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

EXPEDITION PROGRAMME PS99

Polarstern

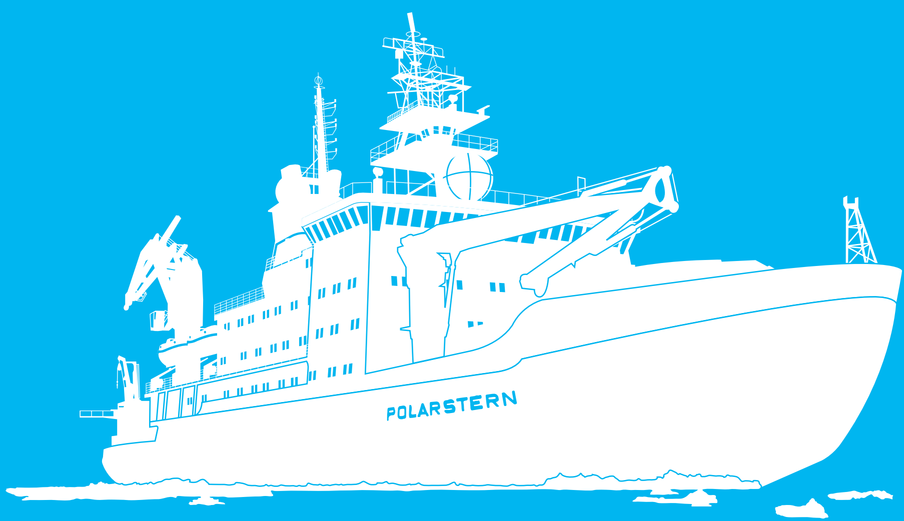
PS99

Bremerhaven - Longyearbyen - Tromsø

13 June 2016 - 16 July 2016

Coordinator: Rainer Knust

Chief Scientist: Thomas Soltwedel



Bremerhaven, Mai 2016

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EUROFLEETS2

Access to Research Vessels for European Scientists

and

HAUSGARTEN

Long-Term Ecological Research at an Arctic marine Observatory

Coordinator
Rainer Knust

Chief Scientist
Thomas Soltwedel

CONTENTS

1.	**Überblick und Fahrtverlauf**	**2**
	Summary and itinerary	**4**
2.	**BURSTER: Bottom currents in a stagnant environment**	**5**
3.	**DEFROST: Deep flow regime off Spitsbergen**	**10**
4.	**Abundance and latitudinal distribution of floating marine litter and natural flotsam**	**13**
5.	**HAUSGARTEN: Impact of climate change on arctic marine ecosystems**	**15**
6.	**Investigating physical and ecological processes at a meltwater front using an Autonomous Underwater Vehicle and an Unmanned Aerial Vehicle**	**24**
7.	**Plankton ecology and biogeochemistry in the changing Arctic Ocean**	**27**
8.	**Particle processes through the water column in Fram Strait**	**32**
9.	**Assessment of archaeal and bacterial life and matter cycling in the arctic water column and deep-sea surface sediments**	**34**
10.	**FRAM Pollution Observatory: Assessments of anthropogenic litter and microplastic in different ecosystem compartments**	**37**
11.	**Beteiligte Institute / Participating Institutes**	**39**
12.	**Fahrtteilnehmer / Participants (Bremerhaven - Longyearbyen)**	**42**
13.	**Fahrtteilnehmer / Participants (Longyearbyen - Tromsø)**	**44**
14.	**Schiffsbesatzung / Ship’s crew**	**46**

1. ÜBERBLICK UND FAHRTVERLAUF

Thomas Soltwedel
AWI

Die RV *Polarstern* Expedition PS99 in die Arktis wird am 13. Juni 2016 in Bremerhaven beginnen und in Arbeitsgebiete nordwestlich der Bäreninsel, vor der Südspitze Spitzbergens und in der zentralen und östlichen Framstraße, führen.

Auf dem ersten Fahrtabschnitt der Expedition PS99 (Bremerhaven - Longyearbyen) unterstützt die RV *Polarstern* zwei Forschungsprojekte des Europäischen FP7 Infrastrukturprogramms EUROFLEETS2. Im Rahmen des Projekts BURSTER (Bottom currents in a stagnant environment) sollen die geodynamischen und hydrographischen Verhältnisse sowie Gasaustritte am Boden des Kveithola Troughs untersucht werden, während im Projekt DEFROST (Deep flow regime off Spitsbergen) räumliche und zeitliche Veränderungen in den tiefen Meeresströmungen südwestlich von Spitzbergen im Fokus stehen.

Der zweite Fahrtabschnitt der Expedition PS99 (Longyearbyen - Tromsø) soll genutzt werden, um Beiträge zu verschiedenen nationalen und internationalen Forschungs- und Infrastrukturprojekten (ABYSS, ICOS, $FixO^3$, FRAM, ROBEX, SIOS) 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 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, 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 weitere 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.

Die technisch und logistisch sehr aufwendige Expedition PS99, während der neben einem autonomen unbemannten Fluggerät (Unmanned Aerial Vehicle, UAV) auch verschiedene autonome, in der Wassersäule und auf dem Tiefseeboden agierende Unterwasserfahrzeuge zum Einsatz kommen sollen, wird am 16. Juli 2016 in Tromsø enden.

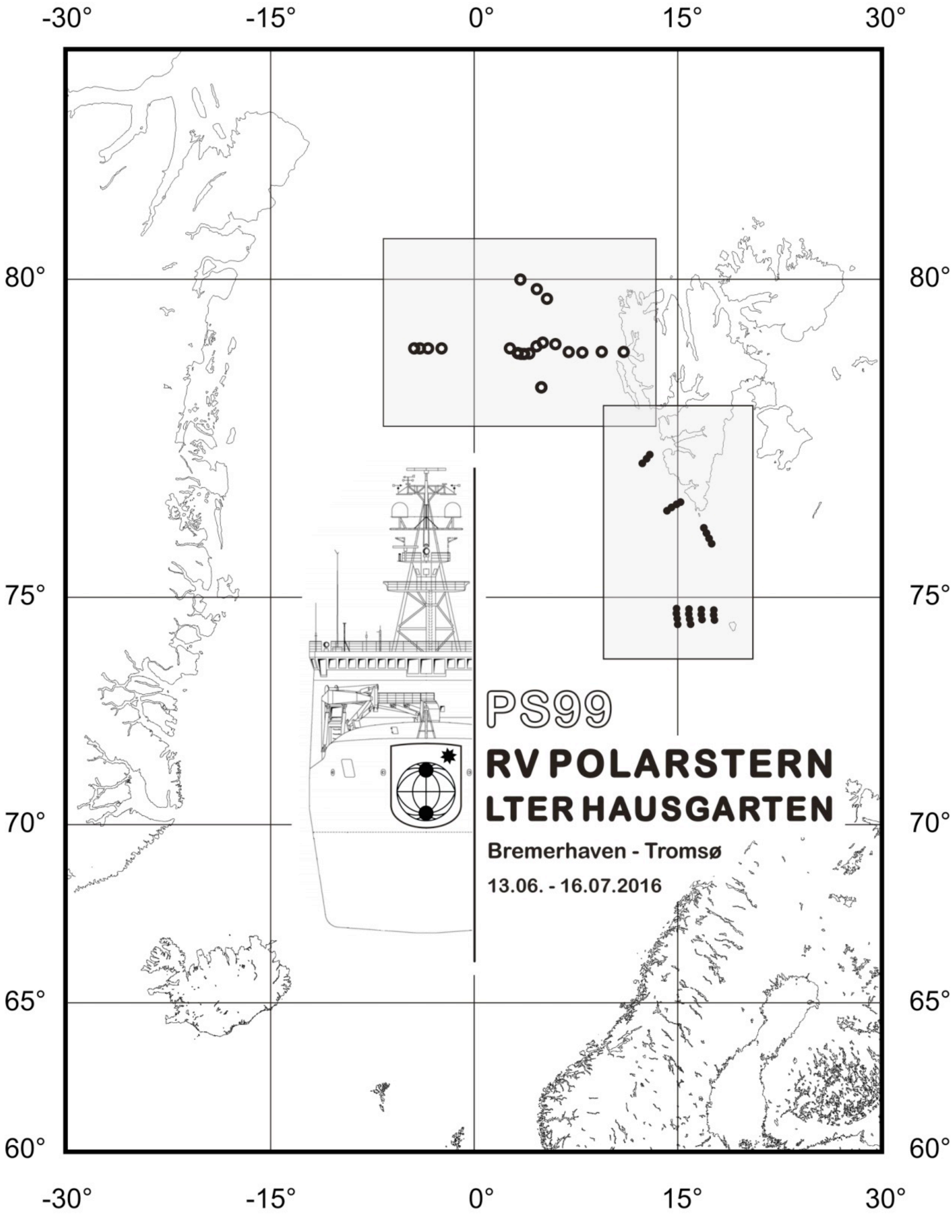

Abb. 1: Untersuchungsgebiete der Polarstern-Expedition PS99
Fig. 1: Areas of investigations during Polarstern expedition PS99

SUMMARY AND ITINERARY

The RV *Polarstern* expedition PS99 to the Arctic will start on 13 June 2016 in Bremerhaven and lead to study areas northwest of Bear Island, south of Spitsbergen and in the central and eastern Fram Strait.

During the first leg of the expedition PS99 (Bremerhaven - Longyearbyen), RV *Polarstern* will be available to support two scientific projects selected by the European FP7 Research Infrastructure programme EUROFLEETS2. The research project BURSTER (Bottom currents in a stagnant environment) aims to investigate the geodynamic and hydrographic conditions, and the active gas seepage present in the pockmark-field piercing the sediment drift located in the inner part of the Kveithola Trough, whereas temporal and spatial variations of deep currents to the southwest of Svalbard are in focus of the DEFROST (Deep flow regime off Spitsbergen) project.

The second leg of the expedition PS99 (Longyearbyen - Tromsø) will contribute to various large national and international research and infrastructure projects (ABYSS, ICOS, $FixO^3$, FRAM, ROBEX, SIOS) 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 the 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, 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 the AWI, 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.

During the technically and logistically very challenging expedition we will, amongst others, use an Unmanned Aerial Vehicle (UAV) and different autonomous underwater vehicles which will operate in the water column and on the deep seafloor. The cruise will end on 16 July 2016 in Tromsø (Norway).

2. BURSTER: BOTTOM CURRENTS IN A STAGNANT ENVIRONMENT

R.G. Lucchi, V. Kovačević, C. De Vittor, M. Bazzaro, M. Bensi, D. Deponte, R. Laterza, M.E. Musco, F. Relitti, L. Rui (OGS); C. Morigi, V.M. Gamboa Sojo (Uni Pisa); A. Sabbatini, F. Caridi, (Uni Marche); S. Graziani, L. Ruggero (Uni Rome); A. Mazzini (Uni Oslo); M. Krüger, D. Zoch (BGR); K. Carbonara (Uni Parma); L. Langone (ISMAR); C. Le Gall, M. Topchiy (GIFT); P. Povea (Uni Barcelona); M. Tagliaferro (HITACHI); D. Wiberg (Uni Tromsø); A. Dominiczak (Uni Poznań); O. Sánchez Guillamón (IEO Malaga); N. Biebow (AWI); not on board: M. Rebesco (OGS)

Objectives and scientific programme

The glacigenic Kveithola Trough (Fig. 2.1) is an abrupt and narrow (100 km-long and 13 km-wide) sedimentary system located in the NW Barents Sea (Rebesco et al., 2011; Ruther et al., 2012; Bjarnadóttir et al., 2013). Along with the larger Storfjorden glacial system, it hosted, during the last glaciation, ice streams draining ice from the southern Svalbard in the north and Bear Island in the south (Andreassen et al., 2008; Pedrosa et al., 2011).

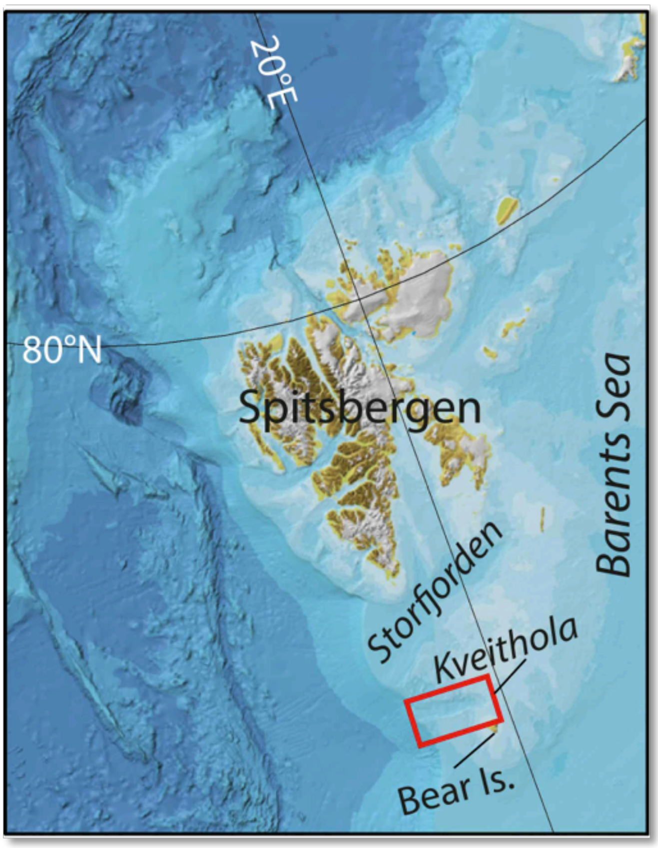

Fig. 2.1: Location map of the study area (the red rectangle shows the position of the Kveithola Trough)

During the CORIBAR Cruise on board RV *Maria S. Merian* (16.07. - 15.08.2013; Tromsø - Tromsø) a wealth of geophysical data including PARASOUND sub-bottom profiles and multibeam, and sediment samples retrieved by gravity-, multi-, boxcorer, and the seafloor drill rig MeBo (Hanebuth et al., 2013) were collected on the Kveithola Drift, a complex morphological and depositional feature confined in the innermost part of the glacially-eroded Kveithola Trough. The internal seismic reflections of the drift show a drastic thinning and termination towards the north. Here a distinct moat can be identified, which implies the strong influence of dense bottom currents, inferred to flow (or at least to have flown in the past) towards the outer shelf (Fig. 2.2).

