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HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

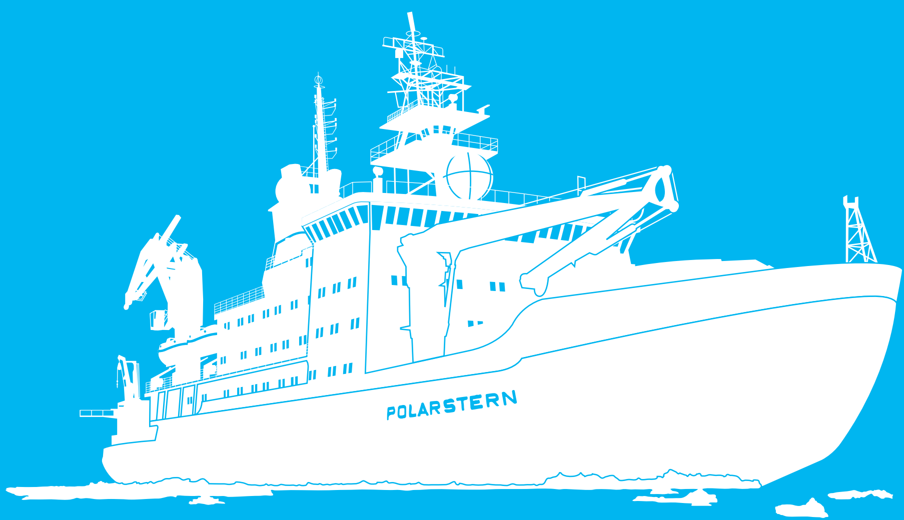
EXPEDITION PROGRAMME
PS155

Polarstern

PS155
Bremerhaven - Tromsø
04 July 2026 - 03 August 2026

Coordinator: Ingo Schewe

Chief Scientists: Autun Purser



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Bremerhaven, May 2026

Alfred-Wegener-Institut
Helmholtz-Zentrum
für Polar- und Meeresforschung
Am Handelshafen 12
D-27570 Bremerhaven

Telefon: +49 471 4831-0
Telefax: +49 471 4831-1149
E-Mail: info@awi.de

Website: http://www.awi.de
Email Coordinator: ingo.schewe@awi.de
Email Chief Scientist autun.purser@awi.de

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Editorial editing and layout
Susan Amir Sawadkuhi

Alfred-Wegener-Institut
Helmholtz-Zentrum für Polar- und Meeresforschung
Am Handelshafen 12
27570 Bremerhaven
Germany

www.awi.de
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1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Autun Purser[1], Jennifer Dannheim[1]

[1]DE.AWI

Die *Polarstern*-Expedition PS155 wird am 04. Juli 2026 von Bremerhaven aus in die Framstraße zwischen Grönland und der Inselgruppe Spitzbergen aufbrechen. Die Expedition wird zu verschiedenen großen nationalen und internationalen Forschungs- und Infrastrukturprojekten (z.B. FRAM, MUSE, HiAOOS, EPOC und Arctic PASSION) sowie zum Forschungsprogramm „Changing Earth – Sustaining our Future" („Erde im Wandel – Unsere Zukunft nachhaltig gestalten") des Alfred-Wegener-Instituts, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) beitragen. In Topic 6 „Marine and Polar Life: Sustaining Biodiversity, Biotic Interactions and Biogechemical Functions" (Subtopics 6.1 „Future ecosystem functionality" und 6.3 „The future biological carbon pump") werden die mit steigenden Wassertemperaturen und dem Rückgang des Meereises verbundenen Ökosystem-verschiebungen im Pelagial und im tiefen Ozean ermittelt und quantifiziert sowie Rückkopplungsprozesse auf ozeanografische Prozesse untersucht. Die Untersuchungen beinhalten die Ermittlung räumlicher und zeitlicher Trends in der Funktion ausgewählter pelagischer und benthischer Lebensgemeinschaften und die Einrichtung eines umfassenden Repositoriums für Beobachtungsdaten. Subtopic 6.4 „Use and misuse of the ocean: Consequences for marine ecosystems" befasst sich mit der Verbreitung der Plastikverschmutzung und den Wechselwirkungen zwischen Plastik und der Meereslebewesen. In Topic 2 (2.4 „Advanced research methodologies for tomorrow") werden fortgeschrittene Forschungsmethoden, einschließlich neuartiger *In-situ*- und Fernerkundungsbeobachtungs-systeme, entwickelt und angewendet. Die Expedition wird die FRAM-Infrastruktur über die Durchführungsphase (2014 – 2023) hinaus erhalten und weiterentwickeln, einschließlich des LTER-Observatoriums HAUSGARTEN und des LTO WSC-Observatoriums als Teil des FRAM-Ozeanbeobachtungssystems.

Die Expedition wird die Zeitreihenuntersuchungen am LTER-Observatorium (Long-Term Ecological Research) HAUSGARTEN weiterführen, welches 21 Stationen entlang eines bathymetrischen und longitudinalen Gradienten über die Framstraße umfasst, darunter Stationen bis zu 5.500 m (Molloy Deep) und Stationen von der Nähe des Svalbard-Archipels bis zum nordöstlichen Grönlandschelf (Abb. 1.1). Zu diesem Zweck wird eine Reihe von schiffsbetriebenen Probenahmegeräten (z.B. MUC, Box Core, CTD/Rosette, EBS) eingesetzt. Darüber hinaus werden auch hochkomplexe autonome robotische Forschungsplattformen (z.B. Benthic Crawler, Lander, OFOBS) eingesetzt. Die Expedition PS155 wird dazu beitragen, die Langzeitbeobachtungen zu gewährleisten, die über mehr als 25 Jahre hinausgehen, Umweltveränderungen im arktischen Tiefsee-Ökosystem zu untersuchen, und weitere Installationen im Rahmen des HGF-Infrastrukturprojekts FRAM (Frontiers in Arctic marine Monitoring) durchzuführen.

Die Hauptziele von LTER HAUSGARTEN und des Ozeanbeobachtungssystems FRAM sind: (i) Fortsetzung der Beobachtungen der benthischen und pelagischen Artenvielfalt und der biogeochemischen Prozesse, um zu untersuchen, wie sich veränderte Umweltbedingungen auf die Artenvielfalt in der Tiefsee in der Übergangszone zwischen dem Nordatlantik und dem zentralen Arktischen Ozean auswirken und (ii) ständige Präsenz auf See (Verankerungen und benthische Plattformen) für die Bereitstellung integrierter und interdisziplinärer Daten über physikalische, biogeochemische und biologische Parameter, die eine umfassende Bewertung der zeitlichen Variabilität (einschließlich der Winterbedingungen) ermöglichen.

Das FRAM-Ozeanbeobachtungssystem unterhält, entwickelt und implementiert hochmoderne synergetische Beobachtungsplattformen für die Polar-, Meeres- und Klimaforschung im Ozean und legt – als Prototyp für groß angelegte integrative, autonome Observatorien – die Grundlage für eine nachhaltige Überwachung und ein Management der ozeanischen Umwelt. An der Schnittstelle zwischen Hydrosphäre, Kryosphäre und Atmosphäre sowie Hydrosphäre und Geosphäre werden kontinuierliche Beobachtungen durchgeführt, um die Variabilität der Erwärmung und der Eisschmelze auf verschiedenen Zeitskalen und der damit verbundenen Aussüßung, Schichtung und Tiefenkonvektion sowie deren Folgen für die Produktivität, die biologische und physikalische Aufnahme, den Export und die Speicherung Kohlenstoff sowie andere Ökosystemfunktionen, einschließlich der biologischen Vielfalt, zu untersuchen.

Die Probenahmen und die während der jährlichen Expeditionen installierten Komponenten werden dazu beitragen, das derzeitige System besser zu verstehen und Konsequenzen aus der raschen Erwärmung der arktischen Atmosphäre auf die Umwelt abzuleiten, die in den letzten Jahrzehnten doppelt so schnell wie der globale Durchschnitt verlaufen ist. Basierend auf den bekannten Wissenslücken beinhalten die aktuellen wissenschaftlichen Ziele für die Langzeitstudien im LTER HAUSGARTEN:

- Bereitstellung täglicher Daten über die Eigenschaften der Meeresoberfläche und der Tiefsee in nahezu Echtzeit;
- Dokumentation der Erwärmung des in den Arktischen Ozeans einfließenden Atlantikwassers und die damit verbundenen Veränderungen des Transports und der Eigenschaften;
- Untersuchung von Wechselwirkungen und Rückkopplungsmechanismen zwischen der Atmo-, Kryo-, Hydro-, Bio- und Geosphäre;
- Beobachtungen, die Variationen von täglichen (z.B. relevant für die Vorbedingungen für Phytoplanktonblüten) bis zu inter-annualen (z.B. relevant für die Entschlüsselung dekadischer Trends) Zeitskalen mit Prozessen in der Atmo-, Kryo-, Hydro-, Bio- und Geosphäre verknüpfen;
- Quantifizierung von Energie- und Stoffbudgets und -transporten in verschiedenen räumlich zeitlichen Auflösungen, von saisonalen Dynamiken bis hin inter-annualen Unterschieden und dekadischen Veränderungen;
- Identifizierung der Mechanismen, die die Artenvielfalt pelagischer und benthischer Gemeinschaften bestimmen;
- Untersuchung der Widerstandsfähigkeit der arktischen Meeresorganismen;
- Identifzierung von Indikatorarten für Veränderungen in den Gemeinschaften;
- Bereitstellung von Daten für die Bewertung von Ökosystemfunktionen, Ökosystemdienstleistungen und der Rolle der biologischen Vielfalt;
- Bereitstellung von Daten zur Bewertung der Qualität von Fernerkundungsbeobachtungen und Modellen, die aktuelle und zukünftige Veränderungen im Arktischen Ozean simulieren;

- Entschlüsselung der Kopplung von Mechanismen des Klimawandels im Nordatlantik und im Arktischen Ozean;
- Bewertung der Plastikverschmutzung im Meereis, in der Wassersäule, auf dem Meeresboden und in benthischen Organismen, um langfristige Trends der Plastikverschmutzung und der Aufnahme von Plastik in das Nahrungsnetz zu untersuchen.

Zusätzlich zu diesen Langzeitstudien wird die PS155-Expedition im Rahmen des Nebennutzerantrags, des ALONGATE-Projekts, die benthische Kontiguität zwischen der Framstraße und den südlichen Gewässern Richtung Island untersuchen. Weitere Nebennutzeranträge werden Untersuchungen zum Kohlenstoff- und Schadstoffkreislauf im Molloy-Tief (UNDER PRESSURE-Projekt) sowie zu Wechselwirkungen zwischen Foraminiferen und Metallen in der benthischen Ökologie (FEMMES-Projekt) durchführen. Im Sommer 2026 erscheint eine Ausgabe der Fachzeitschrift „Deep Sea Research II“, die viele der Beobachtungen aus den ersten 25 Jahren des LTER HAUSGARTEN hervorhebt. Die Expeditionen PS148 und PS155 kennzeichnen die ersten Datenerhebungen, die wesentlich zum Verständnis der Geschwindigkeit und der Auswirkungen des globalen Klimawandels in der FramStraße, dem Tor zur Arktis, beitragen werden.

Die Expedition wird am 03. Aug 2026 in Tromsø, Norwegen, enden.

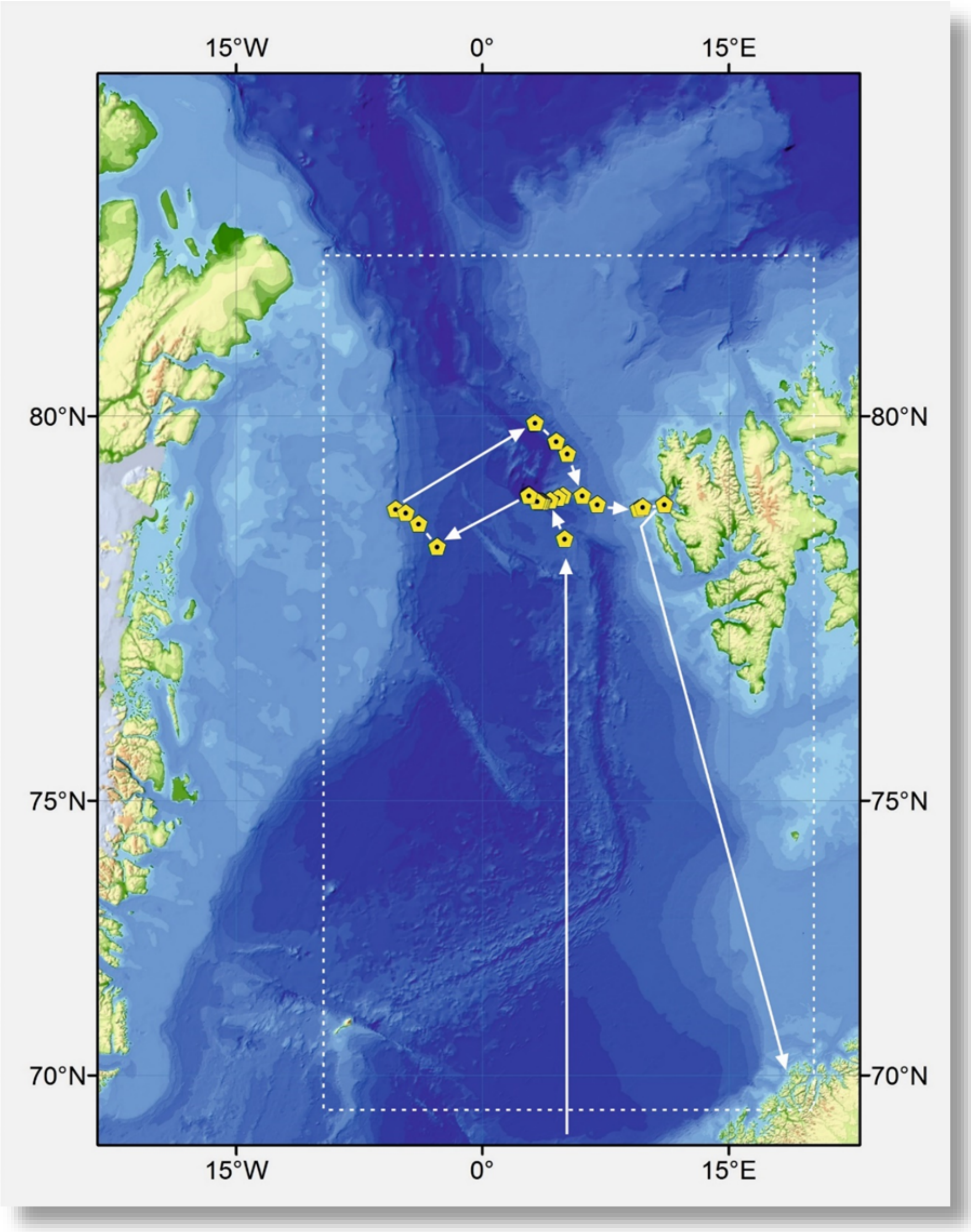

Fig. 1.1: Map of planned cruise track (solid white lines) and main sampling stations (yellow pentagons) of Polarstern expedition PS155 (broken line: geographical area in which the ship will operate).

