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Reports on Polar and Marine Research

The Expeditions PS139/1 and PS139/2 of the Research Vessel POLARSTERN to the Atlantic Ocean in 2023

Edited by

Simon Dreutter and Claudia Hanfland
with contributions of the participants

HELMHOLTZ

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Titel: Kuhreiher unterwegs an Bord von Polarstern
(Foto: Christian Rohleder, DWD)

Cover: Cattle Egret taking a lift aboard Polarstern
(Photo: Christian Rohleder, DWD)

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PS139/1
PS139/2

22 October 2023 – 22 November 2023

Bremerhaven – Las Palmas – Cape Town

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1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Claudia Hanfland, Simon Dreutter DE.AWI

Der Fahrtabschnitt PS139 war der erste Abschnitt der antarktischen Forschungssaison 2023/24 und diente der Überführung des Schiffes nach Kapstadt. Die Expedition PS139 startete in Bremerhaven am 22.10.2023 und endete am 22.11.2023 in Kapstadt (Abb. 1.1). Am 03.11.2023 wurde ein Zwischenstopp in Las Palmas eingelegt, der die Fahrt in die Abschnitte PS139/1 und PS139/2 teilte. Auf der gesamten Reise (Abschnitte 1 und 2) wurden folgende *en route* Messungen und Tätigkeiten durchgeführt:

- Mit den schiffsinternen hydroakustischen Systemen wurde auf der gesamten Strecke ein Streifen Meeresbodentopographie bathymetrisch vermessen. Die Gesamt-Fahrtzeit von vier Wochen umfasste einige Stunden Stationszeit für die Kalibration der Echolotsysteme mittels Wasserschallsonde sowie Durchführung von CTD-Stationen.
- Über hochvolumige Luftprobenehmer wurde kontinuierlich Luftprobem auf dem Peildeck genommen, um chemische Schadstoffe in der Meeresluft zu messen.
- Über die Seewasserpumpe wurden kontinuierlich Oberflächenwasserproben genommen, ebenfalls zur Messung von chemischen Schadstoffen.
- Die Isotopensignatur des Kohlenstoff im Methan der Luft wurde kontinuierlich mit einem Massenspektrometer bestimmt.

Bis Las Palmas waren zusätzlich noch folgende Arbeitsgruppen an Bord:

- Mitarbeitende der Logistik und Reederei für Arbeiten an der Windensteuerung an Bord
- Mitarbeitende des *Polarstern* II Teams zum besseren Kennenlernen des Schiffs
- POLMAR-TRAIN: Masterstudent:innen der Universitäten Bremen und Potsdam, Fachbereich Geowissenschaften, sowie Doktorand:innen des AWI zur Ausbildung in geophysikalischen Methoden an den hydroakustischen Messsystemen. Neben den bathymetrischen Vermessungen mit dem Fächerecholot Hydrosweep hat die Gruppe den Sedimentaufbau der oberen Schichten des Meeresbodens mit dem parametrischen Sedimentecholot Parasound vermessen.
- Mitarbeitende des Bundeswettberwebs Künstliche Intelligenz
- Schüler der Auricher Wissenschaftstage

SUMMARY AND ITINERARY

The expedition PS139 was the first leg of the Antarctic season 2023/24 and was used to transfer the ship to Cape Town. PS139 started in Bremerhaven on 22 October 2023 and ended in Cape Town on 22 November 2023 (Fig. 1.1). On 3 November 2023, a stopover took place in Las Palmas, which divided the journey into two legs, PS139/1 and PS139/2. The following *en route* measurements and activities were carried out during the entire voyage (legs 1 and 2):

- A strip of seabed topography was bathymetrically surveyed along the entire route using the ship's internal hydroacoustic systems. The total cruise time of four weeks included several hours of station time for the calibration of the echo sounder systems using water sound velocity profilers as well as CTD casts.
- High volume air samplers were used to continuously take samples on the monkey deck to measure chemical pollutants in the air.
- Surface water samples were taken continuously via the ship's seawater in-take, also to measure chemical pollutants.
- The isotopic signature of carbon in methane in the air was determined continuously using a mass spectrometer.

The following working groups were on board until Las Palmas:

- Staff of logistics and shipping company for work on the winch control system on board
- Staff of AWI *Polarstern II* team for familiarization with the ship
- POLMAR-TRAIN: master students from Universities of Bremen and Potsdam, department of geosciences, as well as doctoral candidates from AWI for a hands-on training in geophysical methods on the ship-mounted hydroacoustic systems. Next to bathymetric surveys of the seafloor with the multibeam echosounder Hydrosweep, the group also investigated the upper part of the sedimentary layer with the parametric sediment echosounder Parasound.
- Staff of the Student Federal Competition in Artificial Intelligence
- High school students from Auricher Wissenschaftstage

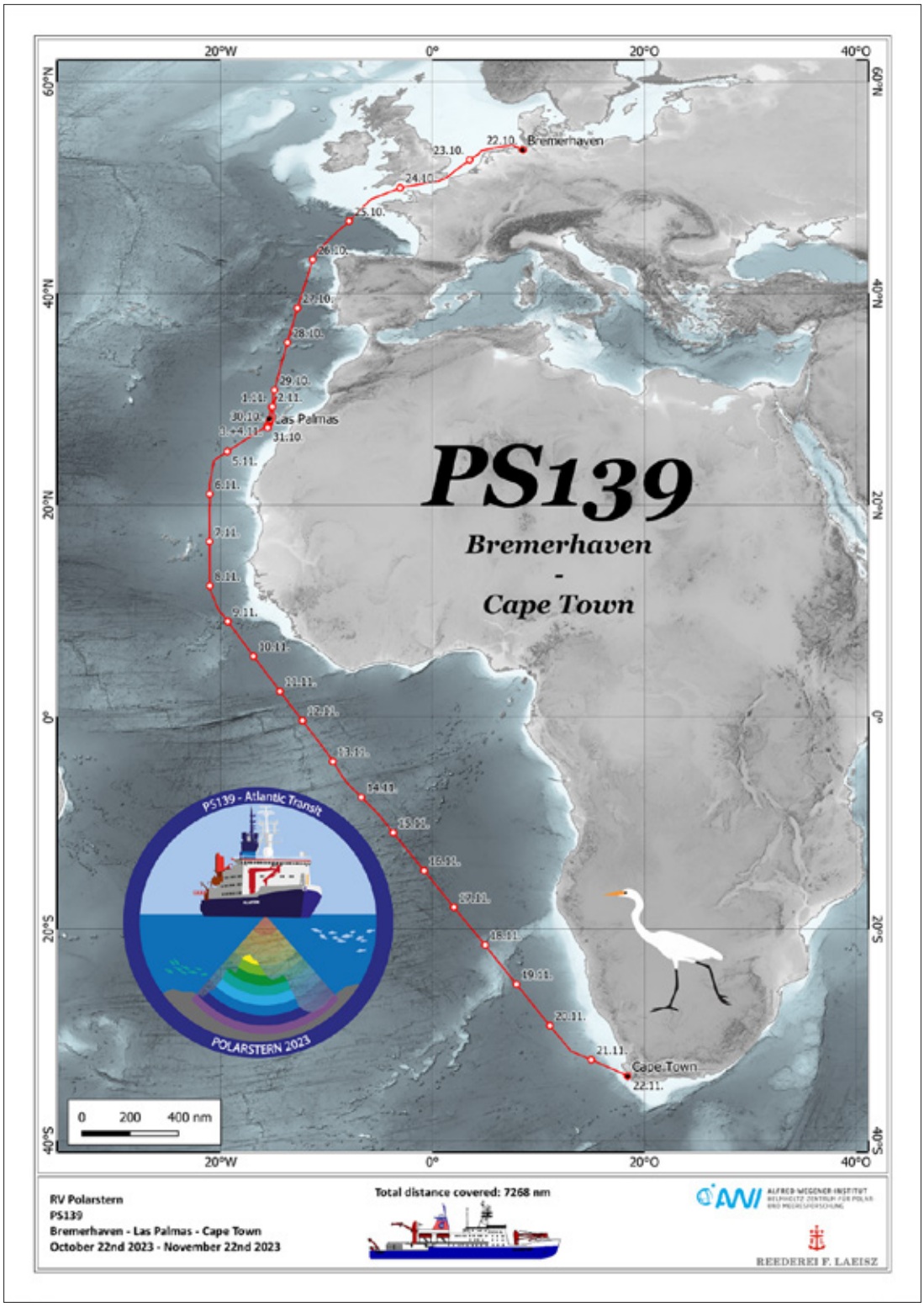

Abb. 1.1: Fahrtverlauf der Expedition PS139. Siehe https://doi.pangaea.de/10.1594/PANGAEA.965457 und https://doi.pangaea.de/10.1594/PANGAEA.965462 für eine Darstellung der Master tracks in Verbindung mit den Stationslisten für PS139/1 und PS139/2.

