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

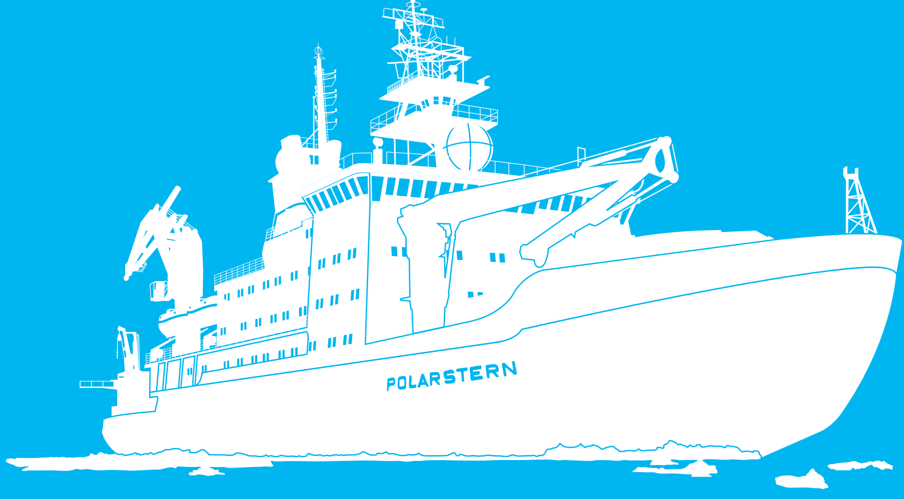
EXPEDITION PROGRAMME
PS148

Polarstern

PS148
Bremerhaven - Tromsø
29 May 2025 - 29 June 2025

Coordinator: Ingo Schewe

Chief Scientist: Jennifer Dannheim



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Bremerhaven, April 2025

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The papers contained in the Expedition Programme *Polarstern* do not necessarily reflect the opinion of the AWI.

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Contents

1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Jennifer Dannheim DE.AWI

Die *Polarstern*-Expedition PS148 wird am 29. Mai 2025 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“) die mit steigenden Wassertemperaturen und dem Rückgang des Meereises verbundenen Ökosystemverschiebungen im Pelatigal und im tiefen ermittelt und quantifiziert sowie Rückkopplungsprozesse auf ozeanografische Prozesse untersucht. Die Untersuchungen beihnalten 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 oft he ocean: Consequences for marine ecosystems“ befasst sich mit der Verbreitung von Plastikversmüll und den Wechselwirkungen zwischen Plastik und der Meeresbiota. In Topic 2 (2.4 „Advanced research methodologies for tomorrow“) werden fortgeschrittene Forschungsmethoden, einschließlich neuartiger In-situ- und Fernerkundungsbeobachtungssysteme, 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 PS148 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 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 Versüßung, Schichtung und Tiefenkonvektion sowie deren Folgen für die Produktivität, die biologische und physikalische Aufnahme, den Export und das Vergraben von 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 Jahrzenten doppelt so schnell wie der globale Durchschnitt verlaufen ist. Basierend auf den bekannten Wissenslücken umfassen 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 zu erhalten, 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 zu zwischenjährlichen Unterschieden und dekadischen Veränderungen.
- die Mechanismen zu identifizieren, die die Artenvielfalt pelagischer und benthischer Gemeinschaften bestimmen.
- die Widerstandsfähigkeit der arktischen Meeresorganismen zu untersuchen und Indikatorarten für Veränderungen in den Gemeinschaften zu identifizieren.
- Daten für die Bewertung von Ökosystemfunktionen, -dienstleistungen und der Rolle der biologischen Vielfalt bereitzustellen.
- Bereitstellung von Daten zur Bewertung der Qualität von Fernerkundungsbeobachtungen und Modellen, die aktuelle und zukünftige Veränderungen im Arktischen Ozean simulieren.
- zu entschlüsseln, wie die Mechanismen des Klimawandels im Nordatlantik und im Arktischen Ozean gekoppelt sind
- 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.

Die Expedition wird am 29. Juni 2025 in Tromsø, Norwegen, enden.