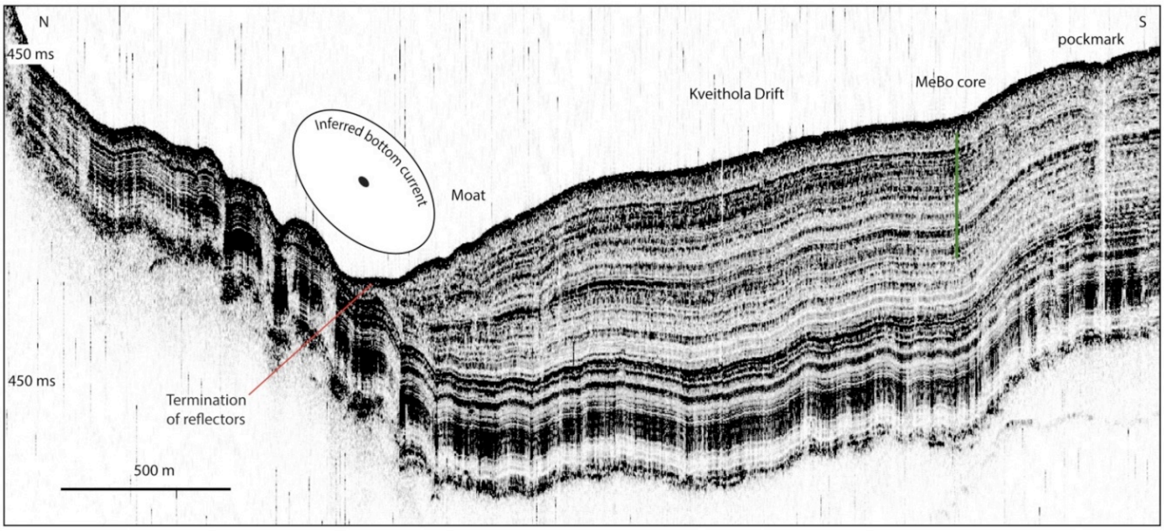

Fig. 2.2: CORIBAR parasound profile showing the Kveithola Drift, separated from the northern flank by a moat in which reflectors abruptly terminate. The core of a westward bottom current is inferred to flow in the moat. Location of a MeBo site is also shown. A pockmark is visible few hundred meters to the south of the core site

The highly dynamic environment depicted from the morphological and structural characteristics of the sediment drift is in contrast with the sediment facies and preserved biota observed in surface sediments. The retrieved sediments have a strong smell of H_2S and are mostly black, organic matter-rich, with abundant black worm tubes (*Pogonophora* worms), and occasionally with living reddish polychaetes (possibly *ampharetid* polychaetes).

The recent and living benthic foraminiferal assemblage observed in the sediments is characterized by the presence of typically oxygen-depleted environmental taxa. Any bottom current-related sedimentary structure was observed on surface sediments. The Kveithola Drift that formed under persistent dense bottom currents appears today as a "stagnant environment" strongly affected by low-oxygen conditions with likely ongoing seep activity.

The presence of an apparently stagnant, possibly chemosynthetic, environment in the sediment drift area of the inner Kveithola Through was an unexpected discovery. We therefore think it is of primary importance to better define the bio-geochemical and oceanographic characteristics of the inner area of the Kveithola Trough in order to better define this "anomalous" sedimentary system and to understand the local and global impact of this type of environment in terms of carbon cycle and the transfer of chemosynthetic-derived products to the deeper environments as consequence of regional oceanographic patterns.

The BURSTER project aims to investigate the geodynamic and hydrographic conditions, and the active gas seepage present in the pockmark-field piercing the sediment drift located in the inner part of the Kveithola Trough. The type of investigation is strongly multidisciplinary including physical and biological oceanography, water, sediment and gas geochemistry, micropaleontology, microbiology geophysics, and sedimentology. The investigations will be carried out within three working days with the aim of outlining the principal oceanographic, biological and geological aspects of the area on which building up further investigations.

Oceanographic objectives

- Study of water mass properties through hydrographical sections along key transects (synoptic CTD measurements over the area);
- Definition of water masses characteristics through bio-geochemical analyses of water samples.

Geo-biological objectives

- Definition of the isotopic signature to assess the origin of the seeping fluids;
- Characterization of natural seepage using geophysical and geochemical data;
- Investigation of the presence of authigenic carbonates and/or chemosynthetic communities on the seafloor (video surveys and sampling);
- Analyses of past and recent benthic foraminiferal communities and their resilience to oxygen depletion and methane emissions as potential indicators of variation in oxygen and carbon dioxide concentrations and hydrocarbon seeps;
- Evaluation of existing and future impacts of dysoxia on pelagic and benthic ecosystems (including macrofauna) by assessment of its biogeochemical, biological and ecological consequences in the Kveithola drift (seafloor sampling);
- Calibration of geochemical and biological proxies applied to living benthic and planktonic foraminifera in order to assess the variation in oxygen concentration and hydrocarbon emission and their impact in the biomineralization mechanisms. Proxies will be useful to interpret the fossil redox conditions;
- Investigation at high resolution (centennial) sedimentary records of the spatial and temporal changes in the redox conditions of the water column using inorganic and organic proxies, biomarkers, and isotopic signatures;
- Study of the paleoclimatic systems (from previous studies in the area) and their possible relation to oxygen depletion.

Work at sea

BURSTER objectives will be achieved by collecting CTD casts at maximum 47 stations along six hydrographical transects (Fig. 2.3) to determine the physical characteristics of water masses.

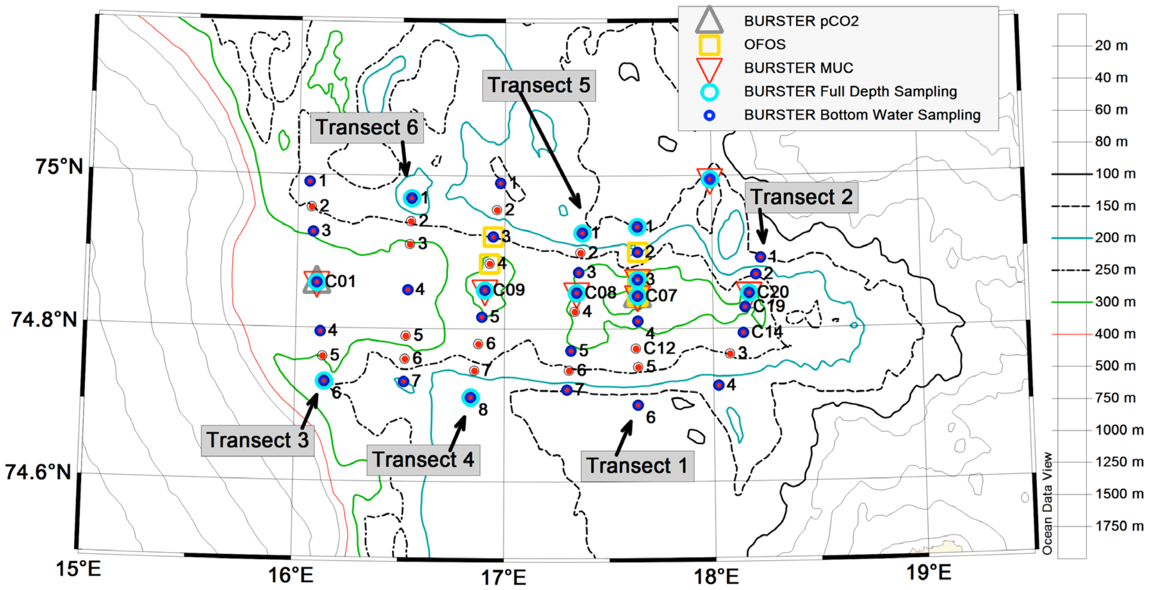

Fig.2.3: The BURSTER working plan includes max. 47 CTD casts, about 20 deep water samples and about 12 sites with discrete sampling through the water column. The investigations include multicorer casts, pCO_2 autonomous probes measurements, and OFOS survey in key areas

Bottom water samples will be collected by a Rosette sampler at about every second CTD stations, whereas discrete samples will be collected along the water column during the up-cast at six stations corresponding to the multi-corer stations (Fig. 2.3). Water sampling depths will be determined during the downcast profiling in order to sample the characteristics of different significant water masses.

Multicorer casts will be performed at the CORIBAR sites already analysed in order to determine bio-geochemical and living fauna temporal variations (i.e., sites C01, C07, C20, C22, C08, C09). The coupled multicorer samples and Rosette water samples at the same sites will allow us to analyse the sea water just above the sediment surface and at the sediment-water interface.

Water samples for the analyses of carbonate system (pH, total alkalinity, and dissolved inorganic carbon), inorganic nutrients and H_2S, will be pre-processed and stored for detailed shore based analyses, while dissolved oxygen and salinity will be directly analysed on-board.

Remotely sensed information will be used for the Absolute Dynamic Topography, SST and Chlorophyll concentration prior/during the cruise to assess the surface circulation pattern in the study area.

Multicorer samples will be opened, described, photographed and sampled on board for sedimentological microbiological and geochemical analyses (gas and pore water content). Samples of living micro- and macro-fauna will be analysed and photographed with a portable electron microscope (Hitachi). Additional sediment and water samples will be frozen at -20°C for detailed shore-based analyses.

Underway measurements will be conducted by means of the ship-borne Acoustic Doppler Current Profiler (ADCP) and thermosalinograph to constraint water circulation.

Autonomous pCO_2 probes will be deployed at the seafloor for *in-situ* measurements (up to 24 h) at two sites located in the outer and inner part of the Kveithola Trough (i.e., sites C01, C07).

Simultaneous and co-registered data collection of bathymetry, seabed backscatter imagery and water column imaging (WCI) will be carried out for the detection of pockmarks and gas seepage features.

PARASOUND sub-bottom profiles will be assessed to detect acoustic masking related to the presence of gas seepage from the underlying sediments, and through the water column using a Fishfinder sonar system.

Visual inspections using a towed camera system OFOS will be performed at a total of three sites: two sites located in the inner part of Kveithola Trough (chemosynthetic habitat; sites C07 to 1.3, and site 1.2) and one site closer to the outer part where gas bubbles were depicted on the CORIBAR PARASOUND record of the water column (between sites 4.3 and 4.4).

Data management and samples

Water and sediment samples will be partly processes during the cruise, and partly stored at +4°C and -20°C for additional, shore-based investigations at the laboratories of OGS, University of Rome, University of Pisa, Polytechnic University of Marche, the Centre for Earth Evolution and Dynamics of the University of Oslo, and the BGR of Hannover. Preliminary results will be indicated in the cruise report submitted to the EUROFLEETS2 Evaluation Office, and raw data / metadata (CSR) will be stored at the National Oceanographic Data Centre (OGS-NODC; nodc.ogs.trieste.it) within the SeaDataNet network. Processed data will be merged and shared between the scientific party of the first leg of expedition PS99 for publications and communications at international conferences and workshops.

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3. DEFROST - DEEP FLOW REGIME OFF SPITSBERGEN

M. Bensi, V. Kovačević, C. De Vittor, R.G. Lucchi, F. Relitti, M. Bazzaro, D. Deponte, R. Laterza (OGS); L. Langone (ISMAR)

Objectives and scientific programme

The region southwest of Svalbard (Fig. 3.1) is an area where water masses with different properties interact with each other: Atlantic waters, considerably warmer than the locally formed dense waters, flow northwards (West Spitsbergen Current) along the eastern side of the Fram Strait, keeping this region nearly ice-free even during winter season, while cold Arctic waters (East Greenland Current) flow southward in western parts of the strait contributing to the maintenance of the Greenland ice cap. Additionally, dense waters are formed in winter through freezing and brine release in the polynyas of the Barents Sea, particularly in the Storfjorden. These ocean processes have strong implications on the climate. Shelf dense water plumes are also responsible for the accumulation of contourites (sedimentary structures affected by along slope bottom currents), whose onset coincides with the Early Pleistocene glacial expansion. The study of these contourites can provide valuable information on the history of ocean circulation and climate. In particular, two contourite depositional systems were recently discovered in the area: the Isfjorden and Bellsund contourite drifts (Rebesco et al., 2013).

