ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

EXPEDITION PROGRAMME PS93.2

Polarstern

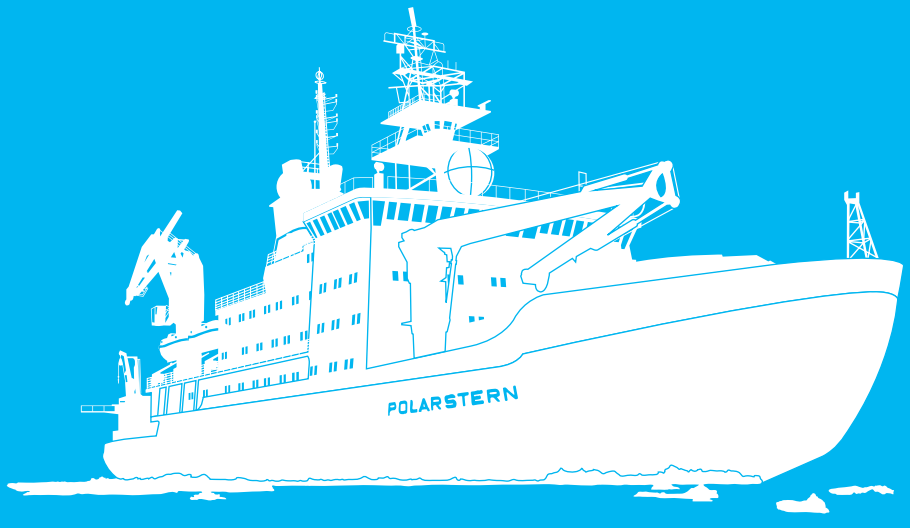
PS93.2

Tromsø - Tromsø

21 July 2015 - 15 August 2015

Coordinator: Rainer Knust

Chief Scientist: Thomas Soltwedel



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Long-Term Ecological Research at the Deep-Sea Observatory HAUSGARTEN

Coordinator
Rainer Knust

Chief Scientist
Thomas Soltwedel

Contents

1. ÜBERBLICK UND FAHRTVERLAUF

Thomas Soltwedel
AWI

Der zweite Fahrtabschnitt der RV *Polarstern* Expedition PS93 in die Arktis wird am 21. Juli 2015 in Tromsø (Norwegen) beginnen und in die zentrale und östliche Framstraße führen (Abb. 1.1).

Die Expedition PS93.2 soll genutzt werden, um Beiträge zu verschiedenen nationalen und internationalen Forschungs- und Infrastrukturprojekten (ABYSS, TRANSDRIFT, ICOS, SIOS, FixO^3, ROBEX, FRAM) sowie dem Forschungsprogramm PACES II (Polar Regions and Coasts in the changing Earth System) des Alfred-Wegener-Instituts Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) zu leisten. Im Arbeitspaket WP4 (Arctic sea ice and its interaction with ocean and ecosystems) des PACES-II Programms werden die mit dem Rückgang des Meereises verbundenen Ökosystemverschiebungen im Pelagial und im tiefen Ozean ermittelt und quantifiziert und Rückkopplungsprozesse auf zeitliche und räumliche Prozesse untersucht. Unser Beitrag zum PACES-II Arbeitspaket WP6 (Large scale variability and change in polar benthic biota and ecosystem functions) beinhaltet die Identifizierung räumlicher und zeitlicher Entwicklungen in der Funktion ausgewählter Benthos-Gemeinschaften sowie den Aufbau eines umfassenden Repositoriums für Beobachtungsdaten. Die Arbeiten stellen einen weiteren Beitrag zur Sicherstellung der Langzeitbeobachtungen am LTER (Long-Term Ecological Research) Observatorium HAUSGARTEN dar, in denen der Einfluss von Umweltveränderungen auf ein arktisches Tiefseeökosystem dokumentiert wird. Diese Arbeiten werden in enger Zusammenarbeit der HGF-MPG Brückengruppe für Tiefsee-Ökologie und -Technologie, und der PEBCAO-Gruppe (Phytoplankton Ecology and Biogeochemistry in the Changing Arctic Ocean) des AWI und der Helmholtz-Hochschul-Nachwuchsgruppe SEAPUMP (Seasonal and regional food web interactions with the biological pump) durchgeführt.

Die Expedition soll darüber hinaus genutzt werden, um Installationen im Rahmen der HGF Infrastrukturmaßnahme FRAM (Frontiers in Arctic marine Monitoring) vorzunehmen. Das FRAM Ocean Observing System wird kontinuierliche Untersuchungen von der Meeresoberfläche bis in die Tiefsee ermöglichen und zeitnah Daten zur Erdsystem-Dynamik sowie zu Klima- und Ökosystem-Veränderungen liefern. Daten des Observatoriums werden zu einem besseren Verständnis der Veränderungen in der Ozeanzirkulation, den Wassermasseneigenschaften und des Meereisrückgangs sowie deren Auswirkungen auf das arktische, marine Ökosystem beitragen. FRAM führt Sensoren in Observationsplattformen zusammen, die sowohl die Registrierung von Ozeanvariablen, als auch physiko-chemischer und biologischer Prozesse im Ozean erlauben. Experimentelle und Ereignis-gesteuerte Systeme ergänzen diese Beobachtungsplattformen. Produkte der Infrastruktur umfassen hochaufgelöste Langzeitdaten sowie Basisdaten für Modelle und die Fernerkundung. Im Rahmen des EU-Infrastrukturprojekts FixO^3 (Fixed-point Open Ocean Observatories) gewährt die Expedition europäischen Partnern den Zugang zum FRAM Ocean Observing System sowie logistische Unterstützung bei der Umsetzung externer und gemeinsamer Forschungsprojekte.

Die technisch und logistisch sehr aufwendige Expedition PS93.2, während der neben einem großen ferngesteuerten Unterwasserfahrzeug (Work-Class Remotely Operated Vehicle, ROV) und einem autonomen Unterwasserfahrzeug (Autonomous Underwater Vehicle, AUV)

auch autonome unbemannte Fluggeräte (Unmanned Aerial Vehicles, UAVs) zum Einsatz kommen sollen, wird am 15. August 2015, wiederum in Tromsø, enden.

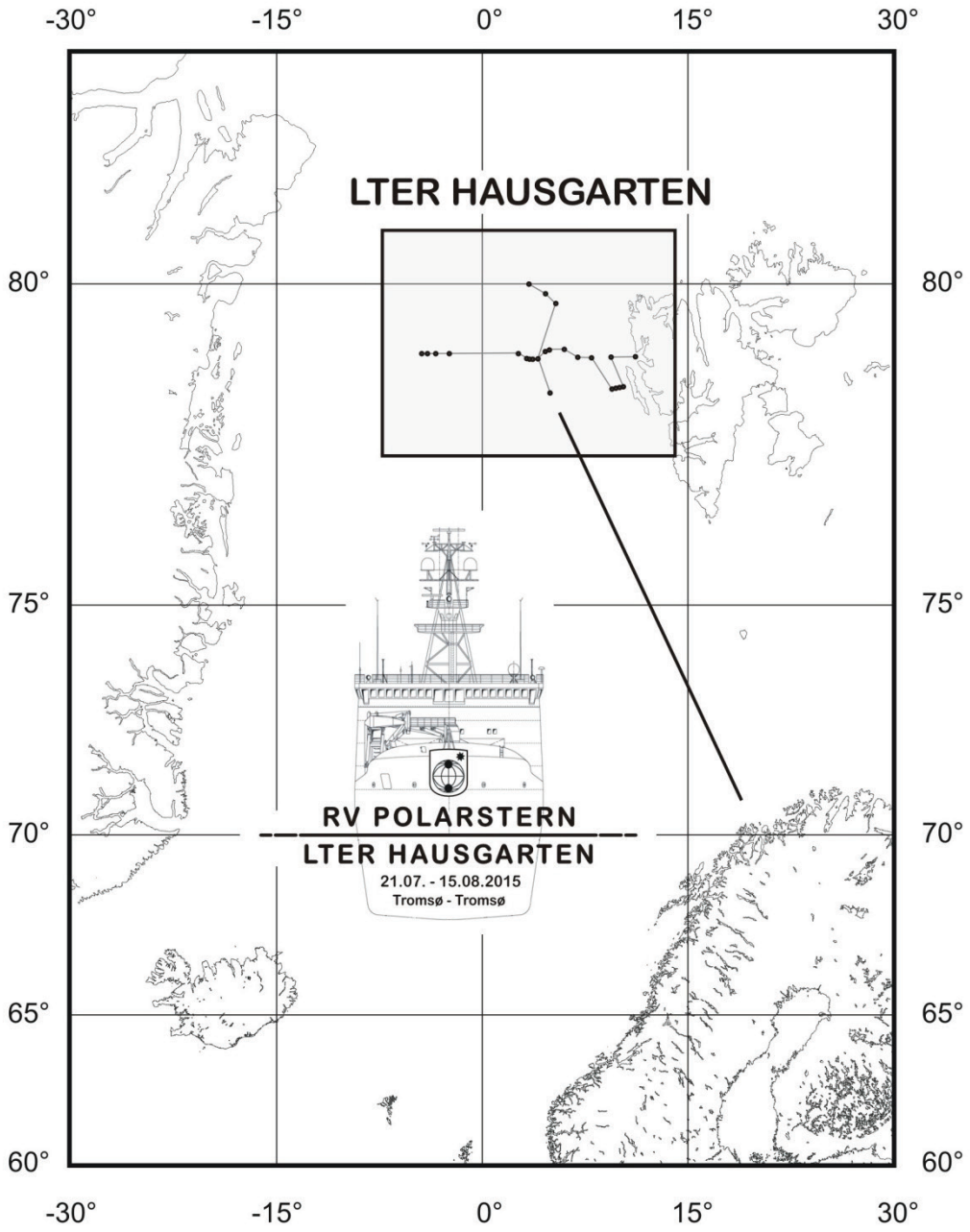

Abb. 1.1: Geplante Fahrtroute der Polarstern-Expedition PS93.2
Fig. 1.1: Planned cruise track during Polarstern expedition PS93.2

SUMMARY AND ITINERARY

The second leg of the RV *Polarstern* expedition PS93 to the Arctic will start on 21 July 2015 in Tromsø (Norway) and lead to the central and eastern Fram Strait (Fig. 1.1).

