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Reports on Polar and Marine Research

The Expedition PS93.2 of the Research Vessel POLARSTERN to the Fram Strait in 2015

Edited by
Thomas Soltwedel
with contributions of the participants

HELMHOLTZ GEMEINSCHAFT

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Titel: Fotografie vom Meeresboden der Station HG-IV des LTER Observatoriums HAUSGARTEN (2.500 m Wassertiefe, OFOS). Kleiner 'dropstone', der mit Schwämmen (Caulophacus acticus, Cladorhiza cf. gelida) besiedelt und von weichem Sediment mit Seelilien (Bathycrinus carpenterii) und Seeanemonen umgeben ist.

Cover: Image of the seafloor taken at station HG-IV of the LTER observatory HAUSGARTEN (2,500m water depth, OFOS). Small dropstone colonised by sponges Caulophacus acticus and Cladorhiza cf. gelida surrounded by soft sediments with sea lilies (Bathycrinus carpenterii) and sea anemones.

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21 July 2015 - 15 August 2015

Tromsø – Tromsø

Chief scientist
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Coordinator
Rainer Knust

Contents

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Thomas Soltwedel
Alfred-Wegener-Institut

Der zweite Fahrtabschnitt der *Polarstern*-Expedition PS93 begann am 21. Juli 2015 in Tromsø (Norwegen), führte zum Tiefsee-Observatorium HAUSGARTEN in der Framstraße (ca. 78°30'N - 80°00'N, 05°00'W - 11°00'E) und endete am 15. August 2015 wiederum in Tromsø (Abb. 1.1). Die Reise dauerte insgesamt 24 Tage. Etwa 285 Std. (fast 12 Tage) wurden für Stationsarbeiten genutzt, die restliche Zeit wurde für die Anreise in das Untersuchungsgebiet, Transitstrecken zwischen den Stationen und die Rückreise von 79°N nach Tromsø benötigt. Die Expedition umfasste über 30 ozeanographische und biologische Stationen, an denen in der Regel jeweils eine Vielzahl von wissenschaftlichen Geräten eingesetzt wurde. Während der Expedition wurden ca. 1.800 Seemeilen zurückgelegt.

Die Forschungsaktivitäten während der *Polarstern*-Expedition PS93.2 stellten einen weiteren Beitrag zur Sicherstellung der Langzeitbeobachtungen am LTER (Long-Term Ecological Research) Observatorium HAUSGARTEN dar, mit denen der Einfluss von globalen Umweltveränderungen auf ein arktisches Tiefseeökosystem dokumentiert wird. Diese Arbeiten wurden in enger Zusammenarbeit zwischen 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 wurde darüber hinaus genutzt, um Installationen im Rahmen der HGF-Infrastrukturmaßnahme FRAM (FRontiers in Arctic marine Monitoring) vorzunehmen. Das FRAM Ocean Observing System wird kontinuierliche Untersuchungen von der Meeresoberfläche bis in die Tiefsee ermöglichen und zeitnah Daten zur Erdsystem-Dynamik sowie zu Klima- und Ökosystem-Veränderungen liefern. Daten des Observatoriums werden zu einem besseren Verständnis der Veränderungen in der Ozeanzirkulation, den Wassermasseneigenschaften und des Meereisrückgangs sowie deren Auswirkungen auf das arktische, marine Ökosystem beitragen. Im Rahmen des EU-Infrastrukturprojekts FixO3 (Fixed-point Open Ocean Observatories) gewährte die Expedition zudem europäischen Partnern den Zugang zum FRAM Ocean Observing System sowie logistische Unterstützung bei der Umsetzung externer und gemeinsamer Forschungsprojekte.

Während der technisch und logistisch sehr aufwendige Expedition PS93.2, kamen neben den „klassischen" Geräten der Tiefseeforschung (z.B. Wasserschöpfer, Planktonnetze, Sedimentprobennehmer, Verankerungen, Freifallgeräte) auch ein großes ferngesteuertes Unterwasserfahrzeug (Work-Class Remotely Operated Vehicle, ROV), ein autonomes Unterwasserfahrzeug (Autonomous Underwater Vehicle, AUV) sowie autonome unbemannte Fluggeräte (Unmanned Aerial Vehicles, UAVs) zum Einsatz.

Durch die effektive Zusammenarbeit zwischen den wissenschaftlichen Arbeitsgruppen und der Schiffsbesatzung, und begünstigt durch das überwiegend gute Wetter, verlief die Expedition PS93.2 insgesamt sehr erfolgreich.

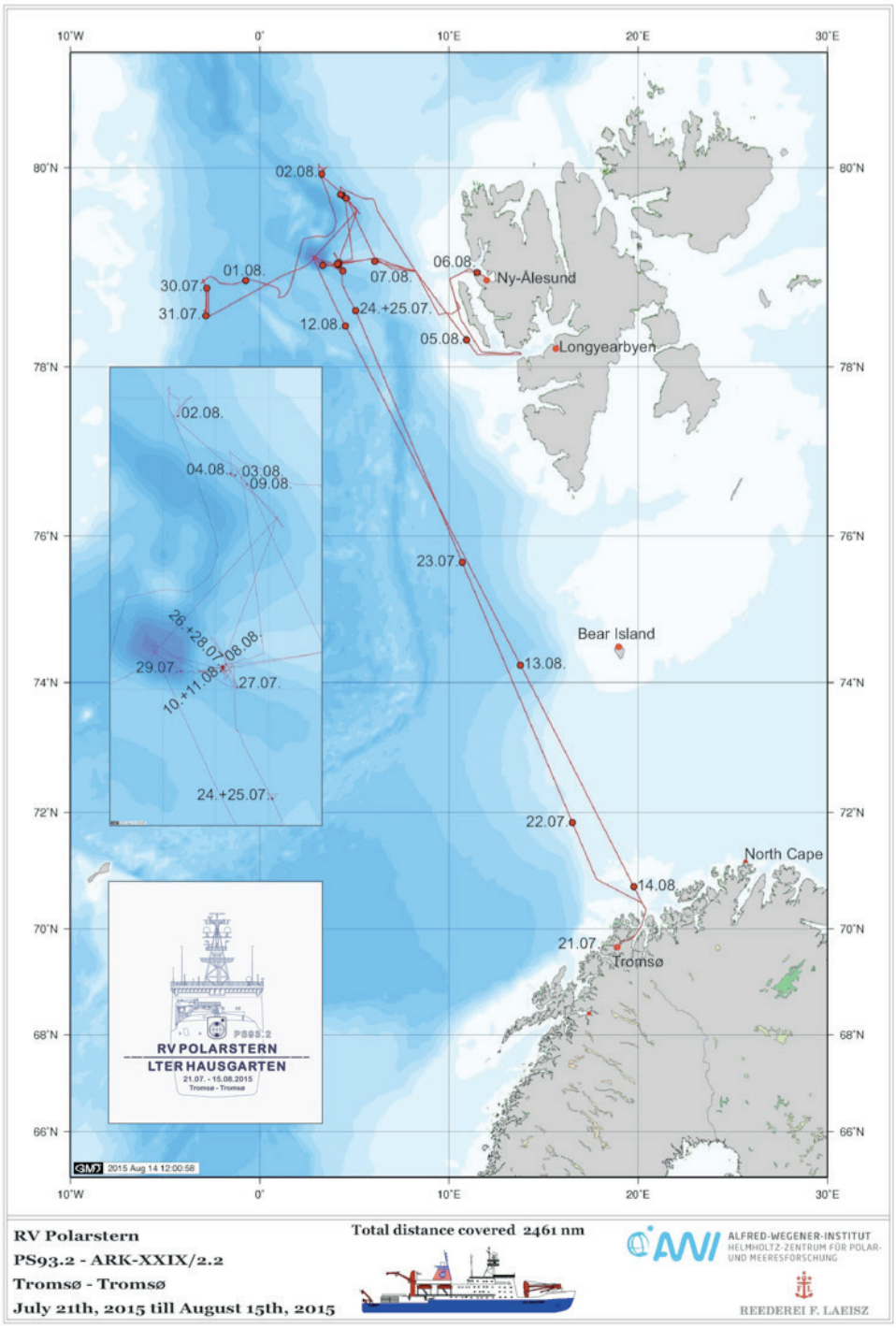

Abb. 1.1: Kursplot der Polarstern-Expedition PS93.2 (21.07.-15.08.2015).

Fig. 1.1: Course plot of Polarstern expedition PS93.2 (21.07.-15.08.2015).

ITINERARY AND SUMMARY

The second leg of the *Polarstern* expedition PS93 to the Arctic started on 21st July 2015 in Tromsø (Norway) and ended on 15th August 2015, again in Tromsø (Fig. 1.1). The cruise led to the deep-sea observatory HAUSGARTEN in the Fram Strait (approx. 78°30'N - 80°00'N, 05°00'W - 11°00'E). The total duration of the expedition was 24 days; about 285 hours (almost 12 days) were spent for station work. The remaining time was used to reach the study area, for steaming between individual stations, and for the transit from 79°N back to Tromsø. More than 30 stations were sampled, thereby usually deploying several scientific instruments per site. The total length of the expedition was approx. 1,800 nautical miles.

The scientific work during expedition PS93.2 supported 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 was 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 AWI and the MARUM - Center for Marine Environmental Sciences at the University of Bremen.

The expedition was also 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. Within the framework of a 'Trans-National Access' (TNA) initiative of the European project FixO3 (Fixed-point Open Ocean Observatories), the expedition provided access to the FRAM Ocean Observing System thereby supporting external and joint scientific projects logistically.

Beside the more "traditional" instruments used for marine research (e.g. water sampler, plankton nets, sediment sampler, moorings, bottom-lander) we operated a deep-diving Work-Class Remotely Operated Vehicle (ROV) as well as an Autonomous Underwater Vehicle (AUV) and different autonomous Unmanned Aerial Vehicles (UAVs) during the overall technically and logistically very challenging expedition.

The effective cooperation between the scientific party and the ship's crew, in combination with perfect weather conditions during most times of the cruise, made this expedition a great success.

2. WEATHER CONDITIONS

Dipl.-Met. Julia Fruntke, Juliane Hempelt DWD

Polarstern left Tromsø in the evening of July 21, 2015 for an expedition to the LTER observatory HAUSGARTEN. A ridge of high pressure originating from Greenland was stretching towards North Cape while an intense low was situated over the Barents Sea. In Tromsø, the sun was shining and north-easterly wind of 4-5 Beaufort was measured. Over the open water, a strong wind of 5-6 Bft from northeast was blowing the next morning. It was backing a little and with the low approaching the sailing area until Thursday evening (July 23) the wind increased to 6-7 Bft. A significant wave height of 3.5 m was estimated.

We reached our first research station on Friday morning (July 24). The front of the low which was already close east of Svalbard had passed our route during the night. The north-westerly wind decreased from 6 to 5 Bft.

During the weekend the weakening low moved from Svalbard towards the north of Greenland. The pressure started to rise and a ridge evolved stretching from the Laptev Sea to HAUSGARTEN. The wind speed decreased to 3 Bft and backed from northwest to south.

On Friday another intense low started its way from Northern Germany across southern Sweden and the Lofoten Islands reaching the Norwegian Sea on Monday morning. The gradient increased only south of the research area and *Polarstern* remained under high pressure influence with southerly wind of 4, later 3 Bft. The front of that low crossed HAUSGARTEN not before Tuesday noon (July 28). While the wind from northeast to north increased to 5 Bft it started to rain a little bit and the swell increased to 2 m from southeast. Until Thursday the pressure rose originating from a ridge of high pressure between the Laptev Sea and Greenland. Even with south-easterly winds of 4-5 Bft fog formed in the humid boundary layer. On the southern flank of the ridge dry air was advected towards HAUSGARTEN, which reached the sailing area only Friday afternoon (July 31).

From Friday until Monday (August 3) high pressure was present between Greenland and the Kara Sea, while low pressure influenced the weather over northern Europe. In that dry air mass the sun was shining and the north-easterly wind proceeded to decrease. Monday evening Svalbard was visible at the horizon over 50 nm away. During the following night the light wind backed to southerly directions and on the forward flank of a low close to the Hebrides warm and humid air reached the sailing area while fog formed.

During Wednesday (August 5) a ridge of low pressure developed between the Arctic north of Canada and the Faroes in which several weak lows were embedded in the periphery of *Polarstern*. With south-easterly winds of 3-5 Bft cold and humid air was advected until Thursday. The visibility differed from good below low clouds to very bad in fog. On the southern flank of one low, which passed Svalbard on its western border, a confused sea of about 1.5 m temporarily developed during Wednesday evening.

After a short impact of high pressure on Friday (August 7th) mild and humid air was advected towards the sailing area on the forward flank of a low at Jan Mayen on Saturday. This was expressed by low clouds, light rain, increasingly bad visibility reaching foggy conditions after

noon until midnight, south-easterly wind of 4-5 Bft, and sea/swell of about 1.5 m. Sunday the occlusion of the low which had already moved to the Greenland Sea passed *Polarstern*. The visibility felled below 4 km in moderate to fresh wind from southeast.

During Monday (August 10) the ship was in between two ocean currents – the cold East-Greenland current and the warm arm of the Gulf Stream and *Polarstern* had to reckon with fog. On Tuesday the easterly wind increased to 5 Bft in front of the occlusion of another low close to Jan Mayen. On the rear side the wind veered to the south and decreased to 3 Bft while the swell rose up to 2 m. Then again fog developed in the warm and humid air.

On Wednesday (August 12) *Polarstern* was on its way to Tromsø. In the lee of Svalbard a cloud-free area developed in easterly winds during the afternoon which grew bigger until the evening. During the night to Thursday many passengers enjoyed the last midnight sun for this cruise in wind from east of 4 Bft. Meanwhile, an intense low moved from the Lofoten Islands towards Bear Island, which crossed *Polarstern*'s route on Thursday. In north-easterly winds of 6-7 Bft wind-sea rose up to 2 m while swell additionally brought 2 m from east. During Thursday the intense low south of Bear Island weakened. The wind backed to northwest and decreased to 4-5 Bft.

Late Friday evening (August 14) we entered Tromsø. The sky was cloudy with few showers and north-easterly wind of 3-4 Bft.

Further weather statistics are shown in Fig. 2.1.

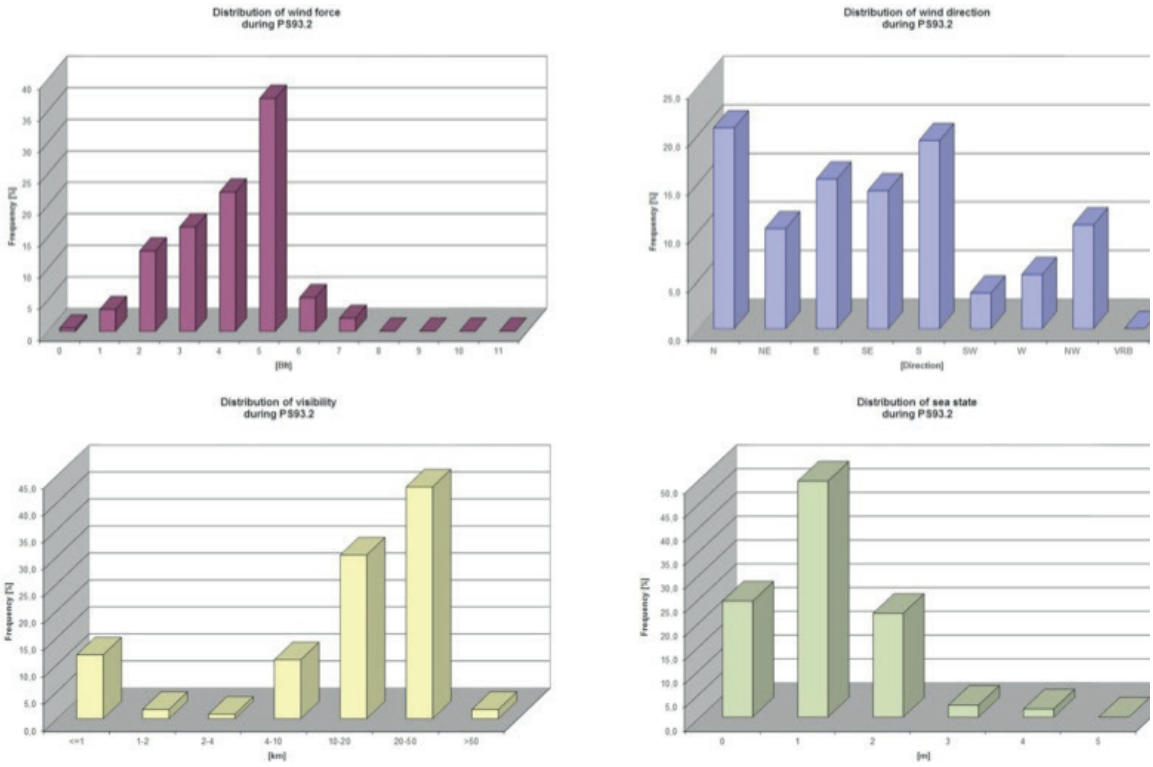

Fig. 2.1: Statistics of various weather parameters

3. IMPACT OF CLIMATE CHANGE ON THE ARCTIC MARINE ECOSYSTEM (LTER HAUSGARTEN)

Deep-Sea Research Group Coordination Ingo Schewe AWI

Grant No: AWI_PS93.2_01

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 the expanding ocean acidification will pose another threat to pelagic and benthic life in the Arctic Ocean.

To detect and track the impact of large-scale environmental changes in the transition zone between the northern North Atlantic and the central Arctic Ocean, and to determine experimentally the factors controlling deep-sea biodiversity, the Alfred-Wegener-Institute Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) established the LTER (Long-Term Ecological Research) observatory HAUSGARTEN in the Fram Strait. Since 2014, this observatory has successively extended within the frame of the HGF financed infrastructure project FRAM (Frontiers in Arctic marine Monitoring). Currently, HAUSGARTEN covers 21 permanent sampling sites on the West-Spitsbergen and East-Greenland slope at water depths between 250 and 5,500 m (Fig. 3.1). Research activities during *Polarstern* expedition PS93.2 on the East-Greenland slope also contributed to the BMBF financed project “TRANSDRIFT (System Laptewsee)”, as this region represents the end member of the Transpolar Drift, which is in focus of the TRANSDRIFT project.

HAUSGARTEN sites were sampled with water samplers and an Autonomous Underwater Vehicle (AUV) to assess water column properties (see Chapters 3.1). At selected sites, long-term moorings equipped with sediment traps, RCMs and self-recording CTDs, additionally equipped with *in-situ* water samplers and nutrient analysers, were used to collect settling particles and record the hydrographic conditions throughout the mooring period (see Chapter 3.2). Benthic respiration rates and biogeochemical processes at the sediment-water interface were studied by means of free-falling instruments (Chapter 3.3). A video-guided multiple corer was used to assess benthic organisms of different size classes and to analyse the activity and biomass of the small sediment-inhabiting biota (see Chapters 3.4 and 3.5). Large-scale distribution patterns of epi/megafauna were assessed by using a towed photo/video system (Ocean Floor Observation System, OFOS) (see Chapter 3.6). A Remotely Operated Vehicle

(ROV) was used to sample previously established biological *in-situ* long-term experiments at the seafloor (see Chapter 3.7).

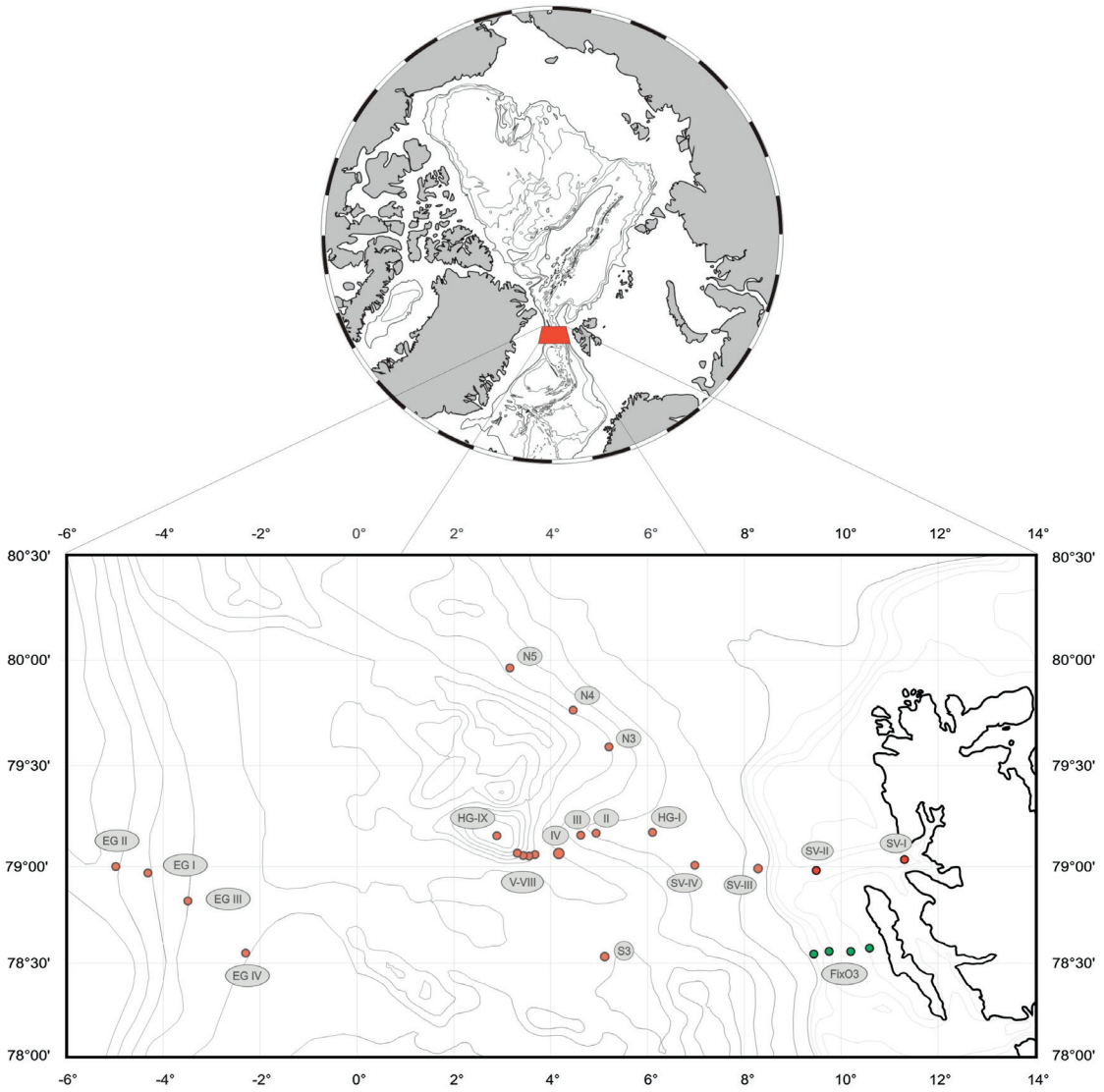

Fig. 3.1: Permanent sampling sites at the LTER observatory HAUSGARTEN (red circles) and additional stations (green circles) sampled within the frame of the European infrastructure programme FixO3 (Fixed-point Open Ocean Observatories)

3.1. Surface-water studies using an Autonomous Underwater Vehicle (AUV)

Thorben Wulff[1], Sascha Lehmenhecker[1], Kimberly Shurn[1], Sandra Tippenhauer[1], Jonas Hagemann[1], Tobias Mikschl[2], Michael Strohmeier[2]

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Objectives

Starting in 2008/2009, the Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (AWI) has regularly deployed an Autonomous Underwater Vehicle (AUV) to investigate biogeochemical processes in the upper water column of the Marginal Ice Zone (MIZ). The interaction between physics, chemistry and biology is in the focus of our investigations

Fig. 3.1.1: Deployment of the Autonomous Underwater Vehicle

During the Arctic campaign in 2013 (*Maria S. Merian*, MSM29), the AUV accomplished several dives in the MIZ of the Fram Strait. Along the melt water front, structures indicating small-scale transport processes were discovered. Such structures have never been observed before. As these transport processes had the potential to supply the surface waters with nutrients, they are of ecological relevance. To understand the dynamic and controlling mechanism of these small scale processes further investigation was needed.

Based on the experiences in 2013, both the scientific payload of the AUV and the MIZ observation program were generally extended. An Acoustic Doppler Current Profiler (ADCP) was integrated into the vehicle for simultaneous observations of the prevailing currents, temperatures, and various biogeochemical parameters. To be able to assess the atmospheric influence on the MIZ, detailed information regarding the ice conditions are important and thus, ice surfaces were mapped via helicopter-mounted cameras. For future expeditions, tasks such as mapping the ice will be commissioned to Unmanned Aerial Vehicles (UAVs). For testing purposes, prototypes of these devices developed by the University Würzburg were operated in the Arctic during the recent expedition. These were the first test flights of the UAVs developed in the context of the project ROBEX.

