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The Expedition of the Research Vessel "Polarstern" to the Arctic in 2011 (ARK-XXVI/2)

Edited by
Michael Klages
with contributions of the participants

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ARK-XXVI/2
13 July 2011 - 3 August 2011
Longyearbyen - Tromsø

Chief Scientist
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1. EXPEDITION ARK-XXVI/2: FAHRTVERLAUF UND ZUSAMMENFASSUNG

Michael Klages Alfred-Wegener-Institut

Der Fahrtabschnitt ARK-XXVI/2 des Forschungsschiffs *Polarstern* im Sommer 2011 begann am 13. Juli in Longyearbyen (Spitzbergen) (Abb. 1.1). Es waren ingesamt 52 Wissenschaftler, Techniker und Studenten an Bord, von denen 2 Wissenschaftler am 19. Juli planmässig wieder ausgeflogen wurden.

Wichtigstes Großgerät an Bord war das Remotely Operated Vehicle (ROV) KIEL 6000 des Leibniz-Institutes für Meereswissenschaften IFM-GEOMAR, das zum ersten Mal auf *Polarstern* zum Einsatz kam. Damit sind seit 1999 neben dem französischen VICTOR 6000 und dem QUEST 4000 des MARUM der Universität Bremen drei verschiedene working class ROV erfolgreich auf *Polarstern* in der Arktis eingesetzt worden. Der erste Tauchgang ist bei rund 240 m Wassertiefe westlich von Prinz-Karl-Vorland durchgeführt worden. Hier wurden vor knapp zwei Jahren unter Federführung britischer Kollegen zahlreiche Gasfahnen mit Hilfe eines Fischereiecholotes registriert. Während des Tauchgangs wurden diese Lokationen gesucht und beprobt. Ein weiterer Tauchgang konnte am Vestnesa-Rücken in rund 1.200 m Tiefe durchgeführt werden. Im weiteren Verlauf der Expedition erfolgten Tauchgänge im Bereich des Tiefsee-Observatoriums HAUSGARTEN in Wassertiefen zwischen 2.310 und 2.470 m. Neben einem Standard-Probennahmeprogramm (Aufnehmen und Ausbringen von Verankerungen, Einsatz von CTD und Rosette, pelagischen Netzen, Multicorer und Freifall-Landern) wurde KIEL 6000 auch genutzt, um unter natürlichen Umgebungsbedingungen in der Tiefsee verschiedene Experimente durchzuführen und um gezielt Sediment- und andere Proben zu sammeln. Erstmalig wurde während der Expedition im Parallelbetrieb das Autonome Unterwasserfahrzeug (AUV) des AWI eingesetzt. Dabei konnte das Fahrzeug in Tiefen bis 600 m unabhängig vom Schiff Proben sammeln und Daten aufzeichnen, während *Polarstern* auf Station war und beispielsweise den ROV-Betrieb ermöglichte. Das AUV wurde für knapp zwei Stunden unter eine, mit 1,5 Stundenkilometern driftenden Meereisnase in 20 Metern Tiefe eingesetzt. Nach erster Sichtung der aufgezeichneten Daten (Leitfähigkeit, Temperatur, Fluoreszenz, PAR, pCO_2) ist deutlich geworden, dass auch ein sich bewegendes, verhältnismäßig offenes Eisfeld den darunterliegenden Wasserkörper beeinflusst, obwohl Wasser und Eis nur kurzfristig in Kontakt stehen. Durch die exzellente Zusammenarbeit zwischen Besatzung und Wissenschaft, den günstigen Witterungs- und Eisbedingungen sowie dem Parallelbetrieb von AUV und anderen Geräten an Bord konnte Zeit eingespart werden. Diese wurde am letzten Tag der Stationsarbeiten genutzt, um mit dem ROV eine ozeanographische Verankerung, die von einem Fischereifahrzeug mit einem Schleppnetz umgepflügt worden war, am Boden zu suchen und einen Bergedraht anzubringen. Dieses Vorhaben ist erfolgreich abgeschlossen worden, so dass nicht nur die Messgeräte, sondern vor allem die wertvollen Messergebnisse geborgen werden konnten. Der Expeditionsabschnitt endete am frühen Morgen des 3. August im Hafen von Tromsø.

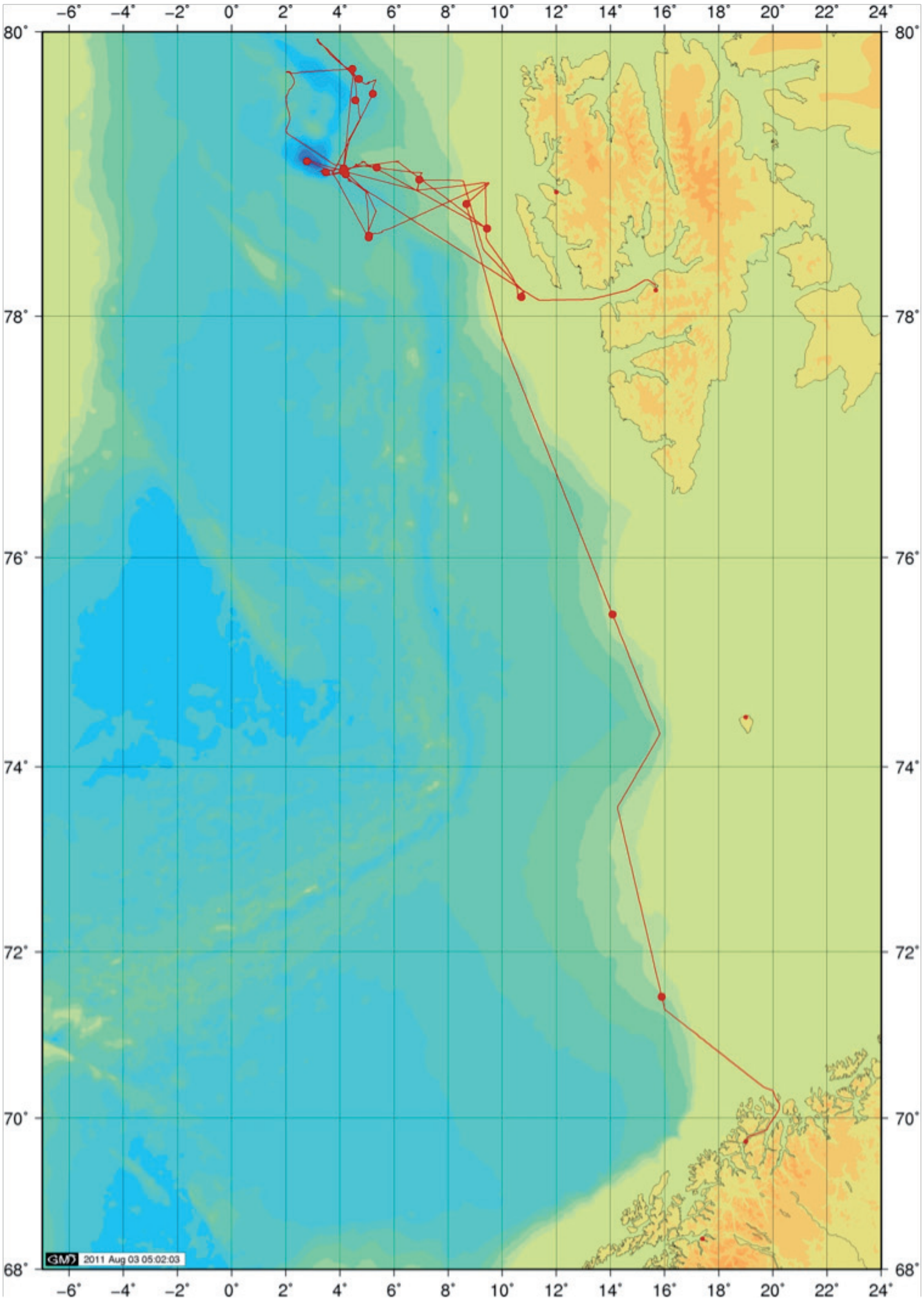

Abb. 1.1: Fahrtroute der Polarstern-Expedition ARK-XXVI/2

Fig. 1.1: Route of Polarstern expedition ARK-XXVI/2

CRUISE NARRATIVE AND SUMMARY

The cruise leg ARK-XXVI/2 of research vessel *Polarstern* during Arctic summer season 2011 begun on 13 July in Longyearbyen (Svalbard) (Fig 1.1). In total 52 scientists, technicians and students were onboard. Two scientists left according to schedule on 19 July. Major infrastructure being applied was the unmanned Remotely Operated Vehicle (ROV) KIEL 6000 of IFM-GEOMAR in Kiel which had been installed onboard *Polarstern* for the first time. Since 1999 three different work-class ROVs have been used succesfully onboard, namely the French ROV VICTOR 6000, the QUEST 4000 owned by MARUM of the University of Bremen and KIEL 6000. The first dive during the cruise took place at Prins Karls Forland in around 240 m depth. This area has been recently identified as a region where numerous methane seeps release gas into the water column. Some of these gas flares have been investigated and sampled with the ROV. During the second dive we worked at the Vestnessa Ridge in 1,200 m depth across two pockmark structures that showed besides the typical slope megafauna areas of methane seeps. Further to the west in the area of the HAUSGARTEN deep-sea observatory three more dives were carried out at water deph between 2,310 and 2,470 m. Among a standard sampling programme (recovery and re-deployment of moorings, CTD and rosette, pelagic bongo and multinet, Multicorer and free falling lander systems) we used KIEL 6000 for several *in-situ* experiments at the deep-sea floor, collected sediment samples and biological material. For the first time we used the Autonomous Underwater Vehicle (AUV) owned by AWI in parallel to ROV operations. The AUV was pre-programmed to dive as deep as 600 m collecting water samples at different depth and other data independent from the research vessel. The AUV was also programmed to dive for about two hours at 20 m water depth beneath a drifting sea ice field. Preliminary analysis of the collected data (conductivity, temperature, fluorescence, PAR and pCO_2) suggests that the impact of a drifting, rather open ice field on the water mass properties below the ice is significant in spite of the short period of contact between ice and water. Because of the excellent cooperation between scientists and crew, the good weather and ice conditions during the cruise leg and the parallel operation of AUV and other instruments onboard we saved some time. This extra time was spent on the last day of work at sea to search for a lost oceanographic mooring that had been obviously dredged by commercial fishing activities in close vicinity to Svalbard. This operation was succesfully completed. Very shortly after arrival at the lost mooring in 230 m water depth a rope was attached to the instruments and recovered with one of the ships' winches. The cruise leg did end in the early morning of 3 August with arrival at the port of Tromsø.

2. WEATHER CONDITIONS

Max Miller, Klaus Buldt
DWD Deutscher Wetterdienst, Hamburg

On 13 July (6:00 pm) *Polarstern* left the berth of Longyearbyen for the second leg of the 2011 Arctic campaign.

A storm over Lapland moved on to Barents Sea and affected us during the next days. While passing the Isfjord we were sheltered from the wind. But on transit to the HAUSGARTEN area the northerly wind increased up to 6 Bft and reached its maximum during the night to Friday, 15 July with Bft 7 to 8. Already on Saturday the wind abated. The next days light to moderate north westerly winds prevailed. This caused fog which became a problem for flight operations. On 19 July *Polarstern* returned to the entrance of Isfjord to carry out flight operations to Longyearbyen. Although there have been fog patches in this area they did not cause any problems to the helicopter flights.

From Wednesday, 20 July *Polarstern* continued work in the HAUSGARTEN area. Here again northerly winds were observed which in times increased up to Bft 6. However fog again became a problem for flight operations.

On Sunday, 24 July a high formed between Iceland and Norway and moved towards Barents Sea. It gave us one of the rare sunny days of this expedition. But later on wind turned to south and fog or low stratus became dominating again. A secondary low moved from Iceland to the east coast of Greenland and therefore the southerly wind increased up to 6 Bft on July 28 and 29.

From Saturday, 30 July the high over Barents Sea was the dominating feature. Approaching the west coast of Svalbard late Saturday night again a remarkable local effect was observed. The above mentioned high caused southerly winds with an average force of 4 to 5 Bft over the entire Fram Straight. As the flow was parallel to the coast, the wind accelerated the closer we came to the shore (jet like effect). Up to Bft 6 has been measured at the closest way point.

During the transit to Tromsø the wind varied from west to north and hardly reached Bft 5. In the early morning of 3 August 2011 *Polarstern* reached the harbour Tromsø.

3. DEPLOYMENT OF ROV (REMOTELY OPERATED VEHICLE) KIEL 6000 DURING EXPEDITION ARK-XXVI/2 IN THE NORTH ATLANTIC / FRAM STRAIT WEST OF SVALBARD

Inken Suck[1)], Martin Pieper[1)], Patrick Cuno[1)], Hannes Huusmann[1)], Arne Meier[1)], Wolfgang Queisser[1)], Greg Engemann[2)], James Cooper[3)], Simon Dodd[3)], Sebastian Albrecht[4)], Frederic Tardeck[4)]

[1)] ROV-Team IFM-GEOMAR, Kiel

[2)] Schilling Robotics, USA

[3)] NOCS, Southampton, UK

[4)] FIELAX, Bremerhaven

Objectives and work at sea

ROV KIEL 6000 (Fig. 3.1) is a 6,000 m rated deep diving platform manufactured by Schilling Robotics LLC, Davis, USA. It is based on commercially available ROVs, but customized to our demands, e.g. being truly mobile. KIEL 6000 has been operated from a variety of different research vessels (RV *Sonne*, N/O *l'Atalante*, RV *Maria S*. *Merian*, RV *Meteor*, RV *Celtic Explorer* and *Polarstern*) until today. As an electric work class ROV of the type QUEST, this is build No. 7. ROV KIEL 6000 is based at the Leibniz Institute for Marine Sciences IFM-GEOMAR in Kiel, Germany.

Including this cruise, ROV KIEL 6000 has accomplished 125 dives during 10 expeditions. During ARK-XXVI/2 (PS 78), 5 scientific dives and 1 recovery dive were completed. Maximum depth was 2,445 m and maximum bottom time was more than 11 hours. In total, bottom time accumulated to approx. 51 hours (total dive time 62 hours).

In addition, the IFM-GEOMAR Ocean Elevator (Fig. 3.2) was deployed to transport more and larger tools and gear to and from the seafloor. It was used to carry additional pushcores, a microprofiler (MPI Bremen) as well as bring up 2 MAV sensors (current measuring devices).

9 pilots/ technicians made operations of both systems possible at any time on demand.

Tasks accomplished during this leg by ROV KIEL 6000 at the seafloor included sediment sampling by pushcores, searching for starvation cages by means of our high resolution Sonar MS 1000 (Kongsberg), the position of which was unclear, dispersal of luminophores at selected sites using "salt-shakers", establishing a long-term photo-transect (using newly integrated marker dropper & MegaCam), gas sampling, deployment of tools (microprofiler), handling of long-term equipment (cages, flume), recovery of MAVS sensors that had been deployed some years ago, as well as the recovery of a "trawled" mooring using a recovery hook on a ship's wire.