The expedition PS93.2 will contribute to various large national and international research and infrastructure projects (ABYSS, TRANSDRIFT, ICOS, SIOS, FixO^3, ROBEX, FRAM) as well as to the research programme PACES-II (Polar Regions and Coasts in the changing Earth System) of the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI). Investigations within Work Package 4 (Arctic sea ice and its interaction with ocean and ecosystems) of the PACES-II programme, aim at assessing and quantifying ecosystem changes from surface waters to the deep ocean in response to retreating sea ice, and at exploring the most important (feedback) processes determining temporal and spatial variability. Contributions to the PACES-II Work Package 6 (Large scale variability and change in polar benthic biota and ecosystem functions) include the identification of spatial patterns and temporal trends in relevant benthic community functions, and the development of a comprehensive science community reference collection of observational data. Work carried out within WPs 4 and 6 will support the time-series studies at the LTER (Long-Term Ecological Research) observatory HAUSGARTEN, where we document Global Change induced environmental variations on a polar deep-water ecosystem. This work is carried out in close co-operation between the HGF-MPG Joint Research Group on Deep-Sea Ecology and Technology, and the PEBCAO Group (Phytoplankton Ecology and Biogeochemistry in the Changing Arctic Ocean) at AWI and the Helmholtz Young Investigators Group SEAPUMP (Seasonal and regional food web interactions with the biological pump), representing a joint effort between AWI and the MARUM - Center for Marine Environmental Sciences, and the University of Bremen.

The expedition will also be used to accomplish installations for the HGF infrastructure project FRAM (Frontiers in Arctic marine Monitoring). The FRAM Ocean Observing System aims at permanent presence at sea, from surface to depth, for the provision of near real-time data on Earth system dynamics, climate variability and ecosystem change. It serves national and international tasks towards a better understanding of the effects of change in ocean circulation, water mass properties and sea-ice retreat on Arctic marine ecosystems and their main functions and services. FRAM implements existing and next-generation sensors and observatory platforms, allowing synchronous observation of relevant ocean variables as well as the study of physical, chemical and biological processes in the ocean. Experimental and event-triggered platforms complement the observational platforms. Products of the infrastructure are continuous long-term data with appropriate resolution in space and time, as well as ground-truthing information for ocean models and remote sensing. Within the framework of a 'Trans-National Access' (TNA) initiative of the European project FixO^3 (Fixed-point Open Ocean Observatories), the expedition will provide access to the FRAM Ocean Observing System thereby supporting external and joint scientific projects logistically.

During the technically and logistically very challenging expedition we will operate a deep-diving Work-Class Remotely Operated Vehicle (ROV) as well as an Autonomous Underwater Vehicle (AUV) and different autonomous Unmanned Aerial Vehicles (UAVs). The cruise will end on 15 August 2015, again in Tromsø (Norway).

2. IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE ECOSYSTEMS (LTER HAUSGARTEN)

I. Schewe, E. Bauerfeind, M. Bergmann, C. Hasemann, R. Hoffmann, I. Kolar, N. Lochthofen, J. Ludszuweit, B. Sablotny, I. Salter, M. Spill, S. Tippenhauer (AWI); U. Braekman, A. Chennu, A. Nordhausen (MPIMM)

Objectives and scientific programme

Polar Regions play a central role for the global climate, as the ice albedo has a crucial influence on the Earth's heat balance. While always in fluctuation, the global climate is presently experiencing a period of rapid change, with a warming trend amplified in the Arctic region. Results of large-scale simulations of the future Earth's climate by several global climate models predict a further increase in temperatures, also leading to further reduction in ice cover. Moreover, there has been a significant thinning of the sea ice by approximately 50 % since the late 1950s. In its recent report, the Intergovernmental Panel on Climate Change (IPCC) prophesied that the Arctic could become ice free at the end of this century, while others argue that this scenario might even take place much earlier, with predications as early as end of Arctic summer 2040.

The shift from a white cold ocean to a darker, warmer ocean will have severe impacts on the polar marine ecosystem. Thinner ice may permit better growth of ice algae, but more rapid spring melting may reduce their growing season. The timing and location of pelagic primary production will generally alter. Whether sea ice retreat generally leads to an increase in primary productivity is under debate, but biogeochemical models predict no or even negative changes in productivity and export flux. Altered algal abundance and composition will affect zooplankton community structure and subsequently the flux of particulate organic matter to the seafloor, where the quantity and quality of this matter will impact benthic communities. Changes in the predominance of certain trophic pathways will have cascading effects propagating through the entire marine community. Generally, arctic marine organisms will be compromised by temperature regimes approaching the limits of their thermal capacity. As a consequence, warmer waters in the Arctic will allow a northward expansion of sub-arctic and boreal species. Besides water temperature increase, expanding ocean acidification will pose another threat to pelagic and benthic life in the Arctic Ocean.

To detect and track the impact of large-scale environmental changes in 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 Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) established the LTER (Long-Term Ecological Research) site HAUSGARTEN. Since 2014 this observatory has been successively extended within the frame of the HGF financed infrastructure project FRAM (Frontiers in Arctic marine Monitoring) and currently covers 21 permanent sampling sites on the West-Spitsbergen and East-Greenland slope at water depths between 250 and 5,500 m.

During RV *Polarstern* expedition PS93.2, multidisciplinary research activities will be conducted at all HAUSGARTEN stations (Fig. 2.1). The research programme will cover almost all compartments of the marine ecosystem from the pelagic zone to the benthic realm. Regular sampling as well as the deployment of moorings and different free-falling systems (bottom-lander) which act as local observation platforms, has taken place since the observatory was established back in 1999.

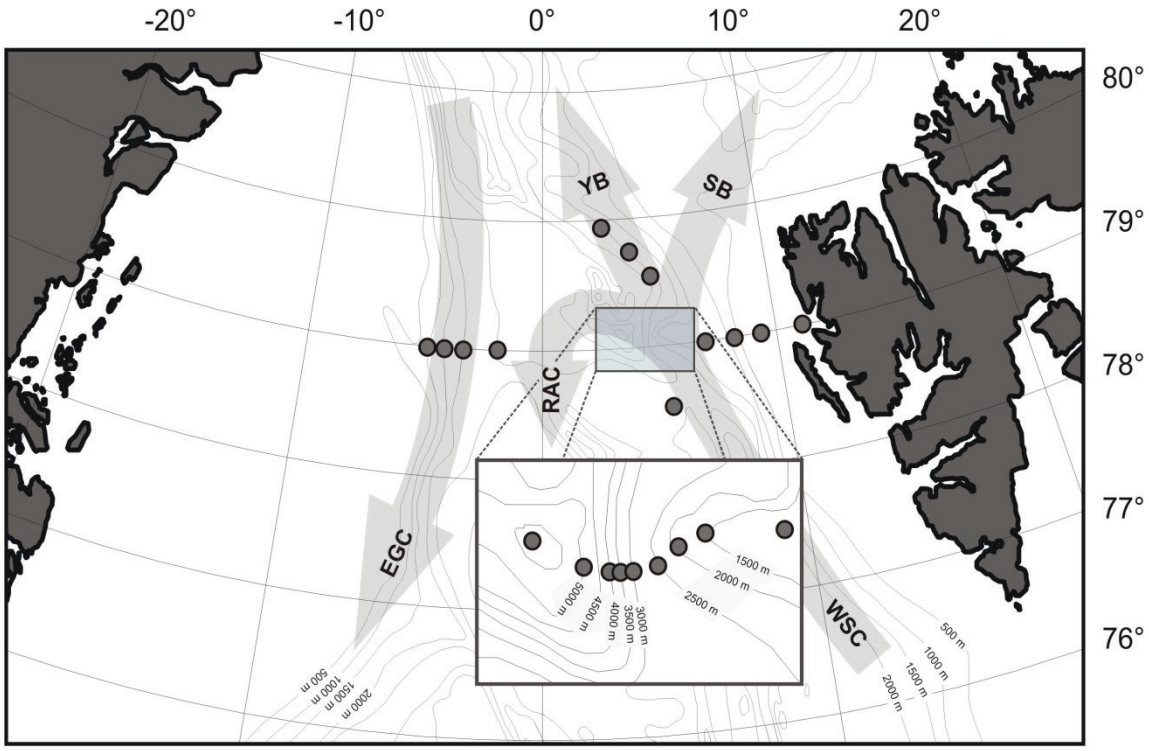

Fig. 2.1: Permanent sampling sites of the LTER Observatory HAUSGARTEN in Fram Strait

Work at sea

Hydrographic data and upper ocean properties will be assessed using a cabled CTD-rosette water sampler and an Autonomous Underwater Vehicle (AUV; see Chapter 5).

