2-2
Station/Argos	AWI 34, Argos: 29466	AWI 35, Argos: no	AWI 36, Argos: 29468	AWI 28, Argos: no	AWI 29, Argos: 29467
Deployment	14.07.08, 21:04 N 80° 39,02' W 1° 18,59'	19.07.08, 17:15 N 80° 17,67' W 1° 36,77'	14.07.08, 20:42 N 80° 29,75' W 1° 20,53'	39648, 0,775 N 80° 10,46' W 1° 52,44'	14.07.08, 17:35 N 80° 25,6' W 1° 38,36'
Checkflight	19.07.08, 16:20 N 80° 17,78' W 1° 37,03'	kein Checkflight kein Checkflight kein Checkflight	kein Checkflight kein Checkflight kein Checkflight	kein Checkflight kein Checkflight kein Checkflight	19.07.08, 18:00 N 80° 9,71' W 1° 52,48'
Batteries	AGM 23 wurde getauscht; Aktuelle Batterie = AGM 12 AGM 17 (Batterie wurde nicht getauscht) --- ---	AGM 10 (Batterie wurde nicht getauscht) AGM 8 (Batterie wurde nicht getauscht) --- ---	AGM 13 (Batterie wurde nicht getauscht) AGM 14 (Batterie wurde nicht getauscht) AGM 1 (Batterie wurde nicht getauscht) ---	AGM 6 (Batterie wurde nicht getauscht) AGM 22 (Batterie wurde nicht getauscht) --- ---	AGM 18 wurde getauscht; Aktuelle Batterie = AGM 3 AGM 19 (Batterie wurde nicht getauscht) --- ---
Recovery	27.7.08, 16:20 N 80° 4,53' W 0° 27,84'	27.7.08, 12:21 N 80° 4,54' W 0° 28,63'	27.7.08, 12:00 N 80° 4,49' W 0° 27,23'	27.7.08, 20:47 N 79° 47,67' W 1° 25,86'	27.7.08, 21:05 N 79° 47,2' W 1° 21,04'
Reftek	Card 36 (blauer Punkt): A107 Card blauer Punkt:	Card 29 (blauer Punkt): A10C Card 28 (blauer Punkt):	Card 37 (blauer Punkt): A10E Card blauer Punkt:	Card blauer Punkt: A088 Card blauer Punkt:	Card 32 (blauer Punkt): A0F8 Card blauer Punkt:
Rec Batteries	AGM 17 mit 7 V AGM 12 mit 12,15 V --- ---	AGM 10 mit 12,12 V AGM 8 mit 11,34 V --- ---	AGM 1 mit 12,33 V AGM 13 mit 11,73 V 14 AGM mit 11,84 V ---	6 AGM mit 11,83 V 22 AGM mit 12,16 V --- ---	19 AGM mit 11,31 V 3 AGM mit 12,04 V --- ---
Remarks	Falsch benannt!? Lena 3-3 zu Lena 1-1 --- --- ---	--- --- --- ---	1 Kabel zu viel --- --- ---	in Nähe von grosser aufragender Sedimentscholle --- --- ---	--- --- --- ---
Remarks Check	ACQ OFF um 16:20 Uhr GPS Antenne und Kabel getauscht Erneuerung Schneehaufen ---	--- --- --- ---	--- --- --- ---	--- --- --- ---	ACQ OFF um 18:05 Uhr nach Tausch ACQ ON Schneehaufen erneuert und Flagge neu gesteckt ---
Remarks Rec	--- ---	Eimer wurde von Seismometer weggeweht Seismometer nicht mehr level	Seismometer nicht mehr level Fahne umgefallen	Seismometer nicht level durch Landung Kübel weggesegelt	Seismometer nicht mehr level ---

Tab. 6.1: Deployment and recovery data of the seismic station setup (in German), continued

	LENA 2-3	LENA 3-1	LENA 3-2	LENA 3-3
Station/Argos	AWI 30, Argos: 29469	AWI 31, Argos: no	AWI 32, Argos: 29462	AWI 33, Argos: 29470
Deployment	14.07.08, ca. 16:30 N 80° 25,94' W 1° 42,71'	20.07.08, 13:24 N 80° 19,5' W 2° 29,31'	20.07.08, 14:00 N 80° 19,59' W 2° 26,12'	20.07.08, 10:00 N 80° 19,589' W 2° 29,108'
Checkflight	kein Checkflight kein Checkflight kein Checkflight	kein Checkflight kein Checkflight kein Checkflight	kein Checkflight kein Checkflight kein Checkflight	kein Checkflight kein Checkflight kein Checkflight
Batteries	AGM 7 (Batterie wurde nicht getauscht) AGM 24 (Batterie wurde nicht getauscht) AGM 21 (Batterie wurde nicht getauscht) ---	AGM 2 (Batterie wurde nicht getauscht) AGM 15 (Batterie wurde nicht getauscht) --- ---	AGM 20 (Batterie wurde nicht getauscht) AGM 11 (Batterie wurde nicht getauscht) --- ---	AGM 16 (Batterie wurde nicht getauscht) AGM 5 (Batterie wurde nicht getauscht) AGM 9 (Batterie wurde nicht getauscht) ---
Recovery	29.7.08, 16:20 N 79° 37,92' W 1° 18,19'	27.7.08, 15:40 N 80° 6,68' W 1° 12,13'	27.7.08, 18:00 N 80° 7,37' W 1° 11,14'	27.7.08, 18:25 N 80° 7,02' W 1° 12,34'
Reftek	Card 35 (blauer Punkt): A0F9 Card blauer Punkt:	Card 31 (blauer Punkt): A0FA Card 34 (blauer Punkt):	Card silberne Karte: A0FE Card blauer Punkt, schwarz X:	Card 30 (blauer Punkt): A101 Card blauer Punkt:
Rec Batteries	21 AGM mit 8,32 V 24 AGM mit 11,88 V 7 AGM mit 12,26 V ---	15 AGM mit 12 V 2 AGM mit 11,9 V --- ---	20 AGM mit 11,9 V 11 AGM mit 12 V --- ---	16 AGM mit 12 V 9 AGM mit 12,1 V --- ---
Remarks	"Send to DAS" vergessen --- --- ---	centered! --- --- ---	Kabel vertauscht - Batterie an Argos Serial --- --- ---	--- --- --- ---
Remarks Check	--- --- --- ---	--- --- --- ---	--- --- --- ---	--- --- --- ---
Remarks Rec	Seismometer nicht level	---	Seismometer nicht level	Fahne umgefallen

Preliminary results

Wind and ice drift: While the stations were recording data the ice floes drifted, so from the synoptical charts that were created in the weather office on board we tried to create a daily average wind table in the area of interest. This is listed in Table 6.2.

Tab. 6.2: Wind speed and direction during the recording time

Day	Wind direction	Wind speed (Beaufort)
14/07	N	4
15/07	SSW	1
16/07	W	3
17/07	NW	3
18/07	N	2
19/07	NNW	2
20/07	N	3
21/07	SSW	2
22/07	WNW	2
23/07	S	2
24/07	WNW	2
25/07	SE	3

By simply applying Nansen´s rule of thumb that ice floes drift about 28° to the right of the dominant wind direction and with a speed $1/50^{th}$ of the wind speed, we tried to model the ice floes in order to use this as a forecasting tool.

There is reasonable agreement between the real drift and the predicted drift as displayed in Fig. 6.2, so that a daily visit to the meteorologist is not only essential to get a fog forecast for flying conditions but also to estimate the amount of ice drift. Late in the recovery phase we discovered that the meteorological station aboard *Polarstern* also receives messages from the Argos messages via the NOAA16 and Feng Yung satellites so that next time decoding of the messages using a local software is possible.

Seismic data: All the seismic stations contributed continuously data to the experiment. Not all the channels, however, worked well during the entire period so that a first inspection rendered an overview over the working periods of the single channels. This leads us to believe that rather than as a homogeneous 3-component-experiment we have to treat the data as a heterogeneous 1-component-experiment, because sometimes horizontal and sometimes vertical sensors worked better.

During the deployment a local seismic earthquake with a distance of about 60 km was recorded on 7 of the 9 seismographs and is depicted in Fig. 6.3. Many further earthquakes are expected but the present example is a good display of the stations setup performance during the experiment. Further waveforms and bulletins will only be published after careful data analysis.

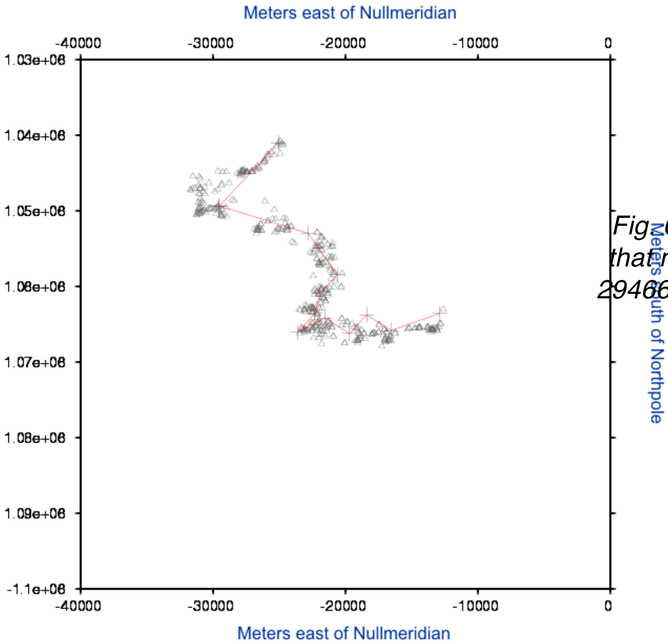

Fig. 6.2: Real ice drift displayed by triangles that mark every position of Argos transmitter 29466 and predicted ice drift by Nansen´s rule of thumb as a red line

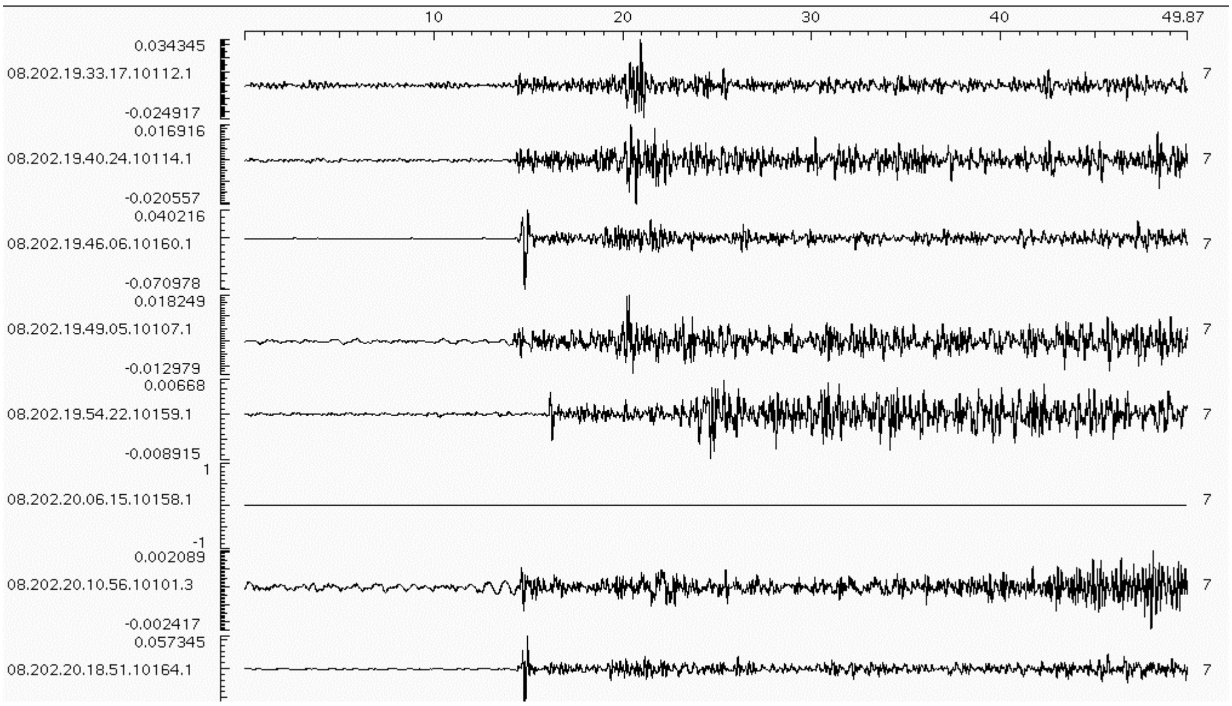

Fig. 6.3: Waveforms in pql of a local earthquake registered on the temporary setup of our stations. From a s-p-time of 6 seconds we calculated a distance of around 60 km.