As a consequence, there were scientific and technological objectives in the framework of the AUV project during the *Polarstern* expedition PS93.2:

Scientific objectives:

- Investigating the water column at a melt water front to a depth of 50 m and detecting the micro-stratification of the water column.
- Determining the distribution of nutrients and the concentration of phytoplankton and dissolved oxygen. Measuring physical parameters such as temperature and salinity.
- Measuring water currents at a melt-water front using an AUV mounted ADCP.
- Determining relevant ice related parameters such as drift velocity, direction of drift and surface topography.
- Recording relevant surface parameters such as wind velocity and intensity of solar radiation.

Technological objectives:

- UAV operations at high latitudes, including camera controlled take-off and landing on *Polarstern* and ice floes, and camera controlled flights beyond visual range.

Work at sea

During the expedition the AUV conducted three dives (Table 3.1.1), with the first dive being a merely technological test dive.

Tab. 3.1.1: Overview on AUV missions accomplished during PS 93.2

Dive No.	Latitude	Longitude	Date [dd.mm.yy]	Duration [hh:mm]	Distance [km]	Samples
1	78° 54.74' N	0° 43.63' W	01.08.15	05:16	19.6	5
2	79° 56.28 'N	3° 17.02' E	02.08.15	05:14	15.7	14
3	79° 4.71' N	4° 6.83' E	11.08.15	01:19	5.9	0

Dive 1

The first dive was conducted to check main vehicle systems. Running six short transects of 800 m in length and in 50 m water depth, basic vehicle functions and different ADCP settings were tested. Furthermore, short transects in which the vehicle was supposed to maintain defined pitch angles provided data on the control dynamics of the vehicle. This test was important as the ADCP is a rather heavy instrument, significantly changing the mass properties of the AUV. Two more missions of 30 and 40 min were conducted to determine the response time of the vehicle's pCO_2 sensor and to collect a first set of water samples.

After this dive had been accomplished, the vehicle was recovered with minor problems as a tag line was wrapped around the ADCP. Due to a programming error, only five instead of 22 water samples were collected.

Dive 2

The first scientific dive of the AUV was conducted on August 2nd north of the HAUSGARTEN station N5 (Fig. 3.1). To prepare the dive and determine the deployment position, *Polarstern* located the melt water front. As the ship approached the ice, temperature and salinity values steeply dropped – clearly marking the position of the melt-water front. After the front has been

crossed once again further east, not just the position but also the orientation of the front could be identified rather precisely (Fig. 3.1.1).

The AUV was deployed approx. 4 – 5 km off the melt water front. While covering a 10 km-long transect perpendicular to the front, the vehicle intermittently varied its depth between 50 and 3 m to record high resolution profiles of the water column. Vertical profiles were recorded applying the float manoeuvre where the vehicle´s thruster is deactivated at a certain position – making it behave like a float and slowly ascending towards the surface with a speed of 10 – 20 cm s^{-1}. Interpolating between the floats, the water column can be studied as a cross section. Due to issues with deploying the GAPS acoustic tracking system, there was no contact to the vehicle most of the time and the mission was run unattended. After the dive the vehicle was recovered without any problems. A total of 14 water samples were collected during this dive.

Dive 3

The third dive was conducted on August 11th close to the central HAUSGARTEN station (HG-IV) and was supposed to be a repetition of the previous dive. As this dive was executed far from the ice, it was intended to provide data of a water column unaffected by the presence of ice. Thus the data could have served as a comparative case. Unfortunately, the dive had to be aborted due to time constraints and only less than half of the intended programme could be accomplished. The collection of water samples had to be cancelled.

The recovery of the vehicle turned out to be problematic as the vehicle started to swing when it was lifted by the crane. Swinging was caused by a relatively high sea state and a rather long crane arm. Fortunately, the vehicle remained undamaged.

Samples

Handling and processing of the samples were done in a laboratory cooled down to 2 – 4°C, so that the temperature of the samples does not change between the collection and preservation. 8 ml of each sample are used to determine the content of nitrate. To be able to calibrate the fluorometer, the rest of each sample was filtered and the amount of chlorophyll *a* on the filters will be measured at the AWI. For this purpose, the filters are frozen at -20°C and are transported to Bremerhaven in cold storage.

Ice survey

Within the framework of ice survey flights, a total number of six flights was conducted. The first two flights were conducted to test the cameras and their settings. During the remaining four flights the ice was mapped. The helicopter was flying ‘mattresses’ maintaining altitude of 300 feet and speed of 100 knots.

Two automatic cameras took high resolution images, one image per second for each camera. Taking images of *Polarstern* from the same altitude provided a scale for the images.

Flight tests UAVs

First tests of the UAVs were done on the helicopter pad of *Polarstern* to determine the ship´s influence on the navigation. At a later point, the UAVs were tested on the ice to provide an environment free of magnetic disturbances, caused by the ship’s hull. Furthermore different sensors measuring the altitude over the ice needed to be tested as the UAVs are supposed to land on the ice autonomously in the future.

Preliminary results

Autonomous Underwater Vehicle

The melt-water front was clearly identified by a temperature difference of 3 K (Fig. 3.1.2). At the second crossing of the front, the temperature gradient was extremely steep – possibly indicating that *Polarstern* did not cross the front perpendicularly during the first crossing.

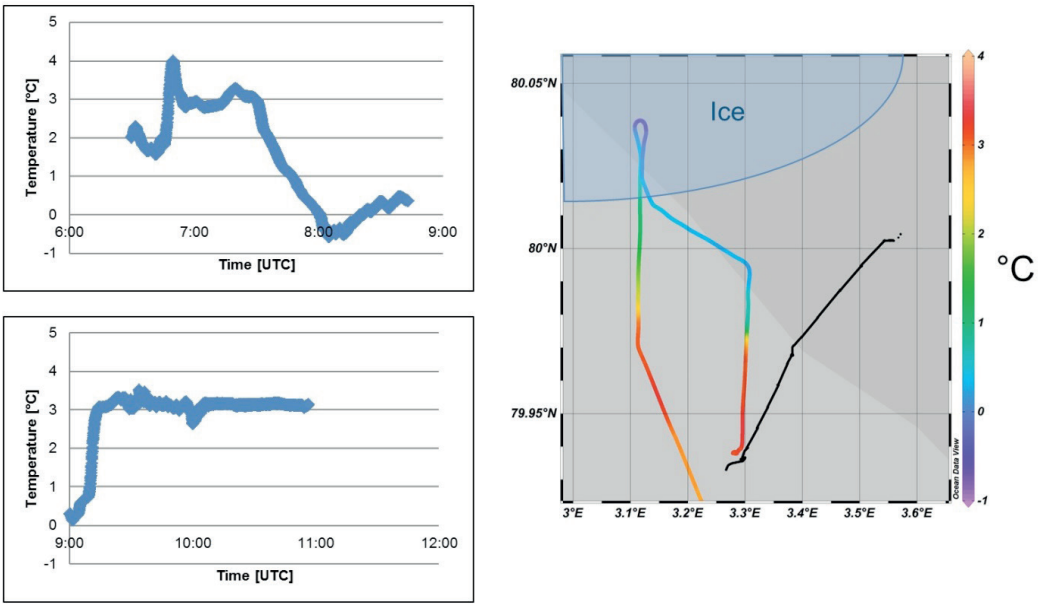

Fig. 3.1.2: Temperature observed during first (left top) and second (left bottom) crossing of the front by Polarstern; Map of the Polarstern track while searching for the front (right); Position of the front (broken red line) marked by large temperature gradient; Track of AUV dive 2 indicated in black

In the AUV data, the front can be seen as the transition zone between a warmer water body of 3 - 4°C and a colder water body of 1.5°C. The temperature minimum of the cold water layer was found between 20 and 30 m water depth. Prominent features are spots of warm water (5°C, at 3 km section distance) and cold water respectively (-0.5°C, at 9 km section distance) (Fig. 3.1.3). Conductivity, which is a proxy for salinity, shows a similar pattern (data not shown).

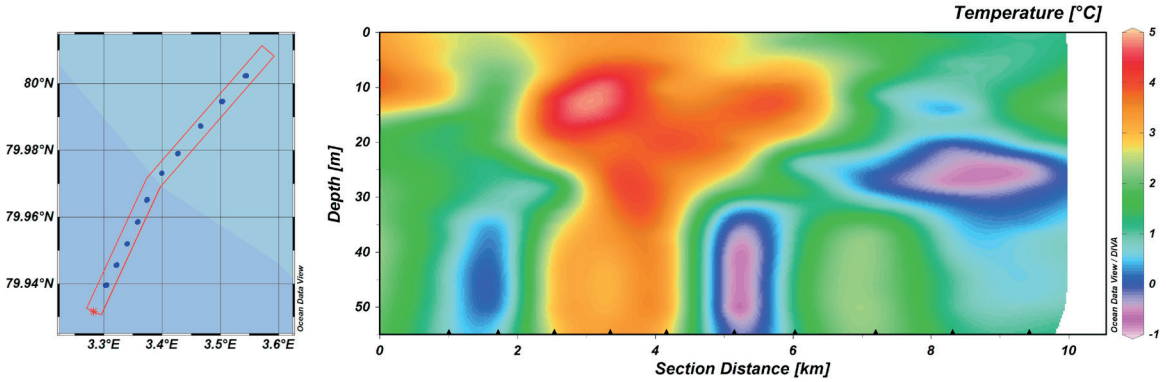

Fig. 3.1.3: Map showing the AUV transect covered during dive 2 (left); temperature observed by the AUV-CTD (right); black triangles indicate the positions of the float

The concentration of chlorophyll *a* (Fig. 3.1.4; here given as raw voltage data of the fluorometer) showed no correlation to the position of the front. The chlorophyll concentration seems to be slightly increased above 25 m water depth, yet a “classical” fluorescence maximum cannot be identified. In two small areas on the cold side of the front, the Chl. *a* concentrations appear to

be elevated. However, as the water samples are not yet analysed, the fluorometer data are so far not calibrated and values cannot be quantified.

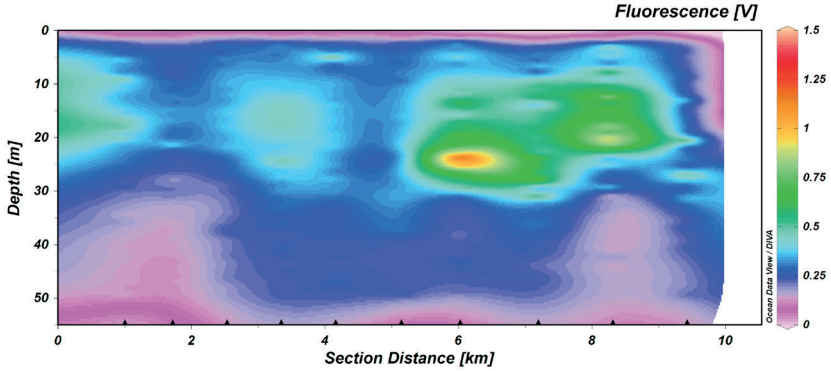

Fig. 3.1.4: Fluorescence observed by the AUV during dive 2; black triangles indicate the positions of the floats

The nitrate concentration was reduced above 25 m water depth (Fig. 3.1.5). Additionally, a funnel-like structure can be seen at 4 km section distance. The structure most likely indicates sinking surface water which is low on nitrate. Next to this feature, “domes” of increased nitrate concentrations can be identified near 2 and 5 km distance.

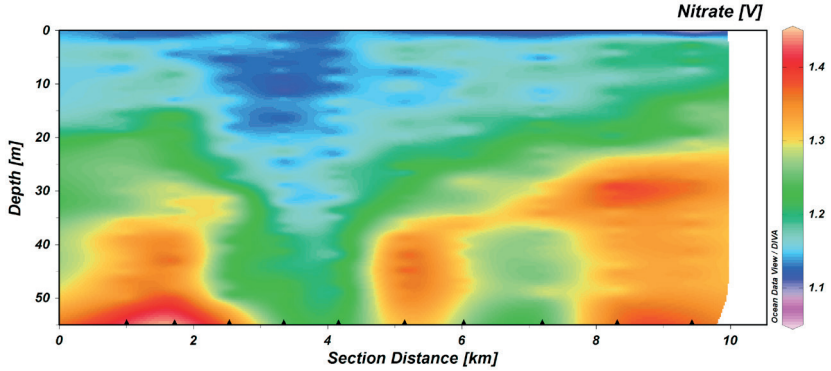

Fig. 3.1.5. Nitrate concentrations observed by the AUV during dive 2; black triangles indicate the positions of the floats

Similar structures have already been observed during our studies in 2013. As a preliminary result it might be assumed that these structures are a common feature created by physical processes at the melt water front. Using the entire data set which was collected during the expedition including atmospheric- and ice-parameters as well as ship- and, AUV-based observations, this question is to be worked on in the coming months.

Ice survey with the helicopter

In the course of the ice survey flights 481 km² ice and ocean surface were mapped (Fig. 3.1.6). For the applied flight parameters and camera settings, the smallest recognizable objects are about 7 cm in size. As the surface roughness of the ice will be derived from the length of the shadow of the respective object, this resolution is sufficient to resolve the surface topography down to the scale of centimetres.

Flight tests with Unmanned Aerial Vehicles (UAVs)

Testing the UAVs (Fig. 3.1.7) clearly demonstrated that using the earth´s magnetic field for navigation purposes at high latitudes is no promising approach. As the magnetic field lines are

almost perpendicular to the ground in high latitudes, the horizontal component is small and easy to disturb. Consequently, determining its orientation is a very challenging task for an UAV. Additionally, in the vicinity of a ship, the magnetic field is refracted in an unpredictable way. For these reasons, reliable autonomous flights were unfeasible during the expedition in ship vicinity. However, an autonomous flight on ice was possible. The collected data will enter the further development process.

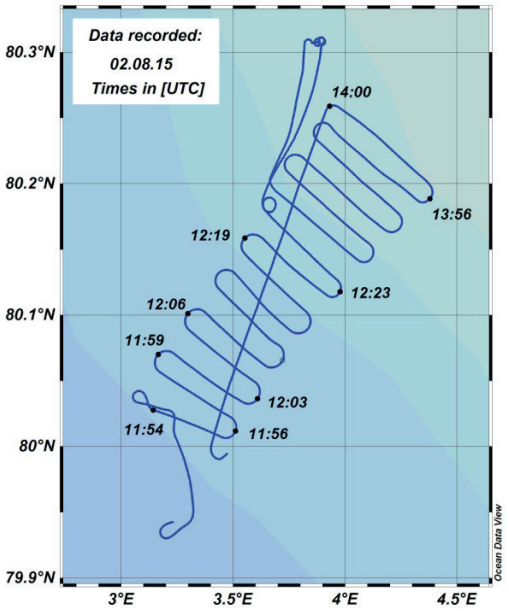

Fig. 3.1.6: Exemplary map of an ice survey flight conducted on August 2nd in parallel to AUV dive 2

Fig. 3.1.7: Flight tests with an Unmanned Aerial Vehicle (UAV)

Data management

As soon as the AUV data is completely processed they will be made publicly available by storing them on the PANGAEA database. Exceptions are made in case of the ADCP data and the ice survey images. As these two projects are still in an experimental stage, submitting the data to PANGAEA is not planned for the nearer future. Data of the UAV flight tests are courtesy of the University Würzburg and publication is subject to the legal regulations of the University.

3.2 Sedimentary processes and interactions

Eduard Bauerfeind, Normen Lochthofen, Janine Ludszuweit, Burkhard Sablotny, Ian Salter | AWI

Objectives

The transfer of organic matter from the upper productive layer in the water column to the bottom of the ocean is one of the key processes that facilitate life at the seafloor, as organisms living in the deep sea mainly live on the organic matter that sinks out of the productive layer and finally reaches the deep seafloor. Measurements of settling particles are performed by means of year-round moored sediment traps that provide information on the quantity and seasonality of vertical particle flux. The moorings are also equipped with current meters (RCMs) and self-recording CTDs to gain information on the hydrographic conditions in the study area. Results obtained by these instruments are of major importance for the interpretation of the results derived by the sediment traps, as the settling particles can be transported over long distances before arriving at the seabed.

Work at sea

During the *Polarstern* cruise PS93.2, several moorings as well as a benthic lander carrying sediment traps were exchanged in eastern and western parts of the Fram Strait (Table 3.2.1). All recovered instruments worked satisfactorily. In addition to the above mentioned instruments automatic water samplers were installed at approx. 80 m water depth in the moorings FEVI-32 and TD-2015-LT (Table 3.2.1). The mooring deployed at the northern HAUSGARTEN site N4 (FEVI-31) was equipped with a new type of bio-optical platform, consisting out of a modified sediment trap and a camera system (see Chapter 5).

Tab. 3.2.1: Station data of moorings and free-falling systems recovered and deployed during *Polarstern* cruise PS93.2

Recoveries of moored instruments during PS93.2:						
Deployed	**Station ID**	**Gear**	**Latitude**	**Longitude**	**Depth [m]**	**Comment**
20.06.2014	PS85.0450-1	Mooring	78° 36.68' N	2° 52.84' W	2445	TD-2014-LT
20.06.2014	PS85.0453-1	Mooring	78° 31.69' N	2° 45.87' W	2535	TD-2014-ST
20.06.2014	PS85.0452-1	Mooring	78° 33.84' N	2° 45.10' W	2518	McLane Moored Profiler
23.06.2014	PS85.0462-1	Mooring	79° 00.24' N	4° 24.76' E	2517	FEVI-30
25.06.2014	PS85.0472-1	Mooring	79° 44.87' N	4° 16.78' E	2618	FEVI-29
29.06.2014	PS85.0489-1	Mooring	78° 51.32' N	4° 21.98' E	2443	McLane Moored Profiler
26.06.2014	PS85.0478-1	Lander	79° 04.16' N	4° 04.59' E	2495	Long-term Bottom-Lander
Deployments of moored instruments during PS93.2 (recovery planned for summer 2016):						
Deployed	Station ID	Gear	Latitude	Longitude	Depth [m]	Comment
30.07.2015	PS93.0058-3	Mooring	78° 50.11' N	2° 47.96' W	2536	TD-2015-LT
09.08.2015	PS93.0079-1	Mooring	79° 44.39' N	4° 30.36' E	2716	FEVI-31
11.08.2015	PS93.0083-1	Mooring	79° 00.43' N	4° 19.92' E	2605	FEVI-32
11.08.2015	PS93.0084-1	Lander	79° 04.74' N	4° 06.58' E	2497	Long-term Bottom-Lander

Preliminary results

At present there are only a few Preliminary results from the moorings recovered at HAUSGARTEN observatory. A first overview on sedimentation patterns can be obtained by visible inspection of the amount of material collected in the sampling bottles (Fig. 3.2.1).

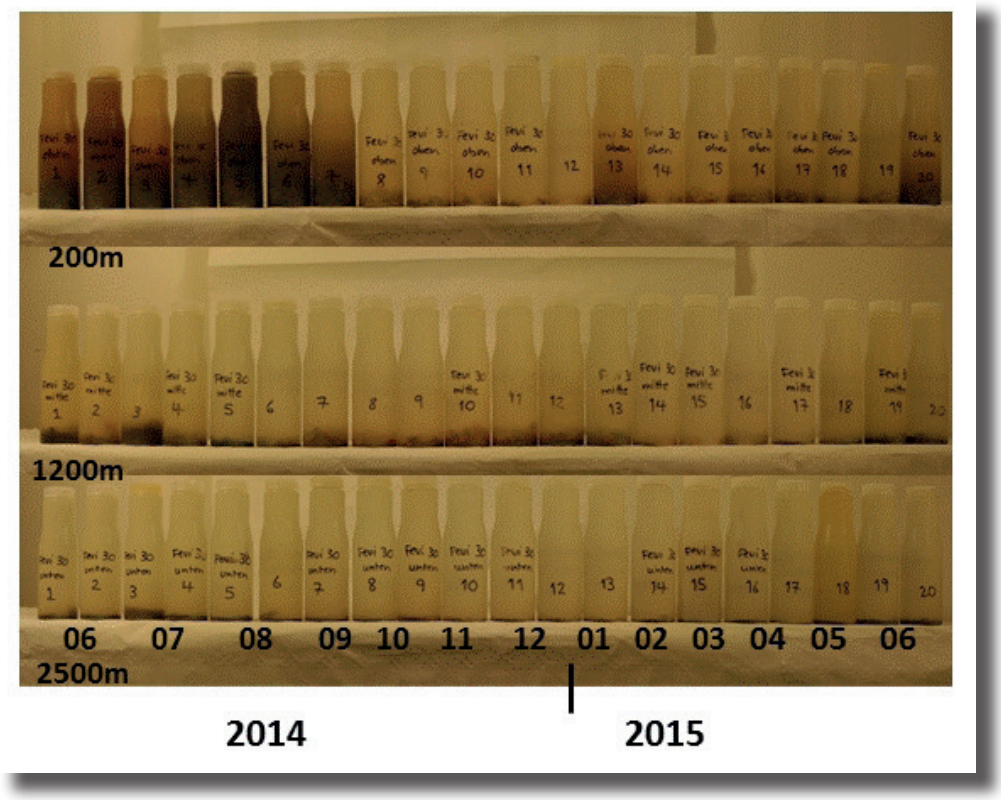

Fig. 3.2.1: Sampling jars of annually moored sediment traps in different depths at the central HAUSGARTEN station HG-IV from 06/2014 until 06/2015

As an example, this figure shows the sampling jars of the sediment traps in 3 different depths at the central HAUSGARTEN station HG-IV. A seasonal pattern in sedimentation can be deduced, with larger amounts of material in the sampling jars during the beginning of the sampling period July to September 2014. After this period sedimentation seemingly diminished and stayed at a low level till June 2014 when sedimentation increased again. Highest sedimentation was present at the shallow traps and diminished with depth, however the seasonal pattern can also be traced to greater depths. A similar pattern of the settled particulate matter in the collector cups is present in the sediment trap material from the western part of Fram Strait (not shown here); however the amount of collected matter is much less than at the central HAUSGARTEN site. More profound results on sedimentation, the quantity and composition of the settled matter will be obtained only after detailed, chemical, biochemical and microscopic analyses of the samples in the land based laboratory.

Data management

The finally processed data will be submitted to the PANGAEA data library. The unrestricted availability from PANGAEA will depend on the required time and effort for acquisition of individual datasets and its status of scientific publication.

3.3. Benthic respiration rates and biogeochemical fluxes

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Frank Wenzhöfer[1] (not on board) [3]MPIMM

Objectives

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. 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).

Work at sea

Benthic carbon mineralization was studied *in-situ* at two sites (HAUSGARTEN HG-IV at 2,500 m, and HG-I at 1,280 m), as well as *ex-situ* along the HAUSGARTEN depth gradient (from 2500 m to 1,280 m water depth) extended to Kongsfjorden (1,300 m and 275 m) and two sites close to the ice edge (Eastern Greenland and HAUSGARTEN N5 at 2,500 m) (Table 3.3.1). The benthic O_2 uptake is a commonly used measure for the total benthic mineralization rate. We measured benthic oxygen consumption rates at different spatial and temporal scales. A benthic lander was equipped with different instruments to investigate the oxygen penetration and distribution as well as the oxygen uptake of the arctic sediments: (1) Microprofiler, for high-resolution pore water profiles (O_2, T, conductivity) to quantify diffusive oxygen uptake (DOU), which is generally assigned to microbial respiration. The microprofiler was equipped with eight oxygen sensors as well as a temperature and a conductivity sensor. The measurements across the water-sediment interphase were performed with a vertical resolution of 100 µm and a total length of 9 cm. During the deployments the microprofiler performed four vertical profiles separated by 10 cm. (2) Three benthic chambers measured total oxygen uptake (TOU) and nutrient exchange of the sediment integrating all relevant solute transport processes (diffusion, advection and fauna-mediated transport) and an area of 400 cm². During the deployment an oxygen optode measured changes in oxygen concentration and 7 syringes took water samples in pre-programmed time intervals for analyses of nutrients. The overall benthic reaction was followed by measurement of sediment community oxygen consumption to calculate carbon turnover rates.

Using a multiple corer (MUC), sediment samples were used to measure on board gradients and fluxes. Furthermore we added a bromide tracer to the *ex-situ* experiments to quantify bio-irrigation. From the sediments recovered from the benthic chambers and MUC cores, subsamples were taken to quantify microbial and meiofauna biomass and the larger macrofauna was sieved out. We will identify these organisms in the laboratory and try to relate their functional biodiversity (how they bioturbate) to the fluxes observed.

