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

EXPEDITION PROGRAMME PS121

Polarstern

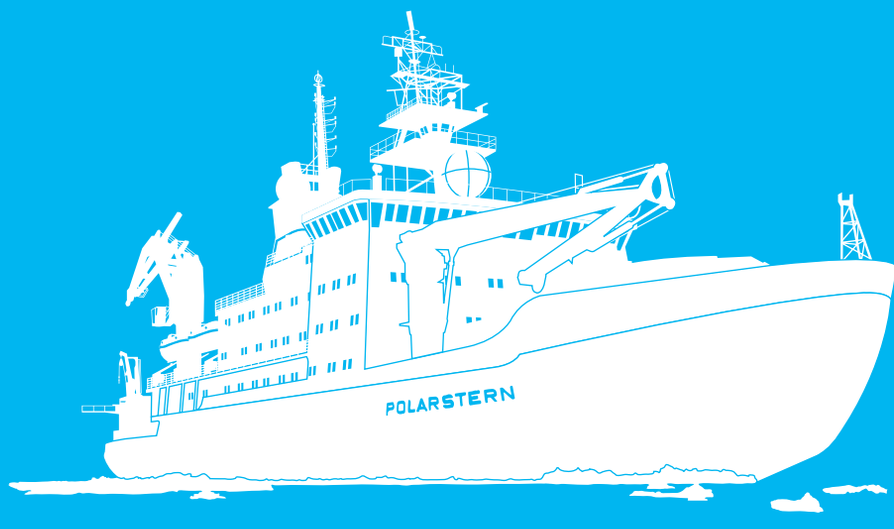
PS121

Bremerhaven - Tromsø

10 August 2019 - 13 September 2019

Coordinator: Rainer Knust

Chief Scientist: Katja Metfies



Bremerhaven, July 2019

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1. ÜBERBLICK UND FAHRTVERLAUF

Katja Metfies (AWI)

Expedition PS121 des Forschungsschiffes *Polarstern* startet am 10. August 2019 mit dem Auslaufen in Bremerhaven. Das Untersuchungsgebiet im Bereich des Langzeitobservatoriums HAUSGARTEN (Framstraße) wird nach etwa 5-7 Tagen Transit erreicht sein. Ziel der Expedition ist es, die marine Biodiversität und klimarelevante Prozesse des arktischen Ozeans vor dem Hintergrund des Klimawandels genauer zu erfassen und verstehen zu können. Ein Großteil der geplanten Arbeiten und Projekte dieser Expedition stehen im engen Zusammenhang mit der Fortführung des vor 20 Jahren durch das AWI etablierten Langzeitobservatoriums HAUSGARTEN und der Umsetzung der Helmholtz Infrastruktur Initiative FRAM (Frontiers in Arctic Marine Monitoring). Darüber hinaus tragen sie zum Forschungsprogramm PACES II des AWIs bei und unterstützen verschiedene AWI-externe Projekte, die im Einklang mit der übergeordneten Zielsetzung der Expedition stehen.

An den HAUSGARTEN-Stationen werden multidisziplinäre Forschungsaktivitäten durchgeführt, die fast alle Bereiche des marinen Ökosystems abdecken. Dies umfasst die Aufnahme und das Ausbringen von Verankerungen, die mit Sedimentfallen, Sensorsystemen oder automatischen Probennehmern bestückt sind, sowie den Einsatz eines Autonomen Unterwasserfahrzeugs (AUV) und eines ROVs (Remotely Operated Vehicle). Darüber hinaus werden verschiedene optische Beobachtungssysteme und gezielt eingesetzte Probennehmer für pelagische und benthische Studien verwendet.

In der Wassersäule werden im Rahmen von FRAM, sowie der Projekte IMMIPLANS 2019 und CarCASS Untersuchungen zur Biodiversität, Biomasse und Verteilung verschiedener Plankton-Gruppen und der zugehörigen biogeochemischen Parameter durchgeführt. Dabei werden klassische Mikroskopie und biogeochemische Analytik parallel zu modernsten optischen und molekulargenetischen Hochdurchsatzmethoden eingesetzt. Komplementär zu den Untersuchungen in der Wassersäule werden Untersuchungen der Biodiversität, Biomasse und Verteilung von benthischen Organismen verschiedener Größenklassen sowie hoch aufgelöste Messungen des benthischen Sauerstoffverbrauchs und Experimente zu Auswirkungen von Ozeanversauerung auf benthische Organismen durchgeführt. Die Messungen biologischer und biogeochemischer Parameter im Pelagial und im Benthos der Framstraße werden durch Messungen ozeanographischer und chemischer Parameter ergänzt. Zusammen mit Studien zu Mechanismen und Umfang des vertikalen Exports organischen Materials in der Wassersäule sollen die Erkenntnisse und Daten aus den pelagischen und benthischen Untersuchungen zu einem besseren Verständnis des Kohlenstoffflusses im arktischen Ozean beitragen.

Nach Ablegen in Bremerhaven werden parallel zum vorher beschriebenen Arbeitsprogramm kontinuierlich Proben aus der unteren Atmosphäre genommen, um die Konzentrationen von Ammoniak- und Ammonium der Atmosphäre zu bestimmen.

Auf internationaler Ebene sind die im Bereich des Hausgartens geplanten Probennahmen und Experimente wichtige Beiträge zu SIOS (Svalbard Integrated Observing System) und ICOS (Integrated Carbon Observation System).

Die Stationsarbeiten werden im östlichen Teil des Hausgartens beginnen, um dann zunächst im westlichen Hausgarten und anschließend im nördlichen Hausgarten weiter geführt zu werden. Nach Abschluss der Stationsarbeiten wird die Expedition nach einem kürzeren Transit von ~ 2-3 Tagen am 13. September 2019 mit dem Einlaufen in Tromsø enden.

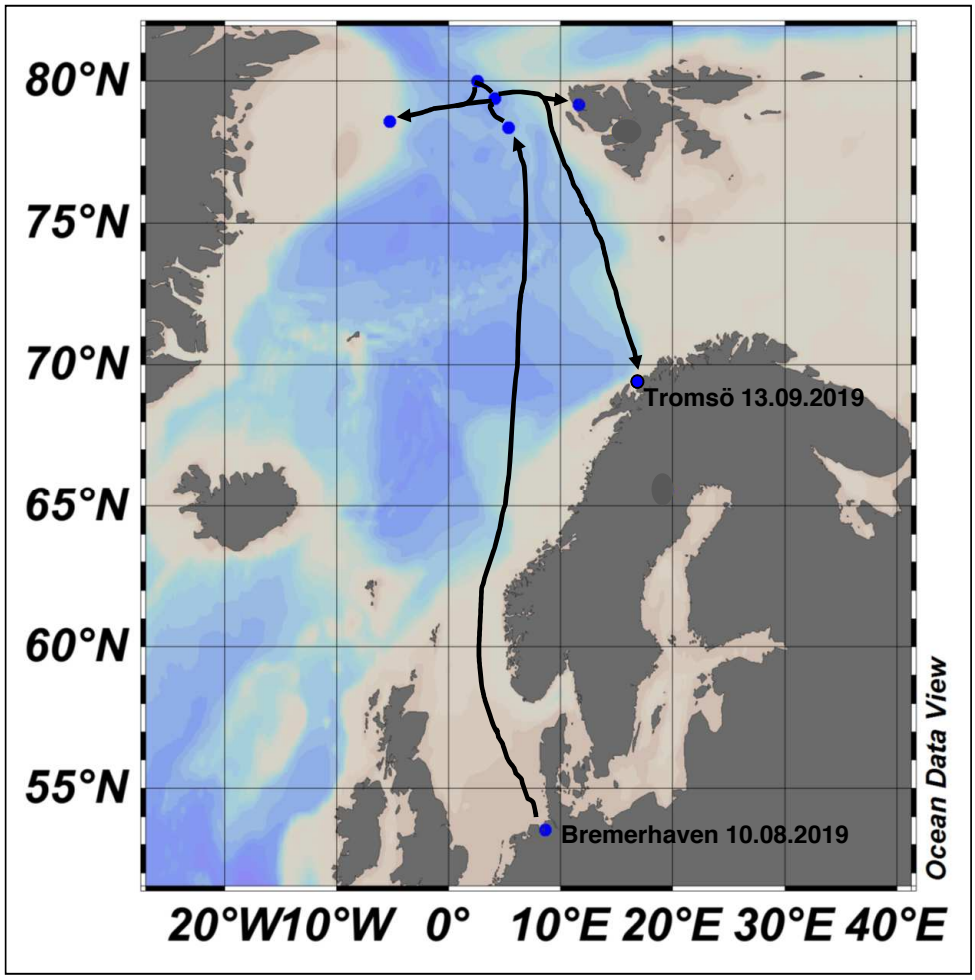

Abb. 1: Expedition PS121 des Forschungsschiffes Polarstern wird am 10. August 2019 mit dem Auslaufen in Bremerhaven beginnen. Das Untersuchungsgebiet im Bereich des Langzeitobservatoriums HAUSGARTEN (Framstraße) wird nach etwa 5-7 Tagen Transit erreicht sein. Die Stationsarbeiten werden im östlichen Teil des Hausgartens beginnen, um dann zunächst im westlichen Hausgarten und anschließend im nördlichen Hausgarten weiter geführt zu werden. Nach Abschluss der Stationsarbeiten wird die Expedition nach einem kürzeren Transit von ~ 2-3 Tagen am 13. September 2019 mit dem Einlaufen in Tromsø enden.

Fig. 1: Expedition PS121 of the research vessel Polarstern will start on 10 August 2019 with the departure in Bremerhaven. The research area at long-term observatory HAUSGARTEN (Fram Strait) will be reached after about 5-7 days of transit. The station work will begin in the eastern part of HAUSGARTEN, before being continued first in the western HAUSGARTEN and then in the northern part of the long-term observatory. After completion of the station work, the expedition will end on 13 September 2019 after a shorter transit of 2-3 days with the arrival in Tromsø.

SUMMARY AND ITINERARY

Expedition PS121 of research vessel *Polarstern* will start on 10. August 2019 with the departure in Bremerhaven. The research area at the long-term ecological research site (LTER) HAUSGARTEN in Fram Strait will be reached after about 5-7 days of transit. The aims of the expedition are to better capture and understand Arctic marine biodiversity and climate-relevant processes in the context of global change. Much of the planned work and projects of this expedition are closely related to the continuation of LTER HAUSGARTEN established 20 years ago by the AWI, and the implementation of the Helmholtz Infrastructure Initiative FRAM (Frontiers in Arctic Marine Monitoring). In addition, they contribute to the PACES II research programme of the AWI and support various external projects in line with the overarching objective of the expedition.

During PS121 multidisciplinary research activities will be carried out at the HAUSGARTEN stations that cover almost all areas of the marine ecosystem. This includes the recovery and deployment of long-term moorings equipped with sediment traps, sensor systems or automated water samplers, the operation of an Autonomous Underwater Vehicle (AUV) and a Remotely Operated Vehicle (ROV) as well as the use of various optical observation systems and targeted sampling devices for pelagic and benthic studies.

Within the framework of FRAM as well as the projects IMMIPLANS 2019 and CarCASS, investigations on the biodiversity, biomass and distribution of various plankton groups, and the associated biogeochemical parameters will be carried out in the water column. Here, classical microscopy and biogeochemical analysis will be used in parallel to state-of-the-art optical and molecular genetic high-throughput methods. Complementary to the investigations in the water column there will be studies of biodiversity, biomass and distribution of benthic organisms of various size classes as well as high-resolution measurements of benthic oxygen consumption alongside with experiments on the effects of ocean acidification on benthic communities. The measurements of biological and biogeochemical parameters in the pelagic and the benthos of Fram Strait are supplemented by measurements of oceanographic and chemical parameters. Together with studies on mechanisms and extent of vertical export of particulate organic matter in the water column, the findings and data from the pelagic and benthic investigations of PS121 will contribute to a better understanding of the carbon flux in the Arctic Ocean.