Discussion

A lot of experience on the setup of seismic stations with the new equipment of the MOVE group at AWI was gathered during the cruise. Discussions with other cruise participants developed a pool of ideas that will be analysed in the near future on how to ease recovery operations and detecting the seismic stations.

Operating with ice floe stations on the southern ice edge of the Arctic Ocean is a thrilling task, and it should also be thought about operating ocean bottom seismic stations instead, since deployments can be arranged on longer time scales and by breaking the ice recovery is straight-forward. If we make use of the full instrument pool and software tools at AWI and aboard *Polarstern* we can further improve our experiment next time.

7. WHAT CONTROLS BIOGEOGRAPHIC BOUNDARIES OF NORTH ATLANTIC AND ARCTIC ZOOPLANKTON SPECIES? LIGHT FRAME ON-SIGHT KEY SPECIES INVESTIGATION (LOKI)

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Objectives

The composition and distribution of pelagic fauna in the Arctic Ocean is strongly affected by the inflow of Atlantic water. This inflow advects North-Atlantic zooplankton populations from the Greenland Sea via the Fram Strait and from the Barents Sea shelf into the Eurasian Basin (Hirche & Mumm 1992; Kosobokova & Hirche 2000). The conditions to which these populations are physiologically adapted are quite different from the conditions in the Arctic Ocean, so that their survival in the Arctic largely depends on their tolerance to Arctic conditions. While many species die off shortly after entering the Arctic Ocean, others survive due to their starvation potential or even continue their development for some time. Consequently, the Arctic Ocean is a large sink for organic carbon produced in the North Atlantic.

During the 1990s, various observations indicated that the circulation of Atlantic-derived water in the Arctic Ocean had changed considerably. In the Eurasian Basin the Atlantic layer had become warmer and saltier (Schauer et al. 2004), and the boundary between the Atlantic and Pacific waters moved into the Canadain Basin to an extent not previously observed (McLaughlin et al., 2002). These changes may have strong consequences for the pelagic ecosystems and hence sequestration of carbon and biogeochemical cycles in the Arctic Ocean. Further warming could favor the survival of the highly productive Atlantic communities, which finally could replace the Arctic fauna characterized by low biomass and low production (Hirche & Mumm, 1992; Kosobokova & Hirche, 2000). Shifts in species distributions will have dramatic effects on higher trophic levels such as birds and planktivorous fish, which select for prey size. Different timing of the life cycle changes food availability for predators.

In the northern North Atlantic, several large species of copepods dominate the water column and determine secondary production and vertical carbon flux. The hydrographic domains (Atlantic, Arctic, and polar) are inhabited by different species which are distinguished by size and life cycle strategies.

Although there are large interfaces between the hydrographic domains, at present these copepod species are contained within their different domains. When exported with currents they are expatriated and not able to maintain self-supporting populations. Thus, the troughs on the East Greenland Shelf are areas of expatriation of Atlantic species advected onshelf with the Return Atlantic Current.

However, only little is known on the factors constraining biogeographic shifts. Temperature and/or timing of food availability are possible controls. Predicting shifts in species distributions require detailed knowledge on physiological and behavioral constraints. In addition, both direction and velocity of advection depend on vertical distribution pattern which may change on a diurnal and seasonal scale. Therefore high resolution sampling is required to describe the vertical distribution of zooplankton in relation to the physico-biological environment.

The goal of our work during this cruise is to describe the habitat of key mesozooplankton species in their source regions with a high resolution (Greenland Sea Gyre, Greenland shelf) and where water masses overlap (e.g. the East Greenland Polar Front and the Return Atlantic Current), to understand the magnitude and temporal scale of environmental stress they are exposed to.

Work at sea

The LOKI system is a newly developed optical gear. The abbreviation stands for Lightframe On-sight Keyspecies Investigation. It can be used to study the vertical and horizontal variability of mesoplankton distributions on small scales down to the decimeter level. An adopted setup of camera and an especially designed illumination unit allows LOKI to take up to 25 frames per second with shutter times below 50 μs at good signal to noise ratios. From the underwater unit, objects are cut out from the taken frames in real time and stored with a time-stamp. This time-stamp is coupled with the assignment of environmental parameters and metadata of each object during the data processing procedure. Each image of an organism has the complete information on environmental parameters (temperature, salinity, depth, fluorescence, oxygen, position). The data processing setup is done in a browser frontend, connected with a SQL based database. LOKI can be operated vertically and in a horizontal, towed modus (ship speed 2 knots).

Bongo net samples (300 μm mesh size) were taken on 10 stations (sampling depth ~150 - 200 m). Samples were sorted aboard for lipid analyses, and the remaining sample were preserved in 4 % formalin seawater solution.

Preliminary results

The LOKI system was deployed vertically at 21 stations (Table 7.1, Fig. 7.1). Whenever bottom depths allowed, the system was deployed down to its temporary maximum operation depth of 500 m. One additional haul was taken in a horizontal modus to test the towing behavior of the system.

The image quality is sufficient to discriminate clearly between large taxonomic groups. In most cases it is also possible to determine down to the species level by distinct properties, when individuals were not imaged sagittally (Fig. 7.2).

Copepods were the most abundant zooplankton group. At least three species were determined by preliminary image analyses: *Calanus hyperboreus*, *Euaugaptilus hyperboreus*, *Aetideopsis* spp. Besides several other zooplankton groups (e.g. Chaetognatha, Ostracoda, Amphipoda, Euphausidacea, Medusae, Ctenophora, Radiolaria), also cf Acantharia and the larvae of Polychaeta and Echinodermata were imaged in high quality.

Further data analyses will enable us to correlate species distribution with their physico-biological environment on a very small scale and to understand their physiological requirements.

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Tab. 7.1: LOKI stations during ARK-XXIII/2

Station	Date	Haul No.	Objects imaged
PS72/130	10.07.2008	1	2162
PS72/191	23.07.2008	2	692
PS72/196	23.07.2008	3	6428
PS72/204	24.07.2008	4	1160
PS72/208	24.07.2008	5	1663
PS72/211	25.07.2008	6	575
PS72/212	25.07.2008	7	1542
PS72/215	25.07.2008	8	1092
PS72/217	26.07.2008	9	1104
PS72/219	26.07.2008	10	756
PS72/228	27.07.2008	11	1272
PS72/237	28.07.2008	12	3615
PS72/241	29.07.2008	13	2421
PS72/248	29.07.2008	14	1418
PS72/252	30.07.2008	15	694
PS72/256	30.07.2008	16	511
PS72/258	31.07.2008	17	874
PS72/265	31.07.2008	18	794
PS72/268	02.08.2008	19	670
PS72/274	02.08.2008	20	1648
PS72/281	05.08.2008	21	500
Total			31591

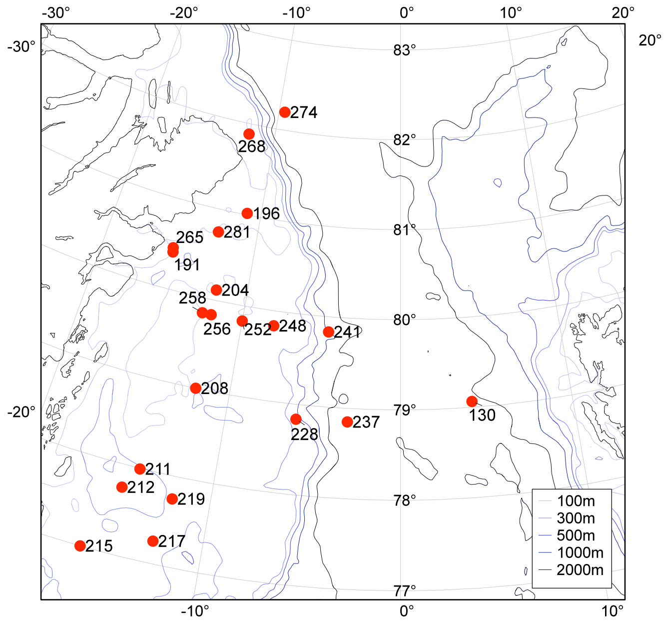

Fig. 7.1: LOKI stations during ARK-XXIII-2

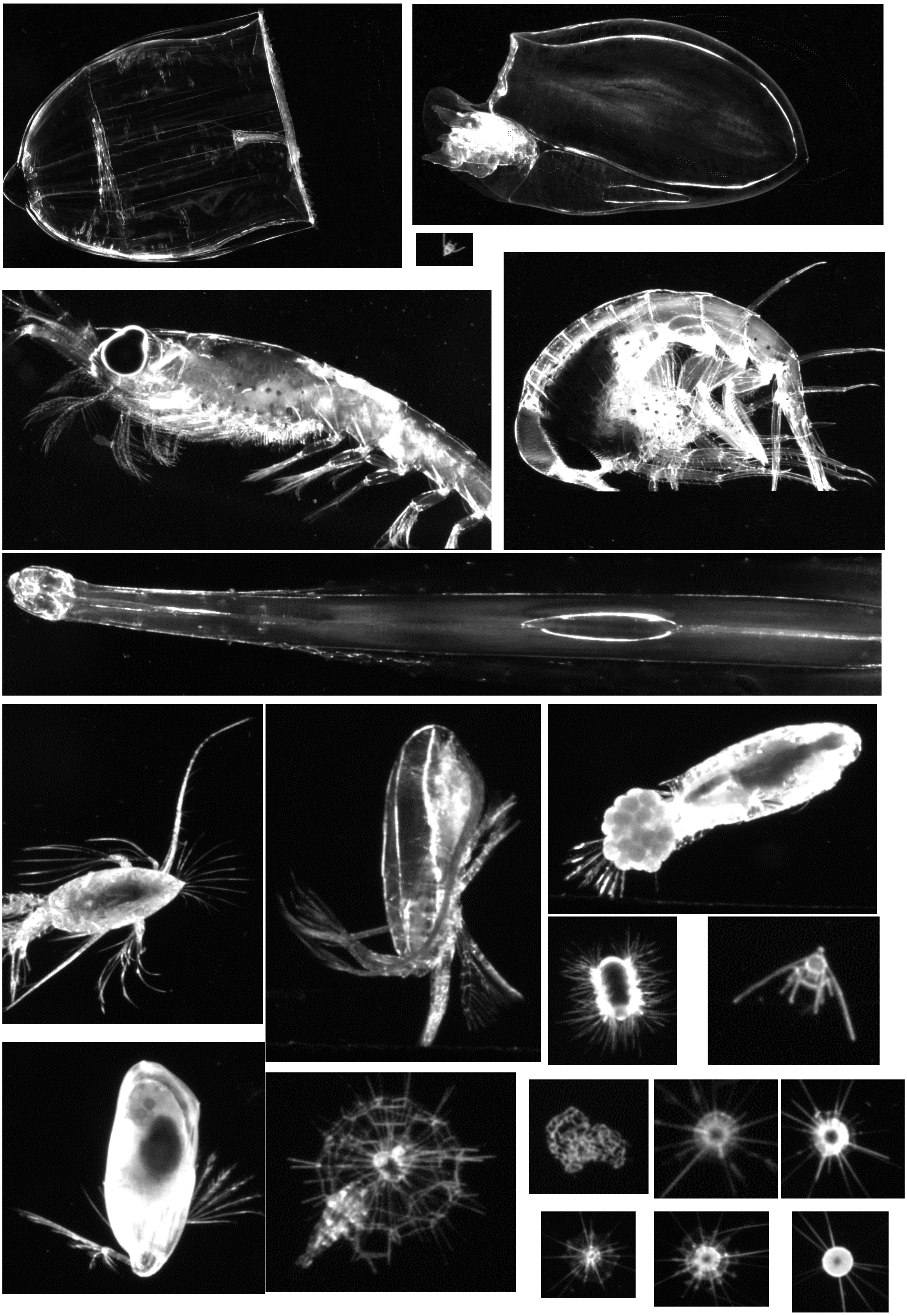

Fig. 7.2: Plankton species recorded with LOKI during ARK-XXIII/2. Images are not the same scale.