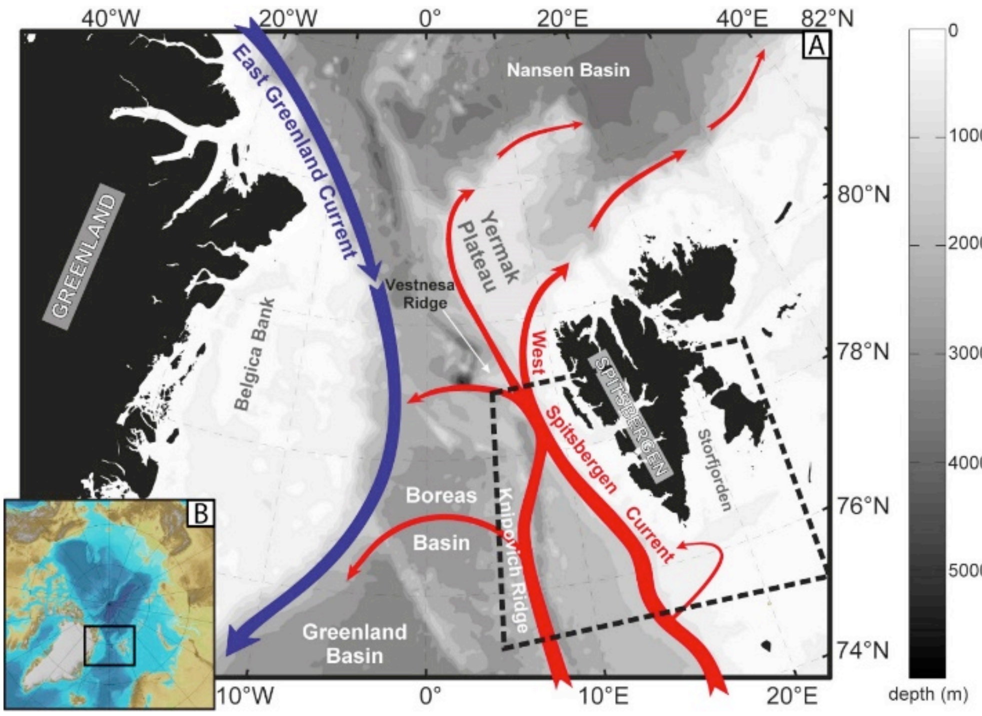

Fig. 3.1. Study area (dashed square). A) Bathymetry of the region with a schematic representation of the general ocean circulation. B) Location of the study area within the Arctic Ocean (adapted and modified from Jakobsson et al., 2012)

The research project DEFROST (DEep Flow Regime Off SpiTsbergen) aims to investigate the temporal and spatial variability of the deep flow in the area of the above mentioned contourites, with emphasis on the near-bottom currents and their associated physical and biogeochemical properties. *In-situ* measurements will be conducted mainly by means of deep moorings, deployed in the layer between 1,000 and 1,500 m water depth. They are equipped with current meters, temperature, salinity, dissolved oxygen sensors, and sediment traps. The choice of using the moorings is motivated by the fact that the most energetic processes, which are able to reshape the seabed and form contourites, occur in late winter and early spring, when surveys done by means of research vessels are hardly feasible due to the harsh environmental conditions in the area. Moreover, winds and ocean cooling change according to mild or strong winters, and so affect the volume and density of the dense water plumes, and hence of the cascading flow. Therefore, long lasting measurements, extended to more than one year by means of the moored sensors are needed to assess the year-to-year variability. A multidisciplinary team composed by oceanographers and geologists will study current characteristics, thermohaline properties, sedimentary processes, and seismic data in order to assess the link among the present seabed shape, deep-water flow and dense water plumes cascading. This scientific activity follows up previous international initiatives: the EUROFLEETS2 PREPARED (Present and past flow regime on contourite drifts west of Spitsbergen) cruise carried out in summer 2014 (RV *G.O. Sars*), and two following cruises carried out in the same region in June and September 2015 on board the RV *Helmer Hansen* (Uni Tromsø, Norway) and RV *OGS-Explora* (OGS, Italy).

Work at sea

Hydrographic data and ocean properties will be assessed using a CTD-rosette water sampler. Particular attention will be paid to the bottom water properties, as their spatial variability will be compared with the data gathered through the two moorings S1 and I2 located in the region (Fig. 3.2). Information about dissolved oxygen, carbonate system (pH, total alkalinity, and dissolved inorganic carbon), inorganic nutrients, and hydrogen sulphide will be obtained from water samples. Two deep moorings (S1 and I2, Fig. 3.3) located at ~1,000 m depth will be recovered. The mooring S1 will be maintained and possibly re-deployed. Mooring lines are equipped with CTD, thermistors, 150 KHz ADCP (Acoustic Doppler Current Profiler), single point current-meters, a sediment trap, and acoustic releasers. The sediment trap is a Parflux Mark 7G-21 by McLane Research Lab, designed to collect a series of settling particulate matter to investigate the variability of particle fluxes.

Data management and samples

Water sample processing will be carried out partly on board, and partly at OGS and ISMAR-CNR facilities. Data from the CTD, as well as the data retrieved from the two moorings, will be pre-processed on board, and afterwards post-processed, quality checked, and analysed at OGS and CNR-ISMAR. The finally processed data from the DEFROST activities will be submitted to the NODC - National Oceanographic Data Center, following the data restrictions of the Italian PNRA (Programma Nazionale di Ricerca in Antartide) programme.

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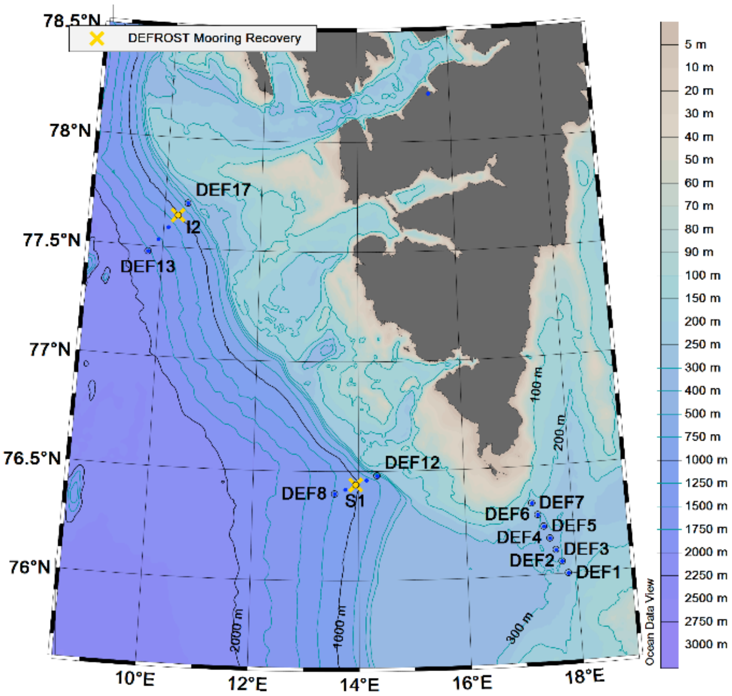

Fig. 3.2: Map with DEFROST CTD stations (blue dots) and mooring positions (yellow crosses)

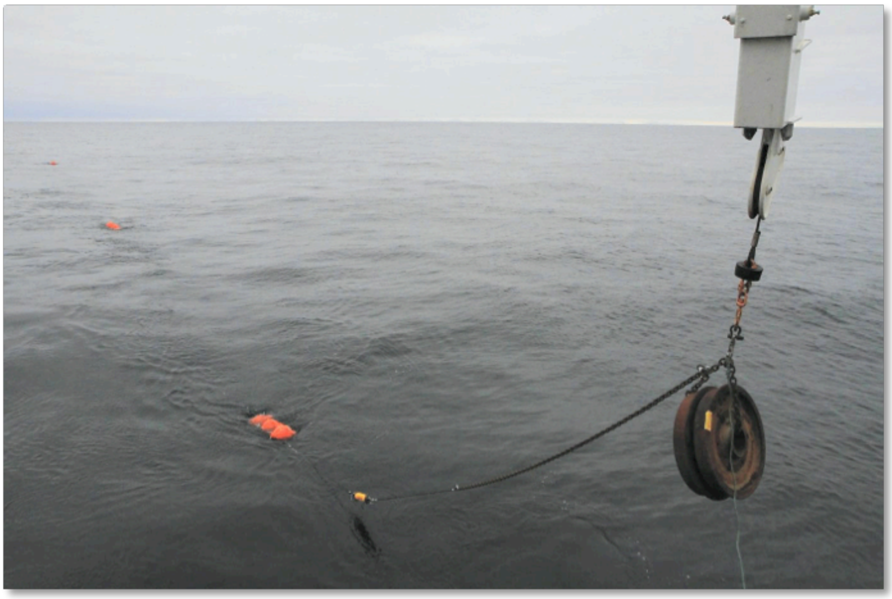

Fig. 3.3: Deployment of the mooring S1 during the RV G.O. Sars expedition in 2014

4. ABUNDANCE AND LATITUDINAL DISTRIBUTION OF FLOATING MARINE LITTER AND NATURAL FLOTSAM

L. Gutow, C. Daniel (AWI)

Objectives and scientific programme

The increasing global production and careless handling of industrial and household goods has resulted in an accumulation of anthropogenic litter in the world's oceans. Once at sea, marine litter becomes a threat to a great variety of marine organisms and habitats and is, therefore, considered a major marine environmental hazard. Numerous organisms suffer directly from ingestion of litter items or entanglement with discarded fishing gear. Biogeographic implications of marine litter arise from the large-scale transport of rafting organisms on litter items floating at the sea surface (Fig. 4.1).

Fig. 4.1: Rafting hydrozoans and bivalves on floating marine litter from the North Atlantic

The efficiency of rafting as dispersal mechanism strongly depends on the availability and persistence of floating substrata. Accordingly, rafting dispersal has to be considered in an environmental context taking into account the regional composition and quantity of natural flotsam. Hence, changes in rafting opportunities due to the occurrence of floating marine litter are particularly pronounced in regions with naturally rare incidence of floating substrata. Therefore, a sound knowledge of the quantity and distribution of marine litter in relation to natural flotsam is essential for estimating the biogeographic implications associated with this new form of pollution.

The major sources of marine litter have been identified and are closely associated with human activities. Accordingly, litter densities in the oceans are particularly high close to urban centres but decrease towards remote regions, resulting in a pronounced latitudinal gradient with high litter densities in densely populated regions in low to mid latitudes and low densities towards the sparsely populated polar regions. This global pattern has repeatedly been confirmed in previous studies. However, results from recent studies indicate a rapidly increasing littering of polar waters. For example, AWI investigations revealed considerable densities of litter on the seafloor and at the sea surface in the Fram Strait region. Furthermore, exceptionally high densities of microplastic particles and fibres were found in arctic sea ice.

The reasons for the increasing litter densities in the arctic waters are yet unknown. Possible explanations include enhanced maritime and fishing activities at high latitudes as well as enhanced climate-induced intrusion of water masses from mid latitudes carrying along huge amounts of suspended and floating litter. This development indicates a weakening of the latitudinal gradient in litter densities over recent decades.

Buoyant seaweeds predominantly occur in temperate and sub-polar regions. Recent studies indicate that some seaweed species might shift their distributional range towards higher latitudes in response to climate change. Both developments, the increase of litter in arctic waters and the distributional shift of seaweeds towards higher latitudes, may substantially alter the distribution and composition of anthropogenic and natural flotsam with unpredictable consequences for the dispersal of associated species.

The first leg of the RV *Polarstern* expedition PS99 provides an ideal opportunity to investigate densities of floating litter and natural flotsam during the transit from Bremerhaven to Longyearbyen, a distance covering about 22° of latitude (approx. 2,500 km). With visual ship based observations we will test the hypothesis that densities of floating marine litter are decreasing from temperate to high latitudes. Relating the observed litter densities with abundances of floating seaweeds and other types of flotsam will allow for describing historical changes in flotsam composition and distribution and quantifying opportunities for rafting dispersal in a changing polar ocean.

Work at sea

No specific station time will be required for the quantification of flotsam. From aboard the moving vessel, floating items will be counted along a transect of defined width. For each floating item the position will be recorded from a handheld GPS. Additional information on each object, such as size and colour, will be recorded as well. This information may later help to describe the flotsam composition and latitudinal changes thereof and to identify possible sources of flotsam. Depending on the vessel speed, the single observation periods will last 60 to 90 minutes with breaks between two periods of at least 60 minutes.

Data management

The data set will be completed by the end of the cruise leg. After the cruise the data will be submitted to the PANGAEA data repository from where they are will be available without restrictions.

5. HAUSGARTEN: IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE ECOSYSTEMS

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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 approx. 50 % since the late 1950s. In its recent report, the Intergovernmental Panel on Climate Change (IPCC) predicted that the Arctic Ocean could become ice free at the end of this century, while others argue that this scenario might even take place much earlier, with a forecast 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-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) established the LTER (Long-Term Ecological Research) observatory HAUSGARTEN. Since 2014, this observatory is successively extended within the frame of the HGF financed infrastructure project FRAM (Frontiers in Arctic marine Monitoring) and covers currently 21 permanent sampling sites on the West-Spitsbergen and East-Greenland slope at water depths between 250 and 5,500 m.