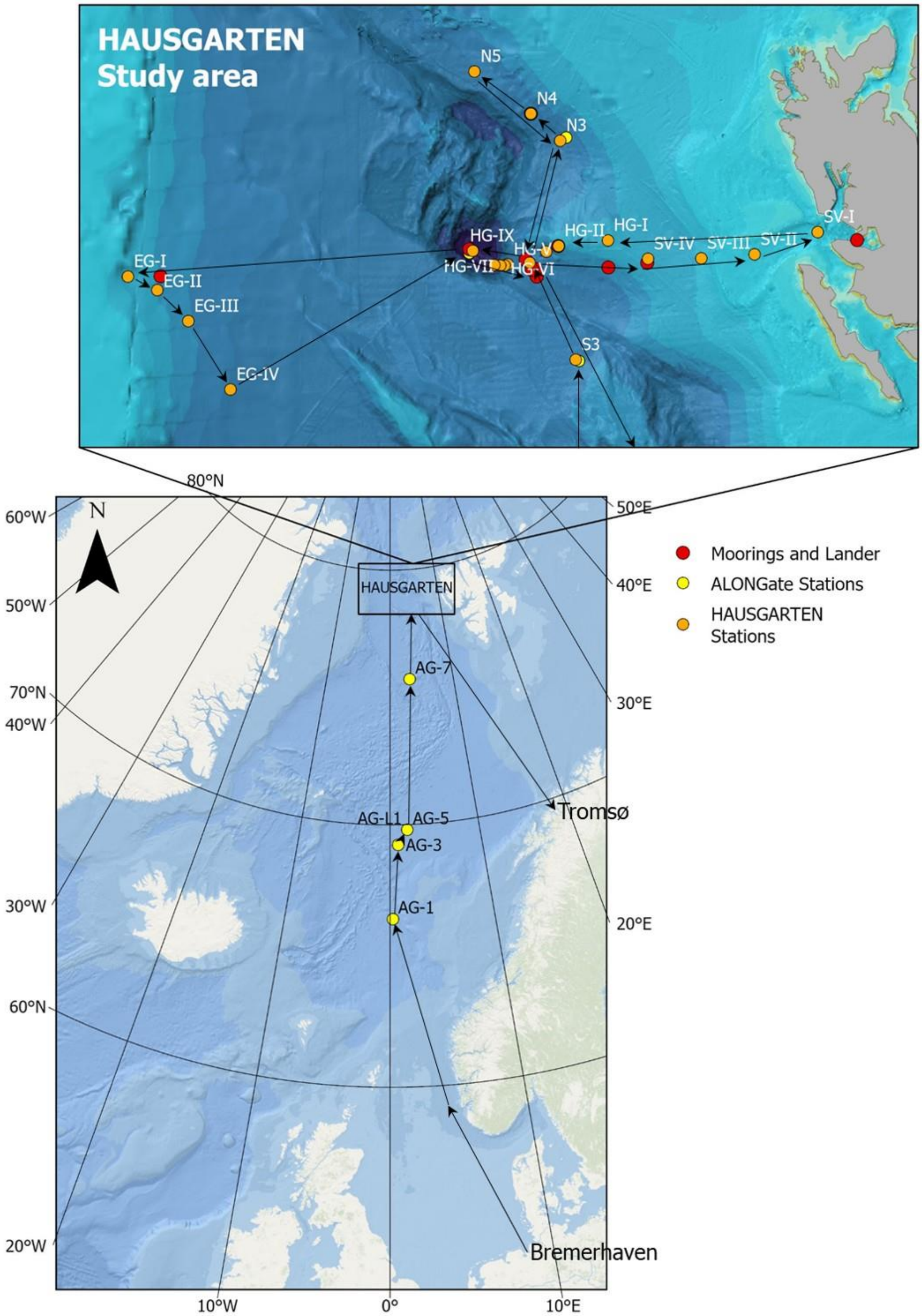

Abb. 1.1: Geplante Fahrtroute (Pfeile) und die wichtigsten Messstationen der Polarstern Expedition PS148

Fig. 1.1: Planned cruise track (arrows) and main sampling stations of Polarstern expedtition PS148

SUMMARY AND ITINERARY

The *Polarstern* expedition PS148 will depart on 29th May 2025 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 PS148 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.

The expedition will end on 29th June 2025 in Tromsø, Norway.

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

Christiane Hasemann[1], Lucas Arnold[2], Christina Bienhold[1], Leonie Buchele[1], Stine Bucholz[1], Michael Busack[1], Miriam Claver[3], Jennifer Dannheim[1], Nils Handelmann[1], Ulrich Hoge[1], Katharina Kohlenbach[1], Sascha Lehmenhecker[1], Normen Lochthofen[1], Janine Ludszuweit[1], Autun Purser[1], Sonja Rückert[2], Ingo Schewe*[1]

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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.