Starting in Bremerhaven, there will be continuous sampling from the lower atmosphere to determine the concentrations of ammonia and ammonium in parallel to the pelagic and benthic work programme.

On international level, the sampling and experimentation planned at LTER HAUSGARTEN are an important contribution to SIOS (Svalbard Integrated Observing System) and ICOS (Integrated Carbon Observation System).

The station work will begin in the eastern part of LTER HAUSGARTEN and then continue in the western and northern parts of study area. After completion of the station work, the expedition will end following a shorter transit of ~ 2-3 days with arrival in Tromsø on 13 September 2019.

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

T. Soltwedel, M. Busack, C. Gräser, J. Hagemann, T. Hargesheimer, C. Hasemann, M. Hofbauer, F. Krauß, S. Lehmenhecker, N. Lochthofen, J. Ludszuweit, A. Purser, B. Sablotny, I. Schewe, F. Wenzhöfer, M. Wietz, T. Wulff, M. Cardozo Mino, A. Nordhausen (MPIMM); K. Meyer-Kaiser (WHOI); C. Bienhold (MPIMM) not on board

Objectives and scientific programme

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

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

To detect and track the impact of large-scale environmental changes in the transition zone between the northern North Atlantic and the central Arctic Ocean, and to determine the factors controlling deep-sea biodiversity, the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) established the LTER (Long-Term Ecological Research) observatory HAUSGARTEN. Since 2014, this observatory has been successively extended within the frame of the HGF financed infrastructure project FRAM (FRontiers in Arctic marine Monitoring) and currently covers 21 permanent sampling sites on the West-Spitsbergen and East-Greenland slope at water depths between 250 and 5,500 m.

During RV *Polarstern* expedition PS121, multidisciplinary research activities will be conducted at all HAUSGARTEN stations (Fig. 2.1). The research programme will cover almost all ranges of the marine ecosystem from the pelagic zone to the benthic realm. Regular sampling as well as the deployment of moorings and different free-falling systems (benthic lander), which act as local observation platforms, has taken place since the observatory was established back in 1999.

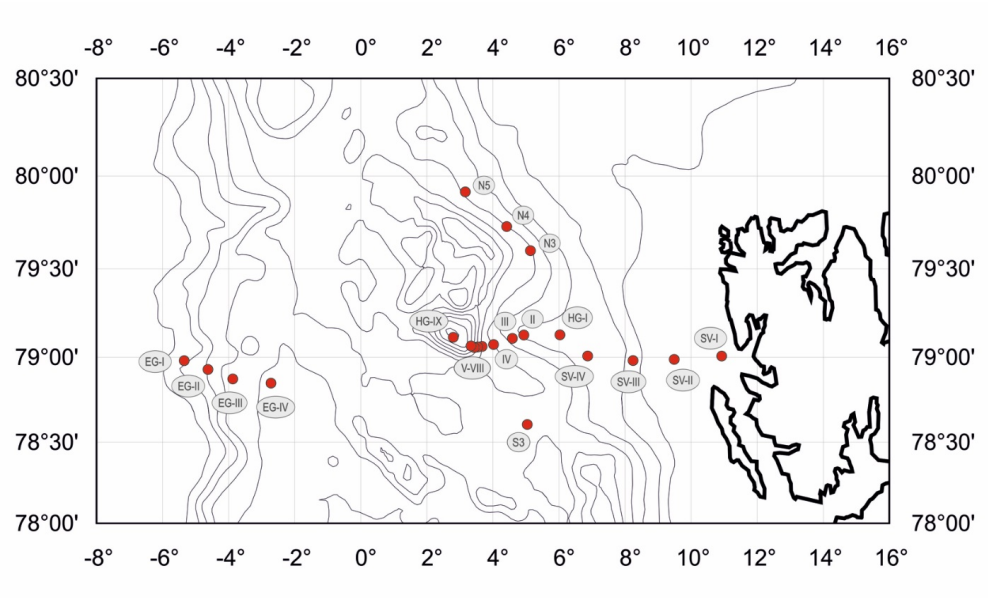

Fig. 2.1: Permanent sampling sites of the LTER observatory HAUSGARTEN in Fram Strait

Work at sea and expected results

Water column and benthic studies using an Autonomous Underwater Vehicle (AUV)

For RV *Polarstern* expedition PS121, AWI's Autonomous Underwater Vehicle (AUV) PAUL (Fig. 2.2) is intended to cover a two-part work programme:

1) PS121 will be the first cruise with the AUV team focusing on benthic missions. During these missions, the vehicle is supposed to map the seafloor acoustically by means of a dual frequency (600 & 1200 kHz) sidescan sonar and a camera system. Within the course of the expedition, it is planned to gradually increase the mission depth as *Polarstern* generally heads into Fram Strait's central part. Mission depths will thus increase from 400 to 2,600 m. The sidescan sonar will be able to resolve details of about 10-15 cm in size which allows the identification of sampling points of single MUC cores. The final objective is to entirely map the HAUSGARTEN station HG-IV (see Fig. 2.1), as this station has been sampled longer than any other station of the observatory. The camera will provide pictures with a resolution of 1.3 mm/pixel as PAUL travels over the seafloor in 6 m altitude.

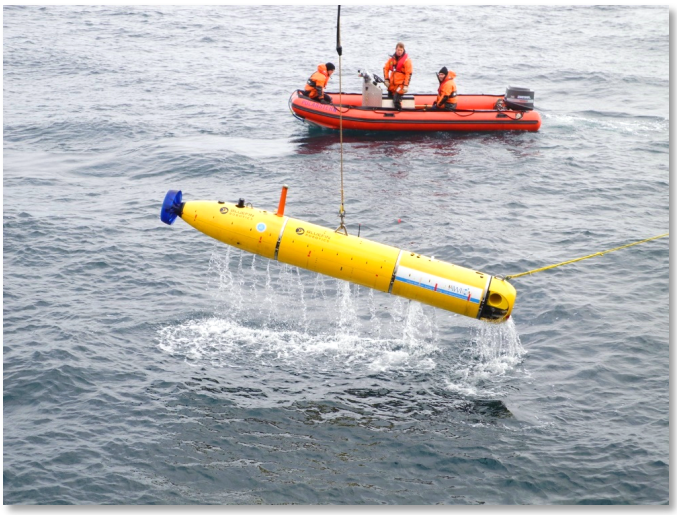

Fig. 2.2: Recovery of the Autonomous Underwater Vehicle PAUL

2) Depending on weather and ice conditions, it is also intended to investigate the coupling between physics and ecology at frontal systems and in the Marginal Ice Zone (MIZ). In terms of biological activity, these zones are among the most relevant regions in the world ocean. Previous observations suggest the high biological activity to be triggered by physical processes which take place in the upper water column and might be related to atmospheric forcing. Until today these processes are understood insufficiently – at least partly caused by the challenge of observing various processes with high spatial and temporal resolution simultaneously.

The physical mechanisms governing the conditions in these zones will be observed with a set of physical sensors on the AUV such as a conductivity, temperature and depth probe (CTD) and an acoustic doppler current profiler (ADCP). With these instruments, we will be able to distinguish different water bodies, determine small-scale mixing processes at their interfaces, estimate fluxes, measure the water column´s stability, and gather data on the underwater light field. These physical parameters are essential to understand the ecological response. To observe the respective biological activity, the AUV is equipped with a sensor for photosynthetically active radiation (PAR), a chlorophyll a fluorometer, a fluorometer for coloured dissolved organic matter (CDOM), and a nitrate sensor to determine the water column´s nutrient inventory. A water sample collector which is able to collect 22 samples with an overall volume of 4.8 litres is used to calibrate the nitrate as well as the chlorophyll a sensor and to study the composition of plankton communities.

During a first deployment, the vehicle's trim and balance will be checked and adapted if necessary. Afterwards, the vehicle will execute a number of short missions to ensure its general functionality. Given that the initial deployment is successful, benthic missions will be conducted at as many stations as possible. Mission files will be prepared prior to the cruise so that preparation time for the benthic missions will be relatively short. To ensure the best possible data quality, *Polarstern* will stay above the investigation area while PAUL is submerged or descending respectively. Using the GAPS Ultra-Short Base-Line (USBL) system to track the vehicle on its way to the seafloor, the AUV team will thus be able to correct the navigation data and to compensate for the drift in the inertia navigation system. Each benthic study will consist of two dives: A preceding sonar dive at a safe altitude of 13-26 m followed by a camera dive with PAUL approaching the seafloor to a minimum distance of 5 m.

In order to prepare PAUL's water column studies, satellite imagery will be applied to monitor the ice edge and sea surface temperatures. Thus, the position of both the small-scale meltwater fronts and the permanently present, larger scale Polarfront will be known. Special attention will be paid to ice structures that indicate high regional ice dynamics (e.g. ice tongues

or jets) or highly stable ice edges (no drift for several days). To determine the orientation of an expected front, *Polarstern*'s thermosalinograph will be monitored while steaming in a zig-zag pattern across the front.

PAUL will be deployed several kilometres off the front. The missions will be planned such that the vehicle crosses the front and advances several kilometres beyond it. The mission depth will vary between 3 and 50 meters about every 300 m – either propeller driven in a zig-zag manner or free floating after the thruster has been deactivated. Thus, numerous high-resolution profiles will be recorded. Water samples will be taken at the end of each mission. After completing the missions, PAUL will guide itself to the pre-programmed recovery location. Water samples will then be processed in a cold room and stored deep frozen.

The benthic missions will, for the first time, provide comprehensive high-resolution seafloor maps of the HAUSGARTEN stations. Especially at the station HG-IV (see Fig. 2.1), we expect these data to be extremely valuable to assess the impact of 20 years of sampling and research on a confined deep-sea area.

From the AUV water column studies, we expect to gather a holistic picture of the small-scale processes occurring in frontal systems. We hope this will help to understand the complex interactions in this dynamic zone and ultimately help to understand the reasons for its high biological productivity.

Vertical flux of particulate organic matter

Measurements of the vertical flux of particulate matter at HAUSGARTEN have been conducted since the establishment of the observatory. By means of these measurements we are able to quantify the export of organic matter from the sea surface to the deep sea, and trace changes in these fluxes over time. The organic material which is produced in the upper water layers or introduced from land is the main food source for deep-sea organisms. Measurements of organic matter fluxes are conducted by bottom-tethered moorings carrying sediment traps at approx. 200 and 1,000 m below sea-surface, and about 180 m above the seafloor (Fig. 2.3). In addition to moored sediment traps new autonomous infrastructure will be deployed on the HAUSGARTEN moorings to track seasonal changes in the dissolved and particulate constituents of the upper water column. These include McLane RAS 500 water samplers that are programmed to collect and preserve water samples (~0.5 L) with approximately weekly resolution, and particle samplers that filter and preserve ~10 L water samplers with approximately bi-weekly resolution. Besides sediment traps the moorings are equipped with Aanderaa currentmeters (RCM8, RCM11), self-recording CTD's (Seabird MicroCATs), and a suite of biogeochemical sensors. During the RV *Polarstern* expedition PS121, we will recover moorings and instruments that were deployed during the RV *Polarstern* expedition PS114 in summer 2018.