Details on individual dives are given in the scientific chapters of this report below.

Fig. 3.1: ROV KIEL 6000 with marker dropper and vertical megacam installed on the toolskid drawers just before station 164ROV04

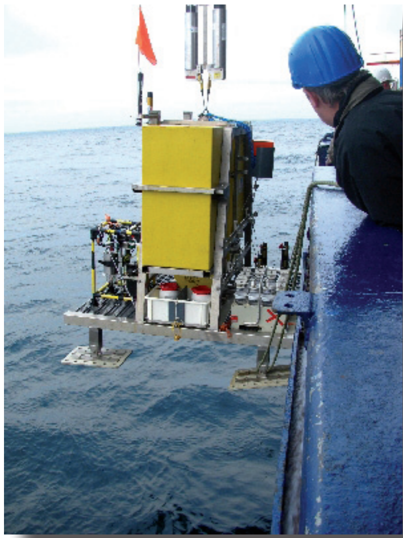

Fig. 3.2: IFM-GEOMAR Ocean Elevator during launch, carrying microprofiler, "saltshakers", pushcores and HOMER Beacons (Station 161ROV03)

System description

The vehicle is equipped with 7 electric thrusters. Power is supplied through a 19 mm diameter steel armoured umbilical with 4160VAC/460 Hz. The deep sea winch (manufactured by Hatlapa, Uetersen, Germany) takes up 6,500 m of umbilical (NSW, Nordenham, Germany).

The ROV is configured as a "free flyer" and thus does not require a tether management system (TMS). Floats mounted onto the first 100 metres of the umbilical decouple the ROV from ship's movements and the ROV is capable of making excursions of up to 200 metres away from the aft of the ship.

KIEL 6000 is equipped with two manipulator arms. A seven-function position controlled manipulator ORION used for dexterious operations, and a five-function rate controlled manipulator RIGMASTER for more rugged tasks and heavy lifting.

Further tools standardly installed on the vehicle include 7 cameras (for more details see 'Video Setup, HDTV and archiving of video material' below), a depth sensor, a high resolution sonar system MS1000, a compass and a motion reference unit (MRU) containing a fibre optic gyro.

An RDI Doppler velocity log (DVL) allows the small-scale positioning /displacement of the vehicle in the range of 10s of centimetres at the seafloor, especially important during crucial operations.

For large scale general navigation, a USBL-based IXSEA POSIDONIA™ system is used (for more details on positioning and navigation see 'Telemetry and navigation' below).

A tool sled in the lower-most part of the vehicle is configured to take up the scientific payload. A SBE 49 FastCAT CTD is permanently mounted. Located on the portside front of the tool sled is a sample tray which can be opened hydraulically and can be customized on demand using a modular set-up. On starboard front there is a drawer, likewise hydraulically driven, which can take up sample containers, probes or other scientific tools continuously mounted or used by the manipulator. Port aft and starboard aft are reserved for additional scientific payload which differ from mission to mission.

Telemetry and navigation

Data transfer between the vehicle and the topside control van is managed by the digital telemetry system (DTS™) which consists of two surface and four sub-sea nodes, each representing a 16-port module. Each port may be individually configured for serial (SIM), video (VIM) or network (NIM) purposes. During the present cruise, for example, communication to the AWI marker dropper was realized via a SIM, while the MPI mega cam was controlled via a NIM. Both were directly operated by the scientists.

The topside telemetry logging system ROVMon which has been developed and customized to our needs by our IT engineer, collects incoming data from ROV, ship, winch, CTD and IXSEA POSIDONIA™. It distributes data to several subsystems like the navigation system, the video overlay and data display clients. The telemetry system can handle TCP/IP, UDP and serial connections. The data usually is transferred as NMEA strings; if other formats are transferred, these can be converted by specialized frontends. The configuration of data logging is declared in advance where protocols, devices (sensors) and exports are specified for the ship and the cruise. The whole data set is written each second in CSV (comma separated values) files. The telemetry system starts a new file after a given interval for security reasons.

For navigation and coordination with the ship during the dive we use the navigation software OFOP by Jens Greinert (NIOZ) in version 3.2. Coordinates and heading data from the ship and the ROV are overlayed on a calibrated map. This navigation screen is also provided to the bridge via VNC viewer to show where the ROV position is relative to the ship. A self built trigger box sends a trigger signal to the transponder (responder mode) on the ROV and simultaneously to POSIDONIA™ which is setup to external trigger mode.

Scientific data management

The navigation software OFOP also includes the protocol function for the scientists to describe the dive and actions like sampling and taking pictures with coordinates and timestamps. After each dive, the scientific protocol is converted into an Excel file to provide it to the scientists. The telemetry files are packed and copied onto the server for public access and post-processing (see 'ROV navigation and dive log post-processing' below).

Video setup, HDTV and archiving of video material

Cameras standardly installed on the vehicle include an HDTV camera, two high-resolution colour zoom cameras (on pan&tilt units), one digital still camera as well as three black and white observation cameras.

All colour cameras' footage is recorded on harddrives. The HDTV Camera (1080i) is recorded on demand using an Apple MacPro with a HD-Videocard (AJA KonaLHe) and Final Cut Pro 7.

The HD video is standardly recorded in DVCProHD (13.5 Mbytes/sec). Other formats like Apple ProRes or even uncompressed recording are possible. The video is first stored on the Macs internal RAID-System (1.5TB). After each dive it is copied to a second MacPro for postprocessing and downconverting using Telestream Episode software. All HD Videos are converted to SD resolution (DV) with an IFM-GEOMAR Logo imprint.

Both SD-Cameras are permanently recorded on an IBM-Z pro Computer using two Focus Capture Cards and Focus capture suite software. The video is recorded in Mpeg2. The software automatically starts a new file every 20 minutes to generate smaller sized, thus user friendly files. The SD material contains an imprinted data overlay including date, time, depth, temperature and pan angle of the specific camera.

All SD video files are uploaded on the fly into the Como ProxSys video asset management system. The ProxSys system is accessible over ship's network and normal webbrowser like internet explorer or safari. The System provides a structured overview of the complete video and data files for each dive of the cruise.

The Kongsberg Digital Still camera has a resolution of 5 MPixel, images are taken on demand. After each dive, all images are downloaded from the camera and logo, date and time are imprinted and images uploaded onto the ProxSys server subsequently.

Users can then preview and download videos, photos and data.

At the home institute, the ROV KIEL6000 ProxSys system is synchronized with an onshore system of the IFM-GEOMAR. The onshore system contains all media- and data-material ever collected by ROV KIEL6000.

ROV navigation and dive log post-processing

FIELAX provided the post processing of ROV navigation and dive log data. Acoustic positioning systems are helpful tools for tracking gears under water. Nevertheless, they have a limited accuracy and regularly produce outliers which can deviate several 100 meters from the actual track. As the dive log and consequently all ROV sampling positions are based on the raw navigation provided, a post-processing of that navigation is essential. For every dive these steps were done: Manual rejection of outliers, position filtering according to positions not reachable at a certain maximum speed, smoothing of the track by a Gaussian filter and interpolation to achieve a continuous navigation track at one second interval. Based on that original positions in the dive logs were replaced. Samples and measurements taken by the ROV were extracted from the dive log and added to the expedition's station list

ROV based tools, installed on vehicle:

Toolskid containing 2 hydraulically driven drawers in the front,

in the aft section 2 pallets for custom configuration

CTD real-time probe

Pushcores, 6 in portside drawer

Hand-Nets (IFM-GEOMAR)

Acoustic HOMER Beacon markers (IFM-GEOMAR / AWI)

Passive site markers (AWI)

Autoclaves mounted in boxes, equivalent to our drawers, replacing these both port- and starboardside (AWI)

Simple knife for manipulator operations

Slurpgun (IFM-GEOMAR)

Tube Shovel (IFM-GEOMAR)

Chain Saw (IFM-GEOMAR)

Chisel (IFM-GEOMAR)

Further tools integrated and/or deployed/ handled/ recovered especially during this cruise were:

IFM-GEOMAR Ocean Elevator

IFM-GEOMAR Bubble sampler

IFM-GEOMAR pushcore 6-packs

AWI Marker Dropper

MPI MegaCam (network based compression)

AWI “Saltshakers” w/ luminophores

AWI seafloor cage installation

AWI seafloor flume installation

AWI 16 pushcore racks

AWI MAVS

MPI Benthic Microprofiler

Recovery gear with steelwire/hook assembly (mooring recovery on ships wire)

Tab. 3.1: ROV station list PS 78/ ARK-XXVI/2

Station Number PS78	Dive No.	Date	Time Start (UTC)	At Bottom (UTC)	Off Bottom (UTC)	Time End (surface) (UTC)	Location	Depth (m)	ROV Bottom Time
	119	13.07.2011	Harbour Test Longyearbyen						
141 ROV01	120	15.07.2011	06:30	07:09	15:28	16:00	Shelf Flare Alley	247	08:19
149 ROV02	121	18.07.2011	09:03	10:01	18:59	19:47	Vestnesa Ridge	1219	08:58
161-2 ROV03	122	22..7.2011	08:15	09:58	21:00	22:11	HG IV Cages	2445	11:02
164 ROV04	123	24.07.2011	09:12	10:19	19:00	20:13	HG IV Frame	2467	08:41
175-3 ROV05	124	28.07.2011	07:45	08:57	19:11	20:22	S3	2309	10:14
186 ROV06	125	31.07.2011	07:20	07:34	11:52	12:09	Mooring Recovery	243	04:18
Total: 5 scientific dives + 1 recovery									51:32:00

For more details please visit http://www.geomar.de/institut/einrichtungen/technik-und-logistikzentrum/rov-gruppe/

4. PLANKTON ECOLOGY AND BIOGEOCHEMISTRY IN A CHANGING ARCTIC OCEAN (PEBCAO)

Judith Piontek, Nicole Hildebrandt, Martin Sperling, Luisa Federwisch, Kristin Hardge, Maria Winkler, Balamuralli Rajasakaren,
Alfred-Wegener-Institut

Eva-Maria Nöthig, Anja Engel, Katja Metfies, Barbara Niehoff, Ilka Peeken (not on board)

Objectives

The project PEBCAO (Plankton Ecology and Biogeochemistry in a Changing Arctic Ocean) is focused on the plankton community and the microbial processes relevant for biogeochemical cycles of the Arctic Ocean. The Arctic Ocean is highly sensitive to climate change. The decline in seawater pH is amplified by an increasing freshwater input from melting sea ice and river discharge that reduces alkalinity and hence the buffering capacity of the sea. In order to understand and track potential consequences for the pelagic ecosystem in the Arctic Ocean both long-term field observations and experimental work with Arctic plankton species and communities are needed to gain knowledge about the biological feedback potential of pelagic communities in the future Arctic Ocean. During this cruise leg, samples have been collected in the area of the deep-sea long-term observatory HAUSGARTEN of the Alfred Wegener Institute (Fram Strait) located between 2-6°E and 78-80°N which represents the frontal zone separating the warm and cold water masses originating from the West Spitsbergen current and the East Greenland current.

Biogeochemistry & Phytoplankton

Recent investigations have shown that rising temperatures as well as freshening of surface waters promote a shift in phytoplankton community towards a dominance of smaller cells. A change in size of the primary producers could have significant consequences for the entire food web in polar waters as well as for the cycling and sequestering of organic matter. An increase in ice free water surface as well as CO_2- and temperature-related changes in the carbonate chemistry of the ocean will also affect the cycling of biogenic elements. Because of the vast spatial dimensions of the oceanic system, even small changes in the biological pump could significantly affect atmospheric CO_2 concentration.

Bacterioplankton

The bioreactivity of particulate and dissolved organic matter is determined by its biochemical composition and diagenetic state. The loss of organic matter within and below the euphotic zone is mainly mediated by the degradation activity of heterotrophic bacteria, colonizing sinking particles and their surroundings (Cho & Azam 1988, Karl et al. 1988). Hence, bacterial activity co-determines the efficiency of carbon export to the deep ocean. Furthermore, bacterioplankton plays a fundamental role at the basis of microbial foodwebs. Dissolved organic matter is almost exclusively accessible for bacterial cells that make it available for higher trophic levels by the production of bacterial biomass. Effects of increasing temperature and decreasing pH on bacterial communities and their activity are thereby of outstanding importance, but yet hardly considered. Studies conducted in the past decades revealed strong physiological responses of marine bacteria to changing temperature and pH, but their relevance for biogeochemical cycles in the future ocean is only poorly investigated.

Zooplankton

Zooplankton organisms are associated with different water masses. Thus, the community composition and depth distribution of zooplankton species change over the Fram Strait, as relatively warm Atlantic water masses encounter cold polar waters. With increasing Arctic water temperatures, a shift in the community composition of the zooplankton may occur. This could have severe consequences for the ecosystem functioning.

Work at sea

Biogeochemistry & Phytoplankton

We sampled seawater of 5 - 8 depths by a CTD/rosette sampler at the HAUSGARTEN area to determine the impact of microbial processes on the aggregation of sedimentation of organic matter. Samples have been taken for biogeochemical parameters such as chlorophyll *a* and pigments (HPLC), seston, dissolved and particulate organic carbon (DOC and POC), dissolved and particulate organic nitrogen (DON and PON) and particulate biogenic silica (PbSi). Additionally samples were taken by CTD casts and hand net to examine the phytoplankton and protozooplankton abundance. All samples are preserved or frozen at -20°C or -80°C. Samples for carbohydrates and amino acids were collected and stored at -20°C. Concentrations will be determined by the use of IC and HPLC, respectively. Samples for transparent exopolymer particles (TEP) and Coomassie stainable particles (CSP) were taken and stored at -20°C until analysis by photometry and microscopy back at the institute. Samples for dissolved organic carbon (DOC) and total alkalinity (TA) were collected at all stations and stored refrigerated. Additionally, water samples were collected from the CTD from the top 100 m depth in order to assess differences in the phytoplankton community composition by automated ribosomal intragenic spacer analysis (ARISA) and 454-next generation sequencing. The samples were fractionated by three filtrations on 10.0 µm, 3.0 µm and 0.2 µm filters and stored at -80°C. Because the molecular methods are lab-based the samples will be analyzed back at the Alfred Wegener Institute.

Bacterioplankton

Bacterioplankton activity was investigated in the field and by pH-manipulation experiments to consider both the present-day Arctic Ocean and potential changes induced by future decrease in pH. Rates of bacterial extracellular enzymes (b-glucosidase and leucine-aminopeptidase), glucose uptake and bacterial biomass production were determined in samples from CTD casts. Furthermore, samples were taken to analyze bacterial abundance (flow cytometer) and diversity (ARISA, FISH). At three stations (KH, HG-IX9, N4) bioassays were set-up to test the response of bacterial extracellular enzymes to gradually changing seawater pH.