At central the HAUSGARTEN station HG-IV, a long-term exclusion experiment was set up in the past by installing cages on the seafloor. These allow horizontal inflow but exclude vertical food input from the photic zone. Sediment samples from inside the cages and, for comparison, of unaffected seafloor were taken by the Remotely Operated Vehicle (ROV) “Quest 4000”. To study the influence of the exclusion on the oxygen flux high-resolution profiles of the oxygen concentration over the water-sediment-interface were measured on board to calculate the DOU.

Tab. 3.3.1: Location of stations sampled with a video-guided multiple corer (MUC) and Benthic Chamber Lander (BL_C)

Station ID	Date	Gear	Latitude	Longitude	Water Depth [m]	Comment
PS93.0050-1	23.07.15	BL_C	79° 4.98' N	4° 20.23' E	2277.5	deployment lander at HG-IV
PS93.0050-18	25.07.15	BL_C	79° 5.27' N	4° 19.67' E	2277.5	recovery lander at HG-IV
PS93.0050-19	27.07.15	MUC	79°3.914´N	4°10.791 E	2465	HG-IV
PS93.0058-12	31.07.15	MUC	78°51.733´N	2°42.611 W	2592	EG-IV (new)
PS93.0058-17	31.07.15	MUC	78° 54.88' N	2° 57.71' W	2500	EG-IV (old)
PS93.0060-10	03.08.15	MUC	79°56.295' N	03°11.588' E	2546	N5
PS93.0066-2	06.08.15	MUC	79°01.718' N	11°05.230' E	275	SV-I
PS93.0074-3	08.08.15	MUC	79° 01.782' N	07° 00.016' E	1304	SV-IV
PS93.0075-1	08.08.15	BL_C	79° 8,06' N	6° 5,56' E	1282.2	deployment lander at HG-I
PS93.0077-2	09.08.15	MUC	79° 06.478' N	04° 36.019' E	1915	HG-III
PS93.0078-2	09.08.15	MUC	79° 07.811' N	79° 07.811' N	1549	HG-II
PS93.0080-8	10.08.15	BL_C	79° 8,01' N	6° 5,97' E	1282.2	recovery lander at HG-I
PS930.080-9	10.08.15	MUC	79° 08.335' N	06° 05.028' E	1289	HG-I

Preliminary results

Both diffusive (DOU) and total oxygen uptake (TOU) seem to decrease with water depth. At least for HG-I (~1,250 m), *in-situ* and *ex-situ* measurements agree very well. At HG-IV (~2,500 m), DOU rates seem similar, whereas TOU estimated from the *ex-situ* measurements seems to be somewhat higher than the *in-situ* estimates. EG-IV and N5 are the two stations located closely to the current ice edge. However, TOU and DOU at these stations resemble the rates at 2,500 m stations located far from the current ice edge.

First analyses of the DOUs within the exclusion experiment show a two to three times lower oxygen flux in the affected sediments compared to the unaffected.

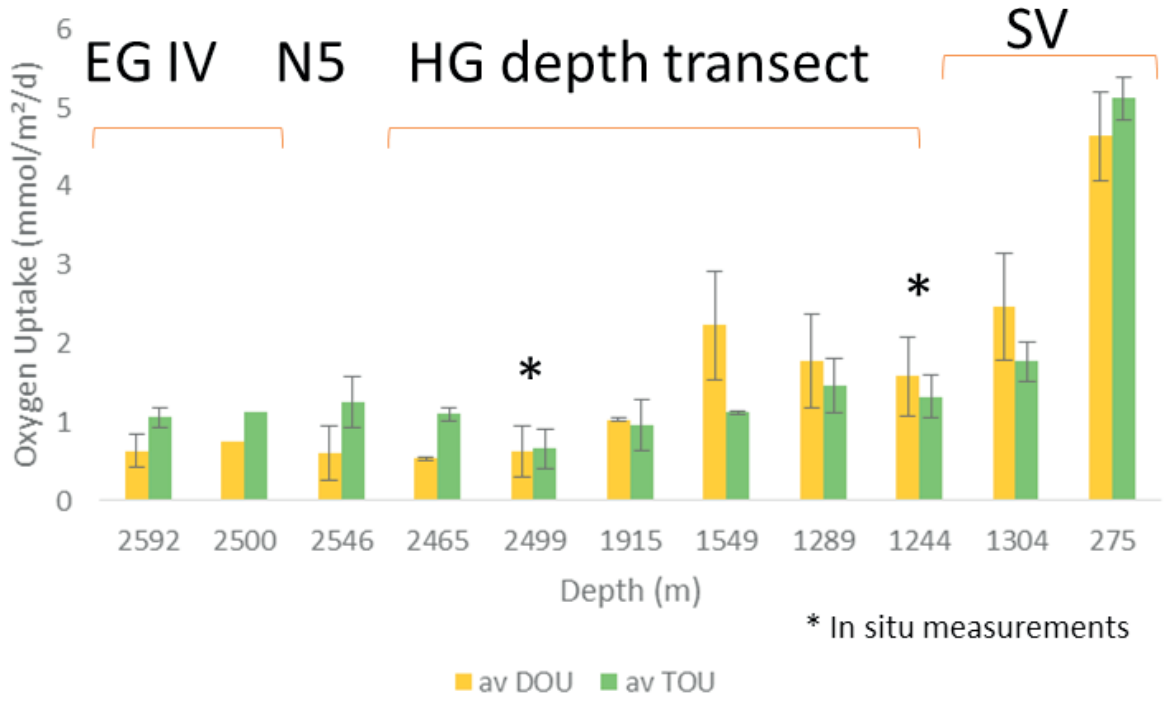

Fig. 3.3.1: Average diffusive and total oxygen uptake (DOU and TOU in yellow and green bars, respectively) ± SD per station. Station depth and location are indicated. EG-IV: Eastern Greenland station IV; N5: northernmost HAUSGARTEN station; HG depth transect: HAUSGARTEN station HG-I to HG-IV; SV: Svalbard stations. In-situ measurements are indicated with an asterisk.

Data management

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

3.4 Microbial studies at the deep seafloor

Katy Hoffmann[1,2], Josephine Z. Rapp[1,2]; [1]AWI
Christina Bienhold[1,2] (not on board) [2]MPIMM

Objectives

Approximately 70 % of the world's surface is covered by deep-sea sediments, yet only a fraction of this vast ecosystem has been explored yet and many questions remain to be answered. Deep-sea sediments are dominated by benthic bacteria in terms of biomass and diversity, accounting for up to 90 % of the total benthic biomass (Rowe et al. 1991). They therefore play a central role in the biogeochemical cycling at the seafloor (Jørgensen and Boetius 2007), yet, the functions of specific bacterial groups, e.g. in organic matter remineralisation are still little understood. Also, it is still not clear how environmental parameters and other abiotic factors affect the diversity and activity of environmental microbial communities from the deep sea, including changes in organic matter export from the surface or the effect of depressurization. To address these questions we sampled deep-sea surface sediment samples for bacterial DNA and RNA analyses, as well as for dissolved organic matter analyses. We also use experimental approaches, including incubations of deep-sea sediments with different algal food sources or incubations at *in-situ* and atmospheric pressure on board of *Polarstern* expedition PS93.2.

Our work will also contribute to the time-series analyses of bacterial diversity in deep-sea sediments at this site (Jacob et al. 2013; Jacob et al. *unpublished*) and results will be interpreted in conjunction with other environmental parameters from the same sites (see chapter HAUSGARTEN). The work contributes to the European Research Council Advanced Investigator grant ABYSS (no. 294757; Antje Boetius).

Work at sea

Sediment samples

In total, 14 stations were sampled for undisturbed sediment cores by the deployment of a video-guided multiple corer (MUC) to the seafloor (Table 3.4.1; Fig. 3.4.1). Cores were either subsampled in 20 ml cut-off syringes for later processing of individual depth layers or directly subsampled in ten depth layers (0-1 cm, 1-2 cm, 2–3 cm, 3–4 cm, 4–5 cm, 5-6 cm, 6-7 cm, 7-8 cm, 8-9 cm, 9-10 cm). Subsequently, samples were frozen for microbial DNA.RNA extraction, either directly at -20°C or shock-frozen in liquid nitrogen and then stored at -80° C. Also, subsamples were fixed in formaldehyde for the determination of microbial cell numbers (Table 3.4.2). The respective analyses will be performed in the home laboratory. For specific stations, potential extracellular enzyme activities (beta-glucosidase, chitobiase) in the first 5 cm were measured on board. Data and results will be interpreted in the context of additional environmental parameters that were sampled from the same cores (see Chapter 3).

Fig. 3.4.1: Retrieval of surface sediments using a multiple corer (left); Subsampling of multiple corer tubes with plastic syringes (right)

Tab. 3.4.1: Sediment samples for DNA.RNA extraction from MUC deployments. Samples are stored at -20°C or -80°C, respectively.

Date	Station ID	Gear	Site	DNA	RNA
25.07.15	PS93.0048-11	MUC	S3	x	x
27.07.15	PS93.0050-19	MUC	HG-IV	x	x
28.07.15	PS93.0051-4	MUC	HG-V	x	x
28.07.15	PS93.0053-3	MUC	HG-VI	x	x
29.07.15	PS93.0055-2	MUC	HG-VIII	x	x
29.07.15	PS93.0056-1	MUC	HG-IX	x	x
31.07.15	PS93.0058-12	MUC	EG-IV (new)	x	x
31.07.15	PS93.0058-17	MUC	EG-IV (old)	x	
03.08.15	PS93.0060-10	MUC	N5	x	x
06.08.15	PS93.0066-2	MUC	SV-I	x	x
08.08.15	PS93.0074-3	MUC	SV-IV	x	x
09.08.15	PS93.0077-2	MUC	HG-III	x	x
09.08.15	PS93.0078-2	MUC	HG-II	x	x
10.08.15	PS93.0080-9	MUC	HG-I	x	x
26.07.15	PS93.0050-6	MUC	HG-IV	x	
03.08.15	PS93.0060-10	MUC	N5	x	

Tab. 3.4.2: Sediment samples from MUC deployments, stored for total prokaryotic cell counts for the depth horizons 0-1 cm to 4-5 cm. Storage for Acridine Orange Direct Counts (AODC) in 4% formalin at 4°C, for Fluorescence *in-situ* Hybridization (FISH) samples are washed with 1xPBS and stored in 1xPBS:EtOH at -20°C.

Date	Station ID	Gear	Site	Core
25.07.15	PS93.0048-11	MUC	S3	Cores 1+2
27.07.15	PS93.0050-19	MUC	HG-IV	Cores 2+3
28.07.15	PS93.0051-4	MUC	HG-V	Cores 1+2
28.07.15	PS93.0053-3	MUC	HG-VI	Cores 1+2
29.07.15	PS93.0055-2	MUC	HG-VIII	Core 1+2
29.07.15	PS93.0056-1	MUC	HG-IX	Cores 1+2
31.07.15	PS93.0058-12	MUC	EG-IV (new)	Cores 1+2
31.07.15	PS93.0058-17	MUC	EG-IV (old)	Core 5
31.07.15	PS93.0058-17	MUC	EG-IV (old)	Core 5
03.08.15	PS93.0060-10	MUC	N5	Cores 1+2
06.08.15	PS93.0066-2	MUC	SV-I	Cores 1+2
06.08.15	PS93.0067-2	MUC	FixO3-I	Cores 1+2
08.08.15	PS93.0074-3	MUC	SV-IV	Cores 1+2
09.08.15	PS93.0077-2	MUC	HG-III	Cores 1+2
09.08.15	PS93.0078-2	MUC	HG-II	Cores 1+2
10.08.15	PS93.0080-9	MUC	HG-I	Cores 1+2

Furthermore, the upper sediment layers of benthic chambers from two lander deployments (see Chapter 3.3) were sampled for microbiological analyses, including microbial DNA.RNA extraction and cell numbers, and for a characterization of the geochemical environment, e.g. chlorophyll pigment concentrations and total organic carbon content (Tables 3.4.3 and 3.4.4). Samples from these chambers were also fixed for biomarker and faunal analyses (see Chapter 3.3).

Tab. 3.4.3: Sediment samples from Lander deployments, stored at -80°C for DNA.RNA extractions and total prokaryotic cell counts for the depth horizons 0-1 cm to 4-5 cm. Storage for Acridine Orange Direct Counts (AODC) in 4% formalin at 4°C, for Fluorescence *in-situ* Hybridization (FISH) samples are washed with 1xPBS and stored in 1xPBS:EtOH at -20°C. K1 – Chamber 1, K2 – Chamber 2.

Date	Station ID	Gear	Site	Core
27.07.15	PS93.0050-18	Lander	HG-IV	K1+2
10.08.15	PS93.0080-8	Lander	HG-I	K1+2

With the help of the ROV “Quest 4000” (Zentrum für Marine Umweltwissenschaften, MARUM) push cores were taken from starvation experiments that were initiated in 2008 (see Chapter 3). By deploying large cages on the seafloor, certain areas experienced restricted food input over the last years. The obtained push cores from inside and outside the cages were subsampled for microbial DNA.RNA extraction and cell numbers and results will be interpreted in the context of additional environmental parameters that were sampled from the same cores (see Chapter 3). Also, push cores taken with the ROV were used to sample sediments along a gradient of iron contamination that was introduced by the metal frame of the cages. Again, cores were subsampled for microbiological analyses (Tables 3.4.4 and 3.4.5).

Tab. 3.4.4: Sediment samples for DNA and RNA extraction taken during the ROV dives. Samples are stored at -20°C or -80°C, respectively.

Date	Station ID	Gear	Site	Core	DNA	RNA
26.07.15	PS93.0050-10	ROV	HG-IV	Push cores, Cages	x	x
28.07.15	PS93.0052-1	ROV	HG-IV	Pressure Incubation	x	x
28.07.15	PS93.0052-1	ROV	HG-IV	Push corer 3, iron enriched	x	x
28.07.15	PS93.0052-1	ROV	HG-IV	Push cores, fluffy layer	x	
08.08.15	PS93.0077-1	ROV	HG-IV	Push cores	x	x
10.08.15	PS93.0081-1	ROV	HG-IV	Pressure Incubation	x	x
10.08.15	PS93.0081-1	ROV	HG-IV	Push cores	x	x

Tab. 3.4.5: Sediment samples taking during ROV dives, stored for total prokaryotic cell counts for the depth horizons 0-1 cm to 4-5 cm or 0-2 cm. Storage for Acridine Orange Direct Counts (AODC) in 4 % formalin at 4°C, for Fluorescence *in-situ* Hybridization (FISH) samples are washed with 1xPBS and stored in 1xPBS:EtOH at -20°C.

Date	Station ID	Gear	Site	Core
26.07.15	PS93.0050-10	ROV	HG-IV	Push corer, Cages 1+2
26.07.15	PS93.0050-10	ROV	HG-IV	Push corer, Cage control
28.07.15	PS93.0052-1	ROV	HG-IV	Push corer 3, iron enriched
10.08.15	PS93.0081-1	ROV	HG-IV	Push corer 16, control
10.08.15	PS93.0081-1	ROV	HG-IV	Pressure Incubation

Feeding experiments

Live surface sediments obtained from MUC cores were used to initiate feeding and pressure experiments with chitin and algal material (4 different algae species) at *in-situ* temperature and at both atmospheric and *in-situ* pressure directly on board. Subsamples were taken for the determination of prokaryotic cell numbers, microbial diversity and potential extracellular enzyme activity. This will help to (i) evaluate the bacterial community response to differences in food quality, (ii) identify key players in the degradation of organic material and (iii) test the effect of pressure on microbial community structure and activity.

Pressure incubation experiments

Experiments to test the effect of pressure on bacterial diversity and activity were conducted with sediment samples from the central HAUSGARTEN station (HG-IV). In one experiment surface sediments sampled with the MUC were re-pressurized to *in-situ* pressure (250 bar), and pressure was subsequently released and re-applied for a maximum of 10 times in a row. Half of the sediment was sampled directly for microbial diversity, activity and prokaryotic cell numbers. The other half was stored at 0°C and 1 bar for 7 days, and then also fixed for the aforementioned analyses and evaluation in the home laboratory.

A second approach aimed at the retrieval of sediment samples without decompression. Sediments were sampled using a specifically designed pressure incubator (collaboration Y. Morono and F. Inagaki, Kochi Institute for Core Sample Research, JAMSTEC) handled by the ROV “Quest 4000” (MARUM) (Fig. 3.4.2). Instrument handling and retrieval of the core were successful, although pressure in the core dropped from 250 bar to 90 bar upon retrieval. Sediments were fixed for microbiological analyses, and results will be compared to samples obtained with a push core (depressurized) from the same site.

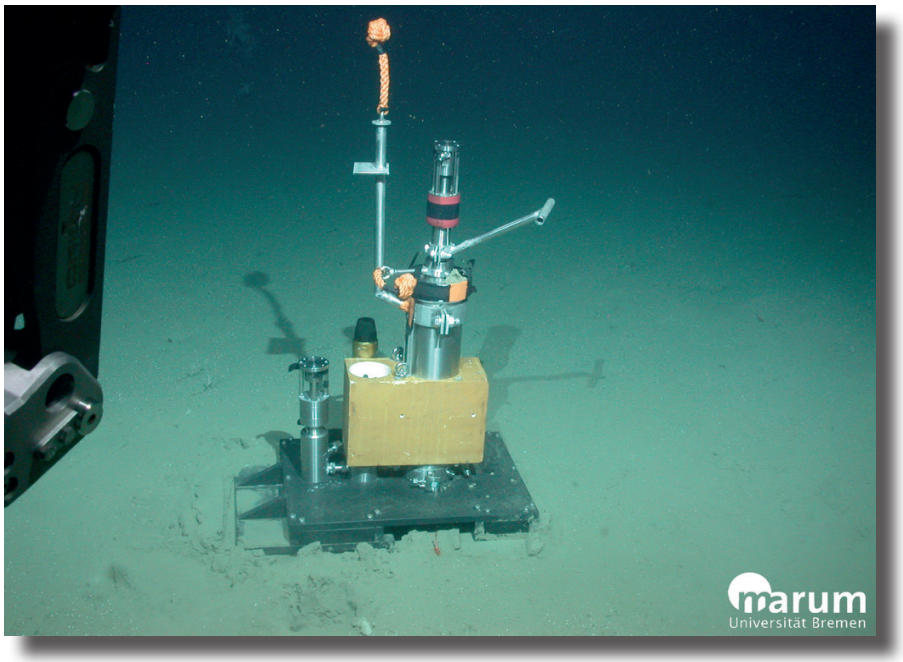

Fig. 3.4.2: Pressure incubator deployed at the central HAUSGARTEN site HG-IV

Additional live sediments for laboratory experiments were stored at 0°C for further analyses and experiments in the home laboratory (Table 3.4.6).

Tab. 3.4.6: Live sediments retrieved from the upper 2 cm of MUC or ROV push cores. Sediments were mixed with sterile filtered deep water and stored at 0°C.

Date	Station ID	Gear	Site	Dilution
25.07.15	PS93.0048-10	MUC	S3	1:1
26.07.15	PS93.0050-6	MUC	HG-IV	1:1
28.07.15	PS93.0051-4	MUC	HG-V	1:1
28.07.15	PS93.0052-1	ROV	HG-IV	1:1
26.07.15	PS93.0050-5, -6	MUC	HG-IV	3.5-fold
28.07.15	PS93.0053-3	MUC	HG-VI	1:1
29.07.15	PS93.0055-2	MUC	HG-VIII	1:1

Date	Station ID	Gear	Site	Dilution
29.07.15	PS93.0056-1	MUC	HG-IX	1:1
31.07.15	PS93.0058-12	MUC	EG-IV (new)	1:1
03.08.15	PS93.0060-10	MUC	N5	1:1
07.08.15	PS93.0072-1	ROV	HG-I	1:1
09.08.15	PS93.0077-2	MUC	HG-III	1:1
09.08.15	PS93.0078-2	MUC	HG-II	1:1
10.08.15	PS93.0081-1	ROV	HG-IV	1:1

Dissolved organic matter

We took porewater samples for dissolved organic matter (DOM) analyses at the deepest East Greenland station (EG-IV) at around 2500 m water depth (Table 3.4.7). Rhizons (www.rhizosphere.com.rhizons) were used to directly extract porewater from modified MUC cores (with pre-drilled holes). Porewater samples are stored at *in-situ* temperature (0°C) and will be sampled over a time frame of several months to monitor changes in the DOM molecular composition. Geochemical measurements will be conducted using ultra high-resolution mass spectrometry (Fourier Transform Ion Cyclotron Resonance Mass Spectrometry, with P. Rossel (AWI / MPIMM) and T. Dittmar (ICBM Oldenburg / MPIMM) and results will support an experiment performed at the same station one year earlier during *Polarstern* cruise PS85 (ARK-XXVIII/2).

Tab. 3.4.7: Porewater samples for DOC analyses were extracted from MUC cores with rhizons and were stored in 50 ml tubes (pre-rinsed with MilliQ-H_2O) at -20°C.

Date	Station ID	Gear	Site	Core	Depth
24.07.15	-	Milli-Q-H_2O MPIMM		Milli-Q	blank test
01.08.15	PS93.0058-17	MUC	EG-IV	Cores 1-6	0-2 cm

Preliminary results

On board measurements of the extracellular potential enzymatic activity were conducted for selected stations along the HAUSGARTEN depth transect from 1100 m water depth at HGI to 5500 m at HG-IX. We measured the activity of the sediment community in centimetre steps for depth horizons from 0 cm to 5 cm. Chitobiase activity was three times higher than ß-glucosidase activity at all included stations. Further we saw that the extracellular activities measured for both enzymes decreases with increasing water and sediment depth. The only exception was observed at station HG-IX where the potential enzymatic activity of both enzymes dropped in the first centimetre and then remained stable down to 5 cm below the seafloor. This might be due to the funnel-like topography of the seafloor at this station, which leads to increased sedimentation rates and organic matter input.

Sediment samples from the pressure and feeding experiments will be analysed in the home laboratory. We expect to see that differences in food quality, as well as pressure changes affect the bacterial activity of the sediment communities in the deep sea. While it is already known that pressure affects the bacterial activity (Picard and Daniel 2013), it remains to be resolved whether pressure changes also affect the bacterial community diversity and thereby also their potential function.

We will use Illumina next generation sequencing for DNA and RNA sequencing from the sediment samples. This will help to get a better understanding of bacterial diversity and activity changes along environmental gradients, such as changes of water depth, food input or pressure changes. All analyses will be conducted in the home laboratory.

Data management

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

References

Jørgensen BB, Boetius A (2007): Feast and famine - microbial life in the deep-sea bed. Nat. Rev. Microbiol., 5: 770-781.

Jacob M, Soltwedel T, Boetius A, Ramette A (2013): Biogeography of Deep-Sea Benthic Bacteria at Regional Scale (LTER HAUSGARTEN, Fram Strait, Arctic). PLoS ONE, 8: e7277.

Picard A, Daniel I (2013): Pressure as an environmental parameter for microbial life – A review. Biophys. Chem., 183: 30-41.

Rowe G, Sibuet M, et al. (1991): Total sediment biomass and preliminary estimates of organic-carbon residence time in deep-sea benthos. Mar. Ecol. Prog. Ser., 79: 99-114.

3.5. Biogenic sediment compounds and the small benthic biota

Christiane Hasemann, Ingrid Kolar, Burkhard Sablotny, Ingo Schewe, Meike Spill — AWI

Objectives

Benthic investigations at the HAUSGARTEN observatory comprised biochemical analyses to estimate the input of organic matter from phytodetritus sedimentation and to analyse the activity and biomass of the small benthic biota. Further sediments were retrieved to study the composition of small sediment-inhabiting organisms (meiofauna). Results from these studies will help to describe the eco-status of the benthic system.

Work at sea

Virtually undisturbed sediment samples were taken by push-cores using a video-guided multiple corer (MUC) at 12 HAUSGARTEN stations along a depth gradient between 275 and 5500 m water depth (SV-I, SV-II, SV-IV, and HG-I through HG-IX), and at three stations along a latitudinal transect following the 2,500 m isobath (S3, N3, N5) (Tab. 3.5.1; Fig. 3.1). Within

the framework of the BMBF project TRANSDRIFT ("System Laptewsee" – Das transpolare System des Nordpolarmeeres) we sampled one station at the East Greenland continental shelf at 2,500 m water depth (EG-IV).