8. METHANE IN-SITU PRODUCTION AND ITS RELATIONSHIP WITH DMSP CATABOLISM DURING A PHYTOPLANKTON BLOOM IN THE NEW POLYNYA (GREENLAND)

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Objectives

Recent changes in the Arctic may have profound effects on natural biogeochemical cycles in seawater. Especially feedback effects to pathways of climatically relevant biogases like methane will loom large in the equation of change. The present marine methane cycle is influenced mainly by atmospheric methane transported by downward diffusion and convective ventilation into the deeper ocean, by fossil methane released from gas venting sites at the sea floor, microbial *in-situ* methane production in the upper ocean and microbial oxidation in the whole water column. A methane surplus relative to the atmospheric equilibrium concentration is a persistent feature of most ocean surface water. Although it is evident that microbial-induced production within the photic zone generates this super-saturation, the mechanism remains poorly understood. A principal pathway, by which methane is readily formed, is the methylotrophic methanogenesis. An abundant methylated substrate in the surface ocean is dimethylsulfoniopropionate (DMSP). Large amounts are produced annually by phytoplankton, and its turnover plays a significant role in carbon and sulphur cycling. With this expedition we expect to expand the knowledge about the coupling of methane production/consumption cycle with turnover in polar water during phytoplankton bloom in the marginal ice zone. Additional experiments were carried out to create a methane production under laboratory conditions. The aim of our investigations is to estimate the balance between the pathways and the resultant isotopic fractionation processes. The methane budget in the upper polar water will be estimated related to background concentrations and super-saturations. A further goal is to calculate sink and source capacities of these areas to estimate its contribution to the atmospheric methane budget at high northern latitudes.

Work at sea

Methane concentrations were measured at 40 stations along the western part of the Fram Strait transect and in the Northeast Water Polynya region (NEW). Water samples were collected with Niskin bottles mounted on a rosette sampler from bottom water depths up to the surface (0.5 m). The dissolved gases were immediately extracted from the water and were analysed for methane by a gas chromatograph equipped with a flame ionization detector (FID) on board ship. Gas samples were stored for investigations of the $^{13}C_{CH4}$ values in the home laboratory. Furthermore at each station samples for the analyses of DMSP(p), DMSP(d) were taken, which will be also analyzed in the home lab. Further laboratory experiments running for several days were carried out to produce methane while different substrates are used as precursor.

Preliminary results

During the expedition methane concentrations exceeding the normal background values of roughly 4 nM are detected along the Fram Strait transect and in the polynya region. However, an extended methane anomaly identified in Storfjorden in 2006 was missing. The increased methane concentrations were located in the near-surface water (<100 m) which points to methane *in-situ* produced during the phytoplankton bloom. However, the source of methane can be finally determined if the isotopic analyses are done in the home laboratory. First results of the experiments clearly show a methane production created in seawater if DMSP and NADPH are added. The methane production is proved as well as in seawater with normal oxygen content and in degassed sea water (Fig. 8.1).

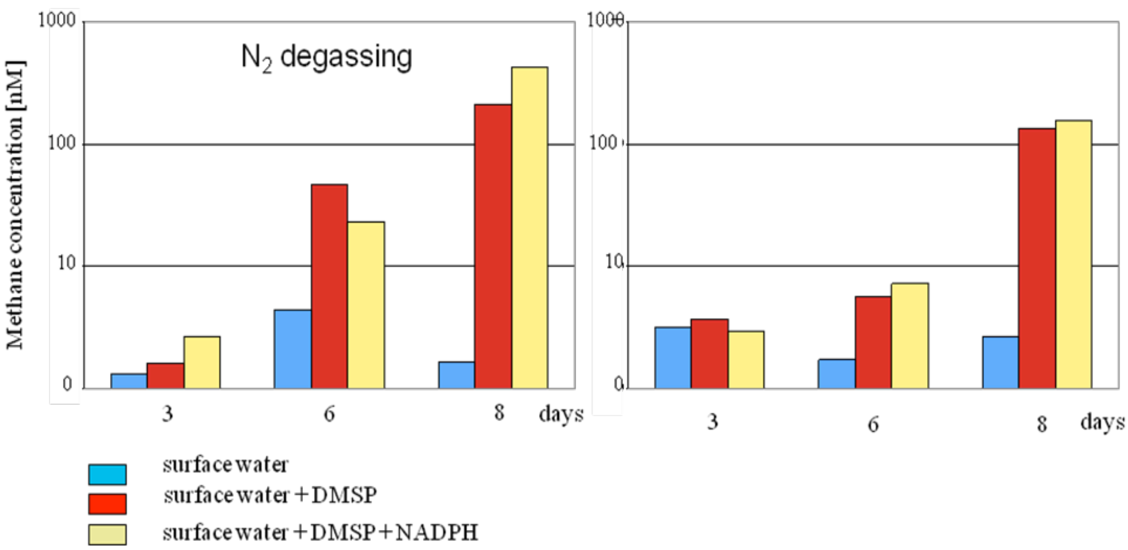

Fig. 8.1: Methane production in degassed sea water and with normal oxygen content.

9. DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

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Objectives

The main conclusion, as expected, is that numbers of birds are extremely low, with many counts presenting less than 5 birds. Exceptions are linked with hydrological changes such as fronts between water masses, ice edge and Outer Marginal Ice Zone (OMIZ). The best example concerns the little auk, one of the most numerous species of the region with 1.3 million pairs breeding in Svalbard. This zooplankton eating species is known to feed at the ice edge on the polar *Calanus* zooplankton spp (*hyperboreus* and *glacialis*). During summer, breeding adults must thus fly to the ice edge and back to the colony with food for their chicks. The maximum distance should not exceed 100 to 150 km. Our results show however that the situation is a bit more complex. If due to decreasing ice coverage the ice edge is much too far from the breeding grounds, they might interrupt their breeding cycle and massively leave the colony northerly in order to reach the OMIZ (this was the case for the Jan Mayen colony in 2005). In 2007 (79°N transect), the birds were able to detect a cold water core eddy underway, with mixed polar/ arctic water 50 m deep (water temperature lower than -1°C, salinity lower than 34, at 1°E), and stayed there instead of flying to the ice edge.

Work at sea

Almost 700 half-an-hour transect counts were devoted to the quantitative distribution of the "higher" trophic levels (seabirds, cetaceans, pinnipeds), i.e. on a continuous basis, visibility conditions allowing.

Preliminary results (selected species)

During our expedition, a similar eddy, as mentioned above, with mixed polar/ arctic water was ice covered (the pack ice drifted East due to abnormally frequent northwestern and westerly winds). This eddy is clearly to be detected around 4°E (Fig. 9.1). The consequence was that little auks were present in huge numbers at such locations (Table 9.1): Almost all little auks counted during the whole expedition were encountered at these few stations. As a consequence, we conclude that huge amounts of zooplankton must be present there as well. Similarly, high fish density is supposed taking into account the concentration of harp seals.

Birds: Fulmar and kittiwake were present almost everywhere, with higher concentrations in the eastern part (from Spitsbergen to 0°E). The next most numerous species were little auk and Brünnich's guillemot (eastern part), followed by ivory gull (western part: polynya). Among the indicator species, in comparison with data collected from 1991 to 1993, figures were very high for the Sabine's gull (c. 20 individuals), low for the glaucous gull, while the Ross's gull was not encountered at all. It was, however, expected in good numbers from the second half of July on.

Cetaceans: *The* most numerous species was the fin whale (20, mainly in the eastern part), minke whale (5, idem), sperm whale (1, idem), and white-beaked dolphins (10, idem). These data could be confirmed during the only helicopter flight devoted to counting. Worth mentioning are the high numbers of bowheads (10, mainly eastern part) confirming the recent increase noted from 2007 on, and probably reflecting an important transfer from the high Pacific stock to the very poor, close to extinction, NE Atlantic one (comments on humpback whale, killer whale, pilot whale, white-beaked dolphin, blue whale: see below).

The main pinniped species was the harp seal (100, mainly at the ice edge), followed by ringed (25 on large ice floes, one very close to the ship on a very small peace of ice), bearded (10, idem), hooded (10), and 1 single walrus.

Numbers of polar bears were high, with a total of 25 including 4 mothers, each accompanied by 2 pups from less than 1 year to more than 3 years old. Both the high density and the high proportion of pups reflect the healthy situation of the population with good reproduction success. Two were seen feeding on a seal, and 1 abandoned, half eaten seal carcass was observed.

Selected stations: Not only is the distribution of various species very patchy, but the coincidence of peaks of different species at the same localization is also of great ecological importance. The case of little auks and harp seals was already described revealing the presence of zooplankton and fish in high concentrations. Very special stations were encountered on August 9th, 2008, from 12 am to 7 pm: Important concentrations of seabirds (thousands of fulmar and kittiwake, common guillemot by hundreds: swimming pairs of an adult and a flightless chick) were noted, as well as cetaceans: 200 humpback whales, 125 white-beaked dolphins, 6 pilot whales, 5 killer whales, 1 blue whale. The echo-sounder showed very high concentrations of "krill" (zooplankton) under the surface, as well as fish deeper in the water column. After 7 pm, we crossed the very sharp front between Arctic and Atlantic water, and typical Atlantic species replaced the Arctic ones: fin whale, gannet.

Tab. 9.1: Numbers of “local” little auks and harp seals at special hydrological events.

Date 2008	Time	Transect count	Position °N	°E	Water temp. °C	Salinity	Ice %	Little auk	Harp seal
Jul-13	12:25	100	79	3.5	-1.4	32.4	75	10	0
	12:55	101	79	**4.0**	**-0.5**	32.2	60	**250+**	**2**
	13:30	(HG IV)	79	4.0	0.7	32.7	70		
	16:40	102	79	4.2	0.0	32.2	60	10	0
	17:10	103	79	4.4	1.3	33.1	20	4	1
15	06:10	134	79.3	4.4	-0.1	32.4	65	15	0
	06:40	135	79.1	**4.4**	**-0.8**	32.2	50	**1500+**	**6**
	07:10	136	79.2	4.4	-0.4	32.2	40	30	0
	07:04	137	79.1	4.3	2.3	33.2	1	2	0
16	05:30	145	78.5	4.2	-0.9	32.2	80	15	1
	06:10	146	78.5	**4.3**	**-1.1**	32.4	70	**300+**	**4**
	07:00	(HG IV)	79	4	0.7	32.7	40	10	0
Aug-04	02:50	505	79.6	5.4	-0.4	30.8	30	25	1
	03:20	506	79.5	6.0	-0.8	30.9	20	14	1
	03:50	507	79.5	6.3	1.5	31.8	50	30	0
	04:20	508	79.4	6.5	6.5	34.8	1	3	0
	04:50	509	79.4	7.0	5.5	33.6	20	770+	25
	05:15	509 *	79.3	**7.2**	**-0.7**	**27.7**		**750+**	**22**
	05:20	510	79.3	7.2	5.8	33.6	15	2	0
	05:50	511	79.2	7.4	6.8	35.0	0	0	0

* in a few minutes.