Zooplankton

We investigated the mesozooplankton community (size range: 0.2 – 20 mm) in the HAUSGARTEN area, focussing on the species composition and depth distribution as well as the nutritional status of dominant mesozooplankton species. Abundance and depth distribution of the mesozooplankton were studied by use of a multi net, equipped with 5 nets (mesh size 150 µm). At 5 HAUSGARTEN stations (HG 1, HG 4, HG 9, N 5, S3) five depth strata (1,500 - 1,000 - 500 - 200 - 50 - 0 m) were sampled by vertical net hauls. The samples were immediately preserved in formalin buffered with hexamethylentetramin for analyses at the AWI laboratories in Bremerhaven.

For biochemical and enzyme activity analyses, bongo net hauls (mesh size 300 or 1,000 µm) were conducted at 14 different stations in the HAUSGARTEN area. Live individuals of the dominant copepod species, i.e. *Calanus hyperboreus* and *C. finmarchicus* were sorted in cooling containers and immediately deep-frozen. Their carbon and nitrogen content as well as citrate synthase and digestive enzyme activities will be analysed at the AWI. In addition, more than 1,200 females of *C. hyperboreus* were sorted from the bongo and multi net samples and incubated onboard in filtered seawater. These females will be used in experiments on the effect of ocean acidification, which will be conducted at the AWI throughout autumn and winter.

Samplings accomplished by the PEBCAO team from CTD casts and by net hauls are summarized in Tables 4.1 and 4.2.

Tab. 4.1: Biogeochemical parameters sampled from CTD casts

	Chla& HPLC	**POC PON**	**bPSi**	**DOC**	**TEP CSP**	**CHO AA**	**TA**
HG-I	x	x		x	x	x	x
HG-II	x	x		x	x	x	x
HG-III	x	x		x	x	x	x
HG-IV	x	x	x	x	x	x	x
HG-V							
HG-VI	x	x		x	x	x	x
HG-VII	x	x		x	x	x	x
HG-VIII	x	x		x	x	x	x
HG-IX	x	x	x	x	x	x	x
N5	x	x		x	x	x	x
N4	x	x	x	x	x	x	x
N3	x	x		x	x	x	x
N2	x	x		x	x	x	x
N1	x	x		x	x	x	x
KH	x	x		x	x	x	x
S1	x	x		x	x	x	x
S2	x	x		x	x	x	x
S3	x	x	x	x	x	x	x

Chl*a*: chlorophyll *a*; HPLC; pigment analysis, POC/PON: particulate organic carbon & nitrogen; bPSi: biogenic particulate silica; DOC: dissolved organic carbon; TEP: transparent exopolymer particles; CSP: Coomassie stainable particles; TA: total alkalinity; CHO: carbohydrates; AA: amino acids;

Tab. 4.2: Biological parameters

	microscopy	**PhytoCells** (flow cytometrie)	**Genetic fingerpring** phytoplankton	**BacCells**	**Bacterial** Activity	**Genetic fingerpring** bacteria	**Net Hauls**
HG1	x	x	x	x	x	x	x
HG2	x	x		x	x	x	x
HG3	x	x	x	x	x	x	x
HG4	x	x	x	x	x	x	x
HG5	x	x					
HG6	x	x	x	x	x	x	x
HG7	x	x		x		x	x
HG8	x	x		x	x		
HG9	x	x	x	x	x	x	x
N5	x	x		x		x	x
N4	x	x	x	x	x	x	x
N3	x	x		x	x	x	x
N2	x	x		x	x	x	x
N1	x	x		x	x	x	x
KH	x	x		x	x		
S1	x	x		x	x	x	x
S2	x	x		x	x	x	x
S3	x	x	x	x	x	x	x

PhytoCells: phytoplankton cell numbers; BacCells: bacterial cell numbers

Preliminary/expected results

Biogeochemistry & Phytoplankton

Species composition of unicellular microplankton

At the AWI HAUSGARTEN, phytoplankton and protozooplankton abundance and composition were examined in net samples taken at 15 stations from 14 – 29 July

2011. With an Apstein net (mesh-size 20 µm), the upper 10 m of the water column were gently towed. Samples were stored refrigerated until the further examination with the microscope within the following 24 hrs. Identification of species was done at least to genus level and the occurrence was noted. Diatoms, dinoflagellates and tintinnids dominated the samples. Centric diatoms (mostly *Chaetoceros* spp., *Thalassiosira* spp. and *Rhizosolenia* spp.) were more frequently than pennate diatoms (mostly *Nitzschia* spp). *Protoperidinium* spp., *Gymnodinium* spp. and *Dinophysis* spec. predominated the dinoflagellates. *Acanthostomella norvegica* and *Parafavella denticulata* were the most abundant tintinnids observed in the net samples. There were only little differences in the abundances and composition of phytoplankton and protozooplankton between the 15 stations. Slightly more species were found at the northern (79°16'N – 79°57'N) stations, here *Thalassiosira* spp., *Eucampia zoodiacus* and the pennate diatom *Navicula* spp. were the most frequently found diatoms. At only one station, the ice-coverage amounted up to 10 %, however, the species abundances and composition were nearly the same as at the other northern stations, indicating a recent drift of sea-ice into the area. Along the East-West transect (2°45'E – 9°22'E) species like *Corethron hystrix* and *Nitzschia* spp. were somewhat more observed und the microscope, than at the other stations. All other samples have to be analysed in the home laboratory at AWI.

Bacterioplankton

First results reveal that bacterial biomass production at the surface of the northern HAUSGARTEN stations exceeds that in the southern area although seawater temperature in the south was clearly higher. This indicates that temperature was not the main regulatory factor for bacterial activity in the HAUSGARTEN area during this study.

The pH manipulation experiments show that rates of extracellular b-glucosidase and leucine-aminopeptidase had their optimum at a pH of 6.7-7.3 in seawater. Hence, *in-situ* pH conditions do not provide optimum conditions for these hydrolytic enzymes. These results suggest impacts of ocean acidification on the degradation activity of the bacterioplankton communities in the HAUSGARTEN area.

Zooplankton

The mesozooplankton community was dominated by two species of Calanoid copepods: *Calanus finmarchicus* and *C. hyperboreus*. In the bongo net samples, *Calanus finmarchicus* as a typical boreal species of the North Atlantic occurred in highest numbers in the warm southern part of the HAUSGARTEN, while in the northern area relatively few individuals were present. The Arctic copepod species *C. hyperboreus* dominated the northernmost stations, while it was completely absent on station S3. In both species, adult females dominated the life stages present. Detailed analyses of the community composition and depth distribution of the mesozooplankton species from the multi net samples will be done at the AWI. A comparison of the results with those from previous cruises will give an insight to possible northward shifts in community composition in the Eastern Fram Strait due to a warming Arctic.

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5. SEDIMENTARY PROCESSES AND INTERACTIONS AT HAUSGARTEN

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Objectives

The transfer of organic carbon from the upper productive layer in the upper water column to the bottom of the Ocean is one of the key processes that facilitates life at the seafloor. During the process of sedimentation the organic material is exposed to a multitude of processes that modify the organic composition of particles thus determining the nutritional value for the benthos. In the HAUSGARTEN sedimentation studies have been performed by means of annually moored sediment traps since the year 2000 to get insights into the amount and composition of the sedimenting material. The results of this long-term study on sedimentation are the basis against which changes can be judged, that most likely will occur in the near future due to the proposed effect of global warming.

Work at sea

During the cruise ARK-XXVI/2 two deep sea moorings equipped with sediment traps, self-recording CTDs and current meters were successfully recovered. These moorings were deployed at the central HAUSGARTEN position (HG-IV) and in the northern HAUSGARTEN region at station N4 (Fig. 7.1) during the *Polarstern* cruise ARK-XXV/2 in 2010. Seasonally resolved samples of the traps were obtained from ~200 m and ~1,200 m below sea surface as well as 150 m above the seafloor at the central position and from (~200 m below surface and 150 m above the seafloor at the northern position. Another sediment trap installed in a benthic lander was also successfully recovered in the central HAUSGARTEN region.

All the moorings were redeployed at the same positions during the cruise after overhaul and exchange of the instruments.

Preliminary results

A first and rough impression of sedimentation during 2010/11 can be obtained from the amount of material collected in the sampling bottles. (Fig. 5.1). This figure shows the sampling jars of the sediment trap obtained in ~ 200 m at the central HAUSGARTEN station. A seasonal pattern in sedimentation can be clearly deduced with larger amounts of material collected at the start of the sampling during beginning of July and at the end of August 2010. The amount of collected material decreased afterwards and stayed at a low amount during the winter period until April/May 2010. Starting at this period an increasing tendency of the flux till the end of the mooring period in July can be noted.

Generally the amount of collected material during the whole mooring period 2010/11 seems to be less than in the previous years. More detailed information on sedimentation, the quantity and composition of the sedimented matter will be obtained after biochemical and microscopic analyses of the samples in the laboratory.

Fig. 5.1: Sampling jars of a sediment trap moored at the central HAUSGARTEN station in ~ 200 m depth obtained during 2010/11

6. ARCTIC PELAGIC AMPHIPODS

Angelina Kraft, Nicole Knüppel Alfred-Wegener-Institut
Ulrich Bathmann, Eva-Maria Nöthig (not on board)

Objectives

Among the Arctic zooplankton community, pelagic amphipods are expected to play a key role in marine ecosystems, providing a central link between small herbivore plankton organisms like copepods and higher trophic levels. However, their role in the polar ecosystems, especially in ice-covered Arctic seas, is still poorly understood.

Nowadays, the amphipods in the Arctic are faced with a drastically changing environment including increasing ocean temperatures and acidification as well as a rapidly declining sea ice cover. As the sea ice disappears, we expect that typical large cold water amphipods, such as the Arctic specialist *Themisto libellula*, will be replaced by smaller and more temperature tolerant Atlantic generalists. With the opportunity to collect amphipods onboard the research icebreaker *Polarstern*, we aim to investigate the geographical and depth distribution of dominant pelagic amphipod species in the eastern Fram Strait and address their nutritional value for marine sea-birds and mammals. In detail, the BMBF-funded 'Arctic pelagic Amphipoda' project will investigate the following aspects:

1.) What are the species composition patterns of Arctic pelagic Amphipoda in the HAUSGARTEN & Fram Strait area and how do they relate to changes of the environment?

Thereby, the results from plankton net samples taken during the cruise ARK-XXVI/2 will be compared to the amphipod samples from moored sediment traps since the year 2000 in order to investigate possible changes in the population structure and life cycles of these organisms.

2.) Determine differences in nutritional ecology (lipid biomarkers and gut content) of the dominating pelagic Amphipoda *Themisto libellula*, *T. abyssorum*, *T. compressa* and *Cyclocaris guilelmi.*

To address this objective we test the following hypothesis: *Themisto libellula*, *T. abyssorum*, *T. compressa* and *Cyclocaris guilelmi* have different feeding and overwintering strategies leading to differences in gut content and lipid content compositions. Hence, investigations on lipid biomarkers & gut contents will be carried out in the home laboratory in order to understand differences of the utilization of food and on the nutritional value for higher trophic levels.

Work at sea

The net sampling included vertical hauls from 2,000 m to the surface Thereby, a large multinet (HYDRO-BIOS type Maxi with an aperture of 0.5 m^2 and nine 1,000 micron net bags) was hoisted at 0.8 m/s with stops at 1,500 m, 1,000 m, 800 m, 600 m, 400 m, 200 m, 100 m and 50 m in order to analyse the occurrence of pelagic amphipods at the different depth horizons. In the HAUSGARTEN area the hauls were carried out at the following stations: HG-I, HG-II, HG-III, HG-IV, HG-VI, HG-VII, HG-VIII, HG-IX, N4, N3, N2, S1, S2 and S3. From the collected zooplankton samples all amphipods were sorted out, determined to a species level, counted, measured and frozen at -80° C for the later analyses of their gut content and lipid composition at the AWI home laboratory. The other collected zooplankton groups were preserved in a 4 % formaldehyde/seawater solution and will later be analyzed with regard to abundance, biomass and species composition in order to describe the macro- and mesozooplankton community structure.

Preliminary results

With the on-board dataset, a first analysis of the densities and vertical amphipod distributions was started. In total, 10 different amphipod species from 8 families (Table 6.1) were found in the HAUSGARTEN area, including the epipelagic target species *Themisto abyssorum*, *T. libellula* and *T. compressa* as well as typical deep-water species like *Cyclocaris guilelmi* and *Lanceola clausi*.

Tab. 6.1: The collected amphipod composition in 14 multinet hauls at the long term observatory HAUSGARTEN during ARK-XXVI/2.

Family Hyperiidae
Themisto abyssorum
Themisto compressa
Themisto libellula
Family Eusiridae
Eusirus holmii
Family Gammaridae
Gammarus wilkitzkii
Family Lanceolidae
Lanceola clausi
Family Lysianassidae
Cyclocaris guilelmi
Family Uristidae
Onisimus nanseni
Family Calliopiidae
Apherusa glacialis
Family Stilipedidae
Astyra longipes

Throughout the HAUSGARTEN area the sub-arctic species *Themisto abyssorum* dominated the epipelagic amphipod community. This species is known to be widely distributed in Atlantic, Polar Front and Arctic waters; however it is predominant in Atlantic water masses. The highest densities of this species were recorded at the stations HG-VII, HG-IX and HG-S1 with more than 200 ind. 1,000 m^{-3}. Other frequently appearing species included the typically Arctic amphipod *T. libellula*, which had its highest appearances (35 ind. 1,000 m^{-3}) at the easternmost HAUSGARTEN station, HG-I (Fig. 6.1).

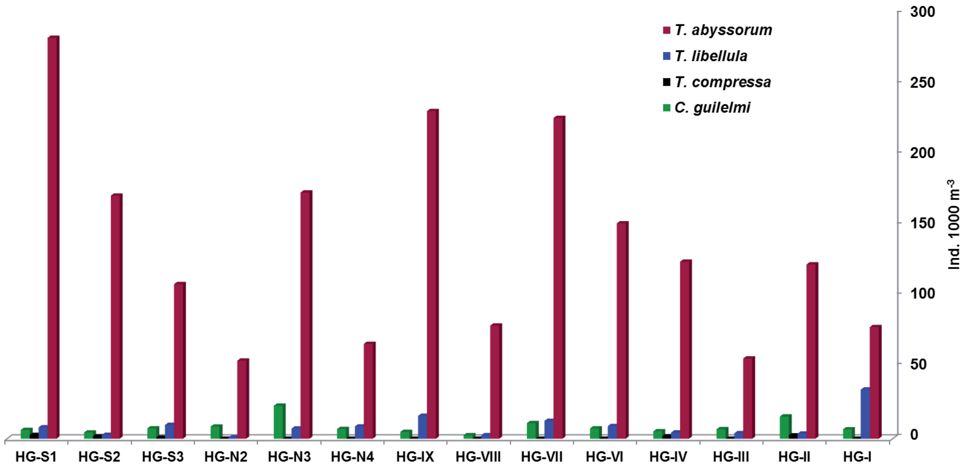

Fig 6.1: Density (Ind. 1,000 m^{-3}) of the four amphipod key species recorded at 14 sampling stations at the long-term deep sea observatory HAUSGARTEN in the eastern Fram Strait.