SUMMARY AND ITINERARY

The *Polarstern* expedition PS155 will depart on 04 July 2026 from Bremerhaven to the Fram Strait between Greenland and the Svalbard achipelago. The expedition will contribute to various large national and international research and infrastructure projects (e.g., FRAM, MUSE, HiAOOS, EPOC, and Arctic PASSION) as well as to the research programme "Changing Earth – Sustaining our Future" ("Erde im Wandel – Unsere Zukunft nachhaltig gestalten") of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI). In Topic 6 "Marine and Polar Life: Sustaining biodiversity, Biotic Interactions and Biogeochemical functions (Subtopic 6.1 "Future ecosystem functionality" and 6.3 "The future biological carbon pump") ecosystem shifts in the pelagic and deep ocean associated with water temperature increase and sea ice retreat are identified and quantified, and feedback processes on oceanographic processes investigated. These studies include the identification of spatial and temporal trends in the function of selected pelagic and benthic communities and the establishment of a comprehensive repository of observational data. Subtopic 6.4 "Use and misuse of the ocean: Consequences for marine ecosystems" addresses the distribution of plastic pollution and the interactions with marine biota. In Topic 2 (2.4 „Advanced research methodologies for tomorrow"), advanced research methodologies, including novel in situ and remote sensing observing systems will be developed and applied. The expedition will maintain and further develop FRAM infrastructure beyond the implementation-phase (2014-2023), including the LTER observatory HAUSGARTEN and the LTO WSC observatory as part of the FRAM Ocean Observing System.

The expedition will support the time-series studies at the LTER (Long-Term Ecological Research) observatory HAUSGARTEN which comprise 21 stations along a bathymetric and longitudinal gradient across the Fram Strait, including stations down to 5,500 m (Molloy Deep) and stations from near Svalbard archipelago to the North East Greenland area (Fig. 1.1). For this purpose, a series of ship-operated sampling devices (e.g., MUC, box core, CTD/rosette, EBS) will be used. In addition, highly complex autonomous robotic research platforms (e.g., benthic crawler, lander, OFOBS) will also be deployed. The expedition PS155 will contribute to ensure long-term observations, excceeding more than 25 years of sampling, investigating environmental changes on the Arctic deep-sea ecosystem and carrying out further installations as part of the HGF infrastructure project FRAM (Frontiers in Arctic marine Monitoring). The main objectives of LTER HAUSGARTEN and the FRAM Ocean Observing System are: (i) to continue observations of benthic and pelagic biodiversity and biogeochemical processes to study how changing environmental conditions affect deep-sea biodiversity in the transition zone between the North Atlantic and central Arctic Ocean and (ii) to be permanently present at sea (moorings and benthic platforms) for the provision of integrated and interdisciplinary data on physical, biogeochemical and biological variables allowing a more thorough assessment of temporal variability (including winter conditions).

The FRAM Ocean Observing System maintains, develops and implements cutting-edge synergistic observation platforms for polar, marine and climate change research in the ocean, and – as a prototype for large-scale integrative, autonomous observatories – lays the foundation for sustainable monitoring and management of the oceanic environment. Continuous observations are provided at the interface between the hydrosphere, cryosphere and atmosphere, as well as hydrosphere and geosphere, to investigate variability at different time scales in freshening, stratification and deep convection related to warming and ice melt, and their consequences for productivity, biological and physical carbon uptake, export and burial, as well as other ecosystem functions, including biodiversity. The sampling and the components installed during annual expeditions help to better understand the current system and infer consequences from the rapid warming of the Arctic atmosphere onto the environment, prescient given the continuing trend of Arctic amplification. Based on knowledge gaps, the current scientific goals for long-term studies in LTER HAUSGARTEN include:

- providing daily near-real time data on ocean surface and deep-water properties;
- providing a record documenting the warming of the Atlantic Water inflowing to the Arctic Ocean and its associated changes in transport and properties;
- study interactions and feedback mechanisms between the atmo-, cryo-, hydro-, bio-, and geosphere;
- obtain observations which link variations of daily (e.g., relevant for the preconditioning for phytoplankton blooms) to inter-annual (e.g., relevant to decipher decadal trends) timescales with processes in the atmo-, cryo-, hydro-, bio- and geosphere;
- quantify budgets and transports of energy and matter at different spatio-temporal resolutions from seasonal dynamics to inter-annual differences and decadal changes;
- identify the mechanisms which shape biodiversity of pelagic and benthic communities;
- assess the resilience of Arctic marine organisms and identify indicator species for community changes;
- contribute data for the assessment of ecosystem functions, services and the role of biodiversity therein;
- provide data for assessing the quality of remote sensing observations and of models simulating current and future changes in the Arctic Ocean;
- decipher how climate change mechanisms in the North Atlantic and the Arctic Ocean are coupled;
- assess plastic pollution in sea-ice, water-column and on the seafloor and benthic organisms to investigate long-term trends in plastic pollution and uptake in the food web.

In addition to these long-term studies, the PS155 expedition will additionally conduct secondary user research on the degree of benthic contiguity between the Fram Strait and the southerly waters toward Iceland (the ALONGATE project). Additional secondary user projects will continue work on investigating carbon and pollutant cycling in the Molloy Deep (the UNDER PRESSURE project) and the interactions between foraminiferans and metals in benthic ecology the FEMMES project).

During the summer of 2026 an issue of the journal ‘Deep Sea Research II’ will be published, highlighting many of the observations made during the initial 25 years of the LTER HAUSGARTEN. The PS148, and PS155 expeditions, mark the collection of the first data which will contribute greatly into developing our understanding of the speed and impacts of global climate change across the FRAM gateway to the Arctic.

The expedition will end on 3 August 2026 in Tromsø, Norway.

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

J. Dannheim[1], M. Bergmann[1], L. Buchele[1], M. Busack[1], J. Hagemann[1], S. Hamisch[1], C. Hasemann[1], F. Hemmateenejad[2], K. Jia[1], S. Lehmenhecker[1], N. Lochthofen[1], J. Ludszuweit[1], J. Maring[1], F. Möller[1], A. Purser[1], I. Schewe[1], U. Hoge[1], F. Wenzhoefer[1,3]
C. Krämmer (not on board)[1], L. Boehringer (not on board)[1]
*Jennifer.dannheim@awi.de

[1]DE.AWI
[2]IT.UNIMIB
[3]DK.SDU

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Objectives and scientific program

The marine Arctic has played an essential role in the history of our planet over the past 130 million years and contributes considerably to the present functioning of the Earth and its life. The past decades have seen remarkable changes in key Arctic variables, including a decrease in sea-ice extent and sea-ice thickness, changes in temperature and salinity of Arctic waters, and associated shifts in nutrient distributions and pollution (Bergmann et al. 2022). Since Arctic organisms are highly adapted to extreme environmental conditions with strong seasonal forcing, the accelerating rate of recent climate change challenges the resilience of Arctic life. The stability of a number of Arctic populations and ecosystems is probably not strong enough to withstand the sum of these factors, which might lead to a collapse of subsystems.

Benthos, particularly in deep waters, is a robust ecological indicator for environmental changes, as it is relatively stationary and long-lived and reflects changes in environmental conditions in the oceans (e.g. organic flux to the seabed) at integrated scales (Gage and Tyler 1991; Piepenburg 2005). 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 Centre for Polar and Marine Research (AWI) established the deep-sea observatory HAUSGARTEN, which constitutes the first, and until now only open-ocean long-term observatory in a polar region (Soltwedel et al. 2016).

HAUSGARTEN is located in the eastern Fram Strait and comprises 21 permanent sampling stations along a depth transect (250 – 5,500 m) and along a latitudinal transect following the 2500 m isobath crossing the central HAUSGARTEN station (Fig. 2.1). Multidisciplinary research activities at HAUSGARTEN cover almost all compartments of the marine ecosystem from the pelagic zone to the benthic realm, with a focus on benthic processes. Regular sampling as well as the deployment of moorings and different stationary and mobile free-falling systems (bottom lander, benthic crawler), which act as local observation platforms, have taken place since the observatory was established in 1999. Visual observations were regularly undertaken by towed photo/video systems to assess spatial patterns and temporal dynamics of epibenthic megafauna and habitat characteristics.

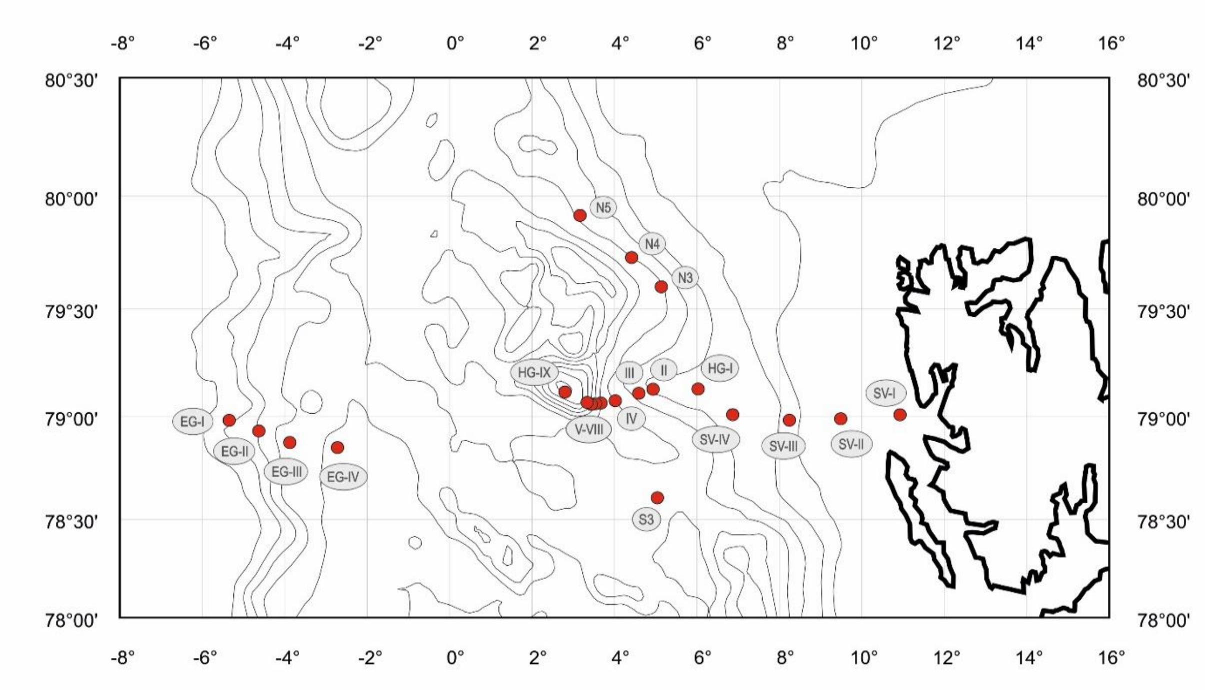

Fig. 2.1: Permanent sampling sites of the LTER (Long-Term Ecological Research) observatory HAUSGARTEN in Fram Strait, Arctic Ocean

Geographical features in the HAUSGARTEN area provide a variety of contrasting marine landscapes and landscape elements (e.g. banks, troughs [marine valleys], ridges and moraines, canyons and pockmarks) that generally shape benthic communities over a variety of different scales (Buhl-Mortensen et al. 2010; 2012). The habitat-diversity (heterogeneity) hypothesis states that an increase in habitat heterogeneity leads to an increase in species diversity, abundance and biomass of all fauna groups (Whittaker et al. 2001; Tews et al. 2004). Advances in technology, particularly the recent use of towed side-scan sonar systems by the Deep-Sea Research Group (Purser et al. 2019), have revealed the high-resolution topographic variability of many deep-sea enviroments, including HAUSGARTEN (Schulz et al. 2010; Taylor et al. 2016; Purser 2020). To date, the time-series stations across the region do not adequately capture the high degree of local heterogeneity in seafloor terrain (e.g., slope, rugosity, aspect, depth). Therefore, during *Polarstern* expedition PS155, spatially resolved data will be collected using these towed systems to assess the role of this heterogeneity in shaping biodiversity and biomass patterns, thereby complementing exisiting studies on the temporal variability of the benthic communities in the HAUSGARTEN area.

As these time-series photographs have also brought to light a sevenfold increase in marine debris between 2004 and 2017 (Parga Martínez et al. 2020) a pollution observatory has been added to HAUSGARTEN to assess plastic pollution in all ecosystem compartments. This research has shown particularly high microplastic concentrations in sediments (Tekman et al. 2020). To determine the exposure of sediment-dwelling biota to micro- and nanoplastic pollution, we thus aim to assess ingestion rates and the level of plastic additives in their tissues.

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. While benthic communities themselves are sampled annually using dedicated benthic sampling devices, lander-based instruments provide complementary measurements of environmental parameters, including oxygen fluxes and sediment traps, that inform on seasonal and interannual variations in carbon supply and benthic metabolism. 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 instruments deployed on benthic laders provide information on the interannual variations. Benthic crawler, mobile seafloor platforms capable to perform weekly oxygen gradient measurements for a 12-month period, provide information on the seasonal variations. In addition, long-term benthic lander systems equipped with sediment traps and cameras for time-lapse imaging of the seafloor record the supply of organic material throughout the year.

Work at sea – benthic work

The current cruise will build upon a dataset spanning over 25 years, enabling the assessment of long-term changes in benthic communities. The composition, diversity, density and biomass of benthic communities will be analysed together with environmental data to detect changes due to environmental regime shifts in the deep sea of the Fram Strait. Within a complementary sampling design covering all size classes of benthic communities from meio- to megafauna.

Long-term meiobenthic study

Virtually undisturbed sediment samples are collected using a video-guided multiple corer (MUC). These samples are analysed to characterise meiofaunal communities, with special emphasis on nematodes, including both their quantitative and qualitative composition.

Sampling allows the investigation of spatial and temporal patterns, from vertical gradients within the sediment to large-scale variations across different water depths. Data from the first 19 years of the HAUSGARTEN time series have been analysed specifically for nematode communities, revealing long-term trends. Continued monitoring is essential to detect changes in benthic community structure and their responses to environmental variability.

Sediments are also examined for environmental parameters that serve as proxies for food supply to the deep seafloor. These include microbial communities, which are not only considered as potential food for meiofauna but are also analysed for their taxonomic composition and functional diversity to characterise benthic microbial ecology. Overall, the environmental parameters, in their role as food proxies, provide baseline data for future biological experiments aimed at understanding the drivers of biodiversity and community composition.

