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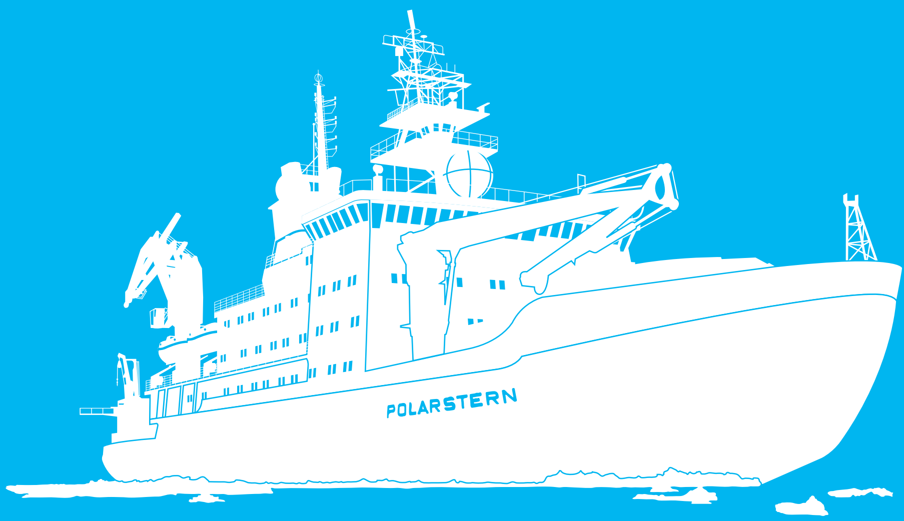
EXPEDITION PROGRAMME
PS153

Polarstern

PS153
Punta Arenas - Port Stanley
06 February - 09 April 2026

Coordinator: Ingo Schewe

Chief Scientists: Christian Haas and Ilka Peeken



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PS153
Summer Weddell Outflow Study
SWOS

06.02.2026 – 09.04.2026

Punta Arenas – Port Stanley

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Coordinator
Ingo Schewe

Contents

1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Christian Haas[1] and Ilka Peeken[1] [1]DE.AWI

Das nordwestliche Weddellmeer entlang des nordwärts gerichteten Zweigs des Weddellwirbels ist eine Region mit einem großen Ausstrom verschiedener Wassermassen von globaler Bedeutung, sowie von dickem Meereis und biogeochemischen Stoffen, die den antarktischen Kontinent mit den Weltmeeren verbindet. Es verfügt über ein tiefes Schelfmeer und das zweitgrößte Schelfeis (Larsen C) im Weddellmeer, und seine ganzjährige Meereisdecke gehört zu den dicksten auf der Erde. Die Region gehört daher zu den am wenigsten erforschten Gebieten der Erde. Die Wechselwirkungen zwischen Eis und Ozean formen die Wassersäule und kontrollieren das Meereis sowie die pelagischen und benthischen Komponenten. Allerdings hat sich die Region seit etwa 2017 stark verändert, als die Meereisausdehnung stark zurück ging, was wahrscheinlich durch das Auftreten von wärmerem Wasser nahe der Meeresoberfläche verursacht wurde. Diese Veränderungen könnten die Vorboten bedeutender Veränderungen im nordwestlichen Weddellmeer sein, die sich auf das gesamte physikalische und biologische Eis-Ozean-System in der Region auswirken, einschließlich des Larsen-C-Schelfeises, das, wenn es offenerem Wasser ausgesetzt ist, in den kommenden Jahrzehnten kurz vor dem Zusammenbruch stehen könnte.

Das Ziel der Summer Weddell Sea Outflow Study (SWOS) ist es daher, multidisziplinäre Informationen über den nordwestlichen Weddellmeer-Kontinentalhang, den Schelf und in der Nähe von Larsen C zu sammeln, um

1. die Prozesse zwischen Meereis, Schelfeis und Ozean zu verstehen und ihre Auswirkungen auf die hydrographischen und nährstoffbezogenen Eigenschaften sowie auf die Kohlenstoffflüsse von der Oberfläche in die Tiefsee zu beurteilen;
2. Messungen der Meereisdickenverteilung und der Schneeeigenschaften auf regionaler Ebene zu sammeln;
3. die ozeanographischen Wassermassen zu charakterisieren und ihre Bildung, Ausbreitung und Wege sowie die Mechanismen des Austauschs zwischen Schelf und Becken zu verstehen;
4. Verständnis und Kartierung von kryopelagischen und kryobenthischen Prozessen sowie von Ökosystemparametern und -gradienten in Abhängigkeit von den Meereisbedingungen zu entwickeln.

Die Forschungsarbeiten werden zu einem kritischen Zeitpunkt durchgeführt, an dem das marine Klimasystem der Antarktis in eine Phase des beschleunigten Meereisverlustes und der Ozeanerwärmung eingetreten ist. Die Ergebnisse werden dringend benötigt, um den Einfluss des Aufbrechens der Larsen-Schelfeise auf das gesamte marine System zu verstehen. Außerdem werden sie für die Verbesserung und Validierung der Antarktis-Komponenten von Erdsystemmodellen benötigt.

Die Karte in Abbildung 1.1 zeigt das Forschungsgebiet von SWOS im nordwestlichen Weddellmeer. Das Ziel ist es, umfassende Beobachtungen zwischen dem Meeresboden und der Atmosphäre entlang von fünf Transekten durchzuführen, die den Kontinentalschelf in Ost-West-Richtung überqueren und sich so weit wie möglich auf den Schelf und in Richtung des Larsen C-Schelfeises erstrecken. Auf diese Weise können der ausströmende Zweig des Weddellwirbels und die Veränderungen, die das Meereis und die Wassermassen auf diesem

Weg erfahren, gut charakterisiert werden. Außerdem gibt es einige wenige feste Stellen, an denen wir benthische Beobachtungen und Probenahmen wiederholen wollen, die während früherer Fahrten durchgeführt wurden, um so zeitliche Veränderungen zu beobachten, die z.B. auf veränderte Meereis- und Ozeanbedingungen sowie auf Kratzspuren von Eisbergen zurückzuführen sind.

Der Zeitpunkt für SWOS wurde so gewählt, dass er am oder nach dem Ende der sommerlichen Schmelzsaison liegt, wenn die Meereisausdehnung am geringsten ist und die saisonale Akkumulation von Schneemetamorphose, Meereisschmelze und Süßwasserzufuhr aus dem Ozean wahrscheinlich ihr Maximum erreicht hat. Die Reise beginnt am 6. Februar in Punta Arenas, Chile, und endet am 9. April in Port Stanley, Malwinen/Falklandinseln. Zunächst werden wir eine benthische Station beproben (MUC-Station 190-6), bevor wir uns auf den südlichsten Transekt begeben. Die Verankerungen werden wahrscheinlich am Ende von SWOS auf dem Rückweg nach Port Stanley geborgen.

Die Beprobung entlang der Transekte wird von der Wassertiefe bestimmt, um tiefenabhängige Gradienten entlang des Meeresbodens zu erfassen. Längere Stationen werden am Anfang und am Ende jedes Transekts durchgeführt, wobei auch längere Eisstationen von bis zu 12 Stunden Dauer geplant sind. Die genaue Lage der Transekte wird von den Eisbedingungen bestimmt und kurzfristig geplant. Wenn es die Eisverhältnisse erlauben, können die Transekte noch weiter nach Süden verlegt werden. Oder wenn die Eisbedingungen zu schwierig sind, können bestimmte Transekte ausgelassen werden, um die Ziele des Projekts dennoch zu erreichen.

Zu den wichtigsten Instrumenten, die während der Transekte eingesetzt werden, gehören zwei Hubschrauber zur Vermessung der Eisdicke und für Landungen auf Eisschollen zur Entnahme von Eis- und Schneeproben, das Sea Ice Monitoring System (SIMS), die CTD-Rosette, der Micro Structure Profiler (MSS), ozeanographische Verankerungen, Ice Tethered Platforms (ITPs), Surface and Under-Ice Trawl (SUIT), Rectangular Midwater Trawl (RMT), Multinet, TV-Multi-Corer (TV-MUC), Ocean Floor Observing and Bathymetry System (OFOBS), Box Corer; Fächerecholot (MBES), Sedimentecholot (SES), ADCP. Darüber hinaus werden wir das britische Autosub Longranger (ALR) einsetzen, ein autonomes U-Boot für hochauflösende Messungen unter dem Eis. Mehrere dieser Systeme erfordern günstige Eisbedingungen und das Vorhandensein größerer offener Rinnen.

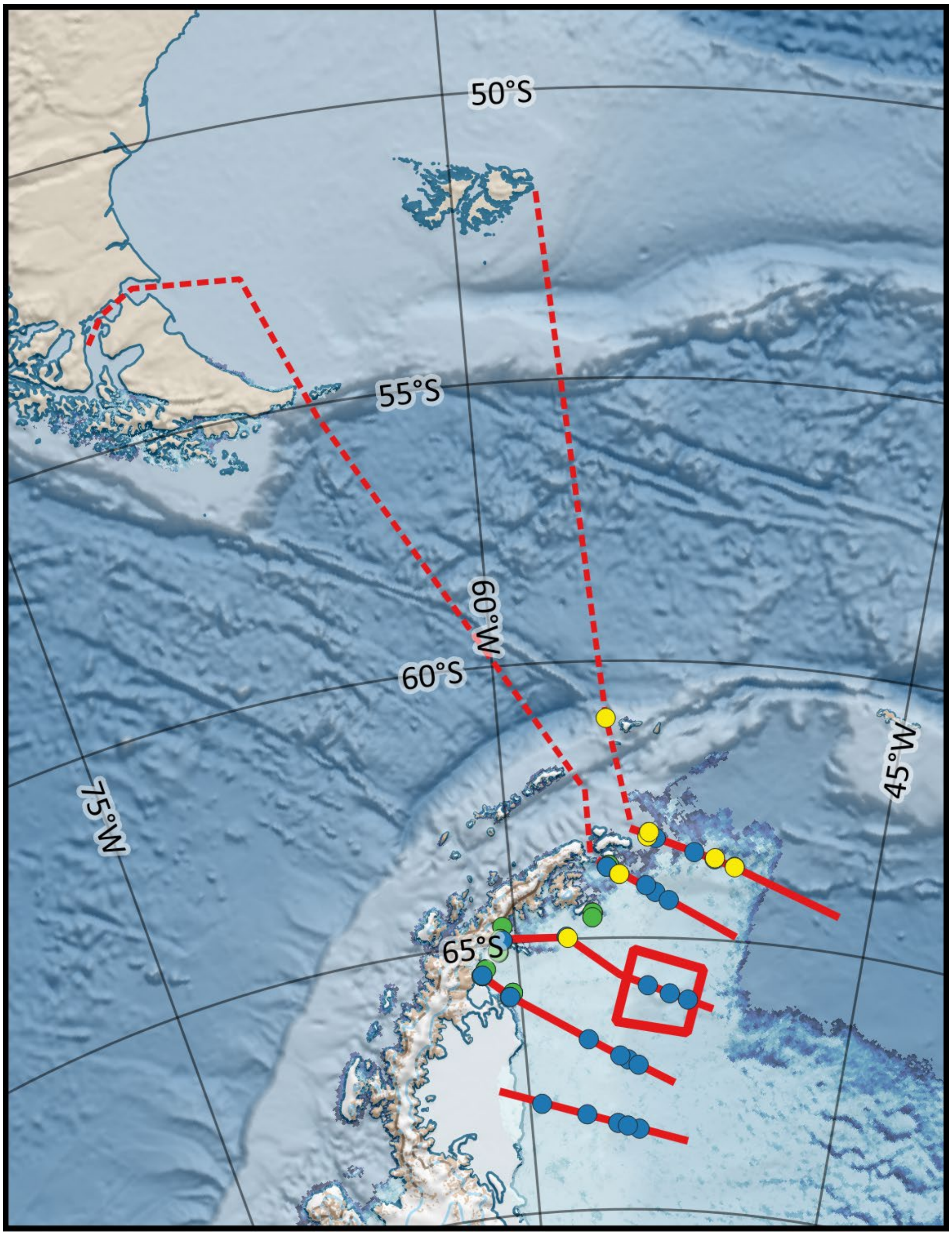

Abb. 1.1: Karte der SWOS-Untersuchungsregion und der voraussichtlichen Fahrtroute. Die dicken roten Linien zeigen die vorläufige Lage der fünf geplanten Transekte, wobei die benthischen Probennahmestationen durch blaue Kreise gekennzeichnet sind. Gelbe Kreise sind benthische Stationen und ozeanographische Verankerungen, die mit Sicherheit besucht werden. Grüne Kreise zeigen zusätzliche benthische Probenahmestellen an. Die rote Box zeigt das prioritäre Gebiet für bathymetrische Fächerlotungen an. Die Eiskonzentration ist als Referenz für den 15. März 2025 angegeben.

Fig. 1.1: Map of the SWOS study region and expected cruise track. Thick red lines show the tentative location of the five planned transects, with benthic sampling stations indicated by blue circles. Yellow circles are benthic stations and oceanographic moorings that will be visited with certainty. Green circles show additional benthic sampling sites. Red box indicated priority region for bathymetric multibeam surveys. Ice concentration is shown for March 15, 2025, for reference.

SUMMARY AND ITINERARY

The northwestern Weddell Sea along the northward branch of the Weddell Gyre is a region of major outflow of various water masses of global importance, thick sea ice, and biogeochemical matter, linking the Antarctic continent to the world oceans. It features a deep shelf and the second largest ice shelf (Larsen C) in the Weddell Sea, and its perennial sea ice cover is among the thickest on Earth. The region is, therefore, among the least explored areas on the planet. Ice-ocean interactions shape the water column and control the sea ice, pelagic, and benthic components. However, there have been major changes in the region since about 2017 with large reductions of sea ice extent that were probably caused by the appearance of warmer water near the ocean surface. These changes may be the harbinger of significant transitions in the northwestern Weddell Sea affecting the complete physical and biological ice-ocean system in the region including the Larsen-C ice shelf which, if exposed to more open water, may be close to collapse in the coming decades.

The goal of the Summer Weddell Sea Outflow Study (SWOS) is therefore to collect multidisciplinary information on the northwestern WS continental slope, shelf, and near Larsen C in order to

1. understand sea ice/ ice shelf/ ocean processes and to assess their impact on hydrographic and nutrient properties as well as on carbon fluxes from the surface to the deep sea;
2. collect region-scale measurements of sea ice thickness distribution and snow properties;
3. characterize oceanographic water masses and understand their formation, dispersion and pathways and shelf-basin exchange mechanisms;
4. understand and map cryo-pelagic and cryo-benthic processes, and ecosystem parameters and gradients in dependence of sea ice conditions.