The vertical amphipod distribution varied among the stations, with the highest appearances in the upper 100 m or between 600 - 800 m in the water column. An example of a deep distribution maximum of *T. abyssorum* is shown at the vertical distribution profiles of HG-IX in Fig. 6.2. At a depth below 800 m, the amphipod density decreased rapidly and pelagic deep-water amphipods became more prominent in the species composition. Among these samples *Cyclocaris guilelmi* appeared to be the most important representative.

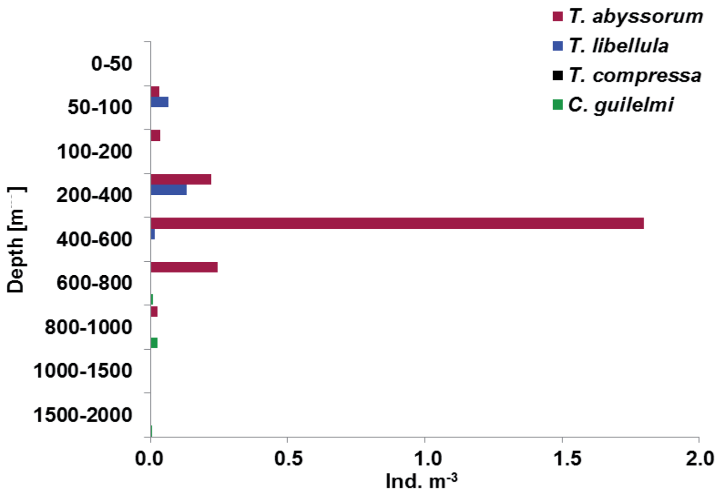

Fig. 6.2: Vertical distribution (Ind. m^{-3}) of Themisto abyssorum, T. libellula, T. compressa and Cyclocaris guilelmi at the HAUSGARTEN station HG-IX.

With a further detailed analysis of abundances as well as length-frequencies and the relation to temperature and salinity data at different depth levels, new insights are expected regarding the vertical migration capacity and population structure of the genera *Themisto* and *Cyclocaris*. A connection of this data with sediment trap and literature records and the combination with results from the lipid biomarkers and gut content analysis is expected to give a reliable view of the past and present development of pelagic amphipod community in the eastern Fram Strait.

7. IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE ECOSYSTEMS

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Objectives

The marine Arctic has played an essential role in the history of our planet over the past 130 million years and considerably contributes to the present functioning of the Earth and its life. The past decades have seen remarkable changes in key Arctic variables, including a decrease in sea-ice extent and sea-ice thickness, changes in temperature and salinity of Arctic waters, and associated shifts in nutrient distributions. Since Arctic organisms are highly adapted to extreme environmental conditions with strong seasonal forcing, the accelerating rate of recent climate change challenges the resilience of Arctic life. The stability of a number of Arctic populations and ecosystems is probably not strong enough to withstand the sum of these factors which might lead to a collapse of subsystems.

To detect and track the impact of large-scale environmental changes in a the transition zone between the northern North Atlantic and the central Arctic Ocean, and to determine experimentally the factors controlling deep-sea biodiversity, the Alfred Wegener Institute for Polar and Marine Research (AWI) established the deep-sea long-term observatory HAUSGARTEN, which constitutes the first, and until now only open-ocean long-term station in a polar region.

Work at sea

The HAUSGARTEN observatory in the eastern Fram Strait includes 17 permanent sampling sites along a depth transect (1,000 – 5,500 m) and along a latitudinal transect following the 2,500 m isobath crossing the central HAUSGARTEN station (Fig. 7.1). Multidisciplinary research activities at HAUSGARTEN cover almost all compartments of the marine ecosystem from the pelagic zone to the benthic realm, with some focus on benthic processes. Regular sampling as well as the deployment of moorings and different free-falling systems (bottom-lander) which act as local observation platforms, have taken place since the observatory was established in summer 1999. Frequent visual observations with towed photo/video systems (Ocean Floor Observation System, OFOS) allow the assessment of large-scale epifauna distribution patterns as well as their temporal development. To determine the factors controlling deep-sea biodiversity, a number of biological short- and long-term experiments are carried out using a Remotely Operated Vehicle (ROV).

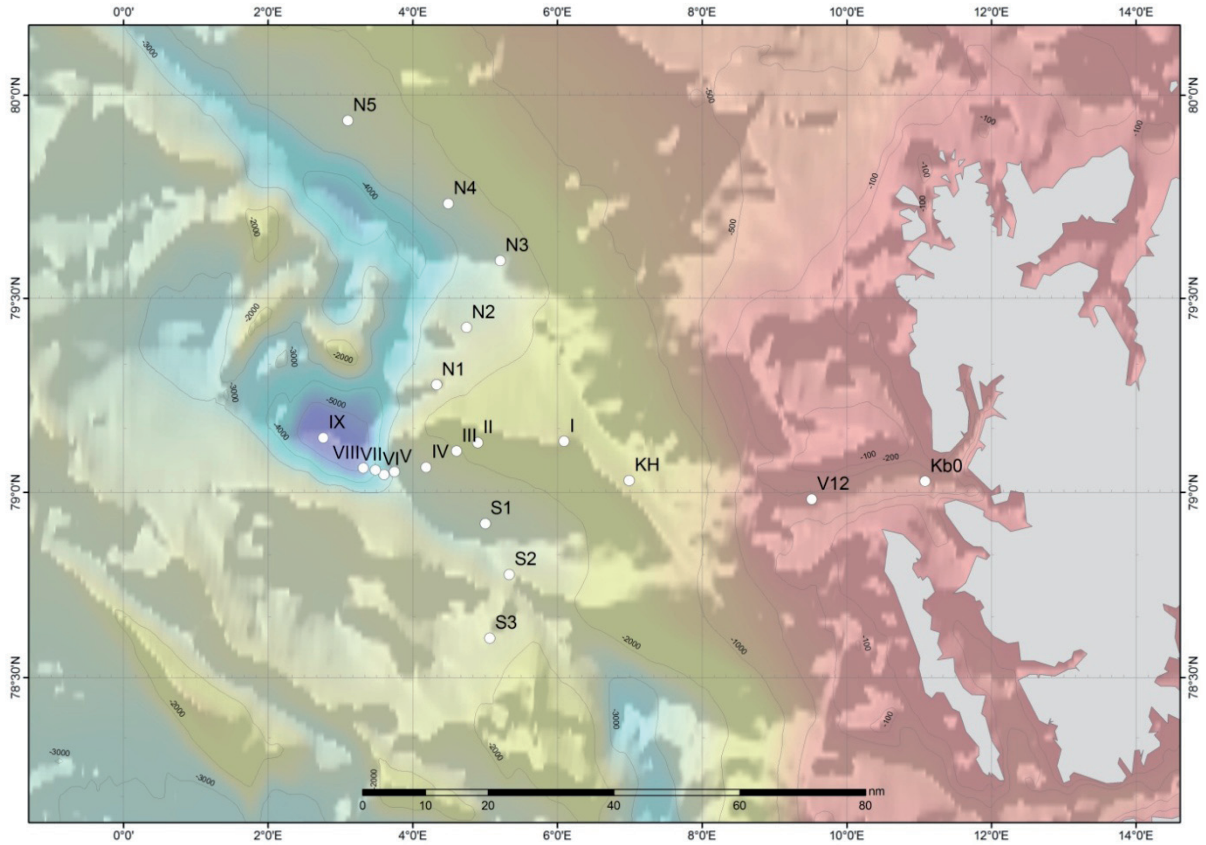

Fig. 7.1: Permanent sampling sites of the HAUSGARTEN observatory (HG-I – HG-IX, N1 – N5, and S1 – S3), including stations repeatedly sampled within the KONGHAU project (KH, V12, and Kb0)

Our work during ARK-XXVI/2 included the sampling of benthic stations on the continental shelf off Svalbard, thereby continuing time-series work started within the former international project KONGHAU ("Impact of climate change on Arctic marine community structures and food webs"), co-financed by the EU Integrated Project HERMES ("Hotspot Ecosystem Research on the Margins of European Seas") and the Norwegian oil company Statoil/Hydro. The KONGHAU project combined data collected over the past 10 years from time-series work at Kongsfjord and HAUSGARTEN observatory.

Benthic work during ARK-XXVI/2

Virtually undisturbed sediment samples have been taken using a video-guided multiple corer (MUC; Fig. 7.2) at 9 HAUSGARTEN stations along the bathymetric (1,000 – 5,500 m water depth) and 8 stations along the latitudinal transect in 2,500 m water depth. Additional samples were taken at two stations at 230 and 1,200 m water depth on the continental shelf off Svalbard.

Fig. 7.2: Sampling of undisturbed surface sediments using the multiple corer (MUC)

Various biogenic sediment compounds will be analysed to estimate the input of organic matter from phytodetritus sedimentation, benthic activities (e.g. bacterial exo-enzymatic activity), and the total biomass of the smallest sediment-inhabiting organisms (size range: bacteria to meiofauna). Additional sediments were preserved in 4 % formalin to assess densities and distribution patterns of meiofaunal organisms. Other sediment samples retrieved by the MUC will be used to analyse bacterial cell numbers, RNA, DNA, and to conduct fluorescent *in-situ* hybridization (FISH) analyses. The microbial community structure and their variability along the HAUSGARTEN depth transect will be determined by ARISA (a molecular fingerprinting method). The application of statistical methods will allow correlation of shifts in the community structure with environmental parameters to explain causes of structural changes. Using another fingerprint method, the terminal restriction fragment length polymorphism method (T-RFLP), the functional gene diversity will be determined, compared and correlated to environmental factors. These microbiological analyses contribute to the long-term ecological change assessment at the HAUSGARTEN observatory. Results will help to describe ecosystem changes in the benthal of the Arctic Ocean.

A bottom-lander supporting a current-meter, an optode, and a small sediment trap at 2.5 m above ground (Fig. 7.3) had been recovered and re-deployed for one year at the central HAUSGARTEN site (HG-IV; 2,500 m). Results from the optode measurements will contribute to the EU-project HYPOX. A second lander system carrying two large traps was deployed for about three days at HG-IV to catch benthic scavengers (e.g. amphipods) and demersal fish (Fig. 7.4).

Fig. 7.3: Long-term bottom-lander equipped with a current-meter, temperature and oxygen sensors, and a small sediment trap to collect settling particulate matter

Fig. 7.4: Recovery of the trap-lander deployed to catch benthic scavengers and demersal fish

The OFOS (Fig. 7.5) was deployed at the central HAUSGARTEN site, at N3, S3, and at the KONGHAU station V12, thereby repeating transects observed already several times over the last decade to assess temporal changes in large-scale distribution patterns of mega/epifauna in the HAUSGARTEN area.

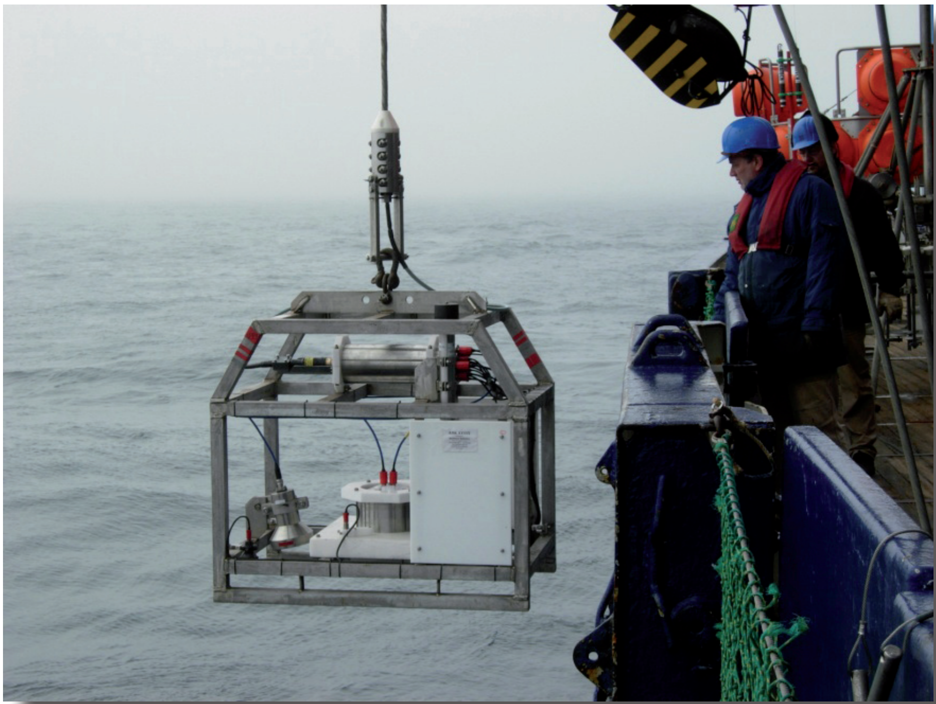

Fig. 7.5: Deployment of the Ocean Floor Observation System (OFOS)

The ROV KIEL 6000 (IfM-GEOMAR, Kiel; Fig. 7.6) was used to sample two experiments carried out to study causes and effects of physical, chemical and biological gradients at the deep seafloor and their implication for benthic biodiversity: (1) a starvation experiment that was installed in summer 2008 at the central HAUSGARTEN station (2,500 m water depth), and (2) a flume experiment already started in 2003 at the southernmost HAUSGARTEN site S3.

