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

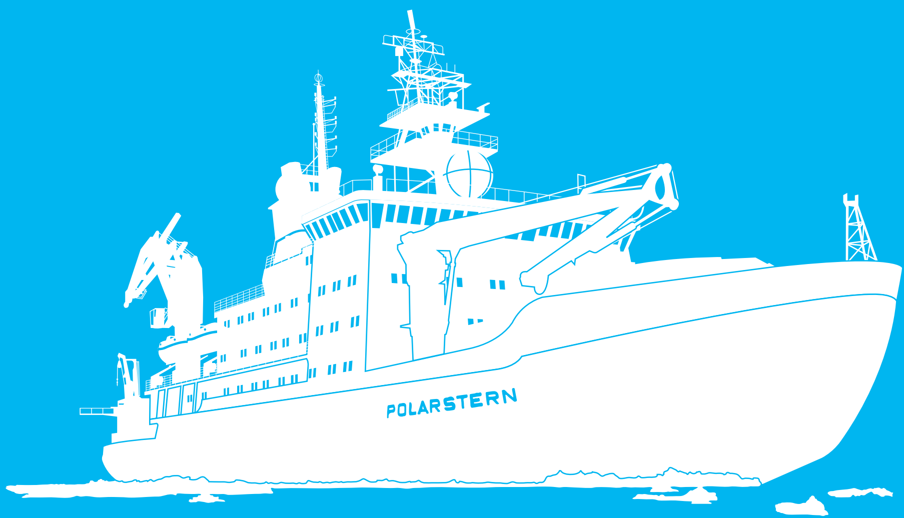
EXPEDITION PROGRAMME
PS150

Polarstern

PS150
Longyearbyen - Bremerhaven
04 September 2025 - 23 October 2025

Coordinator: Ingo Schewe

Chief Scientist PS150: Torsten Kanzow



HELMHOLTZ

Bremerhaven, August 2025

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The Expedition Programme *Polarstern* is issued by
the Alfred Wegener Institute, Helmholtz Centre for Polar and
Marine Research (AWI) in Bremerhaven, Germany.

The Programme provides information about the planned goals and scientific work programmes of expeditions of the German research vessel *Polarstern*.
The papers contained in the Expedition Programme *Polarstern* do not necessarily reflect the opinion of the AWI.

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PS150 / EGC Sources

4 September 2025 – 23 October 2025

Longyearbyen – Bremerhaven

Chief scientist
Torsten Kanzow

Coordinator
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1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Torsten Kanzow DE.AWI

Die *EGC-Sources* Expedition verfolgt wichtige Ziele des „Erde und Umwelt" Programms POF IV der Helmholtz-Gemeinschaft. Der Ostgrönlandstrom (EGC) ist für den Export von süßem, polarem Oberflächenwasser (PSW) und Meereis aus dem Arktischen Ozean bekannt und hat dabei große Veränderungen erfahren. Der EGC exportiert zudem recht warmes, submarines Arktisches Atlantikwasser (AAW), das durch den Zustrom von warmem Atlantikwasser (AW) in den Arktischen Ozean gespeist und entlang der Kontinentalabhänge Eurasiens und Kanadas sowie entlang mittelozeanischer Rücken gelenkt wird. Es fehlt uns ein gutes Verständnis der Schließung der arktisweiten Zirkulation nördlich von Grönland, wo AAW das Schmelzen großer Gletscher antreibt. Wir werden zunächst die Zirkulation von AAW und PSW auf dem Schelf und am Kontinentalabhang nördlich von Grönland und ihre Verbindung zum EGC bestimmen, einschließlich des Nährstofftransports und der Verbindung zur Biologie. Wir werden untersuchen, wie die ozeanisch getriebene Schmelze der großen, sich zurückziehenden Gletscher von AAW und AW beeinflusst wird und wie das Schmelzwasser die Schelfströmungen und den Kohlenstoffexport antreibt. Wir werden die ablandigen Meereisdickengradienten untersuchen und anhand seismologischer und geodätischer Techniken Deglaziationsprozesse studieren. Wir planen, diese Ergebnisse mit der paläodynamischen Entwicklung von Eisschild-Ozeansystemen während wärmerer Zeiträume als heute zu verknüpfen. Die Expedition soll während des Meereisminimums stattfinden, um schiffbare Bedingungen zu gewährleisten. Unser interdisziplinärer, skalen-übergreifender Ansatz beruht auf Messungen entlang gemeinsam genutzter Schnitte. Wir werden uns auf die stationäre Profilierung und Probenahme von physikalischen, geochemischen, biogeochemischen und biologischen Eigenschaften der Wassersäule und des Sediments stützen und Verankerungen und Lander einsetzen, um einen ganzjährigen Beobachtungskontext zu schaffen, der durch luftgestützte Techniken ergänzt wird.

Polarstern wird am 4. September von Longyearbyen (Spitzbergen) zur EGC-Sources Expedition aufbrechen. Nach Ankunft auf dem nordostgrönländischen Schelf wird sich die Reihenfolge unserer Arbeiten sehr stark an den Eisverhältnissen ausrichten. Die Zirkulationen von ASW und PSW inklusive der Nährstofftransporte sowie der biogeochemisch-biologischen Verteilungen sollen mittels mehrerer hydrographischer Schnitte nördlich von 80°N jeweils von der Küste bis etwa 40 nm über die Schelfkante hinweg vermessen bzw. beprobt werden. Ein Verankerungsarray entlang einer der Schnitte wird zudem die zeitlichen Änderungen der Zirkulationen im Jahresverlauf erfassen. Die Installation eines Arrays von Ozeanbodenseismometern, der Besuch geodätischer Stationen auf dem Festland und ein Eis-basiertes Messprogramm inklusive Auslegung eisgebundener Bojen erfolgen entlang der Fahrtroute von Süden nach Norden entlang der Küste. Zur Erforschung Ozean-Schelf-Fjord-Gletscherwechselwirkung sollen im Bereich des 79N Gletschers / Zachariae Isstrøm und, falls möglich im Bereich Hagen Fjord / Independence Fjord zahlreiche schiffsgestützte hydrographisch-chemisch-geochemische Messungen erfolgen. Nach Abschluss der Arbeiten wird *Polarstern* die Rückreise nach Deutschland antreten, wo die Fahrt am 23. Oktober zu Ende gehen wird (Abb. 1.1).

SUMMARY AND ITINERARY

The *EGC-Sources* expedition addresses important goals of the program POF IV of the research field “Earth and Environment” of the Helmholtz Association. The East Greenland Current (EGC) is widely known for exporting fresh Polar Surface Waters (PSW) and sea ice from the Arctic Ocean and has recently shown major changes. The EGC also exports rather warm and saline, subsurface Arctic Atlantic Water (AAW) – supplied to the Arctic Ocean by the inflow of warm Atlantic Water (AW) – which is steered along both the continental slopes of Eurasia and Canada and along mid-oceanic ridges. We lack a good understanding of the closure of the Arctic-wide circulation in the Last Ice Area north of Greenland, where AAW drives the melt of major glaciers. First, we will determine the circulation of AAW and PSW on the shelf and continental slope north of Greenland, and its downstream connection to the EGC, including nutrient transports and the coupling to biology. We will further investigate how the ocean-driven melt of major, retreating glaciers is affected by AAW and AW, and how the meltwater drives shelf currents and carbon export. We will study ice thickness gradients away from the coast and exploit seismological and geodetic techniques to infer deglaciation processes. Finally, we plan to connect the findings to the paleo-dynamic history of ice sheet systems and ice sheet-ocean interactions during warmer-than-present time intervals. The expedition should take place during the sea ice minimum to ensure navigable conditions. Our interdisciplinary, scale-bridging approach relies on concentrating our efforts along selected sections – shared by all teams – from the coast to the continental slope. We will rely on station-based profiling and sample collection of physical, geochemical, biogeochemical, and biological properties of the water column and the sediment, and we will deploy moorings and bottom landers to provide a year-round observational context, complemented by air-borne techniques.

Polarstern will depart from Longyearbyen (Spitsbergen) on 4 September for the EGC-Sources expedition. After arriving on the northeast Greenland shelf, the sequence of our work will be very much dictated by the ice conditions. The circulation of ASW and PSW, including nutrient transport and biogeochemical-biological distributions, will be measured and sampled by means of several hydrographic transects north of 80°N from the coast to about 40 nm above the shelf edge. A mooring array along one of the transects will also record the temporal changes in circulation over the course of the year. The installation of an array of ocean bottom seismometers, visits to geodetic stations on the mainland and an ice-based measurement program including the deployment of ice-bound buoys will take place along the route from south to north along the coast. To investigate ocean-shelf-fjord-glacier interaction, numerous ship-based hydrographic-chemical-geochemical measurements will be carried out in the area of the 79N Glacier / Zachariae Isstrøm and, if possible, in the area of Hagen Fjord / Independence Fjord. Once the work has been completed, *Polarstern* will return to Germany, where the voyage will end on October 23 (Fig. 1.1).

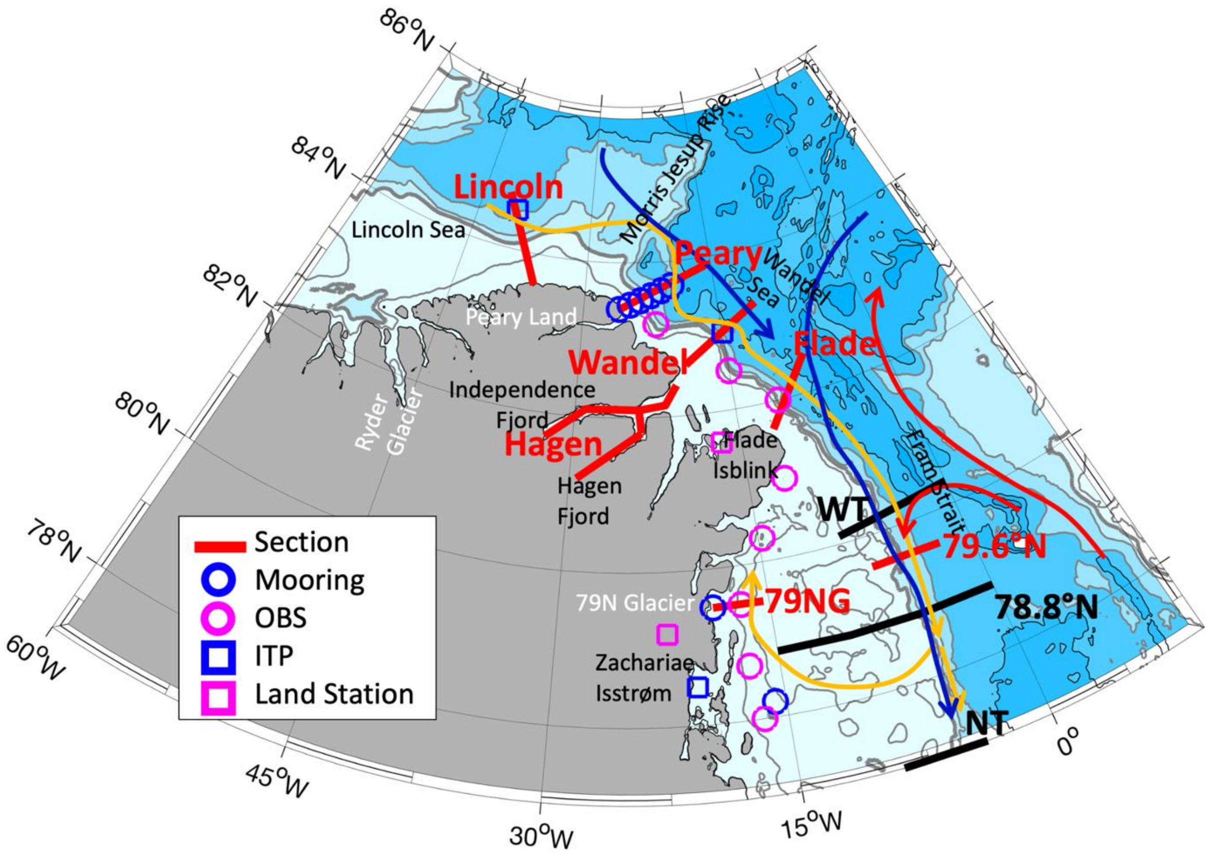

Abb. 1.1: Arbeitsgebiet der Expedition PS150. Die hydrographischen Schnitte sind als durchgezogene rote Linien markiert. Die Orte der Verankerungen, OBSs, ITPs und Landstationen sind in der Legende angegeben. Das vom NPI unterhaltene Langzeit-Observatorium im Ostgrönlandstrom befindet sich auf 78,8°N.

Fig. 1.1: Working area of the expedition PS150. The seven sections are marked as solid red lines. The locations of the moorings, OBSs, ITPs, and Land Stations are shown according to the legend. The long-term Fram Strait Arctic Outflow Observatory maintained by NPI is at 78.8°N.

2. PHYSICAL OCEANOGRAPHY

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Grant-No. AWI_PS150_01

Objectives

The East Greenland Current (EGC) is widely known for exporting fresh Polar Surface Waters (PSW) and sea ice from the Arctic Ocean and has recently shown major changes. The EGC also exports rather warm and saline, subsurface Arctic Atlantic Water (AAW) – supplied to the Arctic Ocean by the inflow of warm Atlantic Water (AW) – which is steered along both the continental slopes of Eurasia and Canada and along mid-oceanic ridges. We lack a good understanding of the closure of the Arctic-wide circulation in the Last Ice Area north of Greenland, where AAW drives the melt of major glaciers. First, we will determine the circulation of AAW and PSW on the shelf and continental slope north of Greenland, and its downstream connection to the EGC. We will further investigate how the ocean-driven melt of major, retreating glaciers is affected by AAW and AW, and how the meltwater drives shelf currents.

The Arctic Ocean is undergoing rapid change with the ongoing Atlantification (Polyakov et al. 2017), meaning the subsurface inflow of warm Atlantic Water is gaining importance in limiting the growth of sea ice in the Eurasian Basin of the Arctic Ocean as it is no longer strictly subsurface in the Eurasian Basin. Simultaneously, multi-year sea ice has all but disappeared in the fraction of sea ice that is exported out of the Arctic Ocean within the East Greenland Current (EGC) in Fram Strait (Sumata et al. 2023) after the year of 2007.