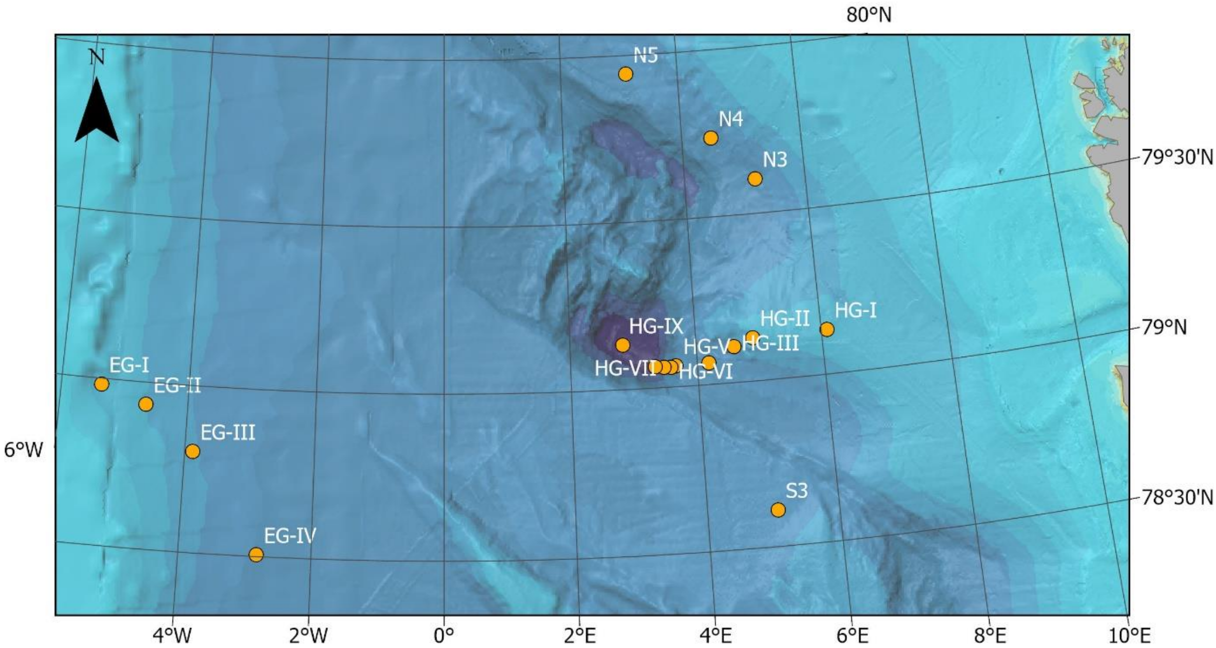

Fig. 2.1: Permanent sampling sites of the LTER (Long-Term Ecological Research) observatory HAUSGARTEN in Fram Strait, Arctic Ocean

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). Improved technologies, particularly the recent deployment of side-scan sonar systems within the Deep-Sea Research Group (Purser et al., 2019), towed across the seafloor by camera sleds, have highlighted the high-resolution topographic variability of many deep-sea areas, including HAUSGARTEN (Schulz et al., 2010; Taylor et al., 2016; Purser, 2020). So far, the time-series stations maintained across the region do not capture the high degree of local heterogeneity (in terms of physical seafloor terrain variables such as slope, rugosity, aspect, depth). Therefore, during *Polarstern* expedition PS148, dedicated attempts to collect spatial data to capture the role of this heterogeneity in biodiversity and biomass estimation are planned to complement studies on the temporal variability of the benthos 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.

Work at sea

The current cruise will complete the dataset over more than a 25-years time span and will serve to detect long-term changes of 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 taken using a video-guided multiple corer (MUC). Various biogenic compounds from these sediments are analysed to estimate activities (e.g. bacterial exoenzymatic activity) and the total biomass of the smallest sediment-inhabiting organisms. Results will help to describe ecosystem changes in the benthal of the Arctic Ocean. Sediments retrieved by the MUC will also be analysed for the quantitative and qualitative assessment of the small benthic biota.

Meiofauna spatial and temporal distribution patterns, with special focus on density and diversity of nematode community composition will be analysed.

Sediments are sampled to describe small-scale spatial patterns as vertical gradients within the sediment as well as large-scale patterns for different water depths. The first 19 years of the HAUSGARTEN time series have been or are being evaluated as part of doctoral dissertations focusing on nematode community patterns. In order to continue this unique time series in the future, sediment cores are taken along the HAUSGARTEN depth transect for the analysis of the meiofaunal communities. These cores will also be sub-sampled for various environmental parameters indicative of the food input to the deep seafloor.

In addition, these samples will serve as background information for various biological experiments investigating the causes and effects of gradients on biodiversity patterns and community composition of benthic organisms to be installed at the central HAUSGARTEN station during future expeditions.

Long-term macrobenthic study

Macrobenthos in the HAUSGARTEN area has been studies only irregularly over the past 25 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 PS148 will continue the time-series work to allow the assessment of long-term changes in the deep-sea habitat, and the fifth 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. Currently, all available data of the last years are compiled in the ecological data information system CRITTERBASE.

Moreover, GBC, MUC and supernatant samples will be taken to continue the feasibility testing for parasitological studies of the macrobenthos. Sieved benthos (GBC 500 µm, MUC 125 µm sieve) and filtered water samples will be preserved for either microscopic and/or molecular investigations of potential parasites associated with the macrofauna. This can add valuable information, as parasites might affect diversity and community composition of their hosts.

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 to the OFOBS system, the AWI AUV ‘PAUL 3000’ will be used during the PS148 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).