Long-term macrobenthic study

Macrobenthos in the HAUSGARTEN area has been studies only irregularly over the past 26 years. The focus has been on investigating depth gradients, horizontal distribution patterns in the sediment and temporal variability between 2003 and 2007. Sampling of the macrofauna during PS155 will continue the time-series work to allow the assessment of long-term changes in the deep-sea habitat, and the fourth sampling of a study of the inter-annual variability of benthic populations at HAUSGARTEN. Samples will be obtained by using a 0.25 m² USNEL box corer (GBC). Particularly for deep-sea samples the box corer is a preferred sampling gear, as it provides reliably deep and relatively undisturbed sediment samples. Box-corer samples will be divided into subsamples and sieved over 500 µm sieves. The macrofauna in the sieve residues will be preserved for later taxonomic analysis in the laboratory.

Complementary to box corer sampling, vertical sediment profiles images will be acquired using a sediment profile imaging (SPI) camera. The SPI camera will be used to assess habitat and ecological changes by characterising sediment layer structure, the apparent redox potential discontinuity (aRPD), benthic successional stages, and bioturbation activity as key benthic functions. These observations will enhance our understanding of long-term changes in Arctic macrofauna biodiversity and ecological functioning, including bioturbation and carbon storage, under evolving sea-ice conditions in the Fram Strait. The resulting data will complement ongoing meiofauna and megafauna image-based surveys.

Long-term megabenthic study and seafloor mapping

The Ocean Floor Observation and Bathymetry System (OFOBS; Purser et al. 2019) will be deployed along previously established and analyzed camera tracks to assess interannual dynamics of megafauna on the seafloor at selected stations (ideally HG-I, HG-IV, N3, S3, but with potential changes made in response to ice and weather conditions). The OFOBS will be towed at 1.5 m altitude for 4-hours at each survey site. A subset of images will be analyzed and compared with previous data to assess interannual dynamics of megafaunal assemblages. The AWI "Remora class" MiniROV will be attached to OFOBS for some deployments and used to close up imaging work, or equipment retrieval, as required. Additionally, the new sampling net (deployed very successfully during the recent PS146 expedition) will be available for collection of target fauna from the seafloor if desired. The OFOBS is equipped with a multibeam system allowing to collect spatial data to develop the high-resolution seafloor topographical maps of the HAUSGARTEN. In addition, a CTD is integrated into the OFBOS system and two software-triggerend, sealable Nicken bottles (each with a capacity of 12 liters).

In addition to the OFOBS system, the AWI AUV 'PAUL 3000' will be used during the PS155 expedition to continue the spatial mapping of HAUSGARTEN stations, and to further explore the seafloor surrounding the time series stations. During the expedition, the intention is to operate the AUV autonomously without direct attendance by the research vessel. This will allow the expedition to carry out additional work whilst AUV seafloor surveys are conducted with the AUV mounted sidescan and camera systems. A key aim is to continue the seafloor image transects between HAUSGARTEN stations started in 2024 with expedition PS143/2, the linking of the various HAUSGARTEN stations with seafloor image transects, to identify spatial patterns in community structure across the survey region.

All AUV and OFOBS imagery will also be used to quantify litter on the seafloor. All data collected with the OFOBS and AUV will be used using the new data archiving ingest protocol developed by C. Krämmer and L. Boehringer, strictly following the guidelines and metadata schemes presented in Schoening et al. (2022).

Benthic flux study

Seafloor carbon mineralization will be studied in-situ at sites with varying sea-ice conditions (HG-IV, N4, HG-IX) using a benthic lander system (Hoffmann et al. 2018). The benthic O2 uptake is a commonly used measure for the benthic mineralization rate. We plan to measure benthic oxygen consumption rates at different spatial and temporal scales. The benthic lander will be equipped with two different profiling instruments to investigate the oxygen penetration and distribution as well as the benthic oxygen uptake of Arctic deep-sea sediments: i) electrode-microprofiler, for high-resolution pore water profiles (O2, resistivity) across the sediment-water interface, and ii) a deep optode-profiler, to measure the entire oxygen penetration depth. The overall benthic reaction is followed by measurement of sediment community oxygen consumption to calculate carbon turnover rates.

We will also deploy and test a benthic Lander-Crawler-Sytem (TRAMPER) (Wenzhöfer et al. 2016). The lander-crawler system will be placed at the seafloor as mooring. At pre-programmed intervals the crawler will move out of the lander for 15 m and perform measurements. TRAMPER uses oxygen optodes to measure vertical concentration profiles across the sediment-water interface (one set of profiles each interval). Additionally, the crawler is equipped with a seafloor imaging and scanning camera system to take images of the seafloor combined with a laser scan. From this information we are able to reconstruct the sediment surface at high resolution. When seafloor images and topography scans are overlaid, we will be able to identify hot spots of intensified organic matter accumulation. These two seafloor observations are performed during the 10 – 15 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 providing information on the oxygen consumption related to carbon mineralization.

Preliminary (expected) results

Our assessments of benthic biodiversity, function and biogeochemistry will contribute significantly to the existing knowledge of the deep sea and polar regions. By continuing this unique time-series work at HAUSGARTEN in the deep-sea Arctic, we expect not only to improve our understanding of the dynamic diversity and distribution of benthic communities, but also to shed light on how these ecosystems respond to changing environmental conditions over decades (Soltwedel et al. 2016) in times of rapid climate warming. Further, the result will add to our growing database on microbial carbon mineralization in deep-sea (Jørgensen et al. 2022) and allow for comparison environments experiencing different regimes of vertical carbon export.

The results will add to our time series and various other databases in relation to the Arctic fauna and thus will feed into international networks such as CBMP (Circumpolar Biodiversity Monitoring Program) and ADBO (Atlantic-Arctic Distributed Biological Observatory), as well as panels for scientific advice such as the Conservation of Arctic Flora and Fauna (CAFF) in the Arctic Council and the Arctic Monitoring and Assessment Program (AMAP).

Data management

Environmental, image, video and acoustic mapping data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 6, Subtopic 1 and 3.

In all publications based on this expedition, the **Grant No. AWI_ PS155_01** will be quoted, and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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3. PEBCAO – PLANKTON ECOLOGY AND BIOGEOCHEMISTRY IN THE CHANGING ARCTIC OCEAN

Nadine Knüppel[1], Joris Rckert[1], Claudia Brenner[1], Barbara Doermbach[1], Christian Konrad[1], Tania Klüver[2], Carla Pein[2], Catherine Amanda Garcia[2], Lena Pflaum[2], Maruša Kerenčič[4]
not on board: Anja Engel[2], Alexandra Kraberg[1], Morten Iversen[1], Katja Metfies[1], Barbara Niehoff[1], Marlis Reich[3]
* cgarcia@geomar.de

[1]DE.AWI
[2]DE.AWI
[3]DE.UNI-Bremen
[4]SI.NIB

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Outline

The Arctic Ocean has gained increasing attention in recent decades due to the ongoing decrease in sea-ice cover and increase in sea temperature. Moreover, it is expected that the chemical equilibrium and the elemental cycling in the surface ocean change due to ocean acidification. Over the past two decades, measurements of biogeochemical parameters, microscopy, optical methods, satellite observations, and molecular genetic approaches have provided valuable information on ecosystem variability in response to environmental change. This includes information on biodiversity, biogeography and biomass of the bacterial, microbial and mesozooplankton plankton communities, as well as primary production and bacterial activity on annual basis. These annual measurements are complemented with year-round sampling based on the deployment of sediment traps and automated water samples on long-term moorings within the framework of the FRAM/HAUSGARTEN observatory.

Fram Strait is an ideal location to investigate potential effects of changing environmental conditions, including sea-ice coverage on plankton communities. The long-term observations and process studies have already given us valuable insights into mechanistic linkages between environmental conditions, biodiversity and ecosystem functionality, and into ongoing change in the marine ecosystem of Fram Strait. Our results clearly indicate that chlorophyll a (Chl-a) values increase in summer in the eastern but not in the western Fram Strait (Nöthig et al. 2015, 2020). This is in accordance with the increasing contributions of *Phaeocystis pouchetii* and nanoflagellates to the summer phytoplankton community in relation to diatoms, linked to decreasing availability of silicic acid in the water column. Biogeographical studies of PEBCAO based on 18S metabarcoding indicate that a year-round semi-stationary sea-ice edge serves as a strong biogeographical boundary between Atlantic conditions to the southeast and polar conditions to the Northwest of Fram Strait (Metfies et al. 2016). Recent work indicates the timing of phytoplankton blooms in the north-western Fram Strait occurs earlier in May (Lampe et al. 2026), and may be influenced by blooms below the sea-ice (McPherson et al. 2026). Regional differences in bloom timing may be related to seasonal peaks among phytoplankton functional types (Xi et al. 2025; Bracher et al. 2026). Correspondingly, the mesozooplankton communities also consistently differ with respect to composition and abundances in the eastern and western Fram Strait (Dolinkiewicz et al. 2026). In 2017, the marginal ice zone (MIZ) extended further eastwards and southwards into Fram Strait compared to the climatological average, with profound impacts on the ecosystem. Sea ice melt in a sub-mesoscale filament, characterized by a thin surface meltwater layer, led to comprehensive changes in plankton-biodiversity, carbon export and primary production in vicinity of the filament (Fadeev et al. 2021). Moreover, results from an interdisciplinary study in a sub-mesoscale filament suggest that sea-ice melt is enhancing the growth of sea-ice associated phytoplankton, that might be positively linked to zooplankton abundance and biomass (Kaiser et al. 2025; Weiss et al. 2024). In sea-ice impacted regions of Fram Strait, diatoms dominate the diet of zooplankton, while they have less impact in open water areas of Atlantic Water (Kaiser et al. 2025).

Moreover, the population size of bloom-forming species can also be impacted by mycoplankton (defined here as saprotrophic and parasitic fungi and pseudofungi (oomycetes). These taxonomic groups have not yet been part of our investigations although its ecological impact can be considerable (Buaya et al. 2019). Even in well-studied areas such as the North Sea new species are being described (Buaya et al. 2017), but in polar regions, with few exceptions the diversity and dynamics of the mycoplankton remain to be discovered (Hassett et al. 2019 a,b).

In the past, PEBCAO also contributed to year-round interdisciplinary observations indicating that increased meltwater-stratification during spring/summer of 2017 slowed down the biological carbon pump in the Atlantic Water region of the central Fram Strait with significant impacts on pelagic and benthic communities in comparison to the warmer year 2018 (von Appen et al. 2021). The data suggest, that sea-ice melt might serve as a barrier for a northward movement of temperate phytoplankton taxa in Fram Strait (Oldenburg et al. 2024). Furthermore, based on our year-round automated water sampling, we characterized the annual succession of microbial communities at a station in West Spitsbergen Current (WSC) and East Greenland Current (EGC). The ice-free West Spitsbergen Current displayed a marked separation between a productive summer (dominated by diatoms and carbohydrate-degrading bacteria) and regenerative winter state (dominated by heterotrophic Syndiniales, radiolarians, chemoautotrophic bacteria, and archaea). In the East Greenland Current, deeper sampling depth, ice cover and polar water masses concurred with weaker seasonality and a stronger heterotrophic signature. Low ice cover and advection of Atlantic Water coincided with diminished abundances of chemoautotrophic bacteria while other taxa such as Phaeocystis increased, suggesting that Atlantification alters the microbiome structure and eventually the biological carbon pump (Wietz et al. 2021). PEBCAO was able to show that a change in microbiome structure might affect the biological carbon pump. For instance, we found strong correlations between Phaeocystis and transparent exopolymer particle concentration (TEP), which are known to play a crucial role in the biological carbon pump (Engel et al. 2017). However, despite the observed shift in phytoplankton community composition, the concentration of dissolved organic carbon (DOC) was relatively stable over the last two decades, but we observed a slight decrease in the particulate organic carbon (POC) during the summer months (Engel et al. 2019). More recently, Engel et al., (2025) report an increase in DOC from 2016-2021 in the East Greenland Current is linked to increases in semi-labile riverine sources due to increased ice melt of Polar Water. Conversely, DOC composition in the south-western Fram Strait is linked to seasonal phytoplankton blooms producing labile-DOC from Atlantic Water sources. While these results point to inter annual changes in the Fram Strait (von Jackowski et al. 2022), additional data suggest an intra annual (seasonal) succession of prokaryotic microbes that was related to a succession in the biopolymer pool, indicating seasonally distinct metabolic regimes. Data of our long-term sediment-trap programme suggest that over the period 2009–2016 the abundance of *Micromonas polaris* and *Micromonas commoda*-like cells is positively correlated with lower standing stocks of phosphate and nitrate in the upper water-column at the LTER observatory HAUSGARTEN, and that they are exported to the deep sea, despite of their small size (Bachy et al. 2022).

In summary, our data suggest that already now the ecosystem in Fram Strait is subject to profound changes, likely induced by changing climate conditions, which warrants further, sustained observation.

Objectives

The effects of changes on the polar plankton ecology and biogeochemical processes can only be detected through a combination of dedicated interdisciplinary process studies and long-term observations, as implemented by PEBCAO within the HAUSGARTEN/FRAM observatory for more than a decade. Overall, the overarching objectives of PEBCAO are to improve the mechanistic understanding of biogeochemical and microbiological feedback processes in the changing Arctic Ocean, to document ongoing and long-term changes in the biotic and abiotic environment, and to assess the potential future consequences of these changes for ecosystem functioning. In particular we aim to identify climate-induced changes in the biodiversity of pelagic ecosystems and, concomitantly, in carbon cycling and sequestering, and improve our mechanistic understanding of linkages between key environmental parameters and ecosystem functionality in the Arctic Ocean. The objectives are addressed in an interdisciplinary approach. In this context, the current expedition is contributing specifically to the question of how sea ice coverage over different geographical scales affects the composition of plankton and the associated ecological processes.

Primary production is expected to increase in the changing Arctic Ocean, however, it is currently unclear if this will lead to increased export of particulate organic carbon or if organic carbon will remain at the surface, fueling heterotrophic bacteria. Heterotrophic bacteria play a vital role in global biogeochemical cycles. To improve our understanding of bacterial activity, we will determine bacterial abundance, biodiversity and bacterial production. By linking compound dynamics with rate measurements and community structure, we will gain further insights into the flow of carbon through the Arctic food web. To address the effects of global change on microbial biogeochemistry in the Arctic Ocean, we will also continue to monitor concentrations of organic carbon, nitrogen, and phosphorus, as well as specific compounds like amino acids, carbohydrates, and gel particles. To assess cell abundances, we will sample for microscopic counts and flow cytometry that allows us to determine phytoplankton (< 50 µm), bacteria, and viral abundances. Phytoplankton primary production will be determined by radioisotopes (via 3H leucine-incorporation) and distinguished into particulate primary production (carbon remaining in the cells) and dissolved primary production (organic carbon subsequently released by cells). In addition, active fluorometry will be applied with using a LabSTAF instrument running in underway mode to determine phytoplankton fitness and productivity.