During the second leg of RV *Polarstern* expedition PS99 (Longyearbyen - Tromsø), multidisciplinary research activities will be conducted at all HAUSGARTEN stations (Fig. 5.1). 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.

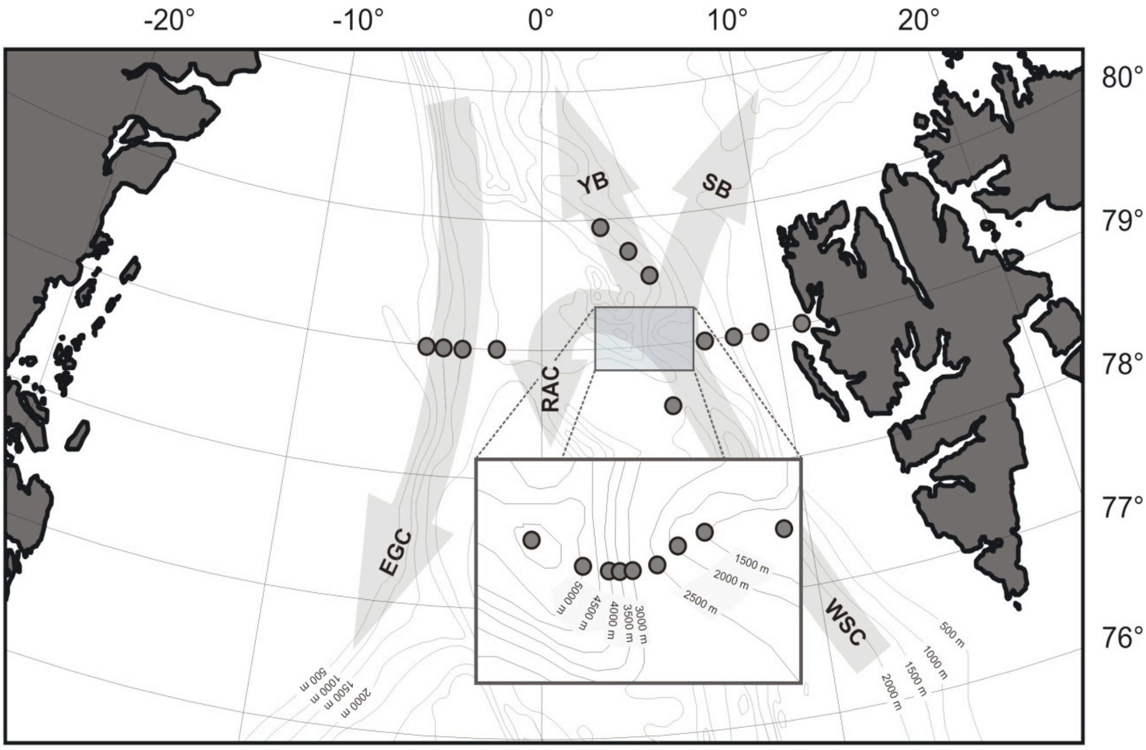

Fig. 5.1: Permanent sampling sites of the LTER Observatory HAUSGARTEN in Fram Strait

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 6).

Vertical flux of particulate organic matter

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. 5.2). In addition to moored sediment traps new autonomous infrastructure will be deployed on the HAUSGARTEN moorings to track seasonal changes in the dissolved and particulate constituents of the upper water column. These include McLane RAS 500 water samplers that are programmed to collect and preserve water samples (~0.5 L) with approximately weekly resolution, and particle samplers that filter and preserve ~10 L water samplers with approximately bi-weekly resolution. Besides sediment traps the moorings are equipped with Aanderaa currentmeters (RCM8, RCM11), self-recording CTD’s (Seabird MicroCATs), and a suite of biogeochemical sensors (full details below). During the RV

Polarstern expedition PS99, we will recover moorings and instruments that were deployed at ~2500 m water depth during the RV *Polarstern* expedition PS93.2 in 2015 as below.

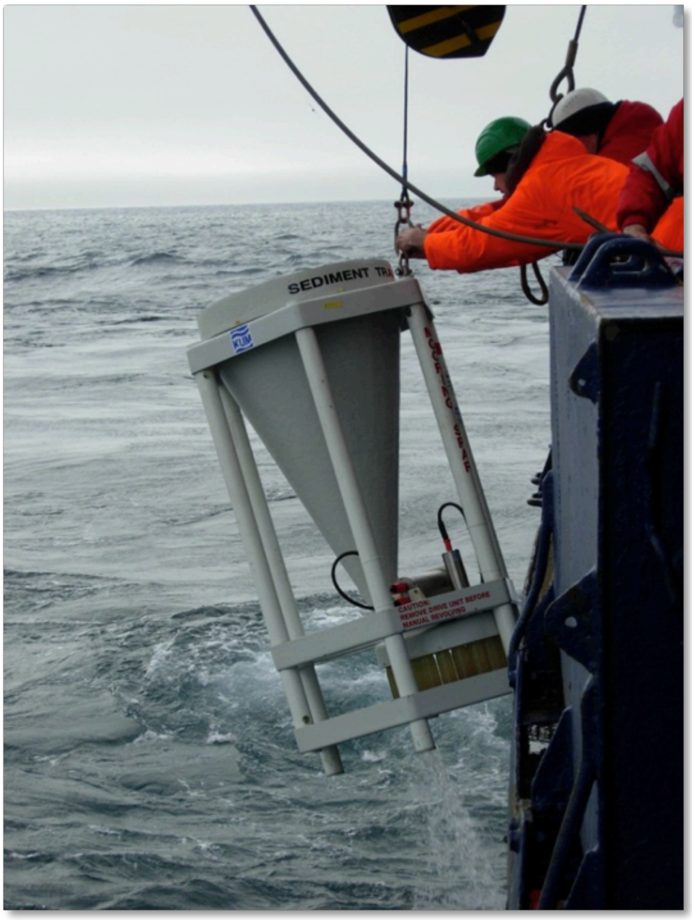

Fig. 5.2: Deployment of a sediment trap to assess particle fluxes to the seafloor

Western Fram Strait (78°50.10'N, 02°47.96'W) (TD-2015-LT):

90 m – Greeneyes Aquamonitor water sampler
90 m – Lab-on-a-chip nitrate sensors from NOC *(see DYNAMITE contribution below)*
500 m – KUM 21 cup sediment trap
2245 m – KUM 21 cup sediment trap

Central HAUSGARTEN site (79°00.43'N, 04°19.92'E) (FEVI-32/HG-IV):

90 m – McLane RAS 500 water sampler
90 m – Lab-on-a-chip nitrate sensors from NOC *(see DYNAMITE contribution below)*
200 m – KUM 21 cup sediment trap
1200 m – KUM 21 cup sediment trap
2300 m – KUM 21 cup sediment trap

Northern HAUSGARTEN site (79°44.39'N, 04°30.36'E) (FEVI-31/N4):

200 m – KUM 21 cup sediment trap
2500 m – KUM 21 cup sediment trap

Following the deployment of two nitrate sensors on a mooring in the East Greenland Current and a third nitrate sensor in the West Spitsbergen Current during PS93.2, we now plan to recover those sensors. As part of the $FixO^3$ project DYNAMITE, considering the development of new technologies, these deployments represented a great opportunity to test the nitrate sensors in cold water conditions. Our Lab-on-chip sensors have been previously deployed in rivers, coastal waters and glacier streams, but have not previously been deployed at high pressures (80 m water depth) and in polar conditions. The sensors were programmed to perform two measurements per day for the duration of the deployment. The combination of results from sensors (provided these work as expected), data derived from the future analysis of samples collected and samples from the autosamplers deployed during PS93.2 will yield information relevant to understand temporal changes in the concentration of nutrients associated with upper waters (100 m) inflowing and outflowing across the Fram Strait. This in turn will provide the information needed to evaluate the Arctic Ocean nutrient budget. Additionally, we will take the opportunity to collect more samples from CTD-rosette water sampler casts and from the autosamplers recovered. One of our main aims off the DYNAMITE project is to start tackling the issue of temporal changes (seasonal, interannual) in nutrient concentrations of waters flowing in and out of the Arctic Ocean, which is relevant if we are to understand the effects of climate change on Arctic Ocean nutrient biogeochemistry and how this may also impact the transport of nutrients to the North Atlantic.

During RV *Polarstern* expedition PS99 we will re-deploy moorings and instruments at the three main HAUSGARTEN sites in the Western Fram Strait as well as at HG-IV and N4. In addition to these long-term mooring locations two "high-risk moorings" will be deployed at the newly defined stations F4-S and HG-IV-S that have the objective to place autonomous water column sampling devices shallower in the water column to try and follow the seasonality in biological and chemical parameters in the upper 30 m of the water column. This will include RAS-500 water sampling devices and McLane phytoplankton and particle sampling devices. Numerous biogeochemical sensors will be attached to the frames of these autonomous sampling devices. Full details are described below.

Western Fram Strait (78°50.1'N, 02°48.0'W) (TD-2016-LT):

80 m – RAS-500 water sampler
500 m – KUM 21-cup sediment trap
2300 m – KUM 21-cup sediment trap

Central HAUSGARTEN site (79°00.5'N, 04°20.0'E) (FEVI-34/HG-IV):

68 m – RAS-500 water sampler
197 m – KUM 21-cup sediment trap
1223 m – KUM 21-cup sediment trap
2341 m – KUM 21-cup sediment trap

Northern HAUSGARTEN site (79°44.4'N, 04°30.4'E) (FEVI-31/N4):

210 m – KUM 21 cup sediment trap
2454 m – KUM 21-cup sediment trap

Central HAUSGARTEN surface (79°00.0’N, 04°33.0'E) (HG-IV-S-1):

25 m – McLane RAS-500 water sampler
27 m – McLane PPS phytoplankton and particle sampler
25 m – sensor package (SBE37-SMP-ODO, pH Sensor, ECO triplet, PCO_2 sensor, PAR sensor)

F4 TMA surface (79°00.0’N, 07°00.0'E) (F4-S1):

25 m – McLane RAS-500 water sampler
27 m – McLane PPS phytoplankton and particle sampler
25 m – sensor package (SBE37-SMP-ODO, pH Sensor, ECO triplet, PCO_2 sensor, PAR sensor)
200 m – KUM 21-cup sediment trap

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 preprogrammed 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), particulate phosphorous, biogenic particulate silica (bPSi), total particulate matter (seston), calcium carbonate ($CaCO_3$), and the stable isotopes content (δ15N/δ13C) 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 7.

Investigations of the smallest benthic biota

Virtually undisturbed sediment samples will be taken using a video-guided multicorer (TV-MUC; Fig. 5.3). 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).

To determine and characterise suspected differences in community structure and dynamics of nematode assemblages in relation to the confined flow regime and patchy food availability around dropstones, mimics with different shapes (rectangular, cylindrical and hemispheric) will be deployed at 2,500 m water depth at the central HAUSGARTEN station for one year. First sediment sampling around the artificial dropstones will take place during next year’s HAUSGARTEN expedition using a ROV (Remotely Operated Vehicle).

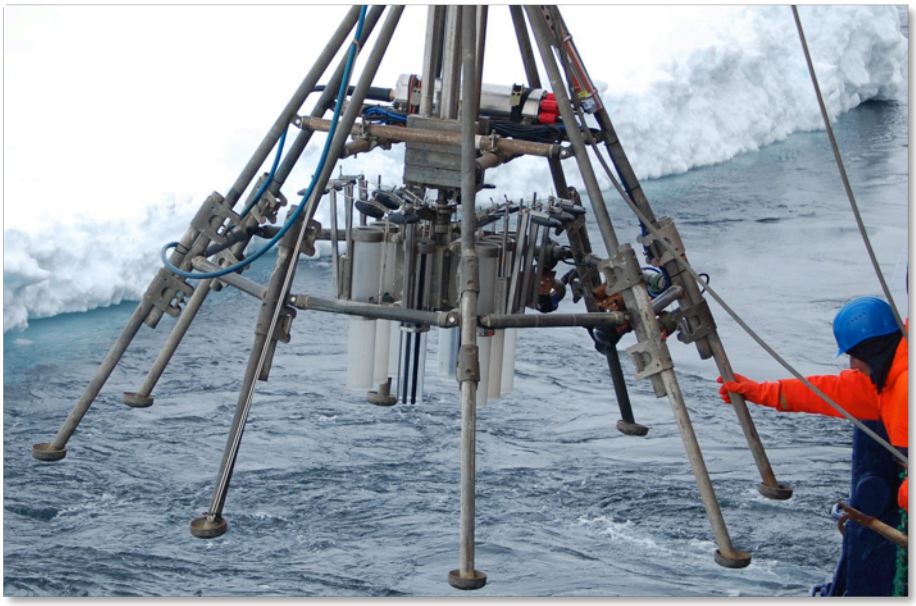

Fig. 5.3: Sediment sampling using a video-guided multicorer (TV-MUC)

Oxygen consumption rates to assess benthic carbon mineralization

Deep-sea benthic communities are strictly dependent on carbon supply through the water column, which is determined by temporal and spatial variations in the vertical export flux from the euphotic zone but also lateral supply from shelf areas. Most organic carbon is recycled in the pelagic, but a significant fraction of the organic material ultimately reaches the seafloor, where it is either re-mineralized or retained in the sediment record. One of the central questions is to what extent the sea ice cover controls primary production and subsequent export of carbon to the seafloor on a seasonal scale. Benthic oxygen fluxes provide the best and integrated measurement of the metabolic activity of surface sediments. They quantify benthic carbon mineralization rates and thus can be used to evaluate the efficiency of the biological pump (export of organic carbon from the photic zone). In order to link long-term variations in surface and sea-ice productivity and consequently in export flux to the seafloor, detailed investigation of the temporal variations in benthic oxygen consumption rates would be very valuable. We therefore deploy the newly developed benthic crawler TRAMPER (Fig. 5.4) to perform weekly oxygen gradient measurements for 12-months period.