Measurements of the vertical flux of particulate matter at HAUSGARTEN have been conducted since the establishment of the observatory. By means of these measurements we are able to quantify the export of organic matter from the sea surface to the deep sea, and trace changes in these fluxes over time. The organic material which is produced in the upper water layers or introduced from land is the main food source for deep-sea organisms. Measurements of organic matter fluxes are conducted by bottom tethered moorings carrying sediment traps at a ~200 m and 1,000 m below sea-surface, and about 180 m above the seafloor (Fig. 2.2). Besides sediment traps the moorings are equipped with Aanderaa current meters (RCM8, RCM11) and self-recording CTD's (Seabird MicroCATs). During the RV *Polarstern* expedition PS93.2, we will exchange moorings and instruments that were deployed at ~2,500 m water depth during the RV *Polarstern* cruise PS84.1 in 2014 in the Western Fram Strait (78°31,69'N, 02°45,87'W), at the central HAUSGARTEN site (79°00'N, 04°20'E), and in the northern HAUSGARTEN area (79°43'N, 04°30'E). Two other moorings, equipped with McLane Moored Profilers (MMP) and deployed in 2014 near the central HAUSGARTEN station and in Western Fram Strait, will be recovered.

In addition to the instruments mentioned above, the moorings in the western Fram Strait and at the central HAUSGARTEN site will be equipped with *in-situ* water samplers and *in-situ* nutrient analysers (see Chapter 6) at ~80 m below sea surface.

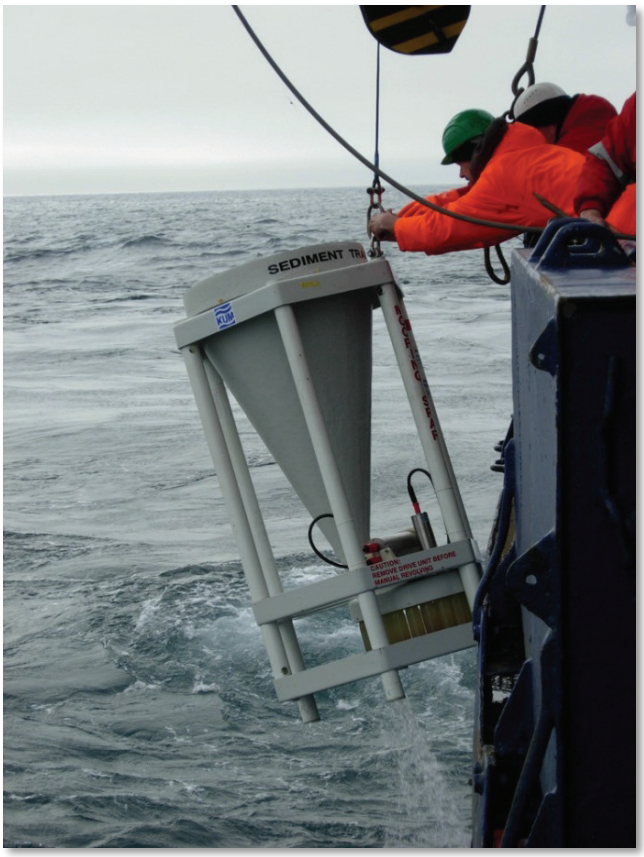

Fig. 2.2: Deployment of a sediment trap to assess particle fluxes to the seafloor

At the central HAUSGARTEN site, we will deploy a special mooring with a prototype profiling winch system carrying a sensor package. This device has been developed within the BMBF funded project ICOS-D (Integrated carbon Observation system, Germany) and shall conduct measurements within the upper 200 m of the water column at regular pre-programmed intervals. At present the sensor package consists of instruments for measuring carbon dioxide, oxygen, conductivity, temperature, pressure, and chlorophyll fluorescence.

At all stations where moorings are deployed we will conduct CTD-rosette water sampler casts from the surface close to the seafloor. Water samples will be taken for the analyses of chlorophyll *a*, particulate organic carbon and nitrogen (POC/N), biogenic particulate silica (bPSi, total particulate matter (seston), calcium carbonate ($CaCO_3$), and the stable isotopes content ($\delta^{15}N/\delta^{13}C$) in the particulate matter. This work as well as the sampling at the other HAUSGARTEN stations will be conducted in close cooperation with the PEBCAO group. For further details regarding the work in the water column see Chapter 4.

Virtually undisturbed sediment samples will be taken using a video-guided multiple corer (TV-MUC; Fig. 2.3). Various biogenic compounds from these sediments will be analysed to estimate activities (i.e. bacterial exoenzymatic activity) and the total biomass (i.e. particulate proteins, phospholipids) of the smallest sediment-inhabiting organisms. Results will help to

describe ecosystem changes in the benthal of the Arctic Ocean. Sediments retrieved by the TV-MUC will also be analysed for the quantitative and qualitative assessment of the small benthic biota (meiofauna).

Fig. 2.3: Sediment sampling using a video-guided multiple corer (TV-MUC)

During the RV *Polarstern* expedition PS93.2, we will continue studying inter-annual dynamics of megafaunal organisms using the towed photo/video system OFOS (Ocean Floor Observation System; Fig. 2.4). The OFOS will be towed along established tracks at HAUSGARTEN stations on the East-Greenland rise (EG-IV), in the Molloy Hole (HG-IX), at the central HAUSGARTEN site (HG-IV) as well as a northern station (N3) and at the southernmost site (S3). The new footage will extend image time series studies that started already in 2002.

A Remotely Operated Vehicle (ROV) will be used to sample previously established biological *in-situ* long-term experiments at the sea floor and to repeat high resolution epibenthos observations.

By means of the ROV-handled pushcorers we will retrieve sediments from surface sediments covered by 4 m² cages with solid lids, preventing the sedimentation of particulate organic matter, i.e. the main food/energy source for benthic organisms. These cages were deployed in summer 2008 and will be repeatedly sampled over the next years to assess the reaction of the small biota to decreasing food availability. Moreover, we will use the ROV to sample different bioturbation experiments established in 2011 and 2013, where we spread out small inert fluorescing microspheres, so-called luminophores (60 µm [pink] and 80-125 µm [green] in diameter), on defined areas at the seafloor to assess the mixing efficiency of larger benthic organisms at HAUSGARTEN stations HG-I (1,250 m), HG-IV (2,500 m) and S3 (2,300 m water depth). The ROV will also be used to install and redeploy autonomous instruments (e.g. microprofiler, incubation chambers) for short-term measurements during the expedition.

Part of the pelagic and benthic work planned during RV *Polarstern* expedition PS93.2 will

also serve the BMBF project TRANSDRIFT (System Laptewsee – Das transpolare System des Nordpolarmeeres).

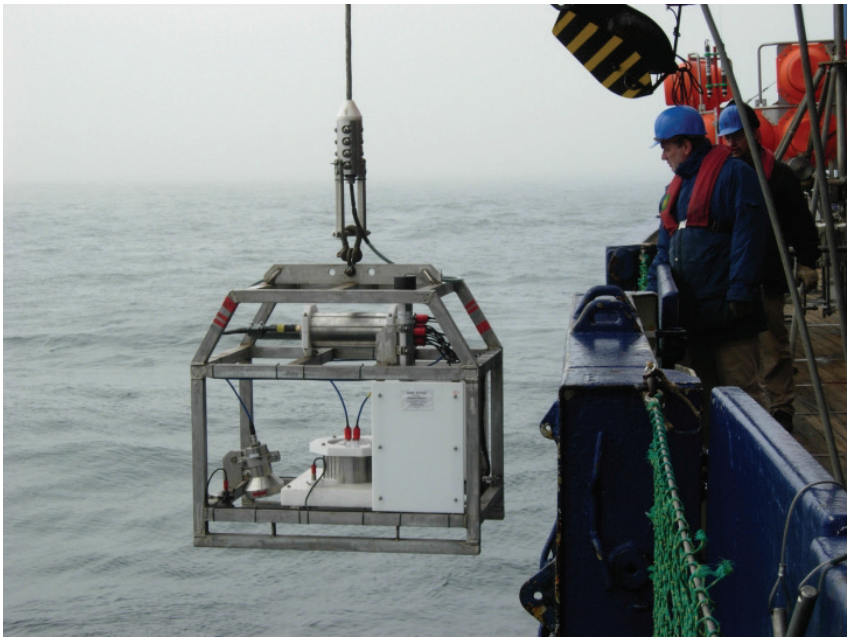

Fig. 2.4: Deployment of the Ocean Floor Observation System (OFOS)

Data management and samples

Sample processing will be carried out at AWI. Expenditure of time needed for the respective data acquisition of the several types of investigation will be different. The time periods from post processing to data provision will vary from one year maximum for sensor data, to several years for organism-related datasets. Until then preliminary data will be available to the cruise participants and external users on request to the senior scientist. The finally processed data will be submitted to the PANGAEA data library. The unrestricted availability from PANGAEA will depend on the required time and effort for acquisition of individual datasets and its status of scientific publication.

3. ASSESSMENT OF BACTERIAL LIFE AND MATTER CYCLING IN DEEP-SEA SURFACE SEDIMENTS (ABYSS)

C. Bienhold, K. Hoffmann (AWI/MPIMM)

Objectives and scientific programme

The deep seafloor covers more than 60 % of the Earth's surface. Deep-sea surface sediments are dominated by bacteria in terms of abundance and biomass, and these bacteria play important roles in carbon and nutrient recycling (Jørgensen and Boetius, 2007).