In order to investigate the effects of global change and anthropogenic pollution on the microbial community and biogeochemistry in the Arctic Ocean, we will continue to monitor the concentrations of organic carbon and nitrogen, amino acids, lipids, carbohydrates, and gel particles, and we will assess abundances of phytoplankton, bacteria and viruses.

We expect that the small algae at the base of the food web gain importance in mediating elemental and biomass turnover as well as energy fluxes in Arctic pelagic systems. In order to detect changes in smaller plankton size fractions, traditional microscopy will be complemented by optical (see below) and molecular methods that are independent of cell-size and morphological features, and we will determine their contribution to Chl-a biomass. Changes in Eukaryotic microbial communities are tightly linked to prokaryotic community composition. The assessment of the biodiversity and biogeography of Arctic Eukaryotic microbes, including phytoplankton and their linkages to prokaryotic microbial communities, will be based on analyses of eDNA via 16S and 18S meta-barcoding, and quantitative PCR. A suite of automated sampling devices in addition to classical sampling via Niskin bottles attached to a CTD/Rosette Water Sampler will be used to collect samples for eDNA analyses. This includes the automated filtration device AUTOFIM deployed on RV Polarstern for underway filtration, automated Remote Access water Samplers (RAS) and long-term sediment traps deployed on the FRAM moorings for year-round sampling.

Similarly to the phytoplankton community, the zooplankton community may change due to the increasing inflow of warmer Atlantic water into the Fram Strait. Altered zooplankton trophic interactions and community compositions will have consequences for the carbon sequestration and flux. Most of our knowledge on zooplankton species composition and distribution has been derived from traditional multiple net samplers, which integrate depth intervals of up to several hundred meters. Nowadays, optical systems, such as the zooplankton recorder LOKI (Light frame On-sight Key species Investigations), continuously take pictures of the organisms during vertical casts. Linked to each picture, hydrographical parameters are being recorded, i.e. salinity, temperature, oxygen concentration, and fluorescence. This allows us to exactly identify distribution patterns of key taxa in relation to environmental conditions. We will also use the UVPv5 (Underwater Vision Profiler), which is mounted on the ship´s CTD to also tackle zooplankton distribution patterns, albeit with much less taxonomic resolution than with LOKI.

Moreover, we will also include research dedicated to protistan parasites. These are severely understudied in the marine realm although they are likely to affect the population dynamics of phytoplankton (including bloom timing and magnitude) and zooplankton. We will therefore conduct a baseline study of the diversity of different parasite groups and their association with potential hosts. This investigation will also form the basis for future biogeographic studies. The analyses will combine different microscopy techniques (LM, SEM, CFLM) as well as molecular data, the latter facilitating observation of parasitism even at times where easily discernible parasite life-cycle stages are absent. Furthermore, we will conduct zooplankton grazing experimets with phytoplankton, their parasites and saprotrophic fungi, to investigate trophic tranfer and feeding preferences.

In summary, during PS148 PEBCAO is addressing the following objectives:

- Monitoring biogeochemical parameters
- Determine autotrophic and heterotrophic microbial activities
- Monitoring plankton species composition and biomass distribution
- Assessing the flux of particulate organic matter to the seafloor
- Investigating selected phyto- and zooplankton (including their parasites)
- Determining the composition of organic matter and gel particles
- Studying host-parasite systems in phytoplankton

Work at sea

Microbial communities and biogeochemistry

In order to investigate the effects of global change and anthropogenic pollution on the microbial community and biogeochemistry in the Arctic Ocean, we will continue to monitor the concentrations of organic carbon and nitrogen as well as specific compounds such as amino acids, lipids, carbohydrates, and gel particles. Furthermore, we will continue to assess cell abundances via flow cytometry to determine the distribution of phytoplankton, bacteria and viruses.

All parameters will be sampled from the water column using a CTD/rosette sampler at 5-6 depths in the upper 200 m. At selected stations amino acids, carbohydrates, and gel particles will be sampled at 5 additional depth between 200 m and the sea floor to further investigate the export of carbon into the deep sea. Those samples will be preserved or frozen at 4°C, -20°C or -80°C and analysed in the laboratory at GEOMAR. We will address the following parameters:

- Dissolved organic carbon (DOC)
- Total dissolved nitrogen (TDN)
- Total alkalinity (TA)
- Transparent exopolymer particles (TEP)
- Coomassie-stainable particles (CSP)
- Dissolved combined carbohydrates (dCCHO)
- Hydrolysable amino acids (dHAA)
- Phytoplankton, bacterial and viral abundance

Additionally, bacterial and primary production measurements will be performed at sea using ^{3}H leucine and ^{14}C bicarbonate incorporation, respectively. Phytoplankton primary production will be distinguished into particulate primary production (carbon remaining in the cells) and dissolved primary production (organic carbon exudation by cells). To investigate photosynthetic processes in more detail, we will connect a LabSTAF instrument that automatically exchanges the sample and acquires fluorescence light curves (FLCs) in approximately 20-minute intervals to the continuous underway seawater supply.

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

We will collect particles for eDNA analyses of the microbial communities close to the surface (~ 10 m) with the automated filtration system for marine microbes AUTOFIM (Fig. 3.1.) and at 5-6 different depth in the photic zone using Niskin-bottles mounted on a CTD rosette. Using AUTOFIM, we will collect seawater samples at regular intervals (~ 1° longitude/latitude on the way to the study area starting as soon as possible after *Polarstern* has left Bremerhaven), while the CTD will be deployed at the permanent stations of the HAUSGARTEN observatory.

Along two transects from the open water into heavily ice-covered areas, samples for eDNA analyses will be taken in parallel to high-resolution measurements of physical and chemical parameters, as well as the composition and biomass of the phytoplankton, whose 18S DNA will already be sequenced on board using a MinION. The sequence data will be used to identify areas in which vertical profiles of the transects are to be generated at selected stations. In addtition to the pelagic sampling, we will collect sea-ice samples for eDNA analyses and quantification of Chla biomass.

Fig. 3.1: The fully automated filtration module AUTOFIM is installed on RV Polarstern in the "Bugstrahlruderraum" close to the inflow of the ships-pump system. AUTOFIM is suitable for collecting samples with a maximum volume of 5 Liters. Filtration can be triggered on-demand or after fixed intervals. PHOTO: Katja Metfies

From the Niskin bottles, we will also sample for measuring the following parameters to asses biogeochemistry and biomasses:

- Chlorophyll a concentration
- Phytoplankton pigments and major groups (HPLC)
- Absorption by phytoplankton, non-algal particles and colored dissolved organic matter (CDOM)
- Particulate organic carbon and nitrogen (POC, PON)

Phytoplankton analyses and cultivation work

At all stations samples from 4-5 depths (surface, 10, above chlorophyll maximum, chlorophyll maximum and below the chlorophyll maximum) wil be collected from the CTD Rosette and fixed in Formalin (for overall diversity) as well as Lugol iodine solution (for detailed assessments of fungal particles and microzooplankton') respectively. As part of the BMBF project INDIFUN-AI these samples will be analysed post-cruise in Bremerhaven using a Planktoscope, a modular device for the high-throughput analysis of phytoplankton samples. For quality control purposes, selected samples will also be analysed using inverted microscopy.

In addition, net samples (20 µm mesh size) will be collected at all stations for later analysis in the home laboratory. Like the CTD samples these will be analysed by planktoscope but aliquots of the samples will also be prepared for scanning electron microscopy. At 15 stations, 2 l of water from the CTD Rosette will be collected for molecular analyses to specifically target fungal and parasitic (especially oomycete) diversity.

Zooplankton sampling and optical surveys

We will study the zooplankton biodiversity and biogeography by deploying a multi net (type Midi, Hydrobios, Kiel) equipped with five nets (150µm meshes). These net samples will be immediately preserved in 4 % formalin, buffered with hexamethylene-tetramin, and later the mesozooplankton composition, biomass, size structure and depth distribution will be determined using the lab-based ZooScan system (Cornils et al. 2022). Standard sampling depths are 1,500–1,000–500–200–50 m. To determine the fine scale vertical distribution of key species, we will use the optical system LOKI, continuously imaging organisms and particles at a frame rate of approx. 20 f sec^{-1} during casts from 1,000 m to the surface. At each CTD station, we will deploy the UVPv5, also taking images of particles and zooplankton but at less optical resolution than LOKI. However, this allows to get a better spatial distribution of zooplankton abundances in the entire HAUSGARTEN area.

Flux measurements and sampling of settling aggregates

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. 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 200 m above the seafloor. In addition to moored sediment traps, 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 remote access water samplers (RAS) that are programmed to collect and preserve water samples (~0.5 L). Besides sediment traps and RAS, the moorings are equipped with current meters, self-recording CTD's, and a suite of biogeochemical sensors. During the PS155 *Polarstern* expedition we will recover instruments deployed during ther PS148 expedition. The BioOptical Platform (BOP) currently deployed in Fram Strait will be recovered and a new one will be deployed to measure size-specific settling velocities of individual particles in relation to their type and composition throughout a whole year. The system has been an integral part of the HAUSGARTEN mooring-array since 2015.

Grazing Experiments with Calanus spp. and diatoms, parasites

We will verify experimentally the links in the food web between diatoms, their parasites with zooplankton, though grazing experiments with Calanus spp. on board of Polarstern. The copepods will be collected with a WP2 net. To alanyze the trophic transfer and feeding preferences, different feeding treatments will be conducted. We will analyze grazing rates, fecal pellets and biochemicial composition of copepods and the fecal pellets, analyzing C:N ratio, lipidomics and POC composition. The biochemical analysis will be later performed at GEOMAR and at the University of Bremen, while grazing rates and fecal pellet microscopy will be conduced on Polarstern using the Planktoscope and an inverted microscope. The experimets will be performed on a plankton wheel in a cold container.

Expected results

Results from pelagic and sea-ice studies are expected to provide a better understanding of i) the variability and biodiversity of pelagic and sea-ice associated biomass with respect to environmental conditions, ii) trophic pathways of microbial biomass, iii) linkages between plankton community composition or biomass and biogeochemistry. The results will be published in peer reviewed scientific journals and data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data. Analysis of BOP and SWIPS-Particle-Camera is quite time consuming and will therefore be done in the home laboratories at AWI and MARUM.

Data management

During our cruises, we sample a large variety of interrelated parameters. Many of the samples (i.e. Chl-a, 16S/18S eDNA, phytoplankton and zooplankton biodiversity etc.) will be analyzed at AWI or GEOMAR within approximately one year after the cruise. We plan that the full data set will be available at the latest about two years after the cruise. Samples taken for microscopical and molecular analyses, which cannot be analyzed within two years after the cruise, will be stored at the AWI for at least ten years and available upon request to other scientists. Data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied. Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration

The expedition will be supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 6, Subtopic 6.1 and Subtopic 6.3.

In all publications based on this expedition, the Grant No. AWI_PS155_02 will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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4. PHYSICAL OCEANOGRAPHY AND PHYTOOPTICS

Wilken-Jon von Appen[1], Jacob Allerholt[1], Ina Schmidt[1], Nils Müller[1,3], Ida Schatz[2], Katharina Kistrup[3]

[1]DE.AWI
[2]DE.UNI-Heidelberg
[3]DE.UNI-Bremen

Not on board: Rebecca McPherson[1], Astrid Bracher[1,3], Hongyan Xi[1], Norbert Frank[2]

* Wilken-jon.von.appen@awi.de

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Objectives

The physical conditions that lead to enhanced primary and export production in the Arctic Ocean remain unclear. With both, rapid increases in ocean temperatures amplified in the Arctic region and sea ice retreat of the past two decades, the connection between these physical changes and the effect on polar marine ecosystem only increases in importance.

The intermittent presence of sea ice and meltwater affects both the physical and biochemical vertical structure of the water column but also limits *in situ* observations to summer months when the ice has retreated. The effects of changes in the environmental conditions on the polar marine biodiversity can only be detected through long-term observation of the species and processes. The FRAM multidisciplinary observatory attempts to observe the coupling across the system atmosphere, upper ocean, pelagic, and benthic environments.

The monitoring program of the Atlantic Water (AW) inflow into the Arctic via the West Spitsbergen Current (WSC) started in 1997. PS155 will contribute to maintaining this long-standing time series observatory, as the AW inflow conditions drive the changing physical (and also biogeochemical and biological) properties of the Arctic Ocean.

The Frontiers in Arctic Marine Monitoring (FRAM) Helmholtz infrastructure initiative has increased the ability to observe the temporal evolution of the coupled physical-chemical-biological system in the upper water column and troughout the water column to the sea floor. Continuing these interdisciplinary time series will allow for the evaluation of interannual variations in addition to shorter term interactions on submesoscale to seasonal timescales. Two main multidisciplinary time series locations are pursued in the framework of FRAM and its continuation: F4 site at 1,000 m water depth in the inflowing Atlantic Water boundary current (West Spitsbergen Current) and EG4 site at 1,000 m water depth in the outflowing Polar Water boundary current (East Greenland Current). By clearly being embedded in very different water masses representing end points of Arctic conditions, they will allow for a better prediction of what is to be expected in the Arctic Ocean.

Submesoscale dynamics take place on horizontal scales of <1km to a few km in Fram Strait. They are a key process that achieves the subduction of Atlantic Water below Polar Water as the Atlantic Water recirulates in Fram Strait. However, the temporal statistics of the submesocale are still unknown.

Our study also aims to understand the complex physical-chemical-biological interactions that control biogeochemical cycling and ecosystem functioning. Marine phytoplankton is the basis of the marine food web and also a main component of biogeochemical fluxes, thus, an important source of dissolved and particulate organic substances, including volatile organic substances (e.g. DMS, isoprene, halocarbons). The contribution of the Phytooptics group is the acquisition of highly resolved information on the amount and composition of phytoplankton and its pigments, dissolved organic matter and particles along the cruise transect. These data enable via the complementation to satellite and previous field data acquisition the analysis of long-term trends of these parameters in the Fram Strait region. The analysis of our 2015-2024 high resolution optical data set in Fram Strait resolves the spring to summer phenology and the interannual variability of phytoplankton dynamics along the different water masses and regions in the Fram Strait (Bracher et al. 2026). It shows that sea-ice conditions allowing the MIZ forming earlier as opposed to later in spring, alter the composition of the Fram Strait spring blooms, with shifting from a medium contribution of diatoms to a very highly diatom-dominated phytoplankton composition. The data set also showed that the multi-year warm and cold AW temperature anomalies identified in the WSC are also linked to our observed variability of phytoplankton abundance and composition in our data sampled during mid-summer data. The measurements taken during PS155 will clarify if these responses to sea temperature anomalies and sea-ice properties ae similarly identified in 2026.