Atlantic Water (AW) is warm saline water of subtropical origin that flows along the eastern Nordic Seas to the Arctic Ocean. Some of the AW enters the Arctic Ocean through the Barents Sea Opening as well as the West Spitsbergen Current (WSC) on the eastern side of Fram Strait. Analysis of mooring observations suggests that the AW in the WSC has warmed by >0.5°C over the past 2.5 decades (McPherson et al. in press). The surface of the Arctic Ocean is occupied by cold and fresh Polar Surface Water (PSW) of Pacific, riverine, and sea ice melt origin. A strong halocline separates the PSW from the AW below. As the AW travels through the Arctic Ocean for years to decades, it gets transformed to colder (<2°C) Arctic Atlantic Water (AAW). The AAW, PSW and sea ice exit the Arctic Ocean through the western side of Fram Strait. As not all AW (>2°C) enters the Arctic Ocean, some of it "recirculates" from the eastern to the western side of Fram Strait. This recirculating AW and the AAW join and form the East Greenland Current (EGC) which flows southward along the East Greenland shelfbreak in Fram Strait. When the mixture of AW and AAW in the EGC moves southward and onto the Greenland shelf, we call it Atlantic Intermediate Water (AIW).

The East Greenland Current (EGC) represents the major export route of liquid freshwater and sea ice from the Arctic Ocean. It has long been established that the EGC is fed by Polar Surface Water (PSW) by the Transpolar Drift (Carmack et al. 2016), which provides an upstream connection to the Laptev Sea, a major formation region of sea ice (Krumpen et al. 2019) affected by Atlantification (Polyakov et al. 2017). The amount of Pacific origin water in the PSW exiting the Arctic Ocean through Fram Strait changes on interannual time scales (Dodd et al. 2012). In hydrographic sections along the EGC south of Fram Strait to Denmark Strait, (Håvik et al. 2017) demonstrate the presence of AIW below the PSW above. Thereby the EGC is found to be split into 3 branches, a shelfbreak EGC, an outer EGC further offshore and a jet transporting PSW inshore of the shelfbreak. Based on sections across the shelfbreak within Fram Strait, both Falck et al. (2005) and Richter et al. (2018) show that AW recirculating westward from the WSC across Fram Strait is not present at the East Greenland shelfbreak north of ~79.5°N. Rather, in northern Fram Strait, below the PSW, there is a broad outflow of AAW returning from its long journey around the Arctic Ocean proper. How the circulation connects to the flow of AAW further upstream within the Arctic is not known for lack of observations. We hypothesize that a boundary current exists along the northeastern and northern shelfbreak of Greenland. It likely feeds an important contribution to the East Greenland Current in Fram Strait. The structure, strength, variability, and the properties carried by this boundary current are unknown and, to this day, present a blank space of lacking oceanographic knowledge on the map.

The inflow of AW into the Arctic Ocean and along the Eurasian continental slope is well known in terms of its dynamics, strength, and variability from mooring array-based observations north of Svalbard at 30°E (Pérez-Hernández et al. 2019), Zervernaya Semlya at 95°E (Ruiz-Castillo, et al. 2022), and in the Laptev Sea at 126°E (Pnyushkov et al. 2021). Aksenov et al. (2011) described an Arctic Ocean Boundary Current of both AAW and halocline waters around the entire rim of the Arctic Ocean. However, the evolution of the Atlantic Water flow east of 126°E is less clear, where it may split into three branches, along Lomonosov and Mendeleyev Ridges (Woodgate et al. 2001) across the central Arctic Ocean toward North Greenland, and along the continental slope of the Canada Basin into the Lincoln Sea (Karcher et al. 2012; Newton & Sotirin 1997; Rudels et al. 1994). The partitioning into the three branches is related (besides topographic steering) to the large-scale wind forcing (Smith et al. 2021). As we approach the Greenland shelf in the Lincoln Sea, the situation is less clear, as the eastward flow in the boundary current system reaches a speed maximum in the AW layer but not in the halocline waters above (Aksenov et al. 2011; Newton & Sotirin 1997). Using satellite altimetry, Doglioni et al. (2023) describe a coherent wintertime strengthening of the entire Arctic boundary current between Barents Sea and Alaska, but they found no such signal north of Greenland.

The above discussion indicates a boundary current north of Greenland that feeds AAW into the East Greenland current, e.g. de Steur et al. (2014) detect AAW in long-term observations of Fram Strait moorings. To date, however, nobody observed the strength, structure, or variability of this boundary current. It is thus unclear whether the AAW flow north of Greenland constitutes a well-defined boundary current or a diffusive circulation branch. The flow structure impacts the residence time of AAW in the Arctic Ocean and thus affects how the Arctic Ocean heat content varies.

In order to diagnose the potential circulation north of Greenland, we conducted and assessed a model simulation using the global ocean-sea ice model FESOM2.1 at 4.5 km horizontal resolution in the Arctic Ocean (McPherson et al. 2023). It shows a coherent, narrow, and eastward moving boundary current within the AAW layer at 295-m depth. This boundary current feeds into the Fram Strait EGC after it is strengthened by additional supply of AAW from the Lomonosov Ridge and after it is steered offshore around Morris Jesup Rise. In contrast, the surface layer circulation at 60 m appears less impacted by bottom topography. Surface waters along the Lomonosov Ridge move eastward as a broad flow toward Morris Jesup Rise, where the waters move onto the shelf to feed a coastal current that enters Nares

Strait (Münchow, 2016) while there also exists evidence that fresh PSW is fed to Fram Strait from north of Greenland (Dmitrenko et al. 2019).

We expect large shelf-slope exchanges as observed to the west off Svalbard (Kolås et al. 2020). For example, an Ekman bottom boundary layer over the slope may advect buoyant water across the slope (Kolås & Fer, 2018) resulting in unstable vertical stratification and mixing. Alternatively, baroclinic instability may form eddies of EGC shelf waters (Koenig et al. 2018). While such processes are observed on Arctic shelves, we know little on dominant processes on the northern shelf of Greenland. Investigating such exchange processes, we will understand the dynamics and water mass transformation along the flow's path towards the EGC in Fram Strait. Mixing will influence both biogeochemical cycles and ecosystem dynamics.

One prominent example of rapid glacier retreat in Northeast Greenland is the collapse of the floating ice tongue of Zachariæ Isstrøm (ZI) (Mouginot et al. 2015). The largest remaining floating ice tongue of Greenland is the neighboring Nioghalvfjerdsfjorden Glacier which is also known as the 79 North Glacier (79NG). Together, ZI and 79NG drain the Northeast Greenland Ice Stream (NEGIS) – encompassing 15% of the total area of the Greenland ice sheet. Continuous thinning of the 79NG tongue by up to 30% has occurred over the past 20 years (Mayer et al. 2018), caused by increased melting along the ice tongue base (Mayer et al. 2018; Wilson et al. 2017), driven by ocean heat fluxes. Münchow et al. (2020) demonstrated the existence of a year-round, subsurface pathway of warm saline AIW from the shelfbreak following Norske Trough all the way to the 79NG. Consistent with the decadal warming of AW in the WSC, the AIW on the shelf close to 79NG has warmed by 0.5°C and there has been a vertical redistribution of principal water masses on the shelf (Gjelstrup et al. 2022). Once reaching the calving front of the 79NG, the inflow of AIW into the cavity of the 79NG is hydraulically controlled by a local bathymetric sill-system (Schaffer et al. 2020). This means, the height of the layer of AIW above the sill ultimately controls the ocean heat transport into the cavity and thus the melting of the glacier from below, which we can explicitly resolve with the FESOM2.1 model. Using annual-mean, mooring-based estimates of ocean heat transport into the cavity, the basal melt rates below the floating ice tongue of 79NG were estimated to be 10.4±3.1 m/yr (Schaffer et al. 2020) which compare favorably with a snap-shot melt rate estimate of 8.6±1.4 m/yr by Huhn et al. (2021), based on water samples of noble gas concentrations using helium (He) and neon (Ne).

The first ever hydrographic measurements close to the calving front of the ZI (Schaffer et al. 2020) revealed that it is exposed to warm AIW just like 79NG. We thus suspect the increased ocean heat supply to have caused the collapse of the ZI. Using numerical modeling based on the FESOM model, McPherson et al. (2023) showed that temperatures on the shelf of Northeast Greenland correlate with those in the WSC with a 3-year lag. In addition, wind forcing anomalies over the Barents Sea significantly strengthen both the AW flow within the WSC and the recirculation branches on interannual time scales, while the export of AAW along the shelfbreak is weakened. Regional wind patterns may thus control the relative contributions of warm AW and colder AAW to the AIW. Despite an emerging long-term warming of the AIW on the shelf of Northeast Greenland, neither the interannual temperature variability of AIW nor the role of AAW, AW and PSW to drive it are known. Our analysis of mooring-based observations at the calving front of the 79NG since 2016 revealed a cooling of the AIW since 2018 exceeding 0.5°C, and goes along with marked weakening of the heat transport into the cavity. PS150 EGC-Sources will conduct observations that will explain how changes in the AW branches and AAW outflow affect basal melt of the 79NG.

Only two other outlet glaciers of the Greenland Ice sheet retain major floating ice tongue: They are Petermann Glacier which drains 4% of the Greenland Ice sheet area and Ryder Glacier. Both are located within fjords on the coast of North Greenland and are thus affected by water masses in the Lincoln Sea. There is strong evidence that they are exposed to the inflow of AAW (Jakobsson et al. 2020; Münchow et al. 2016). The sill-controlled inflow of AAW appears to be particularly critical for determining the basal melt rate of Ryder Glacier (Nilsson et al.

2023), who emphasize that an increase in AAW interface height in the Lincoln Sea increases the basal melt rate. Petermann Glacier, unlike the other glaciers, appears to be in a melt controlled rather than a hydraulically controlled state with basal melt rates sensitive to rising AAW temperature. Another major marine terminating glacier of Northeast Greenland is the Flade Isblink Ice Cap near Wandel Sea. It is the largest peripheral ice mass of Greenland and exhibits a small floating ice tongue (Bendtsen et al. 2017). Here, however, the bottom water interacting with the ice tongues is PSW close to the freezing point, so that melting is controlled by seasonal warming of the surface water during sea ice retreat in the summer. PS150 EGC-Sources will determine both of these control parameters (AAW temperature and interface height, PSW properties) in the Lincoln Sea and Wandel Sea.

Ocean-glacier interaction also concerns the impact of the meltwater on the ocean. Huhn et al. (2021) showed that the basal meltwater from the 79NG stays at a depth range of 100-200 m, i.e. roughly at the interface of AIW and PSW while it dilutes from the calving front towards the shelfbreak and the EGC. We thus expect the melt rates to play a significant role for circulation close to the Greenlandic coast, but not within the EGC. The light and hardly soluble noble gasses helium (He) and neon (Ne) provide a unique tool to identify submarine meltwater, to quantify its fractions, and to trace its further pathways inside the ocean (e.g. Huhn et al. 2021). So far, noble gas observations in the northern part of Greenland are restricted to shelf regions around the 79NG. The PS150 EGC-Sources will explore the meltwater signatures of the other North Greenland floating ice tongues to the EGC.

Work at sea

We will deploy the CTD-rosette with lowered-ADCP attached at as many stations as possible given the expected sea ice conditions. We will operate the vessel-mounted ADCP throughout the cruise. At selected stations, we will deploy a microstructure probe. Where ice conditions do not allow operation of the regular CTD and from the helicopter, we will deploy XCTDs. We will deploy a mooring array north of Greenland and recover a small number of moorings deployed during PS131 in 2022. For the mooring recovery, we will operate a small remotely operated vehicle. To access areas that are uncharted or too shallow for *Polarstern* or too close to the calving front of tidewater glaciers, we will operate an uncrewed surface vehicle. We will deploy various oceanographic ice tethered instruments during sea ice stations.

We aim to occupy the following sections:

79.6N	Start point CTD section with 30 stations	7	18.00	W	79	36.00	N
79.6N	End point CTD section with 30 stations	9	0.00	E	79	36.00	N
79NG	Start point CTD section with 10 stations	19	0.00	W	79	30.00	N
79NG	End point CTD section with 10 stations	15	24.00	W	79	30.00	N
Flade	Start point CTD section with 20 stations	12	0.00	W	81	39.00	N
Flade	End point CTD section with 20 stations	7	30.00	W	82	30.00	N
Wandel	Start point CTD section with 20 stations	19	12.00	W	82	39.00	N
Wandel	End point CTD section with 20 stations	10	54.00	W	83	18.00	N
Peary	Start point CTD section with 20 stations	26	0.00	W	83	24.00	N
Peary	End point CTD section with 20 stations	15	30.00	W	83	54.00	N
Lincoln	Start point CTD section with 20 stations	36	0.00	W	83	36.00	N
Lincoln	End point CTD section with 20 stations	41	30.00	W	84	42.00	N

The following mooring operations are planned:

Y8-1	Mooring recovery	3	10.27	E	81	18.82	N
VMF-1	Mooring recovery	14	29.10	E	77	38.50	N
WF-2	Mooring recovery	15	42.70	E	79	30.30	N
79N1-4	Mooring recovery	19	27.58	W	79	34.13	N
79N1-5	Mooring deployment	19	27.58	W	79	34.13	N
79N Heli-01	Mooring deployment	19	46.64	W	79	26.40	N
79N Heli-02	Mooring deployment	19	20.56	W	79	35.06	N
IdF3-2	Mooring recovery	15	43.12	W	78	10.73	N
IdF3-3	Mooring deployment	15	43.12	W	78	10.73	N
GG1	Mooring and buoy deployment	25	0.00	W	83	24.00	N
GG2	Mooring and buoy deployment	23	36.00	W	83	30.00	N
GG3	Mooring and buoy deployment	22	6.00	W	83	36.00	N
GG4	Mooring and buoy deployment	20	42.00	W	83	42.00	N
GG5	Mooring and buoy deployment	19	18.00	W	83	48.00	N
GG6	Mooring and buoy deployment	17	54.00	W	83	54.00	N
GG7	Mooring deployment	25	28.00	W	83	22.04	N
GG8	Mooring deployment	25	32.00	W	83	21.76	N
GG9	Mooring deployment	25	36.00	W	83	21.48	N

Expected results

We expect that we will acquire a number of cross-shelfbreak oceanographic sections that can show the structure of the boundary current along the upper continental slope north of Greenland. We expect this to show a complete absence of Atlantic Water and moderate transport of Arctic Atlantic Water. The Polar Water layer is expected to be thick which combined with weak velocities would indicate moderate transport. We expect not to find Atlantic Water in the fjord systems of northern Greenland.

Data management

All environmental data obtained during this expedition 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. Unless specified otherwise, a CC-BY license will apply. Measurements from autonomous systems, which transmit data in near real time via satellite communication, will be made immediately available through the data and information portal https://www.meereisportal.de/. 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 is supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 2, Subtopic 2.1.