The research will be carried out at a critical time when the Antarctic marine climate system has entered a phase of accelerated sea ice loss and ocean warming. Results are urgently needed to understand the influence of the break-up of the Larsen ice-shelves on the overall marine system. They are further required for the improvement and validation of Antarctic components of Earth System Models.

The map in Figure 1.1 shows the SWOS study region in the northwestern Weddell Sea. The goal is to carry out comprehensive observations between the sea floor and atmosphere along five transects crossing the continental shelf break in east-west direction and extending onto the shelf and towards the Larsen C ice shelf as far as possible. This way the outflowing branch of the Weddell Gyre can be well characterized and the modifications it's sea ice and water masses experience along the way. In addition, there are few fixed locations at which we aim to repeat benthic observations and sampling that have been carried out during previous cruises, thus allowing to observe temporal change due to, e.g. changed sea ice and ocean conditions, and iceberg scouring.

The timing of SWOS has been chosen to be at or after the end of the summer melt season, with minimum sea ice extent and when the seasonal accumulation of snow metamorphism, sea ice melt, and ocean freshwater input has probably reached its maximum. The cruise will start in Punta Arenas, Chile, on February 6 and will end in Port Stanley, Malvinas/Falkland Islands, on April 9. At first, we will aim to sample a benthic station (MUC station 190-6) before heading to the southernmost transect. Moorings will probably be recovered at the end of SWOS on the way back to Port Stanley.

Sampling along the transects will be informed by water depth in order to capture depth-related gradients along the sea floor. Longer stations will be carried out at the start and end of each transects particularly supporting longer ice stations up to 12 hours long. The exact location of transects will be dictated by ice conditions and agreed upon on short notice. If ice conditions allow, transects may be shifted even farther south. Or if ice conditions are too severe, certain transects may be skipped which will still allow achieving the goals of the project.

Major instruments operated during transects include 2 helicopters for ice thickness surveying and ice and snow sampling, Sea Ice Monitoring System (SIMS), CTD-rosette, microstructure profiler (MSS), oceanographic moorings, Ice Tethered Platforms (ITPs), Surface and Under-Ice Trawl (SUIT), Rectangular Midwater Trawl (RMT), Multinet, TV-Multi-Corer (TV-MUC), Ocean Floor Observing and Bathymetry System (OFOBS), Box Corer; Multibeam echosounder (MBES), Sediment echosounder (SES), ADCP. In addition, we will operate the UK Autosub Longranger (ALR), an autonomous submarine for high-resolution, under-ice measurements. Several of these systems require favourable ice conditions and the presence of larger open leads.

2. OCEANOGRAPHIC PROCESSES AND WATER MASSES IN THE WESTERN WEDDELL SEA

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Objectives

The western Weddell Sea continental shelf and slope are characterized by the thickest year-round sea ice cover around Antarctica (Worby et al. 2008). Extensive first- and second-year sea ice, along with numerous icebergs, strongly shape the regional cryosphere and ocean ecosystems (Gutt et al. 2010). This persistent ice cover severely limits accessibility, resulting in sparse observational data from the region. The disintegration of the Larsen A (Rott et al. 1996) and Larsen B (Glasser & Scambos 2008) ice shelves has left Larsen C as the last remaining major ice shelf in the western Weddell Sea. However, recent large-scale calving events from Larsen C indicate that further retreat is likely, with potential consequences for the dynamics of adjacent glaciers and, more broadly, the West Antarctic Ice Sheet.

In several Antarctic regions, warm water intrusions beneath ice shelves drive intense basal melting. Yet, the oceanography of the Larsen continental shelf remains poorly observed due to the generally thick sea ice cover in the western Weddell Sea. The overall objectives of the PS153 oceanography program are therefore to:

- Improve understanding of regional ocean circulation, water masses, and physical mixing processes;
- Assess the ocean's role in sea ice decline and ice shelf melt; and
- Investigate how the retreat of sea ice and ice shelves may alter water mass formation and circulation patterns.

The oceanography of the Weddell Sea is dominated by the cyclonic Weddell Gyre, which advects warm Circumpolar Deep Water (CDW) from the Antarctic Circumpolar Current across the Prime Meridian toward the continental slope (Vernet et al. 2019). These warm, saline deep waters contrast sharply with the near-freezing, fresher surface layers. Along the ice shelf margins, dense shelf water masses are formed that play a key role in global ocean circulation. High-Salinity Shelf Water (HSSW) forms in coastal polynyas during winter as sea ice production increases salinity in surface waters. When HSSW descends into ice shelf cavities, it remains above the local freezing point and can induce melting at the base of ice shelves. The resulting cooling and freshening of this water produce Ice Shelf Water (ISW), a supercooled (<-1.9 °C) water mass that exits the sub-ice-shelf cavities to the continental shelves. These dense waters, HSSW and ISW, provide the precursors to Antarctic Bottom Water (Fahrbach et al. 2004; van Caspel et al. 2015) and are thus relevant for the global ocean circulation. The dense shelf waters are separated from basin waters by the Antarctic Slope

Front (Thompson et al. 2018), which inhibits a large-scale flooding of the shelf regions with Weddell Deep Water (WDW) and it's modified derivative MWDW. A swift current is known to propagate along the continental slope northward, which makes the region dynamic, and exchange processes between shelf and basin particularly interesting to study. In contrast to the year-round ice cover of the western Weddell Sea around Larsen C, annual polynya openings in Filchner Trough allow easier access to the Southeast Weddell Sea, which makes this region comparatively better studied than the Larsen area. The PS153 expedition will thus provide a unique opportunity to advance understanding of the western Weddell Sea, one of the most inaccessible and fastest changing regions around the Antarctic.

PS153 is closely linked to ongoing efforts in the southern Weddell Sea, connecting the source regions of sea ice and shelf water (Filchner and Ronne) with the throughflow region of the Larsen continental shelf. Sampling strategies and data analyses will draw upon the experience from previous *Polarstern* expeditions (PS96, PS111, PS118, PS146) and ongoing hydrographic monitoring near the Filchner Ice Shelf (Ryan et al. 2020) and the northwest Weddell continental slope (Llanillo et al. 2023).

Fieldwork during PS153 will combine traditional oceanographic methods including CTD (Conductivity-Temperature-Depth) profiling, ADCP (Acoustic Doppler Current Profiler) measurements, and oceanographic moorings, with specialized approaches such as microstructure profiling and autonomous drifting systems and the measurement of various trace gases. These efforts aim to produce both a regional-scale hydrographic overview and to resolve smaller-scale processes that govern water mass transformation, vertical mixing, and bio-physical ecosystem dynamics.

Specific objectives

- Specify the physical properties controlling the flow and water mass formation on the western Weddell Sea shelf and slope using CTD and ADCP surveys
- Determine the temporal variability of the hydrography and tracer distribution on the continental shelf and slope with regard to Ice Shelf Water outflow, Antarctic Bottom Water formation, Modified Warm Deep Water inflow, and High Salinity Shelf Water spreading.
- Provide a comprehensive dataset for numerical model validation and initialisation
- Re-visit some previously occupied hydrographic stations on the western Weddell Sea continental shelf and slope for a new snapshot of the dominant water masses.
- Determine vertical fluxes of heat and nutrients in the western Weddell Sea
- Understand the role of canyons incising the continental slope in guiding dense water masses off the shelf
- Utilize tracers (stable noble gas isotopes [^{3}He, ^{4}He, Ne]) to quantify subglacial meltwater drainage and ice shelf basal melting to provide an improved estimate of glacial melt water inventories and Larsen Ice Shelf basal melt rates for the western Weddell Sea (Huhn et al. 2008)
- Utilize tracers to quantify Antarctic Bottom Water formation (transient trace gases [CFCs and SF6] to identify transit time scales and formation rates)

Work at sea

After transit to the target area, measurements will be carried out with the CTD/water bottle system to acquire hydrographic data and water samples. A minimum of 150 ship-based CTD-casts, and another 30 helicopter-based CTD or MSS/VMP casts are planned to survey the area. From the full-depth profiling casts we intend to obtain about 300 water samples for noble gas isotopes and about 600 water samples for CFC analyses in order to derive glacial meltwater content and water mass age, respectively (Schlosser et al. 1990; Loose & Jenkins

2014). Water samples for helium isotopes and neon will be stored in 50 ml gas tight copper tubes, which will be clamped of at both sides. The noble gas samples are to be analyzed at the IUP Bremen noble gas mass spectrometry lab. Water samples for CFC and SF6 measurements will be stored in 200 ml glass ampoules and will be sealed off after a CFC-free headspace of pure nitrogen has been applied. The CFC samples will be later analyzed in the CFC-laboratory again at the IUP Bremen (Bulsiewicz et al. 1998; Sültenfuß et al. 2009).

For the purpose of our objectives, we will (sea ice permitting) occupy zonally-oriented transects from close to the ice shelf front (Antarctic Peninsula), crossing the continental shelf and slope into the deep basin. This will observe the water masses on the shelf, and capture the northward flowing ISW/WSBW. As outlined in the main map, multiple transects will ideally be occupied to generate information from as far south as possible. Standard CTD stations will be complemented by ship- or ice-based microstructure (MSS/VMP) profiling stations, in order to determine mixing rates and vertical fluxes of heat, salt and nutrients. Long (~12hr) ice stations at both ends of the zonal transects will be used for a comprehensive multi-disciplinary study. Upon the start of the ice station, we will deploy an ADCP through the ice along-side an under-ice string of CTDs to observe current profiles and hydrographic parameters every few minutes until the end of the station. Then, the oceanography-team will carry out repeat measurements with a suite of state-of-the-art microstructure profilers. These include a tethered free-fall MSS probe with live data transmission to resolve turbulent dissipation over tidal cycles. In parallel, we will operate battery-powered, stand-alone Vertical Microstructure Profilers (VMP250s) in "upriser" mode, which allows sampling of the thin ice–ocean boundary layer directly beneath the ice. The profilers are equipped with CTD, fluorescence, and shear sensors, which are needed to quantify vertical fluxes and turbulence. Turbulence occurs episodic and in patches, and a multi-hour repeat profiling time series provides an integrative view of the regional dynamics and further allows to for instance capture effects of tides on mixing (Schulz et al. 2021; Schulz et al. 2022). The oceanographic sampling along the transects and during ice stations will be complemented by autonomous high-resolution hydrographic and bio-optical measurements along pre-defined transects, obtained with the Autosub Long Ranger AUV, operated by PS153-participants from the NOC, UK.

One Oceanographic short-term mooring will be deployed upon entering the study region to measure hydrographic parameters and currents throughout the expedition period at high frequency in order to understand the role of tides or internal waves for water mass transformation and vertical fluxes of heat and matter. For longer-term perspectives we plan to deploy two drifter systems on the sea ice, equipped to transmit CTD data via satellite for an expected period of 1–2 years. To gain further long-term information from the poorly-observed southwestern Weddell Sea, we plan to deploy two oceanographic moorings near the continental slope. These will carry standard oceanographic instruments, and additionally will be equipped with RAFOS sound sources in order to allow position-assignments for under-ice CTD profiling floats, which are known to traverse the area. The floats are frequently deployed as part of AWI's HAFOS (Hybrid Antarctic Float and Oceanography System)-program.

Preliminary (expected) results

The results obtained during PS153 will provide new insights into the physical processes and hydrography of the sparsely sampled western Weddell Sea. The physical oceanography program combines ship-based observations, state-of-the-art sea ice-based mixing experiments, and autonomous measurements using moorings, drifters, and autonomous underwater vehicles (AUVs), all conducted within a multi-disciplinary research framework. The resulting PS153 dataset will provide a present-day update on hydrographic conditions relative to those found two decades ago (e.g. ISPOL, Hellmer et al. 2008) and overall advance our understanding of water mass properties, transformations, and circulation patterns in the western Weddell Sea. In particular, it will illuminate the small-scale processes that govern the vertical exchange of heat, salt, and nutrients, key mechanisms influencing ecosystem structure and sea ice-ocean interactions. These small-scale processes are critical for accurately representing ocean dynamics, yet they remain under-resolved in coarse ocean models. Capturing them requires dedicated field experiments and specialized high-resolution measurements. Through its integrated approach and innovative methodology, PS153 has the potential to bridge this observational gap, thereby contributing essential knowledge for improving process understanding and model representation of polar ocean systems.

Data management

All data will undergo careful post-cruise processing, quality control, and calibration. Turbulence dissipation rates, diffusivities, and flux estimates will be derived following established best practices, with metadata and processing codes archived alongside the datasets. In line with FAIR data principles, processed datasets will be submitted to the U.S. Antarctic Program Data Center and the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) ensuring accessibility to the wider community within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Results will also be integrated into large-scale synthesis efforts such as the Southern Ocean State Estimate (SOSE) to improve climate and ocean models. The preparation of the helium/neon and CFC and SF6 samples as well as the analysis and accurate quality control will be carried out in the labs of the IUP Bremen. Once published, all data sets will be transferred to data archives such as PANGAEA or send to the German Oceanographic Data Center (DOD), where they are available for the international scientific community.

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.

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In all publications based on this expedition, the **Grant No. AWI_PS153_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. SEA ICE GEOPHYSICS AND REMOTE SENSING

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Objectives

After decades of little change, Antarctic sea ice has suddenly plummeted to record-low extents both particularly in summer since 2016 (Turner et al. 2022; Abram et al. 2025). However, interannual variability remains high. The causes for the sudden, Antarctic-wide sea ice decline are still debated, however, there is strong indication that increases in near-surface ocean heat flux dominate (e.g. Purich & Doddridge 2023) although the southern reach of this heat and therefore it's impact on the interior sea ice zone are unclear. Concurrently there are satellite observations of sea ice thinning throughout much of the Antarctic sea ice zone (Kacimi & Kwok 2020; Boquet et al. 2024) but attribution to increases in oceanic or atmospheric heat fluxes remains difficult.

While observations of ocean heat content and flux use routine ship-based, moored, or floating/gliding CTD observations, atmospheric impacts are harder to observe as direct observations of the surface energy balance with weather stations are difficult. However, we have pioneered the use of melt-onset observations by satellites (Haas 2001; Arndt & Haas 2019; Xu et al. 2024) and the analysis of superimposed ice to study varying atmospheric energy fluxes related to the metamorphism and internal melt of snow (Haas et al. 2001; Arndt et al. 2021). Arndt & Haas (2019) propose that there will be an Arctification of Antarctic sea ice if atmospheric energy fluxes increase, with increased internal snow melt and superimposed ice formation, and with the eventual emergence of sea ice melt ponds. These processes also have critical impact on the ice's ecosystem function (e.g. Thomas et al. 1998; Kattner et al. 2004) which will be studied in close collaboration with the sea ice and pelagic biology programs (Chapters 4-6).