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.

The results will add to our (Piepenburg et al., 2024) 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_ PS148_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 A CHANGING ARCTIC OCEAN

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Outline

The Arctic Ocean has gained increasing attention in recent decades due to the ongoing significant changes 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). In 2017, the MIZ extended further eastwards and southwards into Fram Strait than in average years, with profound impacts on the ecosystems. 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 (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; accepted).

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 Atlantic waters 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 into 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). 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. 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 in specific to the question of how sea ice coverage over different geographical scales affect 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 ^{3}H 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 element and matter turnover as well as energy fluxes in Arctic pelagic systems. In order to detect changes, also in this smallest fraction of the plankton, 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 *Polarstern* for underway filtration, automated Remote Access water Samplers (RAS) and long-term sediment traps deployed on the FRAM moorings for year-round sampling.

Similar to the phytoplankton community, the zooplankton community composition may shift 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 will allow us to exactly identify distribution patterns of key taxa in relation to environmental conditions. We will also use the UVP5 (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. We will also initiate cultures for fungal plankton (in addition to oomycete cultures established on PS143/1). Co-cultures of parasites and their hosts will be used for experiments planned in the upcoming INDIFUN-AI BMBF project in which we wish to investigate the utility of using parasites and saprotrophic fungi as indicators of environmental change.

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 phyto- and mycoplankton

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 200m 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
- Lipids

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 RV 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. 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.

In preparation for the BMBF project INDIFUN-AI (to start in September 2024), all net samples will be screened.

Zooplankton sampling and optical surveys

We will study the zooplankton biodiversity and biogeography by deploying a multi net. 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 multi-sampling depths are 1,500–1,000–500–200–50 m. To determine the fine scale vertical distribution of key species, we use an optical system, the zooplankton recorder LOKI (Lightframe On-sight Key species Investigations), which continuously takes pictures of 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 also deploy a UVP5 which also takes 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 *Polarstern* expedition PS148, we will recover moorings and instruments that were deployed during the expedition PS133/2 in summer 2024. 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.

Preliminary (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_PS148_02** will be quoted and the following publication will be cited:

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4. PHYSICAL OCEANOGRAPHY AND PHYTOOPTICS

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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. PS148 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 1000m 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.

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 high 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.

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, 2024 in review; 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 HPLC method and the optical properties using spectrophotometric instrumentation.

The Phytooptic 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).

The Phytooptic group's specific objectives for PS148 are to

- collect a highly spatially and temporally resolved data seton 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, 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.

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. Water samples from the CTD rosette will be run on the salinometer and oxygen titration rig to support the calibration/data processing of the conductivity and oxygen sensors, respectively. Water samples will be collected both on full water column profiles and on profiles to only 300 m depth.

Mooring recoveries and deployments

As listed in Tab. 1, we will recover 5 oceanographic moorings and deploy 5 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 will have 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 will also include a winch (F4-W) to measure profiles in the top 100m of the water column. At F4 we will also re-deploy F4-S-9 which will form an equilateral triangle with F4-22 and F4-H-1 (deployed during PS143/2 and to be recovered in summer 2026) with 1,400 m side length. Horizontal velocity and temperature/salinity will be measured at all three moorings between 50m and 250m 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														
F4-S-8	7	2.05	E	79	0.70	N	1222	19	2024	7	17	16	50	PS143_2_010_01
F4-W-5	6	58.02	E	79	0.71	N	1213	134	2024	7	20	14	20	PS143_2_021_01
HG-IV-FEVI-48	4	19.91	E	79	0.00	N	2531	34	2024	7	29	19	40	PS143_2_059_02
HG-EGC-10	5	23.83	W	78	59.78	N	979	49	2024	7	28	8	16	PS143_2_057_01
LT-Lander-2024	4	13.40	E	79	1.86	N	2526	2524	2024	7	29	20	33	PS143_2_059_03
Deployments														
F4-S-9	7	2.05	E	79	0.70	N	1222	19						
F4-W-6	6	58.02	E	79	0.71	N	1213	134						
HG-IV-FEVI-50	4	19.91	E	79	0.00	N	2531	34						
HG-EGC-11	5	23.83	W	78	59.78	N	979	49						
LT-Lander-2025	4	13.40	E	79	1.86	N	2526	2524						

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 noon-time CTD stations:

1. 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.

2. 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 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.
3. 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 6 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).
4. Samples for determination of phytoplankton pigment concentrations and composition are taken at a 3-hourly interval from the underway-sampling system, and from 6 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).
5. 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.

Preliminary (expected) results

Directly on board we aim to 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_ PS148_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.