Fig. 1.1: Cruise track of expedition PS139. See https://doi.pangaea.de/10.1594/PANGAEA.965457 and https://doi.pangaea.de/10.1594/PANGAEA.965462 to display the master tracks in conjunction with the station lists for PS139/1 and PS139/2.

WEATHER CONDITIONS DURING PS139/1 AND PS139/2

Oliver Sievers DE.DWD

When *Polarstern* left port in Bremerhaven at 1,800 LT on 22 October 2023, the general weather situation in the North Sea and the North Atlantic was characterized by intense low-pressure activity. A storm depression, which was initially located near Newfoundland with about 978 hPa and moved (as predicted) to just west of Ireland by 27 October, became immediately relevant for the voyage planning. At normal cruising speed, *Polarstern* would have been caught in the storm's wind and wave field in the Bay of Biscay, which would have resulted in significant wave heights of around 8 meters. It was therefore decided from the beginning to pass through the Bay of Biscay without stopping and as quickly as possible and to start station work off the Portuguese coast at the earliest.

At first, the journey started into a weak high wedge that swung to the east. On its rear, a low-pressure system moved north and passed *Polarstern* in the English Channel close on its easterly side. As a result, there was persistent precipitation and a rapidly circulating and subsequently strongly freshening wind during the night of 24 October. During the day, the Atlantic swell became noticeable in the western part of the English Channel with a height of up to 2 m; a trough of the already mentioned storm depression, which at this time was located near N55 W037 at 973 hPa, approaching from the west and caused the fresh westerly wind to turn back to the southeast during the day. An embedded secondary low reached the western exit of the English Channel at about the same time as *Polarstern*, again causing the wind to veer quickly to the north and induced heavy precipitation in the first half of the night on 25 October.

On 25 October, after crossing another trough with heavy precipitation, *Polarstern* finally entered the wind field of the storm depression in the Bay of Biscay. The wind settled to southwest to west, quickly became strong to gale force and reached strong gale force in gusts. The swell increased to just under 4 m in the Bay of Biscay and to 4.5 to 5 m south of Finisterre. It was not until 27 October at the latitude of Gibraltar that the wind gradually decreased again, but the swell coming in from the west and later northwest initially remained well over 3 m high. As a result, the attempt to run a first station to test the winches had to be aborted in the morning of 28 October due to excessive rolling movements.

Therefore, the working area was moved to the sea area south of Gran Canaria as quickly as possible. On the way, another trough belonging to the storm depression was passed southeast of Madeira on the morning of October 29th, with temporarily strong freshening winds veering 90 degrees (and back) and light precipitation. The new working area was reached on 30 October, where, located south of the mentioned trough, weak, mostly southwesterly, partly circulating winds and a swell of less than 1 m prevailed in the lee of the island. Starting in the afternoon of 31 October, the working area was then shifted back to the north side of the islands for the remaining time of the first leg of the voyage, where a moderate to fresh and initially but only temporarily strong trade wind from northerly directions was able to prevail at the same time as the mentioned trough dissipated. The sea state here was still dominated by the two-meter swell from the north to northwest. These weather conditions remained unchanged until the arrival in Las Palmas on 3 November.

At midday on November 4th, a south-westerly course was set. The moderate to fresh trade winds initially blew from the east, then from the noon hours of 5 November more from the northeast, and freshened up strongly on November 6th with the turn to a southerly course. An old swell of two and a half meters continued to come in from the north, initially shaded a bit by the Canary Islands. Southeast of the Cape Verde Islands, *Polarstern* passed through an extensive area of low clouds on November 8th, which caused significantly reduced visibility for several hours. Behind it, the north-east trade wind dropped to 4 to 5 Bft.

From 9 to 11 November, the active part of the ITCZ was passed. With numerous showers and thunderstorms, some of them very strong, the wind, which fluctuated generously around westerly directions, blew mostly moderate to fresh, in gusts even strong. A second swell coming in from the south finally became dominant and ensured that the significant sea did not fall much below 1.5 meters. After the last shower remained astern in the morning hours of 11 November, moderate to fresh and, at first, temporarily strong southeast trade winds quickly set in.

These kept dominant until the midday hours of 19 November, remaining mainly fresh, locally even strong. During the complete time frame, a swell of about 1 to 1.5 m came in from southeast at first, gradually shifting to directions from southwest. On 19 November at about S25, the vessel passed a wedge expanding east from the subtropical high, with an embedded weak high-pressure maximum located east of the sailing area. Temporarily descending, the wind backed from southerly to northwesterly directions within a couple of hours, becoming fresh again afterwards.

The last days of the journey were influenced by intense low-pressure activity in the south. During the night to 20 November, *Polarstern* entered the wind field of a gale low which was located near SS47 E000 with about 980 hPa at that time, moving east-southeast while intensifying. It passed the Cape south of S50 during midday of 21 November, followed by another, fast intensifying low that moved with similar intensity on a comparable track, but 24 hours later. This sequence of systems caused a strong northwesterly wind during the night to 20 November and the following morning, with near gale gusts and some showers due to a corresponding weak cold front. Apart from temporary weakening on 21 November, the northwesterly to westerly wind remained fresh, sometimes strong, until the end of the trip. The succession of low-pressure systems generated an increasing swell from the southwest to west, which reached a height of three and a half to four meters and only subsided in the last few hours before reaching the port of Cape Town.

Expedition PS139 finished with the arrival in Cape Town in the morning hours of 22 November 2023.

2. BATHYMETRIC UNDERWAY MEASUREMENTS

Simon Dreutter[1], Boris Dorschel[1], [1]DE.AWI
Mia Schumacher[2] [2]DE.GEOMAR

Grant-No. AWI_PS139_02

Objectives

Accurate knowledge of the seafloor topography, hence high-resolution bathymetry data, is key basic information necessary to understand many marine processes. It is of particular importance for the interpretation of scientific data in a spatial context. Bathymetry, or geomorphology, is a basic parameter for the understanding of the general geological setting of an area and geological processes such as erosion, sediment transport and deposition. Even information on tectonic processes can be inferred from bathymetry. Supplementing the bathymetric data, high-resolution sub-bottom profiler data of the top 10s of meters below the seabed provide information of the sediment architecture and the lateral extension of sediment successions. This can be used to study depositional environments on larger scales in terms of space and time, of which the uppermost sediments may be sampled.

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 from satellite altimetry with a corresponding low resolution. Satellite-altimetry derived bathymetry therefore lack the necessary resolution to resolve small- to meso-scale geomorphological features (e.g., sediment waves, glaciogenic features and small seamounts). Ship-borne multibeam data provide bathymetry information in a resolution that is sufficient to resolve those features.

Therefore, the main tasks of the bathymetry/geophysics group on board *Polarstern* during PS139 were:

- collection of bathymetric data, including calibration and correction of the data for environmental circumstances (sound velocity, systematic errors in bottom detection, etc.)
- post processing and cleaning of the data
- data management for on-site map creation
- collection of sound velocity data

Work at sea

Technical description

During the PS139 cruise, the bathymetric surveys were conducted with the hull-mounted multibeam echosounder (MBES) Teledyne Reson HYDROSWEEP DS3. The HYDROSWEEP is a deep-water system for continuous mapping with the full swath potential. It operates on a frequency of ~14 kHz. On *Polarstern*, the MBES transducer arrays are arranged in a

Mills cross configuration of 3 m (transmit unit) by 3 m (receive unit). The combined motion, position (Trimble GNSS), and time data comes from an iXBlue Hydrins system and the signal is directly transferred into the Control Module (CM) of the MBES to carry out real-time motion compensation in Pitch, Roll and Yaw. With a combination of phase and amplitude detection algorithms the CM computes the water depth from the returning backscatter signal. The system can cover a sector of up to 140° with 70° per side. In the deep sea, an angle of ~50° to both sides could be achieved.

Data acquisition and processing

Data acquisition was carried out along the entire cruise track between Bremerhaven and Cape Town. The MBES was operated with Sonar UI and for online data visualization, Teledyne PDS was used. The collected bathymetry was stored in S7K raw files. Subsequent data processing was performed using Caris HIPS and SIPS. For generating maps, the data were exported to Quantum GIS in the GeoTIFF raster format.

Sound velocity profiles

For best survey results with correct depths, frequent CTD (Conductivity Temperature Depth) casts were performed by the Bathymetry group, and were used to measure the water sound velocity in different depths. This is essential, as the acoustic signal travels down the water column from the transducer to the seafloor and back to the surface through several different layers of water masses with each a different sound velocity. The sound velocity (SV) is influenced by density and compressibility, both depending on pressure, temperature and salinity. Wrong or outdated sound velocity profiles lead to refraction errors and reduced data quality.