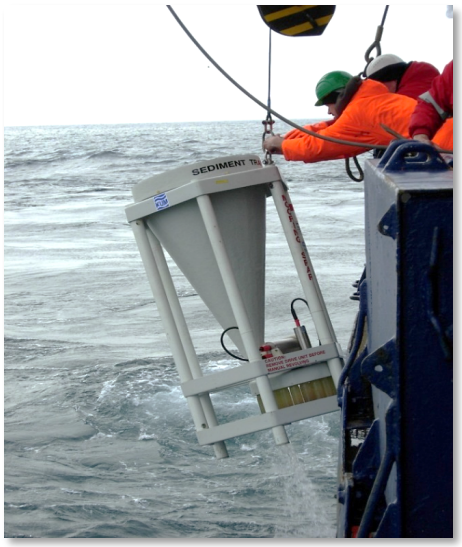

Fig. 2.3: Deployment of a sediment trap to assess particle fluxes to the seafloor

At the central HAUSGARTEN site HG-IV, we will replace a profiling winch system carrying a sensor package (Fig. 2.4). This device has been developed within the BMBF funded project ICOS-D (Integrated Carbon Observation System, Germany) and shall conduct measurements within the upper 200 m of the water column at regular preprogramed intervals. At present, the sensor package consists of instruments for measuring carbon dioxide, oxygen, conductivity, temperature, pressure, and chlorophyll fluorescence.

At all stations where moorings are deployed, we will conduct CTD/Rosette Water Sampler casts from the surface close to the seafloor. Water samples will be taken for analyses of chlorophyll *a*, particulate organic carbon and nitrogen (POC/N), particulate phosphorous, biogenic particulate silica (bPSi), total particulate matter (seston), calcium carbonate ($CaCO_3$), and the stable isotopes content ($\delta^{15}N/\delta^{13}C$) in the particulate matter. This work as well as the sampling and sensing at the other HAUSGARTEN stations will be conducted in close co-operation with the PEBCAO (Plankton Ecology and Biogeochemistry in a Changing Arctic Ocean) group at AWI. For further details regarding the work in the water column see Chapter 3.

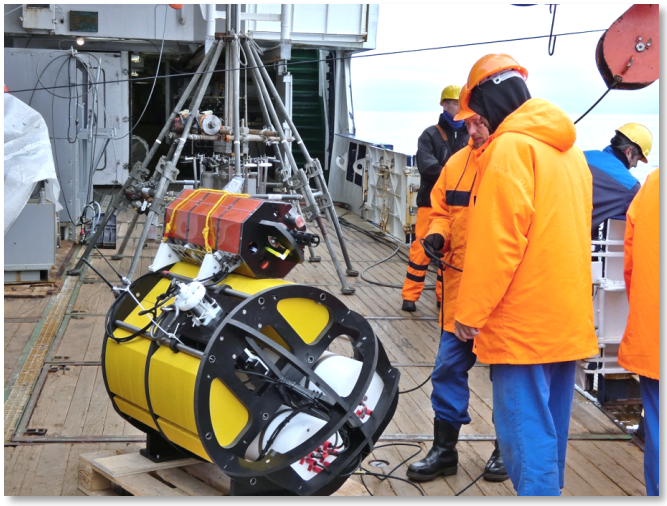

Fig. 2.4: Top float of the winch-mooring (yellow part) carrying the profiling sensor package (reddish part) prior to deployment during RV Polarstern expedition PS114 in summer 2018

Microbial studies in the water column and at the deep seafloor

Major objective of the microbial studies is to characterize microbial communities in seawater and sediment using different molecular techniques. The present subproject focuses on prokaryotes, i.e. bacteria and archaea, across Fram Strait regarding community structure (i.e. numerical composition) and functional capacities (gene content and expression) in relation to environmental parameters.

Seawater will be collected by a CTD/Rosette Water Sampler and filtered through membrane filters for capture of microorganisms. In addition, seawater will be sampled via *in-situ* pumps, capturing large amounts of microbial biomass directly from the water column. Sediment samples will be taken using syringes and fixed for later microbial analyses. Furthermore, sea ice will be collected and used in an on-board incubation experiment to study microbial dynamics during ice melt. Subsamples for prokaryotic and eukaryotic analyses are also obtained from recovered autonomous devices (RAS: McLane Remote Access Samplers; PPS: Phytoplankton Sampler). All samples will be transported back frozen at -20°C or -80°C for further processing in the home lab.

Based on previous work in Fram Strait, we expect clear signals in prokaryotic community structure and functional between different regions of Fram Strait, shaped by local environmental parameters. Factors such as chlorophyll content and ice coverage are expected to influence microbial dynamics. These hypotheses will be studied using sequencing-based methods (amplicons, meta-omics) in the home lab; followed by statistical evaluation in context with environmental data.

High-resolution benthic oxygen consumption rates to assess variations in seafloor carbon mineralization

Deep-sea benthic communities are strictly dependent on carbon supply through the water column, which is determined by temporal and spatial variations in the vertical export flux from the euphotic zone but also lateral supply from shelf areas. Most organic carbon is recycled in the pelagic, but a significant fraction of the organic material ultimately reaches the seafloor, where it is either re-mineralized or retained in the sediment record. One of the central questions is to what extent sea-ice cover controls primary production and subsequent export of carbon to the seafloor on a seasonal and interannual scale. Benthic oxygen fluxes provide the best and integrated measurement of the metabolic activity of surface sediments. They quantify benthic carbon mineralization rates and thus can be used to evaluate the efficiency of the biological pump. In order to link long-term variations in surface and sea-ice productivity and consequently in export flux to the seafloor, detailed investigation of the temporal variations in benthic oxygen consumption rates would be very valuable. Yearly measurements with benthic lander (Fig. 2.5) provide information on the interannual variations. Benthic crawler (Fig. 2.6), capable to perform weekly oxygen gradient measurements for a 12-months' period provide information on the seasonal variations.

Benthic carbon mineralization will be studied *in-situ* at four sites (S3, HG-IV, N4, and EG-II; see Fig. 2.1). The benthic oxygen uptake is a commonly used measure for the total benthic mineralization rate. We plan to measure benthic oxygen consumption rates at different spatial and temporal scales. A benthic lander (Fig. 2.5) will be equipped with two different instruments to investigate the oxygen penetration and distribution as well as the oxygen uptake of arctic deep-sea sediments: (1) microprofiler, for high-resolution pore water profiles (oxygen, temperature, resistivity), and (2) a benthic chamber, to measure the total oxygen consumption and nutrient exchange of the sediment. The overall benthic reaction is followed by measurement of Sediment Community Oxygen Consumption (SCOC) to calculate carbon turnover rates. From the sediments recovered by the benthic chambers, we will take subsamples to quantify the organic carbon content, microbial biomass and sieve out the larger macrofauna.

Fig. 2.5: Deployment of a free-falling system (benthic lander)

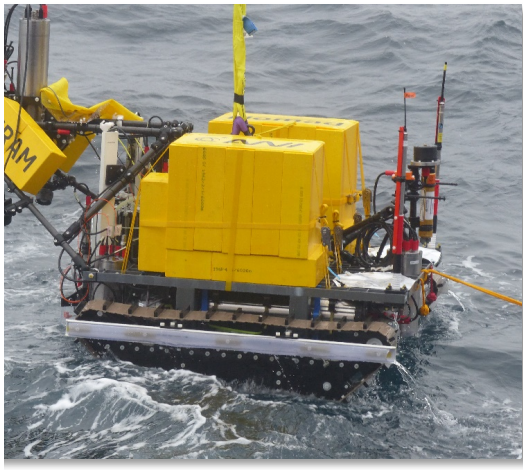

Fig. 2.6: Deployment of the autonomous benthic crawler NOMAD

At the central HAUSGARTEN site HG-IV (see Fig. 2.1), the benthic crawler TRAMPER, deployed in 2018 during the RV *Maria S. Merian* expedition MSM77, will be recovered after a 12-month mission. The crawler was pre-programmed to perform 52 vertical concentration profiles across the sediment-water interface (one each week) along a 1.5 km transect. During PS121, NOMAD will be deployed for two years at HG-IV to investigate seafloor carbon supply and demand on a seasonal scale. NOMAD will take images of the seafloor combined with a laser scan. From this information we are able to reconstruct the sediment surface at high resolution. In addition, hyperspectral images are taken at the same transect to identify chlorophyll *a* as a measure of the supply of labile organic matter. When overlain on the seafloor topography we will be able to identify hot spots of intensified carbon accumulation. These two seafloor observations are performed during a 10 m long transect at the beginning of each measuring cycle. At the end of this transect, concentration profiles of oxygen are measured across the sediment water interface. From these profiles diffusive oxygen fluxes can be obtained. Chamber incubations, performed at the same time, provide the total oxygen demand of the seafloor. Both measurements provide information on the oxygen consumption related to carbon mineralization. These cycles are repeated every week for a period of 24 months.

To compare benthic consumption rates at contrasting sites in the Fram Strait, TRAMPER, equipped with 18 oxygen sensors, will be deployed at EG-II (see Fig. 2.1) to perform benthic oxygen flux measurements during its 24-month mission.

The overall aim of both crawler and lander deployments is to cover a seasonal cycle of settling organic matter on the seafloor with contrasting and changing food supplies and to resolve the impact on the benthic community respiration activity. From the long-term deployment we expect new insights in the benthic oxygen consumption rates over a full seasonal cycle. The use of new underwater technologies will thereby enhance our capabilities to improve our knowledge on the effects of climate change on the arctic ecosystem.

Investigations of the smallest benthic biota and background sediment parameters

Virtually undisturbed sediment samples will be taken using a video-guided multicorer (TV-MUC; Fig. 2.7). Various biogenic compounds from these sediments will be analysed to estimate activities (i.e. bacterial exoenzymatic activity) and the total biomass (i.e. particulate proteins, phospholipids) of the smallest sediment-inhabiting organisms. Compared to long-term data from the time-series work at HAUSGARTEN observatory, results will help to detect and describe ecosystem changes in the benthal of the Arctic Ocean. Sediments retrieved by the TV-MUC will also be analysed for the quantitative and qualitative assessment of the small benthic biota (meiofauna).

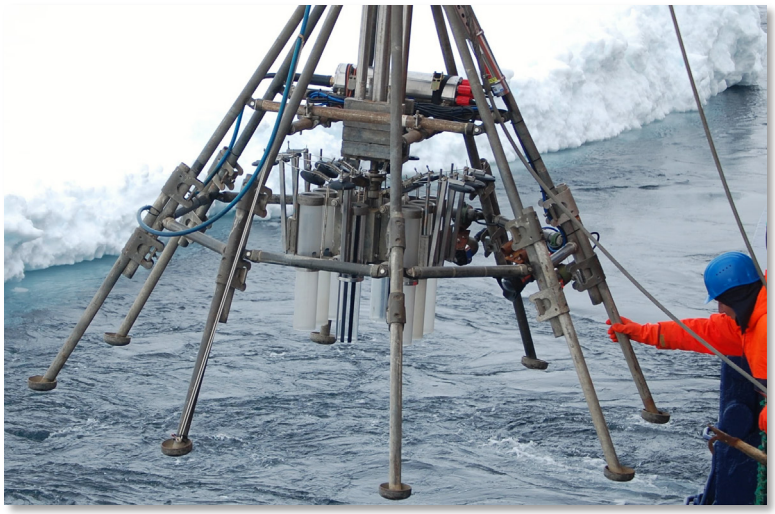

Fig. 2.7: Sediment sampling using a video-guided multicorer (TV-MUC)

Megafaunal dynamics on the seafloor

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

During the RV *Polarstern* expedition PS121 we will continue to study interannual dynamics of megafaunal organisms using a towed camera system (Ocean Floor Observation System, OFOS; Fig. 2.8). The OFOS will be towed along established tracks at HAUSGARTEN stations of the latitudinal transect (N3, HG-IV, S3), at station HG-IX in the Molloy Hole, and at EG-IV on the East Greenland rise (see Fig. 2.1). The new footage will extend our image time-series that started in 2002.

In a new approach, we aim to study smaller-scale changes on the seafloor over time. To this end, a time-lapse camera will be fitted to a benthic lander and deployed to take pictures for a whole year.