The uppermost five centimetres of all sampled sediments were sub-sampled to analyse a variety of parameters, indicating the input of organic matter to the seafloor as well as sediment-bound biomass and benthic activity. The sediments were also sub-sampled to analyse abundance and biomass of bacteria, meiofauna organisms as well as diversity patterns of nematodes. Chloroplastic pigments (chlorophyll a and its degradation products) represent a suitable indicator for the input of phytoplanktonic detritus to the seafloor. They can be analysed with high sensitivity by fluorometric measurements. To estimate the potential heterotrophic activity of bacteria, we measured cleaving rates of extracellular enzymes using the model-substrate FDA (fluorescein-di-acetate) in incubation experiments. FDA was added in saturated concentration to obtain the maximum cleaving-rate of hydrolytic enzymes like esterase, lipase, protease etc. To avoid losses in activity these analyses were done immediately after the recovery of the sediment samples on board *Polarstern*.

To obtain fast and reliable estimations about the total biomass of the microbial community in the sediment, we will analyse various biochemical bulk parameters from deep-frozen sub-samples stored for later analyses in the home lab. The determination of phospholipids, being characteristic cell wall compartments, will provide good estimates about the biomass of living organism in the sediments (i.e. bacteria, yeasts, fungi, flagellates, ciliates, foraminiferans and metazoan meiofauna). To determine the total biomass in the sediments (organisms and detrital matter) we will analyse sediment-bound particulate proteins.

Tab. 3.5.1: HAUSGARTEN- and East Greenland multiple corer stations

Station ID	Site	Date	Latitude	Longitude	Water Depth [m]
PS93.0066-2	SV-I	06.08.15	79° 1.71' N	11° 5.22' E	275
PS93.0073-3	SV-III	08.08.15	79° 0.06' N	8° 14.98' E	903
PS93.0074-3	SV-IV	08.08.15	79° 1.78' N	6° 59.94' E	1304
PS93.0080-9	HG-I	10.08.15	79° 8.33' N	6° 5.01' E	1288
PS93.0078-2	HG-II	09.08.15	79° 7.82' N	4° 54.14' E	1550
PS93.0077-2	HG-III	08.08.15	79° 6.49' N	4° 36.01' E	1916
PS93.0050-19	HG-IV	27.07.15	79° 3.91' N	4° 10.79' E	2465
PS93.0051-4	HG-V	28.07.15	79° 3.81' N	3° 39.46' E	3127
PS93.0053-3	HG-VI	28.07.15	79° 3.61' N	3° 34.98' E	3430
PS93.0054-2	HG-VII	29.07.15	79° 3.63' N	3° 28.56' E	4092
PS93.0055-2	HG-III	29.07.15	79° 3.86' N	3° 20.10' E	5108
PS93.0056-1	HG-IX	29.07.15	79° 8.02' N	2° 50.58' E	5570
PS93.0058-12	EG-IV	31.07.15	78° 51.73' N	2° 42.61' W	2592

Station ID	Site	Date	Latitude	Longitude	Water Depth [m]
PS93.0048-11	S3	25.07.15	78° 35.98' N	5° 4.07' E	2342
PS93.0085-2	N3	11.08.15	79° 36.25' N	5° 10.28' E	2783
PS93.0060-10	N5	03.08.15	79° 56.29' N	3° 11.59' E	2548

Preliminary results

Comparing the concentrations of sediment-bound pigments (Fig. 3.5.1) and the potential bacterial activity (Fig. 3.5.2) at the northernmost, southernmost, westernmost and easternmost HAUSGARTEN sites (all stations at about 2500 m water depth) we found conspicuous differences.

At all four stations exhibited generally decreasing values with increasing sediment depth. Steepest gradients were found for station EG-IV on the east-Greenland rise, shallowest gradients occurred at the northernmost HAUSGARTEN site N5. However, despite comparably low pigment concentrations at EG-IV, bacterial activity at station N5 was unexpectedly high.

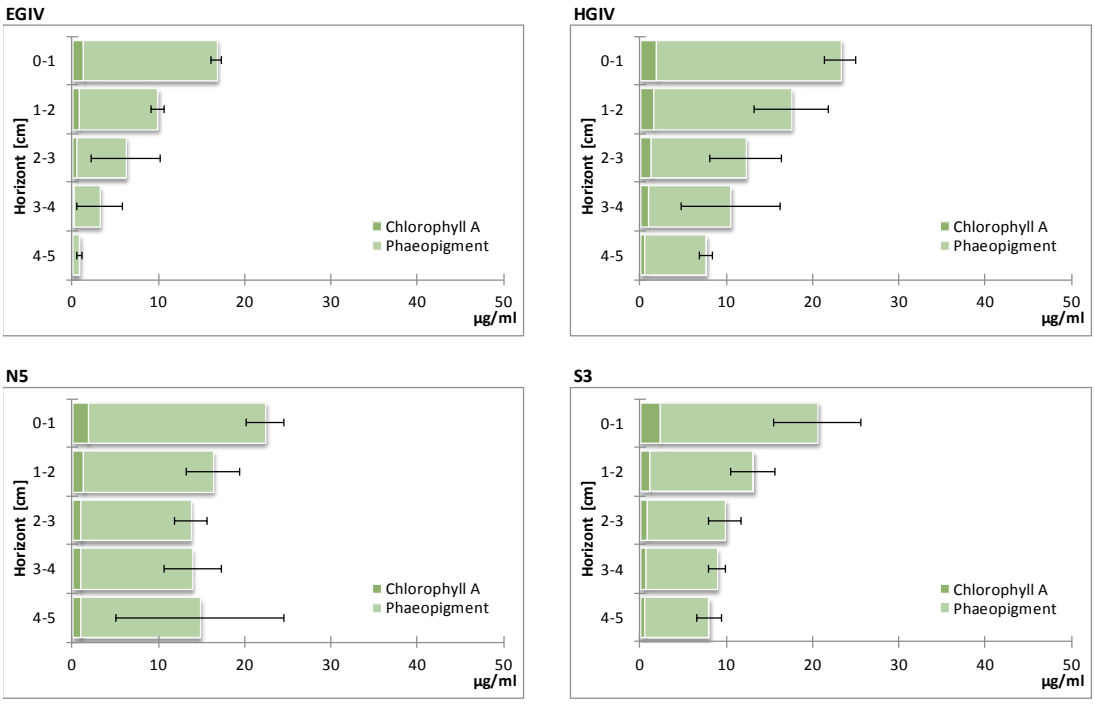

Fig. 3.5.1: Chloroplastic pigments bound in the upper five sediment centimetres of four selected stations at ~2,500 m water depth

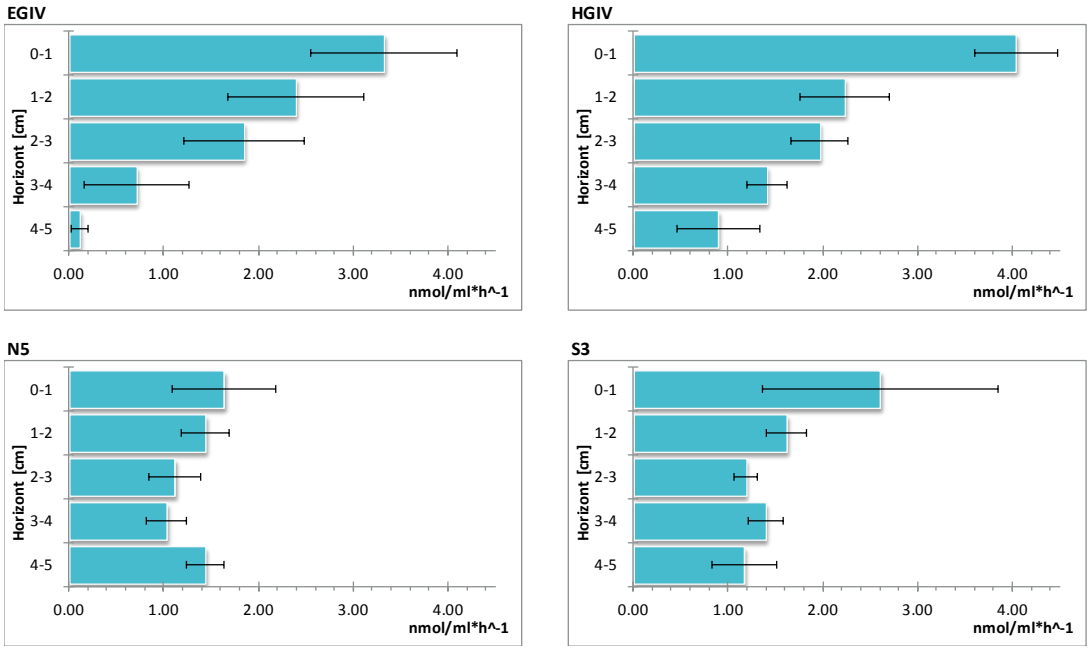

Fig. 3.5.2: Hydrolytic activity of bacteria (FDA) in the upper five sediment centimetres of four selected stations at ~2,500 m water depth

Data management

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

3.6 Abundance of megafauna, litter and microplastic

Melanie Bergmann, Burkhard Sablotny; AWI
James Taylor, Mine Tekman,
Gunnar Gerdts (not on board)

Objectives

Epibenthic megafauna, often arbitrarily defined as organisms large enough to be seen with a camera, play an important role in the deep-sea community. They influence benthic respiration, nutrient cycles and bioturbation, shape community structure through predation and also provide structure at the sediment-water interface. Thus, it is important to understand variations in the megafaunal community with depth, latitude, time and habitat features such as hard substrates. To assess megafaunal dynamics over time, we repeatedly conduct camera surveys along the same transect positions (megafaunal time series) (Bergmann et al. 2011, Meyer et al. 2013).

Anthropogenic litter contamination of the oceans is a global problem of growing environmental concern. Analyses of camera footage obtained earlier at the HAUSGARTEN central station (2500 m water depth) indicated a significant increase of litter on the seafloor between 2002 and 2011 (Bergmann and Klages 2012). Therefore, the footage gained during this expedition will also be assessed to see if litter densities are still increasing at HAUSGARTEN.

Recent evidence also suggests high concentrations of microplastics, a degradation product of larger plastic items, in Arctic sea ice (Obbard et al. 2014). This raises concerns about the fate of entrained microplastics during ice melts and exposure of the ecosystems underneath. Here, we determine microplastic concentrations in sediment samples taken at selected stations by multiple or push cores. In addition, we took snow samples during helicopter flights to icebergs to assess the importance of airborne microplastic contamination pathways.

Work at sea

Megafauna

To sample the benthic megafauna by a non-destructive method at a large scale and to gain *in-situ* views of the organisms, we used a towed camera system (Ocean Floor Observation System, OFOS). Photographed transects were located along the latitudinal transects (N3, HG-IV and S3) and will be used to continue our image time series. An additional transect was done off East Greenland at 2500 m depth to enable comparisons between the megafaunal assemblages from the eastern and western Fram Strait. Thus, a total of four photographic transects were accomplished during PS93.2 (Table 3.6.1). Physical samples were collected by ROV for ground-truthing. In addition, a 360-m ROV high-resolution photo-transect, which was laid out with markers by ROV in 2011 was revisited.

Tab. 3.6.1: Details of OFOS deployments and sampling conducted during PS 93.2.

Date	Time	Station ID	Gear	Type	Site	Latitude	Longitude	Water Depth [m]	Sample no.
24.07.15	17:44	PS93. 048-8	OFOS (start)	Imagery	S3	78° 37.02' N	5° 9.56' E	2351	-
24.07.15	21:51		OFOS (end)			78° 36.98' N	4° 59.39' E	2367	-
26.07.15	21:10	PS93. 050-11	OFOS (start)	Imagery	HG-IV	79° 2.02' N	4° 9.91' E	2629	-
27.07.15	01:08		OFOS (end)			79° 3.93' N	4° 17.28' E	2406	-

Date	Time	Station ID	Gear	Type	Site	Latitude	Longitude	Water Depth [m]	Sample no.
31.07.15	21:23	PS93. 058-18	OFOS (start)	Imagery	EG-IV	78° 54.55' N	2° 58.82' W	2516	-
01.08.15	00:01		OFOS (end)			78° 53.28' N	3° 2.43' W	2512	-
03.08.15	19:57	PS93. 062-1	OFOS (start)	Imagery	N3	79° 35.92' N	5° 10.18' E	2787	-
03.08.15	22:54		OFOS (end)			79° 34.15' N	5° 15.36' E	2659	-
10.08.15	18:14	PS93. 081-1	ROV	Imagery	HG-IV	790.731.872	41.371.925	2460	-
25.07.15	04:12	PS93. 048-11	MUC	Sediment	S3	78° 35.98' N	5° 4.07' E	2342	4
28.07.15	08:18	PS93. 052-1	ROV	Sediment	HG-IV	79° 4.91' N	4° 8.59' E	2460	5
28.07.15	03:47	PS93. 051-4	MUC	Sediment	HG-V	79° 3.81' N	3° 39.46' E	3127	4
28.07.15	22:01	PS93. 053-3	MUC	Sediment	HG-VI	79° 3.61' N	3° 34.98' E	3430	3
29.07.15	04:02	PS93. 054-2	MUC	Sediment	HG-VII	79° 3.63' N	3° 28.56' E	4092	4
29.07.15	11:31	PS93. 055-2	MUC	Sediment	HG-VIII	79° 3.86' N	3° 20.10' E	5108	5
29.07.15	16:41	PS93. 056-1	MUC	Sediment	HG-IX	79° 8.02' N	2° 50.58' E	5570	3
11.08.15	22:18	PS93. 085-2	MUC	Sediment	N3	79° 36.25' N	5° 10.28' E	2783	5
03.08.15	05:10	PS93. 060-11	MUC	Sediment	N5	79° 56.28' N	3° 11.60' E	2549	5
06.08.15	06:20	PS93. 066-2	MUC	Sediment	SV-I	79° 1.71' N	11° 5.22' E	275	1
08.08.15	05:45	PS93. 074-3	MUC	Sediment	SV-IV	79° 1.78' N	6° 59.94' E	1304	1
07.08.15	02:11	PS93. 070-5	MUC	Sediment	Fix03-IV	78° 33.29' N	9° 28.65' E	389	1
31.07.15	08:00	Heli 1	Helicopter	Snow	EG	79° 05.72' N	1° 46.19' W	iceberg	4
31.07.15	15:46	Heli 2	Helicopter	Snow	EG	79° 00.92' N	0° 17.32' W	iceberg	5
02.08.15	13:27	Heli 3	Helicopter	Snow	N5	80° 18.42' N	3° 51.65' E	iceberg	3
02.08.15	17:36	PS93. 060-2	Zodiak	Snow	N3	79° 58.37' N	3° 20.45' E	iceberg	1

Anthropogenic litter

Analysis of the OFOS footage will also enable us to determine litter densities on the seafloor along the latitudinal gradient and over time (when compared with data extracted from previous transects).

The impact of plastic litter covering sediments on infaunal benthic communities was assessed by ROV-based sampling. For this, the ROV carefully lifted a beacon deployed 2 years ago at S3 and placed a microprofiler in the area underneath the plastic stand to measure oxygen

concentrations at different sediment depths (Fig. 3.6.1). Next, the microprofiler was placed on adjacent undisturbed sediments to measure a control profile. Two sediment samples were taken by push cores in the disturbed area and will be analysed for meiofauna and biogeochemical parameters (Fig. 3.6.1). A comparison with control cores will enable assessments of the impact of litter coverage.

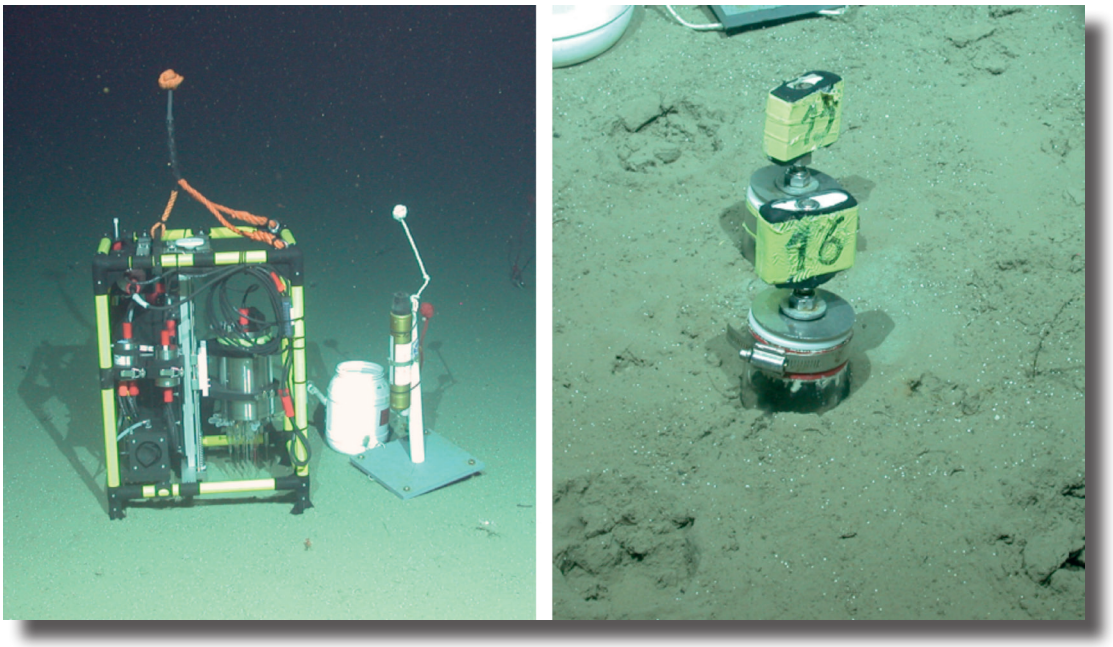

Fig. 3.6.1: Assessment of the effects of plastic coverage of sediments underneath the plastic plate of a beacon at station S3: Microprofiler recording oxygen profile in sediments that had been covered by a plastic plate for 2 years (left), and push cores taken by ROV for assessments of meiofauna and biogeochemical sediment properties underneath plate (right) (©MARUM, Bremen University)

Microplastics

Sediment samples were taken from multiple corer deployments along the latitudinal and bathymetric transect and frozen in tinfoil for assessments of microplastic concentrations, while snow samples were taken during two helicopter flights to icebergs off East Greenland and during one flight and a dinghy visit off N5. In addition, the stomachs of six cod caught by angling at ca. 200 m depth whilst on station at N3 were taken for microplastic analysis.

Preliminary (expected) results

Results of time-series, latitudinal, and substrate analyses will only be available once the collected images will have been analysed and species present have been identified. However, a few selected images and photographed species are shown in Fig. 3.6.2. At first impression, the northern station N3 harboured more dropstones and sponges (*Caulophacus arcticus, Cladorhiza gelida*) but only rigorous analysis will show if this notion is correct. Unfortunately, many of the specimens collected by ROV for ground-truthing (Fig. 3.6.2) were lost during the ascent of the ROV.

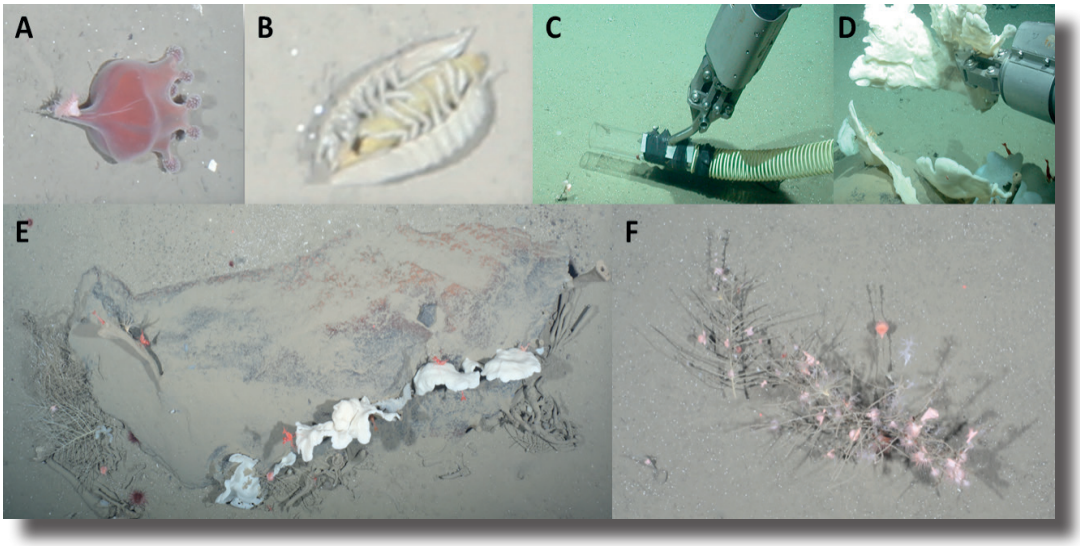

Fig. 3.6.2: Megafauna work at HAUSGARTEN: (A) Stauromeduse at HG-IV (OFOS), (B) isopod Saduria megalura feeding on cf. Fucus at HG-IV (OFOS), (C,D) Ground-truthing by ROV slurp gun and ROV manipulator (©MARUM, Bremen University), (E) dropstone of ca. 1.5 m length at HG-IV (OFOS), (F) megafauna associated with sponge Cladorhiza gelida at S3 (OFOS)

Again, we observed a few items of glass and plastic litter on the seafloor (Fig. 3.6.3). One piece of netting implied fisheries as a possible source of marine litter. At first sight, no litter was observed along the transect off East Greenland (station EG-IV).

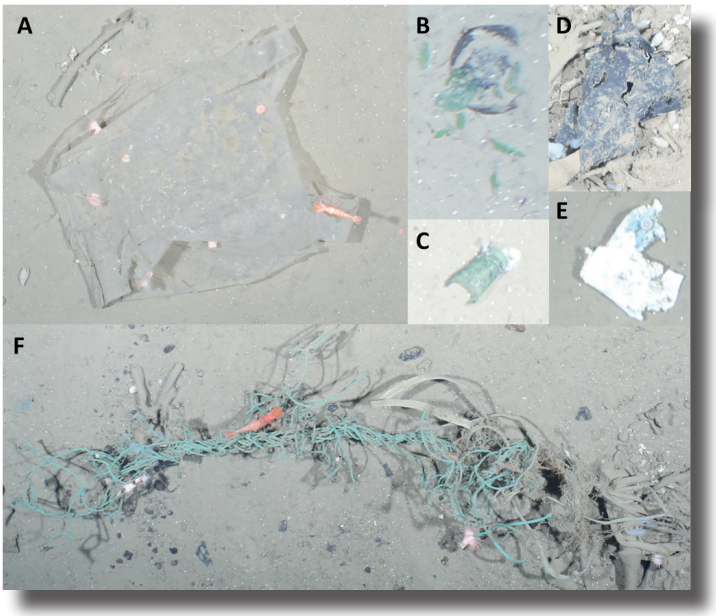

Fig. 3.6.3: Examples of anthropogenic litter observed during OFOS transects at HAUSGARTEN:(A) Plastic bag (HG IV), (B-C) glass (S3), (D-E) plastic fragments, and (F) fisheries-related debris (N3) (©MARUM, Bremen University)

Results on microplastic concentrations of sediments and fish stomachs will only be available after a time-consuming extraction procedures and analysis by Gunnar Gerdts (AWI).

Data management

All OFOS images, videos and metadata will be uploaded to PANGAEA. In addition, all images have been uploaded to the online image data base BIIGLE to enable image analysis.

References

Bergmann M, Soltwedel T, Klages M (2011): The interannual variability of megafaunal assemblages in the Arctic deep sea: Preliminary results from the HAUSGARTEN observatory (79°N). Deep-Sea Res. I, 58: 711-723.

Bergmann M, Klages M (2012): Increase of litter at the Arctic deep-sea observatory HAUSGARTEN. Mar. Poll. Bull., 64: 2734–2741. doi: 10.1016/j.marpolbul.2012.09.018

Meyer KS, Bergman M, Soltwedel T (2013): Interannual variation in the epibenthic megafauna at the shallowest station of the HAUSGARTEN observatory (79° N, 6° E). Biogeosciences, 10: 3479-3492. doi: 10.5194/bg-10-3479-2013

Obbard RW, Sadri S, Wong YQ, Khitun AA, Baker I, Thompson RC (2014): Global warming releases microplastic legacy frozen in Arctic Sea ice. Earth's Future, 2: 2014EF000240. doi: 10.1002/2014EF000240

3.7 Biological long-term experiments at the deep seafloor

Melanie Bergmann[1], Arjun Chennu[2], Christiane Hasemann[1], Ingo Schewe[1], Thomas Soltwedel[1]

[1]AWI
[2]MPIMM

Objectives

The Remotely Operated Vehicle (ROV) “Quest 4000” (Fig. 3.7.1) of the MARUM - Center for Marine Environmental Sciences, Bremen, was used to deploy new and to sample previously established biological *in-situ* long-term experiments at the seafloor. The ROV was furthermore used to conduct surveys with a hyperspectral imaging camera to assess distribution horizontal patterns of algal pigments on surface sediments.