During this expedition, continuous measurements with optical sensors will be taken at the surface water and also at discrete stations with the light profiler. With that as much as possible collocated data to ocean color sensors OLCI data (launched in February 2016 and April 2018, respectively, on Sentinel-3A and -3B) shall be acquired for validation. The Phytooptics group is within the Sentinel-3 Validation Team. In addition to that, these in-situ data are important for the validation of the group's own satellite products on phytoplankton composition and its distribution (EOF-PFT Xi et al. 2020, 2021, 2023, 2025; PhytoDOAS Bracher et al. 2009; Sadeghi et al. 2012) and spectral attenuation of underwater light (Dinter et al. 2015; Oelker et al. 2019; Oelker et al. 2022). The continuous surface and profile biooptical data are regularly calibrated with measurements at discrete water samples determining the phytoplankton pigment composition using the HPLC method and the optical properties using spectrophotometric instrumentation.

The Phytooptics group will focus on the continuation of our high-resolution time series data on phytoplankton, particulate and chromophoric dissolved organic matter (CDOM) abundance and composition by taking optical measurements which directly give information on inherent and apparent optical properties (IOPs, and AOPs, respectively). Optical measurements will be acquired continuously. We will determine the phytoplankton overall (Total) and group specific Chlorophyll *a* (Chla) concentration as well as the concentration of other pigments, but also the absorption by other particles and coloured dissolved organic matter. This large data set will be combined with ocean color satellite data to upscale the station-based information on linkages between the various trophic layers and biogeochemical cycling. Further, these data will be used for validating several ocean color satellite products (e.g., Oelker et al. 2022; Xi et al. 2021; Bracher et al. 2009; Bracher et al. 2025).

The Phytooptics group's specific objectives for PS155 are to

- collect a highly spatially and temporally resolved data set on phytoplankton (total and composition) and its degradation products at the surface and for the full euphotic zone using continuous optical observations during the cruise and from ocean colour remote sensing calibrated with discrete water sample measurements,
- develop and validate (global and regional) algorithms and associated radiative transfer models in accordance to the previous objective by using discrete water samples for pigment analysis and absorption measurement,
- obtain a big data set for ground-truthing ocean color satellite data, specifically from the PACE, EnMAP, Sentinel-3 (A and B) OLCI and the Sentinel-5-Precursor TROPOMI sensors,
- obtain a spectral characterisation of the underwater light field and its interplay with optical constituents, such as phytoplankton and CDOM abundance and composition.

The motivation to the natural U isotopes and radiocarbon in across the FRAM Straight (“FRAMU”) is to understand the influence and transformation of Arctic-sourced waters as those exit through Fram Strait into the Nordic Sea modulating potentially Atlantic Ocean properties.

The project aims to apply radiocarbon and uranium isotopes to investigate ventilation, freshwater fluxes, and sediment-water exchange processes in Fram Strait and its unique bathymetric feature, Molloy Deep. Here we will study the dynamics of radiocarbon and uranium-isotopes across Fram Strait and in particular within Molloy deep. We intend to test the export of freshwater across the mid-depth layers and the transformation and aging of carbon within the organic matter depocenter of Molloy deep, including a study on isotope exchange processes in the isolated bottom water sediment interface. In fact, we want to establish a first flux balance of advective and diffusive (benthic) carbon cycling at the Atlantic - Arctic interface. Given that the Arctic Ocean is a major input region of freshwater, we want to further establish the idea to explore natural uranium-isotopes as measures of continental runoff.

During PS155 we will thus apply combined carbon – isotope and trace element water sampling using small volumes of 150 ml of frozen water in foil bags.

Work at sea

CTD/Rosette Water Sampler

The CTD rosette will be deployed at all mooring sites and at the standard HAUSGARTEN stations. The CTD will be equipped with dual temperature, conductivity, and oxygen sensors as well as single chlorophyll fluorescence, transmissivity, CDOM, and PAR sensors. We will also attach SBE37 microcats and SBE56 temperature loggers to the rosette for a few casts to perform in-situ sensor calibration casts.

Mooring recoveries and deployments

As listed in Table 4.1, we will recover 9 oceanographic moorings and deploy 9 moorings. These moorings generally contain observations for water temperature and salinity as well as current velocity. Additionally, some also target sea ice properties and biogeochemical/biological parameters. The upper ocean physical-biological cluster at F4 has an instrument setup similar to what has been used at HG-IV and F4 in eastern Fram Strait since 2016 (e.g. PS99.2/PS107/PS114/PS121/PS126/PS131/PS136/PS143.2). A mooring also includes a winch (F4-W) to measure profiles in the top 100 m of the water column. At F4 we only recover a mooring (F4-H-1) which together with moorings F4-22 and F4-S-9 forms an equilateral triangle with 1,400 m side length. Horizontal velocity and temperature/salinity are measured at all three moorings between 50 m and 250 m depth. This will allow the calculation of horizontal velocity and buoyancy gradients at the submesoscale. It will provide the first year-round measurements of these submesoscale quantities in a high latitude boundary current.

Tab. 4.1: List of planned mooring operations

Name	Longitude			Latitude			Depth	Top	Deployment time UTC					Deployment station
	Degrees	Minutes		Degrees	Minutes		Meters	Meters	Year	Month	Day	Hour	Minute	
Recoveries														
F2-22	8	19.88	E	79	0.03	N	773	23	2024	7	19	8	7	PS143_2_016_01
F3-21	7	59.74	E	79	0.13	N	1061	43	2024	7	19	14	15	PS143_2_017_02
F4-22	7	0.04	E	79	0.01	N	1197	47	2024	7	17	13	38	PS143_2_009_01
F4-H-1	7	4.05	E	79	0.02	N	1221	38	2024	7	17	9	39	PS143_2_008_01
F5-21	5	40.03	E	79	0.01	N	2068	44	2024	7	30	15	46	PS143_2_061_02
F4-S-9	7	2.08	E	79	0.70	N	1237	15	2025	6	23	13	38	PS148_029_02
F4-W-6	6	58.05	E	79	0.70	N	1223	131	2025	6	23	15	21	PS148_029_03
HG-IV-FEVI-50	4	19.90	E	78	59.99	N	2542	43	2025	6	9	11	11	PS148_008_02
HG-EGC-11	5	27.95	W	79	3.02	N	1030	55	2025	6	16	14	20	PS148_018_04
LT-Lander-2025	4	13.56	E	79	1.90	N	2534	2532	2025	6	24	22	49	PS148_033_02
Deployments														
F2-23	8	19.88	E	79	0.03	N	773	23	2026					
F3-22	7	59.74	E	79	0.13	N	1061	43	2026					
F4-23	7	0.04	E	79	0.01	N	1197	47	2026					
F5-22	5	40.03	E	79	0.01	N	2068	44	2026					
F4-S-10	7	2.08	E	79	0.70	N	1237	15	2026					
F4-W-7	6	58.05	E	79	0.70	N	1223	131	2026					
HG-IV-FEVI-52	4	19.90	E	78	59.99	N	2542	43	2026					
HG-EGC-12	5	27.95	W	79	3.02	N	1030	55	2026					
FH-W-1	4	31.36	E	79	44.48	N	2684	131	2026					
LT-Lander-2026	4	13.56	E	79	1.90	N	2534	2532	2026					

Underway temperature/salinity/velocity

Throughout the cruise we will operate the underway thermosalinograph to get surface ocean hydrographic properties and we will operate the 150kHz RDI OceanSurveyor vessel mounted ADCP.

Bio-optical measurements

Active and passive bio-optical measurements for the survey of the underwater light field, specific light attenuation, particle and phytoplankton composition and distribution, shall be performed continuously on the surface water but also in the profile during daily CTD stations:

a) Continuous measurements of inherent optical properties (IOPs) with a hyperspectral spectrophotometer: For the continuous underway surface sampling an *in-situ*–spectrophotometer (ACS; Seabird) 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. A flow-control with a time-programmed filter is mounted to the ACS 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. The ACS needs to be operated on the seawater supply at the Nasslabor-1, with seawater pumped at Kastenkiel via Spargel with the membrane pump through the Teflon tubing in order to deliver living phytoplankton cells continuously throughout the cruise, also within the ice.

b) Optical profiler: a second ACS instrument is mounted on a steel frame together with a depth sensor and a set of hyperspectral radiometers (Ramses sensors from TRIOS) and operated during CTD stations. The frame is lowered down to maximal 150 m with a continuous speed of 0.1 m/s or during daylight with additionally stops at 5, 10, 15, 20, 25 and 30 m to allow a better collection of radiometric data (see later). The Apparent Optical Properties of water (AOPs) (surface reflectance (RRS) and light attenuation through the water column) will be estimated based on downwelling and upwelling irradiance measurements in the surface water profile (down to the 0.1% light depth) from the radiometers calibrated for the incident sunlight with measurements of a radiometer on deck. The ACS will measure the inherent optical properties (IOPs: total attenuation, scattering and absorption) in the water profile.

c) During the measurements of the optical profiler we will additionaly measure the RRS when the sea is calm using a high spectral resolution (1.5 nm) self configurated hand-held above water radiometer system (Ocean Optics Sensor System, OOSS) operated from the backend of the ship. The OOSS has been developed by the group of Dr. Peter Gege (DLR-Oberpfaffenhofen) and re-build by AWI Phytooptics Group based on a cooperation contract with DLR: The instrument is configured on a gimbal with three spectrometers (Ocean Optics STS-VIS, 350-810 nm, 1.5 nm spectral resolution), 7A-DA Direct-attach Collimating Lens for the upwelling and sky radiance measurements, CC_attach Cosine Corrector for the sunlight irradiance measurements (all from Ocean Optics, USA: https://www.oceaninsight.com), a motor enabling the coordinated alternation of the spectrometers into the different observation geometres, a laser guaranteeing the correct position of the spektrometers at measurement and a GoPro camera enabling the documentation of measurement conditions. The spectrometer measurements are steered via a python-based software using a raspberry computer sending data via wifi to the steering computer. Calibration of the system was done at the beginning of each station measuring the dark signal using a shutter and measurement against a refelxtion standard.

d) Discrete measurements of IOPs (absorption) at water samples are performed 1) for samples from the underway surface sampling (as for the ACS flow-through system at from the ship's sea water pump) at an interval of 3 hours, and 2) for samples from the CTD station water sampling at 5 depths within the top 100 m. 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) following Lefering et al. (2017). 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 following Röttgers et al. (2016).

e) Samples for determination of phytoplankton pigment concentrations and composition are taken at a 3-hourly interval from the underway-sampling system, and from 5 depths (max. 100 m) at CTD-stations. These water samples are filtered on board immediately after sampling and the filters are thermally shocked in liquid nitrogen. Samples are stored at -80°C until ship is back in Bremerhaven. Then, the samples will be analyzed within the next three months by High Performance Liquid Chromatography Technique (HPLC) at AWI following Taylor et al. (2011) adapted to our new instrumentation as described in Álvarez et al. (2022).

f) Water samplers are collected from the ship intake system in the wet lab using 1-L PP bottle and 1-L glass bottle for the determination of different chemical groups. All water samples are stored at 0°C cooling room.

g) Continous radiometric measurements without sun glint and platform shading later on processed to RRS are taken with the Solar-Tracking Radiometry Platform (So Rad, Simis, S.G.H. (2023) to maintain optimal viewing angles of the radiance and irradiance sensors (RAMSES, Trios). The platform is installed at the monkey deck and operated along the whole ship-track with triggering of sensors only happening when optimal measuring conditions are met. Data are uploaded and stored automatically when a data connection is available. This system includes downwelling irradiance and radiance measurements and upwelling radiance measurements finally processed to RRS data which are then used to validate satellite products.

FRAMU activites

Small volume water sampling, assisting in physical oceanography observations, testing the storage conditions of frozen samples.

a) Collect water in depth profiles across Fram Strait and possibly through other remotely operating vehicles (AUV, ROV). The key will be to obtain depth profiles of the radioactive tracers, which span the physical differences of water masses and water mass boundaries and with Molloy Deep, water as close as possible to the sediment - water interface. Small volume seawater sampling from Niskin bottles through (and without) a filter system directly into a foil bag for subsequent freezing and storage.

b) To test the impact of melting and refreezing we will conduct experiment along the cruise with replicated samples. A total of solely 150 ml of water will be sampled for radiocarbon and geochemical (uranium-isotope) analysis but will allow for stable carbon isotope and general trace element analysis also. We will take several larger volume samples 1 liter to explore the possibility to study other rarer isotope systems such as ^{230}Th and neodymium isotopes.

c) Assist in the CTD casts to subsequently decide the sampling depth (10 - 15 samples per profile) for radiocarbon and uranium - isotope analysis.

Preliminary (expected) results

Directly on board we aim to process the continuous optical measurements to final IOP and AOP products and analyse the discrete water measurements of particle, phytoplankton and CDOM absorption which should be completed by the end of the expedition. These data will elucidate the distribution of phytoplankton, particles and CDOM at the surface along the cruise transect and in the vertical for the sampled stations. The phytoplankton pigment composition and their concentrations will be determined back in the home laboratory where also the sensor data will be further processed to obtain quality control hyperspectral particulate and CDOM absorption, reflectance, diffuse attenuation and transmission data. Thereafter, these data will be used using semi-analytical techniques to determine the spectrally resolved underwater light attenuation and the distribution of phytoplankton total and groups' biomass, CDOM and non-algal particles.

Data management

All sensor data, including quality controlled optical and pigment sampled during this expedition and further processed to geophysical quantities, will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

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In all publications based on this expedition, the **Grant No. AWI_ PS155_03** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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5. PELAGIC BIOGEOCHEMISTRY: NUTRIENTS

Sofia Kuzmina[1], Daniel Scholz[1], Sinhué Torres-Valdés[1]*
* sinhue.torres-valdes@awi.de

[1]DE.AWI

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Objectives

Within the frame of the Frontiers in Arctic Marine Monitoring (FRAM) Project, in 2018 (PS114) we started an observational program on nutrient (mostly) and carbon dynamics in the Arctic Ocean, with annual visits to Fram Strait and surveys elsewhere in the Arctic Ocean (e.g., Central Arctic, Northeast Grenlang). Our overarching goal is to infer and assess ocean-basin scale biogeochemical processes via the interpretation of high-quality biogeochemical data, as obtained from ship-based observations and moored instrumentation. In Fram Strait our aims are: 1) to quantify and understand nutrient and carbon variability in inflowing and outflowing waters to/from the Arctic Ocean within the context of the Arctic Nutrient Budget, and, 2) to contribute to the wider goals of the FRAM/HAUSGARTEN scientific community with regard to long-temr observations of the Arctic System, through a multidisciplinary approach. Additionally, we aim to continue the AWI commitments to ICOS (Integrated Carbon Observation System), at its HAUSGARTEN ICOS Station.