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5. PELAGIC BIOGEOCHEMISTRY: NUTRIENTS

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Grant-No. AWI_PS148_03

Objectives

Our overarching goals are two-fold: 1) to understand and quantify nutrient variability in inflowing and outflowing waters to/from the Arctic Ocean within the context of the Arctic Ocean nutrient budget and its implications for its biogeochemical system (i.e., relevance for primary production, ecosystems, interaction between physical, chemical and biological processes); 2) to contribute to the wider goals of the FRAM/HAUSGARTEN community regarding long term observations of the Arctic System through a multidisciplinary approach. Therefore, our aim during PS148 is to continue our time series observations selected biogeochemical variables; dissolved nutrients and dissolved oxygen. We will do this via the collection of seawater samples for analysis onboard or later, and via the deployment of remote acces samplers (RAS) and sensors for moored, year-long observations.

As of 2024, sensor (in particular pH and pCO_2) and RAS biogeochemical data from deployments in the West Spitsbergen Current also represent the AWI contribution and commitment to the ICOS (Integrated Carbon Observation System) Program.

Nutrient and sensor data collected feed into an INSPIRES PhD project, starting February 2025, related to the first overarching goal above.

Work at sea

1. We will collect seawater samples from CTD-Rosette casts, at the highest vertical resolution possible at all stations to be surveyed. Two types of samples will be collected; samples for the determination of dissolved oxygen and samples for the analysis of dissolved nutrients. The latter include: nitrate+nitrite, nitrite, ammonium, total dissolved nitrogen, phosphate, total dissolved phosphorus and silicate.
2. We will collect seawater samples at selected sites and depths for later determination of dissolved inorganic carbon and total alkalinity. Data from these samples will serve for quality control purposes and also as ancillary data for observations of the carbon system in regard to AWI ICOS commitments.
3. We will deploy two remote acces samplers in collaboration with colleagues from the the Microbial Observatory (Katja Metfies, Christina Bienhold and Mathias Wietz), Physical Oceanography of Polar Oceans (Wilken von-Appen, Mario Hoppmann, Matthias Monsees, Torsten Kanzow) and Deep-Sea Ecology and Technology (Normen Lochtofen). One RAS will be deployed close to the surface (~25 m) in moornig F4-S# and another RAS were deployed in mooring EGC-# at ~50 m (where # stands for the consecutive mooring deployment relative to previous deployments). Each RAS will be equipped with the following biogeochemical sensors: SUNA-nitrate, PAR, pH, pCO2, Eco-Triplet (CDOM, backscatter and chl-a fluorescence) and a CTD-O2. RAS will be

programmed to take one sample approximately at weekly intervals. All functioning well, each RAS should provide 48 seawater samples through the year-long deployment. Upon recovery, a 40 mL aliquot will be withdrawn from each RAS bag for nutrient analysis. The remaining 460 mL of sample will be used for phytoplankton (KM) and bacterial genetics (CB, MW).

4. Additionally, a SUNA nitrate sensor will be used in CTD casts shallower than 2,000 m, in order to provide high vertical resolution nitrate profiles, which will help with data interpretation as it provides a more detailed water structure profile than do discrete samples. This sensor will be calibrated using data from the analysis of discrete samples and processed with T-S data from the CTD.

Preliminary (expected) results

Data from dissolved oxygen measurements onboard will be processed for further quality controlled after the expedition. It is envisaged that this will take no longer than one month after the end of the expedition. This data set will also be made available to the physical oceanography team for the calibration of the CTD-O_2 sensors.

Samples collected for dissolved nutrient observations require longer times for processing. If analyses onboard are possible (e.g., lab space onboard, time availability for training of participants), final quality-controlled data will likely be available within 6 months after the end of the expedition. If analyses onboard are not possible, then later analyses may take place within 12 months after the expedition, plus another 6 months for data processing and quality control.

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_PS148_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.

6. ALONGATE: A LONG-TERM OBSERVATORY OF THE NORTH ATLANTIC GATEWAY TO THE ARCTIC

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Outline

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. This ridge system produces „overflow regions“ in the Denmark Strait and between Iceland and the Faroe Islands and its influence in faunal composition and ocean chemistry can be observed as North as Svalbard, Norway (Mauritzen, 1996; Puerta et al., 2020; Semper et al., 2020). Known as the “North Atlantic Gateway to the Arctic Ocean”, the area 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). The influence of the North Atlantic water inflow in this Subarctic boundary region demarcates a distinct ecoregion with a unique fauna (Brix et al., 2018a,b, 2022; Uhlir et al., 2021). The ALONGate North-South transect focuses on biodiversity change 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) and additional new samples from *Polarstern*, which transits every year from Germany north to the HAUSGARTEN LTER site in Fram Strait. 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 (Ramirez-Llodra et al., 2024). This project fills a critical geographic gap that leverages substantial power from these other recent and ongoing studies. The new lander deployment adds 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 is to close sampling and data gaps on the latitudinal transect between Iceland (IceAGE stations) and the LTER HAUSGARTEN (Fig. 6.1). In 2025, the ALONGate-project involves the deployment of a deep-sea benthic lander system in the abyssal plain of the Norwegian Sea, which will be recovered in 2026. 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 drivering 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?