Based on the uncertainties regarding the causes of the recent sea ice retreat and its attribution to changed oceanic and atmospheric energy fluxes the objectives of the sea ice geophysics and remote sensing program during SWOS/PS153 are therefore:

- Observations of regional ice and snow thickness as well as amounts of metamorphic snow and superimposed ice at the end of the summer melt season in continuation of sporadic long-term observations carried out in the northwestern Weddell Sea since 2004 during the ISPOL cruise of *Polarstern* (Hellmer et al. 2008; Haas et al. 2008).
- Quantify the seasonal evolution of sea ice and snow properties by revisiting ice floes initially sampled in the southeastern Weddell Sea in summer 2025 (PS146, HAFOS 2025) and continuously monitored by autonomous ice-tethered platforms during their year-long drift across the Weddell Sea.

- Improvement of airborne and satellite ice and snow thickness retrievals by evaluating novel radar and passive microwave sensors and processing algorithms (Tan et al. 2021; Jenssen & Jacobsen 2021).
- Validation of satellite retrievals of snow and ice thickness, ice drift, ice types, and thaw-freeze cycling.
- Optical properties of snow, ice and leads from hyperspectral imaging and their relation to snow properties like grain size and biological activity.
- Microwave emission of Antarctic sea ice at L-band (1.4 GHz).
- Improved sea ice classification based on multi-frequency/polarimetric satellite SAR imagery and near co-incident ground and airborne measurements.

The study region of SWOS/PS153, i.e. the western Weddell Sea, is a key region in this regard, as it is hosts the majority of remaining sea ice during summer and dominates records of Antarctic summer sea ice extent. The study period of February to April is situated at the end of the summer melt season and this ideally suited to evaluate the impacts of summer melt and initial conditions as the ice goes into its next winter when it will probably melt near the ice edge.

Work at sea

Snow and ice sampling and profiling

Individual ice floes will be sampled during the planned ten 12-hour long ice stations and during shorter, 2 to 4 hours long visits by helicopter. In addition, we may reach ice floes by zodiac if ice conditions allow. On ice floes the following measurements and sampling will be carried out:

- Snow pit analysis of stratigraphy and density, salinity, wetness, grain size, etc.
- Snow micro-penetrometer profiles of ice hardness, density, and stratigraphy
- *In-situ* and drone-based hyperspectral imaging of snow metamorphic state
- Ground-EM and drill-hole measurements of ice and snow thickness as well as freeboard and draft
- Ice coring for studies of the thickness and properties of snow, superimposed ice, the gap layer system, and the underlying ice
- Microwave emission at L-band (1.4 GHz) along transects and for individual sampling sites

Ice-tethered platforms (buoys)

A set of autonomous ice tethered platforms (buoys) will be deployed to monitor the seasonal and inter-annual variability of sea ice parameters, such as sea ice drift and deformation (Surface Velocity Profiler, SVPs) as well as sea ice thickness (Ice Mass Balance Buoys, IMBs), and snow depth (Snow Buoys).

Helicopter-based ice and snow thickness surveys

We will carry out extensive ice thickness surveys by means of electromagnetic induction (EM) sounding using an EM Bird. The EM Bird is a towed sensor slung 20 m below the helicopter. It will be complemented by a 1-5 GHz snow radar mounted to its tail that has a vertical resolution of 5 cm. Typical profiles will follow triangular flight tracks with a side length of 40 nautical miles, i.e. 120 nm in total (1.5 hrs). We plan to carry out as many surveys as possible, over as many different ice regimes as can be identified by satellite radar imagery.

Drone flights

We will carry out routine drone flights with a small consumer drone in order to document general ice and surface conditions in the study region around the ship and at ice stations. Depending on weather conditions this will include grid flights in support of photogrammetric generation of digital elevation models (DEMs) of the snow surface. In addition, flights with a bigger drone carrying a hyperspectral camera will be carried out together with the biology groups for observation of snow types, properties, and metamorphic state as well as of phytoplankton communities and biomass at floe edges and in open leads.

Underway measurements and work on board

- Routine ice observations from the ships bridge while underway (ASPeCt protocol).
- Continuous ship-based ice and snow thickness measurements with the Sea Ice Monitoring System (SIMS) that is, for the first time, complemented by the NORCE snow radar.
- Continuous observations of ice conditions adjacent to ship with an L-band microwave radiometer.
- Processing and analysis of snow, ice, and biological samples, including ice texture analysis.
- Reception and analysis of satellite data, including Sentinel-1 and TerraSAR-X SAR images.

Preliminary (expected) results

Overall, results of the sea ice geophysics project shall lead to a better understanding of sea-ice and snow thickness, properties, and drift in the study area in order to unravel the causes of recent sea ice retreats. Our results with identify the special role of the Weddell Sea's sea ice cover in Antarctica and to help evaluate its state and health. Therefore, our expected results can be summarized as following:

- Observations of the thickness distribution of different ice regimes in the western Weddell Sea in relation to their deformational history and oceanic heat regimes.
- Observations of snow thickness and properties and the degree of snow metamorphism to evaluate the intensity of snow melt during the preceding, 2025/26 summer, and for improvement and validation of radar and passive microwave remote sensing retrieval algorithms.
- Observations of thickness of superimposed ice and gap layers in relation to the observed intensity of snow metamorphism and melt.
- Improved retrievals of snow thickness and properties by airborne radars, passive microwave radiometers, hyperspectral imaging, and satellites.
- During freeze-up (if observed) measurement of thickness of young ice by a L-band microwave radiometer and *in-situ* sampling.
- Comparisons of results with previous results from the same region (ISPOL 2004 and WWOS 2006; PS118 2019, Endurance 2022; HAFOS 2025 cruises) to observe long term sea ice changes in the northwestern Weddell Sea.
- Linking results to previous sampling in the southeastern Weddell Sea (e.g., PS146, HAFOS 2025) and buoy measurements to trace seasonal changes in sea ice and snow properties.
- Improved freeboard to thickness conversions in relation to snow and ice morphology.

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.

Buoy data will be available in near-real time through the online portal www.meereisportal.de, and will be embedded into different international data bases, as through the International Program for Antarctic Buoys (IPAB).

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In all publications based on this expedition, the **Grant No. AWI_PS153_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 ECOLOGY

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Outline

Antarctic sea ice is a highly seasonal and spatially extensive component of the Earth System and strongly influences global climate. Sea ice further provides an active biogeochemical interface at the ocean-atmosphere boundary (Uhlig et al. 2019; Vancoppenolle et al. 2013) that has an impact far beyond the carbon cycle only. Sea ice-associated carbon plays a decisive role for the feeding of key species, e.g. Antarctic krill (*Euphausia superba*) (Kohlbach et al. 2017), which in many Southern Ocean ecosystems is providing a direct food-web link between primary producers and higher trophic levels, e.g. penguins, seals and whales. The Weddell Sea hosts a diverse ecosystem which significantly relies on sea ice associated primary production (Vernet et al. 2019). Sea ice serves as a unique habitat for a diverse community of organisms that have evolved special adaptations to the harsh conditions in sea ice, which include low temperatures, high salinities, and low light levels (Tedesco et al. 2025). Areas of sea ice formation and growth have thus an important role for the biodiversity of the sympagic communities (Hardge et al. 2017a). During sea-ice growth, particles including organisms become entrapped in the ice, enriching particle concentrations in the brine channels and thereby enhancing the critical mass of seeding organisms needed for the development of sympagic communities. Once trapped in the sea ice, algae can produce extracellular polymeric substances (EPS), which help shape their environment (Krembs et al. 2011). Observations and model results indicate that 10–20% of the total annual primary production in the ice-covered Southern Ocean are derived from ice algae (Saenz & Arrigo 2014) Mixoplankton may also play a large role in these communities, having been report to contribute up to 100% of the daily bacterial standing stock in spring in the Ross Sea (Moorthi et al. 2009). The extent of mixoplankton phagotrophic contribution is thought to be seasonal (Gast et al. 2018) but has been largely understudied in relation to other oceanic regions. In particular, the southwestern Weddell Sea (WS) remains still extremely poorly sampled in regard to biogeochemical variables and biodiversity (De Broyer et al. 2014; Vernet et al. 2019). In this region, we witness so-called ice algae surface communities, which result from flooding and internal snowmelt processes. One consequence of downward heat flux and snow thaw is the percolation of melt water to the snow-ice interface and the formation of gap layers, continuous or highly porous layers in the upper ice filled with seawater or slush and high concentrations of algae and other microorganisms (e.g. Haas et al. 2001; Kattner et al. 2004). In these habitats, we find a strong accumulation of organic compounds (e.g. Papadimitriou et al. 2009). In the planned research region of PS153, we expect a widespread occurrence of gap layers, which have rarely been sampled with regard to ice thickness, biodiversity, biomass, dissolved substances, and other biogeochemical processes. *Phaeocystis*, which dominates gap layers in the Antarctic, has recently been described as having a phago-mixotrophic feeding strategy (Koppelle et al. 2022), with implications for the nutrient cycling and ecology of gap layers. The dissolved and particulate components from the sea ice have strongest exchanges with the underlying oceanic habitat during brine rejection and sea ice growth (Hardge et al. 2017b; Kauko et al. 2018). The same is true for gypsum crystals, so far only found in Arctic Sea ice (Wollenburg et al. 2018), which could also be a ballasting factor for *Phaeocystis*, influencing carbon export.

Objectives

In the planned research region of PS153, the sea ice ecology team aims to:

1. Analyse the abundance, biodiversity and community structure of sea ice-associated biota;
2. elucidate the role of sea ice biota for the cryo-pelagic-benthic coupling during the ongoing melt;
3. determine sea ice algal primary productivity along basin to shelf transects during the summer to autumn transition;
4. quantify under-ice water column (0–100m) physical, bio-optical and biogeochemical parameters to characterize under-ice phytoplankton communities and their abiotic drivers;
5. investigate functional biodiversity of phyto- and mixoplankton in and under the sea ice in combination with biogeochemical parameters;
6. characterize the spatial chemical diversity of metabolites such as osmoregulators and cryoprotectants, and identify the environmental drivers that drive the production of these compounds on the genomic level;
7. investigate the potential role of cryogenic minerals for the carbon export in the Western Weddell Sea.

We want to identify the drivers of primary production and microbial niche adaptation in sea ice microhabitats and the underlying water. We will characterise the physiology of psychrophilic microorganisms and their influence on the concentrations of particulate and organic carbon in the ice and brine, and in gap layers. We will also investigate the chemical diversity of metabolites in the ice, brine and adjacent water column that allow these organisms to thrive in these extreme habitats.

The investigations will be complemented by taking sea ice cores for gypsum and other cryogenic crystals. Together with the other research teams this will allow us to improve our understanding of the coupling between physical, chemical and biological processes in the Western Weddell Sea.

Work at sea

We will collect sea ice cores, under ice water, brine and gap water and if present newly formed sea ice during ship-based ice stations or by visiting individual ice floes with helicopters.

The following measurements and sampling will be carried out:

- Measurements of environmental parameters of sea ice such as temperature, snow depth, porosity, freeboard and ice thickness.
- Collection of the biological and biogeochemical variables at each ice station as indicated in Tab. 3.1.
- Primary production measurements of selected ice core horizons
- Characterisation of the under-ice environment by fluorescence probes and using a bio-optical sensor package.

- Assessment of mixotrophy of plankton communities by collecting under ice water including at the chlorophyll maximum and selected ice core sections
- Collection of ice samples for gypsum

For primary production we will sample habitats (e.g., bottom communities, gap-layer communities, brine, communities in discoloured newly-formed frazil ice) to determine ice algal gross primary production and net community production using onboard carbon stable isotope (^{13}C) incubations and oxygen-optode incubations (Campbell et al. 2022), respectively.

Tab. 3.1: Sample types taken from depth-resolved ice core sections, new ice, under-ice water, gap-layer and brine

Parameter	Treatment	Sample volume	Storage container	Storage condition
Salinity	Unfiltered or filtered	40 mL	PP bottle	Direct analysis
Nutrients	Unfiltered or filtered	40 mL	PP bottle	Frozen -20°C
Pigments	Filtration GF/F	0,001-2L	2 mL Apexvials	Frozen -80°C
Particulate organic carbon/nitrogen	Filtration combusted GF/F	0,01-2L	2ml Eppies	Frozen -20°C
Particulate biogenic silicate	Filtration cellulose acetate filter	0,01-2L	2ml Eppies	Frozen -20°C
Fractionated DNA	Filtration Polycarbonate filter (0,4;3;10µm)	0,01-2L	2ml Eppies	Frozen -80°C
Microscopy	Unfiltered	100ml	Glass bottles	4°C
Algal cultures	Unfiltered	15 mL	Sterile falcon tube	4°C (light)
DOC	GF/F filtered, sampling under laminar flow in clean room container	20 mL	HDPE bottle	Frozen -20°C
Osmoregulators, cryoprotectants	Filtration GF/F	500 mL	Filters and UF filters	Frozen -80°C
SPE-DOM	GF/F filtered, acidified	500 mL	ppl resin/PP cartridge	Frozen -20°C
Fluorescence (F-DOM)	GF/F filtered	20 mL	HDPE bottle	Frozen -20°C
Bacterial cultures	Unfiltered	15 mL	Sterile falcon tube	Agar plating
Microbiome genomics	Unfiltered, thawed in sterile SW, 3 µm, 0.2 µm filtration. $FeCl_3$ precipitate (12 h) filtered onto 0.8 µm	1-5 L	5 mL cryotube	Snap frozen in liquid N_2, then -80°C
DMSP	Unfiltered, acidified	12 mL	Glass vial	0°C

During ship-based ice stations, ice habitat sampling (Tab. 3.1) will be complemented by under-water measurements using a bio-optical sensor package consisting of a (i) RbR-Concerto conductivity-temperature-depth (CTD) probe equipped with a dissolved oxygen sensor, pH sensor and a transmissometer, (ii) a Sea-Bird Electronics Wet-Labs ECO Custom Triplet (equipped with a Chl-*a* fluorometer, a Fluorescent Dissolved Organic Matters (FDOM) sensor, and an optical (700 nm) backscatter sensor), as well as (iii) a TriOS hyperspectral radiometer (to measure under-ice transmitted irradiance). This sensor package (lowered through a hole in the sea ice) will allow concomitant determination of vertical profiles (0-100m) of under-ice water temperature, salinity, pH, dissolved oxygen, light attenuation, Chl-*a* concentration, FDOM concentration and hyperspectral irradiance (400 – 700 nm). Combined, these data will allow us to link sea-ice physical properties (sea-ice light transmissivity) with under-ice biogeochemical processes, and in particular will allow to identify physical drivers (light level thresholds) of under-ice phytoplankton communities (e.g., Hague & Vichi 2021). Where necessary (e.g., at stations where ship-based CTD-rosette measurements are not available), under-ice water at 5, 10 and 30 m depth from the ice–ocean interface will also be collected for the calibration of the under-water sensor package. At helicopter-based ice stations the RBR Duo^{3}D.chla fluorescence probe will be used for algae biomass profiles under the sea ice.