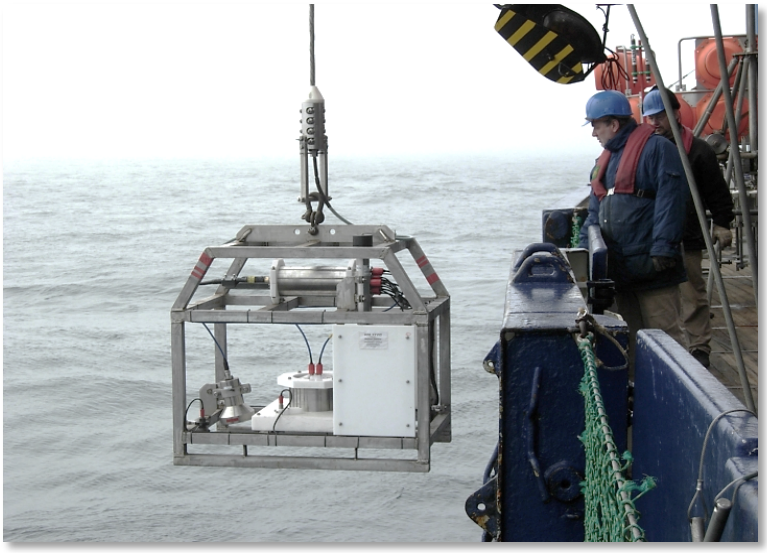

Fig. 2.8: Deployment of the Ocean Floor Observation System (OFOS)

Experimental work at the deep seafloor

Ocean acidification has been identified as a risk to marine ecosystems, and substantial scientific effort has been expended on investigating its effects, mostly in laboratory manipulation experiments. Experimental manipulations of CO_2 concentrations in the field are difficult, and the number of field studies are limited to a few localities. During the RV *Maria S.*

Merian expedition MSM77 in 2018, the HAUSGARTEN observatory was extended with an benthic lander based experimental system (Fig. 2.9) to study impacts of ocean acidification on benthic organisms and communities for the first time in deep Arctic waters with an autonomous system. The autonomous so-called arcFOCE (Arctic Free Ocean Carbon Enrichment) system was developed to create semi-enclosed test areas (mesocosms) on the seafloor where the seawater's pH (an indicator of acidity) can be precisely controlled for weeks or months at a time. The implementation of an arcFOCE for long-term experiments will enable us to generate data on the resistance of arctic marine benthic organisms and communities to a reduction in ocean pH.

Fig. 2.9: Deployment of the bottom-lander based arcFOCE (Arctic Free Ocean Carbon Enrichment) experimental set-up from board Maria S. Merian in Autumn 2018

During RV *Polarstern* expedition PS121, we will use the Remotely Operated Vehicle (ROV) PHOCA (GEOMAR, Kiel) to take sediment samples inside the mesocosms and in the vicinity of the experimental set-up as controls. Sediment samples will be analysed for a variety of biogenic sediment compounds, bacterial activity, numbers, biomass, and composition as well as meiofauna numbers and composition, with special focus on nematodes.

The ROV will further be used to start new biological long-term experiments at a deep-water reef in approx. 2,000 m water depth on the Vestnesa Ridge off Svalbard. This work will include the colouring of sponges to determine their growth rates, the deployment of cages at the seafloor to start an exclusion experiment, the application of hard substrates (stacks of plastic plates; Fig. 2.10) to study their colonization by sessile organisms, and the application of special samplers and *in-situ* pumps for the collection of benthic larvae (Fig. 2.11). Moreover, the ROV will be used to collect sponges for taxonomical studies.

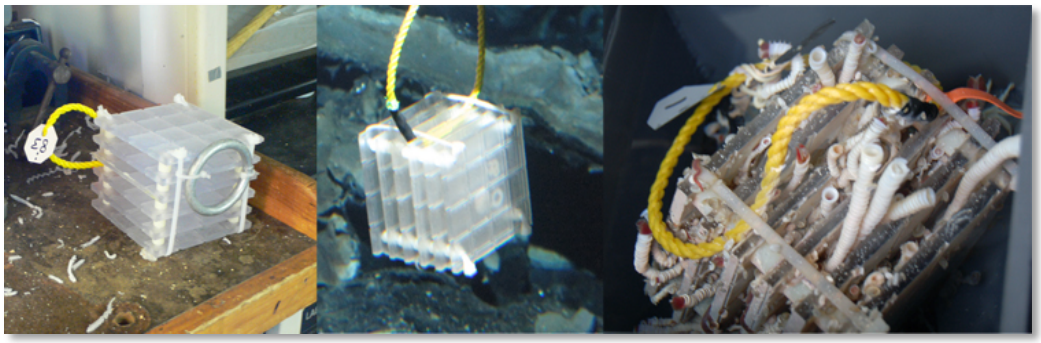

Fig. 2.10: Stack of plastic plates to study the colonisation of hard substrates at the deep seafloor

Fig. 2.11: McLane in-situ pump for the collection of benthic larvae

Data management and samples

Sample processing will be carried out at AWI and at the Max Planck Institute for Marine Microbiology (MPIMM) in Bremen. Microbial samples will be analysed using sequencing-based methods, and obtained sequence data will be deposited at public databases (e.g. EMBL, GEO). Statistical methods and software code will be deposited at public repositories (e.g. GitHub). Time requirements for data acquisition of the several types of investigation will be individual. The time periods from post processing to data provision will vary from one year maximum for sensor data to several years for organism related datasets. Until then preliminary data will be available to the cruise participants and external users after request to the senior scientist. The finally processed data will be submitted to the PANGAEA data library. The unrestricted availability from PANGAEA will depend on the required time and effort for acquisition of individual datasets and its status of scientific publication.

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

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Objectives

The Arctic Ocean has gained increasing attention over the past years because of the drastic decrease in sea ice and increase in temperature, which is about twice as fast as the global mean rate. In addition, the chemical equilibrium and the elemental cycling in the surface ocean will alter due to ocean acidification. These environmental changes will have consequences for the biogeochemistry and ecology of the Arctic pelagic system. The effects of changes in the environmental conditions on the polar plankton community can only be detected through long-term observation of the species and processes. Our studies on plankton ecology started in 1991 and sampling has been intensified since 2009 in the Fram Strait at ~79°N. Since then our studies are based on combining a broad set of analysed parameters. This includes e.g. classical bulk measurements and microscopy, optical measurements, satellite observations, molecular genetic approaches, and cutting edge methods for zooplankton observations to study plankton ecology in a holistic approach. Over the past eight years we have compiled complementary information on annual variability in plankton composition, primary production, bacterial activity or zooplankton composition. Since 2014 the PEBCAO group is a key contributor to the FRAM (**Fr**ontiers in **A**rctic Marine **M**onitoring) Ocean Observatory. The PEBCAO group is providing ground truth information for water column monitoring of plankton ecological, biogeochemical parameters and microbial (prokaryotic and eukaryotic) biodiversity. We are also involved in the development and evaluation of automatic platforms and sampling technology for long-term observation in the Arctic Ocean with main focus on the AWI HAUSGARTEN situated in the Fram Strait.

Climate induced changes will impact the biodiversity in pelagic ecosystems with concomitant changes in carbon cycling and sequestering. At the base of the food web, we expect small algae to gain more importance in mediating element and matter turnover as well as matter and energy fluxes in future Arctic pelagic systems. In order to examine changes, including the smallest fractions, molecular methods are applied to complement traditional microscopy. The characterization of the communities with molecular methods is independent of cell-size and distinct morphological features. The assessment of the biodiversity and biogeography of Arctic eukaryotic microbes will be based on the analysis of ribosomal genes (18S meta-barcoding) via high throughput sequencing based on using Illumina technology. Zooplankton organisms are affected by the changes at the base of the food web and, this may alter the transport and modification of organic matter. Also, the zooplankton community composition may shift due to the warmer Atlantic water in the Fram Strait. Most of our knowledge on zooplankton species composition and distribution has been derived from traditional multiple net samplers, which allow to sample depth intervals of several hundred meters. Newly developed optical methods, such as the zooplankton recorder LOKI (light frame on-sight key species investigations), now continuously take pictures from the organisms floating in the water column from 1,000 m depth to the surface. Linked to each picture, hydrographical parameters are being recorded, e.g. salinity, temperature, oxygen concentration and fluorescence. This allows to exactly identifying distribution patterns in relation to environmental conditions.

Global change increasingly affects also pelagic microbial biogeochemistry in the Arctic Ocean. Thus, we will continue to monitor concentrations of organic carbon, nitrogen and phosphorus as well as specific compounds like gel particles, amino acids and carbohydrates. Additionally, we will perform rate measurements of heterotrophic bacterial production and phytoplankton

primary production. The latter will be distinguished into particulate primary production (carbon remaining in the cells) and dissolved primary production (organic carbon subsequently released by cells). Overall, primary production is expected to increase in the changing Arctic Ocean, however, it is currently unclear if this leads to increased export of particulate organic carbon or if dissolved primary production will remain at the surface fuelling heterotrophic bacteria. Additionally, we will investigate grazing activity of mixotrophic eukaryotic microbes. These represent an important inter-stage between auto- and heterotrophy as these organisms can use both photosynthesis and grazing on bacteria to obtain energy and grow. The importance of this lifestyle was previously neglected but evidence is increasing that a large proportion of small eukaryotic microbes (<20 µm), are indeed mixotrophic. By determining ingestion rates of bacteria we will evaluate the importance of this growth strategy in the Arctic Ocean and set a baseline for future studies as it is believed that this lifestyle will become more advantage in the future ocean. Through linking compound dynamics, rate measurements and bacteria, phyto- and zooplankton community structure we will gain further insights into the flow of carbon through Arctic food webs.

Our overarching goal is to improve the mechanistic understanding of biogeochemical and microbiological feedback processes in the Arctic Ocean and to assess the potential for changes in the near future. The PEBCAO group has started in 2009 and sampled 10 years intensively and will continue in the future. Together with the data obtained from 1991 onwards, 20 years within a much smaller programme, several results have been published during the last years to show the most obvious changes so far (e.g. Cherkasheva et al., 2104, Kraft et al., 2013, Nöthig et al., 2015) but also to set a baseline for future warmer periods expected to come (e.g. Engel et al., 2017and 2019, Metfies et al., 2016). During summer time chlorophyll a values are increasing in eastern Fram Strait but not in the western part. *Phaeocystis pouchetii* and Nanoflagellates also show increasing shares in the summer phytoplankton communities. Dissolved organic carbon is relatively stable whereas the particulate organic carbon shows a slight tendency to decrease during summer month. The pelagic amphipods are dominated by *Themisto* species with increasing importance of the invading species *T. compressa*.

The water column work of the PEBCAO group is complemented by ocean colour remote sensing. This approach allows for estimating the overall phytoplankton biomass (indicated by chlorophyll-a concentration, chl-a), distinctive major groups (abbreviated as phytoplankton functional types, PFT) and coloured dissolved organic matter (CDOM) at greater spatial and temporal scales. However, at high latitudes ocean colour satellite data has a sparse coverage due to the presence of sea ice, clouds and low sun elevation. We use the PEBCAO discrete water *in-situ* data on particulate organic carbon (POC), CDOM, chl-a and phytoplankton pigment concentrations from HPLC, as input and for validation of satellite ocean colour algorithms. Underway spectrophotometry enables to obtain hyperspectral attenuation and absorption data which can be further processed to chl-a, marker pigment concentrations, PFT chl-a and CDOM. Also running the same instrumentation at station to sample the underwater profile delivers high resolved information. However, the derivation of the final products requires the verification with direct analysis of these parameters on regularly sampled discrete water in order to quantify the potential and limitations (in terms of uncertainties of these optically derived biogeochemical parameters, In conjunction with satellite data these data sets are of high value to upscale biogeochemical / phytoplankton quantities at higher resolution and better coverage. With that as much as possible collocated data to Sentinel-3 (launched in February 2016) ocean color sensor OLCI data but also to TROPOMI onboard Sentinel-5Precursor (launched in Oct 2017) shall be acquired for validation. (The group of A. Bracher is part of the Sentinel-3 Validation Team and the PI of the ESA study Sentinel-5P Ocean Colour). This research will further give a fundamental contribution for further development of hyper- and multispectral ocean colour satellite retrievals focusing on fluorescence and absorption signals.