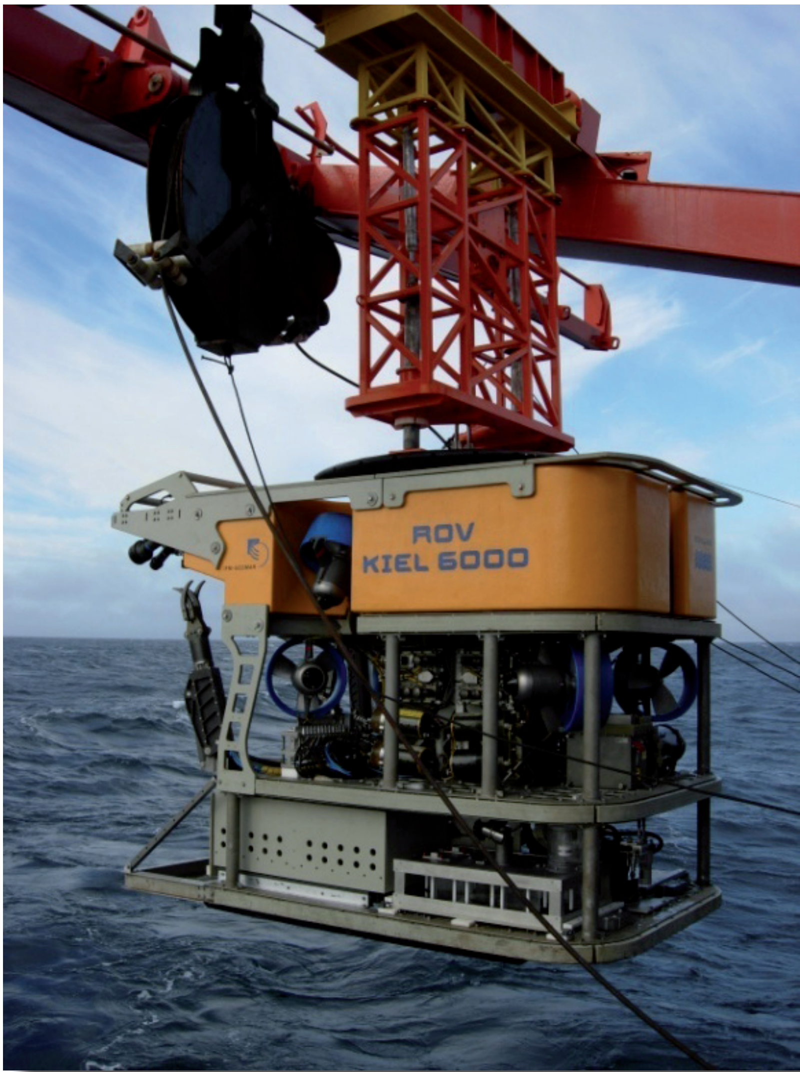

Fig. 7.6: The ROV KIEL 6000 was used to collect surface sediments and benthic organisms, and to install and sample various biological long-term experiments at the deep seafloor

The starvation experiment was designed to study the reaction of the small benthic biota to decreasing food availability. Four cages (2 x 2 m in dimension, 50 cm in height; Fig. 7.7) covered with solid lids preventing the sedimentation of particulate organic matter (representing the main food/energy source for benthic organisms) were sampled using push corers handled by means of the ROVs manipulator. Three replicate samples were taken from each cage; three samples taken outside the cage serve as a control for the starvation experiment.

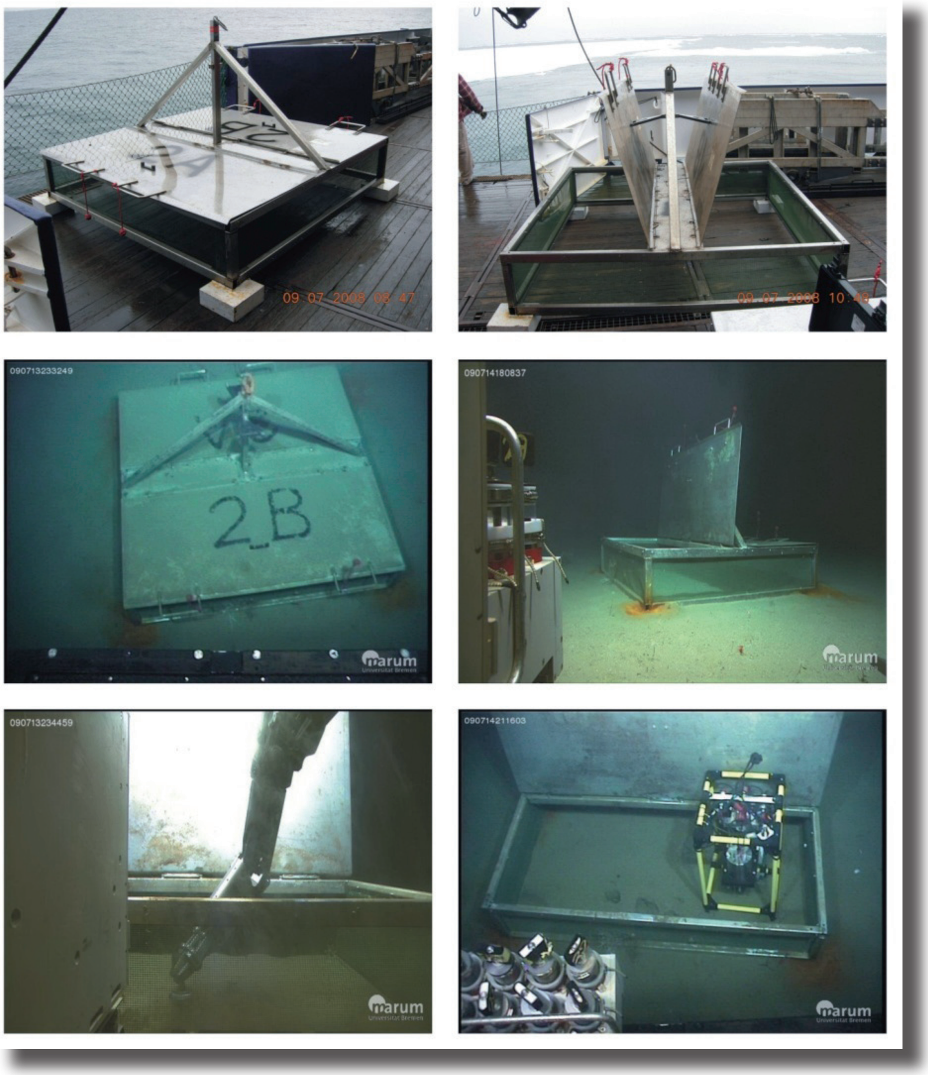

Fig. 7.7: Cages of the starvation experiment on deck (top) and at the seafloor (middle); sediment sampling using push-corers (bottom, left) and measurements of dissolved oxygen in surface sediments inside the cages by means of an autonomous micro-profiler handled by the ROV

To study the reaction of the small benthic biota to increased near-bottom currents we installed a stainless steel flume during *Polarstern* expedition ARK-XIX/3 in summer 2003 at station S3 (78°36'N, 05°04'E; ~ 2,283 m water depth) using the French ROV VICTOR 6000. The channel has a total length of approximately 8.5 m and consists out of a 6 m long passageway with a cross-section of 50 x 50 cm, and funnel-like doorways at both sides (Fig. 7.8). Following an initial sampling in 2007, we retrieved additional sediments samples at two positions inside the channel, in front of the in/outlets, and at a few meters distance to the flume as controls.

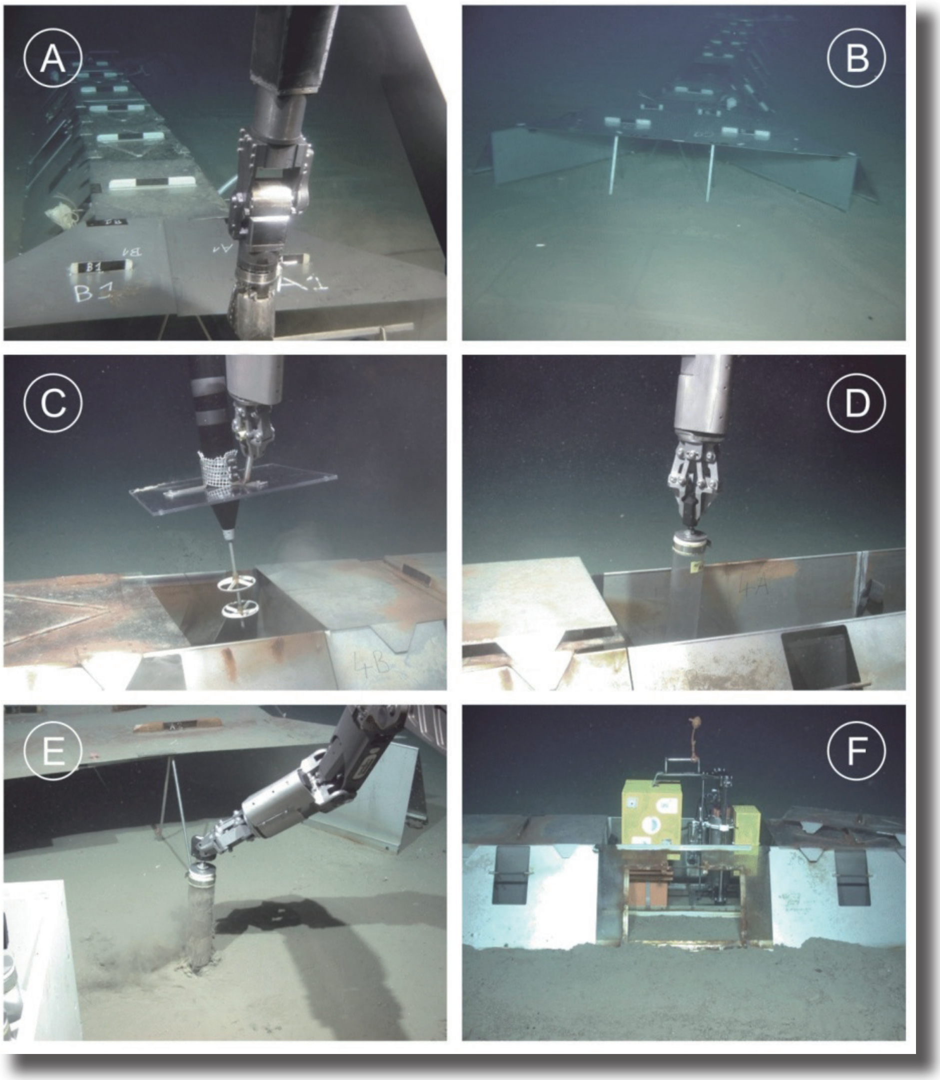

Fig. 7.8: Experimental flume at the deep seafloor: (A) Installation with the French ROV VICTOR 6000" in 2003; (B) v-shaped inlet to accelerate bottom currents; (C) current measurements using a MAVS-3 acoustical current meter; (D) sediment sampling inside the flume; (E) push-coring of sediments close to the outlet; (F) ROV-handled microprofiler unit inserted into the flume to take oxygen profiles in the uppermost sediment layers

Push-corer samples from both experiments were sub-sampled by means of small plastic syringes to separately analyse parameters like bacterial activity, chloroplastic pigments, organic carbon contents, lipids, proteins, granulometry and the small sediment inhabiting biota (bacteria and meiofauna). Most of the sub-samples have been stored for later analyses. Bacterial activity and chloroplastic pigments have been analysed onboard.

The expedition was also used to start another bottom-lander based biological long-term experiment. Small inert fluorescing microspheres, so-called luminophores, were spread by the ROV on a defined area at the deep seafloor to start an experiment assessing bioturbation rates by larger benthic organisms at the central HAUSGARTEN site (Fig. 7.9).

Fig. 7.9: Dispersion of luminophores over a defined area of approx. 4 m² to study bioturbation rates of benthic organisms at the central HAUSGARTEN site

Preliminary results from the benthic work

Only a minor number of benthic parameters were already analysed on board *Polarstern*, most samples were deep-frozen or preserved in formalin for later analyses at the home laboratory. Parameters indicating the input of organic matter to the seafloor (i.e. sediment-bound chloroplastic pigments to quantify the amount of phytodetrital matter at the seafloor) and heterotrophic microbial activity (i.e. esterase turn-over rates) showed values comparable to those determined in summer 2010. Temperature records from the long-term bottom-lander deployment and the mooring work, however, showed again increasing values between 2010 and 2011, thereby continuing the general trend observed since the beginning of our time-series work at HAUSGARTEN in 1999 (Fig. 7.10).

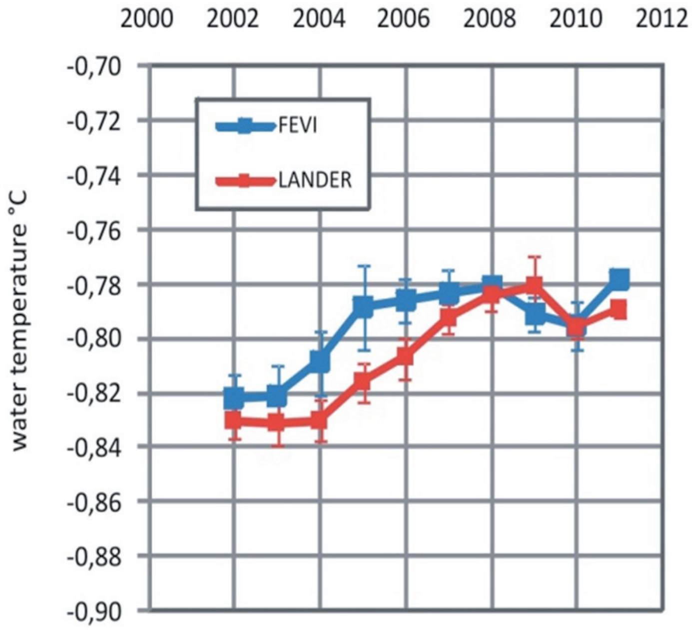

Fig. 7.10: Mean annual bottom-water temperatures at the central HAUSGARTEN site (2,500 m water depth) between 2002 and 2011; red line: 2.5 m (bottom-lander), blue line: 15 m (mooring) above the seafloor

Preliminary results from the starvation experiment show that, compared to the control sediments, food quality and bacterial activity underneath the cage is already slightly reduced (Fig. 7.11).

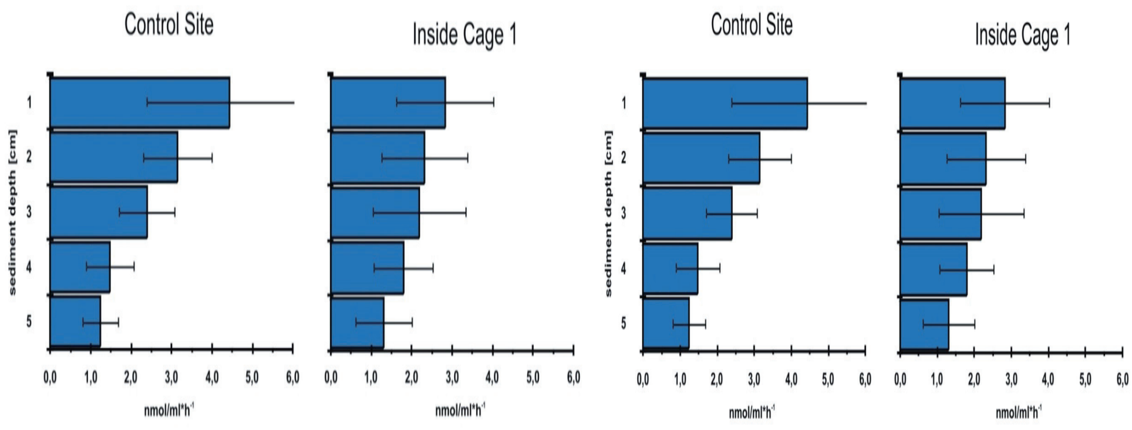

Fig. 7.11: Bacterial enzymatic turn-over rates inside one of the cages from the starvation experiment, compared to heterotrophic activity in control sediments

8. BENTHIC OXYGEN CONSUMPTION

Janine Felden[1)], Volker Asendorf[1)], Axel Nordhausen[1)], Frank Wenzhöfer[2)]

[1)]Max Planck Institute for Marine Microbiology. Bremen
[2)]Alfred-Wegener-Institut

Objectives

Phytodetritus is the major food/carbon source for authochtonous deep-sea benthic communities. A large fraction of the annual carbon deposition can arrive in substantial pulses following surface phytoplankton blooms within a few days at the seafloor. The biogeochemical signature of the surface ocean plankton processes although considerably modified during the process of sedimentation is ultimately transferred to the deep-sea floor. The composition and productivity of the phytoplankton community in interaction with the abiotic regime finally determines the response of the benthic community such as community structure, ecosystem functioning, activity rates and biogeochemical cycling. The benthic oxygen distribution provides detailed information on the turnover of sedimenting organic material, fauna activity and the biogeochemical reactions of the sediment. Only a minor part of the oxygen is used for animal respiration, while microbial heterotrophic and autotrophic activity is responsible for the major part of the benthic oxygen requirement. Benthic oxygen fluxes provide the best and integrated measurement of the metabolic activity of surface sediments and thus can be used to evaluate the efficiency of the biological pump.