To assess phytoplankton community composition and the degree of mixotrophy, sea ice cores under-ice water, and the Chl-*a* maximum will be sampled. Additional on-board incubation experiments will be performed under varied light levels to assess silicification degree and mixotrophy using the fluorophore PDMPO and food vacuole stain LysoTracker Green, respectively. All samples will be stored at 4°C and later quantified using multispectral imaging flow cytometry in the home laboratory.

Preliminary (expected) results

We expect to find distinct bacterial and phytoplankton communities across the various transects from south to north, as well as across the stratified sections of the ice cores. In addition, we anticipate that the ice-algae–associated microbial communities in the sea-ice cores will be characterized by elevated osmolyte and cryoprotectant synthesis relative to those in the adjacent seawater. We further expect to detect an increased catabolic potential of the bacterial community in the ice to degrade these compounds. The expected detailed description of under-ice water column physical and biogeochemical characteristics will be combined with the primary production rates as well as photosynthesis versus light intensity (PvE) curves of different ice algal communities to get a comprehensive understanding of drivers of sea-ice associated primary production.

The degree of diatom silicification and division rates are expected to be constrained by light availability with degree of silicification decreasing with increasing growth rates. Mixoplankton in the various communities is expected to be present in low abundances, but contributing substantially to heterotrophy, particularly in brine channels. Abundance and trophic mode of mixoplankton will be related to a variety of environmental parameters obtained by other groups.

In summary the planned work will give new insights about the to abundance, biodiversity and community structure of sea ice-associated biota. It will quantify ice-associated ecosystem functions and their relationships with biodiversity from the deep basin to the shallow shelf of the Western Weddell Sea.

Data management

Samples

Except for the gypsum samples, all other sea ice variables taken during the cruise will be processed during or after the cruise (within approximately 2 years).

Leftovers of the microscopic samples and DNA samples will be stored at AWI- Polar Biological Oceanography for approximately 10 years.

Data

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 unrestricted availability from PANGAEA will depend on the progress of a PhD thesis based on the data. Obtained sequences will be deposited in publicly available databases upon publication of the work.

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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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Wollenburg JE, Katlein C, Nehrke G, Nothig EM, Matthiessen J, et al. (2018) Ballasting by cryogenic gypsum enhances carbon export in a *Phaeocystis* under-ice bloom. Sci Rep-Uk 8. https://doi.org10.1038/s41598-018-26016-0

5. WATER COLUMN NUTRIENTS, PRIMARY PRODUCTIVITY AND PHYTOPLANKTON CHARACTERIZATION

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Outline

The southwestern Weddell Sea (WS) remains extremely poorly sampled in regard to biogeochemical variables and biodiversity (De Broyer et al. 2014; Vernet et al. 2019). Nevertheless, this region is undergoing dramatic changes due to the breakup of ice shelves along the Antarctic Peninsula, which results in oceanographic conditions unprecedented in the past 10,000 years (Domack et al. 2005). Particular the severe sea ice conditions hampered previous studies in this region and therefore little is known of the environmental drivers of primary productivity and phytoplankton composition in western WS (Bertolin & Schloss 2009; Cape et al. 2014). Understanding primary productivity in relation to sea-ice edge blooms and to southward ice retreat is critical to determine the time and space variability of the WS as a carbon source and sink (Hoppema 2004). Sea ice melting provides stratification, seeding of algae and inorganic nutrients to initiate phytoplankton growth and is also expected to release organic compounds that can affect productivity and cell-size distribution (Pohnert et al. 2007) influencing the zooplankton community and the downward carbon flux (Fischer et al. 2002). As sea ice varies, expected phytoplankton biodiversity changes can be assessed through a combination of pigment analyses, DNA metabarcoding (Andersson et al. 2023) and precise cell counts for pico- and nanoplankton using Flow Cytometry. Additionally, fatty acids can be used as biomarkers for phytoplankton presence and community composition as well as recent grazing activity and microbial processing (Reuss & Poulsen 2002; Desvilettes et al. 1997). Mineral ballasting from cryogenic gypsum could enhance the carbon export of small flagellates like *Phaeocystis* (Wollenburg et al. 2018). Shelf to basin transects along a latitudinal gradient and crossing the MIZ several times, as proposed in SWOS, will allow to understand the processes associated with and developed after these major changes, for the marine ecosystem and biogeochemical cycles.

Objectives

This work package aims to characterize biogeochemical properties, as well as phytoplankton community composition and productivity along all five transects of the SWOS voyage using CTD casts, with additional underway measurements as detailed below. These observations will be interpreted in the context of the ice environment and the physical characteristics of the water column (also derived from the CTD) to infer the limitations on primary productivity and to identify the sources and sinks of nutrients that impact the ecosystem.

Work at sea

CTDs

Nutrient samples for determination of nitrate, phosphate and silicate will be taken from CTDs at up to 12 depths and will be stored frozen for analysis on shore. Phytoplankton pigments and POC/PON samples will be collected at up to 6 depths per CTD, filtered and stored frozen for later analysis on shore, following established protocols by Peeken et al.. Samples to count pico- and nanoplankton using Flow Cytometry will be taken at the same depths, fixed with glutaraldehyde and stored frozen at -80 for later analysis. Samples for bacterial and phytoplankton DNA analyses will be collected and processed by Matthias Wietz (SEACAT, Chapter 11). The data for phytoplankton DNA will be shared with us. At up to 30 CTDs stations, samples for fatty acid analyses will be taken from surface waters, filtered and frozen for analyses on shore. Likewise, at up to 30 stations, large water volumes (~8L) will be drawn from the CTD at 1-2 depths and will be incubated using the ^{13}C method (Balch et al. 2022) for determination of *in situ* primary productivity. Incubations will be conducted for 24 h in a temperature- and light-controlled container, filtered at the end of the experiments, and analysed on shore.

Underway measurements

To further relate phytoplankton characteristics in surface waters to the surrounding ice scape, and to determine the influence of iron limitation on phytoplankton productivity, two instruments will take measurements on the underway seawater line: a hyperspectral acs, which measures absorption and attenuation at ~100 wavelengths (400–750 nm), and an instrument that acquires fluorescence-induction curves (FIRe or LabSTAF). The fluorescence measurements characterize the photophysiological state of the phytoplankton, allowing estimation of Fv/Fm, which can be directly related to the iron-limitation status of phytoplankton. Hyperspectral acs data will be analysed for chlorophyll concentration (using the absorption line height at 676 nm; Roesler & Barnard, 2013), yielding a high-fidelity data point every ~30 seconds that is not affected by the natural light that the phytoplankton receive – unlike fluorescence, which is frequently used to infer chlorophyll concentrations but is affected by non-photochemical quenching during daylight. During the cruise, the acs is connected to a seawater supply taking surface ocean water. A valve with timer switches the in-flow to the acs between filtered and unfiltered water to allow alternating measurements of the total (including particulates) and the dissolved inherent optical properties of the sea water. Flow-control and a debubbler-system ensure that water flows 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. In addition to chlorophyll concentration, analyses of hyperspectral acs data (in conjunction with pigment analyses from associated samples, which will be taken 2-3 times daily) will yield estimates of pigment concentrations at high temporal (and thus spatial) resolution (Chase et al. 2013). This allows us to infer phytoplankton community composition and how it varies along environmental gradients.

Preliminary (expected) results

The proposed work will give insights about basic variables from the deep basin to the shelf in the previous understudied region of the Western Weddell Sea. A combination of CTD profiles compared with the ongoing surface data will allow to upscale the findings of the transect to the western Weddell Sea. The proposed work will yield detailed mapping of nutrients, chlorophyll, POC, and contribution of different phytoplankton functional types. The transects can then be compared and analysed in context of the environmental conditions, such as sea ice cover and bathymetry. Nutrient profiles can be used to infer seasonal productivity based on nutrient drawdown relative to winter water concentrations. Primary productivity estimates will be normalized to POC and run under identical conditions of light and temperature. The results can therefore be directly compared and differences between stations and transects can be related to environmental factors such as iron limitation. Underway data can be directly related to other parameters measured underway, such as sea surface temperature, wind speed, ice scape and heat flux and enlarge the transect approach. 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 absorption and attenuation data. These data of high temporal (and thus spatial) resolution will also be useful to better interpret trends observed in primary productivity from basin to shelf transects.

Data management

Samples

All CTD and underway samples taken during the cruise will be processed during or after the cruise (within approximately 2 years).

Data

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 unrestricted availability from PANGAEA will depend from the progress of a PhD thesis based on the data. Obtained sequences will be deposited in publicly available databases upon publication of the work.

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

In all publications based on this expedition, the **Grant No. AWI_PS153_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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6. ECOSYSTEM FUNCTIONS OF SYMPAGIC AND PELAGIC MESO- AND MACROFAUNA

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Objectives

The objective of the multinational PS153 Summer Weddell Sea Outflow Study (SWOS) is to collect multidisciplinary information on the continental slope, shelf, and Larsen C-near areas in the western Weddell Sea to understand physical and biogeochemical processes and their impacts on hydrography, nutrient balance, and surface-to-deep-sea carbon fluxes; to determine regional sea-ice thickness distribution and snow properties; to characterize water masses and understand their formation, dispersal, and mixing on the shelf; and to understand and map cryopelagic - benthic coupling and ecosystem parameters as a function of sea ice conditions. The team *Ecosystem function of sympagic and pelagic meso- and macrofauna* contributes to this overarching aim by assessing the abundance, biomass and biodiversity of pelagic and under-ice fauna and their ecosystem functions. This includes the analysis of the variability of krill and zooplankton in ice-covered regions and their ecological role. We further intend to study population dynamics of krill in this area.

Work at sea

We will use the broadband mode of the EK80 in four frequency ranges (around 38, 70, 120 and 200 kHz) to achieve higher taxonomic resolution and greater accuracy of biomass estimates than with single-band echosounders. The abundance and community composition of under-ice zooplankton and micronekton in the upper 2 m of the water column will be sampled with a Surface and Under-Ice Trawl (SUIT). A sensor array mounted on SUIT will collect real-time data on sea-ice and water-column properties during fishing. The sensor array includes an Acoustic Doppler Current Profiler (ADCP), an under-water video camera, and a CTD with built-in fluorometer, and spectroradiometers to estimate the amount of ice algal biomass along SUIT profiles (Castellani et al. 2020). Macrozooplankton, Antarctic krill and mesopelagic fish will be sampled in the pelagic layer (0–1,000 m) with a Rectangular Midwater Trawl (RMT). A Multinet will be used to sample the distribution of the mesozooplankton community in 5 depth strata down to 1,000 m depth. The different nets will be used along five transects going from open water into the sea ice. Were possible the Multinet will be used during ice stations. The species and size composition of animals caught with the various nets will be used in combination with hydroacoustic profiles and taxonomic composition derived from eDNA sequencing of fish (in collaboration with Matthias Wietz; Chapter 11), to estimate the species composition, abundance and biomass of the pelagic and under-ice fauna at various overlapping spatial scales and taxonomic resolutions. We will also sample animals, particulate organic matter from sea ice and from the water column for trophic biomarker analysis (fatty acid profiles, HBIs, compound-specific stable isotope composition) to quantify the flux of carbon into the pelagic food web from ice algae and phytoplankton, respectively (Helmholtz Young Investigators Group Double Trouble). In addition, we will collect samples of Antarctic zooplankton for several analyses such as energy content, pollutants and population dynamics.

Preliminary (expected) results

We expect to obtain a comprehensive dataset of the distribution and diversity of pelagic and under-ice fauna in the different areas of investigation. Biomarker, pollutant and other samples will be analysed in the home laboratories and will contribute to a quantitative understanding of the role of ice algal production and sea ice associated zooplankton in the Antarctic food web, and the trophic pathways of contaminants.

Data management

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

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

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

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

In all publications based on this expedition, the **Grant No. AWI_PS153_05** will be quoted and the following publication will be cited:

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7. ECOLOGY OF SOFT-BOTTOM SEAFLOOR: INFAUNA BIODIVERSITY AND FUNCTION ALONG SHELF AND SLOPE TRANSITION AREAS

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Grant-No. AWI_PS153_06

Objectives

Benthic fauna represents the richest component of Antarctic biodiversity in terms of species numbers. The benthic organisms of the Southern Ocean shelf have long been isolated from other oceans (Clarke et al. 2005; De Broyer et al. 2014), resulting in highly unique ecosystem. Aside from evolutionary history, macrobenthic community composition and distribution are generally determined by the combined effects of regional and rather short-term biological and physical processes, such as input of organic matter or disturbances, respectively (Gutt et al. 2019; Säring et al. 2022). Meiobenthic communities are structured by grain size, food quantity and quality and bottom water characteristics (Veit-Köhler et al. 2018; Säring et al. 2022). Despite this, data from the Southern Ocean is scarce and the few results indicate a dependence rather from ice-related primary production than shelf or slope habitat (Segelken-Voigt et al. 2016).

Interactions between infauna communities and their environment, as well as ecological processes driving the benthic ecosystem in the Southern Ocean, remain poorly understood (Gutt et al. 2019), stressing the need to understand the role of environmental (changing) vs topographical (stable) features for benthic communities. Understanding these relations is crucial to identify potential habitats and apply species and community distribution models, and thus to quantify the productivity (biomass) and functions of seafloor habitats along the Antarctic continental shelves. Repeatedly sampled sites subject to a changing environment allow us to disentangle biotic and abiotic effects (Gutt et al. 2013).