In summary during PS 121 the following topics are covered:

- Monitoring plankton species composition and biomass distribution
- Monitoring biogeochemical parameters
- Investigations on selected phyto- and zooplankton and related biogeochemical parameters
- Composition of organic matter and gel particles
- Investigation on the amount and composition of CDOM and its interplay with phytoplankton
- Characterization of the underwater light field and its interplay with optical constituents, such as phytoplankton and CDOM abundance and composition.

Work at sea

Biogeochemical & biological parameters from rosette samples, including the automated filtration system for marine microbes AUTOFIM

We will sample Arctic seawater by CTD/rosette sampler at the main HAUSGARTEN/ FRAM stations at about 5-10 depths (details see below). In addition to this we will collect particles close to the surface (~ 10 m) with the **Auto**mated **Fi**ltration system for marine **M**icrobes AUTOFIM (Fig. 3.1) that is coupled to the ships pump system. Using AUTOFIM we will collect seawater after regular intervals (~ 1° longitude / latitude) starting as soon as possible after *Polarstern* has left Bremerhaven and in parallel to the sampling via CTD. AUTOFIM allows filtration of a sampling volume up to 5 litres. In total 12 filters can be taken and stored in a sealed sample archive. Prior to the storage a preservative can be applied to the filters to prevent degradation of the sample material, that can be used for molecular or biochemical analyses. Water samples for CDOM absorption analysis are filtered through 0.2 µm filters and analyzed onboard with a 2.5-m path length liquid waveguide capillary cell system (LWCC, WPI). Particulate and phytoplankton absorption coefficients are determined with the quantitative filter techniques using sample filtered onto glass-fiber filters QFT-ICAM and measuring them in a portable QFT integrating cavity setup Röttgers et al. (2016).

Measurements for alkalinity will also be performed on board. Primary and bacterial production measurements will be performed on board using ^{14}C bicarbonate and 3H leucin. Mixotrophy grazing experiments will be performed at standard depths in the upper 100 m by adding fluorescent micro-beads as prey. Samples will be frozen at at - 80°C and analysed by flow-cytometry at the home laboratory at GEOMAR.

All other samples will be partly filtered and preserved or frozen at - 20°C and partly at - 80°C for further analyses. At the home laboratory at AWI we will determine the following parameters to describe the biogeochemistry and the abundance and biomass distribution of protists:

- Chlorophyll a concentration (total and fractionated)
- Phytoplankton pigments (HPLC)
- Dissolved organic carbon (DOC)
- Particulate organic carbon (POC)
- Total dissolved nitrogen (TDN)
- Particulate organic nitrogen (PON)
- Particulate biogenic silica (PbSi)
- Dissolved organic phosphorus (DOP)
- Particulate organic phosphorus (POP)
- Transparent exopolymer particles (TEP)
- Coomassie-stainable particles (CSP)

- Dissolved combined carbohydrates and amino acids
- Phytoplankton, protozooplankton and bacterial abundance
- Grazing rates of mixotrophs on bacteria
- Molecular based information (18S meta-barcoding, quantitative PCR) on community structure, diversity and distributional patterns of protists
- Information on the quality of automated sampling and sample preservation using AUTOFIM

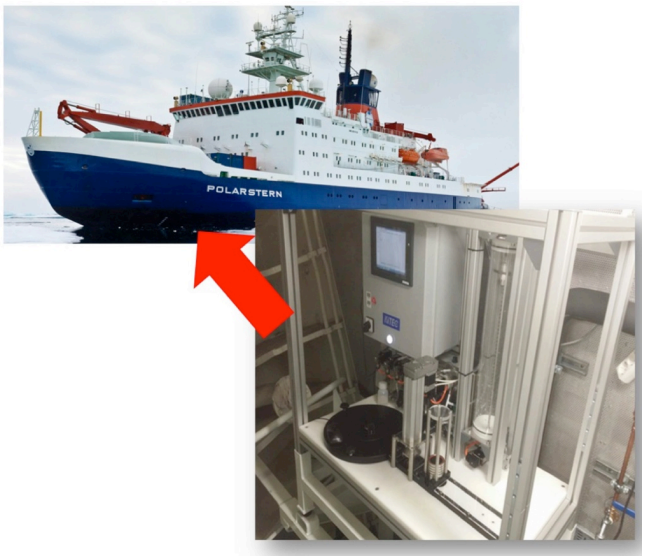


Fig. 3.1: The fully automated filtration module AUTOFIM is installed on Polarstern in the bow thruster room (Bugstrahlruderraum) close to the inflow of the ships-pump system. AUTOFIM is suited to collect samples with a maximum volume of 5 Liters. Filtration can be triggered on demand or after fixed intervals.

Mesozooplankton sampling

Mesozooplankton composition and depth distribution will be determined by means of vertical Multi net tows. Five depth stratified samples will taken from 1,500 m depth to the surface (1,500 – 1,000 -500 – 200 – 50 – 0 m). The samples will be preserved in 4 % formalin buffered with hexamethylentetramin and analysed later in the laboratory.

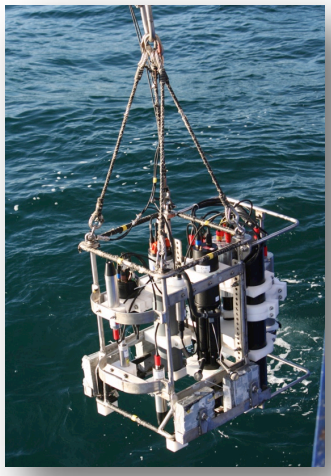
Continuous optical measurements

Continuous inherent optical properties (IOPs) with a hyperspectral spectrophotometer: For the continuous underway surface sampling an *in situ*–spectrophotometer (AC-S; WETlabs) will be operated in flow-through mode to obtain total and particulate matter attenuation and absorption of surface water. The instrument is mounted to a seawater supply taking surface ocean water (Fig. 3.2 B). A flow-control with a time-programmed filter is mounted to the AC-S to allow alternating measurements of the total and the CDOM inherent optical properties of the sea water. Flow-control and debubbler-system ensure water flow through the instrument with no air bubbles.

A second AC-S instrument is mounted on a steel frame together with a depth sensor and a set of hyperspectral radiometers (Ramses sensors from TRIOS, Fig. 3.2 A) and operated during CTD stations. The frame is lowered down to maximal 120 m with a continuous speed of 0.1 m/s or during daylight with additionally stops at 2, 4, 6, 8, 10, 12.5, 15, 20, 25 and 30 m to

allow a better collection of radiometric data (see later). A second set of hyperspectral radiometers will be mounted at the ship's portside ensuring to be out of the shade during underwater light stations. This will be used to start developing an underway system to acquire quality controlled remote sensing reflectance data important for Sentinel-3 validation.

The Apparent Optical Properties of water (AOPs) (mostly light attenuation through the water column) will be estimated based on downwelling and upwelling irradiance measurements in the surface water profile (down to the 0.1 % light depth) from the radiometers calibrated for the incident sunlight with measurements of a radiometer on deck and directly from the radiance and irradiance above water radiometry. The second AC-S will measure the inherent optical properties (IOPs: total attenuation, scattering and absorption) in the water profile.



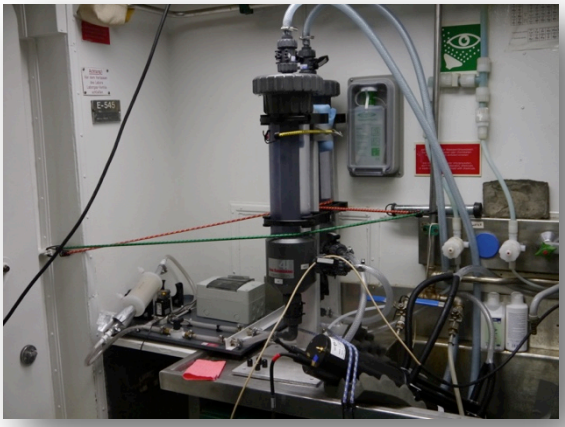


Fig. 3.2: Left (A): Underwater light field measurements (during FRAM expedition PS 99) with TRIOS RAMSES radiometers detecting the hyperspectral up- and downwelling radiation and WETLABS AC-s (including data logger and battery) measuring extinction and absorption within the surface water profile. (In addition, on the right also a SUNA nitrate sensor is mounted on the frame). Right (B): Continuous measurements of the extinction and absorption of light in Arctic surface waters using a WETLABS AC-s mounted to the RV Polarstern surface sea water pump system. From those measurements directly the absorption and scattering of particles and CDOM is determined for the whole spectrum in the visible resolved with a bout 3 nm resolution. This data then can be decomposed various specific algorithms to determine the particle size distribution and the various phytoplankton pigment composition.

Expected results

The continuously measured optical data are used via using semi-analytical techniques to determine the concentration of optical constituents, such as chl-a conc., CDOM absorption and particle backscattering, but also for validating satellite ocean colour retrievals following formerly established procedures for FRAM cruises PS93.2, PS99 and PS107 (see Bracher et al., 2015; Liu et al., 2018; Liu et al., 2019).

We expect a new data set (2019 winter) for our long-term measurements to elucidate further changes in the Fram Strait pelagic environment due to Global Change and/or other environmental shifts.

Data management and samples

During our cruises, we sample a large variety of interconnected parameters. Many of the samples (i.e. pigment analyses, particulate matter in the water column, etc.) will be analysed at AWI and at GEOMAR within about a year after the cruise. We plan that the full data set will be available at latest about two years after the cruise. Samples for analysing species composition with the microscope which will not be analysed immediately or within 2 years after the cruise has ended, will be stored at the AWI at least for another 10 years and will be available for other colleagues. Data will be made available to the public via PANGAEA after publishing (depending on how many comparisons will be made, long-term study 2 to 5 years after the cruise). ACs data are foreseen to be uploaded at the FRAM data portal as raw data immediately after the cruise and as calibrated data set after careful executing quality controls and calibrations with discrete water sample measurements.

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4. DOES SEA-ICE ASSOCIATED RELEASE OF CRYOGENIC GYPSUM INCREASE THE EXPORT OF ORGANIC MATTER IN ARCTIC REGIMES

S. Swoboda (AW/Uni-Bremen/MARUM), C. Konrad (AWI/Uni-Bremen/MARUM), M. H. Iversen (AWI/Uni-Bremen/MARUM, not on board)

Rationale

The continuing reduction and thinning of Arctic sea-ice due to climate change, has enhanced the light availability and thus formation of under ice phytoplankton blooms.

In recent years, the formation of gypsum crystals has been described in the brine channels of sea-ice (Geilfus et al., 2013). Further, gypsum crystals have been observed to ballast under-ice phytoplankton blooms and have thus been thought to promote the export of organic matter (Wollenburg et al., 2018). However, gypsum crystals dissolve in seawater and where therefore overlooked in flux studies up until recent, making it unclear how, and to which extent the ballasting of gypsum affects the export of organic matter in the sea ice associated regimes of the Arctic.

Objectives and scientific programme

Our main objective is to study the impact of cryogenic gypsum on the sinking of marine aggregates in the Fram Strait and how this affects the export efficiency of organic matter in sea-ice associated vs. ice free regimes. This will be achieved by assessing the large-scale flux and composition of organic matter and relating this to on-board laboratory experiments which will elucidate the ballasting impact of gypsum on the sinking of marine aggregates. These will help us to understand the importance of under-ice export and what effects future sea-ice loss will have on the export efficiency of the biological pump in the Arctic. Further it could give implications on the nutrient provision to pelagic and benthic ecosystems in the sea-ice associated areas of the Arctic.