Yet, key bacterial players and their specific functions, e.g. in organic matter remineralisation, in deep-sea surface sediments remain largely unknown. Also, the effects of pressure and depressurization on environmental microbial communities from the deep sea are still not well understood. Rapid environmental changes in the Arctic Ocean lead to shifts in primary productivity and subsequent organic matter export to the deep sea. This may affect both the quantity and the quality of the organic matter reaching the seafloor. Little is known how benthic bacterial communities will respond to events of massive food export or changes in organic matter quality in a changing Arctic. We will address these questions using environmental samples from the LTER observatory HAUSGARTEN, both for direct analyses of bacterial diversity and activity, as well as for experimental set-ups, including incubations of deep-sea sediments at *in-situ* pressure. Samples from the HAUSGARTEN stations will also contribute to the continuation of time-series analyses of bacterial diversity at this site (Jacob et al., 2013). With experimental set-ups and the analysis of dissolved organic matter (DOM) in sediment porewaters, we want to develop a better understanding of the dynamics of organic matter degradation by environmental bacterial communities. In addition to the benthic work, we plan to include deep water column sampling (CTD-rosette water sampler), as well as subsampling of sediment trap material (see Chapter 2), in order to investigate links between the pelagic and benthic environments in terms of bacterial diversity (e.g., Kellogg and Deming 2009). The work will be carried out in the framework of the European Research Council Advanced Investigator grant ABYSS (A. Boetius).

Work at sea

Sediment samples

Undisturbed sediment samples from the seafloor will be retrieved with a video-guided multiple corer (TV-MUC) and a remotely operated vehicle (ROV). Samples will be fixed for the determination of microbial cell numbers and for microbial DNA/RNA extractions. The respective analyses will be performed at the home laboratory. The upper sediment layers will also be sampled for a characterization of the geochemical environment, e.g. chloroplastic pigment concentrations, total organic carbon content (see Chapter 2).

Live deep-sea surface sediments will be utilized for feeding experiments on board, using different algal species, e.g. inactivated *Emiliania huxleyi*, *Thalassiosira weissflogii*, and *Melosira arctica*. Incubations will run over several days to weeks and subsamples will be taken for the analysis of bacterial cell numbers (acridine orange direct counting method, AODC), extracellular enzyme activity, as well as community structure (Illumina tag sequencing), to monitor changes in bacterial biomass, activity and community structure in response to different food sources.

The retrieval of deep-sea sediments without decompression is technically challenging. Technical modifications and operability allowing, we foresee the deployment of a pressure sampler for surface sediments with the ROV. This will allow a comparison of bacterial communities from decompressed, recompressed and compressed samples, including shifts in community structure to be analysed with 16S rRNA Illumina tag sequencing and the quantification of individual groups using fluorescence *in-situ* hybridization.

Additional sediments will be retrieved with the TV-MUC and stored at 0°C for further analyses and experiments in the home laboratory. Furthermore, benthic chambers of lander deployments (see Chapter 2) will be sampled for microbiological analyses, including microbial cell numbers and diversity.

Dissolved organic matter

Porewater samples will be retrieved for a high-resolution profiling of dissolved organic matter using modified TV-MUC cores with pre-drilled holes, and rhizones (Fig. 3.1; http://www.rhizosphere.com/rhizons). Ultra high-resolution mass spectrometry (i.e., Fourier Transform Ion Cyclotron Resonance Mass Spectrometry) will be performed at the home laboratory (with P. Rossel, AWI/MPIMM and T. Dittmar, ICBM Oldenburg/MPIMM).

Fig. 3.1: Porewater sampling from sediment cores retrieved by a multiple corer

Water and sinking particle samples

In order to compare bacterial communities from benthic and pelagic realms, we plan to include sampling of the water column at different depths using the CTD-rosette water sampler as well as *in-situ* water pumps. Water samples will be filtered over 0.22 µm filters and fixed for the determination of cell numbers and microbial community structure. As a potential link between the pelagic and benthic realms, sinking particles from sediment traps (see Chapter 2) will be analysed for bacterial cell numbers and community structure.

Data management and samples

Post-cruise data archival will be mainly hosted by the information system PANGAEA at the World Data Centre for Marine Environmental Sciences (WDC-MARE), which is operated on a long-term base by the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Bremerhaven and the Zentrum für Marine Umweltwissenschaften (MARUM), Bremen. Scientific data retrieved from observations, measurements and home-based data analyses will be submitted to PANGAEA either upon publication or with password protection as soon as the data are available and quality-assessed. This includes also biological data, for most of which parameters are already defined in PANGAEA. Molecular data will be deposited in globally accessible databases such as GenBank. Microbiological samples will be stored deep frozen or fixed at the Max Planck Institute for Marine Microbiology (MPIMM) in Bremen.

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

B. Niehoff, N. Knüppel, S. Wiegmann (AWI); K. Busch, S. Endres (GEOMAR); M. Ramirez (ICM Barcelona); L. Weinisch (Uni Kaiserslautern)

not on board: A. Bracher, K. Metfies, E.-M. Nöthig, I. Peeken (AWI); A. Engel (GEOMAR); T. Stöck (Uni Kaiserslautern)

Objectives and scientific programme

The Arctic Ocean has gained increasing attention over the past years because of the drastic decrease in sea ice and increase in temperature, which is about twice as fast as the global mean rate. In addition, the chemical equilibrium and the elemental cycling in the surface ocean will alter due to ocean acidification. These environmental changes will have consequences for the biogeochemistry and ecology of the Arctic pelagic system.

The effects of changes in the environmental conditions on the polar plankton community can only be detected through long-term observation of the species and processes. Our studies on plankton ecology have started in 1991 and sampling has been intensified since 2009 in the Fram Strait at ~79°N. Since then our studies are based on combining a broad set of analysed parameters. This includes e.g. classical bulk measurements and microscopy, satellite observations, molecular genetic approaches, and cutting edge methods for zooplankton observations to study plankton ecology in a holistic approach. Over the past six years we have compiled complementary information on annual variability in plankton composition, primary production, bacterial activity or zooplankton composition.

Climate induced changes will impact the biodiversity in pelagic ecosystems. A shift in species composition is expected to occur in all plankton size classes. At the base of the food web small algae gain more importance in mediating element and matter turnover as well as matter and energy fluxes in Arctic pelagic systems. In order to examine changes, including the smallest fractions of plankton, molecular methods are well to complement traditional microscopy to assess composition and biogeography of marine protists. The characterization of the communities with molecular methods is independent of cell-size and distinct morphological features. The assessment of the biodiversity and biogeography of Arctic phytoplankton will be based on the analysis of ribosomal genes, taking advantage next generation sequencing technology, Automated Ribosomal Intragenic Sequence Analysis (ARISA), and quantitative Polymerase Chain Reaction (PCR) methods. The zooplankton community composition may also shift due to the warmer Atlantic water in the Fram Strait. In addition, zooplankton organisms are affected by changes at the base of the food web and may thus alter the transport and modification of organic matter.

Global Change increasingly affects also pelagic microbial biogeochemistry in the Arctic Ocean. Thus we will continue to monitor concentrations of organic carbon and nitrogen as

well as of specific compounds like gel particles, amino acids, and carbohydrates. Our overarching goal is to improve the mechanistic understanding of biogeochemical and microbiological feedback processes in the Arctic Ocean and to assess the potential for changes in the near future.

Marine biological production and emissions of trace gases play an important role for atmospheric composition and chemistry. In order to characterize the biogeochemical coupling of the ocean and atmosphere, we need a comprehensive understanding of these processes. Bromocarbons are highly reactive volatile organic compounds and have significant effects on the oxidant chemistry of the atmosphere. Biological production is currently hypothesized as the main source for oceanic bromocarbons, but with little knowledge of the detailed mechanisms. Phytoplankton, especially marine cold-water diatoms and Arctic ice-algae, were found to produce bromocarbons in experimental studies, possibly in order to defend against grazing. We will study the relationship between bromocarbons concentrations and pelagic microbial biogeochemistry in the surface Arctic Ocean.

Through the regeneration of nutrients, the consumption of microbial plankton, and the transfer of energy and organic matter to higher trophic levels phagotrophic protists play key roles in aquatic ecosystems. Their importance as regulators of prokaryotic abundances and in shaping prokaryotic communities in diverse aquatic habitats has been investigated in a number of studies conducted since the early 1980s. In respect to this, our objective is to perform short-term grazing experiments in the Arctic Ocean. The experiments are designed to investigate the contribution of hetero- and mixotrophic protists to the carbon flow in the microbial food web and their influence on heterotrophic and phototrophic bacterial activities.

Ocean colour remote sensing allows for estimating the pigment development of phytoplankton and coloured dissolved organic matter (CDOM) at greater spatial and temporal scales. However, ocean colour satellite data at high latitudes have sparse coverage due to the presence of sea ice, clouds and low sun elevation. Therefore, PEBCAO *in-situ* data is needed to fill gaps and to validate the remote sensing data.

We will run a Wet Labs AC-S hyperspectral transmissiometer and absorptiometer, continuously scanning surface waters but also, during stations, hyperspectral radiometers in the water column in order to develop the analysis of optical data to obtain continuous information on phytoplankton composition, size structure and CDOM loading. These continuously measured optical data require frequent validation with measurements by direct biological or chemical analysis of water samples. We will take surface water samples every 3 to 6 hours and additional water samples at 6 meter water depth during CTD stations for pigment composition (HPLC) and absorption of particles, phytoplankton and CDOM. The received biooptical and biochemical data will also serve for validation of similar measurements obtained with the AUV (see Chapter 5) and other autonomous sensor platforms during the cruise. This research will give a fundamental contribution for further development of hyper- and multispectral ocean colour satellite retrievals focusing on fluorescence and absorption signals.