In all publications based on this expedition, the **Grant No. AWI_PS150_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. PLANKTON ECOLOGY AND BIOGEOCHEMISTRY IN THE CHANGING ARCTIC OCEAN (PEBCAO GROUP)

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Grant No. AWI_PS150_02

Objectives

The PEBCAO group (Plankton Ecology and Biogeochemistry in a Changing Arctic Ocean) is a collaboration team between colleagues from AWI and GEOMAR focusing on plankton community ecology and the microbial processes relevant to biogeochemical cycles of the Arctic Ocean (AO). The work of this group is of particular relevance, considering that the Arctic Ocean is currently undergoing considerable environmental change with the pronounced decrease in sea ice and increase in temperature, given the latter being nearly four times faster than the global annual average during the last four decades (Rantanen et al. 2022). This phenomenon, known as the Arctic Amplification (Serreze and Barry 2011), arises primarily from interacting feedbacks such as sea-ice loss that enhances heat absorption, along with changes in atmospheric and ocean heat transport. Arctic amplification leads to prominent changes that impact the biogeochemistry and ecology of the Arctic pelagic system; detailed monitoring of existing conditions is therefore vital.

The PEBCAO group began its studies on Arctic plankton ecology in 1991. Since 2009 it intensified its efforts by accomplishing yearly long-term observations in the framework of the Long-term Ecological Research Site HAUSGARTEN in the Fram Strait. Over the past decade, the regular observations of the PEBCAO-group included a combination of classical bulk measurements of biogeochemical parameters, microscopy, optical methods, satellite observations, and molecular genetic approaches in a holistic approach. By doing so, we have compiled comprehensive information on annual variability in plankton composition, primary production, bacterial activity and zooplankton composition, including key ecosystem processes such as carbon export. 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 the Fram Strait (e.g., Nöthig et al. 2015, 2020; Metfies et al. 2016; Engel et al. 2019; von Appen et al. 2021).

During the PS150 expedition, we will continue these observations and cover an extended area beyond the HAUSGARTEN region by focusing on the Western Fram Strait, Northeast Greenland shelf, North Greenland shelf including the Wandel Sea and Lincoln Sea. Within the PEBCAO, research and observational work will be undertaken by seven subgroups, addressing both specific disciplines and cross-disciplinary topics. In this chapter we elaborate our topics below and summarize accordingly the objectives and the work onboard.

I. The role of picophytoplankton in the carbon cycle

Picophytoplankton are the smallest group of phytoplankton (<3 µm) and commonly dominate the community of primary producers in the Arctic Ocean (e.g., Tremblay et al. 2009; Metfies et al. 2016), especially in nutrient-poor areas (Iversen and Seuthe 2011; Ardyna & Arrigo 2020). They are key players in the Arctic ecosystem, and in some regions, a shift from larger phytoplankton such as diatoms towards smaller groups is observed (Li et al. 2009; Nöthig et al. 2015; Metfies et al. 2016). This shift is predicted to continue with the progression of climate change (Flombaum et al. 2020; Oziel et al. 2025). The role of picophytoplankton in the marine carbon cycle (e.g., how much carbon they fix, what they are regulated by, how much they sink out of the water column and contribute to the biological carbon pump (Bachy et al. 2022), and what their importance is as prey) is still poorly understood in the Arctic Ocean in general. Better knowledge of the biogeochemical and ecological roles of picophytoplankton in the Arctic Ocean is needed. We will study the role of picophytoplankton in the autumn carbon cycle. We will do so by assessing their abundance, primary productivity, and downward export over environmental gradients (e.g., from tidewater glaciers, coastal areas, and sea ice). Further, we will experimentally quantify and characterize the carbon flow from a key picophytoplankton species (*Micromonas polaris*) to grazers and into the microbial loop.

The increasing prevalence of autumn phytoplankton blooms (Ardyna & Arrigo 2020) is an important feature with biogeochemical impacts on the overall Arctic Ocean carbon budget and its sequestration potential, as well as ecological impacts and interactions in the ecosystem. Declining sea ice causes increased wind-driven mixing and momentum transfer to the ocean (Muilwijk et al. 2024). Abrupt sea ice decline is described in the PS150 study area of the Last Ice Area (Wandel Sea) (Schweiger et al. 2021). We will on this basis experimentally investigate how vertical mixing can impact the development of autumn blooms in our study area by mimicking mixing events and following the ecological and biogeochemical responses of phytoplankton and their primary productivity.

As an overarching framework of our work, we aim to better bridge rate measurements (e.g., primary production) with DNA- and RNA-based molecular approaches (e.g., amplicon sequencing) by integrating traditional and emerging methods in both observational (e.g., quantification of group-specific Rubisco as a proxy for primary production, Roberts et al. 2024) and experimental approaches (e.g., performing RNA-stable isotope probing experiments to trace and quantify carbon flux between trophic levels, Motwani and Gorokhova 2013; Orsi et al. 2018). We will furthermore isolate pelagic and sympagic picophytoplankton to enable future ecophysiological studies at the Kalmar Algae Collection (KAC) of Linnaeus University in Sweden. The following objectives will be addressed by the picophytoplankton team:

- Measure size-fractionated particulate primary production and dissolved primary production through stable-isotope tracing.
    - Assess the impact of autumn vertical mixing on phytoplankton and primary production.
    - Evaluate the usability of Rubisco quantification as an indicator of group/species-specific primary production.
- Investigate phytoplankton in sinking marine snow, with a focus on the contribution and mechanisms of sinking picophytoplankton.
    - Characterize sinking particulate matter with an underwater vision profiler (UVP5) in parallel.
- Experimentally quantify and characterize the carbon flow from a key picophytoplankton (*Micromonas polaris*) into the grazer community and the microbial loop.
- Isolate Arctic picophytoplankton strains for downstream ecophysiological studies.

II. Connectivity between sea ice and the upper pelagic during freeze-up

Sea-ice algae are a critical component of polar food webs, contributing up to 60% of primary production in ice-covered waters, and providing the primary source of nutrition during the early phases of seasonal zooplankton reproduction (Søreide et al. 2010; Fernández-Méndez et al. 2015). As early-season primary producers, the colonisation of sea ice-algae during the ice formation period plays a foundational role in energy supplied to the marine ecosystem. Despite this importance, the composition and dynamics of both sympagic (ice-associated) and pelagic (open-water) microalgal communities during the freeze-up period remain poorly understood. There is an indication that sea-ice algae are recruited from the water column as the sea-ice community is a function of sea-ice origin (Hardge et al. 2017) Improving our understanding of the connectivity between microalgal communities in the sea ice and the underlying water column - including which species are present, their abundance, physiological condition, nutritional quality, and mechanisms of colonization - is essential for predicting how ongoing sea-ice decline will alter trophic dynamics and carbon cycling in polar ecosystems.

The main aim of the sea ice work is to investigate the interactions between under-ice water and bottom-ice phytoplankton communities during the freeze-up period (autumn). To provide rare insights into phytoplankton community composition during the ice-formation period, we will determine species' presence and abundance through molecular and taxonomic methods. To better understand the phytoplankton physiological state and role in the food-web, we will determine the nutritional value of the community and of key taxa through a combination of fatty-acid analysis and single-cell biomolecular investigation. We will quantify extracellular polymeric substances (EPS) in under-ice water and bottom ice with the aim of better understanding the incorporation/interaction of cells between water and ice in sea ice in autumn. Occasionally, we will collect samples for fluorescence-activated cell sorting (FACS) for sequencing of individual cells and/or populations of photosynthetic picoeukaryotes (PPE), allowing comparison of the PPE populations in under-ice water, bottom ice, and the upper epipelagic and identification of ecotypes. The following objectives will be addressed by the sea ice algae team:

- Determine sympagic and pelagic phytoplankton community structure and abundance during the freeze-up period.
- Investigate the nutritional value of the sympagic and pelagic phytoplankton communities as a whole, and of key taxa.
- Assess the role of EPS in sympagic community colonisation during the freeze-up period, by quantifying EPS production in different ice types and environmental conditions.

III. Phytooptics: phytoplankton and dissolved organic matter from highly resolved optical measurements

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 the analysis of long-term trends of these parameters in the East Greenland region via the complementation to satellite and previous field data acquisition. During the expedition, continuous measurements with optical sensors will be taken at the surface water and also at discrete stations with the light profiler.

Time series of phytoplankton community structure have been obtained using in situ data derived from our underway sampling and continuous flow-through system and have revealed remarkable interannual variability in the last decade in the Fram Strait (Bracher et al. 2025, submitted). In addition to that, these in-situ data are also beneficial for the model development and validation of satellite products on phytoplankton composition and its distribution (EOF-PFT Xi et al. 2020, 2021; PhytoDOAS Bracher et al. 2009; Sadeghi et al. 2012; ML-PhyTAO Xi et al. 2025) and spectral attenuation of underwater light (Dinter et al. 2015; Oelker et al. 2019; Oelker et al. 2022).

At this expedition we focus to broaden our sampling frequency of information on phytoplankton, particulate and chromophoric dissolved organic matter (CDOM) abundance and composition by taking continuous optical measurements which directly give information on inherent and apparent optical properties (IOPs, and AOPs, respectively). The specific objectives of PhytoOptics are to

- Collect a high spatial and temporal resolved data set on phytoplankton (total and composition) and its degradation products at the surface and for the full euphotic zone using continuous optical observations during the cruise and from ocean colour remote sensing calibrated with discrete water sample measurements.
- Develop and validate (global and regional) algorithms and associated radiative transfer models in accordance to the previous objective by using discrete water samples for pigment analysis and absorption measurements.
- Obtain a spectral characterisation of the underwater light field and its interplay with optical constituents, such as phytoplankton and CDOM abundance and composition.
- Improve our cal/val activity within Copernicus Marine Service.

IV. eDNA based analysis of arctic eukaryotic and prokaryotic microbial communities

The distribution, thickness, and melt dynamics of sea ice are key drivers of community composition, productivity, biogeochemical cycling, and pelagic-benthic coupling in the AO, while the biodiversity and composition of eukaryotic microbes of pelagic eukaryotic microbial communities are distinct from sea-ice communities (Hardge et al. 2017). Sea-ice associated microalgae, those living attached to or under the ice e.g. diatoms are important food sources of zooplankton (Kaiser et al. 2025). In Fram Strait, the two major currents harbor distinct microbial communities (Metfies et al. 2016), with sea-ice coverage as a major driver of these differences in community composition. The role of sea-ice and meltwater stratification as a driver of Arctic marine ecosystem functionality and pelagic benthic coupling was highlighted in recent studies accomplished in Fram Strait as part of the FRAM observatory and a number of expeditions to LTER HAUSGARTEN since 1999 (von Appen et al. 2021; Weiss et al. 2024). However, information on eukaryotic microbial community composition and biomass from areas with year-round ice-coverage are scarce, especially for picoeukaryotes. In order to comprehensively capture the biodiversity and Chal a biomass in areas with year-round ice-coverage we will complement the optical surveys with 18S meta-barcoding and fractionated chlorophyll a (Chla) measurements. 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.

V. ARJEL: Zooplankton

Fram Strait is not only impacting primary producers, but also higher trophic levels. Zooplankton are tightly bound to the water masses they inhabit, drifting with dominant currents, and their physiology is finely tuned to the thermal gradients they experience. Hence, poleward shifts of zooplankton species have already been witnessed in the Atlantic Arctic (e.g., Schröter et al. 2019; Caspó et al. 2021). One group for which poleward range shifts are expected with further climate warming and sea-ice retreat, and abundances projected to increase in the Fram Strait area, are gelatinous zooplankton (Pantiukhin et al. 2023, 2024). Despite major knowledge gaps persisting on their role in the food web, gelatinous zooplankters can exert major top-down pressures on meso- and macrozooplankton (Irvine et al. 2025) and serve as prey for other plankton and fish more commonly than was historically assumed, also in high-latitude ecosystems (e.g., Dischereit et al. 2024a, 2024b). Previous studies on gelatinous zooplankton in Fram Strait have shown that environmental DNA (eDNA) methods based on the cytochrome *c* oxidase I gene region provide a cost-effective tool to complement net catches and optical studies for diversity assessments (Murray et al. 2024).

The objectives of the ARJEL team are:

- Investigating pelagic and under-ice metazoan communities using eDNA analyses of the mtDNA COI region on filtered seawater, which will be sampled with the CTD rosette and manually deployed water sampler casts under the sea ice.
- Analyzing net samples using the Midi Multi-net and Bongo nets, as well as the images obtained with the Underwater Vision Profiler UVP5, to assess (macro-)zooplankton communities, with a focus on gelatinous zooplankton, in order to continue ongoing studies on zooplankton diversity and their ecological roles in Fram Strait, in complement with the aforementioned eDNA studies.

VI. Microbial communities and biogeochemistry (MB)

To address the effects of global change and anthropogenic pollution on the microbial community and biogeochemistry in the Arctic Ocean, the MB team will:

- Continue to monitor the concentrations of organic carbon and nitrogen, amino acids, and carbohydrates
- Assess abundances of phytoplankton, bacteria, and viruses using flow cytometry.

To better understand the potential risks of microplastics to human and ecosystem health, the team will also study the microbial community on microplastics, focusing on potential pathogens and their resistance mechanisms against antibiotics using field and laboratory experiments.

VII. Plankton imaging

The goal of the imaging-based plankton work in the PEBCAO group (manual microscopy as well as semi-automatic analyses based on instruments such as the underwater vision profiler and PlanktoScope) is to analyse community structure of the phytoplankton and zooplankton communities in different water masses and in relation to ice conditions. One focus is also to examine associations between planktonic organisms especially diatoms and their protistan parasites but also copepods and their external parasites.

Contributing to the general scientific aims of PEBCAO, the summarized objectives on EGC Sources (PS150) are:

- Characterise plankton distribution and biomass both horizontally and vertically at the meso-scale with high resolution in the Northeast and east Greenland ice shelves and adjacent sea areas.
- Analyzing the abundance, biodiversity and community structure of sea ice-associated biota and quantifying ecosystem functions and their relationships with biodiversity.
- Further understand the role of picophytoplankton in the marine carbon cycle and investigate the interactions between under-ice water and bottom-ice phytoplankton communities during the freeze-up period (autumn).
- Continue ongoing studies on zooplankton diversity, especially gelatinous zooplankton, and their ecological roles in Fram Strait.

- Elucidate cryo-pelagic coupling of microbial (prokaryotic and eukaryotic) communities with respect to small scale differences in water column structuring.
- Characterise the underwater light field and its interplay with optical constituents, such as phytoplankton and CDOM abundance and composition.
- Analyse community structure of the phytoplankton and zooplankton communities in different water masses and in relation to ice conditions.
- Address the effects of global change and anthropogenic pollution on the microbial community and biogeochemistry.