Work at sea

A variety of benthic lander systems have been used to quantify the benthic oxygen consumption at different spatial and temporal scales. A chamber lander also equipped with an eddy correlation system was deployed simultaneously with a xyz-microprofiler lander to continue the time series of benthic oxygen consumption measurements at the HAUSGARTEN sites S3, HG-IV and N4. To measure oxygen fluxes at the exclusion (HG-IV) and flume (S3) experiments a ROV operated microprofiler was deployed. Additionally a benthic incubation chamber lander was deployed at HG4 to conduct *in-situ* experiments. This lander allows flux measurements across the sediment water interface using mesocosms either enriched with diatom or coccolithophorid phytodetritus. This simulates a settling food pulse by injection of labelled phytodetritus into the chambers and then following the pathway of tracer through the benthic community. Furthermore a long-term oxygen mircoprofiling lander was deployed at the HAUSGARTEN site N4, to investigate the interannual variability in the uppermost sedimentary oxygen consumption (as a measure for the ultimate benthic carbon mineralization). This newly developed microprofiler performs one set of profiles across the sediment-water interface every week for one year; recovery will take place in summer 2012.

Instrument set-up:

(1) Microprofiler: The xyz-microprofiler and ROV-profiler were equipped with 5 O_2, 3 pH, 1 T and 1 resistivity microsensors covering an area of 180 cm^2. Microprofiles across the sediment-water interface were performed with a vertical resolution of 150 µm on a total length of 19 and 13 cm, respectively. During the xyz-microprofiler deployment the microsensor array performed up to 16 vertical profiles on an area of 625 cm^2. The long-term microprofiler is equipped with 4 optical sensors and profiles are performed in 150 µm increments over a distance of 13 cm.

(2) Benthic chamber: Benthic chamber deployments were used to measure the total oxygen consumption and nutrient exchange of the sediment integrating all relevant solute transport processes (diffusion, advection and fauna-mediated transport). During the deployment an oxygen optode measured the change in oxygen concentration while 7 syringe samples were taken at pre-programmed time intervals for later analyses of DIC and nutrient concentrations. While the chamber incubations integrate the flux over an area of 400 cm^2 the additionally mounted eddy correlation system integrates the benthic flux over a large footprint of several square meters (typically 10 – 100 m^2). *In-situ* enrichment experiments in lander integrated benthic mesocosms were performed to follow the benthic response to diatom- and coccolithophorid-dominated sedimentation pulses by simulated phytodetritus pulses. Therefore $^{13}C/^{15}N$ labeled phytodetritus of different phytoplankton composition was injected into the mesocosms and the benthic oxygen consumption and reaction investigated during several days of incubation.

(3) The eddy correlation system allows measuring exchange rates across the water-sediment interface in a non-invasive manner providing direct measurements with temporal resolution of minutes and a spatial resolution of several meters. The instrument is composed of an Acoustic Doppler Velocimeter, a fast responding O_2 microelectrode (< 0.2 to 0.3 s) connected to an Auto-Zero-Amplifier. Eddy correlation relies on measuring vertical velocity and oxygen concentration in the same measuring volume fast enough to calculate the momentary vertical flux due to turbulent motions. Integrated over time for a period long enough to get a statistically sound average, it gives a net O_2 transport toward the sediment.

Preliminary results

A total of 6 lander deployments were obtained along a South-North transect (S3, HG-IV, N4). Very few data have been evaluated so far. Preliminary results from the benthic chamber incubations at the South-North transect show, however, lower total oxygen consumption rates as compared to the previous years. Further analyses of the oxygen profiles and eddy flux measurements back home may provide additional information on the benthic oxygen dynamics. Due to technical problems with the ROV-module no microprofiles could be obtained at the exclusion and flume experiment sites. From the pulse chase incubation lander experiments only the syringe samples can be analysed because the incubation chambers did not close after the programmed incubation period. These data will, however, provide first insights how the benthic community reacts to increased food availability. All samples will be analysed at the home laboratory. Oxygen profiles following the seasonal cycle of settling organic matter will be obtained next year after the recovery of the long-term profiler. If the system is able to perform several profiles over a seasonal cycle this might give insights how the benthic community respiration changes with varying availability of settling organic matter.

9. CULTURE EXPERIMENTS ON THE ENVIRONMENTAL CONTROLS OF TRACE METAL RATIOS (Mg/Ca, B/Ca; U/Ca) RECORDED IN CALCAROUS TESTS OF ARCTIC DEEP-SEA BENTHIC FORAMINIFERA

Stefanie Kaboth, Mirko Sühs, Reinhold Petereit — Alfred-Wegener-Institut

Jutta Wollenburg (not on board)

Objectives

The overall goal of this expedition was to collect short sediment cores from 1,300 to 1,500 m water depth and to transfer these cores into high-pressure aquaria (autoclaves) as well as atmospheric-pressure aquaria (mesocosms).

Work at sea: Sediment sampling for culture experiments

Sediment sampling was carried out using a standard 8-tube multicorer (MUC) with an inner tube diameter of 10 centimeters. Three MUCs were successfully deployed at 2 stations in the vicinity of the Vestnesa Ridge. Immediately, after recovery of the MUC tubes were transferred into push corers and those into the aquaria. By this method, we have successfully filled 5 autoclaves that are now cultured at pressures of 140 to 145 bar, and 10 mesocosms running at atmospheric pressure. As reference, 2 multiple core liners from each coring site were sliced in 1-cm steps from the surface to 6 centimeters subbottom depth, transferred into a plastic bottle and mixed with a equal volume of ethanol-Rose Bengal mixture (1g Rose Bengal/l ethanol).

The aquaria (high-pressure and atmospheric pressure aquaria) were connected to a supportive seawater system and operated in a cold laboratory running at 1 °C. High-pressure pumps and a chain of in- and outlet valves maintain *in-situ* pressure and a constant sea water flow through the high-pressure aquaria. Each aquarium was connected to a separate seawater circulation system. The seawater used in the system was sampled from 1,300 to 1,500 m water depth. Seawater sampling was accomplished using an SBE 32 carousel water sampler operated by FIELAX GmbH on board *Polarstern*.

The running systems were controlled by frequent measurements (every 4 hours), to keep the experimental environment as close to *in-situ* conditions as possible. Parameters measured and - if necessary - adjusted were pressure and injected seawater volume in the high-pressure aquaria, as well as pH-values of inflow and outflow water of the aquaria. Once a week, a suspension of algae was added to the seawater inflow as a food supply.

The aquaria and seawater circuits will be maintained during the expedition ARK-XX/VI/3 until 7 October 2011. After then the systems will be moved to the laboratories at the Alfred Wegener Institute in Bremerhaven, where pH-related culture experiment will be conducted.

10. METHANE SEEPAGE ON THE WESTERN SVALBARD SHELF AND SLOPE

Olaf Pfannkuche[1)], Martin Pieper[1)], Inken Suck[1)], Hannes Huusmann[1)], Patrick Cuno[1)], Greg Engemann[2)], Wolfgang Queisser[1)], Arne Meier[1)]

[1)]IFM-GEOMAR, Kiel

[2)] Schilling Robotics, USA

Objectives

The Arctic ocean changes rapidly in response to global warming and it is expected that this change will accelerate in the future. Large areas of the shelves and continental slopes bordering the Arctic Ocean are characterized by permafrost and the presence of gas hydrates. In the light of a warming globe and potential hydrate dissociation in the Arctic Ocean this raises concerns for a substantial additional green house gas release into the atmosphere. The recent discovery of more than 250 gas flares at the outcrop of the base of the gas hydrate stability zone west of Spitsbergen (Westbrook et al. 2009) may be evidence that gas hydrate dissociation and accelerated methane release induced by climate change is already ongoing, and there is the possibility that such releases will accelerate global warming in the future.

The gas hydrate stability zone and methane seeps off Prins Karls Forland as well as the methane seeps in the Pockmark region on the crest of Vestnessa Ridge are sites for a future system of permanent multidisciplinary observatories which are planned and developed in the frame of European FP7 Project EMSO and German national Arctic observatory initiatives. A cruise with RV *Poseidon* to investigate the distribution and biogeochemical cycling of methane at these sites is scheduled for 10 Aug. to 6 Sept. 2011.

Aim of the investigations were a pre-site survey with the ROV KIEL 6000 m at presumptive observatory deployment sites (morphological structure, habitat structure, megafauna composition) and to make some direct measurements of flux rates from a discrete gas bubble sites.

Work at sea

Two dives with ROV KIEL 6000 were made at two sites.

- Stat. 141/ ROV: off Prins Karls Forland around 240 m depth in a zone of intense gas flares.
- Stat 149/ ROV: at Vestnessa Ridge around 1,200 m depth in a pockmark region.

Faunal composition and sea floor structure was observed with on line camera and still photography. An autigenic carbonate sample was taken and two measurements of methane release rates were made with a perspex beaker placed on top of a gas bubble holes.

Preliminary results

The sea floor at the shelf site (240 m) was densely covered with ice rafted stones and rocks. The hard bottom was densely populated with filter feeders mainly sponges and soft corals (Fig. 10.1). Methane seeps could be either directly identified by gas bubbling from discrete little holes or by whitish/grey patches of H_2S-oxidizing bacteria surrounding the holes (Fig. 10.1).

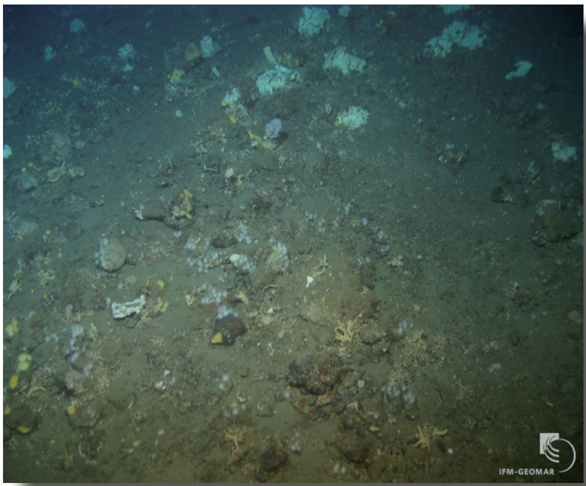


Fig. 10.1: Typical view of the shelf site (240 m) with drop stones and abundant sponges and soft corals (left). Methane escape ("bubble") holes indicated by bacterial mats (right)

Gas flux measurements (Fig. 10.2) were made at two bubble sites of varying strength by placing a beaker with the ROV-arm on top of a gas escape hole. Gas bubble rates of 20 ml/min respectively of 2 ml/min were measured.

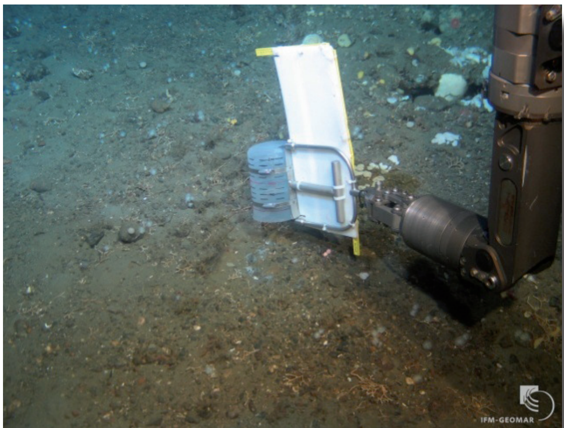


Fig. 10.2: A perspex beaker is placed on top of a gas bubble hole (left). An autigenic carbonate sample densely populated by megafauna (right)

A sample of autigenic carbonate, formed in the process of anaerobic methane oxidation was sampled (Fig. 10.2). Autigenic carbonates are geo-archives containing information about the age, and temporal variation of fluid and gas fluxes. The carbonate sample will be sub- sectioned and analyzed in the home lab for the following proxies: U/Th (dating), Sr/Ca, Ba/Ca, U/Ca, (trace elements); isotopes: $\delta^{13}C$, $\delta^{18}O$, $\delta^{44/40}Ca$, $\delta^{88}Sr$ (variation of geobiochemical environment during $CaCO_3$-precipitation).

At Vestnessa Ridge (1,200 m) sandy sediments dominated. Only a few dropstones occurred. The dive across two pockmark structures showed besides the typical slope megafauna areas of methane seeps indicated by the presence of chemosynthetic megafauna and bacterial mats. Pogonophora (Fig. 10.3.) where found at the rim of seep sites whereas bacterial mats indicated the centre of seeps with surficial gas hydrates (Fig. 10.3).

Fig. 10.3: Pogonophora at the rim of a cold seep on Vestnessa Ridge (left). Bacterial mats indicate stronger seeping activity and surficial gas hydrates (right)

References

Westbrook, G.K., Thatcher, K.E., Rohling, E.J., Piotrowski, A.M., Pälike, H., Osborne, A.H., Nisbet, E.G., Minshull, T.A. Lanoiselle, M., James, R.H., Hühnerbach, V., Green, D., Fisher, R.E., Crocker, A.J., Chabert, A., Bolton, Beszcynska-Möller, A., Berndt, C., and Aquilina, A. (2009) Escape of methane gas from the seabed along the West Spitsbergen continental margin, Geophysical Research Letters, 36, L15608, doi:10.1029/2009GL039191.

11. HIGHER TROPHIC LEVELS: DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS AT SEA

Roselinde Beudels, René-Marie Lafontaine PoIE, Brussels

Work at sea

This second leg consists mostly in a series of short transects to and from each of the numerous stations in the HAUSGARTEN area. The timing of those transects are unavoidably unpredictible and, while carefully planned, often delayed. Large vertebrates census and counting periods of 30 minutes each, done when the boat was moving, totalled 186 in the HAUSGARTEN area, and circa 100 counting periods in the long final transect from 79°N to Tromsœ.