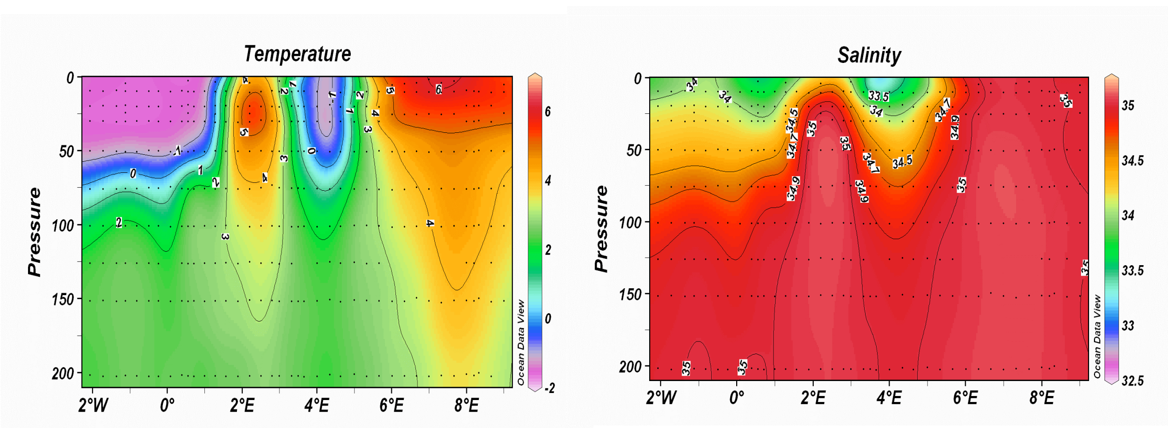
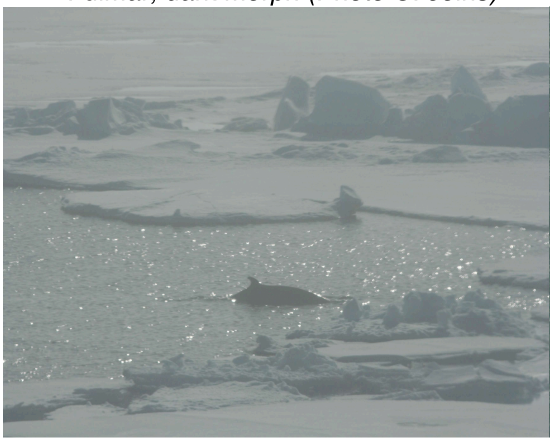


Fig. 9.1: Eddy as determined by temperature and salinity

Fulmar, dark morph (Photo C. Joiris)

Puffin (Photo H. Robert)



Minke whale (Photo C. Joiris)

Fin whale (Photo H. Robert)

Fig. 9.2: Photos of birds and whales

10. GPS OBSERVATIONS IN NORTH-EAST GREENLAND TO DETERMINE VERTICAL AND HORIZONTAL DEFORMATIONS OF THE EARTH'S CRUST

Mirko Scheinert, Ralf Rosenau
Technische Universität Dresden

Objectives

The main goal of the geodetic work was the reconnaissance and set-up of new GPS stations at up to nine ice-free locations in the coastal area of East Greenland between 78° and 81°N. The network configuration of the planned observation stations contains, on the one hand, a west-east component (stations at the ice edge and close to the coast, respectively), and covers, on the other hand, the entire area of investigation, extending south to almost 74°N, where the first seven stations were set up during the first leg.

The stations have been observed for the first time. After having carried out a repetition of the GPS observations at a later time it will be possible to infer deformations, which will deliver as independent information a valuable contribution to the validation and improvement of models of the glacial-isostatic adjustment and of the recent mass balance in North-East Greenland. The significance of horizontal deformations will be checked to contribute to the investigation of the tectonic situation in the area of investigation. The project is a contribution to the internationally coordinated project POLENET (Polar Earth Observatory Network) of the International Polar Year 2007/08 (IPY).

Work at sea

Polarstern with its two helicopters provided a basis for the realization of the work. To reach the locations on land, *Polarstern* had to sail to positions close enough to the Greenlandic coast. Since compact sea ice covered the coastal area between 77°45'N and 80°45'N with a width of up to 90 km a careful planning of the flight paths had to be done. An ice channel going from east to west broke up at about 80°30'N just before the start of the first flights, which allowed *Polarstern* to reach the coast as close as about 8 km. All further flights could be carried out while the ship kept sailing along the ice edge (at about 12°W) so that the work of the other programmes could be continued without interruptions. Starting from *Polarstern*, it was possible to reach all planned locations at land. The helicopter flights took place in the periods listed in Table 10.1.

All nine stations planned for deployment in the area of investigation could be realized and set up for the first observation. For this, a special marker is fixed to the rock, which serves to take the GPS antenna and which works as a forced centring for the antenna. The power supply is realized by means of solar modules and sealed batteries, specially adapted for usage with solar power. GPS receiver, batteries and further devices (charging controller, data logger) are stored in a Zarges aluminium box, which protects the equipment from the influence of the weather. Fig. 10.1 shows an example of the set-up of a GPS station. The receivers collect data for a longer period (due to receiver model, at least for ten days) with a data rate of 30s in order to meet the goal of an accuracy of the determined coordinates of some millimetres. A list of the new GPS stations is given by Table 10.2, the locations are also shown at the overview map (Fig. 10.2).

Tab. 10.1: List of helicopter flights for the deployment of the GPS stations. The start and end times are approximate times, the entire period includes the flights and the work at land. For the location and name of the stations see also Table 10.2 and Fig. 10.2.

Flight No.	Time period		Deployed stations and additional work
	Start	End	
1	22/07/2008 19:30	22/07/2008 24:00	TUD-601, TUD-701
2	23/07/2008 01:30	23/07/2008 04:40	TUD-801
3	23/07/2008 05:20	23/07/2008 11:00	TUD-603, TUD-702
4	24/07/2008 12:30	24/07/2008 18:30	TUD-602, station at glacier (NIOG)
5	24/07/2008 19:00	25/07/2008 01:40	TUD-502, terrestrial survey
6	25/07/2008 08:30	25/07/2008 15:30	TUD-401, TUD-402

One station was set up at the Nioghalvfjerdsbræ (see Fig. 10.1) at a location, which is in the center of the ice stream and where the glacier already floats at the ocean. The analysis of these GPS data will allow us to infer the glacier velocity, which amounts to approximately 2 to 3 m/day as well as the vertical motion due to the ocean tides. Since the location was chosen in such a way that it has a distance of at least 10 km to the northern and southern coast as well as to the grounding zone (the transition zone from the grounded to the floating glacier) it can be expected that the damping of the tidally induced vertical motion is small. In this way, the ground GPS data can be used to validate models of the glacier velocity and of the ocean tides.

Additionally, a terrestrial survey was carried out at the location TUD-502 (Lambert Land West, ID: LAMT). Digital photographs were taken to determine the glacier's velocity in the vicinity of the station. In order to calibrate the camera (to determine the geometrical parameters: the so-called inner orientation) and to orientate the photographs with respect to a local coordinate system (the so-called outer orientation) about twenty marks were deployed at the ground and measured by tachymetry (angle and distance measurements). After completion of this survey the marks were removed again.

The re-collection of the equipment from all 17 locations took place in the period August 5 (3 p.m.) to August 8 (1 a.m.). Since the dismantling of the stations could be done in a much shorter time (about 20 min) than it took them to set-up the successive helicopter flights could be done in a very time-economic way thus allowing *Polarstern* to follow its course south. All equipment could be successfully re-collected, and the data download was already accomplished on board *Polarstern*. The analysis of the data, however, will be done at the home institute.

In addition to the geodetic programme, a small glaciological investigation at the sea ice was carried out. At seven locations – four at about 79°50'N, 13 to 14°W, three at about 82°15'N, 11°W – ice core drillings were realized in order to determine ice thickness and freeboard height of the ice floes. The ice thickness varied between approx. 1.60 m and almost 7 m. The parameters may be used for validation of satellite observations, especially of the ICESat mission, which is utilized for glaciological (sea ice) and geodetic (geoid) applications.

As a scientific service for the group of the University of Bergen (E. Falck) water samples were taken from surface discharges (glacial rivers or other melting water discharge) at five locations in the area of investigation. These water samples deliver valuable *in-situ* material for the analyses in the framework of the oceanographic-hydrochemical investigations at the Greenland Sea.

Acknowledgements. The geodetic programme could be realized that successfully due to the great support by numerous colleagues in the preparation and realization of the expedition as well as by the crew of *Polarstern*. Especially I like to thank: G. Kattner (chief scientist), H. Heckmann and B. Zepick (helicopter pilots), and U. Pahl (master of *Polarstern*).

Tab. 10.2: List of the GPS Stations with approximate coordinates

Institution planning number	ID	Longitude [deg]	[min]	[sec]	Latitude [deg]	[min]	[sec]	Ellips. height [m]	Geographical region
TUD-401	**FRAN**	-18	37	38,4	78	34	42,4	337	Franske Øer S
TUD-402	**BILD**	-23	30	12,0	78	6	59,0	900	Bildsøe Nunatakker (961m)
TUD-502	**LAMW**	-22	18	22,0	79	13	35,3	189	Lambert Land W Nunatak 172m
	LAMT	-22	18	20,8	79	13	38,3	187	Lambert Land W Nunatak 172m
TUD-601	**HOVG**	-18	13	50,0	79	42	0,7	581	Hovgård Ø (Kap Anna Bistrup)

Institution planning number	ID	Longitude [deg]	[min]	[sec]	Latitude [deg]	[min]	[sec]	Ellips. height [m]	Geographical region
TUD-602	**BLAF**	-22	38	58,0	79	31	58,5	572	Blåsø (Kronprins Christian Land S, Blåsø Fjeld)
TUD-603	**CRIW**	-24	18	49,0	80	5	33,0	344	Kronprins Christian Land SW
TUD-701	**HOLM**	-16	25	53,5	80	16	22,9	410	Holm Land E
TUD-702	**CENT**	-21	43	25,0	80	11	29,0	92	Centrumsø (Kronprins Christian Land CS)
TUD-801	**ROME**	-19	3	42,0	81	4	18,5	782	Romer Sø (Kronprins Christian Land CN)
	NIOG	-21	57	48,9	79	26	57,0	75	Nioghalvfjerdsbræ

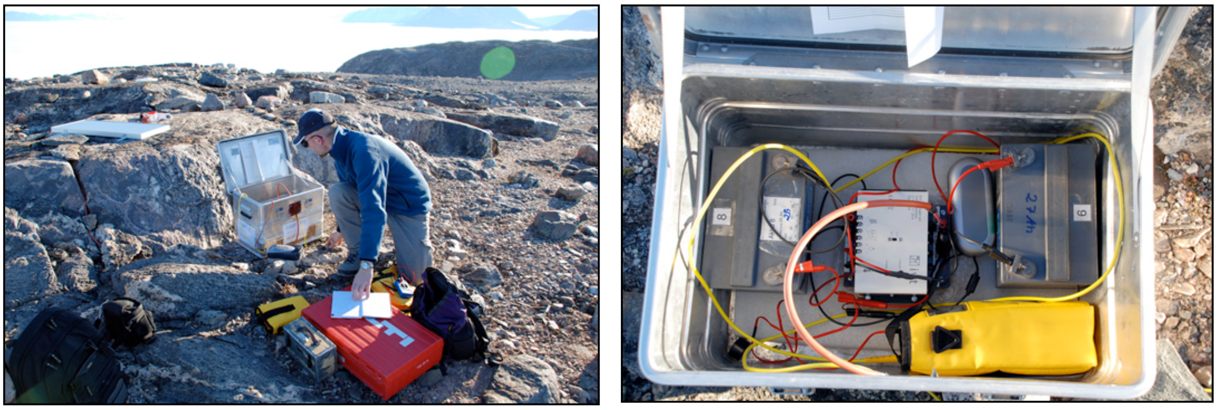


Fig. 10.1: Typical set-up of a GPS station
Left: The GPS station consists of antenna (directly fixed to the rock by a special bolt), solar module(s) and a Zarges aluminium box containing the receiver, batteries and charging controller. Right: View into the Zarges aluminium box with charging controller (center), GPS receiver (yellow case) and two sealed batteries.