Work at sea

I. The role of picophytoplankton in the carbon cycle

The aforementioned objectives will be targeted through the collection of water from the CTD/rosette sampler at 2-5 depths in the upper 200 m. We will regularly (~15-20 stations):

- Perform size-fractionated primary production measurements (stable isotope tracing using ^{13}C-labelled bicarbonate) from the surface and the deep Chla maximum. We will measure both particulate primary production (carbon fixed into cells) and dissolved primary production (exuded carbon from the cells). Water is incubated in bottles in an on-deck tank with continuously flowing surface water to mimic in situ temperatures. Samples are collected at time 0 (T_0) and after 24 hours (T_{24}) for: elemental analyser isotope ratio mass spectrometry (EA-IRMS), dissolved inorganic carbon (δ 13C-DIC), dissolved organic carbon (δ 13C-DOC), and DNA (for quantitative PCR of picophytoplankton).
- Sample for flow cytometry (quantification of cell abundances of bacteria, pico- and nanoplankton, and heterotrophic nanoflagellates) from the five PEBCAO standard depths.
- Perform marine snow catcher deployments to sample actively sinking marine snow particles for characterization and quantification of the contribution of picophytoplankton. A marine snow catcher of 100 L is filled at 10 m below the Chla maximum and left on deck to sediment for 2-6 hours, enabling individual particles to be collected from a tray at the bottom. The remaining water volume will be split into suspended and sinking material. Samples are collected for: DNA, flow cytometry, EA-IRMS, TEP, CSP, and pigments (HPLC). A UVP will be attached to the CTD for optical characterization of marine snow in parallel.

We will, occasionally (~3-5 stations):

- Perform mixing experiments to test if the addition of nutritious deeper water (simulating wind-induced mixing) influences primary productivity in the different size fractions.
- Collect samples for downstream fluorescence-activated cell sorting (FACS) and sequencing of individual cells and/or populations of photosynthetic picoeukaryotes (PPE).
- Collect samples for quantification of group/species-specific Rubisco quantification of different phytoplankton in parallel to primary production quantification.
- Perform RNA-stable isotope tracing experiments with labelled cultures of *Micromonas polaris.* One experimental treatment receives labelled *M. polaris* cells, and a second treatment receives labelled dissolved organic matter of *M. polaris*. We collect samples for EA-IRMS, RNA, DOC, and flow cytometry.
- Isolate pelagic and sympagic picophytoplankton for downstream ecophysiological studies at Linnaeus University.

II. Connectivity between sea ice and the upper pelagic during freeze-up

Sea ice stations will be performed (up to 8 stations), aiming to target different types of ice (e.g., multi-year ice, first-year ice, land-fast ice, sea ice in fjords of tidewater glaciers). Sea ice cores will be collected and split into 4 sections (top, middle 1, middle 2, bottom) for biological, chemical, and biogeochemical analyses during individual ice stations. We will sample brine from sack holes and collect under-ice water with a bilge pump. We will collect samples for the following: snow depth, ice porosity, salinity, freeboard, ice thickness, inorganic dissolved nutrients, abundance of microorganisms (flow cytometry), algae biomass and composition (determined by marker pigments), particulate organic carbon (POC), DNA, cell counts (microscopy), biogenic silicate, transparent exopolymer particles (TEP), Coomassie stainable particles (CSP), fluorescence-activated cell sorting (FACS) for sequencing of individual cells and/or populations of photosynthetic picoeukaryotes, synchrotron Fourier transform infrared spectroscopy (s-FTIR), and fatty acids.

III. Phytooptics: Phytoplankton and dissolved organic matter from highly resolved 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 (ideally noon-time) CTD stations:

- Continuous measurements of inherent optical properties (IOPs) with a hyperspectral spectrophotometer: For the continuous underway surface sampling, the HyperSpecBox mounted with 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 connected 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 HyperSpecBox 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.
- 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 in the water profile.
- Discrete measurements of IOPs (absorption) at water samples are performed 1) for samples from the underway surface sampling 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).

- Samples for determination of phytoplankton pigment concentrations and composition are also taken at a 3-hourly interval from the underway-sampling system, and from Niskin bottles at 6 depths (max. 100 m) during 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, and will be analyzed by High Performance Liquid Chromatography Technique (HPLC) at AWI.

IV. Biodiversity and Chla biomass of eukaryotic microbes

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 and at 5-6 different depth in the photic zone using Niskin-bottles mounted on a CTD rosette. Using the AUTOFIM, we will collect seawater samples at regular intervals (~ 1° longitude/latitude on the way through the study area, while the CTD will be sampled at defined stations in coordination with other parameters. From the Niskin bottles, we will also sample for measuring the following parameters to assess biogeochemistry and phytoplankton biomass. This includes total and fractionated (>3 µm and >3 µm) Chla concentration, and particulate organic carbon and nitrogen (POC, PON).

V. ARJEL: Zooplankton studies

Macrozooplankton will be investigated using the Midi-Multinet and Bongo nets that will be deployed vertically and towed alongside the ship, respectively. The Midi-Multinet allows for vertically stratified sampling; standard multi-sampling depths are 1,500–1,000–500–200–50 m, but these will be adapted to match CTD rosette water sampling for eDNA studies. Water sampling for eDNA metazoan studies will be taken from the CTD rosette and from the under-ice layer using a small water sampler. Seawater will be filtered over Sterivex filters and frozen at 80°C until further processing in the home laboratories. GoPro footage will also be taken from the under-ice environment to compare with the results of the eDNA and eRNA analyses. We will also use the UVP5 mounted on the ship's CTD rosette to investigate small-scale vertical distribution patterns.

VI. Microbial communities and biogeochemistry (MB)

To investigate the effects of global change and anthropogenic pollution on the microbial community and biogeochemistry in the Arctic Ocean, the MB team will continue to monitor the concentrations of dissolved organic carbon and nitrogen, as well as specific compounds such as amino acids and carbohydrates. Furthermore, we will continue to assess cell abundances via flow cytometry to determine the distribution of phytoplankton, bacteria, and viruses. Additionally, during PS150, we will attempt to collect microplastic particles (> 300 µm) at selected stations from the surface water via the underway system and analytical sieves. If successful, analysis of the biodiversity and function of plastic-associated microbes as compared to their free-living counterparts is feasible, using 16S rRNA gene amplicon sequencing, metagenomics, and metatranscriptomics. A special focus is given on potential pathogens and their resistance mechanisms against antibiotics. This will allow us to estimate the potential risks of microplastics to human and ecosystem health. All parameters except microplastic particles will be sampled from the water column using a CTD/rosette sampler. At selected stations, amino acids and carbohydrates will be sampled to cover a representative depth distribution to investigate the export of carbon into the deep sea. These samples will be preserved or frozen at 4°C, -20°C or -80°C and analysed in the laboratory at GEOMAR:

- Dissolved organic carbon (DOC)
- Total dissolved nitrogen (TDN)

- Dissolved combined carbohydrates (dCCHO)
- Hydrolysable amino acids (dAA)
- Phytoplankton, bacterial, and viral abundance
- Microplastic particles
- DNA/RNA

Incubation experiments with environmentally relevant polymers will also be carried out. Previous sampling attempts of naturally occurring microplastic particles in the Arctic Ocean, drawing water from the ship's "Spargel", have proven to be difficult, as no particles were found during previous cruises (PS143/1 and 2). Therefore, we conducted an incubation experiment with surface water (10 m depth) collected from the CTD rosette. During PS150, we will set up the same experiment, using a total of 27 glass jars (1.8 L), filled with surface water, and incubate seven different polymers in triplicate at 4°C. The experiment will be set up during PS150 and shipped at 4°C to GEOMAR, where biofilms will be collected and DNA and RNA extracted. To investigate the biodiversity and function of plastic-associated bacteria, focusing on potential pathogens and their resistome, we will utilize 16S rRNA gene amplicon sequencing, metagenomics, and metatranscriptomics.

VII. Plankton imaging

Phytoplankton

Phytoplankton samples will be taken from the CTD-Rosette (surface, above the Chla maximum (chl-max), chl-max and below chl-max). They will be fixed in Lugol iodine solution as well as Formalin for later analysis in the home laboratories after the cruise.

In addition, live samples will be obtained with oblique phytoplankton net hauls (20 µm mesh size) at all stations. The net samples will be analysed with the PlanktoScope device, a low-cost imaging device for high throughput sample analysis. The samples will be analysed on board and the resulting data sets uploaded to the ecotaxa database for validation. The net samples will also be analysed semi-quantitatively using inverted microscopy onboard for comparison with the PlanktoScope results.

Zooplankton

Zooplankton will be sampled using a Multinet (mesh size 150 µm) at 5 depth intervals (0-50, 50-200, 200-500, 500-1000 and 1000-1500 m). In addition, the UVP will be attached to the CTD frame to generate particle profiles with depth and thus provide an imaging record of the depth distribution of zooplankton taxa.

Preliminary (expected) results

Picophytoplankton and sea ice algae team

The results are expected to provide a better understanding of i) the size distribution of primary production and the degree of carbon exudation from the cells, ii) the composition of settling marine snow particles, iii) the role of picophytoplankton in the autumn carbon cycle, iv) connections between the sympagic and pelagic phytoplankton community structure and function during sea ice formation, and v) the use of EPS by sympagic microalgae during freeze-up. The results will be published in at least two peer-reviewed scientific articles and presented at international conferences. The collected samples are estimated to be analysed within two years of the end of the expedition.

Phytooptics

Directly on board we aim to analyse the HyperSpecBox data to derive the particulate absorption spectra, which will further elucidate the distribution of phytoplankton at the surface along the cruise transect through our established models. 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 controlled hyperspectral particulate and CDOM absorption, reflectance, diffuse attenuation and transmission data. These data then 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.

Zooplankton

eDNA and eRNA analyses from filtered seawater will be carried out in the laboratories of the Marine Zoology Group of Bremen University, under special conditions for eDNA metazoan work. COI libraries will be prepared and sent for NovaSeq sequencing. Multivariate and other statistical analyses will allow us to link environmental parameters with small-scale distributions of zooplankton and assess local and regional diversity patterns. Multi- and Bongo net samples will be investigated based on morphology; a subset of the bulk net samples will also be analyzed based on DNA metabarcoding. These results will be compared with those based on seawater eDNA and eRNA and with the optical surveys. Specimens of certain target taxa (gelatinous and crustacean macrozooplankton) will be preserved for molecular diet analyses and biomarker studies to uncover so-far hidden trophic links.

Plankton imagery

Preliminary quantitative data sets resulting from the PlanktoScope analyses and microscopy will be made available at the end of the cruise. These will give an indication of community composition and thus (potentially) different hydrographic regimes.

Data management

During PS150, we sample a large variety of interrelated parameters. Many of the samples 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 will be 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 (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, SRA, GenBank and DDBJ). Macrozooplankon samples and eDNA extracts will be kept for long-term storage in the laboratories of Marine Zoology at the University of Bremen. All plankton imagery related to the Planktocope will be archived online in the ecotaxa database (https://ecotaxa.obs-vlfr.fr/).

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, Subtopics 6.1 & 6.3, and the Helmholtz Young Investigator Group "ARJEL – Arctic Jellies" with the grant number VH-NG-1400.

In all publications based on this expedition, the **Grant No. AWI_PS150_02** will be quoted and the following publication will be cited:

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

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4. SEA-ICE PHYSICS

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Grant-No. AWI_PS150_03

Objectives

The sea ice in the Last Ice Area, the region north of Greenland, is considered one of the last regions where multiyear ice may survive in the future. The recent occurrence of polynyas, both in winter and summer, has raised questions to the state of the sea ice and its survivability. Ice thickness and drift observations are required to distinguish between thermodynamic and dynamic contributions to sea ice changes in the Last Ice Area. In this respect the sea ice physics work during EGC-Sources aims to

- observe late summer sea ice thickness variability and gradients in the Last Ice Area across and along the shelf related to different ice origins and deformational histories,
- evaluate relationships between occurrence of polynyas, ice thickness, and drift,
- characterize the physical properties of the sea ice in the Last Ice Area and along the drift into Fram Strait to observe seasonal changes in continuation of observations of previous expeditions (airborne and at sea), including the work of the preceding expedition PS149 (Contrasts) and IceBird Winter and Summer 2025.

Navigation through ice-covered waters is a key topic in the Arctic Ocean, including the realization of each single Polarstern expedition. We are currently using various kinds of sea ice information in (near) real time to support navigation and decision making on board. During EGC-Sources, we expect particularly difficult ice conditions, from the navigation point of view, as the expedition visits some of the thickest ice in the Arctic and reaches far into the freeze-up season. So, we aim to:

- systematically observe sea ice conditions along the cruise track and relate this to the vessel's performance,
- investigate which data are most suited to support ice navigation.

The EGC-Sources expedition will start during the summer sea ice extent minimum and experience the freeze-up of the ice pack and the ocean around this. Following the preceding Contrasts (PS149, ArcWatch-3) expedition, which focusses on the melt season, we aim to extend these observations into freeze-up, by:

- re-visiting some of the same ice already studied during Contrasts
- improving our knowledge of atmosphere-ice-ocean interactions, with particular emphasis on thermodynamic processes and sea ice's role as both a habitat and a barrier,

- observing sea ice formation processes as functions of atmospheric and oceanic boundary conditions.
- Enhancing our observational capabilities, testing new instruments and measurement systems in challenging Arctic conditions.

Work at sea

The field activities planned for EGC-Sources can be grouped into five main tasks. Most activities occur directly on the ice while the vessel is stationary, supplemented by helicopter and drone surveys around the ship. Routine observations and continuous remote-sensing measurements will also run along the transits between stations.

Task 1: Measurements during Ice Stations

We will conduct on-ice measurements aimed at quantifying sea ice, snow, and melt pond properties, as well as their distribution. These measurements will cover all relevant ice types and surface features present at each station.

- Sea Ice Thickness measurements along surface transects across the floe with GEM-2 electromagnetic sensors.
- Snow Depth measurements along surface transects across the floe with MagnaProbe sensors.
- Snow/Ice Surface Properties and sampling. Following MOSAiC-type protocols to measure snow and ice characteristics (temperature, salinity, density, stratigraphy)

Task 2: Airborne Measurements

Regional-scale observations of sea ice properties in the Last Ice Area will be carried out with airborne measurements. We will observe late summer sea ice thickness variability and gradients in the Last Ice Area across and along the shelf related to different ice drift origins, to evaluate relationships between occurrence of polynyas, ice thickness, and drift. The work represents a seasonal continuation of airborne surveys previously conducted in this region during July and August.

- Drone-based photo surveys (DJI Mavic 3, Matrice350) will be conducted at each station floe to map sea ice surface conditions. Images will be stitched for:
    - High-resolution surface classification
    - Surface elevation models (digital elevation maps)
- Helicopter-based Sea Ice Thickness measurements with the AWI EM-Bird along the cruise track through sea ice. This provides thickness distribution functions on scales of <60 nm around the ship. The data will also help to develop and refine this new EM Bird under various ice conditions.