Selected specimens collected by benthic sampling will be integrated into the British interdisciplinary 5-year NERC programme BIOPOLE with the goal to examine biogeochemical processes and ecosystem function in polar ecosystems. It addresses a fundamental aspect of the Earth System – how nutrients in polar waters drive the global carbon cycle and primary productivity. The oceans play a vital role in absorbing atmospheric CO_2, mitigating large amounts of manmade carbon emissions. Katrin Linse as part of workpackage 2 (WP2) focuses on how biological processes alter carbon:nutrient ratios in polar environments, including focus on parametrising biological processes of the lipid pump. Research questions to be addressed are:

1. Do benthic animals increase the efficiency of the lipid pump by consuming overwintering zooplankton, especially calanoid copepods, at depth?
2. How can we represent the stoichiometric consequences of the polar lipid pump in a biogeochemical model?

The benthic and copepod samples collected will be used to link benthic biodiversity and productivity patterns to inputs from the upper ocean and in particular to diapausing zooplankton via modelling work within WP2, which aims to improve parameterisation and quantification of the lipid pump within the polar oceans.

Work at sea

Benthic sampling is planned across four Working Areas (WA) on the transect from Bremerhaven to Fram Strait. Within the HAUSGARTEN area, EBS deployments depend on the sea ice extent and will be prioritized at eastern and northern stations. The transect will start at the northernmost IceAGE station and end at the southernmost HAUSGARTEN station (Fig. 6.1). Gear deployment in each WA 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; Multibeam echo sounders EM710/EM122 (MB) will be performed in each area prior to station work; Epibenthic Sledge (EBS, Brenke, 2005) for sampling of macro-epifauna. The programme at the central WA on the transect includes the deployment of an Ocean Floor Observation System (OFOS) to study megafaunal communities, a short-term deep-sea profiling lander as well as a long-term lander equipped with a benthic chamber and imaging system, allowing us to collect invaluable in-situ observations and measurements to fill this critical knowledge void.

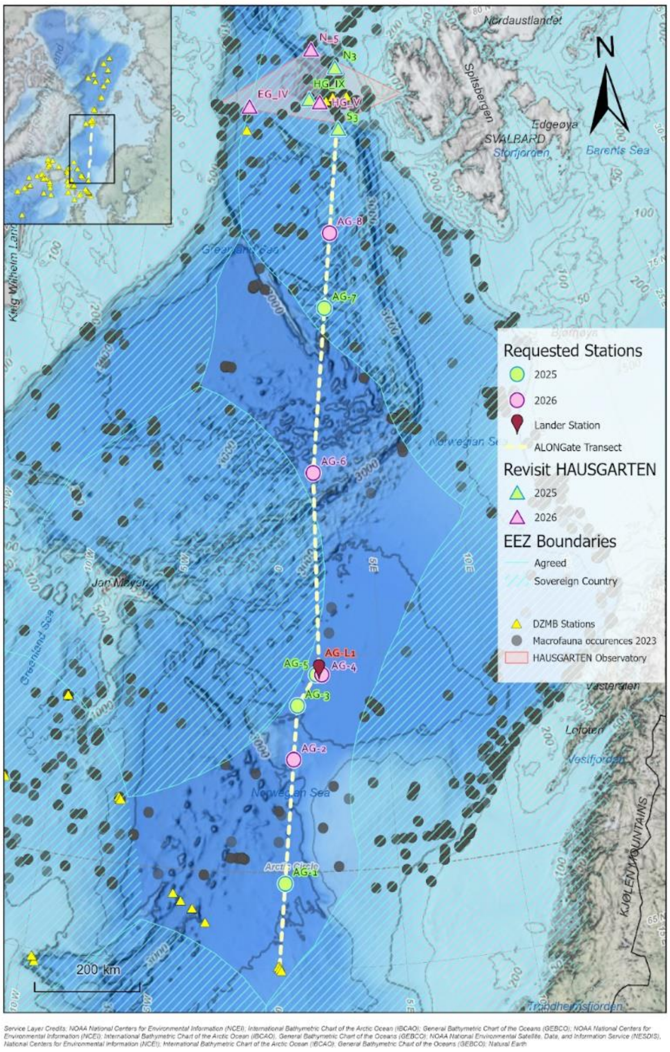

Fig. 6.1: ALONGate 1 meets FRAM: The transect track with Working Areas planned as a connection between earlier IceAGE stations (yellow triangles) and the southernmost HAUSGARTEN station S3 (green triangle). In addition to revisiting the HAUSGARTEN stations sampled in 2023 and 2024 (represented by green 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 visited in 2025 for deployment and in 2026 for recovery of the Lander system. Background data points (gray) show all so far known macrofauna occurrences based on the most recent revised dataset provided by Ramirez-Llodra et al. (2024).