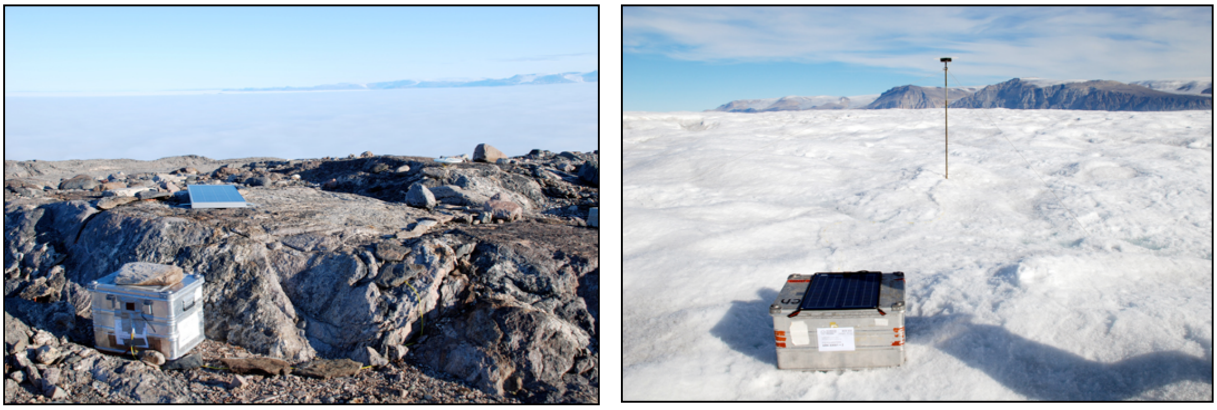


Fig. 10.1 continued: Left: View at the final set-up of station HOVG (Hovgård Ø). Right: At the glacier station NIOG (Nioghalvfjerdsbræ) the antenna is mounted on top of a iron rod fixed to the glacier by additional three guys. The solar panel is directly attached at top of the Zarges aluminium box.

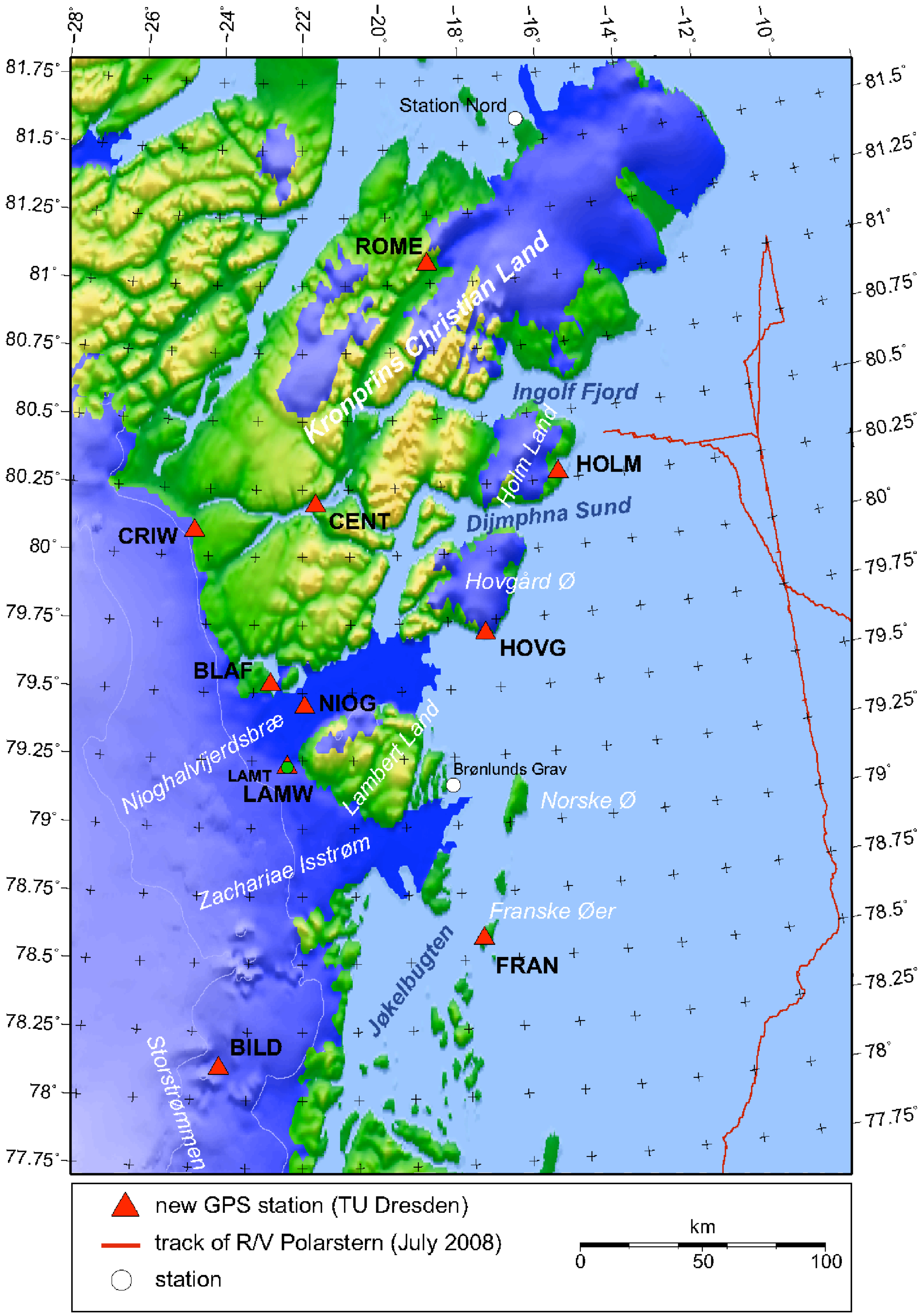


Fig.10.2: Overview map showing the locations of the newly deployed and observed GPS stations (DEM by S. Ekholm, DTU Space Copenhagen; map software: GMT 4.2)

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP'S CREW

A.4 STATION LIST

A.1 TEILNEHMENDE INSTITUTE/ PARTICIPATING INSTITUTIONS

	Adresse **Address**
AWI	Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 120161 27515 Bremerhaven Germany
CNRS	Laboratoire des Sciences du Climat et de l'Environnement Gif-sur-Yvette France
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
Heli	Heli Transair International GmbH Im Geisbaum 2 63329 Egelsbach Germany
IOPAS	Marine Ecology Department Institute of Oceanology Polish Academy of Sciences, Powstancow Warszawy 55, 81-712 Sopot Poland
NPI	Norwegian Polar Institute 9296 Tromsø Norway
Oktopus	OKTOPUS GmbH Kieler Straße 51 24594 Hohenwestedt Germany

	Adresse **Address**
Optimare	Optimare Sensorsyteme AG Am Luneort 15A 27572 Bremerhaven Germany
PolE	Laboratory for Ecotoxicology and Polar Ecology Free University o Brussels (VUB) Pleinlaan 2 B-1050 Brussels Belgium
Senckenb.	Forschungsinstitut und Naturmuseum Senckenberg Marine Evertebraten I Senckenberganlage 25 D-60325 Frankfurt a.M. Germany
Stern	Stern Magazin Am Baumwall 11 20459 Hamburg Germany
TU Dresden	Technische Universität Dresden Institut für Planetare Geodäsie 01062 Dresden Germany
University Göttingen	Universität Göttingen Göttingen Germany
University Bergen	University of Bergen Geophysical Institute Allegaten 70 5007 Bergen Norway

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Barz	Kristina	AWI	Biologist
Basilico	Adrian	AWI	Biologist
Bauerfeind	Eduard	AWI	Biologist
Behrendt	Axel	AWI	Student, Oceanography
Bergmann	Melanie	AWI	Biologist
Beszczynska-Möller	Agnieszka	AWI	Oceanographer
Botnen	Helle Augdal	University Bergen	Student, Physics
Brauer	Jens	Heli	Technician
Buldt	Klaus	DWD	Technician, Meteorology
Catalot	Cecilie	CNRS	Biologist
Damm	Ellen	AWI	Geologist
Erdmann	Hilger	DWD	Meteorologist
Falck	Eva	University Bergen	Oceanographer
Graeve	Martin	AWI	Chemist
Heckmann	Hans	Heli	Pilot
Heckmann	Markus	Heli	Technician
Janussen	Dorte	Senkenberg	Biologist
Jha	Abhinand	AWI	Student, Oceanography
Johansson	Robert	IPY-teacher	Engineer, Chemistry
Joiris	Claude	PolE	Biologist
Kattner	Gerhard	AWI	Chemist
Korger	Edith	AWI	Geophysicist
Läderach	Christine	AWI	Geophysicist
Lichte	Ellen	AWI	Technician, Chemistry
Ludwichowski	Kai-Uwe	AWI	Engineer, Chemistry
Meckel	Dawin	Stern	Photographer
Metzner	Wolfgang	Stern	Journalist
Monsees	Matthias	Optimare	Technician, Physics
Przytarska	Joanna	IOPAS	Biologist
Riedel	Carsten	AWI	Geophysicist
Robert	Henri	PolE	Biologist
Rosenau	Ralf	TUD	Geophysicist
Sablotny	Burkhard	AWI	Engineer, Physics
Scheinert	Mirco	TUD	Geophysicist
Schewe	Ingo	AWI	Biologist
Schönborn	Lisa	AWI	Technician, Chemistry
Schott	Thorsten	Oktopus	Oceanographer
Schröer	Annika	AWI	Technician, Chemistry
Siegmund	Ann-Kristin	University Göttingen	Technician, Biology
Simon	Stephanie	AWI	Student, Biology
Strothmann	Olaf	AWI	Technician, Physics
Wisotzki	Andreas	AWI	Oceanographer
Zepick	Burkhard	Heli	Pilot

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
01.	Pahl, Uwe	Master
02.	Grundmann, Uwe	1.Offc.
03.	Ziemann, Olaf	Ch. Eng.
04.	Bratz, Herbert	2.Offc./L.
05.	Hering, Igor	2.Offc.
06.	Janik, Michael	2.Offc.
07.	Lambrecht, Wolfgang	Doctor
08.	Koch, Georg	R.Offc.
09.	Kotnik, Herbert	2.Eng.
10.	Schnürch, Helmut	2.Eng.
11.	Westphal, Henning	2.Eng.
12.	Holtz, Hartmut	Elec Eng.
13.	Dimmler, Werner	Electron.
14.	Feiertag, Thomas	Electron.
15.	Fröb, Martin	Elec.Tech
16.	Rehe, Lars	Electron.
17.	Clasen, Burkhard	Boatsw.
18.	Neisner, Winfried	Carpenter
19.	Burzan, Gerd-Ekkeh.	A.B.
20.	Grabbert, Steve	A.B.
21.	Hartwig-Lab., Andreas	A.B.
22.	Kreis, Reinhard	A.B.
23.	Kretzschmar, Uwe	A.B.
24.	Moser, Siegried	A.B.
25.	Pousada Martinez, S.	A.B.
26.	Schröder, Norbert	A.B.
27.	Beth, Dethlef	Storek.
28.	Dinse, Horst	Mot-man
29.	Fritz, Günter	Mot-man
30.	Schünemann, Mario	Mot-man
31.	Watzel, Bernhard	Mot-man
32.	Witt, Manfred	Mot-man
33.	Fischer Matthias	Cook
34.	Tupy, Mario	Cooksmate
35.	Völske, Thomas	Cooksmate
36.	Dinse Petra	1.Stewardess
37.	Hölger, Irene,	Stwdss/Kr
38.	Hischke, Peggy	2.Stewardess
39.	Hu, Guo Yong	2.Steward
40.	Streit, Christina	2.Stewardess
41.	Sun, Yong Sheng	2.Steward
42.	Wartenberg, Irina	2.Stewardess
43.	Yu, Kwok Yuen	Laundrym.
44.	Pagels, Christian	Apprent.