Thus, during the RV *Polarstern* expedition PS 93.2 the following topics are covered:

- Monitoring plankton species and biomass distribution
- as well as biogeochemical parameters
- Investigations on selected phyto- and zooplankton
- and related biogeochemical parameters
- Composition of organic matter in a changing Arctic Ocean
- Investigation on the amount and composition of CDOM
- and its interplay with phytoplankton

Work at sea

Biogeochemical and biological parameters from rosette water samples

We will sample arctic seawater by a CTD-rosette water sampler at about 5-8 depths at selected HAUSGARTEN stations. All samples will be partly filtered and preserved or frozen at -20°C and partly at -80° C for further analyses. At the home laboratory we will determine the following parameters to describe the biogeochemistry and the abundance and distribution of protists:

- Chlorophyll *a* concentration
- HPLC pigments
- CDOM (coloured dissolved organic matter)
- Dissolved organic carbon (DOC)
- Particulate organic carbon (POC)
- Total dissolved nitrogen (TDN)
- Particulate organic nitrogen (PON)
- Particulate biogenic silica (PbSi)
- Transparent exopolymer particles (TEP)
- Coomassie-stainable particles (CSP)
- Combined carbohydrates and amino acids
- Bromocarbon concentrations (bromoform, di-bromomethane)
- Light absorption by phytoplankton and particulate matter
- Light absorption and fluorescence by CDOM
- Alkalinity
- Phytoplankton and protozooplankton abundance
- Sampling for genetic analyses and clonal cultures
- Sampling for molecular-biological assessments of protist communities
- Water for short-term grazing experiments

Zooplankton sampling

Mesozooplankton composition and depth distribution will be determined by means of vertical Multi-net tows from 1500 m water depth to the surface (Fig. 4.1). In addition, optical surveys with the LOKI (Light On-sight Key species Investigations; Fig. 4.2) will be conducted to analyse the small-scale distribution of zooplankton in the water column. Bongo-net hauls will be taken to collect organisms for biochemical analyses (carbon, nitrogen, protein, and lipid content, fatty acid composition), enzyme activity analyses (citrate synthase and digestive enzymes), and molecular analyses of phytoplankton communities in the stomach of zooplankton organisms.

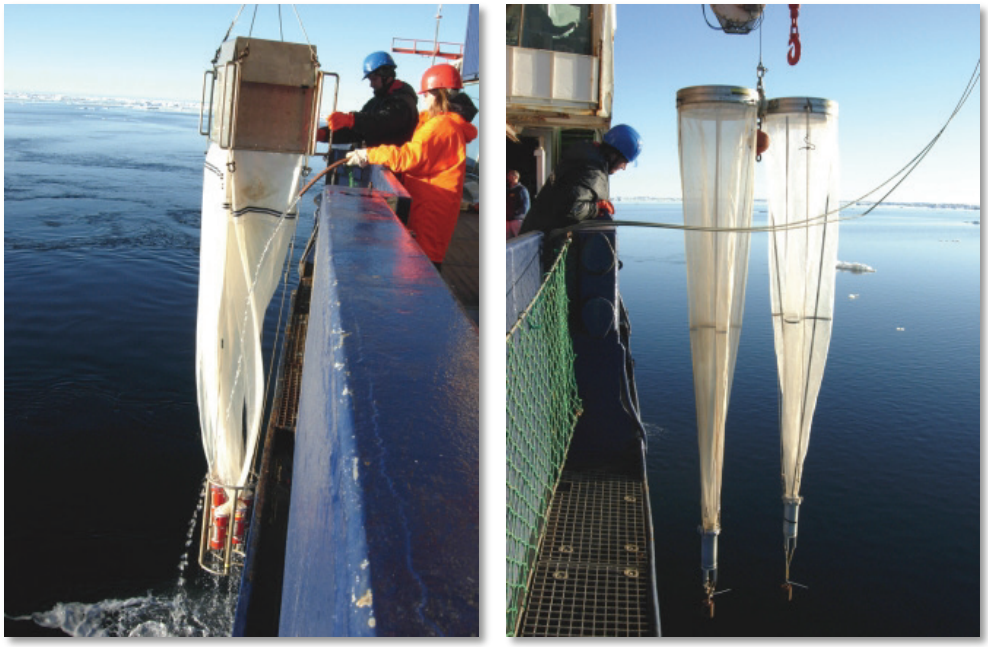

Fig. 4.1: Deployment of the Multi-net (left) and the Bongo-net (right)

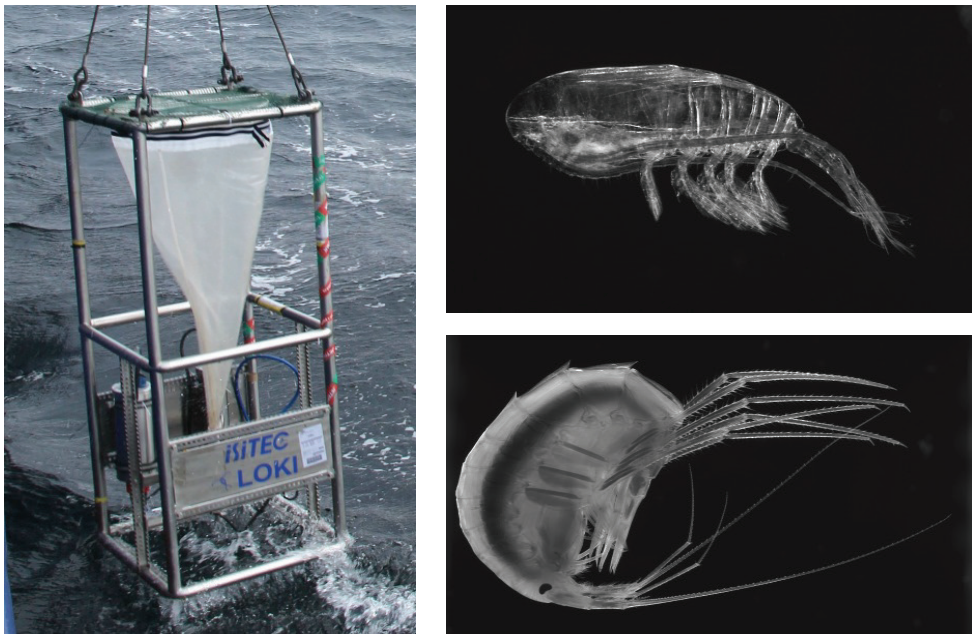

Fig. 4.2: Optical surveys of zooplankton will be conducted with the LOKI (Light On-sight Key species Investigations; left) to determine the small-scale distribution of zooplankton in the water column, e.g. copepods (upper right) and amphipods (lower left)

Experimental work

In order to elucidate the link between pelagic microbial biogeochemistry and bromocarbons concentrations, water samples will be incubated in gas tight bottles to determine bromocarbon production/consumption rates. Attained rates will be compared to biogeochemical parameters (e.g. DOC/DON, amino acids) and measured depth profiles of bromocarbon concentrations.

For short-term grazing experiments we aim to take water samples from six depths at 5-6 selected HAUSGARTEN stations. Evacuated and sterile 1-L Ethyl-Vinyl-Acetate (EVA) bags will be used for the incubation experiments. The samples taken by Niskin bottles will be filled directly into the EVA bags. After the addition of food tracers, subsamples will be taken at predefined time points and fixed immediately with formaldehyde. The fixed material will then be filtered through Isopore membranes with specific pore sizes and stored at -20°C for further processing in the lab. The remaining water from the grazing experiments will be left for additional experiments, i.e. enzymatic activities and next generation sequencing for eukaryotes and prokaryotes.

Optical profiling

The Apparent Optical Properties (AOPs) of water (mostly light attenuation through the water column) will be estimated based on down-welling and upwelling irradiance using radiometers. The instruments are calibrated for the incident sunlight with measurements of a radiometer on deck.

Data management and samples

During the cruise, we sample a large variety of interconnected parameters. Many samples, e.g. for pigment analyses and particulate matter concentrations in the water column, will be analysed at AWI and at GEOMAR within about a year after the cruise. Postprocessing of protozoan samples acquired during the cruise will take place at the Technische Universität in Kaiserslautern. We expect that the full data set will be available about two years after the cruise by the latest. Most of the species samples, and those samples which will not been analysed immediately will be stored at the AWI at least for another 10 years and will be available for other colleagues. Data will be made available to the public via the information system PANGAEA after publishing.

5. PELAGIC FOOD WEB INTERACTIONS WITH THE BIOLOGICAL PUMP

M. Iversen, H. van der Jagt, C. Konrad (AWI/MARUM)

Objectives and scientific programme

Anthropogenic activities have increased atmospheric carbon dioxide (CO_2) levels to 400 ppm, higher than at any point during the past 2 to 5 million years. The oceans have the capacity to sequester large amounts of atmospheric CO_2 by exporting biologically fixed carbon to the deep ocean and sea floor, where it can be stored for hundreds to millions of years. Therefore, efforts have increased to understand the oceans' role in global carbon cycling. The influence of global warming is most pronounced in the Arctic and induces substantial environmental changes such as warming, ocean acidification, melting of sea ice. Although progress has been made in understanding the controls on annual global export of carbon in the oceans from large scale correlations and modelling studies, little is still known

about the processes affecting export on a regional, diurnal, seasonal and decadal scale. Sinking particles, formed from aggregated organic matter are responsible for the export of carbon from the surface to the deep ocean. The amount of organic carbon that reaches the deep ocean is primarily determined by the particle sinking speed and the rate of biologically mediated particle remineralisation and consumption. Therefore, to be able to predict present and future oceanic uptake of atmospheric CO_2, it is important to quantify how marine food webs interact with the export of carbon. This will allow us to estimate export processes for different regions and seasons, as well as future climate scenarios as a function of the prevailing food webs and biogeochemistry.