Benthic sampling

The collection of benthic fauna and epibenthic calanoid copepods will be done via deployment of an EBS. Representatives of the benthic fauna will be photographed and subsequently, depending on the latter scientific purpose, either fixed in ethanol, formalin, RNA-later or frozen at – 80 °C for, e.g. lipid marker and stable isotope analyses. Calanoid copepods present, especially *Calanus* spp., will be imaged to document the lipid sac volume and frozen at -80 °C for lipid marker and stoichiometric analyses.

Bathymetry

Bathymetric assessment of seafloor topography proved essential prior to the deployment of benthic sampling gear and is a conscientious way we can limit our impacts on the seafloor. The global data holdings of the International Hydrographic Office Data Centre for Digital Bathymetry (IHO DCDB) hosted at NOAA, as well as other data platforms (e.g. PANGAEA) or data holding institutes (AWI, Geomar, BSH) show that the North Atlantic Gateway area has been partially surveyed, but there are clear gaps where the stations of the transect are strategically placed. However, the aim is to contribute to Seabed 2030, mapping the entire world's oceans until 2030, by filling these gaps between the existing bathymetry survey lines.

Summarized, each WA is planned to be studied as follows:

WA 1, 3 and 7: MB mapping, CTD, EBS deployment

WA 5 (Lander Area):

- In 2025: MB mapping, OFOS deployment, Lander system deployment
- In 2026: Lander system recovery, EBS deployment

Preliminary (expected) results

With live sorting of EBS samples on board we will document original morphological features of the local macrofauna and give a first 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 as well as quantitative analyses of megafaunal composition by OFOS imagery data. The bathymetric assessment will contribute with high resolution mapping to Seabed 2030 and HAUSGARTEN knowledge. We will be able to answer the previously stated scientific questions and contribute material and data to international projects (e.g. BIOPOLE).

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. BIOGEOCHEMISTRY AND NICROBIAL ECOLOGY AT LTER HAUSGARTEN AND THE MOLLOY DEEP

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Grant-No. AWI_PS148_07

Objectives and scientific program

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

Many areas of the deep sea are still little explored. Deep-sea (or hadal) trenches, for example, only account for less than 2% of the global seabed area, but could via sediment focusing act as regionally important but unexplored traps for organic material. Benthic mineralization is mainly driven by vast numbers of 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 microbes and small eukaryotes in deep sea and trench sediments are missing. We want to use the Molloy Deep (5.5 km) as a model area to quantify the carbon mineralization-efficiency of sediments in and at adjacent shallower reference sites, identify the key players for the processing and compare process rates and microbial communities with other deep sea and trench ecosystems.

Work at sea

Benthic flux study

Seafloor carbon mineralization will be studied in-situ at sites with varying sea-ice conditions (HG-IV, N_4) using a benthic lander system (Hoffmann et al., 2018). The benthic O_2 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 (O_2, 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.

At HG-IV a benthic crawler system (Crawler-III), which was deployed in 2024 (PS143/1) will be recovered after its 12-month mission. The crawler system is pre-programmed to perform >50 measurements along a ca 1.0 km transect. Crawler-III (similar with crawler NOMAD; Lemburg et al., 2018) uses oxygen optodes to measure vertical concentration profiles across the sediment-water interface (one set of profiles each week). Additionally, the crawler is equipped with benthic chambers and 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 m long transect at the beginning of each measuring cycle. At the end of this transect, concentration profiles of oxygen are measured across the sediment water interface. From these profiles diffusive oxygen fluxes can be obtained. Chamber incubations, performed at the same time, provide the total oxygen demand of the seafloor. Both measurements provide information on the oxygen consumption related to carbon mineralization. These cycles are repeated every week for a period of 12-month. If the crawler is operational again after its recovery and maintenance, it is planned to deploy it for another 12-month mission at HG IV.

Quantification of the pelagic export and benthic mineralization of organic carbon

Using state-of-the-art lander technology, we will measure in situ benthic oxygen consumption rates within and around the Molloy Deep. The data will provide a unique assessment of the regional benthic carbon mineralization rates and fill data gaps in the current global data base. The involved diagenetic pathways will be quantified from porewater profiles and the distribution of solid-state iron and manganese, and dissolved inorganic nitrogen as well as onboard measurements of sulfate reduction, denitrification, and anammox. The site-specific turn-over rates will be linked to the pelagic activity and sedimentation rates derived form the distribution of natural radionucleides, but will also be linked to long-term assessments of pelagic productivity at the respective sites estimated from remote sensing (Jørgensen et al., 2022). Thereby we will assess the quantitative link between surface primary production and underlying benthic activity, and evaluate the potential importance of horizontal transport of organic material in the complex benthic seascape of the region.