The project "benthic soft-bottom habitat, biodiversity and function" of the SWOS expedition will investigate community composition of micro-, meio- and macrofauna, fluxes at the sediment-water interface as well as bioturbation and bioirrigation patterns across the topographic depth gradient as well as varying environmental conditions and sea-ice regimes in the north-western Weddell Sea.

The objectives are:

- Identify biodiversity patterns of benthic ecosystems to investigate how micro-, meio- and macrofauna communities differ in their composition (abundances, taxa and functional groups) with regard to different topographical and environmental conditions (e.g., sea ice) to apply multivariate species/ community distribution models.

- Assess ecosystem functions: investigate the influence of ice cover vs shelf-to-slope habitat on the benthic ecosystem functions of oxygen and nutrient fluxes at the sediment-water interface.
- Quantify sediment mixing processes: analyze the benthic bioturbation and biorrigation in shelf and slope habitats and the effect of infauna communities on these processes.

Work at sea

We plan to sample 14 up to 20 sites, along the depth gradient of 3–5 transects. Each transect should contain 4 sites (ca. 200–250 m, 450–500 m, 600–650 m, 800–850 m depth ranges). Importantly, three repeated stations (for comparison with environmental changes) are located at the beginning of the transects. These repeated stations are part of long-term time series and were previously sampled during PS81 in 2013, PS96 in 2016 and PS118 in 2019 (Tab. 7.1).

At all stations we will deploy the TV-guided multicorer (TV-MUC10) to collect sediment cores for incubation and bioturbation studies on board. CTD casts (water temperature, salinity,) will be necessary at each MUC deployment to collect bottom water data and characteristics. Macrofauna (in particular infauna) will be sampled by a giant box corer (GKG) at selected stations for additional fauna classification.

Tab. 7.1: List of repeated MUC sampling sites during PS153. Bold indicates highest priority.

No. repeated station	Transect	Latitude	Longitude	Prior sampling campaign
A	T5	-63°04.956’S	54°19.490'W	PS118
B	**T4**	**-63°50.58'S**	**55°31.66'W**	**PS81, PS96**
C	T3	-64°58.724'S	57°46.379’W	PS118

Experimental approaches including incubations for flux measurements and luminophore tracer studies will be performed on board in temperature-controlled laboratory containers (2°C; Fig. 7.1).

Replicated TV-MUC10 cores, taken at each of the stations, are used to determine short-term oxygen consumption and nutrient fluxes at the sediment-water interface. For this purpose, nutrient and oxygen concentrations in the water layer above the sediments are determined in onboard dark incubation measurements for 48-96 h (2°C; Fig. 7.1). A Fibox-LCD optical sensor is used to determine oxygen concentration non-invasively. Bioirrigation will further be determined using bromide tracers and extracting pore water using rhizones at the end of incubation. Additionally, subsamples for Chl-*a*, TOC, C/N and grain size are taken from sediment cores to enable interpretation of the effects of particle reworking on benthic mineralization. Then, cores are sliced and sediments including macro- and meiofauna are preserved in 96% Ethanol (alternatively 4% formaldehyde solution) for further analyses of biodiversity patterns in the labs in Germany (Link et al. 2013; Säring et al. 2022).

In addition, three sediment cores each are sliced and frozen directly into subsamples for later analysis in lipid, protein, and carbon content, Chl-*a* concentration as well as microbial abundance and genetic diversity.

At six stations, eight additional cores will be obtained from another TV-MUC10 deployment for experimental work (carried out in a temperature-controlled laboratory container, 2°C). The experiments will test the role of the important macrofauna taxa on particle transport (using luminophores) in the area.

We plan to carry out TV-MUC10 and GKG deployments at stations where bottom topography will allow safe use of the gear. We will collect information on sediment composition and bottom topography from the bathymetry group (Chapter 9) and by following the OFOBS deployment (Ocean Floor Observing and Bathymetry System, Chapter 8).

There is close cooperation with Dr. Jerosch's team, which uses OFOBS to determine the heterogeneity of the habitat and correlation between epifauna and infauna patterns, among other things.

Preliminary (expected) results

By combining faunal size classes (micro-, meio- and macrofauna) and different benthic processes synchronously, it will be possible to evaluate, how changes in habitat conditions and topography may affect benthic ecosystems, including their structure, function, and potential for carbon sequestration. Our results will complement to the habitat mapping and assessment of epibenthic diversity patterns (Jerosch et al.) from PS153.

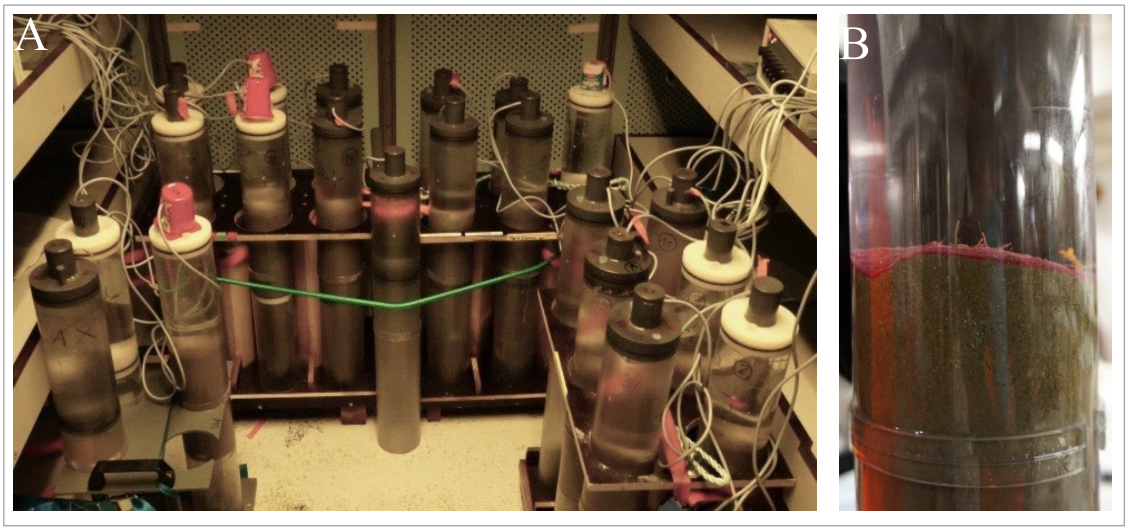

Fig. 7.1: (A) set up of incubation cores in cooling container, (B) Sediment core after luminophore treatment retrieved from TV-MUC at PS129 station EWOS_06, luminophores clearly distinguished by pink color compared to original sediment core. Photo: H. Link & C. Gebhardt (URO)

Data management

Processed 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 expedition at the latest. By default, the CC-BY license will be applied.

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

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

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8. BENTHIC ECOLOGY AND DIVERSITY: QUANTITATIVE SEAFLOOR IMAGING, BENTHIC FAUNA ABUNDANCE AND BIODIVERSITY

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Objectives

Benthic fauna represents the richest component of the Antarctic biodiversity in terms of numbers of species, yet factors shaping its distribution and composition remain partially understood. Besides from evolutionary history, the composition and distribution of benthic communities are generally determined by the combined effects of regional and short-term biological and physical process, such as the input of organic matter or disturbances (Gutt et al. 2019). However, data linking ice-related processes and habitat structure to benthic biodiversity and distribution patterns are still scarce for the Weddell Sea, stressing the need to understand the role of environmental (changing) and topographic (stable) features for epibenthic communities. To address these gaps, high-resolution and acoustic mapping with the Ocean Floor Observation Bathymetry System (OFOBS) will be conducted during PS153. The OFOBS is a towed device capable of deployment in moderately ice-covered regions and capable of concurrently collecting acoustic as well as video and still image data from the seafloor (Purser et al. 2018).

These data will serve three purposes: (i) habitat mapping, (ii) assessment of epibenthic biodiversity patterns (abundances, functional groups) with regard to different topographical and ice-related conditions, and (iii) assess the influence of ice cover *vs* shelf-to-slope habitat on the benthic ecosystem. Moreover, obtained data will be directly comparable with image, video, and high-resolution sidescan data, collected from the Weddell Sea during other recent *Polarstern* cruises, such as PS81 in 2013 (Gutt et al. 2013) and PS96 in 2015/16 (Cape et al. 2014).

For habitat mapping, OFBOS data streams will be integrated to produce high-resolution 3D spatial models (topographic maps) of the seafloor. These models will allow subsequent high-resolution analysis of terrain variables, such as slope, aspect and rugosity, and their relationship to the distribution of benthic fauna on a finer scale than has previously been possible in the PS153 research area. For the description of epibenthic communities and the biodiversity, OFOBS images will be surveyed for the composition, abundance and distribution of megabenthic assemblages/ organisms (mostly epibenthic, i.e., seafloor organisms that are large enough to be visible ain seabed images). From this data ecological indices will be derived, the community structure will be described, and changes to archived community data assessed. The community composition and diversity will be related to environmental parameters and topographical conditions. Megabenthic fauna have a high ecological significance to Antarctic shelf ecosystems and strongly affect small-scale topography of seafloor habitats and do thus exert prime influence on the structure of the entire benthic ecosystem. Some species are especially habitat specific and sensitive to environmental changes, due to their slow growth or reproduction mode and show a high degree of environmental adaptation. Therefore, they can serve as early indicators of ecosystem shifts and specific topographic conditions.

OFOBS will further sample ice fish for the collection of tissue suitable for DNA analysis and the application of genetic methods for the conservation and restoration of biodiversity.

Work at sea

Habitat mapping

OFOBS is a cabled/ towed system deployed ~1.5m above the seafloor at very low ship speeds of max. 0.5 knots (for more detailed information see Purser et al. 2018). While in operation, the exact location of the georeferenced system is determined and verified continuously by *Polarstern's* POSIDONIA system, and refined by the integrated Inertial Navigation System (INS) and Dynamic Velocity Logger (DVL).

In addition to collecting image data comparable with those collected from Southern Ocean waters by previous survey cruises, OFOBS will collect in parallel high resolution topographical information from the seafloor using a sidescan sonar system and a forward-facing acoustic camera. The sidescan system allows a ~100m swath of the seafloor to be investigated acoustically at the same time as the collection of still and video camera images. During previous cruises the facility for this combined system to generate useful data on geological structure distribution, high-resolution topographical products and faunal distribution maps has been demonstrated. Additional water samples will allow analysing environmental data and particles that will be related to the imagery data.

Epibenthic communities and biodiversity

The high diversity of the seafloor megafauna in the Weddell Sea has been made apparent form previous camera surveys (e.g., PS81, PS96 and PS118, in 2013, 2015/16 and 2019, respectively). During PS153 megabenthos will be studied using OFOBS along transects (planned for 6 transects, 5h deployments) plus at each MUC station (200-250 m, 450-500 m and 600-650 m 800-850 m depth ranges) if ice conditions allow. The OFOBS deployments will be carried out in distinct habitats: shelf, upper slope, lower slope and deep sea. Videos and still images will later be analyzed for composition, abundance and distributing of megabenthic assemblages, i.e., those seafloor organisms that are large enough to be identified from seabed images. We aim to cover as many different habitats as possible.

Ice-fish tissue samples

For some deployments, OFOBS will be used to collect fish on the seafloor, and will be equipped with a net comprising two layers (300 µm mesh for catching small fish and 2.5–5 cm mesh for collecting larger fish) For these dives OFOBS will be flown at a height of 1 m above the seafloor and the regular OFOBS camera used to observe the weighted chain opening of the attached net. When the OFOBS is towed at 0.1 kt and a favourable fish is visible in the camera view, the OFOBS will be lowered to a height of 50 cm above the seafloor. At this depth the chain will roll along the seafloor directly scooping fish into the sampling net and filming the whole process. This will be repeated until approximately 10 fish are collected. For the expedition a target of 40 fish is intended. On deck the fish will be transferred in buckets containing sea water for triage. Dead individuals will be delivered to the fish lab and sampled (fin clips, and otoliths), while alive individuals will be quickly photographed and fin clipped taking care to take the picture and collect the portion of tissue directly underwater through the partial fin-clipping technique, and immediately releasing the individual. Therefore, sampling and manipulation of individuals will be carried out mostly in their natural medium. This technique, widely used in other contexts, does not cause obvious harm to individuals, not influencing growth or mortality rates of individuals in nature (Woodall et al. 2011). Fin clips will be conserved in abs ethanol at 4°C, otoliths will be preserved dry in tubes. Tissue samples will be analysed at the by Chiara Papetti (not on board) at the University of Padua Padova, Italy.

Sampling for the analysis of (nano) particles with TOC-MS

For the investigation of the chemical composition and size distribution of particles by single particle analysis using Time-of-Flight mass spectrometry (TOF-MS) at AWI (Pascal Bohleber, Grit Steinhoefel, both not on board), we will sample snow, ice, surface-water, water-column (~seven different depths), bottom water and sediment. Samples will be taken with the niskin bottles from the CTD rosette, MUC and while ice-stations. Samples will be analysed after the cruise at the AWI.

Preliminary (expected) results

Habitat mapping

The collection of images and topographical high-resolution data from topographically different regions of seafloor is envisaged. Should conditions be unfavourable for surveying these regions of seafloor, collecting data from the secondary study target will supplement data collection from previous cruises, such as PS81, PS96 and PS118, to improve our understanding of habitat distribution in the Weddell Sea.

Epibenthic communities and biodiversity

The expected results will provide a qualitative assessment of the megabenthic epifauna in relation to environmental drivers and their habitats from different topographic sites. The findings will provide valuable information on ecosystem functions, such as biodiversity, and will allow a comparative analysis of the ecological impact of topographic and ice-related conditions on benthic communities. Data will identify spatial distribution patterns at local and regional scales.

Ice-fish tissue samples

The expected results will provide an assessment of the ice-fish organisms in relation to environmental drivers and their habitats from different topographic sites. The findings will provide valuable information on ecosystem functions, such as biodiversity, ecophysiological and evolutionary aspects, and will allow a comparative analysis of the ecological impact of topographic and ice-related conditions.

Sampling for the analysis of (nano) particles with TOC-MS

The collection of water samples will enable a quantitative and qualitative assessment of water particles, such as their chemical composition and TOC content at OFOBS sites and will give insights on the particle distribution long the transects.