The CTD measures conductivity, temperature, and depth in the water column while the ship is on station. From these parameters, the sound velocity is calculated.

The sound velocity profiles obtained by the CTD were immediately processed and applied within the MBES for correct beamforming during the survey.

Additionally, these profiles were combined/extended with WOA18 (World Ocean Atlas 2018) data to create full ocean depth SV profiles.

Stations

The Hydrosweep and CTD stations are listed in Table 2.1 (PS139/1) and Table 2.2 (PS139/2).

Tab. 2.1: List of bathymetry related stations during PS139/1

Station Number	Description	Device	Time	Lat	Lon
PS139/1_0_ Underway-28	Multibeam underway survey	Multibeam echosounder	Start: 2023-10-23 06:15 End: 2023-11-02 22:36	Start: 53.48946 End: 28.96447	Start: 4.66129 End: -15.30509
PS139/1_1-1	SVP	CTD/Rosette	2023-10-30 08:09	27.49242	-15.58860

Tab. 2.2: List of bathymetry related stations during PS139/2

Station Number	Description	Device	Time	Lat	Lon
PS139/2_0_ Underway-28	Multibeam underway survey	Multibeam echosounder	Start: 2023-11-05 14:53 End: 2023-11-21 10:47	Start: 24.72752 End: -32.26266	Start: -19.88136 End: 14.7478
PS139/2_1-1	SVP	CTD/Rosette	2023-11-06 13:27	20.78910	-21.02274
PS139/2_2-1	SVP	CTD/Rosette	2023-11-08 13:21	12.14665	-20.998
PS139/2_3-1	SVP	CTD/Rosette	2023-11-09 13:20	8.842589	-19.1797
PS139/2_4-1	SVP	CTD/Rosette	2023-11-10 13:25	5.534741	-16.7422
PS139/2_5-1	SVP	CTD/Rosette	2023-11-11 12:24	2.386166	-14.3545
PS139/2_6-1	SVP	CTD/Rosette	2023-11-13 12:24	-4.24616	-9.37257
PS139/2_7-1	SVP	CTD/Rosette	2023-11-14 12:25	-7.63754	-6.64279
PS139/2_8-1	SVP	CTD/Rosette	2023-11-15 12:20	-10.9653	-3.66579
PS139/2_9-1	SVP	CTD/Rosette	2023-11-16 12:25	-14.5595	-0.74167
PS139/2_10-1	SVP	CTD/Rosette	2023-11-17 11:23	-17.9712	2.031869
PS139/2_11-1	SVP	CTD/Rosette	2023-11-18 11:25	-21.535	4.975862
PS139/2_12-1	SVP	CTD/Rosette	2023-11-19 11:21	-25.2412	7.937676

Preliminary results

During 26 days (PS139/1: 9 days, PS139/2: 17 days), bathymetric data was surveyed along the cruise track by the swath bathymetry system. Figure 2.1 shows the generated bathymetry grid over the Atlantic.

Data management

Geophysical and oceanographic 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 cruise at the latest. By default, the CC-BY license will be applied. Furthermore, bathymetric data will be provided to the Nippon Foundation – GEBCO Seabed 2030 Project.

In all publications based on this expedition, the **Grant No. AWI_ PS139_02** will be quoted and the following publication will be cited:

This expedition was supported by the Helmholtz Research Program “Changing Earth –

Sustaining our Future” Topic 2, Subtopic 3.

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.

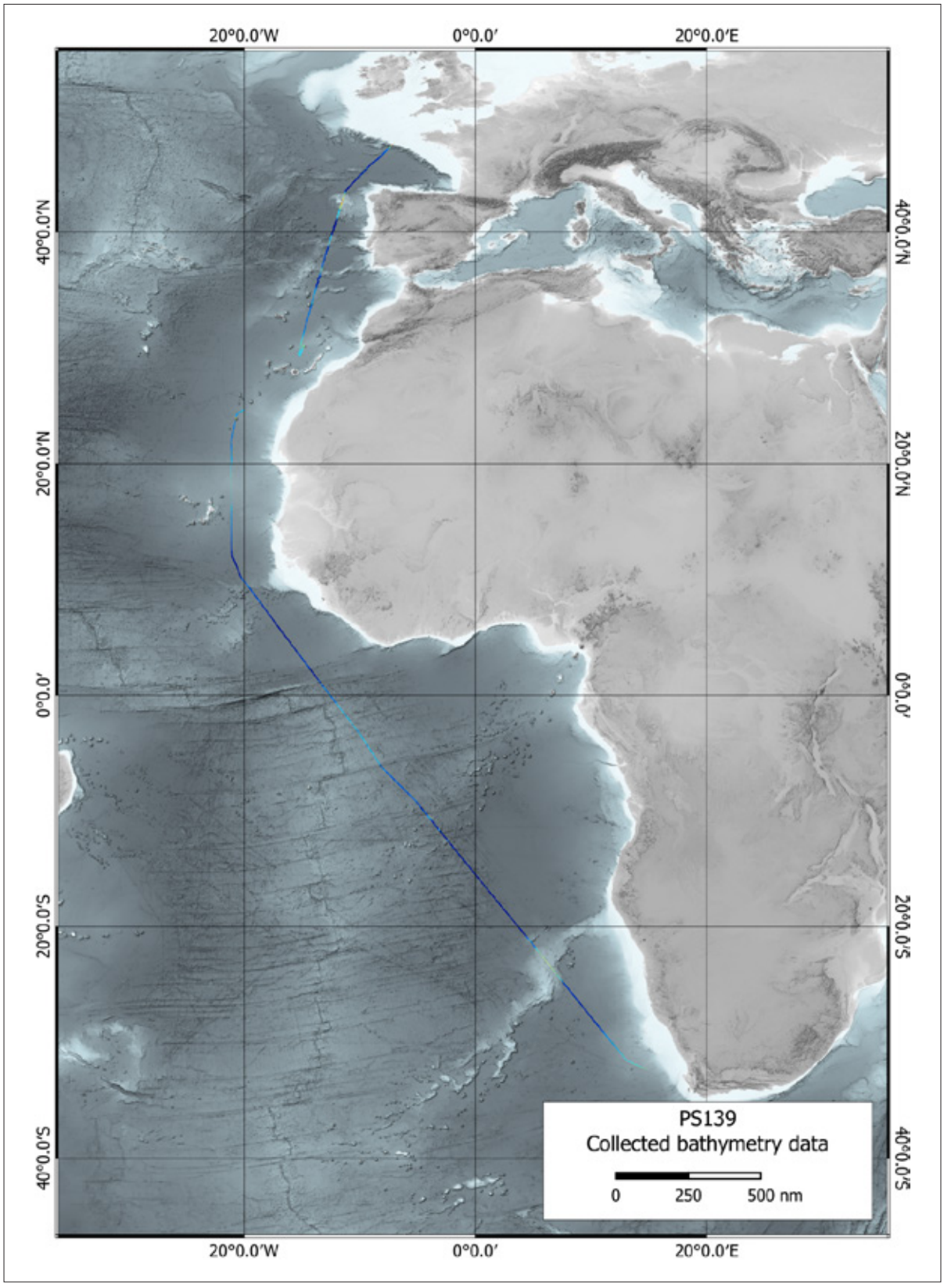

Fig. 2.1: Overview on the bathymetric data acquired during PS139

3. ECHOSOUNDING TRAINING POLMAR-TRAIN

Claudia Hanfland[1], Tabea Altenbernd-Lang[1], [1]DE.AWI
Bernhard Diekmann[1], Boris Dorschel[1],
Estella Weigelt[1]

Grant-No. AWI_PS139_01

Objectives

POLMAR-TRAIN 2023 is a student-training course that was jointly run by the AWI-based Helmholtz Graduate School for Polar and Marine Research (POLMAR) and the departments of geosciences of the Universities of Bremen and Potsdam.

The purpose is to provide master students and doctoral candidates from the field of geosciences, but also from other disciplines, with a hands-on training in operating the hull-mounted echosounding systems of *Polarstern* (Teledyne multibeam echosounder HYDROSWEEP DS3 and sediment echosounder PARASOUND P70). Parallel to the practical training, the aim is to promote peer-learning by combining master students (beginners and advanced stage) and doctoral candidates in this course. In addition, we provide knowledge and literature about the near-surface marine geology and oceanography along the south western and north western continental margin of Europe and Africa, respectively. Thus, the objectives of the work at sea are threefold:

1. learn to operate the systems during 24/7 shifts,
2. store, process, retrieve and interpret the sub-bottom and bathymetric data, and,
3. put the hydro-acoustic results into a broader regional perspective based on published literature, in order to understand the marine geology along the cruise track.