Our main objective during the RV *Polarstern* PS93.2 cruise is to quantify the processes shaping the vertical flux of organic carbon at the base of the euphotic zone and through the twilight zone (100-1,000 m). This will be done by detailed investigations of the turnover of sinking marine particles within distinct depth-layers though the water column; with emphasis on the importance of aggregate settling, microbial degradation, and zooplankton flux feeding on the vertical export. The use of *in-situ* optical imaging and acoustics in combination with marine snow catchers, conventional traps and gel traps will provide depth-specific rates for in-situ microbial degradation, zooplankton flux feeding, particle size-specific sinking speed, as well as high depth resolution vertical flux and flux attenuation.

Work at sea

We will perform deployments of drifting trap arrays and use a combination of different optical, biological, and physical sensors to capture particle processes through the water column. Our investigations will be accompanied by laboratory experiments to investigate specific mechanisms responsible for *in-situ* carbon turnover within marine settling aggregates. These studies will be done on collected material (using the marine snow catcher) to measure rates for zooplankton flux feeding and microbial degradation. Each drifting sediment trap consists of three trap arrays (e.g. 100, 200, 400 m water depths) each with four collection cylinders. At every trap depth, one of the collection cylinders is filled with a special gel to preserve fragile marine snow aggregates sinking into the cylinders. The deployment times will be over a day-night cycle. In addition to the sediment traps, there will be an infra-red camera system on the drifting array which will capture the zooplankton activity and make it possible observe the influence from zooplankton migration and flux feeding on the biological pump.

Concomitant investigations of the water column are planned. These investigations include deployments of the profiling *in-situ* particle camera, the CTD-rosette water sampler, Multi-nets and LOKI for zooplankton distributions (in collaboration with B. Niehoff, AWI), and the use of the ships acoustic system SIMRAD and PARASOUND. The vertically changing particle concentrations and size distribution determined with the *in-situ* optical systems can be used to derive high resolution carbon fluxes and remineralisation rates in various depth ranges. These fluxes will enable determinations of bacterial degradation rates and, in combination with the quantification of zooplankton from vertical hauls with the Multi-net, consumption rates of aggregates due to zooplankton flux feeding. Water samples from the rosette water sampler and sinking aggregates collected with the Marine Snow Catcher are used to study the formation, physical characteristics, organic carbon remineralisation and size-specific sinking rates of marine snow and faecal pellets.

Data management and samples

We expect to be able to quantify the role from microbes and zooplankton and carbon flux attenuation, as well as quantify the export fluxes through the upper mesopelagic zone. The finally processed data will be submitted to the PANGAEA data library. The unrestricted availability from PANGAEA will depend on the required time and effort for acquisition of individual datasets and its status of scientific publication.

6. WATER-COLUMN STUDIES USING AN AUTONOMOUS UNDERWATER VEHICLE (AUV) AND UNMANNED AERIAL VEHICLES (UAV)

K. Kondak, M. Maier (DLR); S. Montenegro, M. Strohmeier (Uni Würzburg);
T. Wulff, K. Shurn, S. Lehmenhecker, J. Hagemann (AWI)

Objectives and scientific programme

In terms of biological activity, the polar marginal ice zones are among the most relevant regions in the world. However, physical and chemical processes which take place in the uppermost layers of the water column and trigger the high biologic activity are understood insufficiently – at least partly caused by the challenge of observing various processes with high spatial and temporal resolution simultaneously. To investigate the complex regime of marginal ice zones, the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) puts increasing emphasis on robotic operations. Thus, AWI has operated its Bluefin-21 Autonomous Underwater Vehicle (AUV; Fig. 6.1) "PAUL" (Polar Autonomous Underwater Laboratory) since 2003. PAUL is equipped with sensors measuring conductivity, temperature and pressure; the concentration of nitrate, chlorophyll *a*, oxygen, CO_2, coloured dissolved organic matter (CDOM) and the intensity of photosynthetically active radiation (PAR). A water sampler which is able to collect 22 samples with an overall volume of 4.8 litres is used to study the composition of plankton communities and to calibrate the nitrate and the chlorophyll *a* sensor.

Within the framework of the Helmholtz Alliance "Robotic Exploration of Extreme Environments – ROBEX", which brings together German deep-sea and space research institutes, AWI's AUV team cooperates with the German Aerospace Center (DLR) in Oberpfaffenhofen and the University of Würzburg. The main objective of this cooperation is to conduct joined operations between autonomous underwater vehicles and autonomous flying drones (Unmanned Aerial Vehicle, UAV; Fig. 6.2). In the upcoming missions, PAUL will collect physical and biochemical data along and under the ice. At the same time, the "Exploration UAV" (operated by the DLR), will fly over the ice and collect images of its surface using cameras and radar. Another drone, the "Landing UAV" (operated by the University of Würzburg) is intended to land on the ice to determine its exact drift and measure PAR intensity on the surface, also serving as a reference for PAR measurements by the AUV. Thus, data are collected above, below and on the ice simultaneously and a holistic picture of the environmental conditions can be obtained.

In addition to its already integrated payload, PAUL will be equipped with an Acoustic Doppler Current Profiler (ADCP) as part of the HGF infrastructure program FRAM (Frontiers in Arctic marine Monitoring). Using the ADCP, physical phenomena such as horizontal shear will be observed. Future missions with the ADCP will lead PAUL into much greater water depths than before. In order to prepare these kinds of missions, PAUL will conduct a dive reaching 2,000 m water depth by the end of the expedition.

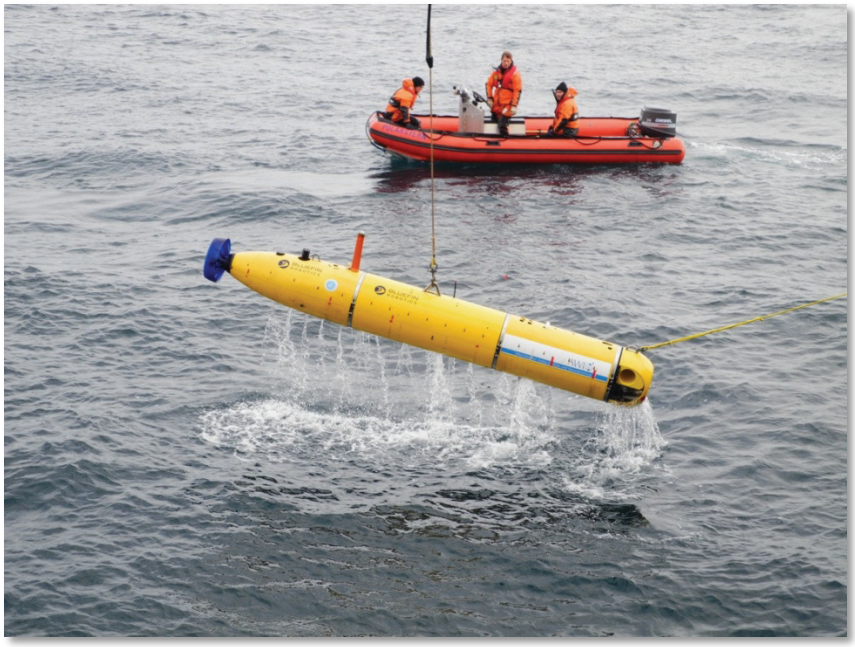

Fig. 6.1: Recovery of the AWI Autonomous Underwater Vehicle (AUV)

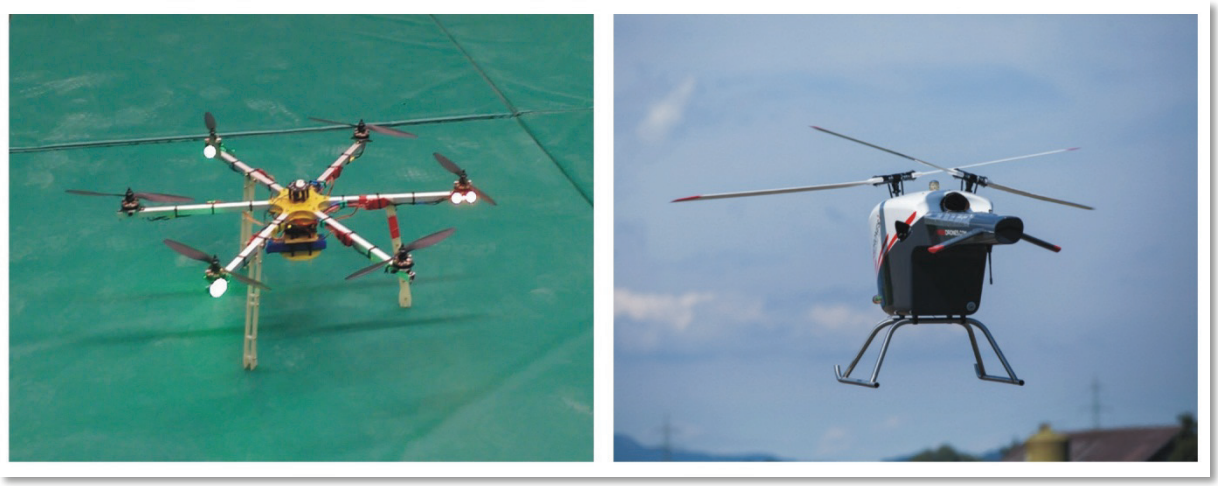

Fig. 6.2: Landing and Exploration UAVs (Unmanned Aerial Vehicles) of the University of Würzburg (left) and the DLR, Oberpfaffenhofen (right)

Work at sea

In order to prepare AUV missions, the ice edge will be monitored several days in advance using satellite imagery. In front of structures that indicate high regional dynamics (e.g. ice tongues or jets) RV *Polarstern* will use its salinity and temperature sensors to determine the orientation and extension of the melt water front. PAUL will cross this front several times and frequently vary the mission depth from 3 to 50 meters. Thus, numerous vertical profiles revealing the stratification of the upper water column will be recorded. Water samples will be taken at the end of each mission.