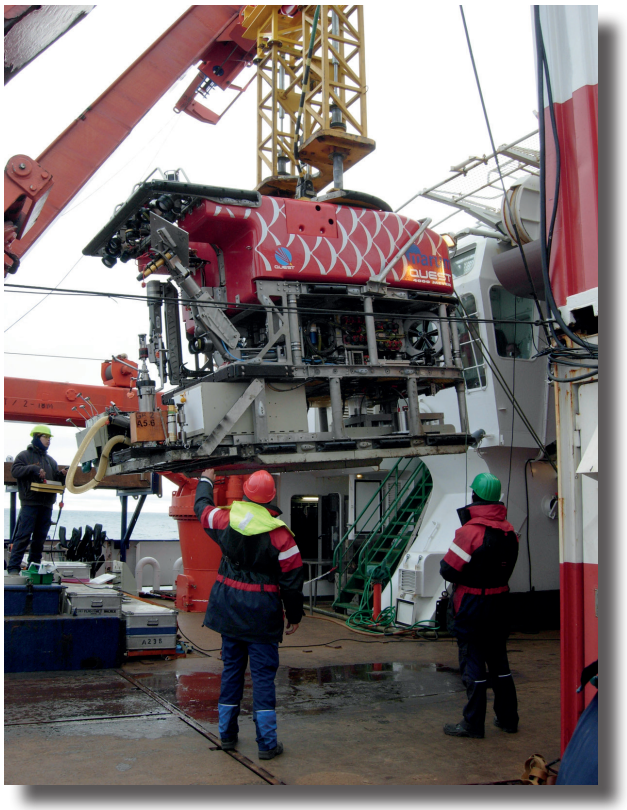

Fig. 3.7.1: Deployment of the Remotely Operated Vehicle (ROV) “Quest 4000”

Work at sea

By means of the ROV-handled pushcorers we retrieved sediments from surface sediments covered by 4 m² cages with solid lids (Fig. 3.7.2), preventing the sedimentation of particulate organic matter, i.e. the main food/energy source for benthic organisms. These cages were deployed in summer 2008 at 2,500 m water depth and will be repeatedly sampled over the next years to assess the reaction of the small biota to decreasing food availability.

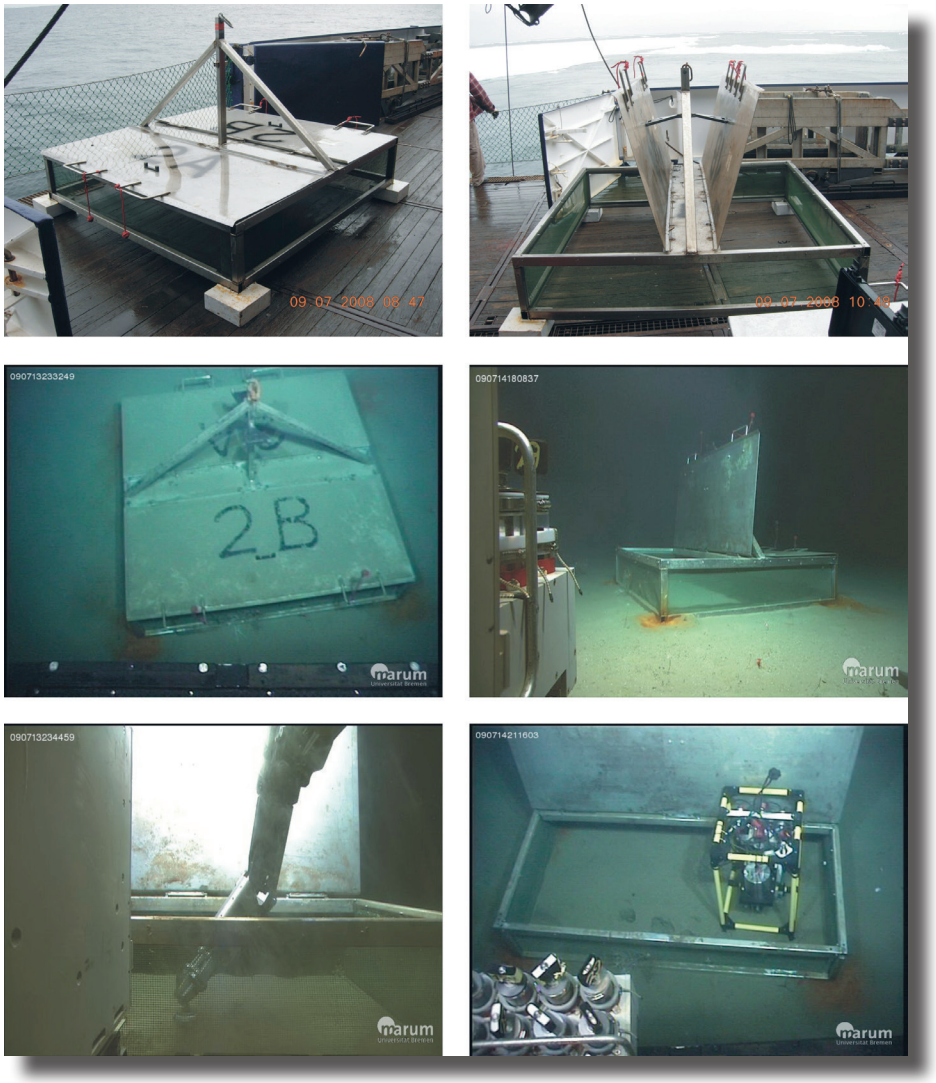

Fig. 3.7.2: Cages for the starvation experiment on board RV Polarstern (top) and at the deep seafloor (middle); sediment sampling and microprofiler measurements during PS93.2 (bottom)

Moreover, we used the ROV to sample different bioturbation experiments established in 2011 and 2013, where we spread out small inert fluorescing microspheres, so-called luminophores (60 µm [pink] and 80-125 µm [green] in diameter), on defined areas at the seafloor to assess the mixing efficiency of larger benthic organisms at HAUSGARTEN stations HG-I (1,250 m), HG-IV (2,500 m) and S3 (2,300 m water depth) (Fig. 3.7.3).

Fig. 3.7.3: Dispersal of luminophores at HAUSGARTEN station S3 during RV Maria S. Merian cruise MSM29 in 2013 (top) and sediment sampling with pushcorers within the experimental areatwo years later during RV Polarstern expedition PS93.2 (bottom)

While there is a growing body of evidence on the impact of litter on charismatic and more visible biota such as seabirds, marine mammals and turtles, there are still big gaps in our knowledge about the impact of litter on benthic organisms. To fill this gap, we started two new ROV-based experiments at HG-IV to simulate plastic coverage of sediments by heavy rigid plastic plates and bags (Fig. 3.7.4). The effects will be assessed next year in a similar approach as described above. Furthermore, experimental plastic bags were placed onto two species of sponge (*Caulophacus arcticus, Cladorhiza gelida*) to assess their effect on sponge tissues (Fig. 3.7.4).

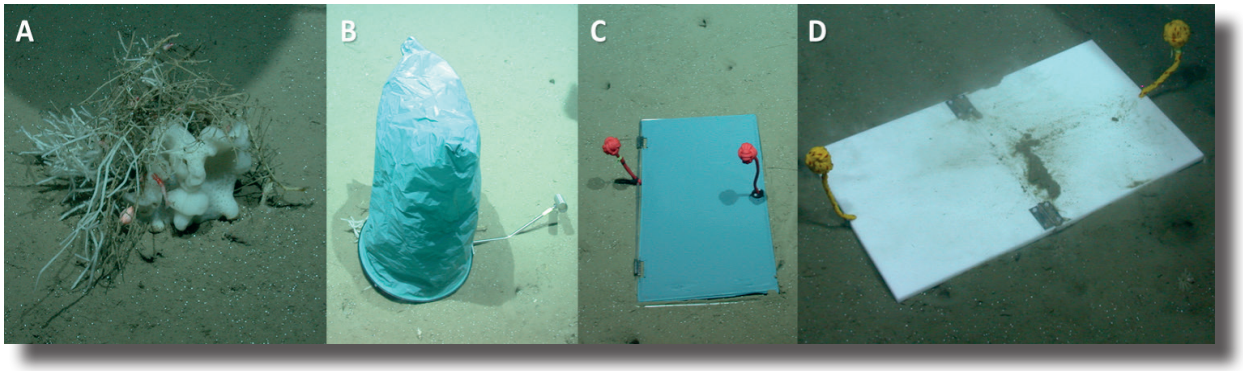

Fig. 3.7.4: ROV-based experiments to simulate the effects of litter on (A) sponges by plastic bag coverage, on meiofauna and biogeochemical sediment properties by (B) plastic bag coverage and (C) plastic plate coverage (©MARUM, Bremen University).

The ROV was also used to test a new Hyperspectral Imaging System (HYPERSUB) developed at the Max Planck Institute of Marine Microbiology (MPIMM) in Bremen. Hyperspectral imaging is a technique of capturing high-resolution optical spectra at each location in an imaged area. The resulting spectral image is a rich data set that allows a variety of spectroscopic as well as image analyses. It enables us to derive information about the function or identity of a target as well as its spatial features (size, location, shape) simultaneously. HYPERSUB has previously been used to map microphytobenthic biomass. The method allows us to non-invasively record the distribution of benthic microalgae in surficial sediments with a high millimetre-scale resolution, while also being quantitative in terms of chlorophyll concentrations.

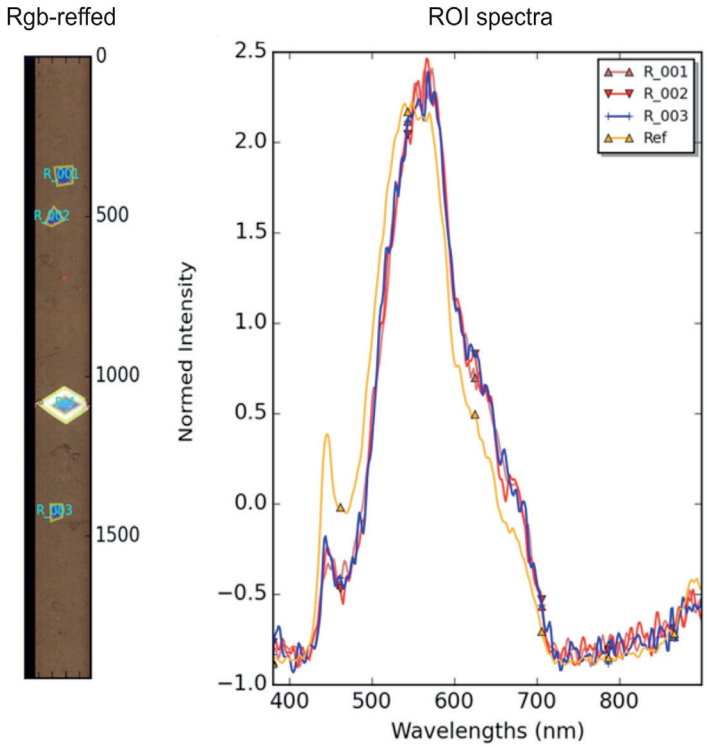

Fig. 3.7.5: Examples from spectral imaging along a short transect over sediments at the central HAUSGARTEN site HG-IV: True-colour image (rgb-reffed); Average spectra (ROI spectra)at specific spots (R_001, R_002, R_003, Ref) in the left panel

HYPERSUB was mounted on the frame of the ROV, facing downwards like a surveying camera. The technical operations of the system through the ROV platform, considering the hardware and the software, were successful. A minor issue was that the high-power (150 W) lamps could not be powered by the ROVs system, and had to be replaced by 70 W lamps resulting in noisier spectral data. Overall, once installed, HYPERSUB was able to record spectral images during routine ROV navigation at a sediment altitude of around 1 m.

To aid the quantification of chlorophyll, some spectral images were captured with a spectral reference board placed in the field-of-view of HYPERSUB. The board is used to perform spectroscopic analysis on reflectance spectra before comparing with pigment values from chemical extraction (see Chapter 3.5). Fig. 3.7.5 shows an example of a spectral image of ambient sediments with some annotations. The rather successful technical performance and insights gained from the pilot deployment of the HYPERSUB system at the deep seafloor provides a promising case for future studies.

Preliminary (expected) results

All samples will be analysed in home laboratories at AWI in Bremerhaven.

Data management

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.

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

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Grant No: AWI_PS93.2_02

Objectives

Acknowledging the sensitivity of the Arctic to environmental change, the project-group PEBCAO (Plankton Ecology and Biogeochemistry in a Changing Arctic Ocean) is dedicated to study plankton communities and microbial processes relevant for biogeochemical cycles of the Arctic Ocean. It is expected that the Arctic will face continuously rising temperatures, declining sea ice coverage, freshening of surface waters and decreasing seawater pH. In order to understand and track potential consequences for the pelagic ecosystem in the Arctic Ocean both long-term field observations and experimental work with Arctic plankton species and communities are needed to gain knowledge about the biological feedback potential of pelagic communities in the future Arctic Ocean.

Biogeochemistry and phytoplankton

Recent investigations suggest that climate change will impact the biodiversity in the pelagic system by promoting a shift in phytoplankton communities towards the dominance of smaller cells. This could have significant consequences for the entire food web in polar waters as well as for the cycling and sequestering of organic matter. Also, the cycling of biogenic elements may be affected by changing environmental conditions and, because of the vast spatial dimensions of the oceanic system, even small changes in the biological pump could significantly affect atmospheric CO_2 concentration. To understand and quantify the processes in the pelagic realm it is thus vital to combine a broad set of parameters. This includes classical bulk measurements (e.g. chlorophyll *a*, POC/N, biogenic silica) and microscopy. In order to study marine protists including the smallest fraction, molecular methods, which are independent on size and morphology, complement the traditional microscopy. Therefore, we asses biodiversity and biogeography of Arctic phytoplankton also by the analysis of ribosomal genes, taking advantage next generation sequencing technology, Automated Ribosomal Intragenic Sequence Analysis (ARISA), and quantitative PCR.

Particulate and dissolved organic matter (POM/DOM)

The distribution and composition of both particulate and dissolved matter in the Fram Strait is influenced by different factors such as the water masses exchanges between the Arctic and Atlantic basins, the intensity of phytoplankton blooms, and the riverine outflow, among others. The main issues to be addressed are related to the amount and composition of the particulate matter (organic and inorganic), and dissolved organic matter and the dynamics

of those optically important components in relation to the water masses (and water column) structure and phytoplankton dynamics.

Bacterioplankton

The bioreactivity of particulate and dissolved organic matter is determined by its biochemical composition and digenetic state. The loss of organic matter within and below the euphotic zone is mainly mediated by the degradation activity of heterotrophic bacteria, colonizing sinking particles and their surroundings. Hence, bacterial activity co-determines the efficiency of carbon export to the deep ocean. Furthermore, bacterioplankton plays an important role in the fate of organic matter in the ocean and contributes substantially to oxygen consumption and CO_2 release in the ocean. Dissolved organic matter is almost exclusively accessible for bacterial cells that make it available for higher trophic levels by the production of bacterial biomass. Effects of increasing temperature and decreasing pH on bacterial communities and their activity are therefore of outstanding importance, but yet hardly considered and their relevance for biogeochemical cycles in the future ocean is only poorly investigated. Also, microbial production and removal processes in the surface ocean affect sea-air fluxes of trace gases, but the underlying processes and the magnitude of the biogenic sources and sinks in the Arctic Ocean are poorly known. We therefore intend to examine the 'present day' situation of pelagic micro-biogeochemistry in the Arctic Ocean, with emphasis on the turnover of organic matter during production and decomposition processes. The data shall serve as a database for a better evaluation of the relevance of changes that are determined in perturbation experiments. Our overarching goal is to contribute to a better understanding of the direction and strength of biogeochemical and microbiological feedback processes in the future ocean.

Phagothrophic protists

Through the regeneration of nutrients, the consumption of microbial plankton, and the transfer of energy and organic matter to higher trophic levels, phagotrophic protists play ecological key roles in aquatic ecosystems. Their importance as regulators of prokaryotic abundances and for shaping prokaryotic communities in diverse aquatic habitats has been investigated in a number of studies conducted since the early 1980s. Our objective is to perform short-term grazing experiments in the Arctic Ocean that are designed to investigate (1) the contribution of hetero– and mixotrophic protists to the carbon flow in the microbial food web and (2) their influence on heterotrophic and phototrophic bacterial activities.

Zooplankton

Zooplankton species are associated with different water masses. Rising water temperatures due to climate change might result in a shift in the zooplankton species composition in the Fram Strait. Furthermore, the organisms might be affected by seawater pH, which decreases due to uptake of anthropogenic carbon dioxide (ocean acidification). This could have severe consequences for the ecosystem functioning. To detect possible impacts of these environmental changes, we studied the zooplankton community composition and depth distribution in the HAUSGARTEN area during PS93.2 and compare these with previous studies from the same area.

Work at sea

During this cruise leg, samples for a large variety of parameters have been collected in the area of the deep-sea observatory HAUSGARTEN of the Alfred Wegener Institute (Fram Strait) located between 2-6°E and 78-80°N which represents the frontal zone separating the warm and cold water masses originating from the West Spitsbergen current and the East Greenland current. Sampling as accomplished by the PEBCAO team from CTD casts and by net hauls is summarized in Tables 4.1 and 4. 2.

Tab. 4.1: Biogeochemical parameters sampled from CTD casts

Station	Chla/ HPLC	POC/ PON	bPSi	DOC/TDN	TEP/CSP	CHO/AA	TA
HG-I	x	x	x	x	x	x	x
HG-II	x	x	x	x	x	x	x
HG-III	x	x	x	x	x	x	x
HG-IV	x	x	x	x	x	x	x
HG-V	x	x	x	x	x	x	x
HG-VI	x	x	x	x	x	x	x
HG-VII	x	x	x				
HG-VIII	x	x	x	x	x	x	x
HG-IX	x	x	x	x	x	x	x
N5	x	x	x	x	x	x	x
N4	x	x	x	x	x	x	x
N3	x	x	x	x	x	x	x
EG-IV	x	x	x	x	x	x	x
SV-IV	x	x	x	x	x	x	x
SV-III	x	x	x	x	x	x	x
SV-I	x	x	x	x	x	x	x
S3	x	x	x	x	x	x	x

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

Tab. 4.2: Biological parameters

Station	DNA of eukaryotes	Bacterial cell numbers	Bacterial colonization	Zooplankton	Protist grazing
HG-I	x	x	x	x	x
HG-II	x	x			
HG-III	x	x			
HG-IV	x	x	x	x	x
HG-V	x	x		x	x
HG-VI	x	x			
HG-VII	x				
HG-VIII	x	x			
HG-IX	x	x		x	
N5	x	x			x
N4	x	x	x	x	x
N3	x	x			
EG-IV	x	x	x	x	x
SV-IV	x	x			x
SV-III	x	x			
SV-I	x	x			
S3	x	x		x	x

Biogeochemistry and phytoplankton

Seawater samples were taken at 6-12 depths by a CTD/rosette sampler. The water from the rosette was filtered for analysing biogeochemical parameters such as chlorophyll *a* and pigments (HPLC), seston, dissolved and particulate organic carbon (DOC and POC), dissolved and particulate organic nitrogen (DON and PON) and particulate biogenic silica (PbSi). In addition, samples were collected for microscopy to determine phyto- and protozooplankton abundance. Also, carbohydrates and amino acids as well as transparent exopolymer particles (TEP) and Coomassie stainable particles (CSP) were sampled in the water column. Samples for total alkalinity (TA) were collected at all stations. Additionally, water samples were collected from the top 100 m in order to assess differences in the phytoplankton community composition by automated ribosomal intragenic spacer analysis (ARISA) and 454-next generation sequencing. These samples were fractionated by three filtrations on 10.0 µm, 3.0 µm and 0.2 µm filters. All samples were preserved, refrigerated or frozen at -20°C or -80°C for storage until analyses in the home laboratories.

Phytoplankton pigments, particulate matter absorption (PAB) and coloured dissolved organic matter (CDOM)

For the first time, we tested and implemented a new advanced biooptical sensor (the AC-s In situ Spectrophotometer from WETLabs) to obtain continuous total, particulate and dissolved matter attenuation and absorption at the surface water by mounting the system to the sea water pump system for continuous water flow-through. Apparent optical properties were measured daily with a TRIOS RAMSES radiometer set throughout the water column at CTD stations. Water samples for HPLC, PAB and the chromophoric and fluorescent fractions of DOM (CDOM and FDOM, respectively) were taken to invert and calibrate the above continuous optical data sets to obtain biogeochemical information, but also to obtain knowledge on those throughout the water column. The continuous hyperspectral optical measurements (Ramses radiometer and AC-s transmission meter / absorption meter used in profile and during underway measurements) together with the discrete water sample measurements for pigment composition, PAB, CDOM and FDOM will be used to assess the dynamics of phytoplankton (functional types and size classes), terrestrial and marine sources of particles and organic matter through the Fram Strait regarding the different water masses and the remarkable oceanographic conditions presented within the area. Samples for HPLC and PAB were filtered on board immediately after sampling and the filters were thermally chocked on liquid nitrogen and stored in the -80°C freezer afterwards. Water samples for CDOM/FDOM analysis were filtered and analysed on board with the LWCC capillary system to determine CDOM absorption properties. The analysis of those CDOM/FDOM samples for their fluorometric and absorption properties will be done back at the AWI with the spectrofluorometer HORIBA® Aqualog. The LWCC versus sensitive CDOM absorption measurements will be used for calibrating the CDOM absorption results from Aqualog measurements and from the filtered sea-water continuous measurements taken with the AC-s 10 min. every hour. Samples for further CDOM analysis back at AWI were stored at 4°C right after filtration.

Bacterioplankton

Samples were taken to determine bacterial abundance by flow cytometry and microscopy. At four selected stations, colonization of gel particles by bacteria will be investigated by microscopy of double-stained filters (DAPI/Alcian Blue). Surface seawater was incubated with ^{13}C-labelled substrate to study the microbial degradation of brominated halocarbons - highly reactive volatile organic compounds that may contribute up to 40% of stratospheric ozone depletion in mid latitudes.

Grazing experiments with phagotrophic protists

We conducted short-term grazing experiments in order to quantify the protistan grazing effect in four depths (in 5 m, 10 m, in the deep chlorophyll maximum (DCM), and below the DCM) and at eight stations in the HAUSGARTEN area (Table 2). From each depth, 3 l water were collected and incubated at 4°C room temperature which was close to ambient temperatures. The fluorescent labelled microspheres (Fluoresbrite™, Polysciences) were added at a concentration of ~ 20% of the respective prokaryotic abundance. After the addition of these food tracers, subsamples were taken at 0, 15 and 30 min and fixed immediately with 2.7% formaldehyde. All grazing experiments were conducted in duplicates.

At the start of the experiment, 1 ml was filtered on 0.2 µm isopore filters to estimate the initial prokaryotic abundance and number of microspheres. For the enumeration of the average number of ingested microspheres by grazers (e.g. ciliates and flagellates) 10 and 20 ml of the subsamples preserved during the experiment were filtered on 0.6 µm isopore filters. All filters were stored at -20°C for further processing in the lab. For molecular analyses, the remaining water from the incubation experiment was filtrated on Durapore Membranes (Millipore) with a pore size of 3 and 0.22 µm. These filters were stored at -80°C for DNA extraction followed by Illumina sequencing in order to describe the microbial community of each depth and station.

Zooplankton

To investigate community composition and depth distribution of the mesozooplankton in the HAUSGARTEN area, we used a multi-net equipped with 5 nets (mesh size: 150 µm). Vertical net hauls sampling five different depth strata (1500-1000-500-200-50-0 m) were conducted on seven stations (HG-I, HG-IV, HG-IX, S3, N4, N5, EG-IV; Fig. 3.1). The samples were immediately preserved in formalin buffered with hexamethylentetramin and will be analysed at the AWI laboratories in Bremerhaven. In addition to net sampling, the newly developed optical zooplankton recorder LOKI (light frame on-sight key species investigations) was deployed, taking 27 pictures sec^{-1} from the organisms floating in the water column from 1000 m depth to the surface.

Preliminary (expected) results

All samples will be analysed in home laboratories at AWI in Bremerhaven (biogeochemical parameters, phytoplankton abundance and molecular biology, zooplankton community composition and distribution), GEOMAR in Kiel (bacterioplankton) and at the Technical University of Kaiserslautern (grazing experiments with phagotrophic protists).

Data management

The nutrient data will be available approximately one year after the cruise and, after compilation and evaluation of the primary data, will be made available for the public in the PANGAEA Data Publisher for Earth & Environmental Science. Other samples (e.g. net or sediment trap samples) require tedious and time-consuming processing (species identification and enumeration) and, therefore, these analyses will take longer than chemical measurements. Thus, depending on the parameter as well as on the methods used for the analyses, it will take up to three years to complete our analyses. As soon as the data sets are available, other cruise participants request and use them. When the data are to be published, they will also be submitted to the PANGAEA Data Publisher for Earth & Environmental Science and are then open for external use.