No.	Name	Rank
45.	Pluhar, Arne	Apprent.

A.4 STATIONSLISTE / STATION LIST PS 72

Station PS72	Date	Time (start)	Time (end)	Position (Lat.)	Position (Lon.)	Depth (m)	Gear
095-1	05.07.08	04:26	04:56	78° 50.18' N	8° 40.36' E	234.7	Mooring
096-1	05.07.08	06:01	06:51	78° 50.05' N	8° 19.97' E	791.7	Mooring
097-1	05.07.08	07:31	08:27	78° 50.06' N	8° 0.26' E	935.0	Mooring
098-1	05.07.08	10:30	11:53	78° 50.11' N	7° 0.19' E	1457.7	Mooring
098-2	05.07.08	12:05	12:28	78° 50.01' N	7° 0.31' E	1460.5	CTD/rosette
098-3	05.07.08	12:12	12:18	78° 49.99' N	7° 0.30' E	1461.2	Hand net
099-1	05.07.08	13:56	15:35	78° 50.02' N	5° 59.95' E	2472.2	Mooring
100-1	05.07.08	16:03	17:57	78° 49.94' N	6° 0.68' E	2464.7	CTD/rosette
101-1	05.07.08	18:55	20:30	78° 49.95' N	6° 20.82' E	2173.7	CTD/rosette
102-1	05.07.08	21:34	22:51	78° 49.98' N	6° 39.86' E	1783.5	CTD/rosette
103-1	05./06.07.08	23:34	00:41	78° 50.01' N	7° 0.19' E	1460.5	CTD/rosette
104-1	06.07.08	01:27	02:23	78° 50.04' N	7° 19.97' E	1239.0	CTD/rosette
105-1	06.07.08	03:10	03:58	78° 49.99' N	7° 39.96' E	1109.7	CTD/rosette
106-1	06.07.08	08:24	08:49	79° 1.67' N	11° 5.22' E	286.7	CTD/rosette
106-2	06.07.08	08:59	09:31	79° 1.71' N	11° 5.59' E	288.2	Multi corer
106-3	06.07.08	09:52	10:07	79° 1.66' N	11° 4.83' E	287.5	Large Box Corer
106-4	06.07.08	11:57	16:31	79° 3.61' N	11° 4.17' E	218.7	Multi Frame
107-1	06.07.08	18:31	19:42	78° 59.32' N	9° 32.93' E	246.4	Agassiz trawl
107-2	06.07.08	20:13	20:33	78° 58.79' N	9° 29.94' E	229.9	CTD/rosette
107-3	06.07.08	20:55	21:28	78° 58.80' N	9° 30.06' E	229.4	Multi corer
107-4	06./07.07.08	21:47	02:18	78° 58.74' N	9° 29.67' E	228.5	Multi Frame
108-1	07.07.08	03:13	03:32	78° 50.04' N	9° 0.60' E	221.3	CTD/rosette
109-1	07.07.08	04:09	04:21	78° 49.99' N	8° 50.03' E	234.3	CTD/rosette
110-1	07.07.08	04:41	05:00	78° 49.98' N	8° 39.83' E	251.3	CTD/rosette
110-2	07.07.08	05:05	05:48	78° 49.99' N	8° 39.99' E	249.4	Mooring
111-1	07.07.08	06:15	06:48	78° 49.95' N	8° 29.80' E	589.4	CTD/rosette
112-1	07.07.08	07:14	07:49	78° 49.96' N	8° 19.98' E	789.5	CTD/rosette
113-2	07.07.08	09:15	10:19	78° 49.97' N	8° 20.10' E	787.2	Mooring
113-3	07.07.08	10:48	11:35	78° 50.52' N	8° 19.37' E	0.0	PIES
113-4	07.07.08	11:58	12:00	78° 50.50' N	8° 19.53' E	794.2	PIES
114-1	07.07.08	13:12	14:04	78° 49.98' N	7° 59.92' E	1032.4	Mooring
115-1	07.07.08	15:24	17:07	78° 50.00' N	6° 59.93' E	1464.7	Mooring
115-2	07.07.08	17:40	19:12	78° 50.16' N	6° 59.39' E	1454.4	PIES
116-1	07.07.08	20:49	21:31	78° 50.08' N	8° 12.40' E	914.1	CTD/rosette
116-2	07.07.08	21:39	22:04	78° 50.00' N	8° 12.49' E	910.4	Bongo net
117-1	07.07.08	22:32	23:18	78° 50.01' N	8° 0.11' E	1031.0	CTD/rosette
118-1	08.07.08	01:06	01:58	79° 2.99' N	6° 59.74' E	1345.0	CTD/rosette
118-2	08.07.08	01:28	01:35	79° 3.03' N	7° 0.15' E	1347.3	Hand net
118-3	08.07.08	02:24	03:22	79° 1.84' N	6° 59.75' E	1307.8	Multi corer
118-4	08.07.08	03:34	04:17	79° 1.81' N	7° 0.00' E	1307.8	Large Box Corer
118-5	08.07.08	04:28	05:09	79° 1.82' N	7° 0.06' E	1308.5	Large Box Corer
118-6	08.07.08	05:40	10:47	79° 1.83' N	7° 0.13' E	1308.3	Multi Frame
118-7	08.07.08	11:07	13:35	79° 4.21' N	6° 57.32' E	1373.3	Agassiz trawl
119-1	08.07.08	14:50	14:53	78° 50.21' N	7° 2.94' E	1424.7	PIES
120-1	08.07.08	16:37	17:59	78° 49.82' N	5° 56.17' E	2494.8	PIES
121-1	08.07.08	19:18	21:04	78° 50.14' N	4° 54.09' E	2543.3	PIES
122-1	08./09.07.08	23:22	00:12	79° 3.81' N	4° 10.83' E	2471.5	CTD/rosette
122-2	09.07.08	00:36	02:12	79° 3.83' N	4° 10.61' E	2473.0	Multi corer
122-3	09.07.08	02:50	04:56	79° 1.98' N	4° 9.99' E	2629.8	Multi Frame

Station PS72	Date	Time (start)	Time (end)	Position (Lat.)	Position (Lon.)	Depth (m)	Gear
123-1	09.07.08	06:06	07:04	79° 5.03' N	4° 10.11' E	2435.2	Bottom lander
124-1	09.07.08	07:23	08:35	79° 4.93' N	4° 8.51' E	2461.2	Bottom lander
124-2	09.07.08	09:17	14:00	79° 5.02' N	4° 5.18' E	2504.0	Bottom lander
124-3	09.07.08	14:21	16:52	79° 4.99' N	4° 7.95' E	2467.0	Bottom lander
124-4	09.07.08	17:22	17:25	79° 4.05' N	4° 11.88' E	2447.0	Hand net
124-5	09.07.08	17:50	21:09	79° 4.89' N	4° 8.54' E	2462.0	Bottom lander
125-1	09.07.08	22:47	00:27	78° 55.01' N	4° 59.72' E	2638.3	CTD/rosette
125-2	10.07.08	00:33	02:08	78° 55.01' N	5° 0.04' E	2637.2	Multi corer
126-1	10.07.08	03:16	04:44	78° 46.87' N	5° 20.26' E	2462.3	CTD/rosette
126-2	10.07.08	04:51	06:28	78° 46.83' N	5° 20.00' E	2466.0	Multi corer
127-1	10.07.08	07:45	08:38	78° 36.46' N	5° 3.90' E	2342.5	CTD/rosette
128-1	10.07.08	09:07	10:33	78° 34.70' N	5° 2.54' E	2347.2	Mooring
129-1	10.07.08	11:12	12:10	78° 36.31' N	5° 5.04' E	2342.0	Mooring
129-2	10.07.08	12:31	12:41	78° 36.40' N	5° 5.19' E	2342.0	Mooring
129-3	10.07.08	12:52	14:25	78° 36.48' N	5° 3.68' E	2343.0	Multi corer
129-4	10.07.08	14:32	15:54	78° 36.54' N	5° 3.84' E	2342.5	CTD/rosette
130-1	10.07.08	19:00	20:12	79° 2.29' N	4° 17.08' E	2544.2	Multi Frame
130-2	10.07.08	20:38	22:20	79° 3.94' N	4° 10.60' E	2467.8	CTD/rosette
130-3	10.07.08	22:43	23:16	79° 2.25' N	4° 17.00' E	2547.5	Multi Frame
130-4	10./11.07.08	23:38	00:25	79° 2.27' N	4° 16.96' E	2546.5	LOKI
131-1	11.07.08	01:09	02:17	79° 6.53' N	4° 36.28' E	1904.7	CTD/rosette
131-2	11.07.08	02:26	03:52	79° 6.46' N	4° 36.10' E	1925.2	Multi corer
132-1	11.07.08	06:36	09:51	78° 50.03' N	3° 59.29' E	2335.0	Mooring
133-1	11.07.08	10:38	12:42	78° 49.83' N	3° 57.29' E	0.0	PIES
134-1	11.07.08	14:08	15:53	78° 49.91' N	5° 0.96' E	2698.5	Mooring
135-1	11.07.08	16:14	16:17	78° 50.10' N	4° 56.08' E	2673.8	PIES
135-2	11.07.08	16:30	16:37	78° 50.01' N	4° 56.90' E	2672.0	Hand net
136-1	11.07.08	19:00	20:00	79° 7.80' N	4° 53.72' E	1558.8	CTD/rosette
136-2	11.07.08	20:04	21:04	79° 7.80' N	4° 53.91' E	1556.0	Multi corer
137-1	11.07.08	22:55	23:44	79° 8.01' N	6° 5.41' E	1258.5	CTD/rosette
137-2	11./12.07.08	23:50	00:47	79° 8.00' N	6° 5.52' E	1280.5	Multi corer
137-3	12.07.08	01:00	01:54	79° 7.94' N	6° 5.57' E	1278.8	Large Box Corer
137-4	12.07.08	02:10	07:02	79° 8.00' N	6° 5.35' E	1280.8	Multi Frame
137-5	12.07.08	07:36	10:02	79° 8.65' N	6° 0.31' E	1306.5	Agassiz trawl
138-1	12.07.08	11:59	13:27	78° 50.05' N	5° 59.98' E	2470.0	Mooring
139-1	12.07.08	14:46	16:08	78° 50.02' N	4° 59.97' E	2704.8	Mooring
140-1	12./13.07.08	18:46	00:30	79° 5.08' N	4° 15.08' E	2349.8	Multi Frame
141-1	13.07.08	02:35	04:33	79° 3.73' N	3° 39.39' E	3132.7	CTD/rosette
141-2	13.07.08	03:20	03:29	79° 3.67' N	3° 40.73' E	3118.3	Hand net
141-3	13.07.08	04:41	06:29	79° 3.42' N	3° 43.21' E	2971.0	Multi corer
142-1	13.07.08	07:16	09:27	79° 3.28' N	3° 33.98' E	3553.5	CTD/rosette
142-2	13.07.08	09:39	11:52	79° 2.95' N	3° 36.16' E	3403.3	Multi corer
143-1	13.07.08	14:31	16:35	79° 0.88' N	4° 20.54' E	2590.1	Mooring
144-1	14.07.08	02:55	04:42	79° 36.14' N	5° 9.20' E	2799.7	CTD/rosette
145-1	14.07.08	08:31	10:02	79° 43.86' N	4° 27.98' E	2694.7	Mooring
145-2	14.07.08	10:19	12:01	79° 44.03' N	4° 28.29' E	2665.7	CTD/rosette
145-3	14.07.08	12:09	13:57	79° 44.12' N	4° 28.95' E	2662.5	Multi corer
145-4	14.07.08	14:05	15:25	79° 44.24' N	4° 29.95' E	2744.7	Mooring
146-1	14.07.08	18:45	20:48	79° 35.75' N	5° 10.91' E	2780.5	Multi corer
147-2	15.07.08	02:46	04:14	79° 25.08' N	4° 42.47' E	2571.0	CTD/rosette