Data management

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

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

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

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

In all publications based on this expedition, the **Grant No. AWI_PS153_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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Purser A, Marcon Y, Dreutter S, Hoge U, Sablotny B, Hehemann L, Lemburg J., Dorschel B, Biebow H & Boetius A (2018) Ocean Floor Observation and Bathymetry System (OFOBS): A New Towed Camera/Sonar System for Deep-Sea Habitat Surveys, IEEE Journal of Oceanic Engineering 44:87–99. https://doi.org/10.1109/JOE.2018.2794095

Gutt J, Cape M, Dimmler W, Fillinger L, Isla E, Lieb V, Lundälv T & Pulcher C (2013) Shifts in Antarctic megabenthic structure after ice-shelf disintegration in the Larsen area east of the Antarctic Peninsula. Polar Biology 36 (6):895–906. https://doi.org/10.1007/s00300-013-1315-7

Gutt J, Arndt J, Kraan C, Dorschel B, Schröder M, Bracher A & Piepenburg D (2019) Benthic communities and their drivers: A spatial analysis off the Antarctic Peninsula. Limnol Oceanogr. 64 https://doi.org/10.1002/lno.11187

Woodall LC, Jones R, Zimmerman B, Guillaume S, Stubbington T, Shaw P & Koldewey HJ (2011) Partial fin-clipping as an effective tool for tissue sampling seahorses, *Hippocampus* spp. J Mar Biol Assoc UK. 92(6):1427–1432. https://doi.org/10.1017/S0025315411001810

9. BATHYMETRY

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Grant-No. AWI_PS153_08

Objectives

Bathymetry is a basic key parameter for marine sciences. Together with the derived topography, they are of fundamental importance for understanding many marine processes. For example, the density-driven flows of water masses across the continental shelves follow density topography defined pathways showing a nice example of the interplay between topography and oceanography. Furthermore, bathymetric information allows for the interpretation of measurements in a spatial context.

While world bathymetric maps give the impression of a detailed knowledge of worldwide seafloor topography, most of the world's ocean floor remains unmapped by hydroacoustic systems. In these areas, bathymetry is modelled using satellite altimetry with a corresponding low resolution. Therefore, satellite-altimetry derived bathymetry lacks the resolution necessary to resolve small- to meso-scale geomorphological features (e.g., troughs, canyons and sills). Ship-borne multibeam data provide bathymetric information at a resolution sufficient to resolve these features and enable site selection for other scientific working groups on board. In addition, underway data collected during PS153 contribute to global initiatives like the General Bathymetric Chart of the Oceans (GEBCO).

Work at sea

The bathymetric data will be recorded with the Atlas Hydrosweep DS3 hull-mounted multibeam echosounder. The main task of the bathymetry group is to plan and run bathymetric surveys in the study areas and during the transit. The raw bathymetric data will be corrected for sound velocity changes in the water column, further processed and cleaned for erroneous soundings and artifacts. Detailed seabed maps derived from the data will provide information on the general and local topographic setting in the study areas. The high-resolution seabed data recorded during the survey will be made available for site selection and cruise planning. During the survey, the acoustic measurements will be carried out by three operators working 24/7-hour shifts (except for periods of stationary work).

Preliminary (expected) results

Expected results will consist of high-resolution seabed maps along the cruise track and from the target research sites. The bathymetric data will be analysed to obtain geomorphological information of the research area. The expected results aim towards an improved bathymetric model as key base dataset to support research in the study area.

Data management

Bathymetric data collected during the 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. By default, the CC-BY license will be applied.

Furthermore, the data will be included in regional data compilations such as International Bathymetric Chart of the Southern Ocean (IBCSO) and provided to the Nippon Foundation – GEBCO Seabed 2030 Project.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 3.

In all publications based on this expedition, the **Grant No. AWI_PS153_08** 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.

10. DEFIANT AUTOSUB LONG RANGE (ALR) UNDER SEA ICE SURVEY

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Note: For ALR technical correspondence: Robert Templeton & Alex Phillips.
For Scientific correspondence: Jeremy Wilkinson & Alberto Naveira Garabato

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Grant-No. AWI_PS153_09

Objectives

The DEFIANT research programme is built around two overarching objectives:

- To deepen our understanding of the physical processes that drive Antarctic sea-ice variability, including the mechanisms behind extreme sea ice loss events
- To determine the drivers and climate consequences of Antarctic sea-ice loss across timescales ranging from short-term weather events to multi-decadal trends.

Meeting these objectives requires a substantial, coordinated research effort capable of capturing detailed observations throughout the entire annual sea-ice cycle. A cornerstone of this effort is the use of the ALR autonomous submarine to obtain high-resolution, under-ice measurements during late summer and early freeze-up (PS153); a period in the Weddell Sea that is generally extremely difficult to observe. These data are essential for understanding ocean–ice interactions, heat transfer, stratification, and the processes that initiate freeze-up or delay it.

Although DEFIANT is primarily focused on physical oceanography and sea-ice physics, discussions with SWOS leaders enabled us to expand the capability of the ALR missions. By adapting and adding several ALR sensors, we can now also gather ecosystem-relevant data, such as optical properties, zooplankton, and indicators of under-ice productivity such as fluorescence. This addition allows us to build a more complete picture of how physical and ecological systems are coupled, and how both respond to changing sea-ice conditions.

The under-ice ALR dataset is genuinely unique. It is the only practical way to collect detailed, undisturbed measurements beneath sea ice far from the ship, avoiding the noise, turbulence, and ice disturbance caused by ship-based surveys. These observations therefore provide an unparalleled window into the natural, but fast-changing, state of the Antarctic ice–ocean system, supporting DEFIANT's and SWOS's goals of transforming our understanding and improving future climate predictions.

Work at sea

There will be three members of the ALR Operations team on *Polarstern*; Stewart Fairbairn, Rachel Marlow, Robert Templeton. With Robert Templeton & Alex Phillips being the main points of contact for all ALR technical queries and ship-based operations. There will be two shore-based members (Jeremy Wilkinson, Alberto Naveira Garabato), who will be involved with the scientific decisions regarding ALR operations.

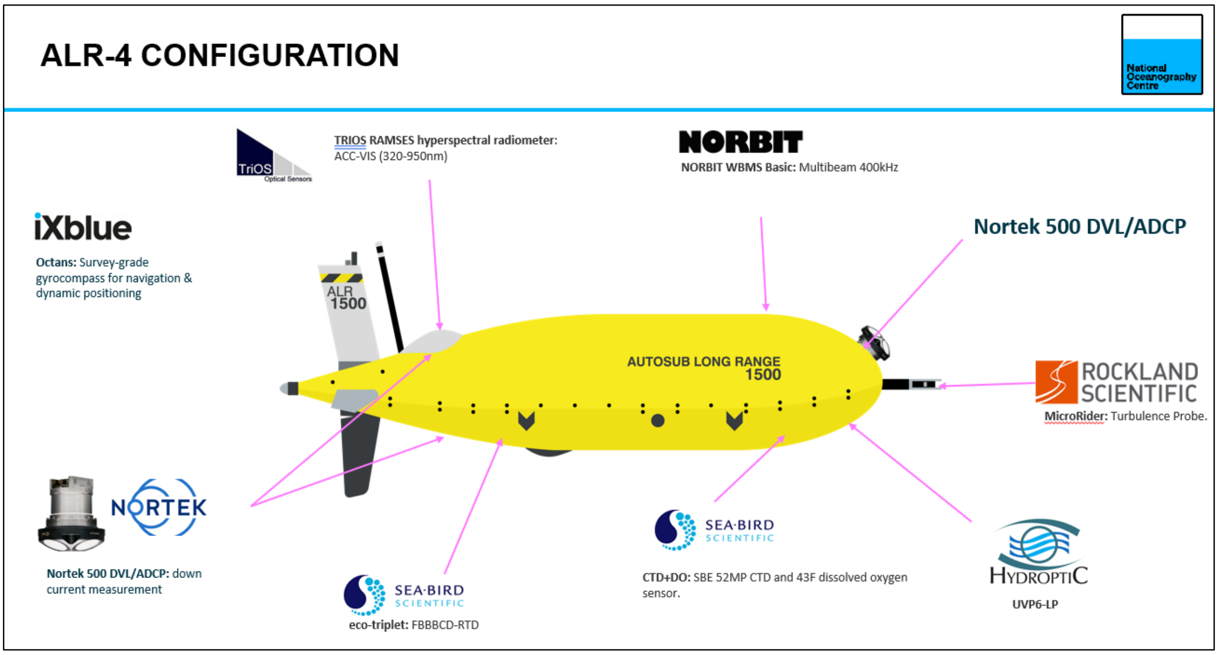

Fig. 10.1: ALR-4 Sensor layout

Autosub Long Range, ALR-4 is a 4.2 m long 770 kg Autonomous Underwater Vehicle. It will be deployed and recovered from *Polarstern* using ships crane through leads and holes in the ice, ideally at least 2x2 km for launch and recovery.

When the ALR in close proximity to *Polarstern* it will be monitored using the ships GAPS system (USBL positions within 4 km), and command and control communications undertaken with the Autosub 'acoustic fish' LinkQuest Tracklink system lowered over the side (up to 10 km, both systems depending on acoustic conditions and position relative to *Polarstern*).

The AUV will use an upwards facing DVL to navigate relative to the ice, performing Multibeam sonar surveys at constant depth, and profiling at +/- 15° pitch to the maximum navigable DVL range.

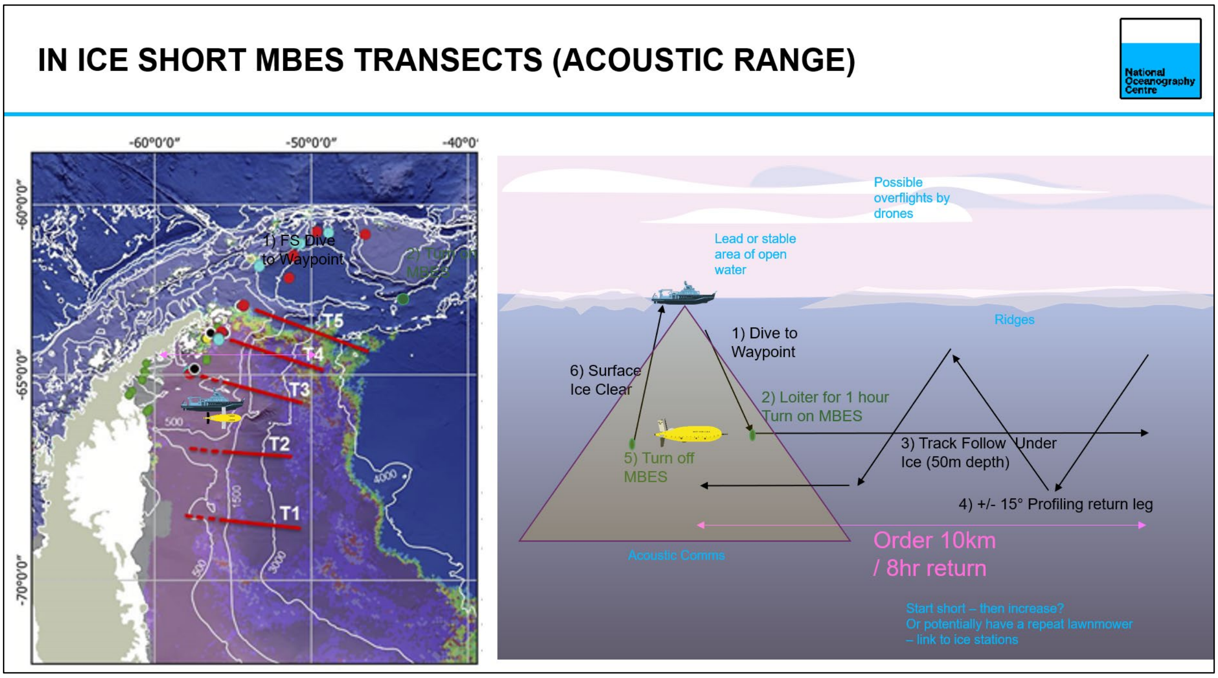

Fig. 10.2: Illustration of potential mission structure, showing cone of likely USBL tracking

Work will, where possible, be performed in conjunction with the SWOS ice stations and respective activities. However, each ALR deployment is dependent on the local ice and lead conditions. As a result, some ice stations performed in regions of close pack will likely not permit ALR deployment.

A second deployment concept, a longer mission from the sea ice, under the marginal ice zone and to open water may come into play later in the cruise. This would likely occur towards the end of SWOS' sea ice programme and will be the final ALR mission, as the vehicle would have to be recovered in the open water north of the ice edge.

Tab. 10.1: Instruments installed on the ALR

Instrument	Parameter	Documentation
DVL/ADCP: Nortek 500 Upward and downward looking	currents; maybe krill from backscatter	https://www.nortekgroup.com/products/dvl500-6000-m/pdf
CTD+DO: SBE 52MP CTD and 43F dissolved oxygen sensor.	Salinity, Temperature, depth, dissolved oxygen	https://www.seabird.com/sbe-52-mp-moored-profiler-ctd-and-optional-do-sensor/product?id=60762467706

Instrument	Parameter	Documentation
UVP6-LP: The Underwater Vision Profiler or UVP (CNRS patent)	Study large (>100 µm) particles and zooplankton	http://www.hydroptic.com/index.php/public/Page/product_item/UVP6-LP
MicroRider: Turbulence Probe. -2x SPM-6000 microstructure turbulence shear probes -2x FP07-1000 microstructure fast thermistors -1x SBE7-6000 microstructure conductivity sensor -1x High resolution pressure sensor -2x high-accuracy accelerometers,	Turbulence	https://rocklandscientific.com/products/modular-systems/microrider/
Multibeam 400kHz: NORBIT WBMS Basic:	Full return waveform for ice draft and water column scatters (krill) in water column	https://norbit.com/media/PS-120005-30_WBMS-bathy_Pn_12003-AACDB4_A4.pdf
hyperspectral radiometer TRIOS RAMSES	Transmitted radiation (hyperspectral: 320-950nm)	https://www.trios.de/en/ramses.html
eco-triplet: FLBBCDRTD	FLBBCDRTD 695, chlorophyll, µg/l 700, Scattering, 460, Coloured Dissolved Organic Matter (FDOM), ppb.	https://seacatalog.com/product/wet-labs-eco-flrtd-fluorometer/
Octans: Survey-grade gyrocompass for navigation & dynamic positioning	Navigational aid and for MultiBeam analysis.	https://www.ixblue.com/store/octans-surface/

Preliminary (expected) results

The ALR missions offer a rare opportunity to collect high-resolution, multidisciplinary datasets from beneath Antarctic Sea ice, data that are extremely difficult or impossible to obtain by other means. Each sensor on the ALR is capable of producing stand-alone, high-impact science, while the combined dataset enables a far more integrated understanding of the coupled ice–ocean–ecosystem system. For instance, by merging acoustic, optical, physical, and biogeochemical measurements, we can begin to unravel how krill and other zooplankton respond to changing light conditions, water masses, turbulence, and sea-ice properties across space and time. Below is an overview of the key sensors and the types of results we expect from each:

DVL/ADCP (upward- and downward-looking): Two acoustic Doppler systems will be mounted to profile currents both above and below the ALR.