The geophysical training was complemented by a primer to sedimentology, enabling students to identify typical marine sediments under the microscope.

POLMAR-TRAIN contributes to the programme “Master of Sciences Marine Geosciences” at the University of Bremen as well as of the scientific programme of POLMAR. Both programmes involve ship-based field-work for students and doctoral candidates. In addition, we take the opportunity to train participants of forthcoming marine expeditions in hydro-acoustic operation. The training was carried out by six lecturers affiliated with AWI, University of Potsdam and GEOMAR.

The group was complemented by two members from the Student Federal Competition in Artificial Intelligence, based in Tübingen. Their aim was to identify possible projects and workflows aboard *Polarstern* that could, potentially, be smoothened by the use of artificial intelligence.

Work at sea

Seven students from the University of Bremen, two students from the University of Potsdam, seven doctoral candidates (POLMAR) and two highschool students from the Berufsbildende Schulen 2 Aurich participated in the training.

The echosounding course started with theoretical introductions (i) into the physics and techniques of echosounding, (ii) the use and handling of the parametric echosounder PARASOUND on *Polarstern*, and (iii) how to work with PARASOUND data. After introduction into the operations of the PARASOUND and HYDROSWEEP systems in the hydro-acoustic centre of the ship, students started going on watches (4 hours each, following the ship's watches) for 24-hour operation in pairs of two each for both systems HYDROSWEEP and PARASOUND.

The geology along the cruise track was introduced by a series of lectures, presenting the different geographic and geological provinces along the cruise track, namely: the English Channel, western Armorican continental slope,the Biskaye Abyssal Plain, the Iberian Margin with its submarine canyons, Galicia Bank, Agadir Canyon, Canary Islands and adjacent seamounts.

Based on these area overviews, participants worked in groups on five designated areas and presented the specific geological/geophysical characteristics along the cruise track in a group presentation at the end of the cruise. They took into account data from past cruises as well as the newly recorded data, described and visualised the topography of the ocean floor and the geology by methods they had learned during the cruise.

The participants learned to interpret submarine geomorphological structures from bathymetric images, sediment echographs combined with information from the literature including seismic-profiles. With regard to multibeam-bathymetric data, participants were introduced to data acquisition, data processing, and visualization with different kind of profiling and GIS mapping software. For processing and replying of PARASOUND data, the Teledyne software PARASTORE was used. The processed PARASOUND data were imported into a HIS Kingdom project. With the help of the Kingdom software, the data were visualized in 2D views and analyzed using the software's various tools. Participants mapped horizons, faults, and geological features. Maps and cross-sections were generated to illustrate the subsurface geology of the study area and explore its evolution.

Additionally, participants had access to both HYDROSWEEP and PARASOUND data from previous cruises, supplementing the data acquired during PS139/1:

- PS88/1
- PS97
- PS105
- PS116/1
- PS130/2

Preliminary results

Educational Results

The concept of combining undergraduates and postgraduates in this training proved to be a successful approach. Next to guidance and discussion with the team of lecturers, peer-learning was an important factor for the success of this training concept. In particular, this turned out to

be successful by grouping students together with higher, to some, to no scientific background in geology (watches and areal working groups).

The combination of theoretical background, practical work on the hydroacoustic systems (including troubleshooting), discussion of acquired and published as well as student presentations was the right combination for a thorough and comprehensive training in echosounding techniques.

Data management

Hydroacoustic data (multibeam and sediment echosounder) collected during the expedition (Tab. 6.1) have been copied to the *Polarstern* data base. From there the data will be transferred to the data mass storage at AWI Bremerhaven. Finally, the data will be stored and linked to the PANGAEA data repository at AWI. Furthermore, the data will be provided to international mapping projects and included in regional data compilations such as the Nippon Foundation-GEBCO (General Bathymetric Chart of the Oceans) Seabed 2030 Project.

In all publications based on this expedition, the **Grant No. AWI_ PS139_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.

4. IN SITU ANALYSES OF METHAN CONCENTRATION AND ITS STABLE CARBON ISOTOPIC SIGNATURE(Δ13C-CH4) IN THE LOWER ATMOSPHERE ALONG THE SHIP TRACK

Not on board: Ellen Damm, Markus Rex DE.AWI

Grant-No. AWI_PS139_04

Objectives

The main objective is to record a time series of the atmospheric of the concentration and stable carbon isotopic signature of methane in the lower atmosphere along the ship track from Bremerhaven to Kapstadt. Methane is the second most important human-influenced greenhouse gas in terms of climate forcing, after carbon dioxide. For methane, both bottom-up and top-down approaches are subject to large uncertainties, leading to a significant mismatch in modelling.

Work at sea

In situ analyses will be carried out with the Picarro 2132 installed on *Polarstern*. The air inlet will be localized on the monkey deck.

Preliminary results

The time series will contribute to quantify methane sources and sinks along a north-south transect in the Atlantic Ocean and to improve the process understanding needed for the improvement of the model parameterization.

Data management

The Picarro G2132 will be calibrated and maintained during the cruise to ensure high data quality. The recorded raw data will be processed with a spike detection code to distinguish the background signal from contamination by local pollution (like pollution from the ship stack). The atmospheric data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

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

In all publications based on this expedition, the **Grant No. AWI_PS139_04** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2023) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

5. ENVIRONMENTAL TRANSPORT OF LEGACY AND EMERGING ORGANIC CONTAMINANTS IN THE ATLANTIC OCEAN

Zhiyong Xie DE.Hereon

Grant-No. AWI_PS139_03

Outline

Legacy and emerging organic contaminants can enter the coast, marine and ocean environment by a number of processes (Xie et al. 2022a). Once introduced they are subject to biogeochemical cycling, sinks, and bioaccumulation processes in the ocean. Apart from the discharge of the rivers and runoff, the atmosphere is considered the primary and most rapid pathway for pollutant transport to the coast and marine environment as a result of their hydrophobic and semi-volatile nature, respectively (Xie et al. 2020). During PS139/1&2 we sample high-volume air and seawater to determine emerging and legacy organic contaminants in moderate latitudes of the Northern and Southern hemisphere in a proposal to further investigate their up to date levels and air-sea interactions in remote oceans. The research program is focused on the determination of selected organic contaminants in air and water, which is subdivided into several major groups. Considering ocean currents and fronts, the origin of air masses as well as changing air-sea gradients of pollutants, field study-based analysis of long oceanic transects from source regions to remote areas are considered a promising approach to improve the understanding of the underlying transport mechanisms (Xie et al. 2022b).

Objectives

The investigation of emerging and legacy organic contaminants (PFAS, BFR, OPE, PAE, UV filters, alkyl phenols, PPCPs and pesticides) in this project aims to improve the knowledge for a better understanding of the occurrence, distribution and transport pathways of chemical contaminants. The main objectives are

- To provide data sets on the occurrence and distribution of selected emerging organic contaminants in atmospheric and seawater samples along latitudinal transects from the north to the south Atlantic Ocean,
- To evaluate atmospheric transport mechanisms of microplastics and related organic chemical additives,
- To compare data on legacy persistent organic pollutants to earlier data regarding temporal trends and the efficacy of international regulations,
- To investigate atmospheric and oceanic transport pathways along the sampling transects with respect to the possible source regions Europe and Africa,
- To improve the understanding of the underlying transport mechanisms based on ocean currents,

- To estimate air-sea gas exchange fluxes and atmospheric deposition of the investigated emerging organic contaminants.

Work at sea

Air sampling. Two high-volume air samplers were mounted on the upper deck of the research vessel. While airborne particles were collected on quartz fiber filters, the gaseous compounds were trapped on PUF/XAD-2 glass cartridges. 22 air samples were collected along the transect (Fig. 5.1). Field blanks were prepared by espousing the PUF/XAD-2 column and quartz fiber filters shortly to the sampling site. The samples were stored at -20°C on board and at the Helmholtz-Zentrum Hereon until sample extraction in a clean laboratory (Xie et al. 2011).