5. PELAGIC FOODWEB INTERACTIONS WITH THE BIOLOGICAL PUMP

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[1]AWI
[2]MARUM

Grant No: AWI_PS93.2_03

Background and objectives

The atmospheric carbon dioxide concentration has increased drastically due to anthropogenic activities, currently 400 ppm (June 2015, www.erls.noaa.gov.gmd.ccgg. trends.global.html). The oceans have the capacity to sequester large amounts of CO2 and, thereby, buffer the high atmospheric concentrations of CO_2 by exporting biologically fixed carbon into the deep ocean, where it can be stored for up to millions of years (e.g. Sabine and Tanhua 2010, Sabine et al. 2004). This process shows that it is increasingly important to understand and quantify the role of the oceans in the global carbon cycle. Presently, we know little about the ocean's for carbon sequestration in the future and studies both suggest that past years have had increased and decreased sequestration (e.g. Ballantyne et al. 2012, Le Quéré et al. 2007).

Due to long-term monitoring and many studies on carbon fluxes, we slowly gain insight into the overall processes that affects the annual carbon export (e.g. Guidi et al. 2009; Henson et al. 2012), but we still know little of the processes affecting the export on a regional, diurnal or seasonal scale. Especially the Arctic is currently undergoing rapid environmental changes including warming, acidification and sea ice loss, as well as changes in ecosystem structure and functioning (e.g. Arrigo et al. 2008). These rapid changes in the Arctic Ocean will have large impacts on carbon cycling in the region. Therefore, there is a need for more extensive investigations to obtain a good understanding of the flux processes in this changing environment. During the *Polarstern* cruise PS93.2 we aimed to perform processes studies that were designed to build on the already existing and ongoing long-term monitoring programs of the AWI FRAM project. Hence, we performed studies to determine and quantify the processes shaping the vertical particulate organic carbon flux in the euphotic zone and the twilight zone (100-1,000 m). This was with special focus the composition of carbon flux, settling velocities of marine particles, microbial degradation, and flux attenuation processes.

Work at sea and preliminary results

We performed six vertical profile deployments with the *In-situ* Camera to assess particle size-distribution and abundance in order to obtain high depth-resolution of particle flux and composition. This will enable us to determine flux attenuation in the upper 1,000 m of the water column at a very high depth resolution (cm to meters). Three drifting trap deployments were made in combination with the vertical camera profiles to measure the amount of flux during 24 h. Further we deployed drifting camera together with drifting traps to be able to observe changes in the composition of settling particles at high temporal resolution (seconds) during the 24 h deployment. Additionally, we used gel traps to collect and preserve the size, shape, and structure of the fragile settling particles, such as marine snow. Intact marine snow was also

collected within and below the euphotic zone via a Marine Snow Catcher (eight deployments). Collection of intact and non-fixed marine snow made it possible to perform laboratory measurements of the size, sinking velocity, microbial degradation, and biogeochemical composition of the marine snow. Next to these short-term process studies, we also deployed a newly developed Bio-Optical Platform, which will determine *In-situ* particle size-distribution, abundance, and size-specific sinking velocities, as well as collect intact particles during a year. The size, abundance and sinking velocities will be obtained daily while the collection of intact particles will be done with two to three days intervals once or twice every month.

In-situ Camera

The *In-situ* Camera (ISC) was used to measure particle size-distribution and abundance in the upper 1000 m of the water column (Fig. 5.1). It consisted of an infrared camera that was connected to a Raspberry Pi and stored the data on a hard drive. The illumination was provided by an infrared LED array placed in front of the camera. The use of infrared instead of visible light was to minimize the zooplankton disturbances. The ISC was deployed six times as a profiling system (Table 5.1) and three times on as a drifting camera on the drifting trap array.

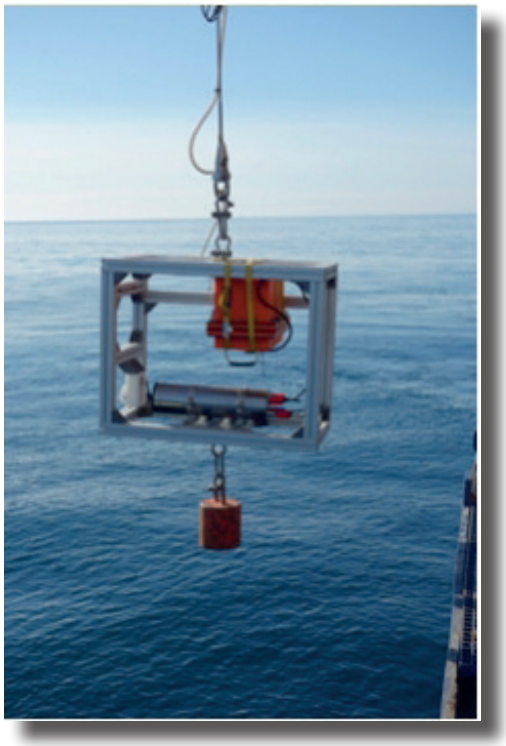

Fig. 5.1: The In-situ Camera when deployed as a vertical profile camera system. The camera and computer pressure housing is observed as the metal cylinder in the lower part of the from with the LED light opposite (white housing to the left on the frame). The power supply was a deep-sea battery (the orange attachment in the upper part of the frame).

The vertical profile made with the ISC at station PS93.0050-2 was made immediately before a CTD deployment and is was, therefore, possible to link the CTD data to the vertical particle profile (Fig. 5.2). We observed a sharp decline in particle abundance at ~80 m, which corresponded well to a steep decline in oxygen, fluorescence, salinity, and temperature. The decline in salinity and temperature may indicate that a pycnocline was formed at ~80 m and that the retention time of the particles increased as they were influenced by the denser water (causing slower sinking velocities). The decline in particle numbers, fluorescence and oxygen indicate that there was intense biological degradation of the particulate organic matter while the aggregates were retained in the pycnocline. We further observed a second peak in particle abundance at 180 m. However, this peak was not correlated to any patterns in the CTD profile and was likely caused by a bloom that occurred before we arrived at the station. The lack of correlation between the particle peak and the oxygen concentration suggested that there was very little biological activity associated with that particle peak.

Tab. 5.1: Deployments of the *In-situ* Camera with information about station ID, date of deployment, time for deployment start, latitude, longitude, deployment depth, and image capture rate (time resolution).

Station ID	Date	Time (UTC)	Latitude	Longitude	Water Depth	Time resolution
PS93.0048-2	24.07.15	09:18	78°36.00'N	5°04.30'E	500 m	300 ms
PS93.0050-2	25.07.15	20:00	79°04.93'N	4°20.07'E	500 m	300 ms
PS93.0058-4	30.07.15	16:53	78°51.73'N	2°45.11'W	500 m	500 ms
PS93.0061-1	03.08.15	09:16	79°45.34'N	4°24.33'E	500 m	500 ms
PS93.0080-4	10.08.15	02:28	79°07.96'N	6°05.86'E	1000 m	500 ms
PS93.0082-3	11.08.15	03:07	79°09.30'N	2°47.75'E	500 m	500 ms

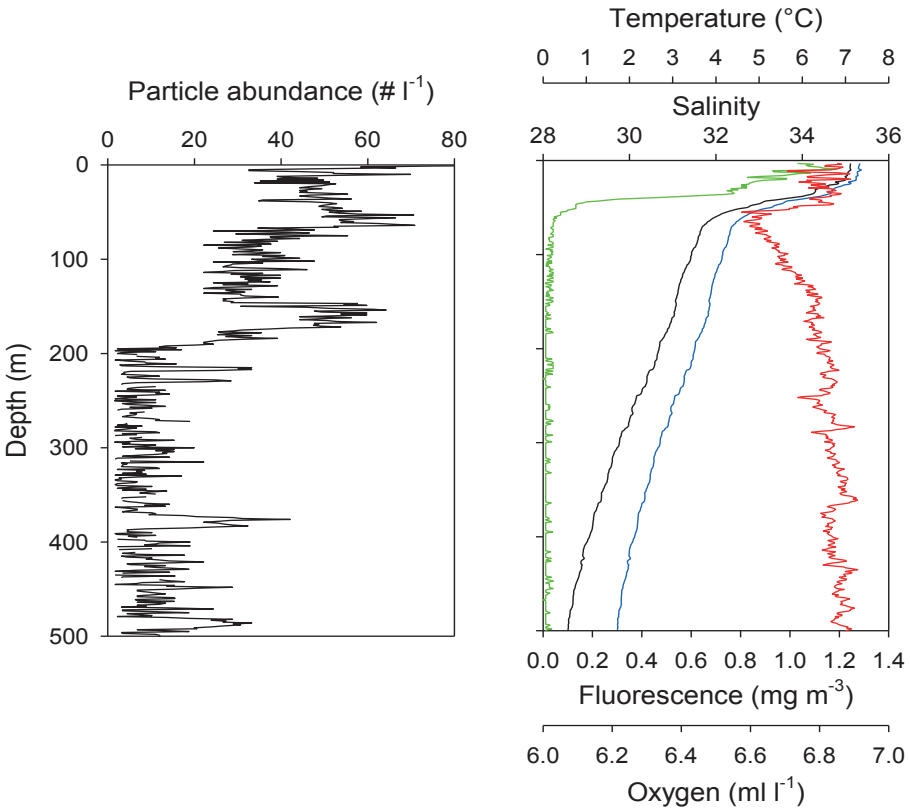

Fig. 5.2: ISC profile 2 made at station PS93.0050-2 (left) shows the particle abundance through the upper 500 m of the water column. The panel in the right side is vertical profiles taken with CTD-Rosette system. Four different profiles are shown from the downcast; temperature (blue), salinity (black), fluorescence (green) and oxygen (red). At ~80 m there was a drop in particle abundance, which corresponded to a decline in all parameters from the CTD cast. The particle peak at ~180 m did not seem to correlate to any of the CTD parameters.

Drift Traps

We used an array of free-drifting sediment traps to measure the export fluxes in the upper 400 m of the water column (Table 5.2, Fig. 5.3a). The drifting trap array consisted out of three trap stations, each with four cylindrical traps attached gyroscopical (Fig. 5.3b). The trap stations were deployed in 100, 200, and 400 m depth. In addition to the sediment trap station, we deployed a drifting camera at 150 m (Fig. 5.3d). Three of the four trap cylinders at each depth were used to collect samples for bulk fluxes, such as biogeochemistry, microscopical investigations, and genetic analysis. The fourth trap cylinder at each depth was equipped with a viscous gel that preserved the structure, shape and size of the fragile particles settling into it (Fig. 5.3c). After recovery of the drifting trap, the samples for bulk fluxes were preserved for later analysis for POC, PON, PIC and silica in Bremen. The particles collected in the gel were photographed with a digital camera and will be used to measure the particle composition, abundance and size distribution.

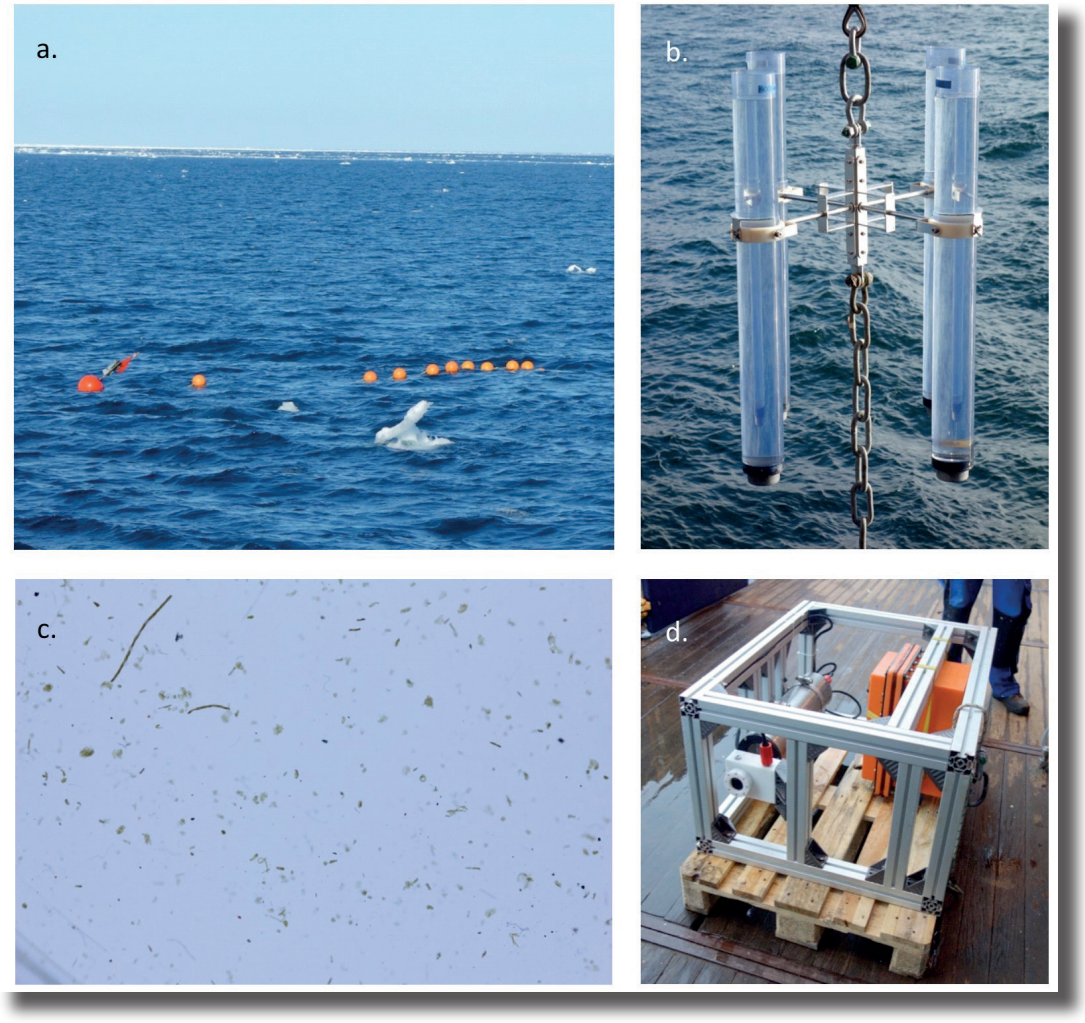

Fig. 5.3: Images of the free-drifting sediment trap when it was floating close to the ice shelf and only the buoy with the GPS positioning system and 10 of the wave-breakers could be seen (a). One of the trap stations with the four sediment trap cylinders (b). One of the cylinders contained a viscous gel for collection of intact settling particles (c). The last image show the drifting cam, which is the same system as the ISC but turned up-side down, whereby the camera sits in the upper part of the frame when it is deployed (d).

Tab. 5.2: Deployments of the free-drifting sediment trap with information about station name, date of deployment, time for deployment and recovery, as well as latitude and longitude for deployment and recovery (see comments).

Station ID	Date	Time (UTC)	Latitude	Longitude	Comments
PS93.0050-9	26.07.15	05.56	79°3.91'N	4°10.76'E	Deployment FDF2
PS93.0050-16	27.07.15	15:11	79°10.93'N	3°55.11'E	Recovery FDF2
PS93.0058-6	30.07.15	18:33	78°51.74'N	2°44.99'W	Deployment FDF3
PS93.0058-15	31.07.15	15:40	78°55.37'N	2°59.29'W	Recovery FDF3
PS93.0061-3	03.08.15	11:05	79°45.34'N	4°24.54'E	Deployment FDF4
PS93.0064-2	04.08.15	15:01	79°48.97'N	4°15.76'E	Recovery FDF4

Marine Snow Catcher

We collected individual settling particles with the marine snow catcher (MSC) to measure size-specific sinking velocities and microbial respiration on single *in-situ* formed particles. The MSC consists of a 100 l cylindrical water samples and a particle collection tray from where the particles can be sampled after they have been allowed to settle for a few hours (Fig. 5.4). We collected settling particles from five different stations (Table 5.3) and measured the size, sinking velocity and microbial respiration of individual particles using a flow-chamber and oxygen microsensors. The measured particles were frozen for later analysis of POC.PON content. The size-specific sinking velocities were similar between the different stations (Fig. 5.5). Microscopic observations of the particles revealed that almost all aggregates consisted of degraded zooplankton faecal pellets, mainly from copepods, that were stuck together (Figs. 5.4b and 5.4c). Generally, the whole plankton community seemed to be a very late bloom with fairly low chlorophyll a concentrations, a heavily grazed phytoplankton community, high abundance of zooplankton, and low nutrient concentrations. Therefore, it is not very surprising that most settling aggregates and particles were made up by faecal pellets. However, very few studies exist during such late bloom. Our preliminary observations suggest that protozooplankton, especially ciliates, had an important role for the breakdown of the aggregates.

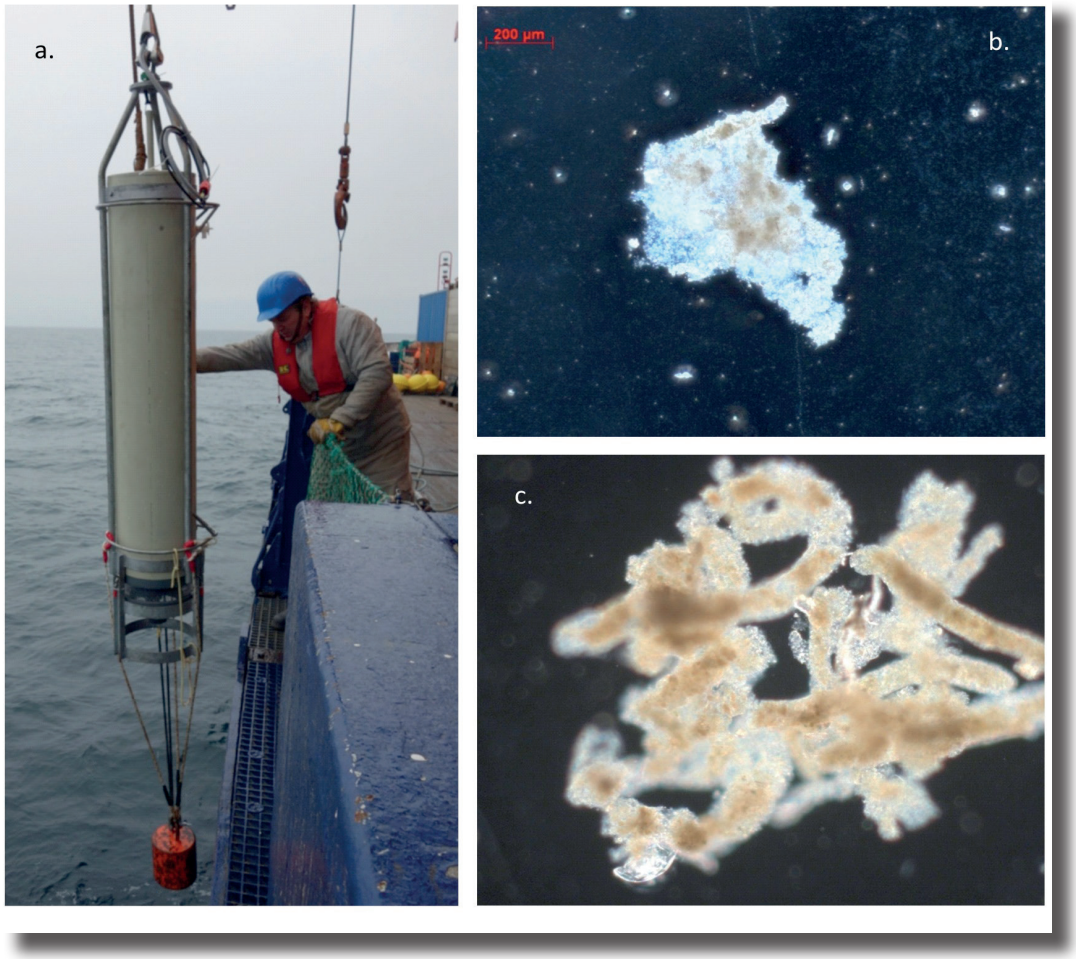

Fig. 5.4: The marine snow catcher was deployed via the ship's winch system and lowered to a specific water depth, where after it was closed by a messenger weight and releaser (a). After recovery the MSC was positioned up-right on deck, typically for three to four hours, to allow the particles to settle to the bottom part of the MSC. Most of the collected particles were faecal pellets or aggregates of faecal pellets (b and c).

Tab. 5.3: Deployments of the marine snow catcher with information about station ID, date of deployment, time for deployment, latitude, longitude, deployment depth, and success of the deployments ('used'). 'Yes' indicates that the deployment and closing of the MSC worked, while 'no' indicates that the deployment did not work due to leakage from the MSC or because it did not close.

Station ID	Date	Time (UTC)	Latitude	Longitude	Water Depth	Used
PS93.0048-3	24.07.15	10:36	78°35.93'N	5°04.14'E	40 m	Yes
PS93.0050-17	27.07.15	16:04	79°10.99'N	3°54.53'E	60 m	Yes
PS93.0058.5	30.07.15	17:52	78°51.73'N	2°45.10'W	30 m	No
PS93.0058-16	31.07.15	16:52	78°54.88'N	2°57.74'W	30 m	No
PS93.0058-19	01.08.15	01:23	78°53.01'N	3°04.16'W	30 m	No

Station ID	Date	Time (UTC)	Latitude	Longitude	Water Depth	Used
PS93.0061-2	03.08.15	10:36	79°45.34'N	4°24.46'E	50 m	Yes
PS93.0080-5	10.08.15	04:34	79°07.97'N	6°06.08'E	65 m	Yes
PS93.0082-4	11.08.15	04:03	79°09.34'N	2°47.47'E	65 m	Yes

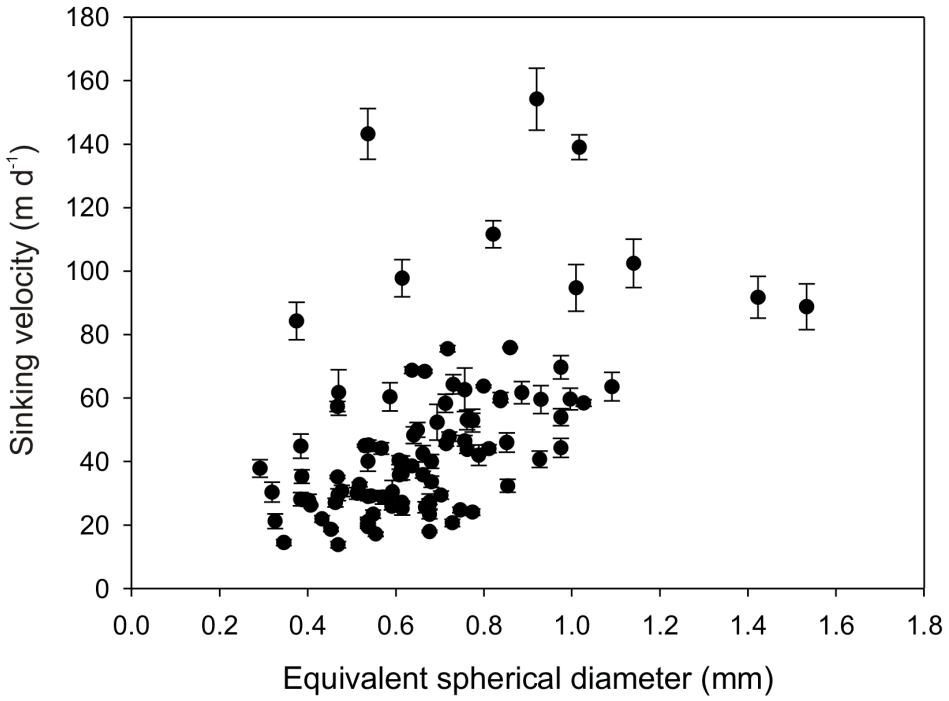

Fig. 5.5: Measured sizes and sinking velocities of the collected particles. There were no clear differences in size-specific sinking velocities between the different station and we have therefore pooled all results. Some of the collected aggregates showed higher sinking velocities, which was mostly caused by a heavy particle attached to the aggregate. The origin of these heavy particles has to be determined microscopically in the home laboratory.