Task 3: Re-visit of Contrasts (PS149) station

We aim to re-visit at least one ice floe that was already surveyed and equipped with autonomous instruments during CONTRASTS. At this station, we will try to gather an additional data set later in the season with all possible methods and approaches in order to observe temporal changes. Beyond the methods described in the other tasks, this will include:

- Operation of the AWI ROV system “Beast” with its interdisciplinary sensor suite. The ROV is deployed via a hole in the sea ice and can move within a radius of ~300 m, accessing different ice types.

- Recovery of autonomous stations and retrieval of data from the stations.
- Intensive documentation of the ice and surface conditions with photography (incl. airborne measurements)

Task 4: Autonomous Measurements / Seasonal Installations

We will deploy autonomous stations (buoys) along the cruise track, with focus on the sea ice stations. These instruments will continue drifting and transmitting data until they fail, extending observations beyond the expedition timeframe. Examples of planned autonomous stations:

- Snow Buoys measuring snow accumulation and basic meteorology.
- Sea Ice Mass Balance Buoys (type SIMBA) measuring temperature profiles (air/snow/ice/water), effective latent heat, and ice thickness.
- Seasonal Ice Mass Balance (Version 3, SIMB3) Buoys.
- Surface Velocity Profilers (SVP) measuring barometric pressure and partial surface temperature.

Task 5: On-Board Measurements

We will continuously observe the sea ice conditions along the cruise track. These data will directly be used to characterize and classify the sea ice and surface conditions. In addition, these data will be used, together with the retrieval of satellite data to actively support the navigation and tactical decisions of the vessel.

- Two panoramic cameras installed above the crow's nest will capture photographs or short videos (e.g., every 10 minutes). Some images may be transmitted in near-real time to a project website for outreach and public engagement.
- Standardized sea ice observations from the bridge, recording sea ice concentration, floe size, ridging, thickness, plus weather conditions and large fauna, within a ~1.5 nm radius.
- Ship-based electromagnetic ice thickness measurements with the Sea Ice Monitoring System (SIMS) to monitor ice thickness along the ship track.
- Measurements of solar (spectral) radiation are measured at the ship's bow along track. These data will support different other observations.

Expected results

We anticipate that our mass balance studies—encompassing airborne, on-ice, and buoy-based observations—will contribute significantly to the long-term record of sea-ice thickness changes in the central Arctic. In particular, we will compare observations from this expedition with previous efforts (e.g., Contrasts, MOSAiC drift, IceBird campaigns, and buoy data), providing fresh insights into the rapid thinning of sea ice along the Transpolar Drift and within different ice regimes.

The expedition will reveal a unique data set of sea ice thickness in the Last Ice Area during freeze-up. This includes sea ice thickness, roughness, and other ice properties. The combination of various methods will allow to discuss sea ice properties on different scales, based on helicopter surveys (EM Bird, cameras), ice station work (Ground EM, drilling, buoy deployments), and satellite data (SAR, optical, and altimetric satellite remote sensing). Parts of the surveys will revisit the same ice observed during earlier airborne and ship-based campaigns in 2025, to characterize seasonal changes.

The re-visit of sea ice stations of the Contrasts 2025 expedition will allow to extend the seasonal data set from the melt season into freeze-up. The re-visit will allow the Contrast's team to keep instruments running beyond their expedition and to receive, to some extent, an additional set of sea ice and snow samples. In addition, more regional snow and sea ice data will result from the additional ice stations along the cruise track, extending the spatial scales of the Contrasts measurements.

Alongside these ice-centric objectives, we also expect improved ship efficiency in ice-covered waters through the strategic use of satellite data, particularly Sentinel-1 and TerraSAR-X. Automated tools such as EDEN (a platform that corrects ice displacement in SAR images directly on board) should enhance real-time ice navigation, reduce travel times, and optimize fuel use. By comparing engine parameters, transit speed, and overall time saved while using or not using satellite-guided routes, we aim to demonstrate how advanced remote sensing can streamline polar operations.

Data management

All environmental data obtained during this expedition 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. Unless specified otherwise, a **CC-BY license** will apply. Measurements from autonomous systems, which transmit data in near real time via satellite communication, will be made **immediately available** through the data and information portal **meereisportal.de**. 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 is supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 2.1.

In all publications based on this expedition, the **Grant No. AWI_PS150_03** or, in case of multidisciplinary work, **AWI_PS150_00** 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.

5. GEOPHYSICS AND GEODESY

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Grant-No. AWI_PS150_04

5.1 Seismology

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Objectives

For a geologically old craton, Northeast Greenland shows remarkably strong earthquake activity focussed in three areas (Fig. 5.1): 1) seismicity in Peary Land near the Harder Fjord Fault Zone (HFFZ) and the Navarana Fjord Escarpment (NFE), 2) seismicity in the Wandel Sea parallel to the trend of the Trolle Land Fault Zone (TLFZ), and further south 3) the area between 78° and 80°N along the N-S trend of the Caledonian fold belt.

A key debate is, whether the present-day seismicity is a consequence of tectonic stresses induced by the nearby plate boundary in the Lena Trough or is generated by post-glacial and elastic rebound processes due to past and ongoing deglaciation (Chung 2002; Olivieri & Spada 2015). Glacially induced stress may reactivate pre-existing tectonic structures and may even trigger earthquakes with tsunami potential in the North Atlantic (Steffen et al. 2020). The concentration of seismicity along the coasts around Greenland supports the idea of seismicity related to deglaciation processes (Chung 2002).

While seismicity in areas 1 and 2 is likely related to known fault zones, the origin of the seismicity in area 3 between 78°N and 80°N, although following the general trend of the Caledonian orogen, may yet have another explanation: the seismically active area 3 coincides with shallow bathymetry (Arndt et al. 2015) near the Zachariae and 79°N glaciers, with frequent occurrence of weak seismic events at locations with water depths shallower than 200 m (Fig. 5.1). Warm ocean currents get access via narrow channels to these glaciers, speeding up disintegration processes (Schaffer et al. 2020), but the ice remains captured between islands and bathymetric highs aligned with the trend of the Caledonian orogen (Henriksen et al. 2000). Ground or mutual contact of icebergs is known to produce considerable seismic energy around Antarctica (Schlindwein 2023).

This highlights that the intraplate seismicity of Greenland is far from being understood, and - with earthquakes exceeding M_w 5-6 - may even pose a considerable seismic hazard (Voss et al. 2007). At the moment, the seismic risk may still be low but as the Arctic is rapidly warming and a blue Arctic Ocean is likely in the next few decades, increased human activities will ultimately result in an augmented exposure to seismic hazards.

Only a single permanent seismic station (NOR, Dahl-Jensen et al. 2010) is located near the three seismically active areas of Northeast Greenland, so little is known about the origin of the earthquakes. In addition, the sparse cover with seismic stations also results in poor locations of earthquake foci along the nearby plate boundary in the Fram Strait. It is therefore not clear where exactly the young plate boundary is situated and whether a magmatic formation of ocean crust has developed here.

DEGLASEIS (Deglaciation seismicity of Northeast Greenland) is an opportunistic project that uses the new technical possibilities of ocean bottom seismometers that can be operated under sea ice and the rare opportunity of two consecutive *Polarstern* cruises to Northeast Greenland to operate an amphibious seismological network there for a year. This network will significantly reduce the detection threshold and improve the location accuracy of earthquakes in a region from Svalbard to North Greenland. DEGLASEIS intends to use this data set to investigate the following questions:

Is the earthquake activity an expression of the deglaciation of Northeast Greenland? Which geological structures are (re)activated in the process? Are some of the seismic events along large outlet glaciers possibly caused by icebergs? Or is the stress field determined entirely by plate tectonics? Where is the active plate boundary in the Fram Strait, and are tectonic or magmatic processes dominating seafloor spreading here?

Another focus is the mechanical state of the sea ice cover over the course of a year and the effect of storms and swell on the sea ice. These processes leave clear traces in the ambient seismic noise (Schlindwein et al. 2025) and can now for the first time be systematically analysed with seismometers located under the ice.

DEGLASEIS will thus make a concerted effort to better understanding of the deglaciation processes in Greenland and the sea ice disintegration in the Arctic Ocean based on their seismological fingerprints.

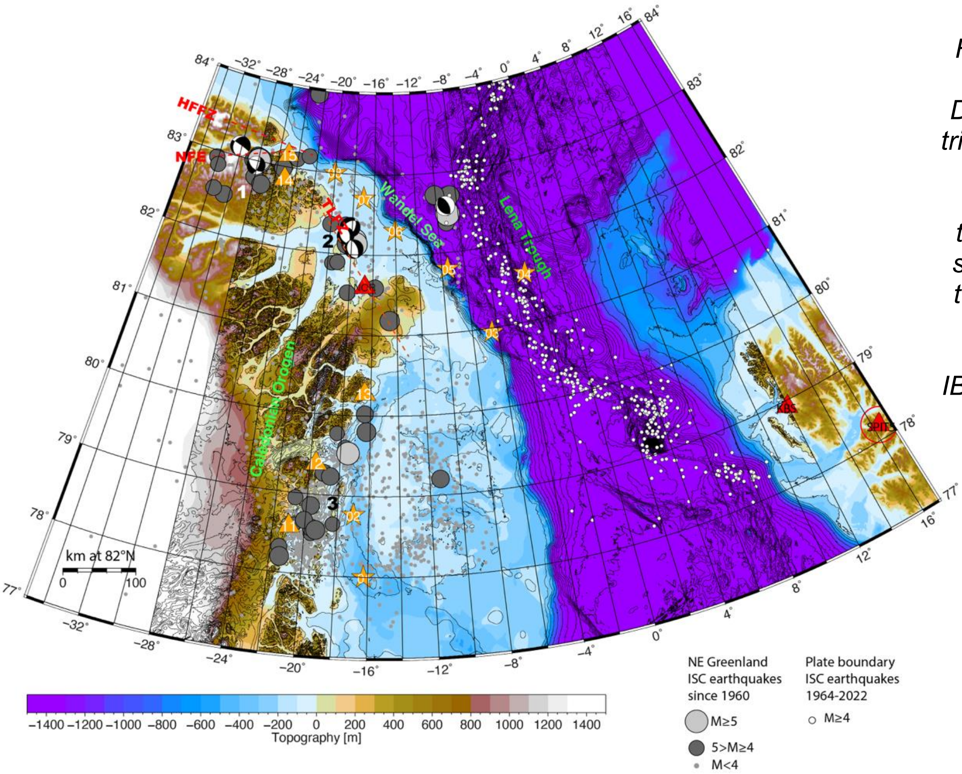

Fig. 5.1: Overview of seismic network DEGLASEIS. Orange triangles: land stations, orange stars: OBS locations. Red triangles: permanent seismic stations. See text for abbreviations of geological fault zones. Bathymetry: IBCAO5 (Jakobsson et al. 2024)

Work at sea

DEGLASEIS will install an amphibian seismic network in Northeast Greenland for a period of 12 months to record seismic events related to deglaciation and tectonic processes.

Our network will consist of 8 off-shore ocean bottom seismometers (orange stars, 01-08, Fig. 5.1), and 5 seismic stations on land (orange triangles, 11-15). To improve the seismic network on land independently from flight operations from board *Polarstern*, we will install a sensitive standard double-ring detection array (600 m and 2 km diameters) at Station Nord. This array will be installed in cooperation with GEUS and relying on entirely independent logistics from land side.

The OBS are provided by DEPAS (Alfred-Wegener-Institut et al. 2017). They are equipped with Trillium broadband (120 s) 3-component seismometers and a hydrophone. Battery power will allow recording for 12-14 months. Battery power of the release units enables instrument recovery up to 24 months after deployment. Land stations are provided by the Geophysical Instrument Pool Potsdam (GIPP). They consist of passive Mark L-4C-3D short period (1 Hz) sensors and low-power consumption data cube loggers. With 2-3 battery packs per station at a sampling rate of 100 Hz we will achieve a continuous recording period of 12 months.

Prior to deployment, the release units of the OBS need to be tested for water tightness and functionality in a basket lowered approximately to deployment depth. OBS will then be assembled and programmed. Deployment is in free-fall mode and the way of the OBS to the sea-floor will be tracked by Posidonia such that the exact position on the seafloor is known.

Land seismic stations consist of a seismic sensor that will be shielded from wind and precipitation under a white bucket weighed down with bricks or rocks. Recording units and batteries fit in an insulation box that allows transmission of GPS signal. The station equipment is optimized for helicopter transport and will be prepared on board for rapid installation in the field (less than one hour). Suitable installation sites, preferably with flat lying bedrock, will have to be spotted from the helicopter.

Access to all planned positions of the seismic stations is heavily dependent on sea ice and weather conditions. The planned network design is a compromise between scientifically optimal network design and chances of instrument recovery in 2026. Positions may have to be adapted during the cruise to adapt to environmental conditions.

Preliminary (expected) results

We do not expect results during PS150, since the instruments need to be recovered in 2026 during PS156 and will only then allow access to the recorded data.

Data management

Raw seismological data will be archived and published by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de). By default, the CC-BY license will be applied. Time-corrected miniseed archives of the seismological data will be submitted to GEOFON from where they are accessible with seismological data base query tools.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 2.3.

In all publications based on this expedition, the **Grant No. AWI_PS150_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.

For OBS data Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung et al. (2017), DEPAS (Deutscher Geräte-Pool für amphibische Seismologie): German Instrument Pool for Amphibian Seismology, Journal of large-scale research facilities, *3*, A122. http://dx.doi.org/10.17815/jlsrf-3-165 will be cited.

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5.2 Geodetic GNSS Measurements in North-East Greenland

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Objectives

The Greenland Ice Sheet (GrIS) is sensitive to changes in atmospheric and oceanic conditions which are triggered by climate change. Meltwater entering the ocean affects both global and regional sea level as well as oceanic circulation patterns. On the contrary, warmer ocean water entering Greenland shelf areas may lead to an increased subglacial melting and, thus, destabilisation of the outlet glaciers. Thus, in the period from 2005 to 2015 the GrIS contributed about 20% to the global mean sea level rise, whereby an acceleration in glacier flow accounts for about 50% of the ice-mass loss (The IMBIE Team 2020, Mouginot et al. 2019). However, ice-mass losses and changes in glacier dynamics vary considerably from region to region. They are determined by the complex interaction of ice, ocean, atmosphere and land (Kanzow et al. 2025). In order to gain a better understanding of these interplays and to arrive at reliable projections, we need, on the one hand, records on regional environmental conditions and glaciation history over the Holocene and, on the other hand, a suit of observations on recent changes of the geometry, flow velocity and mass of the GrIS and its individual outlet glaciers as well as of bedrock displacement. The latter is controlled by, and therefore informs about, past and present-day ice-load changes. Moreover, it modulates the geometry of the ice-ocean interface and thereby feeds back to ice mass change processes. A special aspect is given by the hypothesis that an increased ice-mass loss and subsequent vertical rebound may lead to a considerably large seismic activity along the coastal regions.