Work at sea

During PS155, we aim to:

a) collect seawater water samples from CTD-Rosette casts at the highest vertical resolution possible, for the analysis onboard, of dissolved nutrients and dissolved oxygen. Dissolved oxygen data will also be used to calibrate the CTD-O_2 sensor.

b) collect seawter samples from selected stations and depths for later analysis of dissolved inorganic carbon (DIC) and total alkalinity (TA). These are reference samples for quality control of pCO_2 and pH sensor data and part of ICOS data requirements.

c) deploy, in collaboration with colleagues from the Microbial Observatory (Katja Metfies, Christina Bienhold and Mathias Wietz), Physical Oceanography of Polar Oceans (Wilken von-Appen, Jacob Allerholt, Matthias Monsees) and Deep-Sea Ecology and Technology (Normen Lochtofen), four Remote Access Samplers (RAS) in moorings FS-4# and EGC# (where # stands for the consecutive mooring deployment relative to the last deployment). On each mooring, two RAS will be deployed close to the surface (~25 to 50 m depending on location) and two at ~250 m. Each RAS deployed close to the surface will be equipped with the following sensors, SUNA nitrate, pH, pCO_2, CTD-O_2, PAR and Eco-triplet (CDOM, backscatter and Chl-a fluorescence) and a battery pack. The RAS deployed at depth will have a similar set up, except PAR and Eco-Triplet sensors. RAS will be programmed to take a sample every two weeks, potentially yielding 48 samples through the year. Upon recovery, a 40 mL aliquot will be withdrawn fromm each RAS sample bag, for the analysis of dissolved nutrients. The remaining 460 mL of sample wil be used for phytoplankton (KM) and bacterial (CB, MW) eDNA extraction.

d) recover two RAS and sensors deployed close to the surface in 2025 during PS148. Subsample RAS bags (40 mL) for the analysis of nutrients.

e) whenever possible, we plan to generate high resolution vertical profiles of Nitrate by deploying a SUNA-nitrate sensor attached to the CTD-Rosette, in casts shllower than 2,000 m.

Preliminary (expected) results

All functioning according to plan, data from dissolved oxygen and nutrients measurements onboard will be fully quality controlled during the expedition and will feed directly into an INSPIRES PhD project. Dissolved oxygen data will be made available to the physical oceanography team for the calibration of the CTD-O_2 sensors. If full quality control is not possible during the expedition, it is expected that final results will be availabl within 6 to 12 months.

Sensor data takes much longer for processing, as first there is the need to process data from discrete samples. However, raw sensor data will be submitted to PANGAEA as soon as it is possible as we have been doing in conjuction with colleagues from the sections Physical Oceanography of Polar Seas, Polar Biological Oceanography and Deep-Sea Ecology and Technology.

DIC and TA samples will be analysed within 6-8 months of sample collection. Once analyses are done data will be processed and quality controlled, and made available as part of the AWI ICOS contribution, likely within 6 months of analyses.

Data management

Dissolved nutrients, dissolved oxygen and and DIC/TA data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de), as soon as data is available and fully quality controlled. A 2-year moratorium will be requested in order to analyse the data for scientific purposes and publishing of results. By default, the CC-BY license will be applied.

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data (e.g., ICOS).

This expedition was supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 6, Subtopic 6.2 and 6.3, Topic 2, Subtopic 2.1.

In all publications based on this expedition, the Grant No. **AWI_PS155_04** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

6. A LONG-TERM OBSERVATORY OF THE NORTH ATLANTIC GATEWAY TO THE ARCTIC (ALONGATE) MEETS FRAM 2026

Carolin Uhlir*[1,2], Katrin Linse[3], Nicole Gatzemeier[1], Lennart-Kilian Wenke[1,4], Ole Lorenzen[1,2];
not on board: Saskia Brix[1,2], Bodil Bluhm[5]
* carolin.uhlir@senckenberg.de

[1]DE.SGN
[2]DE.UHH
[3]UK.BAS
[4]DE.UHB
[5]NO.UiT

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Outline

The region between Norway and Greenland is characterized by a staggering array of geomorphological habitats in a relatively small area, from deep-sea abyssal plains to seamounts, ridges, slopes, canyons and hydrothermal activity (Jöst et al. 2019; Ramirez-Llodra et al. 2010). Iceland sits at the top of an underwater mountain chain (Greenland-Iceland-Scotland Ridge: GIS Ridge), which creates an important oceanographic barrier at the border of the North Atlantic to the Arctic Ocean. Influenced by the inflow of North Atlantic water, this subarctic boundary region demarcates a distinct ecoregion with a unique fauna (Brix et al. 2018a,b, 2022; Pampoulie et al. 2024; Puerta et al. 2020; Uhlir et al. 2021). While a huge amount of biodiversity data is available for this area, the accumulation of data in frequently sampled regions shows clear sampling gaps especially in deep and remote regions (Bluhm et al. 2011; Ramirez-Llodra et al. 2024). The ALONGate North-South transect focuses on the documentation and assessment of macrofaunal biodiversity across temporal and spatial gradients and connects data from previous established projects around Iceland (BIOICE: Benthic Invertebrates of Icelandic waters 1992 - 2004 and IceAGE: Icelandic marine Animals: Genetics and Ecology since 2011). Since 2023, annual Epibenthic Sledge (EBS, Brenke 2005) sampling in the HAUSGARTEN LTER observatory contributed to a fundamental understanding of local species (Brix et al. 2025; Linse et al. 2026; Uhlir et al. 2026), and since 2025, samples collected on the transit from Germany to the Fram Strait fills knowledge gaps to observe faunal community shifts towards northern waters. The annually planned deep-sea benthic lander system recovery and deployment add on an intersection of a North-South transect across the North Atlantic Gateway Area complementing the HAUSGARTEN data obtained on PS136 in 2023 and PS143/1 in 2024.

Objectives

The main objective of ALONGate 2 is to close critical geographic sampling gaps on the latitudinal transect between Iceland (IceAGE stations) and the HAUSGARTEN LTER observatory (Fig. 2.1). Based on the compiled dataset of abiotic (bathymetric assessments, benthic oxygen uptake measurements, sediment samples) and biotic parameters (macrofauna samples, image data), a comprehensive comparision of macro- and megafauna community will contribute to a better understanding of benthic biodiversity and its driving parameters.

The following scientific questions shall be approached:

1. Do the sampled stations along the latitudinal transect (N/S in the North Atlantic Gateway Area) differ regarding the composition and diversity of the studied benthic species?
2. Are distinct faunal communities in terms of taxonomic composition/species diversity/abundances discernible at the different working areas?
3. Are there potential endemic or widely distributed species present?

Work at sea

Benthic sampling is planned at four working areas on the transit from Bremerhaven to the Fram Strait. EBS stations are strategically located between previously successful deployments on PS148 (Dannheim 2025; Fig. 6.1). Gear deployment in each working area on the transect (AG-2,-6,-8) is planned in the following order: a deep CTD to measure conductivity, temperature, chlorophyll concentration, O_2 from the water column, and to act as reference for multibeam mapping via a sound velocity profile; if not already conducted during PS148, Multibeam echo sounders EM710/EM122 (MB) will be performed in each area prior to station work; EBS for sampling of macro-epifauna. At AG-4, a short-term deep-sea profiling lander will be deployed prior to the previously mentioned programm. The long-term lander deployed during PS148 will be recovered, EBS sampling will provide corresponding in-situ samples with a subsequent deployment of a new system in close proximity to the same area for another year. Within HAUSGARTEN, EBS deployments depend on the sea ice extent and will be prioritized between previously sampled northern and eastern stations.

Summarized, each working area is planned to be studied as follows:

- AG-2, -6 and -8: MB mapping, CTD, EBS deployment
- AG-4/-5: Short-term lander deployment, long-term lander recovery, CTD, EBS, long-term lander deployment
- HG stations: CTD, EBS

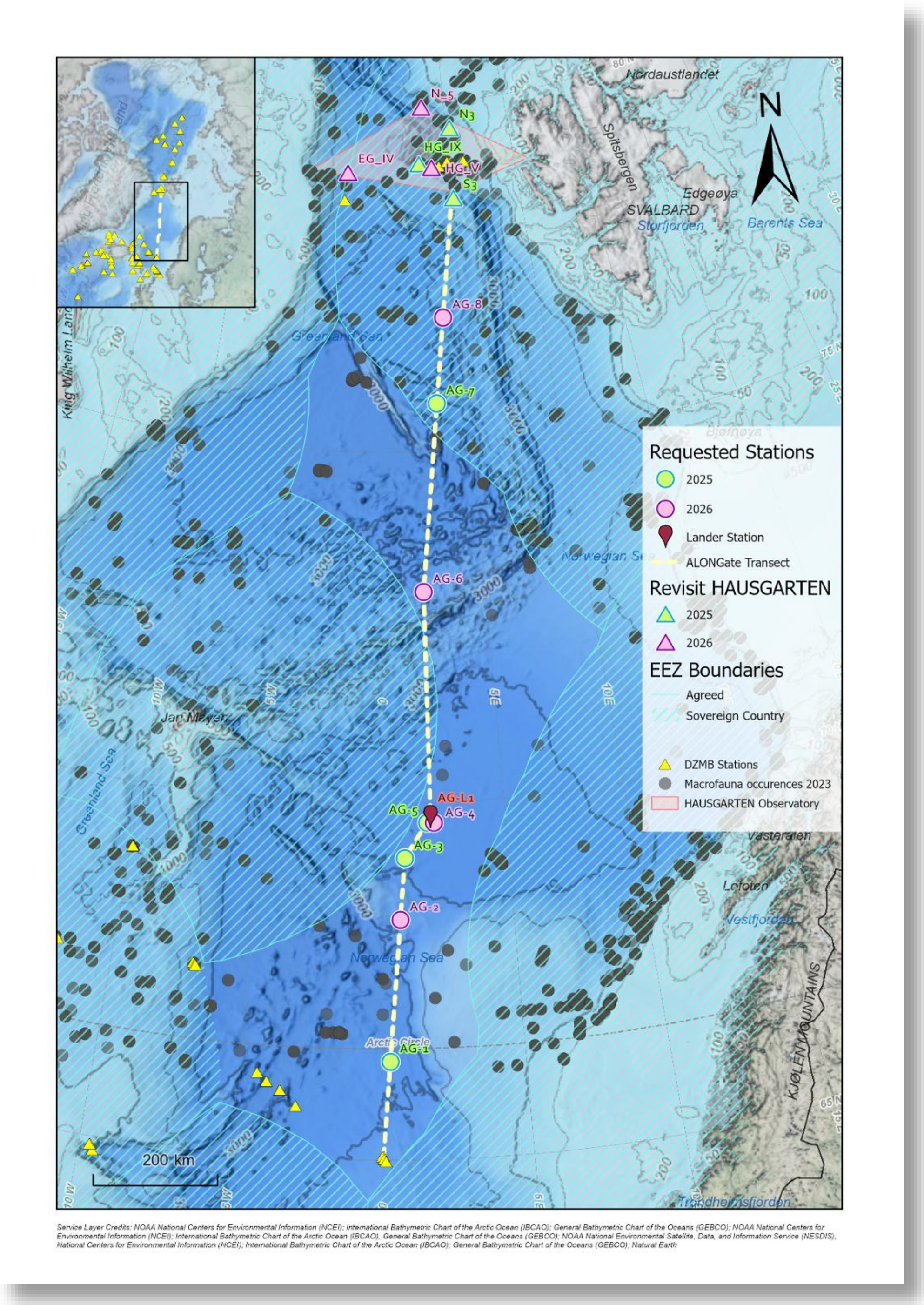

Fig. 6.1: ALONGate meets FRAM: The transect track with working areas planned as a connection between earlier IceAGE stations (yellow triangles) and the previously sampled southernmost HAUSGARTEN station S3 (green triangle). In addition to revisiting the HAUSGARTEN stations sampled 2023–2025 (represented by green triangles), newly established gap-filling stations will be added (represented by circles). Different colors of stations indicate sampling in 2025 (green) and 2026 (purple), respectively. The station AG-L1 (red) will be re-visited for recovery and deployment of the benthic lander system. Background data points (grey) show all so far digitized macrofauna occurrences based on the most recent revised dataset provided by Ramirez-Llodra et al. (2024).

Benthic sampling

Benthic (macro-)fauna will be collected via EBS deployment. Representatives of benthic fauna will be photographed immediately after sampling with a high-resolution photographic system and subsequently, depending on the latter scientific purpose, either fixed in ethanol, formalin, RNA-later or frozen at –80°C. Sediment samples will be sorted as far as possible on board and after the cruise in the laboratories of Senckenberg Society for Nature Research, German Center for Marine Biodiversity Research (DZMB) in Hamburg, Germany.

Preliminary (expected) results

Preliminary results of the first ALONGate leg PS148 in 2025 (Dannheim 2025) showed variing faunal community compositions at each transect station along with oceanographic differences between southern and northern stations. With live sorting of EBS samples on board we will add-on to this existing dataset, document original morphological features of the local macrofauna and give a deeper insight into overall faunal composition from data gap areas. DNA from selected taxa will be extracted on board, which yields the best results for all futher biodiversity studies. Further sorting in home laboratories will give high resolution information on morphological and genetic diversity of the benthic community. Analyses of year-round imagery taken of megafauna by the recovered benthic lander system will give first insights into seasonal community changes in the research area.

Data management

All samples will be stored at the German Center for Marine Biodiversity (DZMB) in Hamburg and Wilhelmshaven. Once all samples are sorted to higher taxa level, groups will be handed over to taxonomic experts for further identification. Molecular DNA and RNA data will be archived, published and disseminated within the publicly accessible repositories GenBank (https://www.ncbi.nlm.nih.gov/genbank/) and BOLD (https://www.boldsystems.org/index.php). After successful identification, records will be uploaded to the Ocean Biodiversity Information System (OBIS, https://obis.org) and the Global Biodiversity Information Facility (GBIF, https://www.gbif.org).

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

In all publications based on this expedition, the **Grant-No. AWI_PS148_05** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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7. THE IMPORTANCE OF THE ULTRA-DEEP OCEAN FOR CARBON AND POLLUTANT CYCLING AS STUDIED IN THE MOLLOY DEEP (FRAM STRAIT): UNDER PRESSURE

Peter Stief*[1], Frank Wenzhöfer[1,2], Leah Brinch-Iversen[1], Carla M. Fischer[3], Niels Peter Jørgensen[1]

not on board: Ronnie N. Glud[1], Mathias Middelboe[3], Karl M. Attard[1], Anna Sobek[4], Emma Kaisa Eklund[4]
* peterstief@biology.sdu.dk

[1]DK.SDU
[2]DE.AWI
[3]DK.KU
[4]SE.SU

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Objectives

Benthic communities are mainly 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 of the exported organic matter is recycled in the pelagic, but a significant fraction ultimately reaches the seabed, where it is either re-mineralized or retained in the sediment record. One of our main questions is to what extent hydrostatic pressure acts as an environmental factor controlling the efficiency of the vertical flux of organic matter by the biological pump and the rate of benthic organic-matter mineralization at ultra-deep sites. Pressure-induced leakage of dissolved organic matter (DOM) from sinking particles may decrease the efficiency of the biological pump (Stief et al. 2026), but the microbial utilization of the released DOM in the deep pelagic remains unknown. Benthic oxygen fluxes provide an integrated measurement of organic-matter mineralization in surface sediments and can thus be used to evaluate the efficiency of the biological pump.