Bio-Optical Platform (MoGelTrap)

The Bio-Optical Platform is designed as a long-term mooring system that can make daily measurements of abundance and size-distribution of the settling particles, as well as measure their size-specific sinking velocities *in-situ*. In addition to those measurements it will also collected intact individual settling aggregates in a viscous gel and, thus, preserve their size, shape, and structure (Fig. 5.6). The optical part of the platform consists of a Plexiglas cylinder with a diameter of 3 cm that is placed between a camera system and an LED light array (Fig. 5.6a). The camera system will make daily image sequences during 5 minutes with a frame rate of one image per second. These image sequences will be used to determine the size-specific sinking velocities of the settling particles and to obtain size-distribution and abundance of the particles. Collection cups are places below the settling cylinder, some of these cups are filled with a poisoned brine solution and some with a viscous gel (Fig. 5.6b). Each of the gel-filled

collection cups will be open for 3 days (Table 5.4), while the cups are open for some weeks. The gel-filled cups will be used for determine changes in particle types and composition of the particles at different seasons throughout the year, while the poison-filled cups will be used for biogeochemical measurements. The Bio-Optical Platform was deployed at 1,300 m depth at the FEVI-31 mooring and will be recovered during the HAUSGARTEN cruise in 2016.

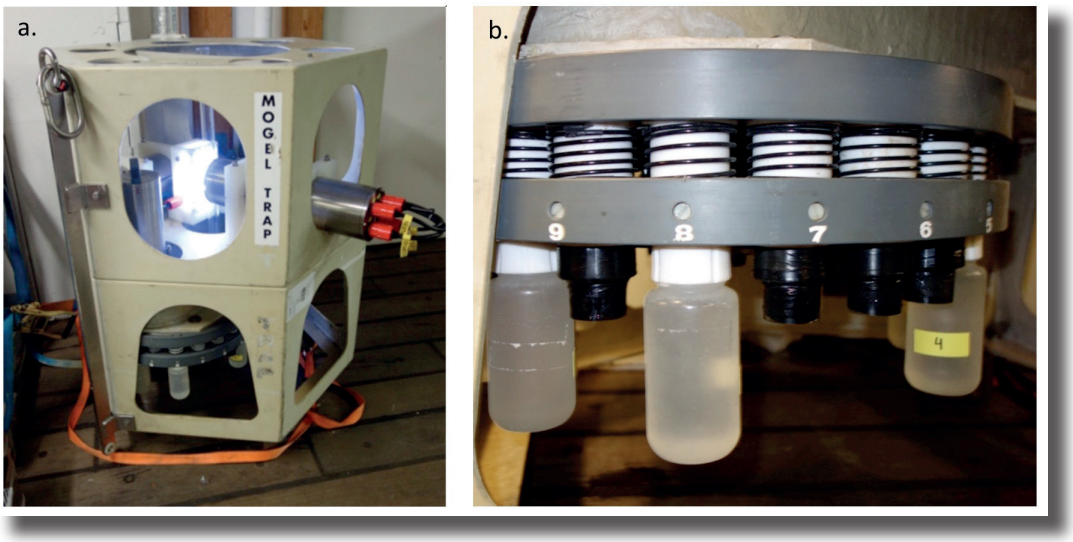

Fig. 5.6: The Bio-Optical Platform before deployment with the light switched on (a). The large cups seen on the collection cup carousel were filled with a poisoned brine solution while the small black cups contain a viscous gel (b).

Tab. 5.4: The table shows the timing of the opening for the different cups. The opening of a new cup will automatic close the previous cup. The type indicates if the cup was filled with gel (gel) or the poisoned brine solution (cup).

Cup no.	Date / Time start	Type	Days open
1	10.08.15 / 00:05 / UTC	Gel	3
2	13.08.15 / 00:05 / UTC	Cup	18
3	01.09.15 / 00:05 / UTC	Gel	3
4	04.09.15 / 00:05 / UTC	Cup	24
5	28.09.15 / 00:05 / UTC	Gel	3
6	01.10.15 / 00:05 / UTC	Gel	3
7	04.10.15 / 00:05 / UTC	Gel	3
8	07.10.15 / 00:05 / UTC	Cup	78
9	24.12.15 / 00:05 / UTC	Gel	3
10	27.12.15 / 00:05 / UTC	Cup	65
11	01.03.16 / 00:05 / UTC	Gel	3
12	04.03.16 / 00:05 / UTC	Cup	25

Cup no.	Date / Time start	Type	Days open
13	29.03.16 / 00:05 / UTC	Gel	3
14	01.04.16 / 00:05 / UTC	Gel	3
15	04.04.16 / 00:05 / UTC	Cup	24
16	28.04.16 / 00:05 / UTC	Gel	3
17	01.05.16 / 00:05 / UTC	Gel	3
18	04.05.16 / 00:05 / UTC	Cup	28
19	01.06.16 / 00:05 / UTC	Gel	3
20	04.06.16 / 00:05 / UTC	Cup	16
21	20.06.16 / 00:05 / UTC	-	

Data management

Data and results will be hosted by the information system PANGAEA at the World Data Center for Marine Environmental Sciences (WDC-MARE), which is operated by AWI and MARUM. Scientific data retrieved from observations, measurements and home-based data analyses will be submitted to PANGAEA either upon publication or with password protection as soon as the data are available and quality-assessed.

References

Arrigo KR, Van Dijken GL, Pabi S (2008): The impact of a shrinking Arctic ice cover on marine primary production. Geophys. Res. Lett., 35: doi: 10.1029.2008GL035028.

Ballantyne AP, Alden CB, Miller JB, Trans PP, White JWC (2012): Increase in observed net carbon dioxide uptake by land and oceans during the past 50 years. Nature, 488: 70-72.

Guidi L, et al. (2009): Effects of phytoplankton community on production, size and export of large aggregates: A world-ocean analysis. Limnol. Oceanogr., 54: 1951-1963.

Henson SA, Sanders R, Madsen E (2012): Global patterns in efficiency of particulate organic carbon export and transfer to the deep ocean. Global Biogeochem. Cycles 26: doi: 10.1029.2011GB004099.

Le Quéré C, et al. (2007): Saturation of the Southern Ocean CO_2 Sink due to Recent Climate Change. Science, 316: 1735-1738.

Sabine C, Tanhua T (2010): Estimation of anthropogenic CO_2 inventories in the ocean. Annu. Rev. Mar. Sci., 2: 175-198.

Sabine CL, et al. (2004): The Oceanic Sink for Anthropogenic CO_2. Science, 305: 367-371.

6. ASSESSING DYNAMICS OF NUTRIENTS USING AUTONOMOUS INSTRUMENTS IN FRAM STRAIT (DYNAMITE)

Alex Beaton[1], Sinhue Torres-Valdes[1], [1]NOCS
Mandy Kiel[1], Ian Salter[2]; [2]AWI
Sheldon Bacon[1] (not on board)

Grant No: AWI_PS93.2_04

Outline

In order to evaluate how current and future climate change affects Arctic Ocean (AO) nutrient biogeochemistry at the pan-Arctic scale, it is important to understand its nutrient budget. While data currently available has allowed us to carry out a first assessment of dissolved inorganic nutrient transports and budget (Torres-Valdes et al. 2013), we still lack information regarding

1) the relevance of dissolved organic nutrient pools to the AO nutrient budget, and

2) temporal changes of nutrient transports into from the AO. This information is required if we are to understand present-day AO nutrient budget closure.

While oceanographic research ships represent invaluable platforms to collect samples, autonomous autosamplers and sensors are unique scientific tools that allow for the generation of data over long periods of time at fixed locations in the ocean. These instruments are particularly useful to generate data over the harsh winter conditions in Polar Regions, when accessibility by research ships is limited.

The marine facilities of the LTER (Long-Term Ecological Research) observatory HAUSGARTEN in Fram Strait provide a great opportunity to investigate temporal changes of nutrient transports across this AO gateway. We aim to generate new data by monitoring nutrient concentrations of the outflowing waters associated with the East Greenland Current and the inflowing waters associated with the West Spitsbergen Current. This will allow us to compute nutrient transports associated with two major ocean currents and to further assess the role of transports across Fram Strait to the wider AO nutrient budget.

Objectives

The objective of the DYNAMITE project is to use cutting edge sensors (Beaton et al. 2012), autosamplers and manually collected samples to study nutrient transports into and out of the AO in Fram Strait. On PS93.2 our objectives were to prepare and deploy lab-on-chip nutrient sensors (developed at the National Oceanography Centre at the University of Southampton, NOCS) and autosamplers, as well as collect samples from CTD casts for the analyses of dissolved organic (nitrogen and phosphorus) and inorganic (nitrate and phosphate) nutrients. Also, we aim to gain insight concerning the bacterial communities associated with dissolved organic matter cycling in the AO.

The original objective was to deploy four lab-on-chip sensors in total, spread over two moorings, where each mooring would contain one nitrate sensor and one phosphate sensor. These would be moored at a depth of approx. 80 m. One mooring would be located in the East

Greenland Current, and the other in the West Spitsbergen Current. Prior to the expedition time was dedicated to test the sensors under simulated polar environmental conditions using the NOCS cooled pressure pot. While the nitrate sensor was shown to operate well under the expected conditions, the phosphate sensor did not initially show sufficiently high performance in the laboratory at low temperatures to warrant deployment on a mooring for one year.

Due to the departure of a team member (Adrian Nightingale), we were unfortunately unable to devote enough resources to the testing and further development of the phosphate sensor. As we were not able to show the sensor working sufficiently well at low temperatures, we decided to not attempt the deployment of the phosphate sensor on PS93.2. In its place, we prepared an extra nitrate sensor to be deployed alongside the original nitrate sensor in order to provide some redundancy. Significant resources at NOCS are now being devoted to the development of the phosphate sensor, and there remains a good chance that we can have the sensor functioning sufficiently well at low temperatures in order to deploy it next year. We are very keen to demonstrate its performance in this environment and obtain a year-round phosphate record at these sites.

Work at sea

We had a total of three nitrate sensors available for deployment. Initial work at sea involved preparing the liquid chemicals for the sensors (reagents and calibration solutions), and running the sensors in the laboratory to ensure these operated correctly. Following tests, all three nitrate sensors were shown to be functioning properly. For each sensor, an on-board 10 µM standard was prepared in artificial seawater, and this was poisoned using a small amount of chloroform in order to promote its stability over the deployment period. A sample of the 10 µM standard was taken and frozen for later analysis. Upon recovery next year, a sample of the remaining 10 µM standard will be taken in order to monitor any drift in its concentration over this period. Each nitrate sensor was also deployed with an artificial seawater blank solution, 1 L Griess reagent (with 35 g L^{-1} NaCl to prevent freezing) and 1 L imidazole buffer (with 10 % ethylene glycol to prevent freezing). Each sensor also has an empty 3 L waste bag to collect the sensor waste so that it is not expelled into the environment (this is one key advantage of microfluidic systems – almost all other *in-situ* analysers would expel waste into the surrounding environment).

The sensors were each powered by 24 lithium metal D-cell batteries, which were inserted into battery holders and place in pressure housings while on board the ship. Lithium metal batteries give significantly better performance at low temperatures compared to alkaline batteries. The battery pressure housings were then mounted to the autosampler frames along with the sensors. We deployed two of the sensors: one on the mooring at HAUSGARTEN station EG-IV and another one on the mooring at HG-IV (Fig. 3.1). The sensors on EG-IV (NOCS Version 3 nitrate sensors, serial numbers SN51 and SN66; Fig. 6.1) were fitted to a custom frame, which also housed a Green Eyes water sampler. A CTD probe was deployed just below this frame.

The nitrate sensors were programmed to take a measurement every twelve hours for the duration of deployment. The initial cycle was programmed so that the sensors turn on automatically on power-up, and then sleep for a pre-determined time period before waking up and performing their first measurement. This is to allow enough time for the deployment of the mooring before the sensor attempts to pump in seawater for measurement. The sleep period was set to 6 hours for SN51 and 12 hours for SN66, meaning that their measurements are staggered. Provided both sensors work correctly, this configuration will yield 4 nitrate measurements per day at EG-IV. On deployment, the frame and sensors entered the water smoothly and were estimated to sit at a depth of 50 m (slightly shallower than we had anticipated, but likely well within the polar outflow).

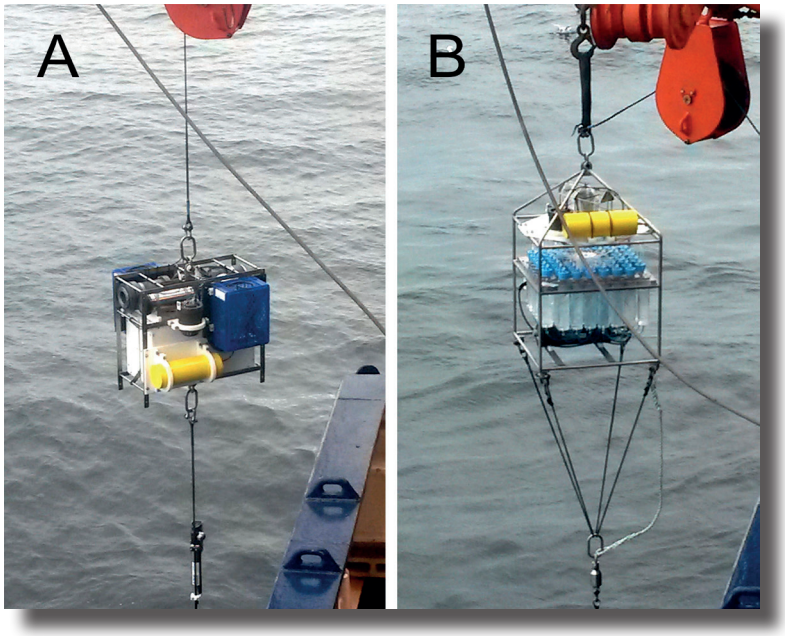

Fig. 6.1: Photographs of the autosampler frames with sensors attached entering the water. a) Custom frame with Green Eyes sampler and two LOC nitrate sensors being deployed at EG-IV. b) McLane RAS sampler with one LOC nitrate sensor being deployed at HG-IV. The yellow tubes are the battery pressure housings.

The remaining nitrate sensor was deployed at HG-IV intending to sample the West Spitsbergen Current. The sensor was attached to the frame of a McLane RAS autosampler using an adapter frame made a NOCS. The sensor (NOCS Version 3 nitrate sensor, serial number SN71) was programmed to take its first measurement 6 hours after power-up and perform a measurement every 12 hours. Data from both sensors will be downloaded when the sensors are recovered next year.

In addition to the preparation and deployment of the sensors, we collected 229 samples (from every CTD cast) for the analysis of dissolved inorganic nutrients (nitrate and phosphate) and dissolved organic nitrogen (DON) and dissolved organic phosphorous (DOP). These were stored frozen at -20ºC for later analysis back at NOCS.

Preliminary results

Following advice by our host partner, samples collected during PS93.2 were left on *Polarstern* until she is back in Bremerhaven. Shipment of samples to NOCS will be then arranged. Once samples are back at NOCS, we expect to complete the analysis of DON and DOP within 4-6 months. Data from the sensors will be obtained when they are recovered in 2016 and samples from the RAS autosamplers will also be drawn for later analysis.

Data management

When available, processed data will be submitted to the PANGAEA and BODC data repositories. Data will also be made available to other participants of the expedition if needed.

References

Beaton AD, Cardwell CL, Thomas RS, Sieben VJ, Waugh EM, Statham PJ, Mowlem MC, Morgan H (2012): Lab-on-Chip Measurement of Nitrate and Nitrite for In-Situ Analysis of Natural Waters. Environ. Sci. Tech., 46: 17.

Torres-Valdés S, Tsubouchi T, Bacon S, Naveira-Garabato A, Sanders R, McLaughlin FA, Petrie B, Kattner G, Azetsu-Scott K, Whitledge TE (2013): Nutrient exports from the Arctic Ocean. J. Geophys. Res. - Oceans, 118: 1625-1644.

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

Katarzyna Zamelczyk, Pær Jansson UiT

Grant No: AWI_PS93.2_05

Objectives and work at sea

The overall purpose of the participation of scientists from CAGE (Center for Arctic Gas hydrates Environment and Climate) on the PS93.2 cruise, *Polarstern*, was to install a methane sensor and a CTD on the deep lander platform in central HAUSGARTEN. Additionally, CTD profiles and water samples for methane concentrations were collected in active methane seep locations. This work was conducted within the FixO3 project. Moreover, WP-2 plankton net and surface sediment samples were collected in the same locations (Table 7.1). These samples will be used to study the impact of methane on planktonic and benthic foraminifera.

Tab. 7.1: Stations and activities

Station ID	Date	Time	Location	Lati-tude	Longi-tude	Water depth [m]	Work description
PS93.0067	06.08.15	16:51	west of Prins Karls Forland	78° 37.62'	10° 34.74'	69	CTD, water samples, WP2, MUC
PS93.0068	06.08.15	19:04	west of Prins Karls Forland	78° 34.17'	10° 11.74'	94	CTD, water samples, WP2
PS93.0069	06.08.15	20:35	west of Prins Karls Forland	78° 34.40'	9° 46.29'	114	CTD, water samples, WP2, MUC
PS93.0070	06.08.15	23:57	west of Prins Karls Forland	78° 33.28'	9° 28.67'	388	CTD, water samples, WP2, MUC
PS93.0067	11.08.15	11:14	central HAUSGARTEN site (HG-IV)	79°04.69'	04°06.78'	2589	Long-term Lander, CTD, methane sensor

Data sampling on the deep lander (Fig. 7.1) was scheduled to start on August 14 and battery endurance should allow for 12 months of sampling. The CTD (Seabird 16+ V2) will record salinity, temperature and pressure every 10 minutes. The Methane sensor (METS, Franatech) needs 12 hours of warm up before it produces qualitative methane concentration data. The sampling schedule was set to "Acquisition time" of 60 hours (Giving 48 hours of data) and

the "Interval time" to 240 hours. The data from the central HAUSGARTEN site will mainly serve as a reference site for the CAGE observatory in an area where no deep-water gas hydrate has been found. The collected water samples (a total of 48 bottles) will be analysed for methane concentrations at The Arctic University of Norway, CAGE, using headspace Gas Chromatography method.

Fig. 7.1. Methane sensor with battery pack and CTD (right) mounted on the AWI Long-term Bottom-Lander (left) deployed for one year at the central HAUSGARTEN site

Preliminary (expected) results

We expect, from the deep-sea lander instrumentation, to obtain a record of bottom water properties such as temperature, salinity and pressure from the CTD and methane concentrations from the METS instrument. Water sampling at the four FixO3 stations will result in methane concentration profiles at 12 discrete depths. Species composition and geochemical analysis on planktonic and benthic foraminifera shells collected in the water column and retrieved from surface sediment samples, respectively, will be analysed and the potential influence of methane on the shell chemistry and distribution and abundance of planktonic foraminiferal species, if any, will be estimated.

Data management

We expect that the resulting data will be available at different times, depending on the type of data. Analysis of water samples taken at the four FixO3 stations for methane concentration will be conducted at the University of Tromsø as soon as the Gas chromatograph has been reinstalled at the institute. We expect that in November 2015. The data from long-term measurements at the deep-sea lander will be available for a first evaluation at earliest by the time of the recovery of the lander - most probably in June or July 2016. The processing of plankton net and surface sediment samples and the picking of shells for geochemical analysis will be carried out at the University of Tromsø. Geochemical assessments will be done within year 2016.

Preliminary data will be available to cruise participants and external users upon request and final, processed data, submitted to the PANGAEA data library. Unrestricted availability from PANGAEA will depend on the required time and effort for acquisition of individual datasets and its status of scientific publication.

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP'S CREW

A.4 STATION LIST

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
GEOMAR	GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel Wischhofstr. 1-3 24148 Kiel Germany
HeliService	HeliService international GmbH Am Luneort 15, D-27572 Bremerhaven Germany
ICM Barcelona	Institute of Marine Sciences Passeig Marítim de la Barceloneta, 37-49 E-08003 Barcelona Spain
MARUM	MARUM - Zentrum für Marine Umweltwissenschaften der Universität Bremen Leobener Str. D-28359 Bremen Germany
MPIMM	Max-Planck-Institut für Marine Mikrobiologie Celsiusstraße 1 28359 Bremen Germany
NOCS	National Oceanography Centre University of Southampton Waterfront Campus European Way Southampton SO14 3ZH United Kingdom

	Address
UiT	University of Tromsø (Universitetet i Tromsø) Norges arktiske universitet Hansine Hansens veg 18 9019 Tromsø Norway
Uni Kaiserslautern	Technische Universität Kaiserslautern Gottlieb-Daimler-Straße 67663 Kaiserslautern Germany
Uni Kiel	Christian-Albrechts-Universität zu Kiel Christian-Albrechts-Platz 4 24118 Kiel Germany
Uni Würzburg	Universität Würzburg Sanderring 2 97070 Würzburg Germany

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name. Last name	Vorname. First name	Institut Institute	Beruf / Profession
Bauerfeind	Eduard	AWI	Biologist
Beaton	Alex	NOCS	Chemist
Bergmann	Melanie	AWI	Biologist
Braeckman	Ulrike	MPIMM	Biologist
Brauer	Jens	HeliService	Helicopter Pilot
Busch	Kathrin	Uni Kiel	Biologist
Büttner	Hauke	MARUM	Technician, ROV-Team
Chennu	Arjun	MPIMM	Biologist
Endres	Sonja	GEOMAR	Biologist
Fruntke	Juliane	DWD	Technician, meteorology
Hagemann	Jonas	AWI	Biologist
Hasemann	Christiane	AWI	Biologist
Heckmann	Hans	HeliService	Helicopter Pilot.Technician
Hempelt	Julia	DWD	Meteorologist
Hoffmann	Ralf	AWI	Chemist
Hoffmann	Katy	MPIMM	Biologist
Iversen	Morten	MARUM	Biologist
Jansson	Pær	Uni Tromsø	Chemist
Kiel	Mandy	AWI	Technician, biology
Knüppel	Nadine	AWI	Technician, biology
Kolar	Ingrid	AWI	Student, biology
Konrad	Christian	MARUM	Technician, biology
Lehmenhecker	Sascha	AWI	Engineer, AUV-Team
Leymann	Tom	MARUM	Technician, ROV-Team
Lochthofen	Normen	AWI	Engineer
Ludszuweit	Janine	AWI	Technician, biology
Mai	Hoang Anh	MARUM	Technician, ROV-Team
Mikschl	Tobias	Uni Würzburg	PhD student, physics
Möllendorf	Carsten	HeliService	Technician, helicopter
Niehoff	Barbara	AWI	Biologist
Nordhausen	Axel	MPIMM	Technician, chemistry
Ramirez Perez	Marta	ICM Barcelona	Physicist
Rapp	Josephine	MPIMM	Biologist
Ratmeyer	Volker	MARUM	Technician, ROV-Team
Reuter	Michael	MARUM	Technician, ROV-Team
Sablotny	Burkhard	AWI	Engineer
Salter	Ian	AWI	Chemist

Name. **Last name**	**Vorname.** **First name**	**Institut** **Institute**	**Beruf / Profession**
Schewe	Ingo	AWI	Biologist
Schröter	Jens	HeliService	Helicopter Pilot
Seiter	Christian	MARUM	Technician, ROV-Team
Shurn	Kimberly	AWI	Engineer, AUV-Team
Soltwedel	Thomas	AWI	Biologist
Spill	Meike	AWI	Student, biology
Strohmeier	Michael	Uni Würzburg	PhD student, physics
Tippenhauer	Sandra	AWI	Oceanographer
Torres-Valdes	Sinhue	NOCS	Chemist
van der Jagt	Helga	MARUM	Biologist
Vittori	Vincent	MARUM	Technician, ROV-Team
Weinisch	Lea	Uni Kaiserslautern	Biologist
Wiegmann	Sonja	AWI	Technician, biology
Wulff	Thorben	AWI	Engineer, AUV-Team
Zamelczyk	Katarzyna	Uni Tromsø	Biologist

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1	Wunderlich, Thomas	Master
2	Grundmann, Uwe	1. Offc.
3	Westphal, Henning	Ch. Eng.
4	Fallei, Holger	2. Offc.
5	Kentges, Felix	2. Offc.
6	Stolze, Henrik	2. Offc.
7	Spilok, Norbert	Doctor
8	Hofmann, Jörg	R. Offc.
9	Buch, Erik-Torsten	2. Eng.
10	Rusch, Torben	2. Eng.
11	Schnürch, Helmut	2. Eng.
12	Brehme, Andreas	Elec. Tech.
13	Redmer, Jens	Elec. Tech.
14	Dimmler, Werner	ELO
15	Feiertag, Thomas	ELO
16	Ganter, Armin	ELO
17	Winter, Andreas	ELO
18	Schröter, René	Boatsw.
19	Neisner, Winfried	Carpenter
20	Burzan, Gerd-Ekkehard	A.B.
21	Clasen, Nils	A.B.
22	Gladow, Lothar	A.B.
23	Hartwig-Labahn, Andreas	A.B.
24	Kretzschmar, Uwe	A.B.
25	Leisner, Bert	A.B.
26	Müller, Steffen	A.B.
27	Schröder, Norbert	A.B.
28	Sedlak, Andreas	A.B.
29	Beth, Dethlef	Storek.
30	Dinse, Horst	Mot-man
31	Klein, Gert	Mot-man
32	Krösche, Eckard	Mot-man
33	Plehn, Markus	Mot-man
34	Watzel, Bernhard	Mot-man
35	Meißner, Jörg	Cook
36	Tupy, Mario	Cooksmate
37	Golla, Gerald	Cooksmate

No.	Name	Rank
38	Wartenberg, Irina	1. Stwdess
39	Schwitzky-S., Carmen	Stwdess.N.
40	Hischke, Peggy	2. Stwdess
41	Chen, Quan Lun	2. Steward
42	Chen, Xiyong	2. Stwdard
43	Hu, Guo Yong	2. Steward
44	Duka, Maribel	2. Stwdess
45	Ruan, Hui Guang	Laundrym.