Exploring the biogeochemical function and community composition in the deep sea

The proposed study is essential for understanding carbon and nitrogen cycling, pelagic-benthic coupling and benthic community structures in this very important region of the Arctic Ocean. However, the work should also be seen in the context of a wider ambition of exploring life and biogeochemical function of the deep sea. The proposed work in the productive region of the Molloy Deep within the Fram Strait will greatly complement investigations on hadal systems of different biogeographic provinces. The combined data will provide generic insights on the biogeochemical function and life in deep-sea and hadal trench systems underlying different productivity regimes. The analysis on community structures will explore the extent by which deep basins and trench systems act as isolated biogeographic habitats dominated by unique co-evolving communities or if they represent interconnected extreme environments.

To assess the effect of hydrostatic pressure on marine microbes, on-board pressure-tank experiments will be carried out. Rates of benthic microbial processes like aerobic respiration, nitrification, denitrification, anammox, and sulfate reduction will be measured at different pressure levels.

Preliminary (expected) results

The result will add to our growing database on microbial carbon mineralization in deep-sea (Jørgensen et al., 2022) and hadal settings (Glud et al., 2021; Wenzhöfer et al., 2016) 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 insight will be compared with similar investigations that we have conducted in the eutrophic Atacama Trench and oligotrophic Kermadec Trench region. This will provide a generic insight on biogeochemical function and community compositions 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_ PS148_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**
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A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Arnold	Lucas	DE.UNI-DUE	Technician	Biology
Barz	Jakob	DE.AWI	Technician	Chemistry
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Bienhold	Christina Andrea	DE.AWI	Scientist	Biology
Brauer	Jens	DE.NHC	Pilot	Helicopter Service
Brenner	Claudia	DE.UNI-Bremen	Student (Bachelor)	Biology
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Busack	Michael	DE.AWI	Engineer	Engineering Sciences
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Knüppel	Nadine	DE.AWI	Technician	Biology
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Vaupel	Lars	DE.NHC	Pilot	Helicopter Service
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Westphal	Matthias	DE.HS-Bremerhaven	Student (Bachelor)	Biology
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A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No	Name/ Last name	Vorname/ First name	Position/ Rank
1	Schwarze	Stefan	Kapitän
2	Strauss	Erik	1. Offizier
3	Eckenfels	Hannes	1. Offizier Ladung
4	Stelljes	Daniel	2. Offizier
5	Peine	Lutz	2. Offizier
6	Guba	Klaus	Schiffsarzt
7	Ziemann	Olaf	Leitender Ingenieur
8	Ehrke	Tom	2. Ingenieur
9	Krinfeld	Oleksandr	2. Ingenieur
10	Rusch	Torben	2. Ingenieur
11	Pommerencke	Bernd	Schiffselektrotechniker Maschine
12	Krüger	Lars	Elektroniker Winden
13	Hofmann	Jörg	Elektroniker Netzwerk/Brücke
14	Ejury	René	Elektroniker Labor
15	Winter	Andreas	Elektroniker System
16	Meier	Jan	Bootsmann
17	Keller	Jürgen	Zimmermann
18	Buchholz	Joscha	Schiffsmechaniker Deck
19	Möller	Falko	Schiffsmechaniker Deck
20	Mahlmann	Oliver Karl-Heinz	Schiffsmechaniker Deck
21	Schade	Tom	Schiffsmechaniker Deck
22	Siegel	Kilian	Schiffsmechaniker Deck
23	Haller	Fabian	Schiffsmechaniker Deck
24	Deutschbein	Felix Maximilian	Schiffsmechaniker Deck
25	Siemon	Leon Anton	Schiffsmechaniker Deck
26	Niebuhr	Tim	Decksmann/Matrose
27	Plehn	Marco Markus	Lagerhalter
28	Schröder	Paul	Schiffsmechaniker Maschine
29	Probst	Lorenz	Schiffsmechaniker Maschine
30	Stubenrauch	Paula	Schiffsmechanikerin Maschine
31	Buchholz	Karl Erik	Schiffsmechaniker Maschine
32	Töben	Carlotta	Schiffsmechanikerin Maschine
33	Skrzipale	Mitja	1. Koch

34	Fehrenbach	Martina	2. Köchin
35	Loibl	Patrick	2. Koch
36	Witusch	Petra Gertrud Ramona	1. Stewardess
37	Stocker	Eileen Sigourney	2. Stewardess
38	Golla	Gerald	2. Steward
39	Holl	Claudia	2. Stewardess
40	Ilk	Romy	2. Stewardess / Krankenschwester
41	Shi	Wubo	2. Steward / Wäscherei
42	Chen	Jirong	2. Steward / Wäscherei
43	Chen	Quanlun	2. Steward / Wäscherei
44	Glawe	Jonathan Elias	Auszubildender Schiffsmechaniker