Heliflights were somewhat difficult to organise due to diverse constraints, such as the ROV operations (when the Remote Operated Vehicule is under the water the helideck cannot be used, because the stern crane is up), or due to unsuitable weather conditions such as mist and fog, and other uses of the helicopter, but we were able nevertheless to make some very useful heli counts (8 flights, totalling 12 hours 5, representing 121 counting periods of 6') with very good numbers of whale sightings in at least five of the transects.

Preliminary results

As a first impression, for us (PolE) the main result of the leg was the very large number of whales encountered, including significant numbers of blue whales. Our whale sightings seem to confirm the importance of the front between the polar and Arctic waters for top predators (birds and marine mammals). Their distribution also tend to fit with the hypotheses that small-scale hydrological events are the main drivers in the distribution of those groups. The presence of an eddy in July 2011, with the associated rich food ressources available at the surface, certainly contributed to the observed distribution of birds and cetaceans during this leg.

Our preliminary results seem to indicate a very high density of cetaceans in the HAUSGARTEN area this year, (around 0.75 large whale per counting periods, either from the boat bridge or from the air). The large numbers of whales encountered (231 individuals with some double countings) compared with the low numbers encountered in the very same area in recent years (since the 90s) suggests a general increase or at least probably an extension of their distribution in the high Arctic to newly accessible rich feeding grounds.

For the birds, in many counting periods, some species were almost always recorded, and represented by a few individuals, often followers: dark fulmar, kittiwake, glaucous gull and occasional ivory gulls in the ice. A total of 10,352 birds were counted, with 3,129 Brunnich's Guillemot (*Uria lomvia*), 2,963 Fulmar (*Fulmarus* *glacialis*), 2,368 Little Auk (*Alle alle*) and 1,656 Kittiwake (*Rissa tridactyla*), the four species most abundant in the Arctic region. Among the pinnipeds, harp seals were observed in the water and on the ice close to the water front, as well as some ringed seals in very large and flat ice floes, a few bearded seals and, last but not least, a lone walrus on his floating floe in the middle of nowhere, equally distant from the Spitsberg or the East Greenland colonies.

We had a few interesting days in the ice, with 3 polar bears observations, several ivory gull and a minke whale very close to the ship.

Interesting discussions for the specialist concern the observation of rarely noticed immature individuals: Brünnich's guillemot, ivory gull and harp seal.

Tab. 11.1: Summer distribution of cetaceans in the Greenland and Norwegian seas

Mysticeti	Baleen Whales	1979-1993	2003	2005	2007	2008 LEG 1-2	2011 LEG2 (up to 31/07)
Balaena mysticus	Bowhead whale	X	0	0	44	7	0
Balaenoptera Musculus	Blue whale	X	0	11	49	4	17
B. physalus	Fin whale	4	15	78	105	16	129+
B. acurostrata	Minke whale	38	7	39	10	26	4
Megaptera novaeanglia	Humpback whale	0	0	11	21	149	2
Physeter macrocephalus	Sperm whale	24	0	10	13	3	2
	Large whale unindentified	7	0	20	49	11	45
	Large whales TOTAL	75	22	169	291	216	199+
	Killer Whale						-
	Pilot Whale						-
	N Bottlenose						-
	W-B Dolphin						-
	Harbour porpoise						-
	TOTAL SMALL						O

Fig. 11.1: One of the 17 blue whales. (Foto taken by R.M. Lafontaine and R. C. Beudels-Jamar, PoIE)

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP'S CREW

A.4 STATION LIST

A.1 PARTICIPATING INSTITUTIONS

Adresse /Address

AWI	Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 12 01 61 27515 Bremerhaven /Germany
Bluefin	BluefinRobotics 553 South Street Quincy, MA 02169 USA
DWD	Deutscher Wetterdienst Geschäftsfeld Seeschifffahrt Bernhard-Nocht Str. 76 20359 Hamburg / Germany
FIELAX	FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH Schifferstr. 10 - 14 27568 Bremerhaven Germany
HeliService	HeliService International GmbH Am Luneort 15 27572 Bremerhaven Germany
IFM-GEOMAR	IFM-GEOMAR Leibniz-Institut für Meereswissenschaften Wischhofstr. 1-3 24148 Kiel Germany
ISITEC	ISITEC GmbH Bussestr. 27 27570 Bremerhaven Germany

Adresse /Address

Laeisz	Reederei F. Laeisz (Bremerhaven) GmbH Brückenstrasse 25 27568 Bremerhaven / Germany
MPI	Max Planck Institute for Marine Microbiology Celsiusstr. 1 28359 Bremen Germany
NOCS	National Oceanography Centre, Southampton University of Southampton Waterfront Campus European Way Southampton SO14 3ZH United Kingdom
PoIE	Laboratory for Polar Ecology Rue du Fodia 18 B-1367 Ramillies Belgium
Schilling Robotics	Schilling Robotics 260 Cousteau Place Davis, CA 95618 U.S.A.

A.2 CRUISE PARTICIPANTS

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Albrecht	Sebastian	FIELAX	Computer scientist
Asendorf	Volker	MPI	Engineer
Bauerfeind	Eduard	AWI	Biologist
Beudels	Roseline	PoIE	Biologist
Büchner	Jürgen	HeliService	Pilot
Buldt	Klaus	DWD	Technician
Cooper	James Andrew	NOCS	Engineer
Cuno	Patrickq	IFM-GEOMAR	Engineer
Dodd	Simon	NOCS	Engineer
Engemann	Greg	IFM-GEOMAR	Engineer
Federwisch	Luisa	AWI	Student biology
Felden	Janine	MPI	Biologist
Gall	Fabian	HeliService	Technician
Hardge	Kristin	AWI	Student biology
Heckmann	Markus	HeliService	Technician
Hildebrandt	Nicole	AWI	Biologist
Hoge	Ulrich	AWI	Engineer electronics
Huusmann	Hannes	IFM-GEOMAR	Engineer
Kaboth	Stefanie	AWI	Geologist
Klages	Michael	AWI	Biologist
Knüppel	Nadine	AWI	Technician biology
Kraft	Angelina	AWI	Biologist
Lafontaine	René-Marie	PoIE	Zoologist
Lalande	Catherine	AWI	Biologist
Lehmenhecker	Sascha	AWI	Computer scientist
Lochte	Karin	AWI	Biologist
Lochthofen	Normen	AWI	Engineer mechanics
Meier	Arne	IFM-GEOMAR	Engineer
Meyer	Kirstin	AWI; U.S. Fulbright	Student biology
Miller	Max	DWD	Meteorologist
Nordhausen	Axel	MPI	Technician biology

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Pappert	Anja	AWI	Technician biology
Petereit	Reinhold	AWI	Technician
Pfannkuche	Olaf	IFM-GEOMAR	Biologist
Pieper	Martin	IFM-GEOMAR	Engineer
Piontek	Judith	AWI	Biologist
Queisser	Wolfgang	IFM-GEOMAR	Technician
Rajasakaren	Balamuralli	JUB	Student biology
Rieper	Norbert	ISITEC	Engineer
Sablotny	Burkhard	AWI	Engineer electronics
Schewe	Ingo	AWI	Biologist
Shurn	Kimberly	BluefinRobotics	Engineer
Soltwedel	Thomas	AWI	Biologist
Sperling	Martin	AWI	Biologist
Suck	Inken	IFM-GEOMAR	Biologist
Sühs	Mirko	AWI	Student biology
Tardeck	Frederic	FIELAX	Geologist
Vaupel	Lars	HeliService	Pilot
Vosteen	Paul	AWI	Student biology
Wenzhöfer	Frank	AWI	Biologist
Winkler	Maria	AWI	Student biology
Wulff	Thorben	AWI	Engineer

A.3 SHIP'S CREW

Name	Rank
Pahl, Uwe	Master
Spielke, Steffen	1.Offc.
Ziemann, Ole	Ch. Eng.
Fallei, Holger	2.Offc./L.
Peine, Lutz	2.Offc.
Kentges, Felix	2.Offc.
Grägel, Eberhard	Doctor
Koch, Georg	R.Offc.
Kotnik, Herbert	2.Eng.
Schnürch, Helmut	2.Eng.
Westphal, Henning	2.Eng.
Holtz, Hartmut	Elec Eng.
Fröb, Martin	Electron.
Stronzek, David	Electron.
Winter, Andreas	Electron
Feiertag, Thomas	Electron.
Clasen, Burkhard	Boatsw.
Neisner, Winfried	Carpenter
Wippich, Reinhard	A.B.
Schultz, Ottomar	A.B.
Burzan, G.-Ekkehard	A.B.
Schröder, Norbert	A.B.
Moser, Siegfried	A.B.
Hartwig-L., Andreas	A.B.
Kretzschmar, Uwe	A.B.
Wolf, Alexander	A.B.
Schröter, Rene	A.B.
Beth, Detlef	Storek.
Kliem, Peter	Mot-man
Fritz, Günter	Mot-man
Krösche, Eckard	Mot-man
Dinse, Horst	Mot-man
Watzel, Bernhard	Mot-man
Fischer, Matthias	Cook
Tupy, Mario	Cooksmate
Völske, Thomas	Cooksmate
Dinse, Petra	1.Stwdess

Hennig, Christina	Stwdss/Kr
Gaude, Hans-Jürgen	2.Steward
Hischke, Peggy	2. Stwdess
Wartenberg, Irina	2. Stwdess
Hu, Guo Yong	2.Stwdard
Chen, Quan Lun	2.Stwdess.
Ruan, Hui Guang	Laundrym.

A.4 STATION LIST

Date	Time	Station	Gear Abbreviation	PositionLat N	PositionLon E	Depth [m]
14.07.2011	08:02:00	PS78/0138-1	MOR	78° 59,37’	4° 28,84’	2569
14.07.2011	17:02:00	PS78/0140-1	CTD/RO	79° 8,04’	6° 5,86’	1284
14.07.2011	17:26:00	PS78/0140-2	APSN	79° 8,08’	6° 6,12’	1285
14.07.2011	18:25:00	PS78/0140-3	MN	79° 8,02’	6° 5,90’	1283
14.07.2011	19:54:00	PS78/0140-4	MN	79° 7,94’	6° 3,74’	1279
14.07.2011	21:31:00	PS78/0140-5	BONGO	79° 7,85’	6° 4,56’	1277
14.07.2011	22:39:00	PS78/0140-6	MUC	79° 8,11’	6° 6,27’	1283
15.07.2011	16:00:00	PS78/0141-1	ROV	78° 39,38’	9° 25,91’	251
15.07.2011	16:00:01	PS78/0141-1	ROV	78° 39,38’	9° 25,91’	251
15.07.2011	23:28:00	PS78/0142-2	APSN	79° 7,92’	4° 52,79’	1558
15.07.2011	23:38:00	PS78/0142-1	CTD/RO	79° 7,97’	4° 52,64’	1555
16.07.2011	01:05:00	PS78/0142-3	MN	79° 7,87’	4° 53,86’	1547
16.07.2011	02:58:00	PS78/0142-4	BONGO	79° 7,96’	4° 53,03’	1549
16.07.2011	04:27:00	PS78/0142-5	MUC	79° 7,82’	4° 54,18’	1545
16.07.2011	07:03:00	PS78/0143-1	CTD	79° 3,63’	4° 11,18’	2481
16.07.2011	09:50:00	PS78/0143-2	OFOS	79° 1,74’	4° 9,56’	2639
16.07.2011	14:58:00	PS78/0143-2	OFOS	79° 3,90’	4° 17,19’	2407
16.07.2011	17:12:00	PS78/0143-3	MN	79° 3,78’	4° 10,72’	2472
16.07.2011	18:40:59	PS78/0143-4	LANDER	79° 3,86’	4° 10,89’	2464
16.07.2011	19:42:00	PS78/0143-5	MN	79° 3,82’	4° 11,55’	2460
16.07.2011	22:07:00	PS78/0143-6	MN	79° 3,85’	4° 10,71’	2467
17.07.2011	00:13:00	PS78/0143-7	MUC	79° 3,86’	4° 10,58’	2468
17.07.2011	02:59:00	PS78/0144-1	CTD/RO	79° 3,38’	3° 44,57’	2841
17.07.2011	06:56:00	PS78/0145-1	MUC	79° 8,70’	2° 45,19’	5574
17.07.2011	07:01:00	PS78/0145-1	MUC	79° 8,70’	2° 45,21’	5574
17.07.2011	10:19:00	PS78/0145-2	MN	79° 7,91’	2° 46,57’	5552
17.07.2011	12:29:00	PS78/0145-3	MN	79° 8,15’	2° 45,91’	5573
17.07.2011	14:11:00	PS78/0145-4	BONGO	79° 8,58’	2° 45,30’	5576
17.07.2011	14:22:00	PS78/0145-5	BONGO	79° 8,63’	2° 45,17’	5576
17.07.2011	14:31:00	PS78/0145-6	BONGO	79° 8,67’	2° 45,07’	5573
17.07.2011	14:40:00	PS78/0145-7	BONGO	79° 8,72’	2° 45,10’	5573
17.07.2011	14:48:00	PS78/0145-8	BONGO	79° 8,76’	2° 45,15’	5574
17.07.2011	14:56:00	PS78/0145-9	BONGO	79° 8,78’	2° 45,17’	5574
17.07.2011	15:04:00	PS78/0145-10	BONGO	79° 8,81’	2° 45,24’	5574
17.07.2011	15:12:00	PS78/0145-11	BONGO	79° 8,84’	2° 45,28’	5574
17.07.2011	15:20:00	PS78/0145-12	BONGO	79° 8,86’	2° 45,30’	5574
17.07.2011	15:28:00	PS78/0145-13	BONGO	79° 8,88’	2° 45,33’	5574
17.07.2011	15:36:00	PS78/0145-14	BONGO	79° 8,91’	2° 45,37’	5574
17.07.2011	15:57:00	PS78/0145-15	BONGO	79° 8,98’	2° 45,39’	5574