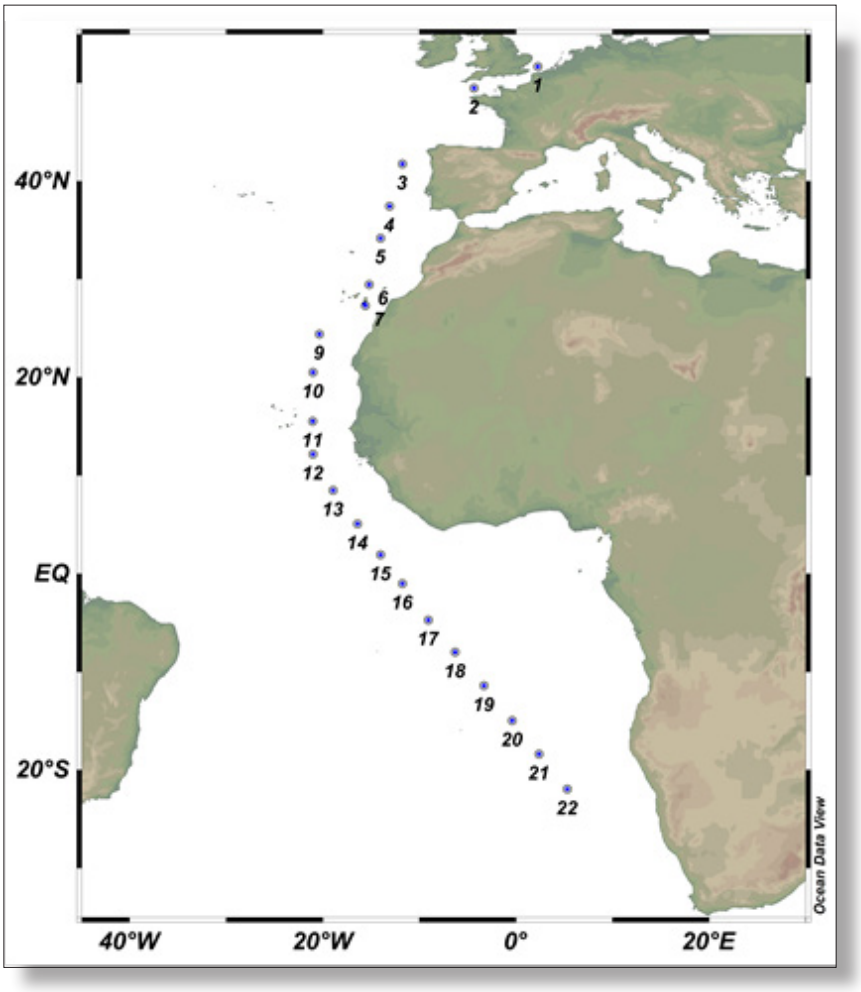

Fig. 5.1: Air sampling stations in the Atlantic Ocean, with the blue dots marked at the starting position of each air sample

High-volume water sampling. Along the entire cruise, high-volume seawater samples (90–400 L) were collected from the ship-intake system in the water lab. A glass fiber filter (GFC, 1.2 µm, 140 mm) was used to collect suspended particulate matter (SPM) and an XAD-2 column was used to catch organic chemicals in the dissolved phase (Fig. 5.2). Samples are stored at 0°C in the cooling room onboard and at 5°C at the Helmholtz-Zentrum Hereon until further sample preparation.

Water sampling. Forty 1-L surface seawaters were collected from the ship's seawater intake system in 11 m depth in the wet lab (Fig. 5.2). Besides, 1L seawater samples were collected from CTD at five depths (50, 250, 500, 750 and 1,000 m) in order to determine the vertical profile of chemical contaminants in the water column (Tab. 5.1). Water samples were extracted using WAX cartridge and HLP cartridge for the analysis of PFAS, PPCPs and endocrine disrupting chemicals (Fig. 5.2).

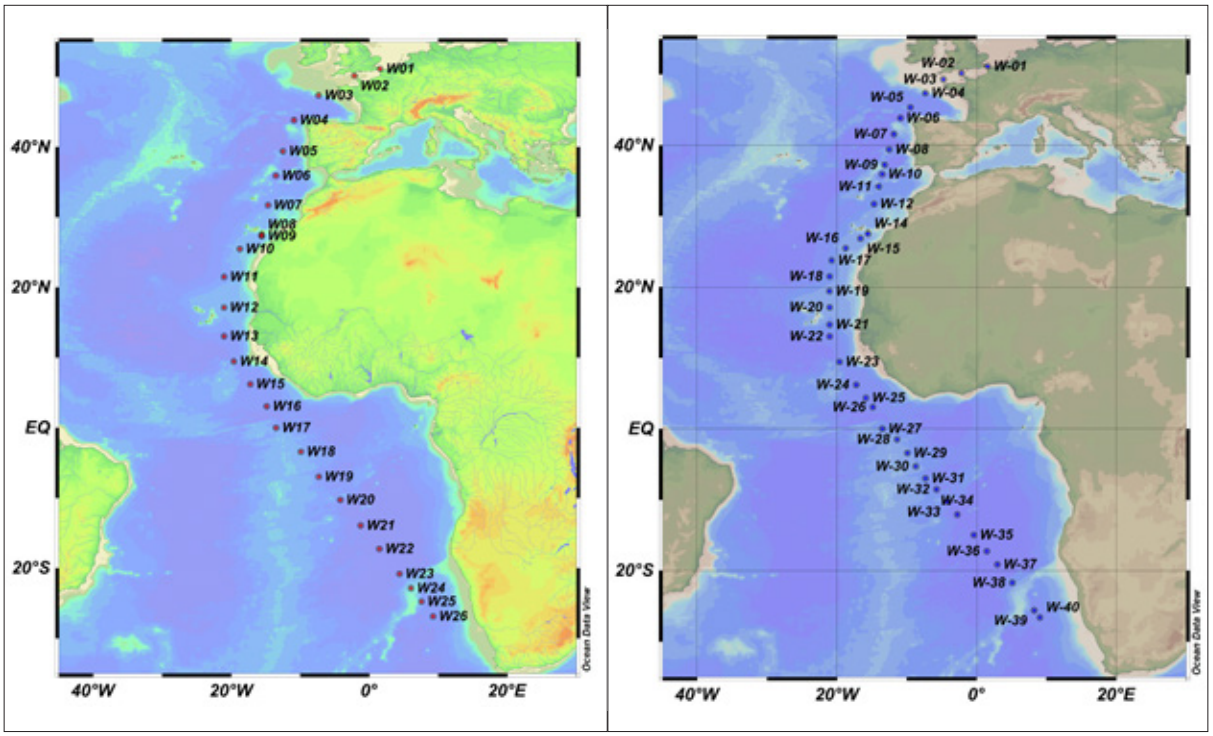

Fig. 5.2: High-volume seawater samples in the Atlantic, with the red dots marked at the starting position of each water sample (left), and forty 1-L seawater samples for solid-phase extraction (right)

Tab. 5.1: CTD stations selected for 1-L sweater samples at 5 depths (50, 250, 500, 750, 1,000 m)

Station Number	Seawater Sample	Date	Lat (N)	Lon (E)	Tw (°C)	Salinity (psu)
PS139/1_1-1	PS139-CTD-1-W01	2023-10-30	27.4924	-15.5886	23.6	36.65
PS139/2_1-1	PS139-CTD-2-W02	2023-11-06	20.7203	-21.0231	25.3	36.51
PS139/2_2-1	PS139-CTD-3-W03	2023-11-08	12.1563	-21.0102	29.24	35.21
PS139/2_5-1	PS139-CTD-5-W04	2023-11-11	2.3465	-14.3251	28.48	34.87
PS139/2_7-1	PS139-CTD-7-W05	2023-11-14	-7.6339	-6.6367	25.18	36.04
PS139/2_10-1	PS139-CTD-10-W06	2023-11-17	-18.0916	2.1323	20.71	35.89
PS139/2_12-1	PS139-CTD-12-W07	2023-11-19	-25.6004	8.2287	20.11	35.38

Preliminary (expected) results

All air and water samples will be processed in the analytical laboratory at the Helmholtz-Zentrum Hereon and analyzed using GC-MS/MS, GC-QTOF-MS, LC-MS/MS and LC-QTOF-MS/MS. Analytical results will show the occurrence and distribution of EOCs in seawater and air through the north to south transect in the Atlantic. Concentrations of EOCs in ocean waters and the atmosphere will be investigated across several provinces of the Atlantic Ocean. Both the particulate and the gas or water phase will be analyzed to identify the partitioning behavior in the oceans and the atmosphere. Vertical profiles deriving from CTD samples may reveal further information on sources and transport of EOCs in this area Based on the data, the transport behavior and long-range transport potential of EOCs on the northern and southern Hemispheres will be studied, and the air-water exchange process will be estimated. Unknown substances and transformed products of chemical contaminants will be identified with nontarget analysis and suspecting programmes.

Moreover, high-volume air samples will be analyzed for microplastics. The results can give information on cotransport behavior of MPs and plastic related chemicals on the northern and southern Hemisphere from different source regions.

Data management

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

By default, the CC-BY license will be applied. 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 4, Subtopic 4.1.