Benthic carbon mineralization will be studied *in-situ* at three sites (S3, HG-IV, and N4) as well as *ex-situ* along a depth gradient off Svalbard (290 to 2,500 m). The benthic O_2 uptake is a commonly used measure for the total benthic mineralization rate. We plan to measure benthic oxygen consumption rates at different spatial and temporal scales.

A benthic lander (Fig. 5.5) will be equipped with different instruments to investigate the oxygen penetration and distribution as well as the oxygen uptake of arctic deep-sea sediments: (1) microprofiler, for high-resolution pore water profiles (O_2, T, resistivity), and (2) a benthic chamber, to measure the total oxygen consumption and nutrient exchange of the sediment. The overall benthic reaction is followed by measurement of sediment community oxygen consumption to calculate carbon turnover rates. From the sediments recovered from the benthic chambers, we will take subsamples to quantify the organic carbon content, microbial biomass and sieve out the larger macrofauna.

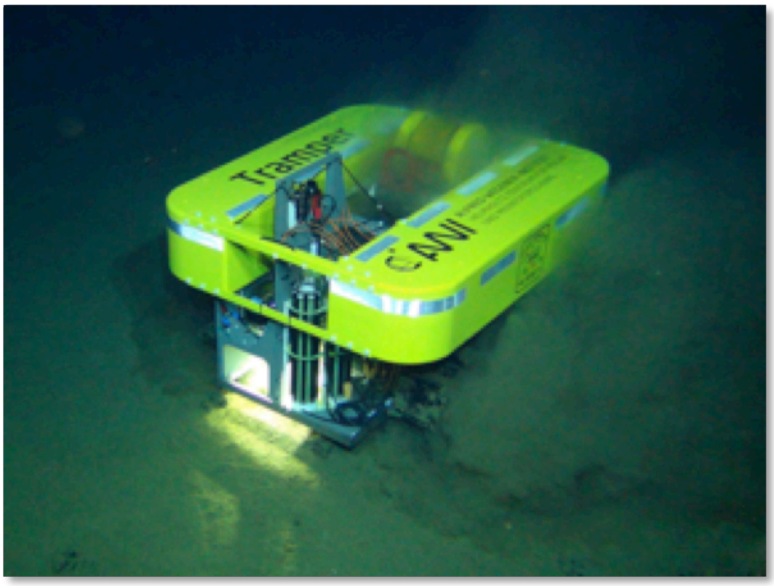

Fig. 5.4: The benthic crawler TRAMPER moving at the deep seafloor (© GEOMAR)

Fig. 5.5: Deployment of a free-falling system (benthic lander)

At the HG-IV the benthic crawler TRAMPER will be deployed. During its mission the crawler, equipped with six oxygen optodes in three revolver systems, is pre-programmed to perform 52 vertical concentration profiles across the sediment-water interface (one each week) along a 1.5 km transect. The aim is to cover a seasonal cycle of settling organic matter on the seafloor and to resolve the impact on the benthic community respiration activity.

Multicorer samples will be used to measure on-board O_2 gradients and fluxes.

Spatial and temporal variations in the structure of macrofaunal benthic communities

The study of spatial variations in the structure of macrofauna communities along the bathymetric transects in the eastern (HAUSGARTEN) and western parts of the Fram Strait will allow estimating the variability of major community parameters in this high-productive polar region. The comparison of previously obtained data from the same area and similar studies conducted seasonally or permanently ice-covered areas will help understanding spatial changes in deep-sea macrobenthic communities in terms of depth and latitude. The repetition of stations sampled by Wlodarska-Kovalczuk et al. (2004), Budaeva et al. (2008) and Vedenin et al. (2016) will provide a unique opportunity to evaluate changes in deep-sea macrofauna communities over a sixteen-year time period. Knowledge gained on spatial variations in macrofauna community structure at different spatial scales along the latitudinal transect will help to detect and separate effects of climate change from spatial heterogeneity in the distribution of deep-sea macrofauna.

Sediment samples will be collected with USNEL box corer. Each sample will be divided into eight subsamples (Fig. 5.6). Each subsample will be washed through 500 µm sieve to make the data comparable with previous studies. Ethanol fixation will allow us to prepare the macrobenthic organisms for future molecular analyses. Nine box-corer samples will be collected along the bathymetric transect (1200 - 5600 m water depth; sites HG-I to HG-IX). Two additional box-corer samples will be collected along the 125 km latitudinal transect following the 2,500 m isobath) off Svalbard. Another four box-corer samples will be collected along the bathymetric transect on the eastern Greenland slope (1000, 1500, 2000, and 2,500 m depth).

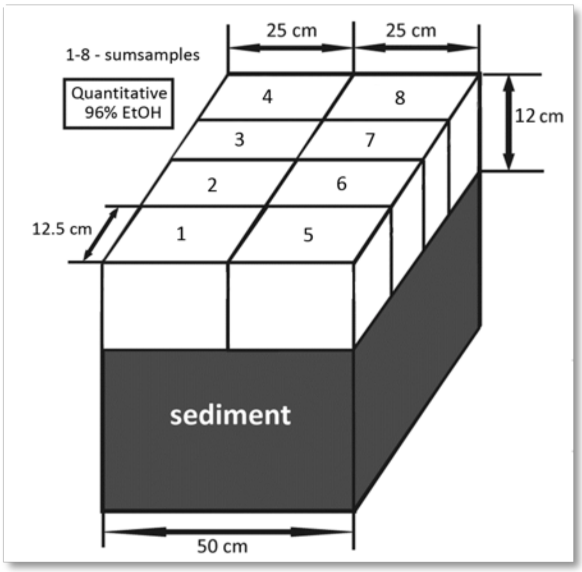

Fig. 5.6: Subsampling scheme of boxcorer samples

Megafaunal dynamics on the seafloor

Through the continuous redistribution of organic matter, oxygen and other nutrients in surficial sediments by remineralisation, bioturbation and burial of sunken matter, benthic biota play an important role in the global carbon cycle. Epibenthic megafauna inhabit the sediment-water interface and are defined as the group of organisms ≥1 cm. They contribute considerably to benthic respiration and have a strong effect on the physical and biogeochemical micro-scale environment. Megafaunal organisms create pits, mounds and traces that enhance habitat heterogeneity and thus diversity of smaller sediment-inhabiting biota in otherwise apparently homogenous environments. Erect biota enhances 3D habitat complexity and provides shelter from predation. Megafaunal predators control the population dynamics of their prey and therefore shape benthic food webs and community structure. Sunken organic matter that is not converted into benthic biomass and forwarded along food chains might be actively transported from the water column-sediment interface into the sediment by bioturbation. Organic matter is then degraded/recycled into nutrients and CO_2. Mega- and macrofaunal species thus actively influence biogeochemical processes at the sediment–water interface. An understanding of megafaunal dynamics is therefore vital to our understanding of the fate of carbon at the deep seafloor, Earth's greatest carbon repository.

During the RV *Polarstern* expedition PS99, we will continue to study interannual dynamics of megafaunal organisms using our towed camera system (Ocean Floor Observation System, OFOS; Fig. 5.7). The OFOS will be towed along established tracks at HAUSGARTEN stations of the latitudinal transect (N3, HG-IV, S3), at station HG-I and in the Molloy Hole. The new footage will extend our image time series that started in 2002 (Bergmann et al., 2011; Meyer et al., 2013).

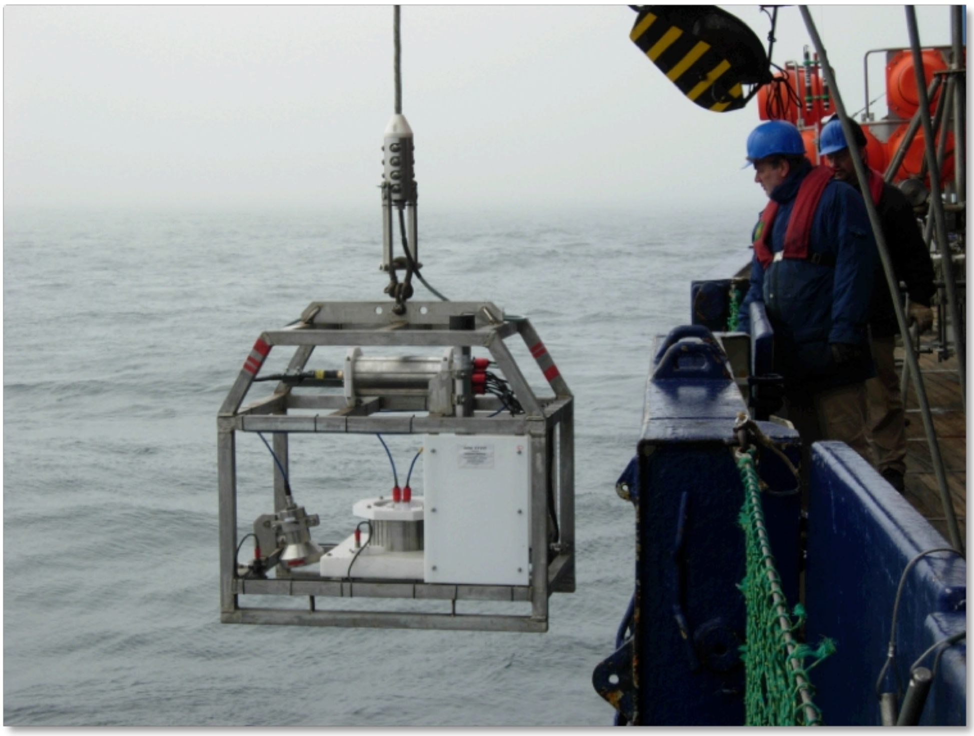

Fig. 5.7: Deployment of the Ocean Floor Observation System (OFOS)

In a new approach, we aim to study smaller-scale changes on the seafloor over time. To this end, a time-lapse camera will be fitted to a benthic lander and tested for a short time period at HG-IV. If trials are satisfactory, the camera will be fitted to the long-term lander and deployed to take pictures for a whole year.

Data and samples

Sample processing will be carried out at AWI. Data acquisition from the several types of investigation will be differently time-consuming. 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 after 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.

6. INVESTIGATING PHYSICAL AND ECOLOGICAL PROCESSES AT A MELTWATER FRONT USING AN AUTONOMOUS UNDERWATER VEHICLE AND AN UNMANNED AERIAL VEHICLE

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Objectives and scientific programme

In terms of biological activity, the polar marginal ice zones (MIZ) are among the most relevant regions in the world. Previous observations suggest the high biological activity to be triggered by physical and chemical processes which take place in the uppermost layers of the water column at the MIZ. Until today these processes are understood insufficiently – at least partly caused by the challenge of simultaneously observing various processes with high spatial and temporal resolution. To investigate the complex processes at the MIZ, the Alfred Wegener Institute (AWI) operates its Autonomous Underwater Vehicle (AUV) “PAUL” (Polar Autonomous Underwater Laboratory; Fig. 6.1). PAUL is equipped with sensors measuring conductivity, temperature and pressure; the concentration of nitrate, chlorophyll *a*, oxygen, coloured dissolved organic matter (CDOM) and the intensity of photosynthetically active radiation (PAR). A water sample collector which is able to collect 22 samples with an overall volume of 4.8 litres is used to calibrate the nitrate as well as the chlorophyll *a* sensor and to study the composition of plankton communities.