Work at sea

We will perform deployments of *in situ* camera systems in combination with drift traps to capture particle dynamics through the water column. This will be accompanied by laboratory roller tank experiments to investigate the role of cryogenic gypsum on the ballasting and formation of marine aggregates, and how this affects their sinking velocity. These studies will be done with *in situ* collections of settling aggregates (using the marine snow catcher) and artificially produced aggregates using seawater from the chlorophyll maximum water layer.

Each drifting sediment trap consists of three trap arrays (e.g. 100, 200, 400 m depths) each with four collection cylinders. At every trap depth, one of the collection cylinders is filled with a special gel to preserve fragile marine snow aggregates and fecal pellets sinking into the cylinders. The deployment times will be over a day-night cycle.

Expected results

The vertically changing particle concentrations and size distribution determined with the *in-situ* camera systems in combination with the drifting traps can be used to derive high resolution carbon fluxes and remineralisation rates in various depth ranges. These high-resolution carbon fluxes will enable determinations of carbon-specific turnover rates in different water layers through the water column.

Together, the *in-situ* and *on-board* studies will provide a detailed full water column perspective on the export of organic matter as a function of sea-ice covered and ice free regimes. These studies are essential to understand the impact of sea-ice reduction on the distribution of organic matter and, thus, its role in provide nutrients to pelagic and benthic ecosystems as well as carbon export to the Arctic seafloor.

Data management and samples

We expect to be able to quantify the role from microbes and zooplankton and carbon flux attenuation, as well as quantify the export fluxes through the upper mesopelagic zone. Data will be made available to the public via PANGAEA after publishing.

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5. CARCASS – CARBON TRANSPORT VIA ARCTIC PELAGIC ANIMALS SINKING TO THE DEEP-SEA SEAFLOOR

H.J.T. Hoving (GEOMAR), V. Merten (GEOMAR), H. Hampe (GEOMAR)

Objectives

An ecological paradox that exists for many deep ocean carbon budgets is the fact that the amount of carbon associated with the organic material captured in sediment traps does not account for the biomass and respiration rates of deep ocean benthic communities (e.g. Kaufmann and Smith, 1999). In some regions the shortage is as much as 30-70 % of the carbon budget (Higgs et al., 2014; Smith et al., 2002). This suggests that there must be other carbon sources reaching the seafloor that are currently not measured. One of the problems with understanding the connection between the seafloor and overlying water column is that baseline information on diversity, distribution and abundance of pelagic communities of larger organisms (> 1cm) is missing for many regions (Robison, 2009; Webb et al., 2010). As a result, the potential role of larger pelagic organisms such as jellyfish, cephalopods and fish, in the carbon flux remains unknown for most ocean basins including the Arctic Ocean. Our overall goal during PS121 is to unravel the role of large pelagic organisms in subsidizing deep-sea benthic communities.

Particulate matter and carcasses of mesozooplankton can be quantified in sediment traps, but these traps do not properly quantify macrozooplankton, nekton and megafauna. The deposition of such larger carcasses on the seafloor results in foodfalls, and may provide local enrichments and attract a variety of benthic scavengers (e.g. Stockton and DeLaca, 1982). The rapid consumption of medium size carcasses (1-100 cm) results in rarity of observations of these foodfalls. While bottom surveys are the most widely used method to document natural

foodfalls (Hoving et al., 2017) they are labor-intensive, time consuming and success is not guaranteed. Therefore, additional techniques should be tried to reveal scavenged foodfalls should be explored to support visual observations.

The sequencing of environmental DNA (genetic material obtained directly from environmental samples without any obvious signs of biological source material) can reveal the identity of the organism based on the DNA in the traces that were left behind by that particular organism (Thomsen and Willerslev, 2015). The method has been successfully applied to study distribution and diversity of pelagic organisms (Sigsgaard et al., 2016). In addition to water samples, eDNA can also be isolated from sediment samples. Sediment preserves eDNA well, and it has enabled the detection of historic and contemporary biodiversity (Sinniger et al., 2016). We will analyze eDNA from sediment samples to test suitability for detection of pelagic foodfalls.

In addition to detection of foodfalls it is necessary to investigate scavenging communities and scavenging rates of foodfalls. A widely used method to study community response to foodfalls is the deployment of artificial foodfalls, via attachment of bait on deep-sea landers (e.g. Kemp et al., 2006; Premke et al., 2006; Soltwedel et al., 2017; Witte et al., 1999). Most artificial food fall experiments have been undertaken using fish and mammals as bait. The few food fall experiments performed with invertebrate fauna show that scavenging rates and communities on invertebrate carcasses may be significant and diverse (Sweetman et al., 2014; Collins et al., 1999). This suggests a significant nutritional role of some invertebrate carcasses when they are deposited on the seafloor but inter-specific differences in scavenging rates and communities between foodfalls are expected, and comparative experiments are needed.

Shifts in the Arctic pelagic community of mesozooplankton have been noted among pelagic gastropods and amphipods captured in sediment traps at the HAUSGARTEN LTER (**L**ong **T**erm **E**cological **R**esearch) site (Bauerfeind et al., 2014). High abundance of gelatinous fauna has been observed under the ice at HAUSGARTEN (Boetius pers. obs.) suggesting importance of this faunal group in the Arctic ecosystem. However, data on diversity and distribution are lacking. To identify potential species of large gelatinous zooplankton and nekton (>1 cm) that have an important role in the carbon flux in the Arctic, and to increase our knowledge on pelagic biodiversity at HAUSGARTEN, we will combine *in-situ* observations and net catches to obtain baseline information on community composition, species distributions and abundance.

Cruise objectives:

1. To detect naturally deposited pelagic foodfalls (using visual and molecular genetic tools)
2. To compare scavenging rates and communities of foodfalls from different pelagic species
3. To collect baseline information on abundance, distribution and diversity of pelagic species of macrozooplankton and nekton (that may form significant source of nutrition for deep-sea benthic communities).

Work at sea

For the detection of pelagic foodfalls we will obtain sediment samples with the multicorer (MUC) for future extraction of eDNA from the sediment to detect traces of organisms with a pelagic origin. From each core we will take samples at different depths to investigate the deposition in time. In addition, where possible, we will utilize the bottom video surveys that are performed during PS121 by the ocean floor observation system (OFOS) and the remotely operated vehicle (ROV) to visually detect pelagic foodfalls and their scavengers.

Deep-sea bottom landers equipped with a time-lapse camera, CTD, current meter, ADCP and a food plate with bait will be used to perform artificial food fall experiments with different species

of pelagic bait including jellyfish, fish and cephalopods. By identifying and quantifying the attracted scavenging bottom communities, the scavenging rates, and successional stages, we will determine how different kinds of foodfalls impact seafloor communities. We will also deploy ampipod traps on landers to collect specimens for identification.

To identify potential sources of pelagic foodfalls and to increase our knowledge on the biodiversity in the area, we will perform horizontal pelagic video transect surveys using the pelagic in situ observation system (PELAGIOS) and discrete net sampling (Multinet maxi). These instruments will be used from the surface down to bathypelagic depths (2,500 m) to quantify abundance, diversity and distribution of plankton and nekton (>1 cm). At the same depths as the video and net surveys, we will collect water samples with a CTD and collect eDNA for metabarcoding of specific taxonomic groups of potential foodfall species (fish, jellyfish and cephalopods). The net samples will be used for DNA barcoding and as a reference library for the eDNA analysis.

Expected results

Based on the objectives of our project we expect to gain new information on the contribution of large pelagic organisms in subsidizing deep-sea benthic communities.

Data management

The Kiel Data Management Team (KDMT) provides an information and data archival system where metadata (e.g. of the onboard DSHIP-System) is collected and publicly available. This Ocean Science Information System (OSIS-Kiel) is accessible for all project participants and can be used to share and edit field information and to provide scientific data, as they become available. The KDMT will take care as data curators to fulfill the here proposed data publication of the data in a World Data Center (e.g. PANGAEA) which will then provide long-term archival and access to the data. The data publication process will be based on the available files in OSIS and is therefore transparent to all reviewers and scientists. This cooperation with a world data center will make the data globally searchable, and links to the data owners will provide points of contact to project-external scientists. Availability of metadata in OSIS-Kiel (portal.geomar.de/osis): 2 weeks after the cruise. Availability of data in OSIS-Kiel (portal.geomar.de/osis): 6 months after the cruise. Availability of data in a WDC/PANGAEA (www.pangaea.de): 2 years after the cruise. The surveys performed by the towed camera platform will result in video, which will be transferred to external hard drives. When transporting the video after the cruise, we will ensure that two people each take a copy and that another third copy stays on board. At GEOMAR a server will be prepared to upload the video. Dedicated storage within the central media server system at GEOMAR (ProxSys) will provide efficient and fast network access. Scientific samples will be sorted and stored in GEOMAR facilities.

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6. INNOVATIVE MOLECULAR METHODS IN PLANKTON STUDIES (IMMIPLANS 2019)

H. Auel (Uni HB), P. Kaiser (Uni HB), J. Biederbick (Uni HB)

Objectives

The IMMIPlanS project has five specific objectives, which are all related to the evaluation and applicability of novel molecular methods for zooplankton studies.

1. The **vertical footprint of zooplankton eDNA signatures** will be established. Many key zooplankton species show highest abundance in the surface layer. Their released/excreted particulate DNA may sink to deeper layers. In order to prevent the risk of false presence signals at depth due to sinking DNA, the vertical distribution of zooplankton eDNA signatures in relation to the actual vertical distribution of the animals must be assessed by comparing eDNA data from water samples to be collected at different depths with the results of depth-stratified MultiNet catches at the same stations.

2. The **temporal footprint of zooplankton eDNA signatures** will be established by determining eDNA residence times and degradation rates in relation to ambient water temperature. In

order to estimate the time window, over which zooplankton eDNA signatures integrate the presence of animals, incubation experiments will be carried out on board to measure eDNA release/excretion rates and - after the removal of the animals - degradation rates over time. As we expect that eDNA degradation by microbial and/or chemical processes will be temperature-dependent, degradation rates will be determined at different temperatures.

3. **Quantification of eDNA signal strength in relation to zooplankton biomass**: For the time being, zooplankton eDNA signatures contain information only on the presence or absence of the respective species, but not on their abundance. In order to provide a first step from solely qualitative presence/absence data to a quantitative signal to be correlated with the biomass of the respective species, incubation experiments will be conducted on board to measure eDNA release/excretion rates per unit time and per zooplankton biomass.

4. **Evaluate the applicability of MALDI-TOF protein fingerprinting for ecological studies** on Arctic zooplankton, in particular for the analysis of vertical distribution, species and stage composition of closely related sister species (i.e. with high taxonomic resolution), where classical morphological approaches reach their limit (juveniles lack secondary sex characters, which are important features for species identification in many copepods) and molecular genetic techniques are too expensive and time-consuming to screen a substantial fraction of the specimens.

5. The overall ecological goal of the project is to track and **monitor changes in zooplankton community composition**, biodiversity, abundance, biomass, and distribution over time in order to study and characterise the **Atlantification of the Arctic zooplankton fauna**. In order to recognize long-term changes in the community composition of zooplankton in Fram Strait, comparative data sets on zooplankton abundance and species composition are available for Fram Strait region from the last 20 years, i.e. from 1997 (ARK-XIII), 2006 (MSM 02/4), and from 2016/2017 (PS100, PS107). To continue this study with novel methods, we will repeat the sampling campaign in summer 2019 during PS121. This will allow us to map the distribution of polar vs. boreal-Atlantic zooplankton species in relation to the hydrography obtained from CTD casts.