A.4 STATIONSLISTE / STATION LIST PS93.2

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water Depth [m]
PS93.0048-1	24.07.2015	08:05:00	CTD.RO	max. depth	78° 35.96' N	5° 4.13' E	2340.5
PS93.0048-2	24.07.2015	09:46:00	ISC	max. depth	78° 35.98' N	5° 4.21' E	2340.0
PS93.0048-3	24.07.2015	10:40:02	MSC	max. depth	78° 35.93' N	5° 4.09' E	2340.2
PS93.0048-4	24.07.2015	12:17:02	LOKI	profile start	78° 35.98' N	5° 4.13' E	2340.2
PS93.0048-4	24.07.2015	12:22:00	LOKI	profile end	78° 35.98' N	5° 4.13' E	2340.2
PS93.0048-5	24.07.2015	13:39:00	MN	max. depth	78° 35.98' N	5° 4.10' E	2340.5
PS93.0048-6	24.07.2015	15:13:00	RAMSES	max. depth	78° 35.94' N	5° 4.16' E	2340.5
PS93.0048-7	24.07.2015	15:59:00	CTD.RO	max. depth	78° 35.94' N	5° 4.10' E	2341.0
PS93.0048-8	24.07.2015	17:44:00	OFOS	profile start	78° 37.02' N	5° 9.56' E	2350.5
PS93.0048-8	24.07.2015	21:51:00	OFOS	profile end	78° 36.98' N	4° 59.39' E	2366.7
PS93.0048-9	25.07.2015	00:11:01	LOKI	profile start	78° 35.94' N	5° 4.13' E	2341.2
PS93.0048-9	25.07.2015	00:49:00	LOKI	profile end	78° 35.92' N	5° 4.14' E	2340.7
PS93.0048-10	25.07.2015	02:07:00	MUC	max. depth	78° 35.98' N	5° 4.09' E	2341.0
PS93.0048-11	25.07.2015	04:12:00	MUC	max. depth	78° 35.98' N	5° 4.07' E	2341.5
PS93.0048-12	25.07.2015	07:55:01	ROV	profile start	78° 36.04' N	5° 3.82' E	n.d.
PS93.0048-12	25.07.2015	11:59:00	ROV	profile end	78° 36.07' N	5° 3.90' E	n.d.
PS93.0049-1	25.07.2015	17:52:00	MOR	recovery	78° 50.85' N	4° 24.59' E	2468.5
PS93.0050-1	25.07.2015	19:39:59	LANDER	deployment	79° 4.98' N	4° 20.23' E	2277.5
PS93.0050-2	25.07.2015	20:30:00	ISC	max. depth	79° 4.92' N	4° 20.07' E	2280.2
PS93.0050-3	25.07.2015	22:20:00	CTD.RO	max. depth	79° 3.93' N	4° 10.72' E	2465.5
PS93.0050-4	25.07.2015	23:45:00	BONGO	max. depth	79° 3.92' N	4° 10.77' E	2465.0
PS93.0050-5	26.07.2015	00:48:00	MUC	max. depth	79° 3.92' N	4° 10.93' E	2464.0
PS93.0050-6	26.07.2015	02:47:00	MUC	max. depth	79° 3.90' N	4° 10.76' E	2467.0
PS93.0050-7	26.07.2015	04:16:00	CTD.RO	max. depth	79° 3.91' N	4° 10.74' E	2466.5
PS93.0050-8	26.07.2015	05:14:00	RAMSES	max. depth	79° 3.91' N	4° 10.74' E	2466.7
PS93.0050-9	26.07.2015	06:53:59	TRAPS	deployment	79° 3.90' N	4° 10.89' E	2465.7
PS93.0050-10	26.07.2015	10:00:00	ROV	profile start	79° 4.98' N	4° 7.62' E	n.d.
PS93.0050-10	26.07.2015	17:35:00	ROV	profile end	79° 4.95' N	4° 7.70' E	n.d.
PS93.0050-11	26.07.2015	21:10:00	OFOS	profile start	79° 2.02' N	4° 9.91' E	2628.7
PS93.0050-11	27.07.2015	01:08:00	OFOS	profile end	79° 3.93' N	4° 17.28' E	2405.7
PS93.0050-12	27.07.2015	03:59:00	MN	max. depth	79° 3.92' N	4° 10.84' E	2464.2
PS93.0050-13	27.07.2015	05:45:00	LANDER	recovery	79° 3.89' N	4° 5.97' E	2539.2
PS93.0050-14	27.07.2015	10:29:00	ROV	profile start	0° 0.00' N	0° 0.00' E	n.d.
PS93.0050-14	27.07.2015	10:29:01	ROV	profile end	0° 0.00' N	0° 0.00' E	n.d.
PS93.0050-15	27.07.2015	11:16:00	MOR	recovery	79° 0.49' N	4° 24.23' E	2575.2
PS93.0050-16	27.07.2015	15:45:00	TRAPS	recovery	79° 11.01' N	3° 54.84' E	2378.7
PS93.0050-17	27.07.2015	16:10:00	MSC	max. depth	79° 10.98' N	3° 54.46' E	2370.7
PS93.0050-18	27.07.2015	17:55:00	LANDER	recovery	79° 5.27' N	4° 19.67' E	n.d.
PS93.0050-19	27.07.2015	20:29:00	MUC	max. depth	79° 3.91' N	4° 10.79' E	2465.2
PS93.0051-1	27.07.2015	22:41:00	RAMSES	max. depth	79° 3.73' N	3° 39.91' E	3115.2

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water Depth [m]
PS93.0051-2	28.07.2015	00:12:00	CTD.RO	max. depth	79° 3.78' N	3° 39.60' E	3117.2
PS93.0051-3	28.07.2015	01:48:00	LOKI	profile start	79° 3.79' N	3° 39.53' E	3124.0
PS93.0051-3	28.07.2015	02:29:00	LOKI	profile end	79° 3.80' N	3° 39.60' E	3115.0
PS93.0051-4	28.07.2015	03:47:00	MUC	max. depth	79° 3.81' N	3° 39.46' E	3127.0
PS93.0052-1	28.07.2015	08:18:00	ROV	profile start	79° 4.91' N	4° 8.59' E	n.d.
PS93.0052-1	28.07.2015	11:58:00	ROV	profile end	79° 4.91' N	4° 8.52' E	n.d.
PS93.0052-2	28.07.2015	13:53:00	CTD.RO	max. depth	79° 4.88' N	4° 8.44' E	2461.5
PS93.0053-1	28.07.2015	18:21:00	CTD.RO	max. depth	79° 3.60' N	3° 34.98' E	3433.5
PS93.0053-2	28.07.2015	20:14:00	RAMSES	max. depth	79° 3.60' N	3° 34.95' E	3460.5
PS93.0053-3	28.07.2015	22:01:00	MUC	max. depth	79° 3.61' N	3° 34.98' E	3429.5
PS93.0054-1	29.07.2015	01:04:00	CTD.RO	max. depth	79° 3.62' N	3° 28.69' E	3986.5
PS93.0054-2	29.07.2015	04:02:00	MUC	max. depth	79° 3.63' N	3° 28.56' E	4091.7
PS93.0055-1	29.07.2015	07:55:00	CTD.RO	max. depth	79° 3.85' N	3° 20.18' E	5106.0
PS93.0055-2	29.07.2015	11:31:00	MUC	max. depth	79° 3.86' N	3° 20.10' E	5108.2
PS93.0056-1	29.07.2015	16:41:00	MUC	max. depth	79° 8.02' N	2° 50.58' E	5569.7
PS93.0057-1	30.07.2015	06:08:00	MOR	recovery	78° 31.64' N	2° 46.98' W	n.d.
PS93.0058-1	30.07.2015	13:02:00	CTD.RO	max. depth	78° 50.07' N	2° 47.95' W	2589.7
PS93.0058-2	30.07.2015	12:33:00	ZODIAK	max. depth	78° 50.07' N	2° 47.92' W	2589.7
PS93.0058-3	30.07.2015	16:19:01	MOR	deployment	78° 50.11' N	2° 47.96' W	2588.5
PS93.0058-4	30.07.2015	17:22:00	ISC	max. depth	78° 51.73' N	2° 45.08' W	2584.0
PS93.0058-5	30.07.2015	18:07:00	MSC	max. depth	78° 51.74' N	2° 45.02' W	2584.2
PS93.0058-6	30.07.2015	19:21:59	TRAPS	deployment	78° 51.82' N	2° 45.75' W	2582.7
PS93.0058-7	30.07.2015	20:06:00	RAMSES	max. depth	78° 51.65' N	2° 42.26' W	2593.0
PS93.0058-8	30.07.2015	20:41:00	CTD.RO	max. depth	78° 51.69' N	2° 42.56' W	2592.5
PS93.0058-9	30.07.2015	21:43:02	LOKI	profile start	78° 51.71' N	2° 42.62' W	2592.2
PS93.0058-9	30.07.2015	22:21:00	LOKI	profile end	78° 51.71' N	2° 42.45' W	2593.0
PS93.0058-10	30.07.2015	22:46:00	BONGO	max. depth	78° 51.70' N	2° 42.54' W	2592.5
PS93.0058-11	31.07.2015	00:12:00	MN	max. depth	78° 51.77' N	2° 42.88' W	2591.7
PS93.0058-12	31.07.2015	02:50:00	MUC	max. depth	78° 51.73' N	2° 42.61' W	2592.0
PS93.0058-13	31.07.2015	07:03:00	MOR	recovery	78° 36.49' N	2° 53.67' W	n.d.
PS93.0058-14	31.07.2015	09:49:00	MOR	recovery	78° 33.59' N	2° 45.22' W	n.d.
PS93.0058-15	31.07.2015	16:14:00	TRAPS	recovery	78° 55.41' N	2° 59.95' W	2502.7
PS93.0058-16	31.07.2015	16:54:00	MSC	max. depth	78° 54.88' N	2° 57.73' W	2518.2
PS93.0058-17	31.07.2015	18:30:00	MUC	max. depth	78° 54.88' N	2° 57.71' W	2518.5
PS93.0058-18	31.07.2015	21:23:00	OFOS	profile start	78° 54.55' N	2° 58.82' W	2516.2
PS93.0058-18	01.08.2015	00:01:00	OFOS	profile end	78° 53.28' N	3° 2.43' W	2512.2
PS93.0058-19	01.08.2015	01:28:00	MSC	max. depth	78° 53.01' N	3° 4.19' W	2504.2
PS93.0059-1	01.08.2015	06:28:00	CTD.RO	max. depth	78° 54.71' N	0° 43.92' W	2661.7
PS93.0059-2	01.08.2015	07:05:00	ZODIAK	max. depth	78° 54.71' N	0° 43.98' W	2661.5
PS93.0059-3	01.08.2015	09:49:00	AUV	profile start	78° 54.74' N	0° 43.58' W	n.d.
PS93.0059-3	01.08.2015	15:05:00	AUV	profile end	78° 54.71' N	0° 44.45' W	n.d.
PS93.0060-1	02.08.2015	09:48:00	CTD.RO	max. depth	79° 56.28' N	3° 17.17' E	2515.2
PS93.0060-2	02.08.2015	11:27:00	AUV	profile start	79° 56.31' N	3° 16.81' E	n.d.

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water Depth [m]
PS93.0060-3	02.08.2015	10:46:00	MIC	Test at 100 m	79° 56,29' N	3° 16,80' E	n.d.
PS93.0060-4	02.08.2015	13:22:00	HN	max. depth	79° 58.11' N	3° 21.03' E	n.d.
PS93.0060-2	02.08.2015	16:42:00	AUV	profile end	80° 0.24' N	3° 32.85' E	n.d.
PS93.0060-5	02.08.2015	18:48:00	RAMSES	max. depth	79° 56.28' N	3° 11.38' E	2547.7
PS93.0060-6	02.08.2015	20:16:00	CTD.RO	max. depth	79° 56.30' N	3° 11.47' E	2546.7
PS93.0060-7	02.08.2015	21:42:00	BONGO	max. depth	79° 56.31' N	3° 11.48' E	2546.5
PS93.0060-8	02.08.2015	22:51:00	LOKI	profile start	79° 56.33' N	3° 11.32' E	2547.2
PS93.0060-8	02.08.2015	23:27:00	LOKI	profile end	79° 56.31' N	3° 11.42' E	2547.7
PS93.0060-9	03.08.2015	00:43:00	MN	max. depth	79° 56.27' N	3° 11.64' E	2548.0
PS93.0060-10	03.08.2015	02:50:00	MUC	max. depth	79° 56.29' N	3° 11.59' E	2548.2
PS93.0060-11	03.08.2015	05:10:00	MUC	max. depth	79° 56.28' N	3° 11.60' E	2548.5
PS93.0061-1	03.08.2015	09:50:00	ISC	max. depth	79° 45.38' N	4° 24.33' E	2600.5
PS93.0061-2	03.08.2015	10:42:00	MSC	max. depth	79° 45.33' N	4° 24.48' E	2604.2
PS93.0061-3	03.08.2015	11:42:59	TRAPS	deployment	79° 45.32' N	4° 24.31' E	2605.7
PS93.0061-4	03.08.2015	12:07:00	MOR	recovery (failed)	79° 44.60' N	4° 17.59' E	2721.0
PS93.0062-1	03.08.2015	19:57:01	OFOS	profile start	79° 35.92' N	5° 10.18' E	2787.0
PS93.0062-1	03.08.2015	22:54:00	OFOS	profile end	79° 34.15' N	5° 15.36' E	2658.5
PS93.0063-1	04.08.2015	03:18:00	CTD.RO	max. depth	79° 44.18' N	4° 29.45' E	2676.0
PS93.0064-1	04.08.2015	05:59:00	MOR	recovery	79° 44.83' N	4° 16.36' E	n.d.
PS93.0064-2	04.08.2015	15:01:00	TRAPS	recovery	79° 48.97' N	4° 15.76' E	2444.7
PS93.0064-3	04.08.2015	16:11:00	RAMSES	max. depth	79° 49.20' N	4° 15.09' E	2447.7
PS93.0064-4	04.08.2015	16:47:00	CTD.RO	max. depth	79° 49.30' N	4° 15.22' E	2423.2
PS93.0064-5	04.08.2015	18:09:00	MN	max. depth	79° 49.45' N	4° 15.68' E	2381.0
PS93.0065-1	05.08.2015	04:47:59	LANDER	deployment	79° 0.03' N	8° 14.97' E	900.7
PS93.0066-1	06.08.2015	05:45:00	CTD.RO	max. depth	79° 1.71' N	11° 5.27' E	275.0
PS93.0066-2	06.08.2015	06:20:00	MUC	max. depth	79° 1.71' N	11° 5.22' E	275.0
PS93.0067-1	06.08.2015	16:57:00	CTD.RO	max. depth	78° 37.66' N	10° 34.96' E	67.3
PS93.0067-2	06.08.2015	17:23:00	WP-2 NET	max. depth	78° 37.68' N	10° 35.03' E	66.9
PS93.0067-3	06.08.2015	17:50:00	MUC	max. depth	78° 37.67' N	10° 35.02' E	67.1
PS93.0068-1	06.08.2015	19:04:00	CTD.RO	max. depth	78° 34.17' N	10° 11.74' E	94.0
PS93.0068-2	06.08.2015	19:33:00	WP-2 NET	max. depth	78° 34.15' N	10° 11.80' E	92.0
PS93.0069-1	06.08.2015	20:58:00	CTD.RO	max. depth	78° 34.39' N	9° 46.35' E	114.0
PS93.0069-2	06.08.2015	21:33:00	WP-2 NET	max. depth	78° 34.37' N	9° 46.39' E	114.0
PS93.0069-3	06.08.2015	21:56:00	WP-2 NET	max. depth	78° 34.37' N	9° 46.35' E	115.0
PS93.0069-4	06.08.2015	22:19:00	MUC	max. depth	78° 34.38' N	9° 46.37' E	114.0
PS93.0069-5	06.08.2015	22:40:00	MUC	max. depth	78° 34.40' N	9° 46.49' E	115.0
PS93.0069-6	06.08.2015	23:07:00	MUC	max. depth	78° 34.36' N	9° 46.72' E	118.0
PS93.0070-1	07.08.2015	00:14:00	CTD.RO	max. depth	78° 33.29' N	9° 28.61' E	388.0

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water Depth [m]
PS93.0070-2	07.08.2015	00:46:00	WP-2 NET	max. depth	78° 33.29' N	9° 28.66' E	388.0
PS93.0070-3	07.08.2015	01:02:00	WP-2 NET	max. depth	78° 33.28' N	9° 28.66' E	387.0
PS93.0070-4	07.08.2015	01:28:00	WP-2 NET	max. depth	78° 33.29' N	9° 28.58' E	389.0
PS93.0070-5	07.08.2015	02:11:00	MUC	max. depth	78° 33.29' N	9° 28.65' E	389.0
PS93.0071-1	07.08.2015	06:30:00	LANDER	recovery	79° 0.10' N	8° 15.37' E	898.5
PS93.0072-1	07.08.2015	13:19:00	ROV	profile start	79° 6.19' N	6° 5.67' E	1245.0
PS93.0072-1	07.08.2015	17:24:00	ROV	profile end	79° 6.11' N	6° 5.79' E	1225.0
PS93.0073-1	07.08.2015	22:32:00	RAMSES	max. depth	79° 0.14' N	8° 15.05' E	900.7
PS93.0073-2	07.08.2015	23:19:00	CTD.RO	max. depth	79° 0.04' N	8° 15.01' E	900.7
PS93.0073-3	08.08.2015	00:21:00	MUC	max. depth	79° 0.06' N	8° 14.98' E	902.5
PS93.0074-1	08.08.2015	03:20:00	RAMSES	max. depth	79° 1.78' N	7° 0.01' E	1303.7
PS93.0074-2	08.08.2015	04:17:00	CTD.RO	max. depth	79° 1.78' N	6° 59.94' E	1303.7
PS93.0074-3	08.08.2015	05:45:00	MUC	max. depth	79° 1.78' N	6° 59.94' E	1304.0
PS93.0075-1	08.08.2015	08:57:59	LANDER	deployment	79° 8.06' N	6° 5.56' E	1282.2
PS93.0076-1	08.08.2015	14:10:00	ROV	profile start	79° 4.87' N	4° 8.40' E	2433.0
PS93.0076-1	08.08.2015	18:49:00	ROV	profile end	79° 4.88' N	4° 8.43' E	n.d.
PS93.0077-1	08.08.2015	22:00:00	CTD.RO	max. depth	79° 6.50' N	4° 36.00' E	1910.2
PS93.0077-2	08.08.2015	23:42:00	MUC	max. depth	79° 6.49' N	4° 36.01' E	1916.0
PS93.0078-1	09.08.2015	01:51:00	CTD.RO	max. depth	79° 7.82' N	4° 54.26' E	1547.2
PS93.0078-2	09.08.2015	03:35:00	MUC	max. depth	79° 7.82' N	4° 54.14' E	1550.2
PS93.0079-1	09.08.2015	11:33:00	MOR	deployment	79° 44.39' N	4° 30.36' E	2716.5
PS93.0079-2	09.08.2015	12:38:00	AUV	profile start	79° 42.79' N	4° 35.22' E	2781.0
PS93.0079-3	09.08.2015	13:06:00	CTD.RO	max. depth	79° 42.88' N	4° 35.52' E	2778.2
PS93.0079-2	09.08.2015	13:38:00	AUV	profile end	79° 43.06' N	4° 35.54' E	2765.2
PS93.0079-4	09.08.2015	14:09:00	WP-2 NET	max. depth	79° 43.15' N	4° 35.85' E	2759.2
PS93.0079-5	09.08.2015	14:45:00	WP-2 NET	max. depth	79° 43.15' N	4° 36.03' E	2760.0
PS93.0079-6	09.08.2015	14:58:00	WP-2 NET	max. depth	79° 43.18' N	4° 36.24' E	2759.5
PS93.0080-1	09.08.2015	22:31:00	CTD.RO	max. depth	79° 8.01' N	6° 5.57' E	1281.5
PS93.0080-2	09.08.2015	23:56:01	LOKI	profile start	79° 7.96' N	6° 5.51' E	1280.7
PS93.0080-2	10.08.2015	00:24:00	LOKI	profile end	79° 7.94' N	6° 5.56' E	1278.2
PS93.0080-3	10.08.2015	01:27:00	MN	max. depth	79° 7.99' N	6° 5.66' E	1287.0
PS93.0080-4	10.08.2015	03:34:00	ISC	max. depth	79° 7.96' N	6° 6.01' E	1282.0
PS93.0080-5	10.08.2015	04:38:00	MSC	max. depth	79° 7.97' N	6° 6.09' E	1281.5
PS93.0080-6	10.08.2015	05:14:00	RAMSES	max. depth	79° 7.96' N	6° 6.24' E	1281.7
PS93.0080-7	10.08.2015	05:46:00	CTD.RO	max. depth	79° 7.98' N	6° 6.06' E	1281.7
PS93.0080-8	10.08.2015	05:59:00	LANDER	recovery	79° 8.01' N	6° 5.97' E	n.d.
PS93.0080-9	10.08.2015	07:45:00	MUC	max. depth	79° 8.33' N	6° 5.01' E	1287.7
PS93.0081-1	10.08.2015	13:39:00	ROV	profile start	79° 4.21' N	4° 8.11' E	n.d.

Station	Date	Time	Gear	Action	Position Lat	Position Lon	Water Depth [m]
PS93.0081-1	10.08.2015	18:18:00	ROV	profile end	79° 4.42' N	4° 7.84' E	n.d.
PS93.0082-1	11.08.2015	00:07:01	LOKI	profile start	79° 8.09' N	2° 51.34' E	5570.5
PS93.0082-1	11.08.2015	00:43:00	LOKI	profile end	79° 8.24' N	2° 50.96' E	5573.5
PS93.0082-2	11.08.2015	01:55:00	MN	max. depth	79° 8.61' N	2° 50.22' E	5576.5
PS93.0082-3	11.08.2015	03:35:00	ISC	max. depth	79° 9.29' N	2° 47.52' E	5572.2
PS93.0082-4	11.08.2015	04:08:00	MSC	max. depth	79° 9.33' N	2° 47.50' E	5571.7
PS93.0083-1	11.08.2015	09:00:00	MOR	deployment	79° 0.43' N	4° 19.92' E	2604.5
PS93.0084-1	11.08.2015	09:49:59	LANDER	deployment	79° 4.74' N	4° 6.58' E	2496.5
PS93.0084-2	11.08.2015	12:30:00	AUV	profile start	79° 4.85' N	4° 6.95' E	2490.2
PS93.0084-2	11.08.2015	13:49:00	AUV	profile end	79° 3.65' N	4° 4.65' E	2577.7
PS93.0085-1	11.08.2015	19:48:00	CTD.RO	max. depth	79° 36.24' N	5° 10.27' E	2783.2
PS93.0085-2	11.08.2015	22:18:00	MUC	max. depth	79° 36.25' N	5° 10.28' E	2783.0
PS93.0086-1	12.08.2015	04:24:00	RAMSES	max. depth	79° 8.03' N	2° 50.51' E	5570.5
PS93.0086-2	12.08.2015	05:08:00	CTD.RO	max. depth	79° 8.02' N	2° 50.54' E	5570.5

(n.d.: no data)

List of acronyms:

AUV	Autonomous Underwater Vehicle
BONGO	Bongo-net
CTD.RO	CTD/Rosette water sampler
HN	Hand-net
ISC	In-situ Camera
LANDER	Bottom-Lander
LOKI	Light Onsight Key species Investigations
MIC	Microprofiler
MN	Multi-net
MOR	Mooring
MUC	Multiple Corer
MSC	Marine Snow Catcher
OFOS	Ocean Floor Observation System
RAMSES	Radiometer
ROV	Remotely Operated Vehicle
TRAPS	Sediment trap mooring
WP-2 NET	Plankton net
ZODIAC	Rubber boat

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