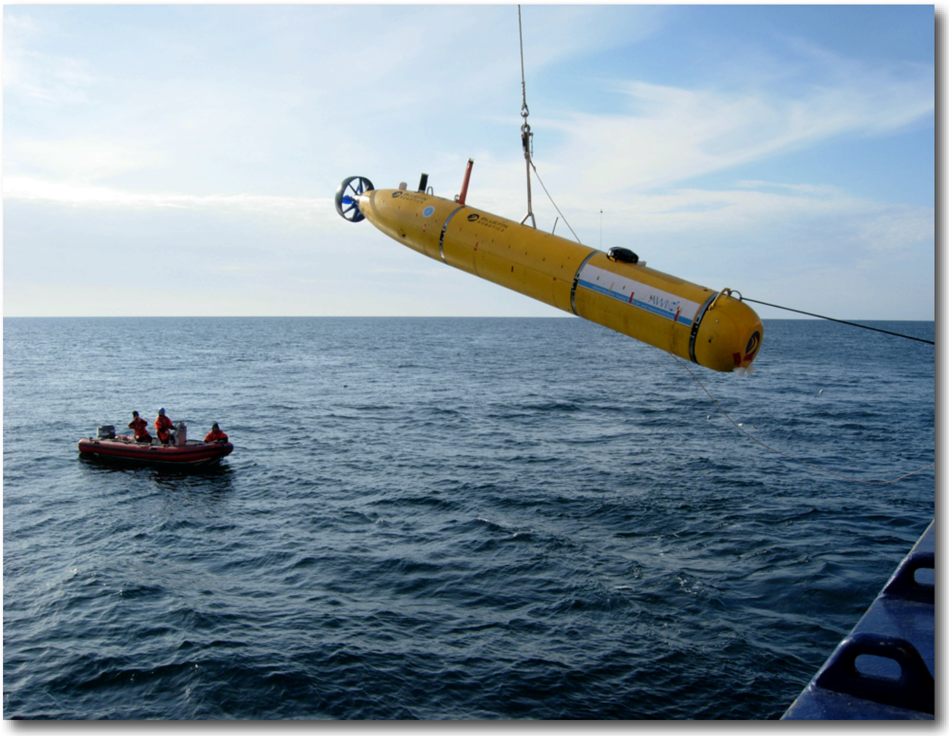

Fig. 6.1: Deployment of the Autonomous Underwater Vehicle "PAUL"

To understand the chemical and biological processes in the MIZ, it is essential to understand the triggering mechanisms, as for example the so-called frontogenesis. To be able to do so, PAUL's measurement capabilities were extended. In the context of the HGF infrastructure program FRAM (Frontiers in Arctic marine Monitoring), PAUL was recently equipped with an Acoustic Doppler Current Profiler (ADCP) and a microstructure probe (MP) – in addition to an already installed biogeochemical sensor package. Using the ADCP, physical phenomena such as horizontal velocity shear along melt water fronts shall be observed. The microstructure probe shall allow investigating small-scale mixing processes and flux estimates. With these additional physical sensors we aim at a better understanding of the interaction between physics and ecology in the MIZ.

Within the framework of the Helmholtz Alliance "Robotic Exploration of Extreme Environments – ROBEX", which brings together deep-sea and space research institutes, AWI's AUV team cooperates with the University of Würzburg and the German Aerospace Center (DLR). The main objective of this cooperation is to conduct joined operations between PAUL and Unmanned Aerial Vehicles (UAVs). During the upcoming expedition, PAUL will collect physical and biochemical data along and under the ice. At the same time, the long-range "Exploration UAV" (operated by the DLR; Fig. 6.2), will fly over the ice and collect images of its surface using cameras and radar. The UAV will use *Polarstern's* helicopter deck for its operations and will execute fully autonomous missions – including the autonomous landing of the UAV on the ship.

Fig. 6.2: Exploration UAV (Unmanned Aerial Vehicle) of the DLR, Oberpfaffenhofen

Work at sea

In order to prepare PAUL's 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 and raster search grids 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 of RV *Polarstern*. Up to a distance of 2.5 km, PAUL can be tracked using an Ultra Short Baseline (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 *Polarstern*. Water samples will then be processed in one of *Polarstern's* cold rooms and stored deep frozen. Biological, chemical and physical data will be checked aboard to avoid unperceived sensor malfunction. Post-processing will be conducted when back at AWI.

The Exploration UAV will first be tested extensively as this kind of autonomous flight operations have never been conducted on *Polarstern*. These initial tests will focus on the autonomous approach to *Polarstern* and landing on its Helicopter deck. During the first leg of the expedition PS99 (Bremerhaven - Longyearbyen), the team of the DLR will test the Exploration UAV conducting missions of approx. 30 - 60 min. flight time. When the sea ice is approached, it is planned to map extensive areas of the ice surface and collect information on the ice sheet's composition and its surface texture. These data will be used to better understand the wind-ice interaction which eventually shapes the marine environment along the ice.

Data and samples

Completely corrected navigation data and preliminary biochemical and physical (CTD) 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 ADCP and MP data processing is still under review and thus no time period can be given at this point. The finally processed data will be submitted to the PANGAEA data library.

7. PLANKTON ECOLOGY AND BIOGEOCHEMISTRY IN THE CHANGING ARTCIC OCEAN (PEBCAO GROUP)

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M. Doble (Polar Scientific Ltd);
not on board: A. Bracher, E.-M. Nöthig, I. Peeken (AWI), A. Engel (GEOMAR)

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 in the Fram Strait at about 79°N has been intensified since 2009. Our studies are based on combining a broad set of analysed parameters. This includes classical bulk measurements and microscopy, optical measurements and 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.

At the base of the food web, we expect small algae to gain more importance in mediating element and matter turnover as well as matter and energy fluxes in future Arctic pelagic systems. In order to examine changes, including the smallest fractions, molecular methods are applied to complement traditional microscopy. The characterization of the communities with molecular methods is independent of cell-sizes and distinct morphological features. The assessment of the biodiversity and biogeography of Arctic phytoplankton will be based on the analysis of ribosomal genes with next generation sequencing technology, Automated Ribosomal Intragenic Sequence Analysis (ARISA), and quantitative polymerase chain reaction method (PCR). Also, the zooplankton community composition may shift due to the warmer Atlantic water in the Fram Strait over the last 10 years. 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. Most of our knowledge on zooplankton species composition and distribution has been derived from traditional multiple net samplers, which allow to sample depth intervals of several hundred meters. Newly developed optical methods, such as the zooplankton recorder LOKI (light frame on-sight key species investigations), now permit to continuously take pictures from the organisms floating in the water column from 1,000 m depth to the surface. Linked to each picture, hydrographical parameters are being recorded, e.g. salinity, temperature, oxygen concentration and fluorescence. This allows to exactly identifying distribution patterns in relation to environmental conditions. Besides optical methods, acoustics have been used to estimate zooplankton abundance. However, acoustical data have yet to be calibrated against the specific species present in the water column. Combining acoustical and optical methods would thus be helpful to elucidate how the deployment of acoustical devices could add to identifying spatial and temporal zooplankton distribution patterns.

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. The analysis of organic compounds will be combined with rates measurements. Particulate and dissolved phytoplankton primary production as well as heterotrophic bacterial production will be analysed. Primary production is expected to increase in the future in response to the loss of sea ice. Whether this increased primary production will translate into increased export of particulate organic carbon is currently unclear. This depends on various processes linked to the phyto- and zooplankton community structure as well as the magnitude of surface recycling provided by heterotrophic bacteria. 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.

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, at high latitudes ocean colour satellite data have sparse coverage due to the presence of sea ice, clouds and low sun elevation. We use the PEBCAO *in-situ* data as input and for validation of satellite ocean colour algorithms. We will continuously run a WET labs AC-S hyperspectral transmissiometer and absorption meter in the surface water, and also hyperspectral radiometers and an additional AC-s during stations, in order to develop the analysis of optical data to obtain continuous information on phytoplankton composition, size structure and CDOM loading. The continuously measured optical data require frequent validation with measurements by direct biological or chemical analysis of water samples. We will regularly take samples from surface waters (every 3 hours) and at 6 water depths during CTD stations for pigment analyses (HPLC) and the absorption of particles, phytoplankton and CDOM. The received bio-optical and biochemical data will also serve for validation of similar measurements obtained with the AUV and other autonomous 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.

Work at sea

Biogeochemical and biological parameters from CTD-rosette water samples

We will sample arctic seawater by CTD-rosette water sampler at the main HAUSGARTEN stations and at a few stations in the East Greenland Current (EGC), at about 3 - 10 depths each. In addition to this, we will collect particles close to the surface with the automated filtration device AUTOFIM. We will collect seawater after regular intervals (~1° longitude / latitude) starting as soon as possible after RV *Polarstern* has left Bremerhaven and in parallel to the sampling via CTD. Sampling will be based on using the Automated Filtration System for Marine Microbes (AUTOFIM, Fig. 7.1) that is coupled to the ships pump system.

AUTOFIM allows filtration of a sampling volume up to 5 litres. In total 12 filters can be taken and stored in a sealed sample archive. Prior to the storage a preservative can be applied to the filters to prevent degradation of the sample material that can be used for molecular or biochemical analyses. 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 at AWI we will determine the following parameters to describe the biogeochemistry and the abundance and distribution of protists:

- Chlorophyll *a* concentration (total and fractionated)
- HPLC pigments
- Dissolved organic carbon (DOC)
- Particulate organic carbon (POC)
- Total dissolved nitrogen (TDN)
- Particulate organic nitrogen (PON)
- Particulate biogenic silica (PbSi)
- Particulate organic phosphorus (POP)
- Transparent exopolymer particles (TEP)
- Coomassie-stainable particles (CSP)
- Combined carbohydrates and amino acids
- Light absorption by phytoplankton and particulate matter
- Light absorption by CDOM
- Alkalinity
- Phytoplankton, protozooplankton and bacterial abundance
- Phytoplankton primary production (C-14 bicarbonate method)
- Heterotrophic bacterial production
- Electron transport system activity (*in vivo* INT reduction)
- Molecular based information (Next Generation Sequencing, quantitative PCR) on community structure, diversity and distributional patterns of protists and prokaryotes

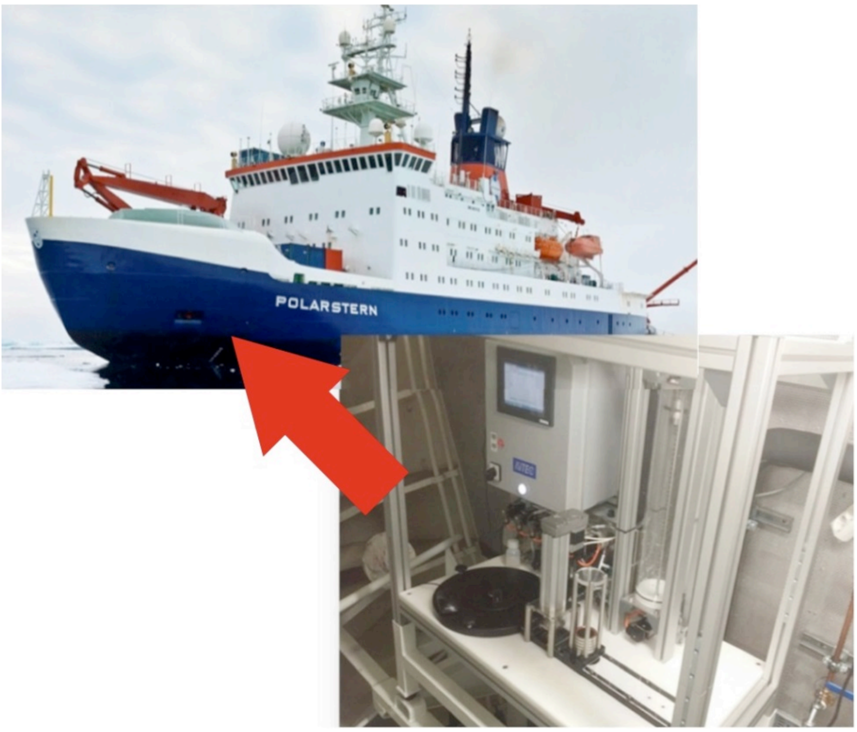

Fig. 7.1: The fully automated filtration module AUTOFIM is installed in the bow section of RV Polarstern close to the inflow of the ship's pump system. AUTOFIM is suited to collect samples with a maximum volume of 5 Litres. Filtration can be triggered on demand or after fixed intervals

Zooplankton sampling

Mesozooplankton composition and depth distribution will be determined by means of vertical Multi-net tows from 1500 m depth to the surface. In addition, optical surveys with the LOKI (light on-sight key species investigations) will be conducted to determine the small-scale distribution of zooplankton in the water column. We will mount an acoustic backscatter system (Aquascat equipped with different transducers 0.3, 0.5, 1, 2, and 4 MHz) on the LOKI. This will allow for parallel sampling of optical and acoustical data. 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, digestive enzymes) and molecular analyses of phytoplankton communities in the stomach of zooplankton organisms.

Continuous optical measurements

For the continuous underway surface sampling starting during the first leg of RV *Polarstern* expedition PS99 (Bremerhaven - Longyearbyen), an *in-situ* spectrophotometer (AC-S; WET labs) will be operated in flow-through mode to obtain total and particulate matter attenuation and absorption of surface water. The instrument is mounted to a seawater supply taking surface ocean water (Fig. 7.2). A flow-control with a time-programmed filter is mounted to the AC-s to allow alternating measurements of the total and the CDOM inherent optical properties of the sea water. Flow-control and a debubbler-system ensure water flow through the instrument with no air bubbles.