Work at sea

At each of the 12 IMMIPlanS 2019 sampling stations, a CTD/rosette water sampler cast will be conducted to record depth profiles of temperature, salinity and fluorescence, which are important to relate zooplankton abundance and species composition to different water masses. Water samples of 1 to 3 litres volume for in situ eDNA sampling will be collected from five discrete depth layers (1,000, 500, 100 m, depth of chlorophyll maximum, and mixed surface layer), pre-screened over a 200 µm mesh to remove all mesozooplankton organisms, before filtering over 0.2 µm cellulose filters.

Abundance, biomass and species composition of mesozooplankton will be determined based on stratified vertical hauls with a multiple opening/closing net system (Hydro-Bios Multinet Midi, 0.25 m^2 mouth opening, 150 µm mesh size). Standard depth intervals of 1,500-1,000-500-200-50-0 m will be sampled. Zooplankton individuals will be sorted from the catch alive in a temperature-controlled laboratory container and either used for incubations on board to measure eDNA release/excretion rate or deep-frozen at -80°C to provide material for MALDI-TOF mass spectrometry and reference material for DNA analysis. The remains of the catches will be preserved in ethanol, as ethanol-preserved samples can also be used for molecular genetic studies and MALDI-TOF protein fingerprinting. In addition, we will also test whether preservation in a 4 % formaldehyde in seawater solution would also allow subsequent MALDI-TOF analysis. If so, this approach would offer a far cheaper preservation method and it would allow the application of MALDI-TOF protein fingerprinting on historic zooplankton collections, which mostly have been preserved in formalin.

For the determination of eDNA release/excretion rates of different zooplankton species, individuals will be incubated on board in 10 litre buckets for several days and the increase in eDNA concentration will be monitored over time. For that purpose, water samples will be taken from the incubation buckets at regular time intervals and filtered. Incubations will be conducted with different numbers of individuals per bucket and at different temperatures in order to provide eDNA release/excretion rates per unit zooplankton biomass for different ambient conditions. After several days, the animals will be removed from the incubation buckets and deep-frozen for subsequent determination of body dry mass, while the regular sub-sampling of the now animal-free incubation buckets will continue to establish eDNA degradation rates over time at different ambient temperatures. eDNA samples will be analysed by quantitative PCR and sequencing at the University of Bremen.

Expected results

In alignment with the objectives of the project we expect to gain new information on the spatial and temporal distribution of zooplankton in the observation area and the applicability of molecular based methods to estimate the biomass of zooplankton.

Data management

Data and samples to be collected during the cruise will be analysed and published by the cruise participants and collaborating scientists. It is expected that results will be published within two to three years after the cruise. Geo-referenced data sets such as zooplankton abundance or biomass, will be archived and made publicly accessible via the PANGAEA Data Publisher for Earth & Environmental Science, jointly operated by AWI and MARUM/Uni HB. The PANGAEA database ensures long-term archiving, data publication and dissemination as well as scientific data management following the principles and responsibilities of the ICSU World Data System. Data will be archived as supplements to publications or as citable data collections. Each dataset includes a bibliographic citation and is persistently identified using a Digital Object Identifier (DOI) allowing it to be identified, shared, published and cited. DNA sequence data to be obtained from molecular genetic analyses will be archived and published in the European Nucleotide Archive (ENA) at EMBL-EBI and/or in GenBank. Quantitative plankton samples preserved in formaldehyde or ethanol will be stored at BreMarE, Bremen University.

7. PHYSICAL OCEANOGRAPHY

W.-J. von Appen (AWI)

Objectives and scientific programme

Given the intermittent presence of sea-ice and meltwater in the Polar regions, it still unclear what differences there are in the physical conditions that lead to primary production and export production in the Arctic Ocean. The FRAM multidisciplinary observatory attempts to observe the coupling across the system atmosphere, upper ocean, pelagic, and benthic environments.

To determine the seasonal changes in nutrient concentrations in the euphotic zone, water samplers have been deployed since 2016 with the most recent deployment in 2018 (PS114) at approximately 20 m and 80 m depth. In total, 24 discrete samples are being taken with weekly to monthly resolution (depending on season) to follow the biological drawdown of

nutrients. The moorings are also equipped with a physical and biogeochemical sensor package including SBE37-SMP-ODO (temperature, salinity, oxygen), SAMI pH, SAMI pCO_2, Wetlabs PAR (photosynthetically active radiation), Wetlabs Ecotriplet (Chlorophyll and CDOM fluorescence plus scattering), SUNA Deep Nitrate, current meters, and Acoustic Doppler Current Profilers. The combination of these sensors and the water samplers, in combination with the deployment of a profiling winch facilitates the assessment of seasonal stratification and nutrient concentrations above and below the pycnocline. The nutrient drawdown enables an estimate of new production. Furthermore, the samples will be used for DNA sequencing to examine seasonal changes in bacterial and eukaryotic microbial community structure. The particle samplers collect and preserve filters for DNA extraction and sequencing that together with the fluorescence sensors allow us to track the progression of phytoplankton biomass and community composition over different seasons. These efforts give us a novel year-round description of biological, chemical, and physical processes in the Fram Strait.

Work at sea

Recovery and deployment of moorings

In total 8 moorings will be recovered on PS121. Those moorings will be redeployed with some modifications and a new mooring (HG-N-S-1) will be deployed. This comprises two mooring clusters (F4 in open water in the West Spitsbergen Current and HG-IV in light ice conditions in the central Fram Strait). At these clusters measurements as shallow as 20 m depth are performed. HG-N-S-1 will add near-surface physical measurements in heavier ice conditions. All of those moorings are designed to measure stratification and shear between about 15 m depth and 250 m depth at a resolution of 8 vertical levels.

CTD

The CTD rosette will be operated at the standard Hausgarten stations. Water will be collected both on full water column profiles and on profiles to only 300 m depth. Water samples will be run on the Optimare Precision Salinometer for salinity calibration.

Expected results

We expect to gain information on seasonal changes and annual variability in nutrient concentrations in the euphotic zone.

Data management

The data recorded by the moored instruments that will be recovered on PS121 will be processed after the cruise at AWI and submitted to the PANGAEA data publisher. The moorings that will be deployed on PS121 will be recovered in 2021. The data recorded on those instruments will accordingly be processed after recovery and submitted to the PANGAEA data publisher at that time. Likewise, the data collected during PS121 from the CTD will be processed at AWI and afterwards submitted to the PANGAEA data publisher.

8. TEMPORAL VARIABILITY OF NUTRIENT AND CARBON TRANSPORTS INTO AND OUT OF THE ARCTIC OCEAN

D. Scholz (AWI), N. Lochthofen (AWI), W.-J. von Appen (AWI), S. Torres-Valdés (AWI), M. Monsees (AWI, not on board)

Outline

Current gaps in knowledge concerning nutrient and carbon biogeochemical cycles at the pan-Arctic scale stem from the lack of information necessary to constrain their budgets. Available computations (MacGilchrist et al., 2014; Torres-Valdés et al., 2013, 2016) indicate the Arctic Ocean (AO) is a net exporter of phosphate, dissolved organic phosphorus, silicate, dissolved organic nitrogen and dissolved inorganic carbon (DIC). Although net nitrate transports are balanced despite known large losses due to denitrification. With the exception of silicate, whose export results from riverine inputs, there are still unknowns with regards to understanding sources and sinks of the other variables. Under ongoing and predicted climate change, identifying and quantifying sinks and sources becomes relevant to: *i)* generate baseline measurements against which future change can be evaluated, *ii)* assess the impact of climate change on biogeochemical processes (e.g., primary production, organic carbon export, remineralisation), *iii)* understand the complex interaction between biogeochemical and physical processes, and how such interactions affect the transport of nutrients downstream and the capacity of the Arctic Ocean to function as a sink of atmospheric CO_2, *iv)* determine whether long-term trends occur, for instance. Available AO nutrient and carbon budgets derive from transport calculations across the main gateways (Fram Strait, the Barents Sea Opening, Bering Strait and Davis Strait). However, these are mostly based on summer time measurements. Hence, it is necessary to generate continuous observations if we are to evaluate budgets over seasonal and longer times scales.

With the aim of addressing the above issues, we started deploying FRAM sensors and remote access samplers to generate continuous observations of nutrients and DIC in Fram Strait, targeting core (~250 m) and surface waters on the West Spitsbergen Current and the East Greenland Current.

During PS114 in 2018 (von Appen 2018) we deployed four package sensors (Fig. 8.1) at selected locations, targeting sub-surface and core waters of the East Greenland Current and West Spitsbergen Current (moorings EGC-5, F4S-3 and F4W-1). These deployments will allow us to generate the necessary data that we will eventually use to assess nutrient and carbon variability in waters flowing in and out of the Arctic Ocean at Fram Strait, within the context of the Arctic Nutrient and Carbon Budgets. During PS121 we will *i)* recover the instrumentation deployed in 2018, collect samples from the RAS and retrieve sensor data, and *ii)* deploy new biogeochemical sensor packages in order to continue our recently started time series.

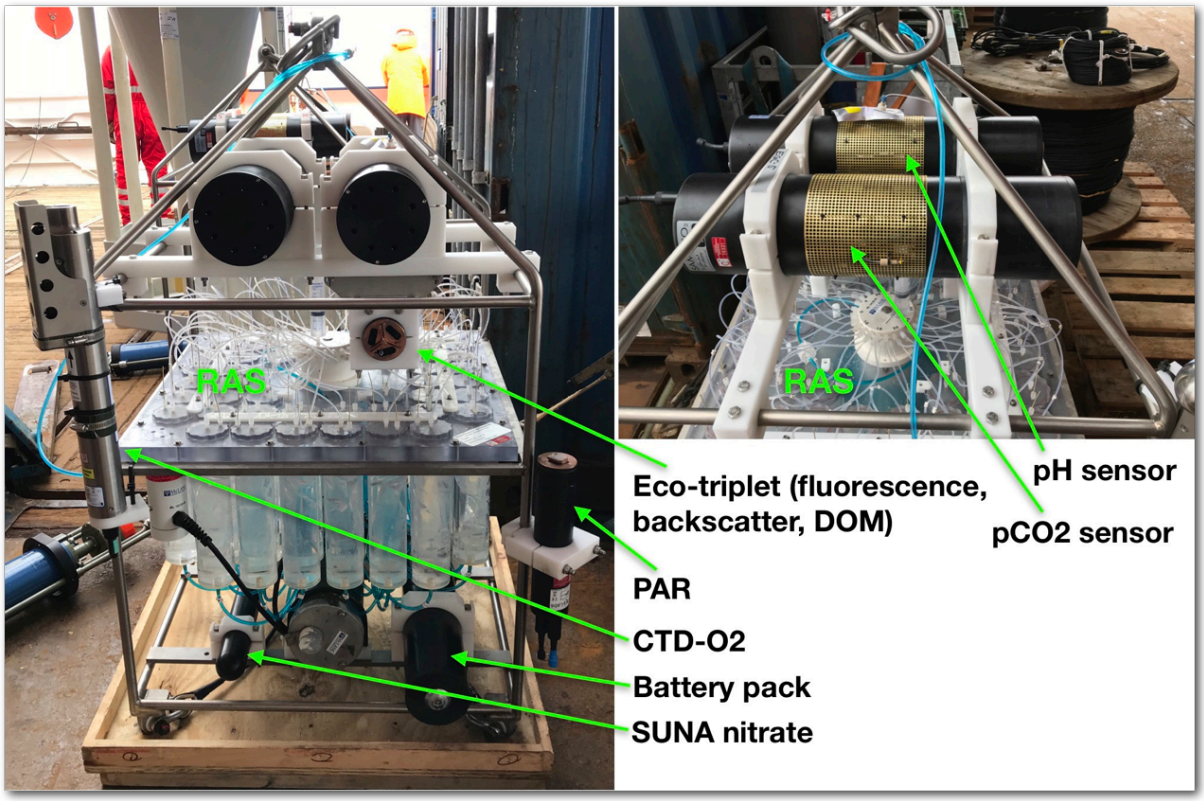

Fig. 8.1: Biogeochemical Sensor Packages, consisting of a Remote Access Sampler (RAS) with a Nitrate, pCO^2, pH, CTD-O_2, PAR and Eco-triplet sensors attached

Objectives

Our long-term 'observational objective', is to generate high quality data of important biogeochemical variables at temporal resolution higher than that allowed by ship-based observations alone. Our scientific long-term objective, is to use the newly generated data to contribute towards the understanding of the Arctic Ocean nutrient and carbon biogeochemical cycles. Furthermore, we aim to extend the use of the data we generate via collaboration, so that our partners within FRAM and beyond, can benefit from our efforts in order to address scientific questions which are beyond our own expertise.