During its missions, which will last approx. 8 hours each, PAUL will operate several kilometres away from the ship. Up to a distance of 2.5 kilometres PAUL can be tracked using an Ultra Short Base Line (USBL) System. Missions that go beyond that range will be conducted "unattended". After completing a mission, PAUL will guide itself to pre-programmed coordinates and will be recovered by RV *Polarstern*. Water samples taken by the AUV will be processed in one of RV *Polarstern*'s cold rooms and stored deep frozen.

Due to the occupancy of the ship it is not possible to accommodate both the teams of the DLR and the University of Würzburg at the same time. Thus, the teams will rotate as soon as Ny-Alesund is in Helicopter range, i.e. by the end of the first half of the expedition.

Both UAVs will first be tested extensively as this kind of autonomous flight operations have never been conducted on a research vessel. The initial tests will focus on the autonomous approach of the UAVs to the ship and the landing on its helicopter deck. During the first half of the expedition, the team of the DLR will operate the Exploration UAV above the ice off the coast of Greenland. Conducting missions of approx. 30 - 60 min. flight time, it is planned to map areas of interest using different payloads for ice exploration. During the second half of the expedition the team of the University of Würzburg will conduct landings on ice floes. Operations of the Landing UAV will mainly take place in central Fram Strait, as it is more likely to encounter young and relatively even ice floes in this region. The Landing UAV will stand on the ice for at least two hours and permanently transmit its position via radio communication. Both UAVs will return to RV *Polarstern* autonomously after they completed their respective mission.

Data management and samples

Completely corrected navigation data and preliminary biochemical and physical data will be available within days after the dives. As sample processing will be carried out at AWI, time periods for data provision will vary from two to four months depending on the parameter. The finally processed data will be submitted to the PANGAEA data library.

7. ASSESSING DYNAMICS OF NUTRIENTS USING AUTONOMOUS INSTRUMENT IN FRAM STRAIT (DYNAMITE)

S. Torres-Valdes, A. Beaton (NOCS)
not on board: A. Nightingale, S. Bacon (NOCS)

Objectives and scientific programme

The Arctic Ocean (AO) receives nutrients from rivers, and from the Pacific and Atlantic Oceans. These nutrient supplies sustain primary production over the Arctic shelf seas, driving CO_2 sequestration via the biological carbon pump. Having undergone biogeochemical transformation within the AO, nutrients are eventually exported to the North Atlantic (NAtl). Changes in the hydrological cycle at high northern latitudes have resulted in increasing riverine fresh water supply, with associated changes in the quantity and quality of nutrients delivered to the AO. At present, we do not understand present-day AO nutrient budget closure, and thus how the AO biogeochemistry will respond to future climate change and how this will impact nutrient transports to the NAtl.

Scientific programme

Our aims are both scientific and technical: Scientifically we follow on from recent and current research within our group concerning the AO nutrient budget and the relevance of dissolved organic nutrients to the budget. One of the big gaps in knowledge concerns the seasonal changes of nutrient transports to and from the AO, which is of great importance if we are to understand the AO nutrient budget under Climate Change. Moreover, we want to gain insight concerning the bacterial communities associated with dissolved organic matter cycling in the AO. This will be done by the deployment of an automated sampler, allowing us to obtain monthly samples for a year. Technically, we follow on the development of lab-on-a chip nitrate and phosphate sensors, which we have tested in coastal environments, on benthic landers and glacier meltwater streams. We now want to deploy them and test them within the AO environment, with the aim of generating high-resolution (1 or 2 measurements per day) measurements of nitrate and phosphate, which will provide invaluable data to assess seasonal changes.

The FRAM Ocean Observing System is located in one of the main AO gateways, which is ideal to monitor and calculate nutrient transports. Hence we aim to deploy the sensors and automated sampler on moorings on either side of Fram Strait to measure dissolved inorganic (sensors) and organic (sampler) nutrient concentrations in waters flowing in and out of the AO. We also aim to enhance this data set with analysis of samples collected during the deployment and recovery cruises. We will then combine these data with volume transports estimates from mooring data to compute nutrient transports through Fram Strait.

Scientific objectives

- To assess temporal (seasonal) changes of nutrient transports to and from the Arctic Ocean through Fram Strait.
- To quantify the significance of organic nutrients in closing the Arctic Ocean-Atlantic Ocean inorganic nutrient imbalances.
- To characterise the microbial communities associated with nutrient transport to/from the Arctic Ocean.

Technical objectives

- To test lab-on-a chip nitrate and phosphate sensors for long-term (~1 yr) deployments in the Arctic for high-resolution measurements.
- To use an autonomous water sampler in a 1 yr deployment to collect samples for dissolved organic nutrients, microbial communities and inorganic reference samples.
- To compare high-resolution sensor measurements with medium resolution water samples for N and P concentrations.

Work at sea

During the RV *Polarstern* cruise PS93.2 we will deploy our lab-on-a chip nutrient sensors and automated sampler in appropriate moorings. This will involve preparing on-board reagents and calibration solutions that are to be deployed with the sensors, preparing battery housings, conducting final tests, and mounting the sensors on the deployment frames. Additionally, we will collect seawater samples for later analysis of dissolved inorganic and organic nutrients. A total of four LOC sensors (Fig. 7.1) will be deployed - 2 nitrate and 2 phosphate sensors. One of each will be deployed on two separate moorings, sampling the West Spitsbergen and East Greenland currents.

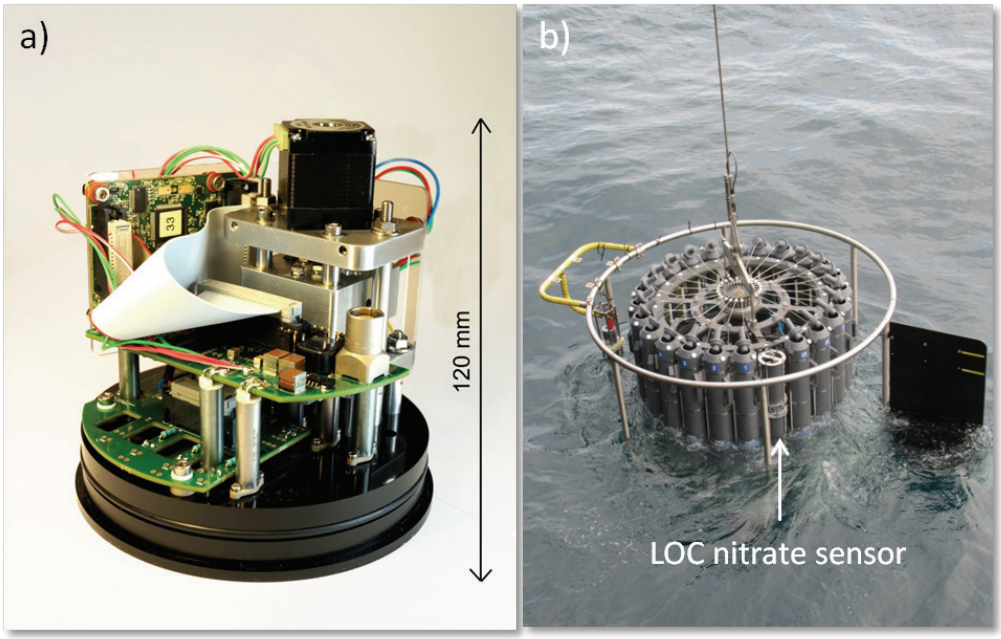

Fig. 7.1: The LOC nitrate chip (a) out of its housing and (b) in a typical housing, here being deployed on a CTD frame

The sensors will be programmed to take a minimum of 365 calibrated measurements (each composed of a sample measurement, blank measurement and a standard measurement) over the course of the one year deployment - equivalent to one per day. Each sensor will be supplied in a secure housing, along with all reagents and standard solutions for the year's deployment. Batteries will be contained in separate pressure housings that are also mounted to the frame. The sensors on the EGC current mooring line will be deployed alongside an autonomous water sampler (AWI) at 100-150 m depth. The water-sampler consists of 1-litre sample bags. It will be programmed to sample 24 temporal events (i.e. ~2 weeks). Each sampling event will fill one bag preserved with mercuric chloride for the analysis of bacterial community structure (DNA sequencing) and inorganic nutrients and a second bag preserved with mercuric chloride for organic nutrients. The samples will be analysed upon recovery. The samples preserved for inorganic nutrients and organic nutrients will be shipped to NOCS, where these will be analysed using well-established colorimetric techniques. The remaining volume will be filtered on board during recovery and frozen at -80°C for DNA extraction and sequencing (Ian Salter, AWI). During deployment and recovery cruises, full depth CTD casts will be required close to the deployment sites. These will be sampled for organic nutrients, which will also be a complement to the inorganic nutrient data (PEBCAO group, AWI). The nutrient concentration measurements will be combined with volume transports obtained from AWI's oceanographic moorings to calculate nutrient transport through Fram Strait.