- Currents: High-resolution measurements of water velocity throughout the water column, essential for understanding circulation beneath sea ice and for identifying flow structures such as jets, shear zones, or mixing layers.
- Backscatter: Acoustic backscatter can be used as a proxy for zooplankton/krill distribution and biomass.
- Sea-ice draft: The upward-looking ADCP provides continuous measurements of the underside of the sea ice, allowing estimation of ice draft and broad-scale ice roughness.

CTD and Dissolved Oxygen Sensor: This package measures conductivity (salinity), temperature, and dissolved oxygen along the vehicle track.

- These parameters reveal the stratification of the water column, water-mass properties, mixing processes, and potential habitats for biological communities.
- Dissolved oxygen serves as an indicator of ventilation, biological activity. Together with conductivity (salinity), temperature can isolate the presence of different water masses.

Underwater Vision Profiler (UVP): The UVP counts and sizes particles and captures images of larger aggregates and organisms along the vehicle track.

- Provides direct imagery-based estimates of zooplankton abundance, size distribution, and spatial organisation.
- Detects marine snow, detritus, and other particulate matter, giving insight into ecosystem functioning and carbon export.

Turbulence Probe (Microstructure Sensors): Mounted at the nose of the ALR, these probes measure fine-scale shear and rapid temperature fluctuations along the vehicle track.

- Enables quantification of turbulent kinetic energy dissipation and mixing rates, key for understanding vertical fluxes of heat, salt, and nutrients.
- Critical for linking physical mixing processes to biological responses and ice–ocean heat exchange and under-ice roughness.

Upward-looking Multibeam Sonar: This system maps the underside of sea ice in high-resolution 3D above the vehicle.

- Produces detailed ice-draft topography, helping identify ridges, keels, melt features, and ice roughness.
- Full-waveform recording allows separation of ice reflections from scattering by zooplankton or other particles, giving an additional biological proxy.

Hyperspectral Radiometer: Measures the downwelling solar irradiance reaching the ALR, using 256 spectral channels from 320–950 nm.

- Provides a detailed spectral light field beneath sea ice, crucial for understanding primary productivity, light-driven behaviour of organisms, and energy transfer through the ice–ocean interface.
- Helps characterise how snow cover, ice thickness and water clarity modify light penetration.

Eco-Triplet (Optical Backscatter and Fluorescence Sensors): A three-channel optical instrument which together help characterise the optical properties of the water column and biological productivity patterns along the vehicle track. They measure:

- Backscattering: Indicates particle concentration and size structure.
- Chlorophyll fluorescence: Proxy for phytoplankton biomass and photosynthetic activity.
- CDOM fluorescence: Measures coloured dissolved organic matter, linked to freshwater inputs, microbial activity, and organic-matter cycling.

Survey-grade Gyrocompass: Although primarily a navigation tool, the gyrocompass provides precise attitude (pitch/roll/yaw) information.

- These motion measurements are essential for post-processing several datasets – particularly the multibeam sonar and turbulence probe – to remove vehicle-induced artefacts and ensure accurate geolocation of observations.

Data management

ALR 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.

All 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 our case data will be archived at the Polar Data Centre located at BAS (UK), and copies can also be included PANGAEA World Data Center.

This expedition was supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2 & 6, Subtopics 2.1 & 6.3.

In all publications based on this expedition, the **Grant No. AWI_PS153_09** 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.

11. SEASONALITY OF CARBON TURNOVER IN THE WEDDELL SEA (SEACAT)

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Grant-No. AWI_PS153_10

Objectives

Understanding the biological carbon pump in the Weddell Sea requires interdisciplinary studies across the major hydrographic and biogeographic regimes. One key aspect is the connection between the diversity and distribution of biological communities – producing and metabolizing organic matter – with the larger dynamics of carbon cycling and export (Iversen 2023). To address this, SeaCaT explores (i) microbial and carbon dynamics across the major water masses in high vertical and spatial resolution, and (ii) bacterial chemotaxis to ecologically relevant organic molecules under the sea-ice. The work on PS153 aligns with the extensive ecosystem observation during PS146 (HAFOS) and PS152 (WOBEC), establishing an interannual portrait of microbial and biogeochemical diversity. In addition to water column sampling, SeaCaT recovers a mooring deployed during PS146; connected to a multiannual initiative to study the seasonality of the BCP via autonomous samplers and sensors.

Work at sea

Water column sampling

Aligned with the SWOS CTD program, SeaCaT will sample all major water masses for eDNA sequencing of biological communities. The same water masses will be sampled for DIC and POC pools as well as chlorophyll (for CTD fluorescence sensor calibration). DOC and nutrient pools will be sampled by Jan Tebben. Furthermore, the spatial particle and mesoplankton distribution will be recorded in high vertical resolution using an Underwater Vision Profiler (UVP). In combination with ocean current data, this data will illuminate vertical and lateral particle transport as well as grazer distributions. As a continuation of PS146 and PS152, our joint effort establishes a multiannual, geographic inventory of microbes and carbon from surface to seafloor (Fig. 11.1a).

For microbial diversity studies, water samples will be filtered and frozen on Sterivex cartridges for eDNA metabarcoding in the home lab. While SeaCaT focuses on bacterial diversity, the resulting DNA will be shared for collaborative studies across trophic levels (for instance pelagic eukaryotes in cooperation with Linn Hoffmann). Further eDNA samples will be autonomously collected by the AUTOFIM system underway, increasing the spatial dimension of eDNA records without extra station time. Likewise, two Niskin bottles mounted on the OFOBS will allow event-triggered water sampling above the seafloor during the regular OFOBS dives. Furthermore, SeaCaT closely cooperates regarding eDNA in sediments.

Water mass specific carbon pools (POC and DIC) will be sampled analogously to eDNA to establish direct linkages of microbial communities and carbon cycling. Carbon pools will be furthermore linked to hydrographic variables, ocean currents and anthropogenic tracers to elucidate their origin and fate.

Under-ice incubations

We will deploy "ISCA" devices under-ice during each long ice station (Fig. 11.1b). Here, different chemoattractants derived from Antarctic ice algae (in collaboration with Tilmann Harder and Jan Tebben) as well as DMSP will be filled in small plastic chambers, creating a plume of metabolites into the surrounding water which attracts bacteria to swim into the chambers (Lambert et al. 2017). ISCAs will be retrieved after approximately 6 hours of incubation, and subsamples frozen for later cell number enumeration (flow cytometry) and eDNA sequencing in the home lab. These assays have been successfully deployed in the Arctic Ocean before (Boetius & Bienhold 2024) and create a unique record of bacteria responding to ecologically relevant molecules.

Mooring

We will recover one "mixed-layer extension" of a HAFOS mooring (AWI-261-3 located at 63° 29.961' S 51° 37.669' W). The extension reaches from the terminal upper end (approx. 250 m depth) into surface waters (approx. 40 m depth), carrying a sensor package that measured conductivity, temperature, depth, O_2, pH, pCO_2, and chlorophyll since deployment in March 2024. A releaser allows separate recovery of the extension, while the HAFOS "mooring base" remains on site.

Preliminary (expected) results

SeaCaT will deliver detailed insights into microbial dynamics and carbon cycling across the Weddell Sea, expanding the spatiotemporal understanding of the biological carbon pump. This strengthens ongoing efforts towards a long-term archive of molecular biodiversity and biogeochemistry; aligned with several other initiatives (WOBEC, HAFOS, SPP1158 project by M. Wietz). Analogous to PS146 where a similar sampling has been done, we expect a considerable number of eDNA and carbon samples throughout the water column (Fig. 11.1a). The incubation of ISCA assays (Fig. 11.1b) under-ice allows the specific enrichment and characterization of chemotactic bacteria, as successfully done in the Arctic Ocean before (Boetius & Bienhold 2024). The resulting insights enable diverse collaborations with other PS153 research.

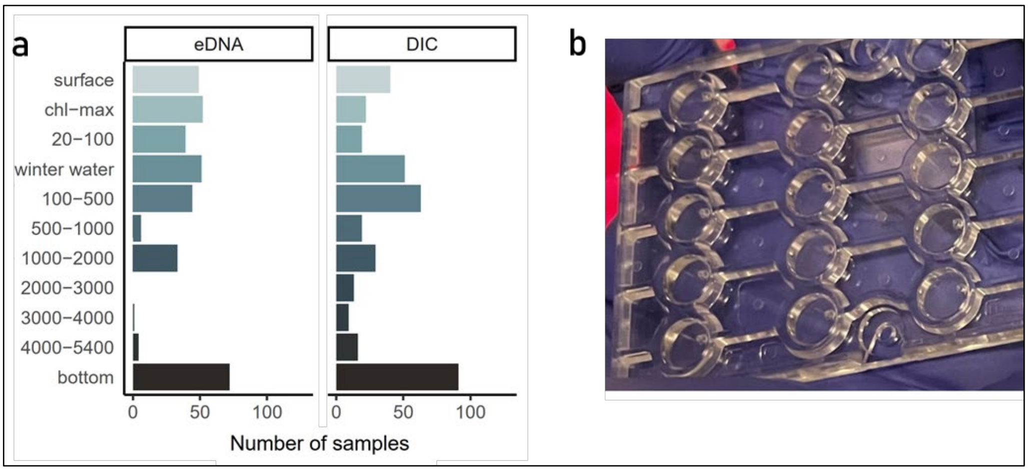

Figure 11.1: DNA and DIC sampling on PS146. A similar program is done on PS153 (a). Furthermore, ISCA assays under-ice will enrich and isolate chemotactic bacteria (b).

Analogous to PS146, we will record particles and mesoplankton in high spatial coverage via the UVP (Fig. 11.2). After image validation and regression with sampled POC inventories, this data will allow detailed insights into POC export dynamics as well as the composition and location of major mesoplanktonic flux feeders.

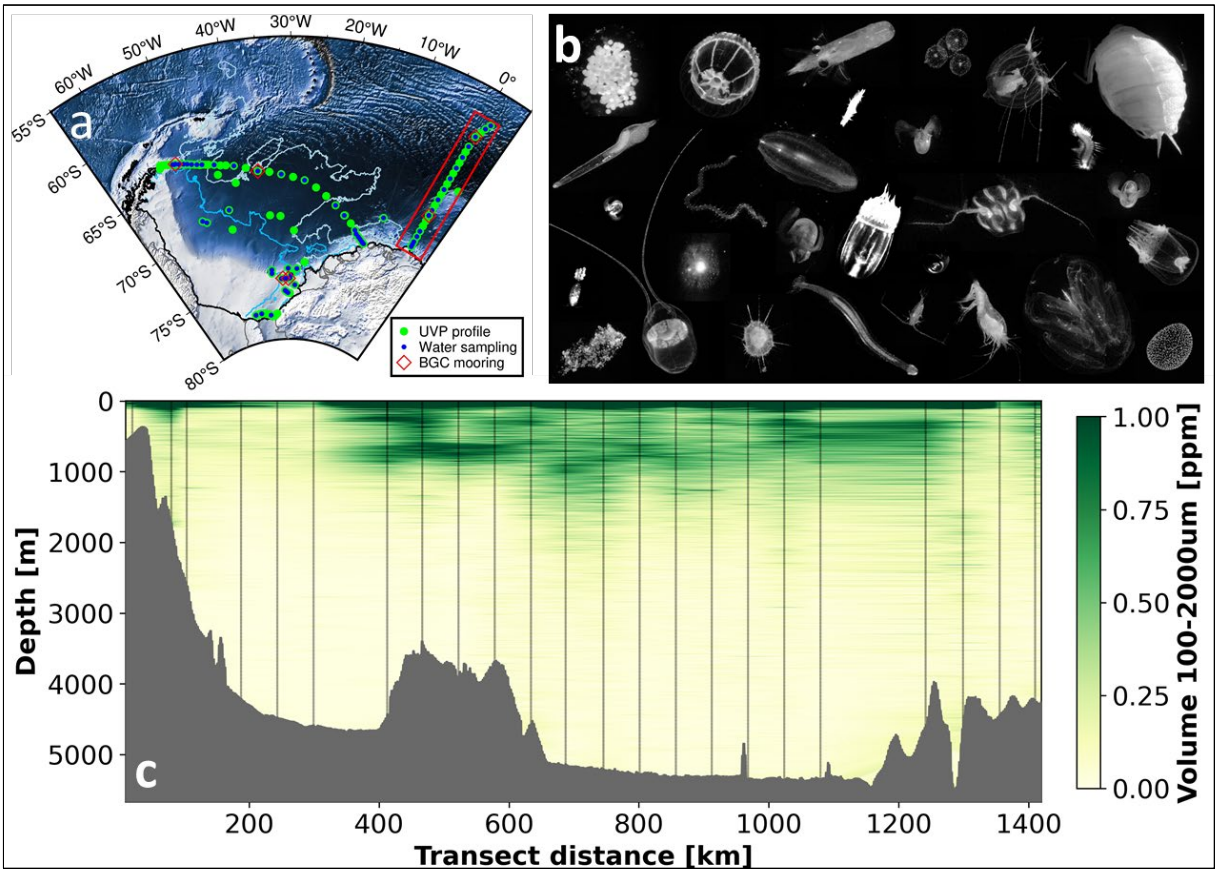

Fig. 11.2: Underwater Vision Profiling in high spatial coverage on PS146 (a). Examples of imaged mesoplankton (b). Distribution of the volumetric concentration of particles 0.1-2 mm along the 0° meridian (red box in panel a) illustrates its high vertical resolution (c).

Data management

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

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

In all publications based on this expedition, the **Grant No. AWI_PS153_10** 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.

References

Boetius A & Bienhold C (2024) The Expedition PS138 of the Research Vessel POLARSTERN to the Arctic Ocean in 2023. Berichte zur Polar- und Meeresforschung = Reports on polar and marine research, 0788.

Iversen MH (2023) Carbon export in the ocean: A biologist's perspective. Annu Rev Mar Sci 15:357–381.

Lambert BS, Raina J-B, Fernandez VI, Rinke C, Siboni N, Rubino F, Hugenholtz P, Tyson GW, Seymour JR & Stocker R (2017) A microfluidics-based *in situ* chemotaxis assay to study the behaviour of aquatic microbial communities. Nat Microbiol 2:1344–1349.