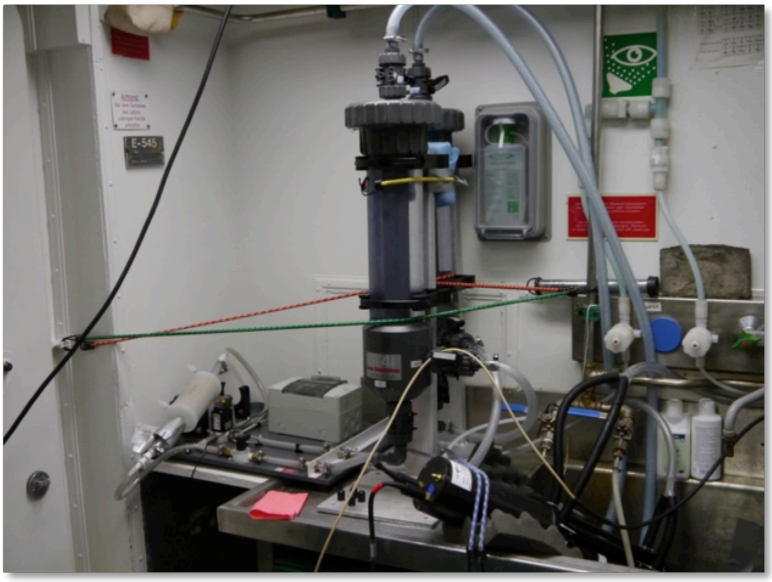

Fig. 7.2: Continuous measurements of the extinction and absorption of light in Arctic surface waters using a WETLABS AC-s mounted to the RV Polarstern surface sea water pump system. From those measurements the absorption and scattering of particles and CDOM is determined for the whole spectrum in the visible resolved with about 3 nm resolution. This data then can be decomposed via specific algorithms to determine particle size distributions and the phytoplankton pigment composition

A second AC-S instrument is mounted on a steel frame together with a depth sensors and a set of hyperspectral radiometers (RAMSES sensors from TRIOS, Fig. 7.3) and operated during CTD stations. The frame is lowered down to maximal 120 m with a continuous speed of 0.1 m/s or during daylight with additionally stops at 2, 4, 6, 8, 10, 12.5, 15, 20, 25, and 30 m to allow a better collection of radiometric data.

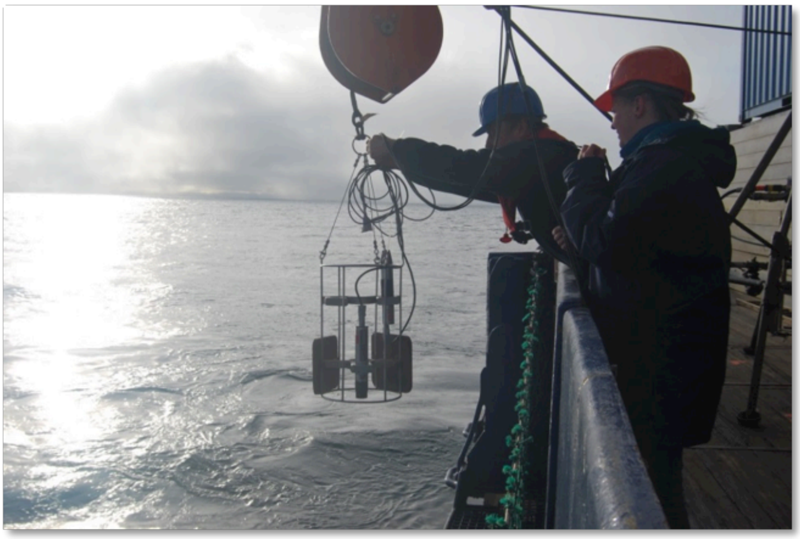

Fig. 7.3: Underwater light field measurements with TRIOS RAMSES radiometers (during FRAM expedition PS 92.2) detecting the hyperspectral up- and downwelling radiation within the surface water profile. The data are used via semi-analytical techniques to determine the concentration of optical constituents such as chlorophyll a, CDOM absorption and particle backscattering, but also for validating satellite ocean colour retrievals

The Apparent Optical Properties of water (AOPs) (mostly light attenuation through the water column) will be estimated based on downwelling and upwelling irradiance measurements in the surface water profile (down to the 0.1% light depth) from the radiometers calibrated for the incident sunlight with measurements of a radiometer on deck. The AC-s will measure the Inherent Optical Properties (IOPs) in the water profile.

Data management and samples

During our cruises, we sample a large variety of interconnected parameters. Many of the samples (pigment analyses, particulate matter in the water column, etc.) will be analysed at AWI and at GEOMAR within about a year after the cruise. We plan that the full data set will be available at latest about two years after the cruise. Most of species samples and samples which will not be 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 PANGAEA after publishing.

8. PARTICLE PROCESSES THROUGH THE WATER COLUMN IN FRAM STRAIT

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Rationale

Sinking particles, formed from aggregated organic matter are responsible for the export of carbon from the surface to the deep ocean. These particles are responsible for a large part of the transport and distribution of organic matter and nutrient throughout the water column. Thus feeding the organisms living below the sunlit parts of the ocean where the majority of the organic matter is produced via primary production. Another important function of settling aggregates is that they remove fixed carbon from the surface ocean and thus governs oceanic uptake of atmospheric CO_2. 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.

Objectives and scientific programme

Our main objective during the 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 - 1000 m). This will be done by detailed investigations on the uptake and transformation of nitrogen and DOC compounds (i.e. nitrate, ammonia, glucose) on marine aggregates, commonly known as marine snow (Fig. 8.1), in Arctic as well as North-Atlantic water masses of Fram Strait. This will give us more insights about the influence of aggregates on nutrient transformation in the respective waters, i.e. with respect to an increased Atlantic inflow and terrestrial DOC input from melting permafrost as a result of global warming. We will use *in-situ* optical imaging and acoustics in combination with marine snow catchers, conventional traps and gel traps to relate the laboratory determined rates to the *in-situ* particle abundance and size-distribution.

Work at sea

Sampling will be performed using a Marine Snow Catcher (MSC), followed by size fractionation and tracer experiments. In addition to bulk uptake and transformation rate measurements, we will investigate the identity and spatial distribution of active organisms as well as their uptake proportion by combining molecular microbiology methods with high resolution imaging mass spectrometry technologies. We will deploy drifting traps and use a combination of different optical, biological, and physical sensors to capture particle processes through the water column. These studies will be accompanied by laboratory experiments to investigate specific mechanisms responsible for *in-situ* carbon turnover within marine settling aggregates. We will relate changes in particle abundance and size-distribution to the vertical distribution of zooplankton measured with a combination of the ships hydro-acoustic systems and zooplankton collection nets such as the multi-nets and LOKI for zooplankton distributions (in collaboration with Babara Niehoff, AWI). 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. We will also deploy a Bio-Optical Platform (BOP) to follow the settling of particles and changes in particle types and sizes throughout a whole year.

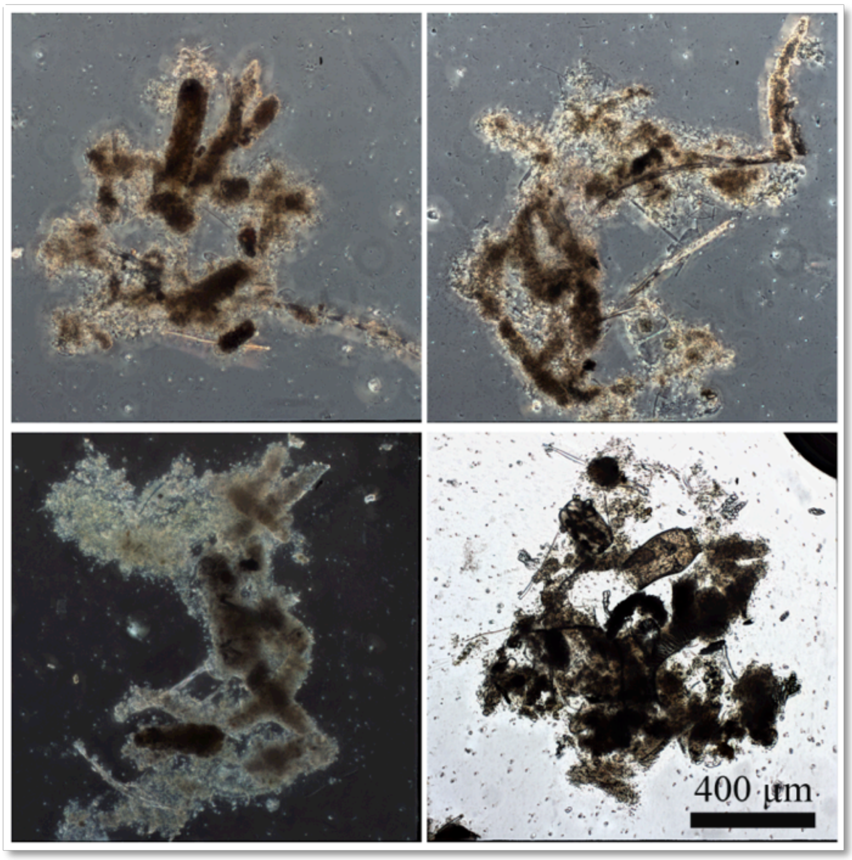

Fig. 8.1: Examples of marine snow collected with the Marine Snow Catcher in the Atlantic Ocean

Data and samples

We expect to be able to quantify settling particles and how they are transformed throughout different seasons at the HAUSGARTEN observatory as well as quantify the export fluxes through the upper mesopelagic zone during the cruise. The finally processed data will be submitted to the PANGAEA data library.

9. ASSESSMENT OF ARCHAEAL AND BACTERIAL LIFE AND MATTER CYCLING IN THE ARCTIC WATER COLUMN AND DEEP-SEA SURFACE SEDIMENTS

J.Z. Rapp, P. Offre, E. Fadeev (AWI, MPIMM)

Objectives and scientific programme

Abundance, diversity and physiology of ammonia-oxidizing archaea in the water column

For decades the nitrification process was exclusively attributed to ammonia- and nitrite-oxidizing bacteria (AOB and NOB, respectively), until a metagenomic survey of Sargasso sea water samples revealed presence of a gene encoding a distant homolog of the subunit A of the bacterial ammonia monooxygenases (AmoA) on an archaeal scaffold (Venter et al., 2004), suggesting the existence of ammonia-oxidizing archaea (AOA). This was confirmed one year later by the description of a marine ammonia-oxidizing archaeon brought to pure culture and, named *Nitrosopumilus maritimus* (Könneke et al., 2005). In the following decade AOA were identified as a widespread and abundant component of microbial communities in various environments, and therefore became a major research focus in environmental microbiology (Stahl & de la Torre, 2012). Several molecular surveys have assessed the distribution of archaeal amoA-like gene sequences in marine waters and surface sediments and showed that most of the sequences fall within two phylogenetically distinct clades referred to as α- and γ/δ-clade. The α-clade consists of sequences essentially from the euphotic zone (<200 m) and deep-sea surface sediments, and the γ/δ-clade comprises sequences mainly obtained from deep waters (>200 m) (Hatzenpichler, 2012). Using samples from the LTER observatory HAUSGARTEN we will attempt to characterize the dynamics of AOAs abundance along the bathymetric transect at HAUSGARTEN observatory and investigate the niche separation between thaumarchaeal organisms belonging to the α- and γ/δ-clade present in the water column and surface sediments of the Arctic Ocean. Collected water samples will be used for both direct microbial diversity analyses and for further physiological assays of cultured strains.

Enrichment of AOA from the water column

Up to date all published isolated strains of marine AOAs are members of the α-clade. Therefore, our goal is to enrich and purify strains belonging to the γ/δ-clade using the water and sediment samples acquired during the cruise sampling. Gain of such a strain, will allow direct testing of hypotheses regarding the metabolism and physiology of these organisms.

Diversity and activity of bacteria in deep-sea surface sediments

It is well known that bacteria dominate deep-sea surface sediments both in abundance and biomass and that they play important roles in carbon and nutrient recycling (Jørgensen & Boetius, 2007). Still it is not quite understood how these communities populate the sediment and to which extend there is an exchange between pelagic and benthic populations (e.g., Kellogg & Deming, 2009). To tackle these questions, we will couple the sampling of surface sediments to sampling of sea ice, the water column, and sinking particles from the water column at specific stations. For all environments we will take samples for bacterial diversity analysis. Further, our sediment sampling of HAUSGARTEN stations will contribute to the continuation of time-series analyses of bacterial diversity at this site (Jacob et al., 2013) to track potential impacts of environmental change on microbial community composition.

All samples from the HAUSGARTEN stations will also contribute to the FRAM microbial observatory project. The work will be carried out in the framework of the European Research Council Advanced Investigator grant ABYSS (A. Boetius).

Work on board

Sea ice samples

We will use a corer to take sea ice cores at selected stations, which will be analysed for nutrients, salinity, and temperature. Triplicate melted ice cores will be filtered through 0.2 µm Sterivex for subsequent DNA extraction in the home laboratory.

Water samples

Water samples will be obtained using 12 L Niskin bottles housed on a rosette equipped with SBE conductivity–temperature–depth (CTD) sensors or using Large Volume Water Transfer Systems (WTS-LV), which allow collecting samples *in-situ* onto 142 mm membrane filters. Samples will be collected from four different depths: 10 m, DCM, 1000 m and bottom depth (according to the bathymetry of the sampling site). For archaeal work, triplicate samples of 12 L seawater from each depth will be filtered using peristaltic pumps through nylon net filter (5 µm pore size, Millipore) for the particulate fraction and a Sterivex capsule (0.22 µm pore size, Millipore) for free living cells. For bacterial work, samples will be directly filtered through 0.22 µm pore size. DNA will be extracted from the filters for further community structure analyses using 16S rRNA and amoA Illumina tag sequencing and the quantification of AOAs and specific bacterial groups will be done using fluorescence *in-situ* hybridization.