Data management and Samples

Samples collected at sea and from the automated samplers will be brought to the lab for the analysis of dissolved organic nutrients (NOCS) and the characterisation of the bacterial communities (AWI). Following analysis of samples and the recovery of sensors and sampler, we will process and analyse data to address scientific questions related to the Arctic Ocean nutrient biogeochemistry. We aim to produce at least two manuscripts for publication in a

scientific journal. Having analysed the data, we aim to submit it to both BODC and PANGAEA data repositories so that is made publicly available.

8. OCEAN CHEMISTRY AND ACOUSTICS IN THE GAS HYDRATE-CHARGED FRAM STRAIT (GASFRAM)

K. Zamelczyk, P. Jansson (UiT), not on board: B. Ferré, T. Rasmussen (UiT)

Objectives and scientific programme

GASFRAM (Ocean chemistry and acoustics in the gas hydrate-charged Fram Strait) is a project granted by the EU project FixO^3 (Fixed-point Open Ocean Observatories) to have access to the FRAM Ocean Observing System and a joint cruise with RV *Polarstern* to install a methane sensor, a CTD and a hydrophone on the platform and perform work at sea. This project is implemented in the frame of the Center for Arctic Gas hydrate, Environment and climate (CAGE; cage.uit.no) based at the University of Tromsø (Norway), aiming at finding out the role of methane from Arctic gas hydrate in past, present and future climate change.

Seepage of methane gas bubbles released from the seabed has been observed in shallow water (<400 m depth) offshore Svalbard (Knies et al., 2004; Hustoft et al., 2009; Westbrook et al., 2009; Berndt et al., 2014), and one of the goals of CAGE is to monitor these methane seeps and provide the link between potential sources of elevated methane concentrations and the reasons for variations. Access to the central HAUSGARTEN site (79°04.16'N, 04°04.59'E, ~2,500 m water depth) will mainly serve as a reference site for the CAGE observatory in an area where no deep-water gas hydrate has been found.

Planktic and benthic foraminifera shells obtained from plankton net samples and surface sediment samples from the multiple corer will give valuable information on 1) changes of ocean carbon chemistry due to shifts in both atmospheric and methane-induced CO_2, and 2) past marine methane emissions by carbon isotope ($\delta^{13}C$) analysis of benthic foraminifera (e.g. Kennett et al., 2000). Scientific objectives of the GASFRAM project are:

- To monitor temporal variability, flux and fate of dissolved and free gas methane release at a reference site
- To provide the link between potential sources of elevated methane concentrations and reasons for variations
- To identify changes in survival, biodiversity and ecology of calcareous foraminifera in Fram Strait for comparison with a methane-influenced region

Work at sea

During the RV *Polarstern* cruise PS93.2, we will install 1) a self-logging methane sensor for local methane measurement (mainly background), 2) a CTD recorder for temperature and salinity time-series, and 3) a self-sustained hydrophone for hydro-acoustic background for a one year deployment at the central HAUSGARTEN site. All instruments will be attached to a free-falling system (bottom-lander) to be deployed for one year.

In addition, we wish to obtain additional data and samples from CTD casts, plankton net and multiple core hauls to investigate the influence of methane on the water column chemistry

and marine organisms. Sampling sites are located at shallow water depths to the north-west off Prins Karls Forlandet:

Latitude	*Longitude*	*Depth (m)*
78.628°N	10.583°E	~75
78.569°N	10.197°E	~100
78.573°N	09.773°E	~240
78.555°N	09.477°E	~410

Data management and samples

Material/samples/data obtained from the long-term lander-based benthic observatory at the central HAUSGARTEN site as well as temperature and salinity data from CTD casts, plankton net samples and sediment samples from the multiple corer during the 2015 cruise will be shared between scientists from both institutions as part of scientific collaborations by mutual agreement. Data will be made available to the public via the information system PANGAEA after publishing.

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9. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

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HeliService	HeliService international GmbH Am Luneort 15 27572 Bremerhaven Germany
ICM Barcelona	Institute of Marine Sciences Passeig Marítim de la Barceloneta, 37-49 E-08003 Barcelona Spain
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MPIMM	Max-Planck-Institut für Marine Mikrobiologie Celsiusstraße 1 28359 Bremen Germany

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3	Bergmann	Melanie	AWI	Biologist
4	Bienhold	Christina	MPIMM	Biologist
5	Braeckman	Ulrike	MPIMM	Biologist
6	Busch	Kathrin	Uni Kiel	Biogeochemist
7	Chennu	Arjun	MPIMM	Biologist
8	Endres	Sonja	GEOMAR	Biogeochemist
9	Hagemann	Jonas	AWI	Student apprentice
10	Hasemann	Christiane	AWI	Biologist
11	Hoffmann	Ralf	AWI	Biogeochemist
12	Hoffmann	Katy	MPIMM	Biologist
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14	Jansson	Pär	UiT	Biologist
15	Knüppel	Nadine	AWI	Technician, biology
16	Kolar	Ingrid	AWI	Biologist
17	Kondak	Konstantin	DLR	Engineer, robotics
18	Konrad	Christian	MARUM	Technician, biogeochemistry
19	Lehmenhecker	Sascha	AWI	Engineer, biology
20	Lochthofen	Normen	AWI	Engineer, biology
21	Ludszuweit	Janine	AWI	Technician, biology
22	Maier	Moritz	DLR	Engineer, robotics
23	Montenegro	Sergio	Uni Würzburg	Engineer, robotics
24	Niehoff	Barbara	AWI	Biologist
25	NN		HeliService	Pilot
26	NN		HeliService	Pilot
27	NN		HeliService	Technician
28	NN		HeliService	Technician
29	NN		DWD	Meteorologist
30	NN		DWD	Technician
31	NN		MARUM	ROV-Pilot
32	NN		MARUM	ROV-Pilot
33	NN		MARUM	ROV-Pilot

No.	**NAME**	**VORNAME/** First Name	**INSTITUT/** Institute	**BERUF/** Profession
34	NN		MARUM	ROV-Pilot
35	NN		MARUM	ROV-Pilot
36	NN		MARUM	ROV-Pilot
37	NN		MARUM	ROV-Pilot
38	NN		MARUM	ROV-Pilot
39	Ramirez-Perez	Marta	ICM Barcelona	Biologist
40	Sablotny	Burkhard	AWI	Engineer, biology
41	Salter	Ian	AWI	Biologist
42	Schewe	Ingo	AWI	Biologist
43	Shurn	Kimberly	AWI	Technician, biology
44	Soltwedel	Thomas	AWI	Biologist, cruise leader
45	Spill	Meike	AWI	Student apprentice
46	Strohmeier	Michael	Uni Würzburg	Engineer, robotics
47	Tippenhauer	Sandra	AWI	Oceanographer
48	Torres-Valdes	Sinhue	NOCS	Biogeochemist
49	van der Jagt	Helga	MARUM	Biogeochemist
50	Weinisch	Lea	Uni Kaiserslautern	Biologist
51	Wiegmann	Sonja	AWI	Biologist
52	Wulff	Thorben	AWI	Engineer, biology
53	Zamelczyk	Katarzyna	UiT	Biologist

11. SCHIFFSBESATZUNG / SHIP'S CREW

	Name	**Rank**
01.	Wunderlich, Thomas	Master
02.	Grundmann, Uwe	1.Offc.
03.	Westphal, Henning	Ch.Eng.
04.	Kentges, Felix	2.Offc.
05.	Stolze, Henrik	2.Offc.
06.	Fallei, Holger	2.Offc.
07.	Spilok, Norbert	Doctor
08.	Hofmann, Jörg	Comm.Offc.German
09.	Schnürch, Helmut	2.Eng.
10.	NN	2.Eng.
11.	Rusch, Torben	2.Eng.
12.	Brehme, Andreas	Elec.Tech.
13.	Redmer, Jens	Elec.Tech.
14.	Ganter, Armin	Electron.
15.	Dimmler, Werner	Electron.
16.	Winter, Andreas	Electron.
17.	Feiertag, Thomas	Electron.
18.	Schröter, Rene	Boatsw.
19.	Neisner,Winfried	Carpenter
20.	Clasen, Nils	A.B.
21.	Burzan, Gerd-Ekkehard	A.B.
22.	Schröder, Norbert	A.B.
23.	Leisner, Bert	A.B.
24.	Hartwig-L., Andreas	A.B.
25.	Kretzschmar, Uwe	A.B.
26.	Müller, Steffen	A.B.
27.	Gladow, Lothar	A.B.
28.	Sedlak, Andreas	A.B.
29.	Beth, Detlef	Storekeep.
30.	Plehn, Markus	Mot-man
31.	Klein, Gert	Mot-man
32.	Krösche, Eckard	Mot-man
33.	Dinse, Horst	Mot-man
34	Watzel, Bernhard	Mot-man
35.	Meißner, Jörg	Cook
36.	Tupy,Mario	Cooksmate
37.	Völske, Thomas	Cooksmate

	Name	**Rank**
38.	Luoto, Eija	1.Stwd.
39.	Schwitzky-S., Carmen	Stwdss/KS
40.	Mack, Ulrich	2.Steward
41.	Hischke, Peggy	2.Stwdess
42.	Wartenberg, Irina	2.Stwdess
43.	Hu, Guo Yong	2.Steward
44	Chen, Quan Lun	2.Steward
45.	Ruan, Hui Guang	Laundrym.

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