In all publications based on this expedition, the **Grant No. AWI_PS139_03** will be quoted and the following publication will be cited:

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

References

Xie Z, Wang P, Wang X, Castro-Jiménez J, Kallenborn R, Liao C, Mi W, Lohmann R, Vila-Costa M, Dachs J (2022a) Organophosphate ester pollution in the oceans. Nature Reviews Earth & Environment 3:309–322. https://doi.org/10.1038/s43017-022-00277-w

Xie Z, Zhang P, Wu ZL, Zhang S, Wei LJ, Mi LJ, Kuester A, Gandrass J, Ebinghaus R, Yang RQ, Wang Z, Mi W (2022b) Legacy and emerging organic contaminants in the polar regions. Science of the Total Environment 835. https://doi.org/10.1016/j.scitotenv.2022.155376

Xie Z, Wang Z, Magand O, Thollot A, Ebinghaus R, Mi W, Dommergue A (2020) Occurrence of legacy and emerging organic contaminants in snow at Dome C in the Antarctic. Science of the Total Environment 741:140200. https://www.sciencedirect.com/science/article/pii/S0048969720337219

Xie Z, Moller A, Ahrens L, Sturm R, Ebinghaus R (2011) Brominated Flame Retardants in Seawater and Atmosphere of the Atlantic and the Southern Ocean. Environmental Science & Technology 45(5):1820–1826. https://pubs.acs.org/doi/10.1021/es103803t

6. FILM PROJECT: WIND

Alexander Riedel DE.P

Grant-No. AWI_PS139_00

Objectives

The documentary film WIND explains the significance of wind over the course of six episodes. We travel with the wind and feel the expansive freedom it provides across the globe. We experience its powerful forces and its gentle hugging, its terrifying violence and its ability to move.

Work at sea and preliminary results

At various locations along our journey, we witness people working on making the phenomenon of wind and its meteorological marvels on Earth measurable, striving to understand it better. The story is about a global vision: a complete and worldwide network of meteorological data for making precise forecasts to help protect us from upcoming climate challenges. Not only for the here and now – but also for future generations.

Data management

In all publications based on this expedition, the **Grant No. AWI_PS139_00** will be quoted and the following publication will be cited:

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

7. LOGISTICS

Ralf Krocker[1], Uwe Hähnel[2], Alexandra Wiedenfeld[2], Andreas Pluder[3], Brieuc Crenan[3]

[1]DE.AWI
[2]DE.MWB
[3]DE.RFL

Grant-No. AWI_PS139_00

Objectives

Staff of AWI's department Logistics and Research Platforms, MWB Elektrotechnik Service, Bremerhaven, and Shipping Company F. Laeisz, Rostock, joined the cruise in order to carry out work on the winch control system and other board systems.

Work at sea and preliminary results

Winch measuring system

The Winch measuring system modernized in 2005 became obsolete and could not be maintained anymore (spare parts, software). In April/May 2023, first tests occurred during the shipyard period in order to permit further development at land during the summer. The final installation and integration took place in the shipyard in October 2023 with sea trials until Las Palmas for final tests and adjustments.

In order to measure the real cable length two measurement method have been used:

on SE31 and SE32.2 the bord CTD was used and delivered the real depth in real time thanks to the COAX cable and the embedded pressure-sensor.

on other winches (without COAX cable) a stand-alone sound velocity profiler and a weight of 700kg where used to perform tests. The comparison real depth vs cable length hat to be calculated after each deployment.

On SE31 + SE32.1, Small differences between these two measurements were detected and a factor (5%) was applied, like the previous system to achieve correct cable lengths.

For other winches (GE72.1, FN62.1, Fn62.2, GE52.1, GE52.2), measurement sensors are installed only on friction winches on port side and starboard side, counting rotations of sheave during lowering and hoisting.

On port side winch, the tests were executed with 18.2 mm fiber optic cable. Only small adjustments needed to apply on length measurement.

On starboard side winch, several casts were executed with 18 mm geo wire and 18 mm fiber optic cable. Applying the geo wire counting errors were detected, by means of a difference in length measurement between haul and lowering. The down cast was measured to be shorter than the upcast. This error was not detected applying fiber optic cable. The situation with geo wire is still under observation.

Details can be taken from MWB service log.

Sea Acceptance Test of echo sounder EK80

The transducers for 38, 70, 120/200 kHz as well as related electronic devices (Wide Band Transceiver – WBT) of EK80 were renewed during shipyard of *Polarstern* in October 2021. A calibration of new devices was executed on scientific cruise PS129 in April 2022. Apart from that, the mandatory Sea Acceptance Test (SAT) executed by Kongsberg engineer was prevented due to COVID-Situation and tense cruise plan. It was repeatedly postponed until PS139/1.

During this cruise, the SAT could successfully been performed. No special profiles were sailed for the tests. Only for noise tests, the ship's speed was adjusted from zero to 10 knots in steps of 2 knots. Some parameter failures could found concerning the GPS-Telegram received from DSHIP and were corrected by the crew.

All results are summarized in corresponding Kongsberg service report. Details can be taken form Kongsberg service log.

Underwater positioning system Posidonia

During previous cruises (PS136, PS137 and PS138) several problems occurred detecting positions by system Posidonia. Some of them rely on inadequate settings others rely on hardware errors. During shipyard in October 2023 the hardware of deck unit "USBL Box" was updated and a new main board and new network board were installed.

During the cruise PS139/1 the flush antenna was tested. A releaser and a transducer were both mounted on CTD rosette. Flush antenna sent out the release command, which was successfully detected by releaser. Flush antenna simultaneously detected positions of both devices, but "sector jumps" still occurred. They are caused by hardware problems of the flush antenna as known. The "Release function" worked perfectly.

An additional test was executed with deployable antenna ("CAGE antenna"), which was installed on device carrier through moon pool. No sector jumps occurred during this positioning.

An error in visualization software "PosiView" could be identified. An update of this software with fixed connection-error will be delivered as soon as possible.

Fiber Optic Telemetry

For communication between ship and sensors mounted on cable-based devices, a telemetry system is used. Deck unit and underwater unit communicate via ship's 18.2mm fiber optic cable. The deck unit is installed in computer rack in winch control room. Two of underwater systems are available on board *Polarstern* to be mounted on cable-based devices. During last cruise, one of these systems did not allow communications. An analysis identified a hardware error, which was eliminated during shipyard. But during PS139/1 a test of repaired underwater unit discovered an additional error. The reason for that error could not been identified. Consequently, during ongoing season only one of both underwater units is available for scientific work.

Net-sonde System Brieuc Crenan (RFL)

On *Polarstern* a hydro acoustic system is used to detect the depth and vertical opening of trawl net. The system from company Scanmar consists of combined sensors and transducers on the net, at the end of net and a transceiver installed on device carrier through moon pool. The system was not used for several years, but the next application is planned for summer 2024.

Therefore, a deployment has arranged to test the system. Unfortunately, a break of cable was detected. It must been repaired to be ready for the following season.

ADCP Calibration

During ship yard the antenna of ADCP Ocean Surveyor 150 kHz was rotated by 45° to starboard side. Now, beam one has heading in this direction. As consequence of this task, a calibration was performed to detect adjustments of mounting parameters to be set in software environment. An L-shaped profile was sailed taking 15 minutes for each of the four legs: leg 1: from south to north, leg2: back from north to south, leg 3: from east to west, leg4: back from west to east. Ship's speed was hold on 6 knots during all profiles. The post processing of data confirmed the correct set of mounting parameters.

Data management

Not applicable.