Date	Time	Station	Gear Abbreviation	PositionLat N	PositionLon E	Depth [m]
17.07.2011	17:01:00	PS78/0145-17	APSN	79° 8,76’	2° 45,55’	5576
17.07.2011	18:03:00	PS78/0145-16	CTD/RO	79° 9,01’	2° 46,31’	5578
17.07.2011	22:24:59	PS78/0146-1	LANDER	79° 3,82’	4° 10,24’	2478
17.07.2011	22:57:59	PS78/0147-1	LANDER	79° 3,74’	4° 11,17’	2471
18.07.2011	03:48:00	PS78/0148-1	MUC	78° 55,84’	6° 50,88’	1424
18.07.2011	05:12:00	PS78/0148-2	MUC	78° 55,82’	6° 50,99’	1424
18.07.2011	10:04:00	PS78/0149-1	ROV	79° 0,36’	6° 56,19’	1236
18.07.2011	19:00:00	PS78/0149-1	ROV	79° 0,81’	6° 51,42’	1231
19.07.2011	12:10:00	PS78/0150-1	AUV	78° 9,11’	10° 41,79’	257
19.07.2011	12:56:00	PS78/0150-1	AUV	78° 9,05’	10° 40,52’	258
19.07.2011	15:09:00	PS78/0150-2	CTD/RO	78° 8,48’	10° 34,87’	244
19.07.2011	19:03:00	PS78/0150-1	AUV	78° 8,36’	10° 33,90’	239
19.07.2011	19:15:00	PS78/0150-1	AUV	78° 8,39’	10° 34,07’	235
20.07.2011	01:32:00	PS78/0151-1	CTD/RO	78° 58,77’	9° 22,63’	226
20.07.2011	01:32:00	PS78/0151-2	APSN	78° 58,77’	9° 22,63’	226
20.07.2011	02:14:00	PS78/0151-3	MUC	78° 58,80’	9° 22,89’	227
20.07.2011	06:05:00	PS78/0152-1	MUC	78° 55,93’	6° 51,00’	1420
20.07.2011	08:04:00	PS78/0153-2	HN	79° 3,15’	7° 0,59’	1349
20.07.2011	08:09:00	PS78/0153-1	CTD	79° 3,17’	7° 0,66’	1349
20.07.2011	09:20:00	PS78/0153-3	MUC	79° 3,07’	7° 0,77’	1346
20.07.2011	13:33:00	PS78/0154-2	APSN	79° 6,52’	4° 36,04’	1898
20.07.2011	13:47:00	PS78/0154-1	CTD/RO	79° 6,49’	4° 35,97’	1903
20.07.2011	15:59:00	PS78/0154-3	MN	79° 6,60’	4° 37,19’	1913
20.07.2011	18:36:00	PS78/0154-4	BONGO	79° 6,64’	4° 37,22’	1897
20.07.2011	19:59:00	PS78/0154-5	MUC	79° 6,77’	4° 36,34’	1809
20.07.2011	21:29:59	PS78/0155-1	LANDER	79° 3,55’	4° 10,19’	2063
20.07.2011	22:02:00	PS78/0156-1	LANDER	79° 3,49’	4° 9,92’	2509
20.07.2011	23:21:00	PS78/0157-1	LANDER	79° 3,45’	4° 11,04’	2509
21.07.2011	02:12:00	PS78/0158-2	APSN	79° 2,81’	3° 35,95’	3403
21.07.2011	02:59:00	PS78/0158-1	CTD/RO	79° 2,85’	3° 35,87’	3435
21.07.2011	05:30:00	PS78/0158-3	MN	79° 2,85’	3° 37,21’	3329
21.07.2011	06:54:00	PS78/0158-4	BONGO	79° 2,76’	3° 37,28’	3340
21.07.2011	08:18:00	PS78/0158-5	MUC	79° 2,63’	3° 37,35’	3271
21.07.2011	10:59:00	PS78/0159-1	CTD/RO	79° 3,51’	3° 28,90’	3987
21.07.2011	13:27:00	PS78/0159-2	MN	79° 3,53’	3° 29,08’	3977
21.07.2011	14:50:00	PS78/0159-3	BONGO	79° 3,49’	3° 28,88’	3988
21.07.2011	16:36:00	PS78/0159-4	MUC	79° 3,50’	3° 28,87’	3988
21.07.2011	18:21:00	PS78/0160-1	CTD/RO	79° 3,74’	3° 19,81’	5096
21.07.2011	20:02:00	PS78/0160-2	MN	79° 3,75’	3° 20,33’	5073
21.07.2011	23:07:00	PS78/0160-3	MUC	79° 3,78’	3° 18,75’	5126

Date	Time	Station	Gear Abbreviation	PositionLat N	PositionLon E	Depth [m]
22.07.2011	07:13:00	PS78/0161-1	LIFT	79° 5,02'	4° 8,21'	2459
22.07.2011	09:49:01	PS78/0161-2	ROV	79° 5,03'	4° 8,50'	2459
22.07.2011	20:57:00	PS78/0161-2	ROV	79° 5,02'	4° 8,07'	2462
22.07.2011	21:46:00	PS78/0161-3	LIFT	79° 5,03'	4° 8,04'	2461
23.07.2011	03:34:59	PS78/0162-1	LANDER	79° 43,67'	4° 26,37'	2695
23.07.2011	03:53:59	PS78/0162-2	LANDER	79° 43,55'	4° 27,32'	2719
23.07.2011	04:39:00	PS78/0162-4	APSN	79° 43,45'	4° 27,66'	2734
23.07.2011	05:05:00	PS78/0162-3	CTD/RO	79° 43,47'	4° 27,69'	2732
23.07.2011	06:10:00	PS78/0162-5	MOORY	79° 44,33'	4° 30,08'	2655
23.07.2011	09:38:00	PS78/0162-6	MN	79° 45,48'	4° 26,49'	2555
23.07.2011	11:27:00	PS78/0162-7	CTD/RO	79° 45,52'	4° 26,75'	2542
24.07.2011	07:06:00	PS78/0163-1	LANDER	79° 3,56'	4° 10,14'	2503
24.07.2011	09:52:00	PS78/0164-2	CTD/RO	79° 4,46'	4° 7,94'	2492
24.07.2011	10:22:00	PS78/0164-1	ROV	79° 4,46'	4° 7,96'	2492
24.07.2011	13:46:00	PS78/0164-3	AUV	79° 4,47'	4° 7,99'	2491
24.07.2011	15:18:00	PS78/0164-3	AUV	79° 4,55'	4° 7,80'	2491
24.07.2011	17:53:00	PS78/0164-3	AUV	79° 4,56'	4° 7,56'	2493
24.07.2011	18:25:00	PS78/0164-3	AUV	79° 4,56'	4° 7,69'	2498
24.07.2011	19:01:00	PS78/0164-1	ROV	79° 4,54'	4° 7,91'	2490
24.07.2011	22:13:00	PS78/0165-2	APSN	79° 16,80'	4° 19,81'	2393
24.07.2011	22:46:00	PS78/0165-1	CTD/RO	79° 16,83'	4° 19,79'	2394
24.07.2011	23:53:00	PS78/0165-3	BONGO	79° 16,84'	4° 19,84'	2395
25.07.2011	01:03:00	PS78/0165-4	MUC	79° 16,80'	4° 19,49'	2396
25.07.2011	03:36:00	PS78/0166-2	APSN	79° 25,76'	4° 45,32'	2608
25.07.2011	04:07:00	PS78/0166-1	CTD/RO	79° 25,80'	4° 45,65'	2608
25.07.2011	06:39:00	PS78/0166-3	MN	79° 25,63'	4° 44,38'	2603
25.07.2011	07:57:00	PS78/0166-4	BONGO	79° 25,62'	4° 44,28'	2603
25.07.2011	09:01:00	PS78/0166-5	MUC	79° 25,62'	4° 44,61'	2601
25.07.2011	14:57:00	PS78/0167-1	CTD/RO	79° 44,38'	4° 30,34'	2670
25.07.2011	17:15:00	PS78/0167-2	MOR	79° 44,38'	4° 30,37'	2690
25.07.2011	17:52:00	PS78/0167-3	LANDER	79° 43,58'	4° 27,50'	0
25.07.2011	19:19:00	PS78/0167-4	BL_C	79° 43,69'	4° 26,49'	2691
25.07.2011	21:42:00	PS78/0167-5	MUC	79° 43,66'	4° 26,62'	2696
26.07.2011	01:30:00	PS78/0168-2	APSN	79° 57,11'	3° 8,98'	2548
26.07.2011	02:04:00	PS78/0168-1	CTD/RO	79° 57,19'	3° 10,17'	2538
26.07.2011	03:54:00	PS78/0168-3	MN	79° 56,86'	3° 11,82'	2536
26.07.2011	05:14:00	PS78/0168-4	BONGO	79° 56,48'	3° 12,36'	2542
26.07.2011	06:17:00	PS78/0168-5	MUC	79° 56,28'	3° 11,67'	2550
26.07.2011	10:25:59	PS78/0169-1	BL_P	79° 43,67'	4° 27,47'	2709
26.07.2011	10:50:00	PS78/0170-1	CTD/RO	79° 43,86'	4° 28,16'	2698

Date	Time	Station	Gear Abbreviation	PositionLat N	PositionLon E	Depth [m]
26.07.2011	17:55:59	PS78/0170-2	TEST	79° 40,19’	5° 2,37’	2552
26.07.2011	19:01:00	PS78/0170-3	AUV	79° 40,42’	5° 7,53’	2483
26.07.2011	20:09:00	PS78/0170-3	AUV	79° 40,40’	5° 10,13’	2467
26.07.2011	21:46:00	PS78/0170-4	BONGO	79° 40,96’	5° 17,36’	2209
27.07.2011	00:24:00	PS78/0171-1	OFOS	79° 35,84’	5° 9,95’	2788
27.07.2011	04:20:00	PS78/0171-1	OFOS	79° 34,11’	5° 15,08’	2663
27.07.2011	06:39:00	PS78/0171-3	APSN	79° 35,70’	5° 13,83’	2746
27.07.2011	06:43:00	PS78/0171-2	CTD/RO	79° 35,70’	5° 13,83’	2746
27.07.2011	08:45:00	PS78/0171-4	MN	79° 35,72’	5° 13,35’	2752
27.07.2011	10:11:00	PS78/0171-5	BONGO	79° 35,71’	5° 13,33’	2753
27.07.2011	11:11:00	PS78/0171-6	MUC	79° 35,71’	5° 13,26’	2753
27.07.2011	18:01:00	PS78/0172-1	MUC	79° 3,15’	3° 43,92’	2866
27.07.2011	22:52:59	PS78/0173-1	BL_C	78° 35,05’	5° 3,95’	2349
27.07.2011	23:05:59	PS78/0173-2	BL_P	78° 35,04’	5° 1,88’	2354
27.07.2011	23:53:00	PS78/0174-2	APSN	78° 36,06’	5° 2,53’	2350
28.07.2011	00:21:00	PS78/0174-1	CTD/RO	78° 36,01’	5° 1,76’	2354
28.07.2011	01:22:00	PS78/0174-3	BONGO	78° 35,98’	5° 0,01’	2359
28.07.2011	05:17:00	PS78/0175-1	LIFT	78° 36,20’	5° 4,37’	2340
28.07.2011	05:22:00	PS78/0175-1	LIFT	78° 36,20’	5° 4,38’	2340
28.07.2011	05:48:00	PS78/0175-2	MOR	78° 36,28’	5° 4,51’	2340
28.07.2011	08:57:01	PS78/0175-3	ROV	78° 36,18’	5° 4,21’	2341
28.07.2011	11:11:00	PS78/0175-4	AUV	78° 36,21’	5° 4,15’	2341
28.07.2011	14:16:00	PS78/0175-4	AUV	78° 36,22’	5° 4,24’	2341
28.07.2011	19:10:00	PS78/0175-3	ROV	78° 36,20’	5° 4,02’	2342
28.07.2011	19:47:00	PS78/0175-5	LIFT	78° 36,20’	5° 3,97’	2342
28.07.2011	22:29:00	PS78/0175-6	MN	78° 36,40’	5° 3,84’	2342
29.07.2011	02:15:00	PS78/0176-2	APSN	78° 55,12’	5° 0,28’	2633
29.07.2011	02:48:00	PS78/0176-1	CTD/RO	78° 54,98’	5° 0,33’	2635
29.07.2011	05:02:00	PS78/0176-3	MN	78° 54,96’	5° 1,21’	2633
29.07.2011	06:25:00	PS78/0176-4	BONGO	78° 54,89’	5° 1,16’	2634
29.07.2011	09:26:00	PS78/0177-1	MOORY	79° 0,42’	4° 19,90’	2605
29.07.2011	10:12:00	PS78/0177-2	CTD/RO	78° 59,85’	4° 19,80’	2621
29.07.2011	11:16:59	PS78/0178-1	LANDER	79° 3,90’	4° 10,24’	2470
29.07.2011	11:23:00	PS78/0179-1	LANDER	79° 3,93’	4° 10,98’	2460
29.07.2011	15:10:00	PS78/0180-1	MUC	78° 55,02’	5° 0,09’	2636
29.07.2011	17:25:00	PS78/0181-2	APSN	78° 46,82’	5° 19,67’	2469
29.07.2011	18:00:00	PS78/0181-1	CTD/RO	78° 46,86’	5° 20,49’	2456
29.07.2011	20:00:00	PS78/0181-3	MN	78° 46,86’	5° 19,90’	2467
29.07.2011	21:22:00	PS78/0181-4	BONGO	78° 46,78’	5° 19,48’	2472

Date	Time	Station	Gear Abbreviation	PositionLat N	PositionLon E	Depth [m]
29.07.2011	22:19:00	PS78/0181-5	MUC	78° 46,78’	5° 19,76’	2466
30.07.2011	01:04:00	PS78/0182-1	OFOS	78° 37,00’	5° 0,19’	2366
30.07.2011	04:46:00	PS78/0182-1	OFOS	78° 36,99’	5° 9,95’	2351
30.07.2011	06:57:00	PS78/0182-2	MN	78° 36,37’	5° 3,73’	2341
30.07.2011	08:37:00	PS78/0182-3	MUC	78° 36,38’	5° 3,92’	2341
30.07.2011	09:37:00	PS78/0182-4	BL_P	78° 35,14’	5° 1,95’	2354
30.07.2011	11:09:00	PS78/0183-1	BL_C	78° 35,11’	5° 4,02’	2345
30.07.2011	14:15:01	PS78/0184-1	MOR	78° 36,18’	5° 5,32’	0
30.07.2011	15:23:00	PS78/0184-3	CTD/RO	78° 36,38’	5° 4,99’	2341
30.07.2011	16:10:00	PS78/0184-2	AUV	78° 37,12’	5° 5,92’	2341
30.07.2011	19:23:00	PS78/0184-2	AUV	78° 37,75’	5° 33,82’	2289
31.07.2011	01:43:00	PS78/0185-1	OFOS	78° 58,80’	9° 29,80’	232
31.07.2011	05:05:00	PS78/0185-1	OFOS	78° 57,27’	9° 23,00’	221
31.07.2011	07:13:00	PS78/0186-1	MOR	78° 50,01’	8° 40,10’	245
31.07.2011	07:32:00	PS78/0186-1	MOR	78° 50,05’	8° 40,09’	243
31.07.2011	09:00:00	PS78/0186-1	MOR	78° 49,95’	8° 40,03’	248

Abbreviations:

APSN	Apstein net
AUV	Autonomous Underwater Vehicle
BL_P	Bottom lander, profile
BL_C	Bottom lander, chamber
BONGO	Bongo net
CTD	CTD
CTD/RO	CTD/rosette water sampler
LANDER	Bottom lander
LIFT	Lift system for ROV support
MN	Multiple net
MOR	Mooring
MOORY	Mooring (Year)
MUC	Multi corer
OFOS	Ocean Floor Observing System
ROV	Remotely Operated Vehicle

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