These ice mass changes occurring over the course of glaciation history, especially since the last glacial maximum, cause a glacial isostatic adjustment (GIA) of the solid Earth (Whitehouse et al. 2018; Caron et al. 2018). Today, the GIA effect is reflected in a long-term linear trend, with the effective elastic lithosphere thickness and upper mantle viscosity being crucial for the focusing and decay behaviour, respectively. In addition, there is an instantaneous response to changes in ice loading on short time scales which can be in the same order as or even larger than the GIA effect. The combined effect of GIA and present-day deformation can be measured by permanent and/or repeated geodetic GNSS recordings with an accuracy at the level of 1 mm/a (Kappelsberger et al. 2021).

Thus, the main goal of this project is to realize geodetic GNSS observations at selected bedrock locations in north-east Greenland to enhance the observational basis for the subsequent analysis of the bedrock displacement. Resulting displacement time series (and rates) will serve as an important constraint to investigate the response of the solid Earth to present-day as well as to past ice-mass changes and, eventually, to refine the modelling of glacial isostatic adjustment (GIA). Furthermore, in conjunction with seismic investigations co-located with the GNSS sites we will contribute to the investigation of the nature and causes of present-day seismicity.

Work at sea

It is planned to visit locations at Lambert Land West, at Holm Land and, if possible, at Peary Land (Fig. 5.2 and Tab. 5.1). At these three locations GNSS campaign measurements shall be realized for one year. The campaign installation includes GNSS receiver and antenna, a sealed battery and solar modules for power supply and further electronics, all packed in a Zarges aluminium box (Fig. 5.3). These installations shall be run for about one year and recovered during cruise PS156 in 2026. At the location Lambert Land West, the already existing permanent GNSS site (Fig. 5.3) shall be visited for maintenance and upgrade of satellite communication to ensure a successful continuation of the permanent GNSS recording, and to download the data.

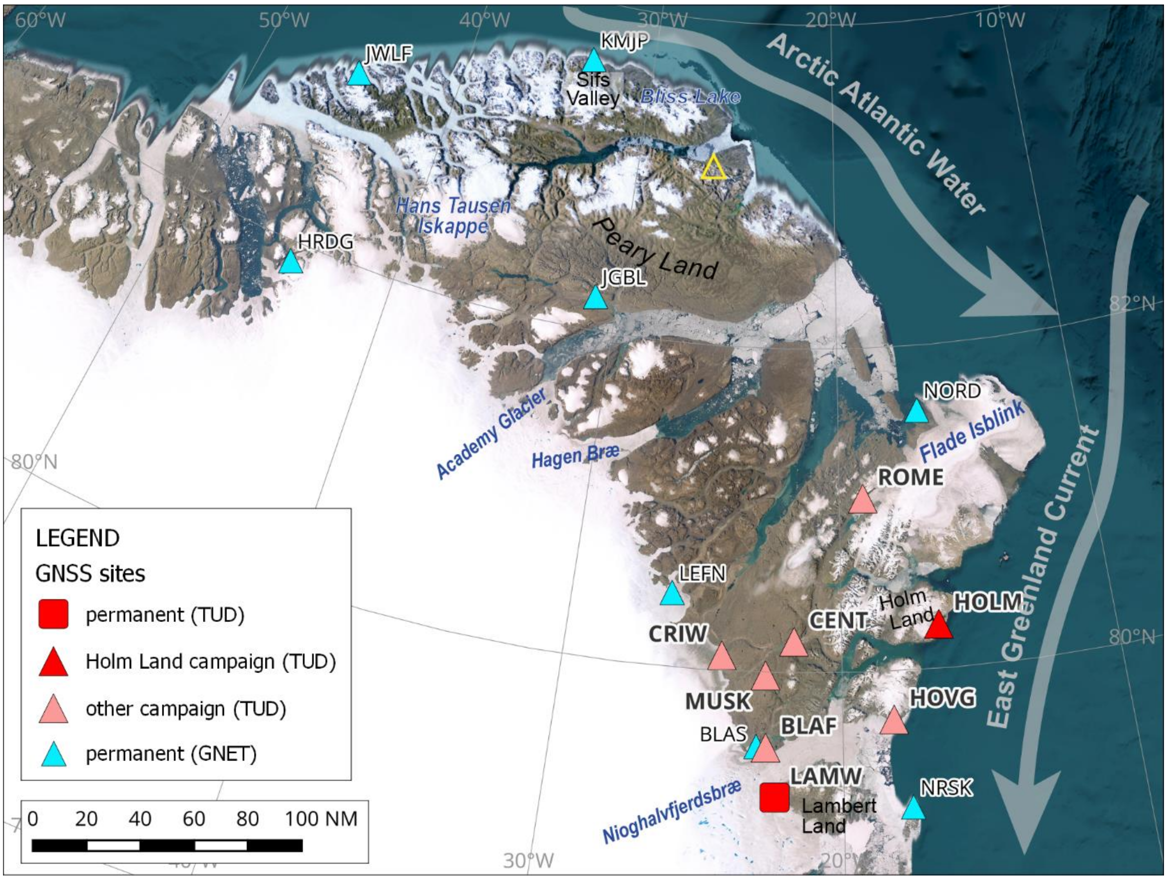

Fig. 5.2: Overview map of the area of investigation. Principal currents (AAW, EGC) are shown by grey arrows. The locations of the GNSS sites to be visited are plotted by red color (campaign sites HOLM and LAMW, permanent site LAP1 is co-located with LAMW). All sites will be co-located with seismometer deployments (see Section 5.1). The yellow triangle denotes a possible further location at Peary Land to set up a GNSS campaign station in conjunction with a seismometer. Further GNSS sites existing in this area are also shown (pink: TUD campaign sites, cyan: permanent GNSS sites of the GNET project).

Fig. 5.3: GNSS installations at Lambert Land West (LAP1, 2022, left) and Holm Land (HOLM, 2008, right). At LAP1 the GNSS antenna is mounted on top of a special pillar fixed to bedrock. Receiver, batteries and further equipment are stored in two Zarges aluminium boxes (mounted at the structure in the background), while four solar panels and a wind generator are used to recharge the batteries. At HOLM the GNSS antenna will be mounted at a special bolt which is fixed in bedrock ("forced centering"). Receiver, battery and further equipment are stored in the Zarges aluminium box, while a solar panel is used to recharge the battery.

Tab. 5.1: Locations and coordinates of the geodetic GNSS sites.

ID	Location	Latitude (North) [°]	Longitude (West) [°]	Remark
LAP1	Lambert Land West	79° 13' 35"	22° 18' 22"	Upgrade and continuation of permanent recording
LAMW	Lambert Land West	79° 13' 35"	22° 18' 22"	Campaign sites: Setup during PS150, retrieval during PS156
HOLM	Holm Land	80° 16' 23"	16° 25' 54"	
PEAR	Peary Land	83° 04'	26° 42'	

Preliminary (expected) results

During or right after the cruise PS150 we do not expect to gain results right away. On the one hand, the GNSS campaign installations are planned to run for about one year and to be recovered in 2026 (during cruise PS156). The data of the permanent GNSS site at Lambert Land West (LAP1) will be processed at the home institution (so-called post-processing). For this, we will use the Bernese GNSS Software adopting up-to-date standards (e.g. consistent and precise realization of the reference frame, reduction of geodynamic and further effects). In the end, we will solve for time series of daily 3D coordinates from which displacement rates will finally be inferred.

Data management

The successfully recorded data are raw data and need to be processed at the home institutions. However, the GNSS raw data will be archived at TU Dresden in close coordination with a database which is being maintained in the frame of the SCAR Expert Group on Geodetic Infrastructure in Antarctica (GIANT). Resulting products from the GNSS processing will be published in conjunction with respective scientific papers and archived according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de). By default, the CC-BY license will be applied.

In all publications based on this expedition, the **Grant No. AWI_PS150_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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5.3 Hydroacoustics

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Objectives

Past glacier dynamics can be inferred from glacial features observed on the seafloor. These were formed by glacial processes during the maximum extent of the NEGIS during both the last glacial and stillstands of the deglacial. Targets for bathymetric and sediment-echosounding data collection are areas where moraines and grounding-zone wedges are encountered, helping to reconstruct past events of ice-sheet and ice-shelf retreat. In addition, accurate knowledge of seafloor topography is generally a basic information to understand marine processes, and reliable seafloor topography data is also needed as a boundary condition in modeling. However, as of June 2024, only 26.1% of the ocean are bathymetrically mapped (Seabed 2030 news of June 21st, 2024), and the target area of EGC-Sources is one of the under-investigated areas. We aim at collecting data of the seafloor and the upper sedimentary layers and contribute to international efforts to enhance seafloor topography resolution such as IBCAO (Jakobsson et al. 2025) as well as to provide information on subbottom acoustic facies (Mosher et al. 2015).

Work at sea

Bathymetric and sediment echosounder data will be recorded simultaneously along all tracks. Bathymetry data will be recorded using the hull-mounted Atlas Hydrosweep DS3 multibeam echosounder, and sediment echosounder data will be collected with the hullmounted Atlas Teledyne Parasound P70 sub-bottom profiling system. The main task of the hydroacoustic group is to collect data, and occasionally plan and run bathymetric and sediment echosounder surveys during downtime of other working groups at selected sites. Raw bathymetric data will be corrected for sound velocity changes in the water column, and further processing and cleaning for erroneous soundings and artefacts will be carried out as time allows. Sediment echosounder data will be quality-checked and converted to standard segy format. Acoustic measurements will be run semi-automated and partly unattended, as with the small team a 24/7 shift mode is not feasible.

Preliminary (expected) results

Expected results consist of first and uncleaned high-resolution seabed maps along the cruise tracks and at selected sites where additional mapping was carried out. Together with the sub-bottom data, this will be used for a first identification of glacial features that may show up in the seafloor morphology and in the uppermost sedimentary sequences of the research area.

The expected results will enable a better understanding of the palaeo-environmental processes around NE Greenland and in front of the present-day glaciers.

Data management

Bathymetry and sub-bottom data collected during the expedition will be archived, pblished and disseminated according to the international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) in accordance to the AWI research data guideline and directive (https://hdl.handle.net/10013/epic.be2ebee5-fb98-4144-9e74-aa1d38378c5e). The data will be made available upon request after a phase of restricted access of 4 years after data acquisition at the latest. By default, the CC-BY license will be applied. Furthermore, bathymetric data will be provided to the Nippon Foundation – GEBCO Seabed 2030 Project.

This expedition will contribute to the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopics 2.1 and 2.3.

In all publications based on this cruise, the Grant No. **AWI_PS150_04** will be quoted and the following article 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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6. MARINE GEOCHEMISTRY

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Grant-No. AWI_PS150_05

Objectives

Burial of organic matter in marine sediments constitutes the ultimate sink of carbon exiting the short-term cycle and entering the geological long-term carbon cycle. Organic matter in marine sediments is composed of a complex mixture of materials of different origins. These comprise materials derived from marine primary production that vertically sink to the seafloor as well as laterally supplied materials from re-suspended sediments and from land. Land-derived materials may include fossil petrogenic organic matter, which has undergone diagenesis and, in some cases, thermal maturation. Chemically, these organic materials exhibit different characteristics, in particular in terms of their bioavailability, which is determined by their molecular composition and by protection against degradation via sorption on mineral surfaces or occlusion in aggregates. Changes in the relative input of the various materials create a dynamic biogeochemical environment. Traditionally, the deposition of petrogenic organic matter in marine sediments has been considered to have no net effect on the short-term (millennial scale) carbon cycle (Galy et al. 2008). However, recent evidence has suggested that rock-derived organic matter may in fact be more bioavailable than previously thought (Guillemette et al. 2017; Lien et al. 2025). If petrogenic organic matter is re-mineralized when exposed and supplied to the ocean, it has the potential to contribute to emissions of fossil greenhouse gases, and the total oxidative carbon release rivals the drawdown by silicate weathering and carbon burial (Lien et al. 2025).

Fjord systems deserve special attention as diverse physical features of fjords are key in controlling the sources, transport, and burial of organic matter in the modern era and over the Holocene (Bianchi et al. 2020). Fjord systems bury the largest amount of organic carbon per unit area in the world, which makes them a crucial ecosystem in regulating the carbon cycle over time. It has been estimated that about 18 Mt of organic carbon are buried in fjord sediments each year, equivalent to 11% of annual marine carbon burial globally (Smith et al. 2015). Per unit area, fjord organic carbon burial rates are twice as large as the global ocean average, and fjord sediments contain twice as much organic carbon as biogenic sediments underlying the upwelling regions of the ocean. At the same time, fjords are undergoing rapid environmental change. They lie at the nexus of terrestrial, cryospheric, oceanic and atmospheric interactions within the Earth system and are particularly sensitive to climate change (Bianchi et al. 2020).

North Greenland fjords can be categorized as Polar fjords, almost permanently covered by sea ice and glaciated in the drainage area (Bianchi et al. 2020, and references therein). Sediments in Polar fjords are mainly derived from the glacier bed, as well as from subglacial rivers and icebergs. They are delivered to such fjords through rafting by icebergs and sea ice (Syvitski 1989). Due to the ice-cover of the drainage basin, terrestrial organic matter supply is purely petrogenic, as there are no vegetated land areas. Gradients between high relative contribution of allochthonous petrogenic OM near the glaciers and high autochthonous marine contributions seaward are expected and constitute a simple two-endmember mixing scenario.

The oceanographic setting determines the relative contributions of allochthonous vs autochthonous OM. The relative contribution of petrogenic versus marine OM in marine sediments of such systems can be readily estimated using radiocarbon ($F^{14}C$) values of bulk organic matter (Galy et al. 2008; Ruben et al. 2023), as petrogenic OM is typically devoid of radiocarbon due to its age of several million years, while marine OM reflects $F^{14}C$ or surface water DIC, which is in exchange with the atmosphere. Furthermore, biomarker analysis may provide additional constraints on the type and maturity of ancient OM (e.g., Meyer et al. 2019). Under climate warming conditions, it is expected that the relative contributions of petrogenic and marine OM in marine sediments will change, depending on the relative position to the glaciers.