Along with particulate organic matter deposition through sinking particles, persistent organic pollutants (POPs) make it from the ocean surface to the seabed and even into deep-sea trenches (Sobek et al. 2023). For many POP compounds (including forever chemicals PFAS), burial in deep-sea sediments is a globally important removal process. Here, we aim to test the hypothesis that benthic microbial communities at ultra-deep sites, which are characterized by high carbon turnover rates and high species diversity, host a particularly large capacity to degrade POPs.

Many areas of the deep sea are still little explored. Deep-sea (or hadal) trenches, for example, only account for <2% of the global seabed area, but could via sediment focusing act as regionally important but unexplored traps for organic matter and pollutants (Wenzhöfer et al. 2016; Glud et al. 2021; Sobek et al. 2023). Benthic and pelagic mineralization is mainly driven by vast numbers of prokaryotes (bacteria and archaea), with direct or indirect contributions by viruses, fungi, protists, and meiofauna. Currently, even the most basic information on abundance and distribution of prokaryotes, eukaryotes, and viruses in deep-sea and trench ecosystems are missing. We will use the Molloy Deep (5.5 km) as a model area to quantify carbon mineralization efficiency and pollutant degradation potential of ultra-deep sites in comparison with shallow reference sites, identify the key players for organic-matter processing and pollutant degradation, and compare process rates and microbial communities with other deep-sea and trench ecosystems.

Work at sea

Utilization of dissolved organic matter in the ultra-deep pelagic

The extent to which DOM leaking from pressure-exposed marine snow will be utilized by heterotrophic microbes is of critical importance for pelagic carbon sequestration (Dittmar et al. 2021; Stief et al. 2026). Through onboard pressure-tank incubations, the hypothesis will be tested that bacterial utilization of bioavailable DOM is reduced or inhibited at high pressure, which potentially enhances pelagic carbon sequestration as persistent DOM. In parallel, the effect of DOM amendment and pressure exposure on bacterial cell division, total abundance, and community composition will be studied. To this end, seawater collected at 0.1 and 5.5 km depth in the Molloy Deep will be amended with diatom-derived DOM and incubated onboard at the respective *in situ* pressure in pressure tanks. In additional seawater samples collected throughout the whole water column, molecular signatures of DOM will be analyzed that could hint to *in situ* pressure-induced DOM leakage from sinking particles.

Benthic oxygen fluxes

Using state-of-the-art lander technology, we will measure *in situ* benthic oxygen consumption rates within and around the Molloy Deep at different spatial and temporal scales. The data will provide a unique assessment of the regional benthic carbon mineralization rates and fill data gaps in the current global data base. 1) One benthic lander will be equipped with two different profiling instruments to investigate the oxygen penetration and distribution as well as the benthic oxygen uptake of Arctic deep-sea sediments (Hoffmann et al. 2018): a) an electrode-microprofiler for high-resolution porewater profiles (O_2, resistivity) across the sediment-water interface, and b) a deep optode-profiler to measure the entire oxygen penetration depth. 2) For comparison, simultaneous chamber incubations will provide the total oxygen demand of the seabed. 3) Unlike these traditional methods, Aquatic Eddy Covariance (AEC) is non-invasive and measures the turbulent transport of oxygen within the benthic boundary layer from high-frequency flow velocity and oxygen concentration data, covering a larger seabed area (10-100 m^2) compared to chambers (Berg et al. 2007). We will make the first AEC measurements in the Molloy Deep using a newly developed, deep-sea-rated instrument equipped with a particle-seeding module to overcome the challenge of low particle abundance at ultra-deep sites. The site-specific rates of benthic mineralization will be linked to sedimentation rates derived from a moored sediment trap deployed during PS148 in 2025 and to be retrieved during PS155 in 2026.

Benthic carbon mineralization

Sediment will be collected at the Molloy Deep (HG-IX) and a shallow reference station (HG-IV) for organic-matter-enrichment experiments at the University of Southern Denmark. In laboratory experiments, the sediments will be enriched with isotopically labeled particulate organic matter and incubated in an array of pressure tanks at the respective *in situ* pressure. The goals of these experiments are to (i) simulate the deposition of labile particulate organic matter (i.e., marine snow particles) onto ultra-deep and relatively shallow sediment using pressure-tank incubations, (ii) follow the degradation of the added labile organic matter in the respective pressure regime, and (iii) test the hypothesis that the degradation of labile organic matter primes the degradation of recalcitrant organic matter in the sediment.

Role of viruses in pelagic and benthic element cycling

Viruses are key components of marine microbial ecosystems, where they affect prokaryote mortality, diversity and biogeochemical cycling (Middelboe & Brussaard 2017). When bacteriophages infect host cells, they can reprogram microbial metabolism through auxiliary metabolic genes (AMGs), altering energy and nutrient flow (Breitbart et al. 2007). Although increased viral abundance has been documented in hadal trench sediments (Schauberger et al. 2021), their functional role in these environments remains largely unexplored. During PS155, we will characterize viral abundances and community composition in the Molloy Deep and compare them with shallower reference stations, examining both water column and sediment environments. By integrating viral metagenomics, metatranscriptomics, and anoxic incubation experiments, we aim to understand how phage-driven metabolic reprogramming influences carbon, nitrogen, and sulfur cycling in these environments.

Degradation of persistent organic pollutants (POPs)

Sediment will be collected at the Molloy Deep (HG-IX) and shallow reference stations (e.g., HG-IV) for POP enrichment experiments at Stockholm University. The goal of these experiments is to study the long-term degradation of specific POPs in sediments incubated at *in situ* and atmospheric pressure in the presence/absence of oxygen. Thereby the hypothesis is tested that microbial communities characterized by high minerlization rates and high species diversity, like in sediments of deep-sea trenches (Wenzhöfer et al. 2016; Glud et al. 2021), possess a greater potential to degrade POPs than less active microbial communities, like in sediments of abyssal plains. The effect of hydrostatic pressure on POP degradation will be studied in anoxic sediments incubated in an array of pressure tanks. The effect of oxygen on POP degradation rates will be studied in manipulated sediment cores incubated at atmospheric pressure.

Preliminary (expected) results

Preliminary investigations during PS143/1 and PS148 indicate that the Molloy Deep shows similar characteristics as the ultra-deep hadal trench systems with steep flanks, down-slope material transport, intensified deposition, and elevated microbial activity in the central basin as compared to the adjacent deep-sea plains. The expected results will add to our growing database on microbial carbon mineralization in deep-sea (Jørgensen et al. 2022) and hadal settings (Wenzhöfer et al. 2016; Glud et al. 2021) and allow for comparison between hadal environments experiencing different regimes of vertical carbon export. Additionally, a multidisciplinary and quantitative approach will be applied to explore the connection, composition, and structure of benthic communities in the deepest area of the Arctic Ocean using up-to-date methods and technologies. The results will be compared with similar investigations that we have conducted in the eutrophic Atacama Trench and the oligotrophic Kermadec Trench region. This will provide a generic insight on biogeochemical function and community composition in hadal trench and deep-sea regions.

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

This expedition was supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 6, Subtopic 3, and the Center of Excellence “Danish Center for Hadal Research – HADAL (DNRF145)”.

In all publications based on this expedition, the **Grant No. AWI_PS155_06** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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8. FEMMES: FORAMINIFERA ECOLOGY WITH METALS AND MICROBES: AN EVOLUTION OF SYMBIOSIS

Franck Lejzerowicz[1]*, Luzie Mai Gallen[1,2]

not on board: Silvia Hess[1], Inés Barrenechea Angeles[3]
* franckl@uio.no

[1]NO.UiO
[2]DE.FU-BERLIN
[3]NO.UiT

Grant-No. AWI_PS155_08

Outline

Metals in marine environments have essential roles supporting fundamental eco-evolutionary mechanisms at the interface of life and minerals (Giovannelli 2023), but toxic effects at high dose. Metal availability in early oceans allowed for ancient lineages to invent key functions, e.g., hydrogenases (Fontecilla-Camps 2022). Yet, the ecology of metal-dependent biological mechanisms resulting from deep-time evolution is largely unknown in the deep sea, especially in the Arctic where rapid changes may drive shallow-time adaption to shifting metal availability regimes. Melting glaciers at high latitudes (Vives et al. 2025) or retreating sea ice (Jensen et al. 2021) release metals that eventually reach the deep seafloor and form diverse species (Paul et al. 2024). Deep-sea benthic redox processes involving microbe-metal inteactions are well known (Nickel et al. 2008), but not with eukaryotes that appear to be adapted to metals – such as Foraminifera. Foraminifera is a phylum of single-celled eukaryotes that appeared in Archaean oceans (Pawlowski et al. 2003) when a major oxidation event changed trace metals bioavailability (Giovannelli 2023). It can adapt to anoxia (Orsi et al. 2020) with the help of microbes (Woehle et al. 2022). In sulfidic environments, microbial endobionts were observed at the periphery of vacuoles in single-chambered “monothalamous” Foraminifera hosts (Bernhard et al. 2006), but the vacuolar content and the nature of such interaction remain elusive (Bernhard et al. 2018). Monothalamiids are highly diverse in the deep sea and at high latitudes (Gooday et al. 2005, 2022) and adapted to metal pollution (Andreas & Bowser 2023): Psammophaga species accumulate metal-rich minerals such as magnetite in Antarctica (Pawlowski & Majewski 2011) or in the deepest trench (Yang et al. 2022). Benthic foraminifera distribution and morphology can indicate metal contamination (Alve 1991), which they can endure at high concentration (Frontalini et al. 2020), using putative metallothioneins (Frontalini et al. 2015) which are known to sequestrate metals in vacuoles. We aim at deciphering deep-sea Foraminifera-microbiome interactions with metals, to discover early symbiotic mechanisms that may facilitate adaptation and resilience to metal pollution. We will collect diverse live benthic monothalamous foraminifera from deep-sea sediment habitats under ice-free Arctic conditions, and under venting influence at the recently discovered Jøtul fields (Bohrmann et al. 2024). These mechansms will be scrutinized with advanced genomics, microscopy and geochemical analyses, incl. on live cells at the arrival port, Tromsø.

Objectives

The main aim is to understand interactions between benthic foraminifera, microbes and metals to better understand deep-sea ecosystem functioning based on metals. FEMMES will reveal mechanisms for different metal bioavailability regimes: sediment deposits at the Jøtul vent fields, or more reduced under high (this summer expedition) or low (GoNorth winter expedition) carbon expor regimes. The expedition objectives are to deploy the video-guided multiple corer (MUC) to collect deep-sea sediment for multi-omics, chemistry, and live benthic foraminifera:

1. Freeze the raw sediment of 1 core per station for DNA extraction (metagenomics, metabarcoding) and for chemical profiling (untargeted metabolomics, metals),
2. Sort and fix the live deep-sea benthic foraminifera cells of 1 core per station for host-microbiome and phylogenomic characterization using multi-omics and systematics,
3. Sort the live deep-sea benthic foraminifera cells of the last station(s), incl. the Jøtul fields, and maintain them alive until arrival in Tromsø for high-pressure freezing,
4. If possible, collect and fix the raw sediment of 1 core per station for Bengal Rose staining and later species idenification and counting.

Work at sea

We will collect undisturbed deep-sea sediment and live benthic foraminifera cells from every station aross the Arctic Ocean's Fram Strait and Jøtul hydrothermal vent fields using a video-guided multiple corer (MUC). Video guiding will be especially useful in the Jøtul field to find a soft sediment area, reported as most frequent during dives with the remotely operated vehicle MARUM-QUEST 5000 (Bohrmann et al. 2024).

Before core extrusion and sediment subsampling, the sediment surface quality will be carefully investigated. Then, the surface sediment will be photographed with a label and described in a sample metadata information satisfying the MIMARKS standards (Yilmaz et al. 2011). Then, the surface water will be drained from the cores over a 63-µm mesh and residue will be check for living foraminiferans. This water will be kept in glass containers to be used later for sieving and as replacement water in jars containing sediment and live cells.

At each station, a maximum of 3 MUC cores will be subsampled for the following purposes:

- Core 1: Environmental chemistry and omics. Four raw sediment sub-samples of ca. 10 ml each will be taken using a sterile glass spoon, transferred in 20 ml glass containers, and frozen at -80°C. These samples will be used to measure total organic carbon, metal concentrations, grain size analysis, and to capture the diversity of eukaryotes, prokaryotes, and metabolites using metabarcoding, metagenomics, and mass spectrometry analyses, respectively. We will follow procedures relevant to studying ancient DNA (see Armbrecht et al. 2018) and use sterile material (non-plastics where possible, or controls) to detect plastics additives.
- Core 2: Live Foraminifera collection. The top 2 centimeters of surface sediment will be extruded and transferred into a 500 ml glass jar, that will be placed in a cooled water bath (tray half filled with water and ice) and brought to a cool container (ca. 4°C). There, the trained researcher and/or its accompanying MSc student will sieve the sediment through a series of meshes of sizes 500, 250, 125 and 63 µm. Each fraction will be kept in designated, 200 ml glass jars for immediate and continuous sorting. These 200

ml jars will be stored in the cooled container for a maximum of 3 days – depending on sorting efficiency, or until fresh material from the next station is obtained.

- *(If possible)* Core 3: Bengal Rose staining. The top 2 cm of surface sediment will be extruded and transferred to a 180-ml Joni container to which will be added the same volume (1:1) of ethanol-dissolved Bengal Rose (70% ethanol mixing, i.e., 2g starin per litre of ethanol). After careful homogenization, it will be stored at room temperature until futher sorting and analysis in the laboratory at UiO.

Live Foraminifera sorting and collection

The sediment of each size fraction secured in the jars placed in the cooled container will be transferred in small volumes of ca. 20 ml into 12 x 8 cm Foraminifera sorting trays, for manual picking under a stereomicroscope, using needles, tweezers, brushes and pipets. Each sorted specimen will be photographed and fixed for morphological and molecular analysis of both the Foraminifera host and its microbiome. For Foraminifera species detected in high abundance, specimens will be fixed in 4 % formalin under the chemical fume hood for later morphological analyses.