12. SEA ICE AEROSOL AND CLOUDS IN ANTARCTICA (SAICA)

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Grant-No. AWI_PS153_11

Outline

Current climate and earth system models predict temperatures, which are too high compared to observations in the surface Southern Ocean and coastal Antarctica (Hyder et al. 2018). One of the largest model uncertainties is due to poor understanding of clouds and cloud-forming particles which are emitted by the surface ocean and sea ice sources (Twohey et al. 2021; Schuddeboom & McDonald 2021). Clouds are extremely important because they influence i) sea ice and the amount of reflected solar radiation, ii) precipitation and surface mass balance and iii) the Southern Ocean carbon sink via sea surface temperature. Cloud-forming particles include cloud condensation nuclei (CCN) and ice nucleating particles (INPs). These particles can originate from wind-driven surface sources such as the open ocean, open leads in sea ice and blowing salty snow, which undergoes sublimation (e.g. Frey et al. 2020). But particle physical and chemical properties and particle flux magnitude in the Southern Ocean/ Coastal Antarctica are poorly known due to a lack of measurements. We will fill that gap with *in situ* observations in Antarctica. We will use the new observations alongside available data sets from other Antarctic coastal stations to improve the representation of sea ice as a particle source in climate models. Finally, we will assess how sensitive clouds and climate respond to particles from sea ice sources at present and in the near future.

Objectives

1. Quantify sources, physico-chemical properties and flux of aerosols and INPs above Antarctic sea ice and open water during late summer/ autumn
2. Understand the main drivers of aerosol flux from Antarctic sea ice sources
3. Quantify the impact of sea ice aerosol on clouds and surface energy balance in coastal Antarctica/ Southern Ocean

Work at sea

Continuous measurements of aerosol and relevant trace gases will be carried out from the **BAS Atmospheric Container Laboratory** onboard *Polarstern*. Underway experiments with an atomiser will be carried out in the wet lab using *in situ* samples collected beforehand.

During the planned short duration ice stations, the sea ice will be accessed to deploy a short flux mast with fuel cell powered aerosol spectrometers, a sonic anemometer and meteorological sensors (T/RH). In addition, surface samples will be collected (shallow snow pits, sea ice, frost flowers, surface ocean water in open leads) and stored at -25ºC in the onboard freezer. The SAICA team will carry out all sea ice work. Anticipated set up (1–2 hr) and pack up (1 hr) times will leave up to 10 hr for *in situ* sampling, sufficiently long to obtain meaningful results.

Preliminary (expected) results

The wider SAICA project will undertake in addition to the Antarctic observations during PS153 also

- Lab experiments (chemical/ INP analysis, wind tunnel, sea ice chamber)
- Data analysis and sea ice flux estimates
- Aerosol-cloud model simulations

Field observations (e.g. Fig. 12.1) and lab experimental results will be used to build and evaluate widely applicable model parametrisations of sea ice aerosol (CCN/ INP) flux. For our model simulations a convection-permitting configuration of the Met Office Unified Model (MetUM) will be used to quantify current sensitivities of Antarctic clouds and surface energy balance to CCN/INP sea ice flux at present and in the near future.

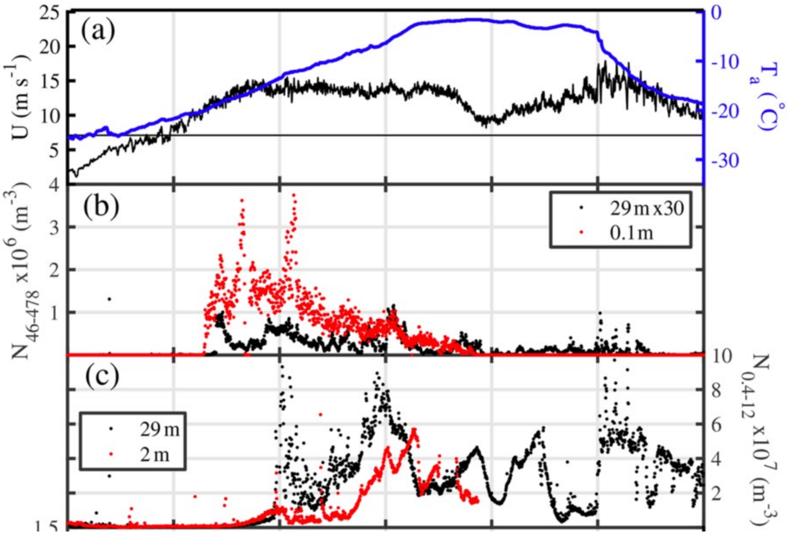

Fig. 12.1: Example of a blowing-snow event above sea ice in the Weddell Sea during austral winter 2013 (vertical grid lines denote 6-hr intervals starting on 14 July at 1200 UTC) generating salt aerosol, which may have significant but so far unknown impacts on clouds and climate: (a) ambient temperature and wind speed, with the horizontal black line showing the snow drift threshold wind speed; (b) total number densities of airborne snow particles at 29 and 0.1 m; (c) total number densities of aerosol sized 0.4-12 µm at 29 and 2 m. (Figure modified after Frey et al. 2020).

Measurements from the SWOS program are highly complementary to SAICA as they provide important context to interpret the atmospheric observations. Of particular interest are the snow/ ice measurements as well as the sympagic and pelagic ecosystem observations, both of which are relevant for assessing atmospheric particle production driven by physical and biogeochemical processes. In turn, results from SAICA in particular related to the atmospheric forcing will be of interest to SWOS to aid their planned research on sea ice / snow dynamics as well as surface ocean processes.

Data management

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

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

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

In all publications based on this expedition, the **Grant No. AWI_PS153_11** 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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Frey MM, Norris SJ, Brooks IM, Anderson PS, Nishimura K, Yang X, Jones AE, Nerentorp Mastromonaco MG, Jones DH & Wolff EW (2020) First direct observation of sea salt aerosol production from blowing snow above sea ice, Atmos. Chem. Phys., 20(4):2549–2578. https://doi.org/10.5194/acp-20-2549-2020

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Schuddeboom AJ & McDonald AJ (2021) The Southern Ocean Radiative Bias, Cloud Compensating Errors, and Equilibrium Climate Sensitivity in CMIP6 Models, J. Geophys. Res. 126(22):e2021JD035310. https://doi.org/10.1029/2021JD035310

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APPENDIX

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

Affiliation	**Address**
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AU.AAD	Australian Antarctic Division Channel Highway 203 7050 Kingston Australia
AU.CSIRO.ENV	CSIRO Environment Castray Esplanade 2-5 7001 Hobart Australia
AU.UTAS	University of Tasmania 20 Castray Esplanade 7004 Battery Point Australia
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DE.UNI-Rostock	Universität Rostock Albert-Einstein-Straße 21 18059 Rostock Germany
DE.UOL	Universität Oldenburg Ammerländer Heerstrasse 114-118 26129 Oldenburg Germany
NL.DORSSEN	M van Dorssen Metaalbewerking Schilderend 113 1791 BE Den Burg Netherlands
NL.WUR	Wageningen Marine Research Ankerpark 27 1781AG Den Helder Netherlands
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NZ.UC	University of Canterbury 20 Kirkwood Ave 8041 Christchurch New Zealand
PE.cientifica.edu	Universidad Cientifica del Sur Panamerica Sur Km 19 Villa 15084 Lima Peru
UK.BAS	British Antarctic Survey High Cross Madingley Rd. CB3 0ET Cambridge United Kingdom

Affiliation	Address
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US. Uni-Austin	The University of Texas at Austin 201 E. 24th Street 78712-1229 Austin TX United States
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Not on board	
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DK.UCPH	GLOBE Institute, Section for Geobiology University of Copenhagen Øster Voldgade 5-7 DK-1350 Copenhagen Denmark
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B.RBINS	l'Université Libre de Bruxelles Avenue F. D. Roosevelt 50, CP 105, 1050 Bruxelles Belgium

Affiliation	Address
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A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
On board				
Batzke	Anja	DE.AWI	Technician	Physics
Birkedal	Anton	DE.AWI	PhD student	Geophysics
Bittner	Oliver	NL.WUR	Scientist	Biology
Bochert	Ralf	DE.UNI-Rostock	Scientist	Biology
Böhringer	Lilian	DE.AWI	Scientist	Biology
Brauer	Jens	DE.NHC	Pilot	Helicopter Service
Brown	Rowan John	DE.AWI	PhD student	Oceanography
Bryan	Natasha	DE.AWI	PhD student	Biology
Buthelezi	Zibusiso Mayibongwe	ZA.Mandela	Scientist	Biology
Dogantekin	Pinar	DE.TU-Braunschweig	Student (Master)	Public Outreach
Dorschel	Boris	DE.AWI	Scientist	Geophysics
Dreutter	Simon	DE.AWI	Technician	Geophysics
Eggers	Sarah Lena	DE.AWI	Technician	Biology
Fairbairn	Stewart	UK.NOC	Engineer	Engineering Sciences
Frey	Markus	UK.BAS	Scientist	Glaciology
Gebhardt	Christopher	DE.UNI-Rostock	Scientist	Biology
Gomez Farfan	Rosby	PE.cientifica.edu	Student (Bachelor)	Biology
Grimm	Jolanda	DE.UNI-Bremen	Student (Bachelor)	Oceanography
Haas	Christian	DE.AWI	Scientist	Glaciology
Haumann	Fabian Alexander	DE.AWI	Scientist	Oceanography
Hoffmann	Linn	NZ.UOtago.ac	Scientist	Biology
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Huhn	Oliver	DE.UNI-Bremen	Scientist	Oceanography
Isler	Tea	DE.AWI	PhD student	Geophysics

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Janout	Markus	DE.AWI	Scientist	Oceanography
Jerosch	Kerstin	DE.AWI	Scientist	Biology
Kadow	Stefanie	DE.AWI	Scientist	other geo sciences
Kagel	Torbjörn	DE.AWI	Student (Master)	Geophysics
Kühn	Susanne	NL.WUR	Scientist	Biology
Marlow	Rachel	UK.NOC	Engineer	Engineering Sciences
Meijboom	André	NL.WUR	Scientist	Biology
Meiners	Klaus	AU.AAD	Scientist	Biology
Monsees	Matthias Udo	DE.AWI	Technician	Oceanography
Nawrath	Katie	AU.UTAS	Student (Bachelor)	Biology
Öhlckers	Nina Susann	DE.AWI	PhD student	Mathematics
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Rogge	Andreas	DE.AWI	Scientist	Biology
Schaafsma	Fokje	NL.WUR	Scientist	Biology
Schallenberg	Christina	AU.CSIRO.ENV	Scientist	Oceanography
Schaubensteiner	Stefan	DE.NHC	Pilot	Helicopter Service
Schulz	Kirstin	EDU.Oden.Texas	Scientist	Oceanography
Seifert	Michael	DE.DRF	Technician	Helicopter Service
Spreen	Gunnar	DE.UNI-Bremen	Scientist	Physics
Suter	Patrick	DE.DWD	Scientist	Meteorology
Tebben	Jan	DE.AWI	Scientist	Chemistry
Templeton	Robert	UK.NOC	Engineer	Engineering Sciences
Tippenhauer	Sandra	DE.AWI	Scientist	Oceanography
van den Heuvel	Floortje Elisabeth Maria	UK.BAS	Scientist	Meteorology
van Dorssen	Michiel	NL.DORSSEN	Technician	Biology
Vortkamp	Martina	DE.AWI	Technician	Biology
Weith	Friederike	DE.AWI	Scientist	Biology
Wietz	Matthias	DE.AWI	Scientist	Biology
Not on board				
Bendtsen	Jorgen	UCPH	Scientist	Biology
Boebel	Olaf	DE.AWI	Scientist	Oceanography
Bracher	Astrid	DE.AWI	Scientist	Biology

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
Cape	Mattias	.BLOS	Scientist	Biology
Cornils	Astrid	DE.AWI	Scientist	Biology
Flores	Hauke	DE.AWI	Scientist	Biology
Garabato	Alberto Naveira	UK.UoS	Scientist	Oceanography
Holtappels	Moritz	DE.AWI	Scientist	Biology
Kohlbach	Doreen	DE.AWI	Scientist	Chemistry
Link	Heike	DE.URO	Scientist	Biology
Niehoff	Barbara	DE.AWI	Scientist	Biology
Pehlke	Hendrik	DE.AWI	Scientist	Biology
Phillips	Alex	UK.NOC	Technician	Oceanography
Ricker	Robert	NO.NORCE	Scientist	Geophysic
Spiesecke	Stefanie	DE.AWI	Scientist	Oceanography
Van de Putte	Anton	RBINS	Scientist	Biology
Vernet	Maria	USCD	Scientist	Biology
Stefels	Jacqueline	RUG	Scientist	Biology
Wilkinson	Jeremy	UK.BAS	Scientist	Physicist
Wollenburg	Jutta	DE.AWI	Scientist	Geology
Xi	Hongyan	DE.AWI	Scientist	Oceanography

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No	Position	Rank	Nachname / Name	Name / 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	Rathke	Wulf Jannik
6	Schiffsärztin	Doctor	Guba	Klaus
7	Leitender Ingenieur	Chief Engineer	Rusch	Torben
8	2. Ingenieur	2nd Engineer	Ehrke	Tom
9	2. Ingenieur	2nd Engineer	Brose	Thomas Christian Gerhard
10	2. Ingenieur	2nd Engineer	Jassmann	Marvin
11	Schiffselektrotechniker Maschine	Ship Electrotechnical Officer Engine	Pommerencke	Bernd
12	Elektroniker Winden	Electrotechnical Engineer Winches	Krüger	Lars
13	Elektroniker Netzwerk/Brücke	Electrotechnical Engineer Network/Bridge	Müller	Andreas
14	Elektroniker Labor	Electrotechnical Engineer Labor	Ejury	René
15	Elektroniker System	Electrotechnical Engineer System	Hofmann	Jörg
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

No	Position	Rank	Nachname / Name	Name / First Name
20	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Mahlmann	Oliver Karl-Heinz
21	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Schade	Tom
22	Schiffsmechaniker Deck	Multi Purpose Rating Deck	tbn	
23	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Decker	Jens
24	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Deutschbein	Felix Maxilmilian
25	Schiffsmechaniker Deck	Multi Purpose Rating Deck	Siemon	Leon Arton
26	Decksmann / Matrose		tbn	
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	Schiffsmechanikerin 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. Koch	2nd Cook	Loibl	Patrick
36	1. Stewardess	1st Stewardess	Witusch	Paula 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