While several studies have been carried out on sediments from East Greenland glaciers (e.g., Scoresby Sound and Kangerlussuaq Fjord; Smith et al. 2002), Northeast Greenlandic fjords are less investigated, partly due to their challenging logistics. *Polarstern* cruise 150 therefore represents a unique opportunity to obtain sample material from these difficult to reach fjord areas, which nonetheless are ideal settings to study the oxidation efficiency and rate of petrogenic organic matter and the processes controlling it, including potential role of priming by biogenic organic matter.

Work at sea

During PS150, multicore samples will be obtained on fjord transects from as close as possible to the glacier front out toward the open ocean, along a gradient of increasing salinity and input of marine primary production. We will sample 3-5 stations in each fjord that is accessible during the cruise. Particular focus will lie on Independence and Hagen Fjord. Similar seaward transect samples will also be taken off 79°N Glacier and in the other working areas to compare fjord to shelf settings.

Sediments from at least two parallel multicores will be sliced in 1cm intervals and stored frozen in pre-combusted glass containers for later analyses in the home laboratory. Planned analytical methods include, but are not limited to, bulk geochemical parameters, radioisotopes for stratigraphy, stable carbon isotopes and $F^{14}C$ of total organic matter, and lipid biomarker contents as well as thermal reactivity. A particular focus will be on the compound-specific radiocarbon analysis of intact polar lipids from life microbes to be extracted from sediment samples.

Porewater from at least one of the parallel multicores will be extracted and preserved for later analyses of nutrients and dissolved inorganic matter, including stable carbon isotopes and $F^{14}C$. For this purpose, we will use Rhizon samplers and extract porewaters from 1 cm intervals; porewater will be split into several aliquots, which are preserved with a saturated $HgCl_2$ solution and stored at 4°C in head-space free vials closely sealed to prevent exchange with the atmosphere. Samples for nutrient analyses will be stored frozen.

At the stations where multicore samples will be taken, high-resolution water column profiles will be sampled with CTD-rosette. Water samples will be collected for the same geochemical parameters as porewaters.

Moreover, methane content in the sediment will be determined on board ship from discrete sample depths within the multicore to complement pore-water data.

Expected results

By combining geochemical and isotopic data of sediments, pore-water geochemistry with stable carbon isotopes and radiocarbon values in these Arctic sediments that receive input from eroding glaciers and marine primary production, we will be able to determine whether or not ancient petrogenic organic matter is oxidized upon deposition on the sea-floor and which conditions promote or prevent its oxidation. Pore-water data will further allow the calculation of carbon fluxes, estimating oxidation rates and attributing the processes to certain geochemical and microbiological processes. Specifically, we aim to:

- Estimate fossil carbon burial in the sediments NE Greenland fjords and shelves
- Quantify remineralization fluxes
- Identify the type of organic matter most vulnerable to oxidation in marine sediments.

Data management

Environmental, organic geochemical and radiocarbon 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.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopics 2.1 and 2.4.

In all publications based on this expedition, the **Grant No. AWI_PS150_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. CHEMISTRY

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Grant-No. AWI_PS150_06

Outline

The Chemistry component of this research expeditions concerns 1) the transport and water mass sources of nutrients associated with the East Greenland Current, 2) the determination of the carbon/carbonate system, air-sea CO_2 exchange and ocean acidification state, and the impact of glacial water, in north east Greenland fjords and coast, and 3) the release of nutrients from melting Greenland Glaciers into the adjacent fjord systems and coastal waters. Therefore, in order to fulfil the goals, put forward in the proposal, we aim to carry out measurements of chemical properties in seawater, including also dissolved oxygen, via the analysis of samples taken from CTD-Rosette casts, sediment and particle samples, as well as via the deployment of biogeochemical packages. The latter consists of a Remote Access Sampler (RAS) equipped with multiple sensors.

Objectives

Our aims in terms of nutrients and carbon are multiple fold. Given one of our main objectives is to compute nutrient and carbon transports (in collaboration with the Physical Oceanography Team) associated with the EGC, we will carry out measurements along all transects (nutrients) and selected transects (carbon) planned across the North East Greenland Shelf. We will also carry out measurements along fjord transects to determine potential nutrient sources. Measurements will be done at the best vertical and horizontal resolution as conditions allow. This is so that we can characterise the nutrient and carbon contents of the source water masses leading to the formation of the EGC, and the EGC itself. At the same time, we aim to exploit nutrient concentrations to constrain source water masses, as nutrient stoichiometry provides information useful to determine upstream sources (albeit with some limitations). We will also measure dissolved oxygen, in part to calibrate the CTD-O_2 sensor(s), but also because via the calculation of the apparent oxygen utilisation we can determine the proportion of regenerated and preformed nutrients, useful to determine biogeochemical signatures resulting from e.g., remineralisation or denitrification. We are also interested in constraining and quantifying temporal (seasonal) changes in nutrient content and their implication for nutrient transports. Therefore, we will deploy biogeochemical packages, which -all working well- should provide biogeochemical data at hourly to weekly resolution, for one year.

Our wider scope goal is to assess the role of the EGC in the balance of nutrient and carbon transports across Fram Strait (e.g., relative to the WSC) and thereby allowing us to further assess the role of Fram Strait in the context of nutrient transports at the pan-Arctic scale (i.e., the Arctic Ocean nutrient budget). We also will estimate the ocean acidification state and the impact of glacial and sea ice meltwater input by dissolution as well as the contribution of carbonate from bedrock-derived minerals in the glacial water.

An additional aim is to collect snow samples during ice stations for the measurement of nutrients. The aim of this is to combine the data with data collected in previous expeditions (PS138 and PS144) to assess the potential role of snow in the external supply of nitrogen species. This work is in collaboration with the sea ice physics team.

In addition to the water and snow samples, sediment samples will be taken to assess the role of glacier flour as a source of nutrients. Glaciers abrade underlying bedrock, producing fine sediments (glacial flour), which is then transported from beneath ice masses by glacial runoff. These fine sediments have greater potential for chemical weathering than the parent bedrock, due to the larger surface area available for chemical reactions and the release of reactive compounds from their crystalline silicate matrix, allowing them to participate in rock-water reactions (Sharp et al. 1995). Consequently, subglacial meltwater outflow is an important nutrient source to downstream rivers and oceans, supporting new primary production (Hawkings et al. 2015) by providing important macronutrients, such as silicon (Si; Meire et al. 2016; Hawkings et al. 2017), phosphorus (e.g. Hawkings et al. 2016) and dissolved inorganic nitrogen (DIN) species (e.g. Wadham et al. 2016) to the wider ecosystem. With the work within PS150 we want to further investigate whether we can directly attribute a significant nutrient source to the glacier flour and how far this signal extends into the fjord and possibly feeds into the EGC, with special focus on Si. We will do this by measuring possible benthic fluxes from the sediment by sampling the nutrient concentration of pore water and bioavailable nutrients laying at the surface of (marine) sediments (sampling in cooperation with Gesine Mollenhauer, geochemistry group). In addition, water samples will be taken for later isotopic analysis of Si to determine if we can find an isotopic signature of light Si along the fjord that could be associated with amorphous Si from the glacier (Hatton et al. 2023).

Work at sea

1. We will collect seawater samples from CTD-Rosette casts at all hydrographic stations, for the measurement of dissolved nutrients (nitrate+nitrite, nitrite, phosphate, silicate, ammonium, total dissolved nitrogen and total dissolved phosphorus) and dissolved oxygen. We aim to carry out the measurements onboard.
2. We aim to deploy three biogeochemical packages at the Peary Section mooring array, with one package close to the surface in mooring GG2 and two packages in mooring GG4, one at approximately 250 m depth and another close to the surface. Each biogeochemical package deployed close to the surface consists of a RAS equipped with the following sensors; SUNA-nitrate, CTD-O_2, pCO_2, pH, PAR and Ecotriplet (chlorophyll fluorescence, backscatter and CDOM). The biogeochemical package to be deployed at depth will not have a PAR sensor. The deployment of the RAS is in collaboration with the microbial observatory led by Katja Metfies.
3. We will collect water samples for analyses of dissolved inorganic carbon (DIC) and total alkalinity (TA) from the CTD-Rosette-Niskin bottles into 250 mL borosilicate bottles. Mercuric chloride (60µL) will be added to the 250 mL water samples to prevent biological activity. Sample will be stored dark and cold (above 4 degC) until analysed in the CO_2 laboratory at the Institute of Marine Research in Tromsø, Norway.
4. Glacial flour sampling: sediment samples will be collected along the transects (for stations along the self and closer to the coast/glacier outlet) with the MUC (in cooperation with Gesine Mollenhauer, geochemistry group). Sediment particles from the sea surface will be collected by using the ships seawater intake (~10.5 m depth), directly pumping the water onto a filtration unit where it will pass through PES membrane filters. In addition to water samples taken for nutrient analysis, ~250 mL seawater samples from the CTD-Rosette casts will be collected at selected stations

(3 – 5 stations along the transects), filtered and stored in HDPE bottles for later Si isotope analysis. Sediment and water samples for this part will be stored cooled until their analysis back on land.

Work on shore

1. Dissolved inorganic carbon (DIC) and total alkalinity (TA) from water samples will be analysed in the CO_2 laboratory at the Institute of Marine Research in Tromsø, Norway after the PS150 cruise, using standard methodology and protocols (Dickson et al. 2007). The other carbon/carbonate system (pH, pCO_2, carbonate ions) and ocean acidification state (OA; aragonite and calcite saturation states) variables will be calculated using the CO_2-chemical speciation model, CO2sys program (Pierrot et al. 2006). In collaboration with the tracer and physical oceanography teams, and using TA, DIC and nutrients from this team, we will estimate freshwater sources (using salinity, oxygen stable isotopes, CDOM) and impacts on the carbon/carbonate system and OA state. We will also calculate the ocean CO_2 uptake, transport of carbon and drivers in the EGC in western Fram Strait.
2. Glacial flour: sediment samples (from MUC and filtered from surface water) will be dried and sequential extractions will be carried out to determine the concentrations and availability of Si, P and N laying on the sediment surface and bound to the sediment. A subsample from the sediment will be analysed for their mineralogy using XRD and surface area analysis. Water samples for isotope analysis will be acidified (0.1% v/v HCl) and measured with an ICP-MS.

Preliminary (expected) results

All working well with the equipment onboard, we expect to have nutrient and dissolved oxygen fields along the planned cruise transects/hydrographic stations by the end of the expedition. We expect that different water masses sourcing the EGC will have a distinct nutrient signature.

The carbon/carbonate system variables will be analysed at the end of 2025 and beginning of 2026, and quality controlled, so data can be ready to submit to the database in 2027 and used for estimates of carbon transport, ocean CO_2 uptake, OA state and drivers, in collaboration with data from this and other teams. Due to increased meltwater, we expect increased ocean CO_2 uptake and ocean acidification (e.g. Fransson et al. 2023). However, due to biogeochemical processes, the net effect can show a different result. Increased glacial meltwater dilutes carbonate ions and alkalinity hence decreasing the buffering capacity. However, the glacial meltwater may contain a mineral composition of carbonate minerals that can partly mitigate the acidification, which has been observed in other Arctic fjords (e.g. Fransson et al. 2015). We also want to investigate the concentrations of carbon/carbonate in different water masses and how they can be used as tracers.

Glacial flour: By analysing nutrients connected to the sediments, we hope to contribute to a more complete picture of the nutrient sources in the NE Greenland region. The concentration of dissolved nutrients in the pore water and the nutrients bound to the surface of the sediments will complete the nutrient profile from the glacier/coast out to the shelf. The isotopic signal will hopefully also allow us to determine whether the glacier signal extends into the shelf regions and eventually into the EGC or whether it remains within the fjord circulations.

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. The nutrient data here collected is part of an

AWI INSPIRES PhD project and thus, data will be made publically available upon research publication. The carbon/carbonate system variables will be published in the Norwegian Polar Data Centre (NPDC) after two years and later submitted to the UN SDG.

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 2, Subtopic 2.1; Topic 6, subtopic 6.3.

In all publications based on this expedition, the **Grant No. AWI_PS150_06** will be quoted and the following publication will be cited:

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

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8. TRACER OCEANOGRAPHY

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Grant-No. AWI_PS150_07

Outline

In recent years, transient tracers such as man-made gases (Tritium, CFC-12 and SF_6) and radionuclides of both natural and anthropogenic origin (e.g., ^{129}I, ^{236}U, ^{14}C, ^{39}Ar) have provided a rich dataset for studying ocean circulation in the Arctic Ocean (Tanhua et al. 2009; Wefing et al. 2021). These tracers are particularly effective because, first, they behave conservatively in the ocean (Casacuberta & Smith 2023). Second, their well-characterized input functions enable the estimation of circulation timescales, mixing processes along flow pathways, and deep-water ventilation rates.

Key findings to date indicate tracer ages of about 10–15 years for surface waters entering through the Barents Sea and West Spitsbergen Current before reaching the North Pole. At mid-depths, Atlantic-origin Arctic Water (AAW) circulates within the Arctic Ocean Boundary Current, reaching the Makarov Basin with mean tracer ages of around 20 years, and the Canada Basin with ages exceeding 25 years (Payne et al. 2024). Finally, AAW exits the Arctic Ocean through Fram Strait with mean ages of approximately 40 years (Wefing et al. 2021), continuing southward with the East Greenland Current (EGC). Recent results by (Wefing et al. 2025) provide a more detailed picture of tracer-based ages in the northern Fram Strait, extending to Eastern Makarov Basin, thus overlapping with the target area of expedition PS150, further underscoring the relevance of this region for understanding Arctic circulation and export pathways.

To date, radionuclide and gas-based transient tracers have typically been sampled and interpreted separately, often yielding slightly differing results (Raimondi et al. 2024). The goal of this project is to integrate these complementary tracer datasets to develop a more unified and robust understanding of transport timescales, mixing processes, and circulation pathways in the Arctic Ocean, and their outflow through the East Greenland Current.

In addition to the Transient Tracers, oceanic measurement of low-solubility and stable noble-gases helium (^3He, ^4He) and neon (Ne) provide a useful tool to identify and to quantify basal glacial melt water Huhn (Huhn et al. 2018). Atmospheric air with a constant composition of these noble gases is trapped in the ice matrix during formation of the meteoric ice. Due to the enhanced hydrostatic pressure at the base of the floating ice, these gases are completely dissolved, when the ice is melting from below. This leads to an excess of helium and neon in pure glacial melt water (He = 1260%, Ne = 890%). Frontal or surface melt water would equilibrate quickly and not lead to any noble gas excess in the ocean water. With an accuracy of <0.5% for He and Ne measurements performed at the IUP Bremen, basal glacial melt water fractions of <0.05% are detectable. Helium has an additional oceanic source (primordial helium from hydrothermal vents with a distinct higher $^3He/^4He$ isotope ratio, and the alpha decay of tritium), which neon does not have. The latter ^4He addition can be assessed by tritium measurements. Moreover, tritium is discharged from Siberian rivers into the Arctic Ocean, and tritium observations might give insight into that source.