Special treatment for live Foraminifera from the last station(s)

For a sediment core from the last requested station JTL1 in the Jøtul hydrothermal vents field (77.6103, 7.8773; 2,867 m), and from station N3 at the South edge of the Yermak plateau if possible (coordinates 79.5981, 5.1965; 2,772 m), the full 0-2 cm of th core will be kept as undisturbed as possible in the cool contained, and transferred to the Advanced Core Microscopy Facility of the Arctic University of Tromsø (Norway) where the cells will be sorted and cryofixed for biovolume analyses using high-pressure freezing coupled with scanning-electron microscopy).

Preliminary and expected results

We are compelled to testing our metal-based endosymbiosis hypothesis based on the results of preliminary multi-omics analyses (Fig. 8.1).

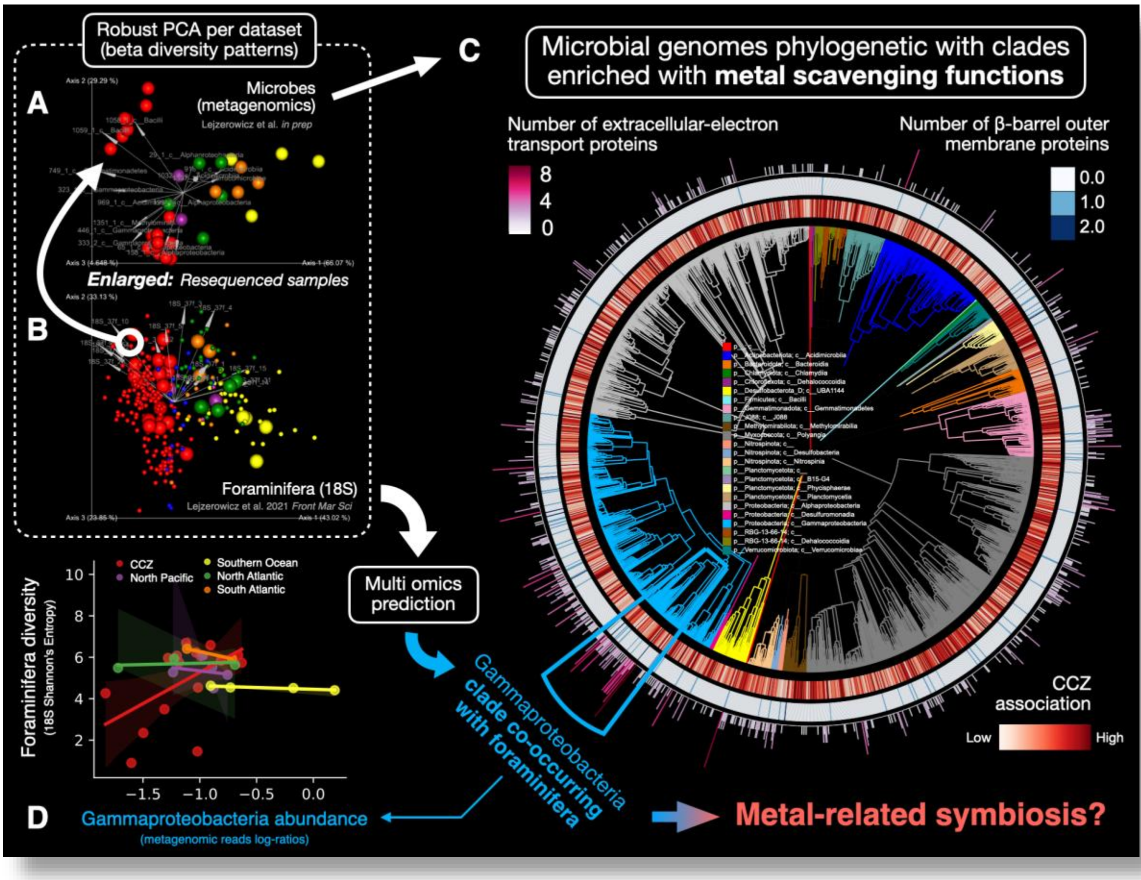

Fig. 8.1. Multi-omics integration suggests that microbes able to scavenge metals determine the diversity of Foraminifera assembled in metal-rich ecosystems. Beta diversity ordinations for microbial metagenome-assembled genomes (A) and for Foraminifera metabarcoding (B) show that metal-rich assemblages are unique. The abundance of a Gammaproteobacteria clade (blue) having genes for metal utilisation (C) and predicted using multi-omics integration (Morton et al. 2019) as most co-occurrent with Foraminifera taxa, correlates with alpha diversity of metal-exposed Foraminifera (D).

We predicted co-occurrences and a relationship between the diversity of foraminifera (from Lejzerowicz et al. 2021) and the abundance of those metagenome-assembled microbial genomes capable of extracellular electron transfer from metal substrates, but only in the metal-rich Clarion-Clipperton Zone sediment. This co-occurrence result based on DNA extracted from sediment samples cannot assert a direct interaction between a Foraminifera host and microbial partners, nor whether metals are involved to support such interaction as symbiosis or commensalism. Hence, this expedition will provide cells onto which to deploy similar multi-omics approaches, combined with advanced microscopy and metabolomics to attempt co-localize microbe and host ultrastructure such as organelles, as well as metals and metabolites. Comparing metagenomes from sediment and cells sorted from this sedment will help understand whether Foraminifera selects microbial partners from its environment or if local geochemistry rather than host species determines these microbiome compositions. The presence of the genomes that we will detect as microbial endobionts will be assessed using shotgun metagenomics on sediment samples collected in the same area (incl. the Jøtul fields) during the precedent winter (GoNorth 2025 expedition), as well as foraminifera cells that will be sampled during the following winter (future GoNorth expedition).

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 6 "Marine and Polar Life", Subtopic 6.2 "Adaptation of marine life: from genes to ecosystems"; Topic 9 "One Healthy Planet – Developing an Exposome Approach to integrate Human and Environmental Assessment", Subtopic 9.2; and Topic 8 "Georesources", Subtopic 8.2 "Raw Material".

In all publications based on this expedition, the **Grant No. AWI_PS155_07** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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APPENDIX

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

Affiliation	Address
DE.AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
DE.DRF	DRF Luftrettung gAG Laval Avenue E312 77836 Rheinmünster Germany
DE.DWD	Deutscher Wetterdienst Seewetteramt Bernhard Nocht Str. 76 20359 Hamburg Germany
DE.FU-BERLIN	FU Berlin Kaiserswerther Str. 16-18 14195 Berlin Germany
DE.GEOMAR	GEOMAR Helmholtz-Zentrum für Ozeanforschung Wischofstr. 1-3 24148 Kiel Germany
DE.NHC	Northern HeliCopter GmbH Gorch-Fock-Str. 103 26721 Emden Germany
DE.SGN	Senckenberg Forschungsinstitut und Naturmuseum Martin-Luther-King-Platz 3 20146 Hamburg Germany
DE.UNI-Bremen	Universität Bremen Leobener Straße, NW2a Otto-Hahn-Allee 1 28359 Bremen Germany
DE.UNI-Heidelberg	Heidelberg University Seminarstr. 2 D-69117 Heidelberg Germany

Affiliation	Address
DK.KU	University of Copenhagen Nørregade 10 DK-1165 Copenhagen K Denmark
DK.SDU	University of Southern Denmark Campusvej 55 5230 Odense Denmark
IT.UNIMIB	University of Milano-Bicocca Piazza della Scienza 1 20126 Milano (MI) Italy
NO.UiO	University of Oslo Boks 1072 Blinden NO-0316 Oslo Norway
SI.NIB	National Institute of Biology Večna pot 121 1000 Ljubljana Slovenia
UK.BAS	British Antarctic Survey Hich Cross CB3 0ET Cambridge United Kingdom
Not on board / Not in the field	
NO.UiT	The Arctic University of Norway Fakturamottak DFØ Postboks 4710 Torgarden 7468 Trondheim Norway
SE.SU	Stockholm University SE-10691 Stockholm Sweden

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
On board				
Autun	Purser	DE.AWI	PhD student	Chemistry
Jacob	Allerholt	DE.AWI	Technician	Oceanography
Melanie	Bergmann	DE.AWI	Scientist	Biology
Jens	Brauer	DE.NHC	Pilot	Helicopter service
Claudia	Brenner	DE.UNI-Bremen	Student	Biology
Leah	Brinch-Iversen	DK.SDU	Scientist	Biology
Leonie	Buchele	DE.AWI	Engineer	Engineering sciences
Michael	Busack	DE.AWI	Engineer	Engineering sciences
Jennifer	Dannheim	DE.AWI	Scientist	Biology
Barbara	Dörmbach	DE.AWI	PhD Student	Biology
Luzie	Gallien	NO.UiO	Student	Biology
Catherine	Garcia	DE.GEOMAR	Scientist	Oceanography
Nicole	Gatzemeier	DE.SNK	Technician	Biology
Jonas	Hagemann	DE.AWI	Engineer	Engineering sciences
Stephan	Hamisch	DE.AWI	PhD Student	Biology
Christiane	Hasemann	DE.AWI	Scientist	Biology
Fereshteh	Hemmateenejad	IT.MIB	PhD Student	Biology
Kangning	Jia	DE.AWI	PhD Student	Biology
Niels	Jørgensen	DK.SDU	Scientist	Biology
Maruša	Kerenčič	SI.NiB	Technician	Biology
Katharina	Kistrup	DE.UNI-Bremen	Student	Oceanography
Tania	Kluever	DE.GEOMAR	Technician	Biology
Nadine	Knüppel	DE:AWI	Technician	Biology
Christian	Konrad	DE.AWI	Engineer	Biology
Sofia	Kuzmina	DE.AWI	PhD Student	Oceanography
Sascha	Lehmenhecker	DE.AWI	Engineer	Engineering sciences

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
Franck	Lejzerowicz	NO.UiO	Scientist	Biology
Katrin	Linse	UK.BAS	Scientist	Biology
Normen	Lochthofen	DE.AWI	Engineering	Engineering sciences
Ole	Lorenzen	DE.UNI-Hamburg	Student	Biology
Janine	Ludszuweit	DE.AWI	Engineering	Engineering sciences
Johannes	Maring	DE.AWI	Engineering	Engineering sciences
Kai	Miehe	DE.DRF	Technician	Helicopter service
Franziska	Möller	DE.AWI	HiWi	Biology
Nils	Müller	DE.AWI	PhD Student	Oceanography
Gabriel	Panter	DE.DRF	Technician	Helicopter service
Carla	Pein	DE.GEOMAR	PhD Student	Biology
Lena	Pflaum	DE.GEOMAR	Student	Chemistry
Joris	Rickert	DE.AWI	Technician	Biology
Ida	Schatz	DE.UNI-Heidenberg	PhD Student	Biology
Ingo	Schewe	DE.AWI	Scientist	Biology
Alex	Schiffer	DE.AWI	Meteorologist	Meteorology
Ina	Schmidt	DE.AWI	Student	Biology
Daniel	Scholz	DE.AWI	Technician	Chemistry
Peter	Stief	DK.SDU	Scientist	Biology
Sinhué	Torres-Valdés	DE.AWI	Scientist	Chemistry
Carolin	Uhlir	DE.SNK	PhD Student	Biology
Wilken-Jon	Von Appen	DE.AWI	Scientist	Physics
Lennart-Kilian	Wenke	DE.UNI-Bremen	Student	Biology
Frank	Wenzhoefer	DE.AWI	Scientist	Biology
Anne	Wiese	DE.DWD	Meterologist	Meteorology
Carla	Fischer	DK.KU	PhD Student	Biology
Lars	Vaupel	DE.NHC	Pilot	Helicopter service
Ulrich	Hoge	DE.AWI	Engineer	Engineering sciences

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No	Position	Rank	Nachname / Name	Name / First Name
01	Kapitän	Master	Lauber	Felix
02	1. Offizier	Chief Mate	Strauß	Erik
03	1. Offizier Ladung	Chief Mate Cargo	Eckenfels	Hannes
04	2. Offizier	2nd Mate	Peine	Lutz
05	2. Offizier	2nd Mate	Heisterkamp	Ole Louca
06	Schiffsärztin	Doctor	Guba	Klaus
07	Leitender Ingenieur	Chief Engineer	Rusch	Torben
08	2. Ingenieur	2nd Engineer	Brose	Thomas Christian Gerhard
09	2. Ingenieur	2nd Engineer	Ehrke	Tom
10	2. Ingenieur	2nd Engineer	Jassmann	Marvin
11	Schiffselektrotechniker Maschine	Ship Electrotechnical Officer Engine	Pommerencke	Bernd
12	Elektroniker Winden	Electrotechnical Engineer Winches	Krüger	Lars
13	Elektroniker Netzwerk/Brücke	Electrotechnical Engineer Network/Bridge	Müller	Andreas
14	Elektroniker Labor	Electrotechnical Engineer Labor	Ejury	René
15	Elektroniker System	Electrotechnical Engineer System	Hofmann	Jörg Walter
16	Bootsmann	Bosun	Meier	Jan
17	Zimmermann	Carpenter	Keller	Jürgen Eugen
18	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Buchholz	Joscha
19	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Möller	Falko

No	Position	Rank	Nachname / Name	Name / First Name
20	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Mahlmann	Oliver Karl-Heinz
21	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Schade	Tom
22	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Brauer	Max
23	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Töben	Carlotta Josefine
24	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Deutschbein	Felix Maximilian
25	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Siemon	Leon Anton
26	Decksmann/Matrose	Able Seaman	Niebuhr	Tim
27	Lagerhalter	Storekeeper	Plehn	Marco Markus
28	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Schröder	Paul
29	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Probst	Lorenz
30	Schiffsmechanikerin Maschine	Multi Purpose Rating Engine	Stubenrauch	Paula
31	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Buchholz	Karl Erik
32	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Cording	Bastian-Fynn
33	1. Koch	1st Cook	Skrzipale	Mitja
34	2. Köchin	2nd Cook	Fehrenbach	Martina
35	2. Köchin	2nd Cook	Loibl	Patrick
36	2. Stewardess	2nd Stewardess	Stocker	Eileen Sigourney
37	2. Steward	2nd Steward	Golla	Gerald
38	2. Stewardess	2nd Stewardess	Holl	Claudia
39	2. Stewardess	2nd Stewardess	Jensen	Eva
40	2. Stewardess / Krankenschwester	2nd Stewardess / Nurse	Ilk	Romy
41	2. Steward / Wäscherei	2nd Steward / Laundry	Shi	Wubo
42	2. Steward / Wäscherei	2nd Steward / Laundry	Chen	Jirong

No	Position	Rank	Nachname / Name	Name / First Name
43	2. Steward / Wäscherei	2nd Steward / Laundry	Chen	Quanlun
44	Auszubildender Schiffsmechaniker	Apprentice Multi Purpose Rating	Seiffert	Nils