APPENDIX

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW

A.4. STATIONSLISTE / STATION LIST

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

Affiliation	Address
DE.AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
DE.BBS2	Berufsbildende Schulen 2 Aurich Am Schulzentrum 15 26605 Aurich Germany
DE.DWD	Deutscher Wetterdienst Seewetteramt Bernhard Nocht Str. 76 20359 Hamburg Germany
DE.GEOMAR	GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel Wischhofstr. 1-3 24148 Kiel Germany
DE.HEREON	Helmholtz-Zentrum Hereon GmbH Max-Planck-Str. 1 21502 Geesthacht Germany
DE.LAEISZ	Reederei F. Laeisz GmbH Bartelstraße 1 27570 Bremerhaven Germany
DE.MWB	MWB Elektrotechnik Service GmbH Rudloffstr. 49 27568 Bremerhaven Germany

Affiliation	**Address**
DE.P	Pelle Film Riedel & Timm GmbH Baaderstr. 45 80469 München Germany
DE.UNI-Bremen	Universität Bremen Klagenfurter Straße 2-4 28359 Bremen Germany
DE.UNI-Potsdam	Universität Potsdam Am Neuen Palais 10 14469 Potsdam Germany
DE.UNI-Tübingen	Eberhard Karls Universität Tübingen Geschwister-Scholl-Platz 72074 Tübingen Germany
ES.KONGSBERG	Kongsberg Discovery Partida Atalayes 20 03570 Villajoyyosa Spain

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

PS139/1: Bremerhaven – Las Palmas				
Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Allertseder	Paula	DE.UNI-Potsdam	Student (Master)	Geology
Allner	Anke	DE.AWI	Other	Science Management
Altenbernd-Lang	Tabea	DE.AWI	Scientist	Geophysics
Audebert	Catherine Josette	DE.AWI	Other	Science Management
Barfs	Fridtjof	DE.BBS2	Other	Biology
Beech	Nathan	DE.AWI	PhD student	Physics
Braun	Alexander	DE.UNI-Tübingen	Student (Master)	Data
Cornish	Natalie Roslyn	DE.AWI	Scientist	Geosciences
Correa Rojas	Claudia Ximena	DE.UNI-Bremen	Student (Master)	Geology
Crenan	Brieuc	DE.LAEISZ	Other	Logistics
Diekmann	Bernhard	DE:AWI	Scientist	Geology
Dorschel	Boris	DE.AWI	Scientist	Geophysics
Dreutter	Simon	DE.AWI	Technician	Geophysics
Freudinger	Christian	DE.AWI	Engineer	Logistics
Gerchow	Peter	DE.AWI	Engineer	Logistics
Giere	Luca	DE.UNI-Bremen	Student (Master)	Geology
Gupta	Aman	DE.UNI-Bremen	Student (Master)	Geosciences
Gürses	Can	DE.UNI-Bremen	Student (Master)	Geosciences
Hähnel	Uwe	DE.MWB	Engineer	Logistics
Hanfland	Claudia	DE.AWI	Scientist	Geology
Heyen	Matthis Remmer	DE.BBS2	Other	Physics
Jörss	Anna-Marie	DE.AWI	PhD student	Meteorolgy
Klingenberg	Malin	DE.UNI-Tübingen	Student (Master)	Public Outreach
Klinkhart	Jan	DE.AWI	Engineer	Logistics
Konyssova	Gaziza	DE.AWI	PhD student	Oceanography
Krocker	Ralf	DE.AWI	Engineer	Logistics
Lin	Tsai-Wen	DE.AWI	PhD student	Geosciences
Matthes	Jörg	DE.AWI	Engineer	Logistics
Mellat Ardakani	Moein	DE.AWI	PhD student	Geosciences
Niraula	Bimochan	DE.AWI	Scientist	Geosciences
Otto	Denise	DE.UNI-Bremen	Student (Master)	Geology
Pluder	Andreas	ES.LAEISZ	Engineer	Logistics

PS139/1: Bremerhaven – Las Palmas				
Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Prasannakumar	Aparna	DE.UNI-Potsdam	Student (Master)	Geology
Rohleder	Christian	DE.DWD	Technician	Meteorology
Schätz	Lina Anita	DE.UNI-Bremen	Student (Master)	Geosciences
Schumacher	Mia	DE.GEOMAR	Technician	Geophysics
Selles Moreno	Javier	ES.KONGSBERG	Engineer	Logistics
Sievers	Oliver	DE.DWD	Scientist	Meteorology
Spettnagel	Ralf	DE.AWI	Technician	Logistics
Vasudeva	Deepanshu	DE.UNI-Bremen	Student (Master)	Geosciences
Vural	Deniz	DE.AWI	PhD student	Geology
Weigelt	Estella	DE.AWI	Scientist	Geophysics
Wiedenfeld	Alexandra	DE.MWB	Technician	Logistics
Xie	Zhiyong	DE.HEREON	Scientist	Chemistry

PS139/2: Las Palmas – Cape Town				
Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Dreutter	Simon	DE.AWI	Technician	Geophysics
Hoop	Denise	DE.LAEISZ	Engineer	Logistics
Riedel	Alexander	DE.P	Filmmaker	Public Outreach
Rohleder	Christian	DE:DWD	Technician	Meteorology
Schumacher	Mia	DE.GEOMAR	Technician	Geophysics
Sievers	Oliver	DE:DWD	Scientist	Meteorology
Xie	Zhiyong	DE.HEREON	Scientist	Chemistry

PS139/1 and PS139/2 not on board				
Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Damm	Ellen	DE.AWI	Scientist	Permafrost Research
Rex	Markus	DE.AWI	Scientist	Atmospheric Physics

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW

Name / Last Name	Vorname / First Name	Position / Rank
Schwarze	Stefan	Master
Kentges	Felix	Chiefmate
Grafe	Jens	Chief
Dmoch	Renè Pascal	2nd Mate
Hering	Igor	2nd Mate
Strauß	Erik	2nd Mate
Müller	Andreas	2nd Mate
Gößmann-Lange	Petra	Ships doc
Bähler	Stefanie	2nd Eng.
Beyer	Mario	2nd Eng.
Brose	Thomas Christian	2nd Eng.
Redmer	Jens Dirk	E-Eng.
Zivanov	Stefan	E-Eng.
Hüttebräucker	Olaf	ELO
Jäger	Vladimir	ELO
Kliemann	Olaf	ELO
Krüger	Lars	ELO
Pliet	Johannes Oliver	ELO
Meier	Jan	Bosun
Neisner	Winfried	Carpen.
Buchholz	Joscha	MP Rat.
Klähn	Anton	MP Rat.
Klee	Philipp	MP Rat.
Bäcker	Andreas	AB
Burzan	Gerd-Ekkehard	AB
Niebuhr	Tim	AB
Preußner	Jörg	Storek.
Hänert	Ove	MP Rat.
Klinger	Dana Maria	MP Rat.
Münzenberger	Börge	MP Rat.
Schwarz	Uwe	MP Rat.
Wieckhorst	André	MP Rat.
Hofmann	Werner	Cook
Dietrich	Emilia Felizitas	Cooksm.

Name / Last Name	Vorname / First Name	Position / Rank
Silinski	Frank	Cooksm.
Wartenberg	Irina Marion	Chief Stew.
Arendt	René	2nd Stew.
Brändli	Monika	2nd Stew.
Chen	Dansheng	2nd Stew.
Cheng	Qi	2nd Stew.
Dibenau	Torsten	2nd Stew.
Silinski	Carmen	2nd Stew.
Deutschbein	Felix Maximilian	Apprent.
Schroeder	Paul	Apprent.

A.4 STATIONSLISTEN / STATION LISTS PS139/1 AND PS139/2

Station list of expedition PS139/1 from Bremerhaven – Las Palmas; the list details the action log for all stations along the cruise track.

See https://www.pangaea.de/expeditions/events/PS139/1 and https://www.pangaea.de/expeditions/events/PS139/2 to display the station (event) list for expedition PS130/1 und PS130/2.
This version contains Uniform Resource Identifiers for all sensors listed under https://sensor.awi.de. See https://www.awi.de/en/about-us/service/computing-centre/data-flow-framework.html for further information about AWI's data flow framework from sensor observations to archives (O2A).