The combination of the transient tracer based “ages” and the noble gas-based melt water inventories allow estimate basal glacial melt rates (Heuzé et al. 2023).

Objectives

The main objective of our work during the PS150 cruise is to generate a comprehensive dataset of transient tracers along the different transects sampled during the expedition. Specifically, we aim to: i) identify the provenance and pathways of the main water masses; ii) estimate transport times and mixing processes of surface waters and Atlantic-derived Arctic Waters; and iii) constrain the ventilation times of deep and bottom waters outflowing from the Arctic Ocean. Additionally, noble gas isotopes (^{3}He, ^{4}He, total Ne) will be key to quantify submarine melt water (i.e., freshwater discharged from basal melting of Greenland ice shelfs and tide water glaciers) in North Greenland fjords and on the shelf. These transient tracer observations will be combined with other chemical tracers collected during PS150, particularly those used to quantify freshwater contributions (i.e. $\delta\,^{18}O$, nutrients, C-DOM), in order to better characterize water mass fractions and to assess the freshwater export through the East Greenland Current.

Work at sea

Radionuclides ^{129}I and ^{236}U transient tracers

We plan to collect about 250 3L water samples to analyze ^{236}U and ^{129}I isotopes. Samples will be collected along the Lincoln, Peary and Flade transects of the PS150 expedition, mostly targeting Polar Surface Waters, halocline waters and Atlantic-derived Arctic Waters. Samples will be collected from the CTD rosette and placed into 3L plastic cubitainers (^{236}U) and 250 ml dark plastic bottles (for ^{129}I analysis), and stored in big wooden boxes (pallet size) for their shipment to ETHZ and further analysis in the lab.

Radionuclides ^{14}C and ^{39}Ar transient tracers

The isotopes ^{14}C and ^{39}Ar will be collected in the outermost stations of Lincoln, Peary and Flade transects, targeting the deep and bottom waters. A total of 15 samples will be collected for ^{39}Ar in 3 different profiles, and a total of 40 for ^{14}C (same deep profiles, but with better resolution compared to ^{39}Ar samples). Samples for ^{39}Ar will be collected using 10L gas propane bottles, previously filled with N_2 gas to create overpressure and avoid any air coming into the bottle. Samples for ^{14}C will be collected in 120 ml glass bottles, sealed with septum and poisoned with $HgCl_2$. While samples for ^{39}Ar analysis will be sent to Heidelberg University, the ^{14}C bottles will be shipped together with ^{129}I and ^{236}U samples to ETHZ.

Gas transient tracers: CFC-12, SF_6, Tritium

About 500 water samples for transient tracers CFC-12 and SF_6 will be collected during PS150 and other 100 water samples for tritium. Water samples for CFC and SF_6 measurements will be stored from the ship deployed water samplers into 200 ml glass ampoules and will be sealed off after a CFC and SF_6 free headspace of pure nitrogen has been applied. The samples will be later analyzed in the CFC-laboratory at the IUP Bremen. All these samples will be taken from the ship deployed full depth profiling CTD and water sample system, targeting the shelf, slope, and deeper ocean. The sampling location will be coordinated with those for ^{236}U and ^{129}I isotopes sampling.

Noble gas tracers

We intend to obtain about 350 water samples for noble gas isotopes (^{3}He, ^{4}He, total Ne), focusing in North Greenland fjords and on the shelf. The oceanic water samples for helium isotopes and neon will be stored from the CTD and water bottle system into 50 ml gas tight copper tubes, which will be clamped of at both sides. The noble gas samples are to be analyzed later in the IUP Bremen noble gas mass spectrometry lab.

Preliminary (expected) results

The combined analysis of gas and radionuclide transient tracers is expected to significantly advance our understanding of the sources and composition of the East Greenland Current. In particular, we aim to determine the provenance of Polar Surface Waters and their freshwater contributions. For Atlantic-derived waters, both at the surface and intermediate depths (Atlantic-derived Arctic Waters), we expect to constrain transport times and mixing regimes more accurately.

For deep and bottom waters, the use of cosmogenic radionuclides such as ^{14}C and ^{39}Ar will provide new insights into ventilation timescales, helping to elucidate their origins and the specific Arctic basins from which they emerge. Furthermore, this dataset will offer an excellent opportunity to systematically compare Transit Time Distribution (TTD) estimates derived from gas tracers with those obtained from radionuclide tracers. By integrating these complementary approaches, we expect to overcome the individual limitations of each tracer type and develop optimized strategies for using transient tracers as tools to improve our understanding of Arctic Ocean circulation.

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.

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_PS150_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
On board / In the field	
CH.ETHZ	Eidgenössische Technische Hochschule Zürich Rämistraße 101 8092 Zürich Switzerland
DE.AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
DE.CAU	Christian-Albrechts-Universität zu Kiel Ludewig-Meyn-Straße 10 24118 Kiel Germany
DE.DRF	DRF Luftrettung gAG Laal Avenue E312 77836 Rheinmünster Germany
DE.driftnoise	Drift + Noise Polar Services Stavendamm 17 28195 Bremen Germany
DE.DWD	Deutscher Wetterdienst Seewetteramt Bernhard Nocht Str. 76 20359 Hamburg Germany
DE.NHC	Northern HeliCopter Gmbh Gorch-Fock-Straße 103 26721 Emden Germany
DE.TU-Dresden	Technische Universität Dresden Dezernat 8 1062 Dresden Germany
DE.Uni-Bremen	Universität Bremern Otto-Hahn-Straße 1 28359 Bremen Germany

Affiliation	Address
On board / In the field	
DE.UNI-Hamburg	Universität Hamburg Olbersweg 24 22767 Hamburg Germany
DE.UNI-Oldenburg	Carl von Ossietzky Universität Oldenburg Carl-von Ossietzky Straße 11I 2826129 Oldenburg Germany
DE.UNI-Potsdam	Universität Potsdam Karl-Liebknecht-Straße 24-25 14469 Potsdam Germany
DK.AU	Aarhus Universitet Frederiksborvey 399 4000 Roskilde Denmark
FR.LOCEAN.UPMC	Laboratoie d'Océanographie et du Climat: Expérimentations et Approches Numériques 4 place Jussieu 75005 Paris France
GL.Natur	Greenland Institut of Natural Resources Kivioq 2 3900 Nuuk Greenland
NL.NIOZ	Koninklijk Nederlands Instituut voor Onderzoek der Zee P.O. Box 59 1790 AB Den Burg Netherlands
NO.NPOLAR	Norsk Polarinstitutt Framsenteret Hjalmar Johansens gt. 14 9296 Tromsoe Norway
NO.UNIS	The University Centre in Svalbard P.O. Box 156 9170 Longyearbyen Norway
PL.UG	Uniwersytet Gdanski Al. Marszalka Pilsudskiego 46 81-378 Gdynia Poland

Affiliation	**Address**
On board / In the field	
SE.LNU	Linnaeus University Stuvaregatan 4 39231 Kalmar Sweden
US.UD	University of Delaware Robinson Hall 19716 Newark DE USA

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
on board				
Aehle	Moritz	DE.UNI-Hamburg	Student (Master)	Biology
Brauer	Jens	DE.NHC	Pilot	Helikopter Service
Casacuberta	Nuria	CH.ETHZ	Scientist	Oceanography
Challet	Francois	FR.LOCEAN.UPMC	Student (PhD)	Oceanography
De Jong	Marieke Femke	NL.NIOZ	Scientist	Oceanography
Detsch	Christian Willibald Guido	DE.UNI-Bremen	Student (Master)	Biology
Dreutter	Simon	DE.AWI	Technician	Geophysics
Duncan	Rebecca	SE.LNU	Scientist	Biology
Eggers	Neele	DE.UNI-Potsdam	Student (Master)	Physics
Engicht	Carina	DE.AWI	Technician	Oceanography
Fricke	Johannes	DE.TU-Dresden	Student (Master)	Other Geosciences
Gebhardt	Andrea Catalina	DE.AWI	Scientist	Geophysics
Torben	Gentz	DE.AWI	Scientist	Other Geosciences
Gorniak	Rebecca	DE.UNI-Bremen	Student (Bachelor)	Biology
Harfst	Alicia Magdalena	DE.UNI-Oldenburg	Student (Master)	Oceanography
Hoppmann	Mario Günther	DE.AWI	Scientist	Oceanography
Huhn	Oliver	DE.UNI-Bremen	Scientist	Oceanography
Kanzow	Torsten	DE.AWI	Scientist	Oceanography
Köhler	Klara	DK.AU	Student (PhD)	Oceanography
Kuzmina	Sofia	DE.AWI	Student (PhD)	Oceanography
Makatun	Adam	PL.UG	Scientist	Oceanography
McPherson	Rebecca	DE.AWI	Scientist	Oceanography
Mersch	Clara	DE.AWI	Student (PhD)	Biology
Mollenhauer	Gesine	DE.AWI	Scientist	Other Geosciences
Monsees	Matthias	DE.AWI	Technician	Oceanography
Mortensen	John	GL.Natur	Scientist	Oceanography
Muenchow	Andeas	US.UD	Scientist	Oceanography

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
on board				
Murray	Ayla Rosina Cherrington Sealey	DE.AWI	Scientist	Biology
Neumann	Zoé	DE.CAU	Student (Bachelor)	Geology
Özkan	Ufuk	DE.AWI	Student (PhD)	Oceanography
Pauls	Stefan	DE.UNI-Bremen	Student (Master)	Physics
Pilot	Matthias	DE.UNI-Bremen	Student (PhD)	Geophysics
Rauschenbach	Quentin	DE.AWI	Student (PhD)	Oceanography
Regnery	Julia	DE.AWI	Scientist	Logistics
Reifenbach	Simon Felix	DE.AWI	Student (PhD)	Oceanography
Rohling	Clemens Michel	DE.UNI-Hamburg	Stundent (Master)	Oceanography
Schlindwein	Vera	DE.AWI	Scienist	Geophysics
Schmitz	Bernhard	DE.driftnoise	Scientist	Other Geosciences
Seifert	Michael	DE.DRF	Technician	Helikopter Service
Selle	Patrick	NO.UNIS	Student (Bachelor)	Physics
Sueltenfuss	Pia	DE.UNI-Oldenburg	Student (Master)	Data
Suter	Patrick	DE.DWD	Scientist	Meteorology
Torres-Valdéz	Sinhué	DE.AWI	Scientist	Oceanography
Von Appen	Wilken	DE.AWI	Scientist	Oceanography
Wefing	Anne-Marie	NO.Npolar	Scientist	Oceanography
Wekerle	Claudia	DE.AWI	Scientist	Oceanography
Welsch	Andreas	DE.UNI-Hamburg	Technician	Oceanography
Winberg von Friesen	Lisa	SE.LNU	Scientist	Biology
Xi	Hongyan	DE.AWI	Scientist	Oceanography
Hölzer	Martin	DE.DRF	Technician	Helikopter Service
Lemire	Annie Catherine Juliette	DE.UNI-Bremen	Student (Master)	Geophysics
Nicolaus	Marcle	DE.AWI	Scientist	Geophysics
Schmidt	Ina	DE.AWI	Technician	Physics
Scholz	Danile Alexander	DE.AWI	Engineer	Chemistry
Vaupel	Lars	DE.NHC	Pilot	Helikopter Service

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No	Dienstgrad	Rank	Nachname / Last name	Vorname / First name
1	Kapitän	Master	Schwarze	Stefan
2	1. Offizier	Chief Mate	Strauß	Erik
3	1. Offizier Ladung	Chief Mate Cargo	Eckenfels	Hannes
4	2. Offizier	2nd Mate	Weiß	Daniel
5	2. Offizier	2nd Mate	Heisterkamp	Ole Louca
6	Schiffsärztin	Doctor	Guba	Klaus
7	Leitender Ingenieur	Chief Engineer	Rusch	Torben
8	2. Ingenieur	2nd Engineer	Ehrke	Tom
9	2. Ingenieur	2nd Engineer	Krinfeld	Oleksandr
10	2. Ingenieur	2nd Engineer	Jassmann	Marvin
11	Schiffselektrotechniker Maschine	Ship Electrotechnical Officer Engine	Pommerencke	Bernd
12	Elektroniker Winden	Electrotechnical Engineer Winches	Krüger	Lars
13	Elektroniker Netzwerk/Brücke	Electrotechnical Engineer Netw./Bridge	Frank	Gerhard Ansgar Leon
14	Elektroniker Labor	Electrotechnical Engineer Labor	Ejury	René
15	Elektroniker System	Electrotechnical Engineer System	Winter	Andreas
16	Bootsmann	Bosun	Brück	Sebastian
17	Zimmermann	Carpenter	Keller	Jürgen
18	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Buchholz	Joscha
19	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Möller	Falko
20	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Mahlmann	Oliver Karl-Heinz
21	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Schade	Tom

No	Dienstgrad	Rank	Nachname / Last name	Vorname / First name
22	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Finkmann	Jan
23	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Decker	Jens
24	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Deutschbein	Felix Maximilian
25	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Siemon	Leon Anton
26	Decksmann/Matrose	Able Seaman	Niebuhr	Tim
27	Lagerhalter	Storekeeper	Plehn	Marco Markus
28	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Schröder	Paul
29	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Probst	Lorenz
30	Schiffsmechanikerin Maschine	Multi Purpose Rating Engine	Stubenrauch	Paula
31	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Buchholz	Karl Erik
32	Schiffsmechaniker Maschine	Multi Purpose Rating Engine	Cording	Bastian-Fynn
33	1. Koch	1st Cook	Skrzipale	Mitja
34	2. Köchin	2nd Cook	Fehrenbach	Martina
35	2. Köchin	2nd Cook	Loibl	Patrick
36	1. Stewardess	1st Stewardess	Witusch	Petra Gertrud Ramona
37	2. Stewardess	2nd Stewardess	Stocker	Eileen Sigourney
38	2. Steward	2nd Steward	Golla	Gerald
39	2. Stewardess	2nd Stewardess	Holl	Claudia
40	2. Stewardess / Krankenschwester	2nd Stewardess / Nurse	Ilk	Romy
41	2. Steward / Wäscherei	2nd Steward / Laundry	Shi	Wubo
42	2. Steward / Wäscherei	2nd Steward / Laundry	Chen	Jirong
43	2. Steward / Wäscherei	2nd Steward / Laundry	Chen	Quanlun
44	Auszubildender Schiffsmechaniker	Apprentice Multi Purpose Rating	Liedtke	Mattes