Station PS72	Date	Time (start)	Time (end)	Position (Lat.)	Position (Lon.)	Depth (m)	Gear
147-3	15.07.08	04:20	05:59	79° 25.35' N	4° 44.51' E	2581.7	Multi corer
148-1	15.07.08	10:14	11:26	78° 50.04' N	3° 59.79' E	2343.3	Mooring
149-1	15.07.08	13:02	15:15	78° 50.03' N	2° 48.49' E	2496.3	Mooring
149-2	15.07.08	15:55	17:28	78° 50.02' N	2° 50.51' E	2489.8	PIES
150-1	15.07.08	17:58	19:36	78° 50.02' N	2° 59.81' E	2461.2	CTD/rosette
151-1	15.07.08	20:32	22:13	78° 50.03' N	3° 19.95' E	2390.8	CTD/rosette
152-1	15./16.07.08	23:05	00:34	78° 49.97' N	3° 39.75' E	2304.5	CTD/rosette
153-1	16.07.08	01:21	02:50	78° 49.97' N	4° 0.50' E	2347.5	CTD/rosette
154-1	16.07.08	04:05	05:32	78° 50.07' N	4° 21.16' E	2401.7	CTD/rosette
155-1	16.07.08	07:45	10:01	79° 1.76' N	4° 18.98' E	2556.7	Mooring
156-1	16.07.08	11:25	16:29	79° 0.25' N	3° 30.71' E	2750.5	Agassiz trawl
156-2	16.07.08	16:31	16:36	79° 4.14' N	3° 47.42' E	2751.0	Hand net
157-1	16.07.08	17:14		79° 4.83' N	4° 5.41' E	2467.0	Bottom lander
158-1	16.07.08	17:29	17:37	79° 5.02' N	4° 8.04' E	2465.3	Bottom lander
159-1	16./17.07.08	20:42	00:12	79° 8.09' N	2° 50.66' E	5574.2	CTD/rosette
159-2	17.07.08	00:24	04:05	79° 8.25' N	2° 47.66' E	5581.0	Multi corer
160-1	17.07.08	06:06	08:30	79° 3.37' N	3° 30.33' E	3935.0	CTD/rosette
160-2	17.07.08	08:39	11:12	79° 3.52' N	3° 29.02' E	3985.5	Multi corer
161-1	17.07.08	15:12	16:43	78° 48.96' N	6° 0.07' E	2467.5	Mooring
162-1	17.07.08	17:15	18:57	78° 50.00' N	5° 39.81' E	2578.3	CTD/rosette
163-1	17.07.08	19:44	21:30	78° 49.99' N	5° 20.13' E	2629.5	CTD/rosette
164-1	17./18.07.08	22:21	00:04	78° 49.97' N	5° 0.16' E	2706.2	CTD/rosette
165-1	18.07.08	01:00	02:36	78° 49.91' N	4° 38.43' E	2524.0	CTD/rosette
166-1	18.07.08	05:00	06:39	78° 50.14' N	2° 48.09' E	2492.5	CTD/rosette
166-2	18.07.08	07:03	08:25	78° 49.85' N	2° 52.04' E	2483.3	Mooring
167-1	18.07.08	08:46	09:22	78° 50.02' N	2° 50.66' E	2485.5	PIES
168-1	18.07.08	12:06	14:24	78° 49.91' N	1° 36.29' E	2538.7	Mooring
168-2	18.07.08	15:09	16:26	78° 50.63' N	1° 39.40' E	2555.0	Mooring
169-1	18.07.08	17:12	18:52	78° 49.99' N	1° 17.23' E	2527.9	CTD/rosette
169-2	18.07.08	18:53	18:56	78° 49.42' N	1° 17.83' E	2527.7	Hand net
170-1	18.07.08	19:46	21:27	78° 49.80' N	1° 33.91' E	2546.3	CTD/rosette
171-1	18./19.07.08	22:30	00:08	78° 50.01' N	1° 53.63' E	2559.7	CTD/rosette
172-1	19.07.08	01:04	02:42	78° 50.02' N	2° 12.32' E	2544.3	CTD/rosette
173-1	19.07.08	03:28	05:08	78° 49.49' N	2° 30.37' E	2529.0	CTD/rosette
174-1	19.07.08	09:11	11:05	78° 32.21' N	1° 41.07' E	2310.3	Glider
175-1	19.07.08	15:22	17:37	78° 49.78' N	0° 31.41' E	2538.8	Mooring
176-1	19.07.08	19:04	20:51	78° 50.37' N	0° 5.53' E	2626.8	CTD/rosette
177-1	19.07.08	21:59	23:32	78° 50.53' N	0° 23.62' E	2581.5	CTD/rosette
178-1	20.07.08	00:09	01:44	78° 50.16' N	0° 33.22' E	2559.2	CTD/rosette
179-1	20.07.08	02:33	04:05	78° 50.13' N	0° 42.87' E	2459.1	CTD/rosette
180-1	20.07.08	04:48	06:21	78° 49.84' N	0° 59.69' E	2479.7	CTD/rosette
180-2	20.07.08	06:28	07:21	78° 49.88' N	1° 2.35' E	2502.8	Mooring
181-1	20.07.08	09:53	11:20	78° 49.85' N	0° 23.15' E	2584.7	Mooring
182-1	20.07.08	14:49	16:13	78° 50.31' N	0° 48.80' W	2663.5	Mooring
183-1	20.07.08	17:19	18:59	78° 49.50' N	0° 13.81' W	2650.0	CTD/rosette
184-1	20.07.08	19:43	21:26	78° 49.74' N	0° 29.58' W	2686.3	CTD/rosette
185-1	20./21.07.08	22:42	00:23	78° 50.00' N	0° 48.66' W	2661.5	CTD/rosette
186-1	21.07.08	01:28	03:12	78° 50.05' N	1° 7.14' W	2601.5	CTD/rosette
187-1	21.07.08	04:36	06:20	78° 50.35' N	1° 21.29' W	2692.5	CTD/rosette
188-1	21.07.08	08:45	09:59	78° 50.40' N	0° 47.99' W	2664.7	Mooring

Station PS72	Date	Time (start)	Time (end)	Position (Lat.)	Position (Lon.)	Depth (m)	Gear
189-1	21.07.08	13:08	14:52	78° 49.82' N	1° 42.93' W	2712.7	CTD/rosette
190-1	21.07.08	15:54	17:28	78° 49.28' N	2° 3.17' W	2719.0	Mooring
190-2	21.07.08	17:54	19:08	78° 49.47' N	2° 5.40' W	2713.8	Mooring
190-3	21.07.08	19:41	21:29	78° 50.63' N	2° 4.12' W	2708.0	CTD/rosette
191-1	23.07.08	05:50	06:11	80° 24.68' N	15° 21.62' W	193.0	CTD/rosette
191-2	23.07.08	06:22	06:43	80° 24.68' N	15° 21.62' W	193.0	LOKI
192-1	23.07.08	11:54	12:26	80° 23.18' N	14° 45.96' W	286.5	CTD/rosette
193-1	23.07.08	13:15	13:46	80° 21.43' N	14° 5.63' W	308.8	CTD/rosette
193-2	23.07.08	13:47	13:51	80° 21.44' N	14° 5.60' W	309.3	Hand net
193-3	23.07.08	13:58	14:05	80° 21.44' N	14° 5.70' W	310.8	LOKI
193-4	23.07.08	14:32	15:11	80° 21.40' N	14° 5.52' W	310.0	Bongo net
194-1	23.07.08	15:57	16:23	80° 19.45' N	13° 27.04' W	281.5	CTD/rosette
195-1	23.07.08	17:53	18:13	80° 18.98' N	12° 0.03' W	180.2	CTD/rosette
195-2	23.07.08	18:19	18:23	80° 19.04' N	11° 59.86' W	184.0	Hand net
195-3	23.07.08	18:24	18:28	80° 19.06' N	11° 59.79' W	186.3	LOKI
196-1	23.07.08	22:37	22:50	81° 1.04' N	10° 59.36' W	62.8	CTD/rosette
196-2	23.07.08	23:01	23:13	81° 1.05' N	10° 59.54' W	61.5	LOKI
197-1	24.07.08	00:00	00:16	80° 56.05' N	10° 59.84' W	84.8	CTD/rosette
198-1	24.07.08	01:09	01:37	80° 48.97' N	10° 59.44' W	223.6	CTD/rosette
199-1	24.07.08	02:40	02:59	80° 42.07' N	11° 0.30' W	131.0	CTD/rosette
200-1	24.07.08	04:27	04:53	80° 35.02' N	12° 0.58' W	271.2	CTD/rosette
201-1	24.07.08	05:48	06:11	80° 27.96' N	11° 59.66' W	269.0	CTD/rosette
202-1	24.07.08	07:09	07:32	80° 20.99' N	11° 59.72' W	255.8	CTD/rosette
203-1	24.07.08	08:29	08:52	80° 14.01' N	11° 59.86' W	191.2	CTD/rosette
204-1	24.07.08	09:49	10:07	80° 6.97' N	11° 59.97' W	169.0	CTD/rosette
204-2	24.07.08	10:17	10:33	80° 7.00' N	11° 59.73' W	168.0	LOKI
205-1	24.07.08	12:13	12:34	79° 52.93' N	11° 59.66' W	146.5	CTD/rosette
206-1	24.07.08	14:03	14:30	79° 39.96' N	12° 0.42' W	268.5	CTD/rosette
207-1	24.07.08	16:43	17:04	79° 19.84' N	11° 59.85' W	199.3	CTD/rosette
208-1	24.07.08	19:17	19:40	79° 0.15' N	11° 59.29' W	203.0	CTD/rosette
208-2	24.07.08	19:41	19:45	79° 0.17' N	11° 58.96' W	212.2	Hand net
208-3	24.07.08	19:46	20:05	79° 0.18' N	11° 58.87' W	214.7	LOKI
208-4	24.07.08	20:12	20:39	79° 0.20' N	11° 58.67' W	218.0	Bongo net
209-1	24.07.08	23:12	23:35	78° 39.18' N	12° 5.17' W	218.5	CTD/rosette
210-1	25.07.08	02:15	02:40	78° 19.94' N	13° 0.07' W	189.0	CTD/rosette
211-1	25.07.08	05:33	05:50	77° 59.52' N	14° 0.15' W	109.2	CTD/rosette
211-2	25.07.08	05:58	06:07	77° 59.47' N	14° 0.09' W	108.7	LOKI
212-1	25.07.08	08:04	08:32	77° 44.95' N	14° 40.95' W	391.2	CTD/rosette
212-2	25.07.08	08:46	09:15	77° 45.03' N	14° 40.79' W	391.0	LOKI
212-3	25.07.08	09:25	09:54	77° 44.99' N	14° 40.34' W	393.5	Multi corer
213-1	25.07.08	11:45	12:16	77° 30.01' N	15° 0.40' W	319.0	CTD/rosette
213-2	25.07.08	12:33	13:42	77° 30.18' N	14° 59.98' W	320.7	Agassiz trawl
214-1	25.07.08	16:02	16:26	77° 15.03' N	15° 29.72' W	241.5	CTD/rosette
215-1	25.07.08	18:13	18:35	77° 0.05' N	15° 56.38' W	214.3	CTD/rosette
215-2	25.07.08	18:39	18:43	77° 0.09' N	15° 56.58' W	210.7	Hand net
215-3	25.07.08	18:43	19:00	77° 0.08' N	15° 56.62' W	217.3	LOKI
215-4	25.07.08	19:06	19:33	77° 0.12' N	15° 56.54' W	210.7	Bongo net
216-1	25.07.08	23:36	23:58	77° 0.04' N	13° 0.09' W	264.2	CTD/rosette
217-1	26.07.08	01:58	02:22	77° 14.96' N	12° 29.85' W	286.0	CTD/rosette
217-2	26.07.08	02:29	02:50	77° 14.81' N	12° 29.90' W	289.0	LOKI