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS139/1_0_Underway-51		2023-10-22T06:00:00	53.56899	8.54969		SWEAS	Station start	
PS139/1_0_Underway-51		2023-11-03T08:08:13	28.18051	-15.37559		SWEAS	Station end	
PS139/1-track		2023-10-23T00:00:00	53.56750	8.55480		CT	Station start	Bremerhaven - Las Palmas
PS139/1-track		2023-11-02T00:00:00	28.14410	-15.40220		CT	Station end	Bremerhaven - Las Palmas
PS139/1_0_Underway-3		2023-10-23T05:46:22	53.52092	4.81076	14	ADCP	Station start	
PS139/1_0_Underway-3		2023-11-02T15:06:46	29.57062	-15.09308	3559	ADCP	Station end	
PS139/1_0_Underway-11		2023-10-23T05:47:17	53.51978	4.80646	14	MYON	Station start	
PS139/1_0_Underway-11		2023-11-02T22:33:57	28.96754	-15.30510		MYON	Station end	
PS139/1_0_Underway-31		2023-10-23T05:48:17	53.51873	4.80139	13	NEUMON	Station start	
PS139/1_0_Underway-31		2023-11-02T22:33:37	28.96805	-15.30511		NEUMON	Station end	
PS139/1_0_Underway-23		2023-10-23T05:49:42	53.51720	4.79380	13	MAG	Station start	
PS139/1_0_Underway-23		2023-11-02T22:35:08	28.96578	-15.30509		MAG	Station end	
PS139/1_0_Underway-24		2023-10-23T05:51:04	53.51565	4.78619	13	GRAV	Station start	
PS139/1_0_Underway-24		2023-11-02T22:32:10	28.97020	-15.30513		GRAV	Station end	
PS139/1_0_Underway-42		2023-10-23T05:52:04	53.51461	4.78075	14	SNDVELPR	Station start	
PS139/1_0_Underway-42		2023-11-02T15:04:50	29.56477	-15.09346	3558	SNDVELPR	Station end	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS139/1_0_Underway-39		2023-10-23T06:15:00	53.48947	4.66129	15	PS	Station start	
PS139/1_0_Underway-39		2023-11-02T22:35:33	28.96516	-15.30508		PS	Station end	
PS139/1_0_Underway-13		2023-10-23T12:42:47	52.50782	3.38717	21	FBOX	Station start	
PS139/1_0_Underway-13		2023-11-02T22:32:36	28.96956	-15.30512		FBOX	Station end	
PS139/1_0_Underway-28		2023-10-23T15:40:14	51.95650	2.64605		DS3	Station start	Event shows start/end point (date/time & coordinates) of first/last data record using Atlas Hydrographic Hydrosweep DS 3 multibeam…
PS139/1_0_Underway-28		2023-11-02T19:13:41	29.30800	-15.28400		DS3	Station end	Event shows start/end point (date/time & coordinates) of first/last data record using Atlas Hydrographic Hydrosweep DS 3 multibeam…
PS139/1_0_Underway-43		2023-10-24T14:04:38	49.77823	-3.53281	65	TSG	Station start	
PS139/1_0_Underway-43		2023-11-02T22:30:52	28.97213	-15.30515		TSG	Station end	
PS139/1_0_Underway-44		2023-10-24T14:05:44	49.77650	-3.53708	63	TSG	Station start	
PS139/1_0_Underway-44		2023-11-02T22:31:15	28.97156	-15.30515		TSG	Station end	
PS139/1_1-1		2023-10-30T09:13:38	27.49711	-15.58755	2295	CTD-RO	max depth	
PS139/1_1-2		2023-10-30T11:58:50	27.49869	-15.58045	2293	CTD-RO	max depth	

** Comments are limited to 130 characters. See https://www.pangaea.de/expeditions/events/PS139/1 to show full comments in conjunction with the station (event) list for expedition PS139/1*

Abbreviation	Method/Device
ADCP	Acoustic Doppler Current Profiler
CT	Underway cruise track measurements
CTD-RO	CTD/Rosette
DS3	Swath-mapping system Atlas Hydrosweep DS-3
FBOX	FerryBox
GRAV	Gravimetry
MAG	Magnetometer
MYON	DESY Myon Detector
NEUMON	Neutron monitor
PS	ParaSound
SNDVELPR	Sound velocity probe
SWEAS	Ship Weather Station
TSG	Thermosalinograph

Station list of expedition PS139/2 from Las Palmas – Cape Town; the list details the action log for all stations along the cruise track.

See https://www.pangaea.de/expeditions/events/PS139/2 to display the station (event) list for expedition PS139/2.
This version contains Uniform Resource Identifiers for all sensors listed under https://sensor.awi.de. See https://www.awi.de/en/about-us/service/computing-centre/data-flow-framework.html for further information about AWI's data flow framework from sensor observations to archives (O2A).

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment [cut]
PS139/2-track		2023-11-03T00:00:00	28.14410	-15.40220		CT	Station start	Las Palmas - Cape Town
PS139/2-track		2023-11-22T00:00:00	-33.90680	18.43370		CT	Station end	Las Palmas - Cape Town
PS139/2_0_Underway-51		2023-11-03T09:00:00	28.11017	-15.37001		SWEAS	Station start	
PS139/2_0_Underway-51		2023-11-21T13:08:43	-32.47891	15.25616		SWEAS	Station end	
PS139/2_0_Underway-11		2023-11-04T11:20:05	28.14028	-15.41232		MYON	Station start	
PS139/2_0_Underway-11		2023-11-21T13:08:43	-32.47891	15.25616		MYON	Station end	
PS139/2_0_Underway-31		2023-11-04T11:20:43	28.14003	-15.41215		NEUMON	Station start	
PS139/2_0_Underway-31		2023-11-21T13:08:18	-32.47831	15.25468		NEUMON	Station end	
PS139/2_0_Underway-24		2023-11-04T11:21:16	28.13987	-15.41199		GRAV	Station start	
PS139/2_0_Underway-24		2023-11-21T13:07:53	-32.47765	15.25311		GRAV	Station end	
PS139/2_0_Underway-42		2023-11-04T14:02:22	27.72199	-15.22995		SNDVELPR	Station start	
PS139/2_0_Underway-42		2023-11-21T13:07:23	-32.47689	15.25127		SNDVELPR	Station end	
PS139/2_0_Underway-23		2023-11-04T14:03:13	27.71896	-15.23007		MAG	Station start	
PS139/2_0_Underway-23		2023-11-21T13:07:03	-32.47639	15.25004		MAG	Station end	
PS139/2_0_Underway-43		2023-11-04T14:03:55	27.71654	-15.23055		TSG	Station start	
PS139/2_0_Underway-43		2023-11-21T13:06:29	-32.47553	15.24795		TSG	Station end	
PS139/2_0_Underway-44		2023-11-04T14:04:21	27.71513	-15.23106		TSG	Station start	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment [cut]
PS139/2_0_Underway-44		2023-11-21T13:06:14	-32.47517	15.24710		TSG	Station end	
PS139/2_0_Underway-3		2023-11-05T14:51:05	24.73300	-19.87341	3746	ADCP	Station start	
PS139/2_0_Underway-3		2023-11-21T13:05:44	-32.47438	15.24521		ADCP	Station end	
PS139/2_0_Underway-13		2023-11-05T14:58:58	24.71716	-19.89685	3775	FBOX	Station start	
PS139/2_0_Underway-13		2023-11-21T13:05:18	-32.47369	15.24366		FBOX	Station end	
PS139/2_0_Underway-34		2023-11-05T15:00:08	24.71476	-19.90037	3772	pCO2	Station start	
PS139/2_0_Underway-34		2023-11-21T13:04:13	-32.47191	15.23980		pCO2	Station end	
PS139/2_0_Underway-28		2023-11-05T15:04:04	24.70660	-19.91200		DS3	Station start	Event shows start/end point (date/time & coordinates) of first/last data record using Atlas Hydrographic Hydrosweep DS 3 multibeam…
PS139/2_0_Underway-28		2023-11-21T10:46:51	-32.26200	14.74720		DS3	Station end	Event shows start/end point (date/time & coordinates) of first/last data record using Atlas Hydrographic Hydrosweep DS 3 multibeam…
PS139/2_1-1		2023-11-06T14:03:07	20.79193	-21.03347	4088	CTD-RO	max depth	
PS139/2_2-1		2023-11-08T14:01:22	12.14899	-21.00409	4885	CTD-RO	max depth	
PS139/2_3-1		2023-11-09T13:53:27	8.84295	-19.17940	36	CTD-RO	max depth	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment [cut]
PS139/2_4-1		2023-11-10T13:54:36	5.53024	-16.73875	4996	CTD-RO	max depth	
PS139/2_5-1		2023-11-11T12:55:27	2.38787	-14.35158	4670	CTD-RO	max depth	
PS139/2_6-1		2023-11-13T12:54:27	-4.24586	-9.37098	4012	CTD-RO	max depth	
PS139/2_7-1		2023-11-14T12:53:18	-7.63627	-6.63981	4494	CTD-RO	max depth	
PS139/2_8-1		2023-11-15T12:45:45	-10.96609	-3.66515	4997	CTD-RO	max depth	
PS139/2_9-1		2023-11-16T12:52:27	-14.55991	-0.74160	4889	CTD-RO	max depth	
PS139/2_10-1		2023-11-17T11:53:32	-17.97096	2.03155	5509	CTD-RO	max depth	
PS139/2_11-1		2023-11-18T11:50:09	-21.53576	4.97497	4472	CTD-RO	max depth	
PS139/2_12-1		2023-11-19T11:47:16	-25.24427	7.93988	4764	CTD-RO	max depth	

** Comments are limited to 130 characters. See* https://www.pangaea.de/expeditions/events/PS*139/2* *to show full comments in conjunction with the station (event) list for expedition PS139/2*

Abbreviation	Method/Device
ADCP	Acoustic Doppler Current Profiler
CT	Underway cruise track measurements
CTD-RO	CTD/Rosette
DS3	Swath-mapping system Atlas Hydrosweep DS-3
FBOX	FerryBox
GRAV	Gravimetry
MAG	Magnetometer
MYON	DESY Myon Detector
NEUMON	Neutron monitor
SNDVELPR	Sound velocity probe
SWEAS	Ship Weather Station
TSG	Thermosalinograph
pCO2	pCO2 sensor

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