Work at sea

1. We will prepare and deploy sensors and RAS (Fig. 2.1). Each package consists of a RAS with a SUNA nitrate, pH, pCO2, CTD-O2, PAR and Eco-triplet sensors attached. PAR and Eco-triplet in surface deployments only. RAS and sensors will be programmed to take samples and measurements for 1 year, rather than the two years until the next expected recovery. This is to maximise temporal resolution and avoid the risk of malfunction.
2. We will also collect seawater samples at all stations, for later analysis of DIC and dissolved inorganic nutrients back in the laboratory at the AWI.
3. We will also recover RAS and sensors from our first deployment, and split RAS samplers in aliquots to cover our work on nutrient chemistry, and also work on bacterial genetics

(Matthias Wietz, MPI/AWI). Samples recovered from RAS will be sent back to the AWI for later analysis.

Expected results

Provided the RAS and sensors functioned as programmed, recovering our biogeochemical packages would yield a full year of observations of biogeochemically important variables. This represents a first whole seasonal cycle of such variables simultaneously collected in two of the main currents exchanging mass between the Arctic Ocean and the Atlantic Ocean; the EGC and the WSC.

Depending on the availability of analytical instruments back at the AWI following PS121, we may be able to measure the samples collected, within 6 months and up to 1.5 years.

Data management

Once data is generated and quality controlled, these will be submitted to PANGAEA.

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9. RATIOS OF STABLE N-ISOTOPES OF AMMONIUM AND AMMONIA AND CONCENTRATIONS OF DNA IN THE AIR OVER THE NORTH-EAST ATLANTIC

U. Hartmann (Uni Gö) (on board), J. Dyckmans, G. Gravenhorst, D. Boy, F. Heimsch (Uni Gö) (not on board)

Objectives and scientific programme

NH_3 is the main alkaline gaseous compound in the atmosphere. NH_4^+-sources for marine samples are rather unknown. Gaseous NH_3 is the source of ammonium (NH_4^+) in atmospheric particles, droplets and ice cores. Ammonia is emitted into the atmosphere on a global scale mainly by volatilisation from liquid cattle waste (e.g. Lenhard and Gravenhorst, 1980). NH_3 can flow between the atmosphere and the ocean in both directions (e.g. Schaefer et al. 1999). The ocean was divided to be a sink in high and, therefore, cold latitudes and a source in low and, therefore, warm latitudes (Johnson et al., 2008). Maritime airborne ammonium is mainly found in the nucleation and accumulation mode (e.g. Gravenhorst et al., 1979). A reaction of existing

acidic sulphate and alkaline ammonia seems to be a realistic formation mechanism (Gravenhorst, 1978).

The isotope ratio $\delta^{15}N$ / $\delta^{14}N$ of NH_3 over the ocean is not known. Our aim is to determine on the North Eastern Atlantic the background pattern of the ratios of stable isotopes $\delta^{15}N$ / $\delta^{14}N$ in particular NH_4^+ and in gaseous NH_3 in the air in order to characterize possible sources of atmospheric NH_4^+ and their regional distribution.

Furthermore, our aim is also to sample bio-aerosols and to characterize them by their DNA.

We want to take airborne samples on board *Polarstern* over the North East Atlantic and to analyse them at home to answer the following questions:

- What $\delta^{15}N$ / $\delta^{14}N$-isotope ratios are found in gaseous ammonia?
- What $\delta^{15}N$ / $\delta^{14}N$-isotope ratios are found in ammonium of size separated airborne particles?
- What species according to their differences in 16S DNA level are found in bioaerosols?

We hope to observe different ratios at different latitudes and to trace back the fate of their constituents. The same is true for bio-aerosols. Even in continental areas the DNA of biogenic constituents of air borne particles is rather unknown, especially in remote areas. DNA-analyses of these particles will be of special importance for identifying their sources, transfer ways and deposition areas. Can the NH_4^+ constituents and DNA-materials in ice cores be transported through the atmosphere from far distances and other sources than the ocean?

Work at sea

Concentrations of gaseous NH_3 and particulate NH_4^+ in the lower atmosphere will be determined on the latitudinal transect of *Polarstern* from Bremerhaven to the Arctic. The airborne ammonium particles as well as the bio-aerosols will be collected at the crow's nest well above the ships boundary layer and at clean wind directions.

Gaseous NH_3 will be absorbed on acidified membran filters in a row of three to determine the absorption efficiency. Particulate ammonium will be separated from NH_3 by a Teflon filter in front of the three NH_3 absorbing filters.

A high volume impactor will deposit the particles on Teflon plates and Teflon membrane filter discs. The impactor separates the particles according to their aerodynamical size. We expect to sample about 10 probes for size separated particles. The aerosols will be separated in particles with diameter larger and smaller than about 2,5 µm in one sampling device and in five different classes in another impactor device. These particles will undergo isotopic analysis.

The bio-aerosol will be collected on glassfibre filters, which have been sterilized before by UV-radiation. The bio-aerosol will be stored at dry ice temperature till analyses at home.

Gas-phase ammonia is expected to be always lighter in their N-isotopes than particle ammonium. Depending on air mass sources these N-isotope ratios could have different values giving hints for the fate of ammonia and ammonium. Bio-aerosols could have terrestrial or marine sources. We hope to sample enough material for DNA analyses and to find different genes characterizing different sources.

Expected Results

We have analysed some preliminary values of $\delta^{15}N$ / $\delta^{14}N$-isotope ratios over the Atlantic and several values in rural Germany: they are lighter than the ratios of the reference material of atmospheric molecular nitrogen, they fall into the range of negative values. In contrast particulate ammonium is heavier than molecular nitrogen. The values in rain water fall in

between. These values depend probably on NH_3-sources, the reaction pathways of NH_3 and NH_4^+ and the transport duration and the sink mechanisms.

Data management

The chemical and genetic data of the sampled trace substances will be deposited in the data bank of PANGAEA.

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3	Bodendorfer	Matthias	ROV-Operator	ROV	GEOMAR
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15	Hasemann	Christiane	Biologist	Biology	AWI
16	Hofbauer	Michael	Engineer	Biology	AWI
17	Hoving	Hendrik Jan Ties	Biologist	Biology	GEOMAR
18	Jager	Harold	Pilot	Aviation	HeliService
19	Kaiser	Patricia	Biologist	Biology	Uni HB
20	Konrad	Christian	Biologist	Biology	AWI
21	Krauß	Florian	Engineer	Biology	AWI
22	Lehmenhecker	Sascha	Engineer	Biology	AWI
23	Leßke	Rebekka	Student	Biology	AWI
24	Lochthofen	Normen	Engineer	Biology	AWI
25	Ludszuweit	Janine	Technician	Biology	AWI
26	Matthiessen	Torge	ROV-Operator	ROV	GEOMAR
27	Merten	Veronique	Biologist	Biology	GEOMAR
28	Metfies	Katja	Biologist	Biology	AWI
29	Meyer-Kaiser	Kirstin	Biologist	Biology	WHOI
30	Morische	Annika	Student	Chemistry	AWI
31	Murawski	Sandra	Technician	Biology	AWI
32	Nordhausen	Axel	Engineer	Biology	AWI
33	Pieper	Martin	ROV-Operator	ROV	GEOMAR
34	Prieto Turienzo	Elena Maria	Helikopter Service	Aviation	HeliService
35	Purser	Autun	Biologist	Biology	AWI
36	Richter	Roland	Helikopter Service	Aviation	HeliService

	Name	**Vorname / First Name**	**Beruf/ Profession**	**Fachgebiet/ Discipline**	**Institute**
37	Rogge	Swantje	Technician	Biology	AWI
38	Rohleder	Christian	Meterologist	Meterology	DWD
39	Sablotny	Burkhard	Engineer	Biology	AWI
40	Schewe	Ingo	Biologist	Biology	AWI
41	Scholz	Daniel	Technician	Chemistry	AWI
42	Soltwedel	Thomas	Biologist	Biology	AWI
43	Strack van Schijndel	Lora	Student	Biology	AWI
44	Stöckle	Sonja	Meterologist	Meterology	DWD
45	Suck	Inken	ROV-Operator	ROV	GEOMAR
46	Swoboda	Steffen	Biologist	Biology	MARUM
47	von Appen	Wilken-Jon	Oceanographer	Physics	AWI
48	von Jackowski	Anabel	Biologist	Biology	GEOMAR
49	Wenzel	Julia	Meterologist	Meterology	DWD
50	Wenzhöfer	Frank	Biologist	Biology	AWI
51	Wiegmann	Sonja	Technician	Biology	AWI
52	Wietz	Matthias	Biologist	Biology	AWI
53	Wulff	Thorben	Engineer	Biology	AWI

12. SCHIFFSBESATZUNG / SHIP'S CREW

	Name	**Rank**
01.	Wunderlich, Thomas	Master
02.	Kentges, Felix	1.Offc.
03.	Westphal, Henning	Ch.Eng.
04.	Fischer, Tibor	2.Offc.Lad.
05.	Peine, Lutz	2.Offc.
06.	Langhinrichs, Jacob	2.Offc.
07.	Dr. Pohl, Klaus	Doctor
08.	Dr. Hofmann, Jörg	Comm.Offc.
09.	Schnürch, Helmut	2.Eng.
10.	Brose, Thomas	2.Eng.
11.	Rusch, Torben	2.Eng.
12.	Brehme, Andreas	Elec.Tech.
13.	Frank, Gerhard	Electr on.
14.	Marker, Winfried	Electron.
15.	Winter, Andreas	Electron.
16.	NN	Electron .
17.	Sedlak, Andreas	Boatsw.
18.	Neisner, Winfried	Carpenter
19.	Brickmann, Peter	A B.
20.	Müller, Steffen	A B.
21.	Burzan, Gerd-Ekkehard	AB.
22	Hartwig-Labahn, Andreas	A B.
23.	Fölster, Michael	AB.
24.	Schröder, Horst	AB.
25.	Meier, Jan	AB.
26.	Luckhardt, Arne	AB.
27.	Plehn, Markus	Store keep.
28.	Clasen, Nils	Mol-man
29.	Waterstradt, Felix	Met-man
30.	Krösche, Eckard	Met-man
31.	Dinse, Horst	Met-man
32.	Walze, Bernhard	Mot-man
33.	Meißner, Jörg	Cook
34.	Tupy, Mario	Cooksmate
35.	Martens, Michael	Cooksmate
36.	Wartenberg, Irina	1.Stwdess
37.	Pommerencke, Kerstin	Stwd/KS
38.	Hischke, Peggy	2.Stwdess
39.	Bachmann, Julia	2.Stwdess
40.	Krause, Tomasz	2.Steward
41.	Hu, Guo yong	2.Steward
42.	Chen, Quan Lun	2.Steward
43.	Ruan, Hui Guang	Laundrym.
44.	Hansen, Jan Nils	Trainee
45.	Lenz, Julien Alexander	Trainee