Station PS72	Date	Time (start)	Time (end)	Position (Lat.)	Position (Lon.)	Depth (m)	Gear
218-1	26.07.08	05:00	05:34	77° 29.85' N	11° 53.05' W	467.8	CTD/rosette
219-1	26.07.08	07:23	07:45	77° 44.99' N	11° 59.54' W	217.7	CTD/rosette
219-2	26.07.08	07:54	08:11	77° 44.93' N	11° 59.56' W	218.0	LOKI
220-1	26.07.08	09:50	10:08	77° 59.96' N	12° 0.02' W	167.0	CTD/rosette
221-1	26.07.08	16:44	17:13	78° 50.00' N	10° 59.67' W	337.2	CTD/rosette
222-1	26.07.08	18:56	19:20	78° 49.97' N	9° 59.89' W	299.0	CTD/rosette
223-1	26.07.08	21:02	21:23	78° 49.98' N	9° 1.74' W	214.0	CTD/rosette
224-1	27.07.08	01:07	01:28	78° 49.79' N	8° 0.91' W	190.8	CTD/rosette
225-1	27.07.08	04:39	05:06	78° 51.20' N	6° 58.97' W	253.8	CTD/rosette
226-1	27.07.08	06:24	06:52	78° 50.40' N	6° 42.59' W	269.5	CTD/rosette
227-1	27.07.08	09:01	09:24	78° 48.76' N	6° 19.97' W	299.5	CTD/rosette
228-1	27.07.08	10:33	10:59	78° 50.18' N	5° 59.90' W	351.7	CTD/rosette
228-2	27.07.08	11:10	11:36	78° 50.68' N	5° 59.69' W	356.8	LOKI
228-3	27.07.08	11:41	12:09	78° 50.99' N	5° 59.54' W	362.2	Bongo net
229-1	27.07.08	12:53	13:24	78° 50.13' N	5° 39.37' W	453.5	CTD/rosette
230-1	27.07.08	14:00	14:40	78° 49.81' N	5° 19.95' W	709.0	CTD/rosette
231-1	27.07.08	15:26	16:20	78° 49.96' N	4° 59.66' W	1050.0	CTD/rosette
232-1	27.07.08	17:16	18:19	78° 49.86' N	4° 39.89' W	1359.0	CTD/rosette
233-1	27.07.08	19:13	20:24	78° 50.28' N	4° 22.15' W	1624.7	CTD/rosette
234-1	27.07.08	21:22	22:48	78° 49.95' N	4° 0.01' W	1925.5	CTD/rosette
235-1	27./28.07.08	23:55	01:32	78° 50.41' N	3° 41.07' W	2181.5	CTD/rosette
236-1	28.07.08	03:38	05:36	78° 49.98' N	3° 19.34' W	2399.0	CTD/rosette
237-1	28.07.08	09:33	11:12	78° 51.13' N	3° 3.39' W	2526.8	CTD/rosette
237-2	28.07.08	11:20	12:17	78° 50.44' N	3° 2.13' W	2520.5	LOKI
237-3	28.07.08	12:29	13:03	78° 49.87' N	3° 1.60' W	2523.8	Bongo net
238-1	28.07.08	14:28	16:21	78° 49.86' N	2° 46.79' W	2596.5	CTD/rosette
239-1	28.07.08	18:13	19:53	78° 49.81' N	2° 21.46' W	2670.0	CTD/rosette
240-1	29.07.08	08:39	10:02	79° 50.16' N	3° 59.06' W	1986.3	CTD/rosette
241-1	29.07.08	12:31	13:47	79° 50.02' N	4° 32.00' W	1637.0	CTD/rosette
241-2	29.07.08	13:58	14:37	79° 49.79' N	4° 29.22' W	1666.2	LOKI
241-3	29.07.08	14:45	15:11	79° 49.63' N	4° 28.02' W	1676.2	Bongo net
242-1	29.07.08	16:16	17:14	79° 50.06' N	5° 2.87' W	1169.3	CTD/rosette
243-1	29.07.08	18:00	18:34	79° 49.86' N	5° 32.70' W	518.0	CTD/rosette
244-1	29.07.08	19:19	19:45	79° 49.98' N	6° 0.30' W	306.5	CTD/rosette
245-1	29.07.08	20:40	21:06	79° 49.96' N	6° 29.37' W	280.7	CTD/rosette
246-1	29.07.08	22:04	22:26	79° 50.00' N	6° 59.44' W	245.8	CTD/rosette
247-1	29.07.08	23:18	23:38	79° 49.99' N	7° 29.55' W	215.0	CTD/rosette
248-1	30.07.08	00:35	01:00	79° 50.08' N	8° 0.20' W	198.0	CTD/rosette
248-2	30.07.08	01:10	01:26	79° 50.10' N	7° 59.35' W	190.8	LOKI
249-1	30.07.08	02:30	02:54	79° 50.20' N	8° 30.10' W	226.0	CTD/rosette
250-1	30.07.08	03:47	04:09	79° 50.00' N	9° 0.02' W	199.5	CTD/rosette
251-1	30.07.08	05:00	05:25	79° 49.98' N	9° 29.99' W	267.8	CTD/rosette
252-1	30.07.08	06:15	06:38	79° 49.95' N	10° 0.44' W	196.5	CTD/rosette
252-2	30.07.08	06:39	06:43	79° 49.94' N	10° 0.83' W	200.2	Hand net
252-3	30.07.08	06:47	07:05	79° 49.95' N	10° 0.92' W	200.3	LOKI
252-4	30.07.08	07:11	07:33	79° 49.96' N	10° 1.39' W	197.5	Bongo net
253-1	30.07.08	08:19	08:40	79° 50.01' N	10° 29.63' W	211.7	CTD/rosette
254-1	30.07.08	09:32	09:54	79° 50.00' N	10° 59.77' W	259.2	CTD/rosette
254-2	30.07.08	10:00	10:33	79° 50.01' N	10° 59.79' W	260.7	Multi corer
255-1	30.07.08	11:32	11:50	79° 50.00' N	11° 29.34' W	0.0	CTD/rosette

Station PS72	Date	Time (start)	Time (end)	Position (Lat.)	Position (Lon.)	Depth (m)	Gear
256-1	30.07.08	12:49	13:10	79° 50.12' N	11° 59.90' W	159.0	CTD/rosette
256-2	30.07.08	13:21	13:35	79° 50.35' N	11° 59.50' W	0.0	LOKI
257-1	30.07.08	14:31	14:55	79° 50.03' N	12° 27.09' W	196.8	CTD/rosette
258-1	31.07.08	00:59	01:18	79° 50.10' N	12° 33.82' W	190.8	CTD/rosette
258-2	31.07.08	01:27	01:42	79° 50.10' N	12° 33.82' W	190.5	LOKI
258-3	31.07.08	01:49	02:13	79° 50.10' N	12° 33.82' W	190.5	Bongo net
258-4	31.07.08	02:25	02:57	79° 50.17' N	12° 33.62' W	185.7	Multi corer
259-1	31.07.08	07:19	07:42	80° 16.95' N	11° 32.69' W	189.0	CTD/rosette
260-1	31.07.08	08:44	09:04	80° 18.99' N	11° 59.90' W	180.0	CTD/rosette
261-1	31.07.08	10:24	10:45	80° 20.03' N	12° 42.53' W	0.0	CTD/rosette
262-1	31.07.08	11:59	12:26	80° 21.04' N	13° 26.12' W	305.0	CTD/rosette
263-1	31.07.08	13:31	13:57	80° 23.01' N	14° 5.95' W	339.0	CTD/rosette
264-1	31.07.08	15:05	15:38	80° 25.05' N	14° 46.05' W	254.2	CTD/rosette
265-1	31.07.08	16:52	17:20	80° 27.44' N	15° 25.17' W	198.0	CTD/rosette
265-2	31.07.08	17:28	17:46	80° 27.76' N	15° 22.85' W	228.5	LOKI
265-3	31.07.08	17:51	18:07	80° 28.00' N	15° 21.79' W	233.7	Bongo net
266-1	31.07.08	22:59	23:25	80° 25.89' N	12° 25.02' W	283.9	CTD/rosette
267-1	02.08.08	05:07	05:34	81° 47.38' N	12° 29.97' W	217.7	CTD/rosette
268-1	02.08.08	06:39	07:05	81° 53.10' N	12° 2.65' W	202.7	CTD/rosette
268-2	02.08.08	07:06	07:10	81° 53.06' N	12° 2.43' W	203.8	Hand net
268-3	02.08.08	07:12	07:29	81° 53.06' N	12° 2.36' W	203.8	LOKI
268-4	02.08.08	07:34	07:56	81° 53.06' N	12° 1.89' W	194.5	Bongo net
269-1	02.08.08	09:04	09:28	81° 59.56' N	11° 22.97' W	234.3	CTD/rosette
269-2	02.08.08	09:33	09:55	81° 59.54' N	11° 22.65' W	235.2	Multi corer
270-1	02.08.08	10:29	10:59	82° 2.04' N	11° 8.33' W	366.8	CTD/rosette
271-1	02.08.08	11:40	12:25	82° 3.71' N	10° 57.19' W	871.8	CTD/rosette
272-1	02.08.08	13:06	14:22	82° 3.82' N	10° 47.66' W	1672.5	CTD/rosette
273-1	02.08.08	15:15	17:01	82° 5.25' N	10° 24.24' W	2503.8	CTD/rosette
274-1	02.08.08	18:05	19:48	82° 11.97' N	9° 32.29' W	2896.3	CTD/rosette
274-2	02.08.08	19:48	19:54	82° 12.02' N	9° 30.38' W	2901.5	Hand net
274-3	02.08.08	19:54	20:33	82° 12.02' N	9° 30.33' W	2901.2	LOKI
274-4	02.08.08	20:38	20:58	82° 11.92' N	9° 30.20' W	2898.7	Bongo net
275-1	02./03.08.08	23:04	01:16	82° 24.09' N	8° 30.12' W	3216.7	CTD/rosette
276-1	05.08.08	14:05	14:31	80° 25.08' N	10° 52.77' W	326.8	CTD/rosette
277-1	05.08.08	15:20	15:47	80° 28.50' N	11° 13.80' W	307.2	CTD/rosette
277-2	05.08.08	16:03	16:06	80° 28.59' N	11° 13.24' W	308.7	LOKI
278-1	05.08.08	16:52	17:19	80° 32.61' N	11° 37.29' W	276.8	CTD/rosette
279-1	05.08.08	18:00	18:24	80° 36.81' N	11° 54.72' W	271.7	CTD/rosette
280-1	05.08.08	20:16	20:38	80° 40.98' N	12° 17.62' W	237.0	CTD/rosette
281-1	05.08.08	21:39	21:52	80° 45.44' N	12° 42.11' W	126.2	CTD/rosette
281-2	05.08.08	21:59	22:09	80° 45.25' N	12° 42.23' W	123.3	LOKI
282-1	05.08.08	22:56	23:05	80° 50.06' N	13° 1.65' W	57.2	CTD/rosette
283-1	05./06.08.08	23:58	00:06	80° 54.43' N	13° 28.08' W	51.0	CTD/rosette

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