Sinking particles

Sinking particles might constitute an important link between the pelagic and benthic realms. Therefore, we will sample sinking particles from marine snow catcher deployments to analyse bacterial cell numbers and community structure.

Sediment samples

We will use a video-guided multiple corer (TV-MUC) to retrieve undisturbed sediment samples from the seafloor. Samples will be taken for microbial DNA/RNA extractions, as well as fixed samples for the determination of microbial cell numbers. 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 5).

Additional live surface sediment samples will be retrieved and stored at 0°C for further analyses and experiments in the home laboratory, including feeding experiments and tests for optimal fixation of surface sediments as a contribution to the microbial observatory project.

Data 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) in Bremerhaven and the Zentrum für Marine Umweltwissenschaften (MARUM) in 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 is 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 public repositories such as NCBI and ENA. Microbiological samples will be stored deep frozen or fixed at the Max Planck Institute for Marine Microbiology (MPIMM) in Bremen.

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10. FRAM POLLUTION OBSERVATORY: ASSESSMENTS OF ANTHROPOGENIC LITTER AND MICROPLASTIC IN DIFFERENT ECOSYSTEM COMPARTMENTS

M. Bergmann, M. Tekman, I. Salter, L. Gutow, S. Lehmenhecker (AWI);
not on board: G. Gerdts (AWI)

Objectives and scientific programme

Marine litter has long been on the political and public agenda as it has been recognized as a rising pollution problem affecting all oceans and coastal areas of the world (Bergmann et al., 2015) (Fig. 10.1). There is currently a discrepancy of several orders of magnitude between estimates of global inputs of plastic litter and figures derived from field measurements highlighting again the question ‘Where is all the plastic?’ (Thompson et al., 2004). The degradation of larger litter items into smaller particles termed ‘microplastics’ may be one reason for this discrepancy. Another possibility is that certain ecosystem compartments have not been considered so far. For example, 50 % of the polymers from municipal waste have a density higher then seawater and sink directly to the seafloor, which has been proposed as a sink of marine litter.

Indeed, analysis of seafloor photographs taken at the central station of the HAUSGARTEN observatory indicated that litter doubled between 2002 and 2011 and reached densities similar to those reported from a canyon near the Portuguese capital Lisbon (Bergmann & Klages, 2012). More recent work has shown that litter has continued to increase and has spread further to the North of HAUSGARTEN (station N3) (Tekman et al., *submitted*). Litter was also observed floating at the sea surface in the Fram Strait and Barents Sea (Bergmann et al., 2015). Recent reports also indicate high concentrations of microplastics in Arctic sea ice (Obbard et al., 2014) and in surface waters south of Svalbard (Lusher et al., 2015), corroborating the presence of a projected sixth garbage patch (van Sebille et al., 2012). Despite the fact that many polymers have a density similar to seawater and may drift in the water column, little is known about the presence of microplastic in the pelagic realm. So, this might be another sink of litter or microplastic.

Work on board

OFOS transects conducted during PS99 (HAUSGARTEN stations N3, HG-IV, S3, HG-I, and HG-IX) will enable us to assess if marine litter continues to increase on the seafloor. The new footage will extend our image time series that started in 2002. *In-situ* pumps will be used to sample microplastics from large volumes of water in different environmental settings and from different depth strata during deep CTD casts: SV-1, SV-II (coastal; 50, 250 m), HG-IV (WSC; 50, 250, 1000, 2500 m), HG-IX (Molloy Hole; 50, 250, 1000, 5500 m), EG-IV (EGC; 50, 250, 1000, 2500 m), N5 (ice edge; 50, 250, 1000, 2500 m). Where possible, sediment samples will be taken to assess microplastic contamination of the seafloor. Snow samples will be gathered during helicopter flights to ice floes to assess atmospheric fallout as a pathway of microplastic to the north. Flights of multicopter-based cameras will enable assessments of surface litter counts over large areas. Observer surveys will be done from the working deck to assess litter densities at the sea surface when the ship is in transit. A large survey will be undertaken during the transit of RV *Polarstern* from Bremerhaven to Longyearbyen (see Chapter 3). Passive polyethylene samplers will be attached to the long-term lander to assess the potential of plastic as vectors of persistent organic pollutants adsorbing to their surface on the deep seafloor and to assess ambient concentrations of persistent organic pollutants.

Fig 10.1: Litter recorded during OFOS deployments at HAUSGARTEN stations

Data and samples

The image data will be uploaded to PANGAEA and BIIGLE. After completion of analyses and publication, the results will be uploaded to PANGAEA and be fed into the marine litter portal LITTERBASE.

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3	Bensi	Manuel	OGS	Oceanographer
4	Biebow	Nicole	AWI	Yeoman
5	Carbonara	Katia	Uni Parma	Student apprentice
6	Caridi	Francesca	Uni Marche	Biologist
7	Daniel	Claudia	AWI	Technician, biology
8	De Vittor	Cinzia	OGS	Biochemist
9	Deponte	Davide	OGS	Technician, oceanograpy
10	Dominiczak	Aleksander	Uni Poznań	Student apprentice
11	Gamboa Sojo	Viviana María	Uni Pisa	Micropaleontologist
12	Graziani	Stefano	Uni Rome	Technician, oceanograpy
13	Gutow	Lars	AWI	Biologist
14	Hellmann	Sebastian	AWI	PhD student
15	Knüppel	Nadine	AWI	Technician, biology
16	Kondak	Konstantin	DLR	Engineer, robotics
17	Kovacevic	Vedrana	OGS	Oceanographer
18	Krauß	Florian	AWI	Student apprentice
19	Krüger	Martin	BGR	Geomicrobiologist
20	Langone	Leonardo	ISMAR	Oceanographer
21	Laterza	Roberto	OGS	Technician
22	Le Gall	Christophe	GIFT	High school teacher
23	Liu	Yangyang	AWI	PhD student
24	Lucchi	Renata Giulia	OGS	Sedimentologist
25	Maier	Moritz	DLR	Engineer, robotics
26	Mazzini	Adriano	Uni Oslo	Geochemist
27	Morigi	Caterina	Uni Pisa	Micropaleontologist
28	Musco	Elena	OGS	Student apprentice
29	NN		DWD	Meteorologist
30	NN		DWD	Technician, meteorology

No.	NAME	VORNAME/ FIRST NAME	INSTITUT/ INSTITUTE	BERUF/ PROFESSION
31	NN			PHINS SAT
32	NN			PHINS SAT
33	NN			PHINS SAT
34	NN			PHINS SAT
35	Povea	Patrizia	Uni Barcelona	Geochemist
36	Relitti	Federica	OGS	Biochemist
37	Richter	Klaus-Uwe	AWI	Engineer, biogeochemistry
38	Rogge	Andreas	AWI	PhD student
39	Rokitta	Sebastian	AWI	Biogeochemist
40	Ruggero	Livio	Uni Rome	Technician, oceanography
41	Rui	Leonardo	OGS	Student apprentice
42	Sabbatini	Anna	Uni Marche	Micropaleontologist
43	Sablotny	Burkhard	AWI	Engineer, biology
44	Salter	Ian	AWI	Biologist
45	Sánchez Guillamón	Olga	IEO Malaga	Student apprentice
46	Soltwedel	Thomas	AWI	Biologist
47	Stronzek	David	AWI	PhD student
48	Tagliaferro	Massimo	HITACHI	Technician
49	Tippenhauer	Sandra	AWI	Oceanographer
50	Topchiy	Maria	Uni Oslo	Geochemist
51	Wiberg	Daniel	Uni Tromsø	Geophysician
52	Wulff	Thorben	AWI	Engineer, biology
53	Zoch	Daniela	BGR	Geomicrobiologist

13. FAHRTTEILNEHMER / PARTICIPANTS

Longyearbyen - Tromsø

No.	NAME	VORNAME/ FIRST NAME	INSTITUT/ INSTITUTE	BERUF/ PROFESSION
1	Asendorf	Volker	MPIMM	Technician, biology
2	Becker	Stefan	MARUM	PhD student
3	Bergmann	Melanie	AWI	Biologist
4	Cisternas Novoa	Carolina	GEOMAR	Biogeochemist
5	Doble	Martin	Polar Scientific	Oceanographer
6	Fadeev	Eddi	MPIMM	PhD student
7	Fong	Allison	AWI	Biologist
8	Hagemann	Jonas	AWI	Student apprentice
9	Hargesheimer	Theresa	AWI	Technician, biology
10	Hasemann	Christiane	AWI	Biologist
11	Hellmann	Sebastian	AWI	PhD student
12	Hofbauer	Michael	AWI	Technician, biology
13	Hoge	Ulrich	AWI	Engineer, biology
14	Huchler	Marie	AWI	Student apprentice
15	Iversen	Morten	MARUM	Biogeochemist
16	Käß	Melissa	AWI	MSc student
17	Knüppel	Nadine	AWI	Technician, biology
18	Kondak	Konstantin	DLR	Engineer, robotics
19	Krauß	Florian	AWI	BSc student
20	Küber	Tim	AWI	Technician, biology
21	Lehmenhecker	Sascha	AWI	Engineer, biology
22	Lemburg	Johannes	AWI	Engineer, robotics
23	LeMoigne	Frederic	GEOMAR	Biogeochemist
24	Liu	Yangyang	AWI	PhD student
25	Lochthofen	Normen	AWI	Engineer, biology
26	Ludszuweit	Janine	AWI	Technician, biology
27	Maier	Moritz	DLR	Engineer, robotics
28	Metfies	Katja	AWI	Biologist
29	Niehoff	Barbara	AWI	Biologist
30	NN		AWI	Student apprentice
31	NN		AWI	Student apprentice

No.	NAME	VORNAME/ FIRST NAME	INSTITUT/ INSTITUTE	BERUF/ PROFESSION
32	NN		HeliService	Pilot
33	NN		HeliService	Pilot
34	NN		HeliService	Technician
35	NN		HeliService	Technician
36	NN		DWD	Meteorologist
37	NN		DWD	Technician
38	Offre	Pierre	MPIMM	Microbiologist
39	Piontek	Judith	GEOMAR	Biogeochemist
40	Rapp	Josephine	MPIMM	Microbiologist
41	Rogge	Andreas	AWI	PhD student
42	Salter	Ian	AWI	Biologist
43	Schewe	Ingo	AWI	Biologist
44	Scholz	Daniel	AWI	Technician, biology
45	Soltwedel	Thomas	AWI	Biologist, cruise leader
46	Stronzek	David	AWI	PhD student
47	Tekman	Mine	AWI	Biologist
48	Tippenhauer	Sandra	AWI	Oceanographer
49	Torres Valdes	Sinhue	NOCS	Biogeochemist
50	Vedenin	Andrey	AWI	Biologist
51	Wenzhöfer	Frank	AWI	Biogeochemist
52	Wischnewski	Laura	AWI	Technician, biogeochemistry
53	Wulff	Thorben	AWI	Engineer, biology

14. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
01.	Wunderlich, Thomas	Master
02.	Lauber, Felix	1.Offc.
03.	Heuck, Hinnerk	Ch.Eng.
04.	Spielke, Steffen	2.Offc.
05.	Kentges, Felix	2.Offc.
06.	Peine, Lutz	2.Offc.
07.	Scholl, Thomas	Doctor
08.	Hofmann, Jörg	Comm.Offc.
09.	0Schnürch, Helmut	2.Eng.
10.	Buch, Erik-Torsten	2.Eng.
11.	Rusch, Torben	2.Eng.
12.	Brehme, Andreas	Elec.Tech.
13.	Ganter, Armin	Electron.
14.	Dimmler, Werner	Electron.
15.	Winter, Andreas	Electron.
16.	Feiertag, Thomas	Electron.
17.	Schröter, Rene	Boatsw.
18.	Neisner,Winfried	Carpenter
19.	Clasen, Nils	A.B.
20.	Schröder, Norbert	A.B.
21.	Wittek, Sönke Fritz Ole	Trainee
22.	Hartwig-Labahn, Andreas	A.B.
23.	Kretzschmar, Uwe	A.B.
24.	Müller, Steffen	A.B.
25.	Brickmann, Peter	A.B.
26.	Sedlak, Andreas	A.B.
27	Beth, Detlef	Storekeep.
28.	Plehn, Markus	Mot-man
29.	Klein, Gert	Mot-man
30.	Krösche, Eckard	Mot-man
31.	Dinse, Horst	Mot-man
32.	Watzel, Bernhard	Mot-man
33.	Schulz, Fabian	Trainee
34.	Meißner, Jörg	Cook
35.	Tupy,Mario	Cooksmate
36.	Möller, Wolfgang	Cooksmate
37.	Wartenberg, Irina	1.Stwdess
38.	Schwitzky-Schwarz,	Stwdss/KS
39.	Carmen	
40.	Hischke, Peggy	2.Stwdess
41.	Duka, Maribel	2.Stwdess
42.	Krause, Tomasz	2.Steward
43.	Hu, Guo Yong	2.Steward
44.	Chen, Quan Lun	2.Steward