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Reports on Polar and Marine Research

The Expedition PS134 of the Research Vessel POLARSTERN to the Bellinghausen Sea in 2022/2023

Edited by

Karsten Gohl

with contributions of the participants

HELMHOLTZ

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Titel: Polarstern passiert den Lemaire Kanal an der Antarktischen Halbinsel auf dem Weg in die Bellingshausen Ses (Foto: Christian Rohleder)

Cover: Polarstern is passing the Lemaire Channel of the Antarctic Peninsula on its route to the Bellingshausen Sea (Photo: Christian Rohleder)

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PS134 / WAIS-BELL

23 December 2022 – 06 March 2023

Cape Town – Punta Arenas

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Contents

1. ÜBERBLICK UND FAHRTVERLAUF

Karsten Gohl DE.AWI

Überblick

Die Expedition PS134 unter dem Titel „West Antarctic Ice Sheet history and processes in the Bellingshausen Sea (WAIS-BELL)“ hatte mit ihrem Hauptnutzerprogramm primär das Ziel, die Eisschildveränderungen der Westantarktis in verschiedenen Zeiten der Vergangenheit zu untersuchen. Die Eisschilde der Westantarktis und der Antarktischen Halbinsel haben in ihrer Entwicklungsgeschichte vermutlich sehr dynamisch auf klimatische Veränderungen reagiert, da ein Großteil der Basis des westantarktischen Eisschildes unter dem Meeresspiegel aufliegt und dadurch besonders einem eindringenden warmen Tiefenwasser ausgesetzt ist. Zusätzlich ist das Eis der Antarktischen Halbinsel einer Oberflächenerwärmung ausgesetzt. Beiträge dieser Eisschilde zu Meeresspiegeländerungen in Zeiten, in denen Klimabedingungen ähnlich denen einer sich gegenwärtig erwärmenden Erde zu erwarten sind, erfordert eine Rekonstruktion der glazialen Vor- und Rückzüge in Relation zu den bathymetrischen, topographischen und ozeanographischen Bedingungen.

Mittels Daten und Proben, die auf dieser Expedition erhoben wurden, sollen Prozesse der Paläoumwelt des südlichen Bellingshausenmeeres entschlüsselt werden, da gerade diese Region und der benachbarte Sektor des Amundsenmeeres gegenwärtig einen dramatischen Eisschildrückzug erleben. Mehrere Hypothesen besagen, dass diese Regionen schon immer am sensitivsten mit ersten Eisschildrückzügen der Antarktis am Ende der Glazialepochen reagierte. Daten von reflexionsseismischen Messprofilen, geothermischen Wärmestrommessungen, Fächersonaraufnahmen des Meeresbodens und der Sedimentechographie dienen der Identifikation den Untersuchungen der Transport-, Ablagerungs- und Erosionsprozesse von glazialen Schelfsedimenten und dem glazial beeinflussten strukturellen Aufbau des Kontinentalhangs. Thermochronologische Daten und Analysen kosmogener Nuklide von Gesteinsproben des küstennahen Festlandes liefern Daten über Hebungsprozesse der Erdkruste sowie über die Rückzugsgeschichte des Eisschildes seit dem letzten glazialen Maximum. In einem biologischen Nebennutzerprojekt wurden antarktische Quallen für das Verständnis über deren Diversität, Verbreitung und trophische Rolle im Südozean beprobt. Weiterhin erfolgte ein walbiologisches Begleitforschungsprogramm zur Validierung der Mitigationsverfahren bei der Anwendung von hydroakustischen und seismischen Messmethoden.

Die Expedition begann am 23. Dezember 2022 in Kapstadt (Südafrika) und führte nach dem Transit über den atlantischen Südozean mit einigen ersten Beprobungsstationen für die Quallenforschung und der Bergung sowie dem Aussetzen einiger ozeanographischer Verankerungen am Maud Rise zuerst zur *Neumayer-Station III* im westlichen Dronning-Maud-Land der Ostantarktis, um die Station zu versorgen. Nach dem Transit über das Weddellmeer und entlang einer sturmausweichenden erstmaligen Route durch die Inselwelt der westlichen antarktischen Halbinsel wurde das Hauptarbeitsgebiet im Bellingshausenmeer erreicht. Dort fand der Großteil der wissenschaftlichen Arbeiten statt, bevor die Rückreise nach Punta Arenas (Chile) angetreten wurde, wo die Expedition am 6. März 2023 endete.

Die außergewöhnliche Meereissituation mit einer antarktisweiten Rekord-Minimalausbreitung in dieser Südsommersaison hat auch im Bellingshausenmeer zu eisfreien Arbeitsbedingungen geführt, die zuvor nicht zu erwarten waren. Dadurch konnten alle Forschungsprojekte auf PS134 nahezu wie geplant durchgeführt werden. Mit über 3700 km an seismischen Profilen hervorragender Qualität auf dem Kontinentalschelf und -hang, detaillierten bathymetrischen Vermessungen von beeindruckenden glazialmorphologischen Formationen in mehreren Trögen im Ausflussbereich von Gletschern in der Ronne Entrance, in der Eltanin-Bucht und vor dem östlichen Abbot-Schelfeis, sowie 29 Sedimentkernstationen und zahlreichen Messungen für geothermischen Wärmestrom auf dem Schelf sind die Erwartungen teilweise übertroffen worden. Das relativ kleine Nebennutzerprogramm der Quallenforschungsgruppe konnte an insgesamt 16 Stationen sehr erfolgreich beproben und hat einige neue Arten entdeckt. Das landgeologische Team sammelte Gesteinsproben von 10 Aufschlusslokationen im Küstenbereich und auf einigen Inseln. Die häufig ungünstigen Flugwetterbedingungen schränkten die Anflugziele allerdings etwas ein. Das Begleitforschungsprogramm zur Walforschung im Zusammenhang mit den seismischen Vermessungen ist zwar durch einen Schaden an der Drohne und ein Fehler in der Datenaufzeichnung des hydroakustischen Landers beeinträchtigt gewesen, konnte aber überraschend viele marine Säuger, insbesondere Wale, im Rahmen von Erkundungsflügen mit systematischen Beobachtungsmethoden dokumentieren.

Die gewonnenen geophysikalischen und geologischen Daten und Proben zeigten schon in ihrer ersten Anschau an Bord deutlich, wie dynamisch sich der westantarktische Eisschild im Sektor des Bellingshausenmeeres in der Vergangenheit verhalten hat. Das umfangreiche Daten- und Probenmaterial wird nun erstmalig eine gesamtumfassende Analyse und Rekonstruktion der eisdynamischen Prozesse der klimarelevanten jüngeren und älteren vergangenen Zeiten im Bellingshausenmeer-Sektor ermöglichen.

Die Projekte der Expedition tragen direkt dazu bei, die Forschungsziele des Topic 2 “Ocean and Cryosphere in Climate” und seine Subtopics 2.1 “Warming Climates” and 2.3 “Sea Level Change” sowie Topic 6 “Marine and Polar Life: Sustaining Biodiversity, Biotic Interactions and Biochemical Functions“ und seine Subtopics 6.1 “Future Ecosystem Functionality“ und 6.2 “Adaptation of Marine Life: From Genes to Ecosystems“ im Helmholtz-Forschungsprogramm “Changing Earth – Sustaining our Future“ zu erfüllen, und unterstützen darüber hinaus nationale und internationale Kooperationen mit Universitäten in diesem Forschungsgebiet.

Fahrtverlauf

Siehe Tabelle 1.1 des Fahrtverlaufs (*Itinerary*) im englischen Abschnitt dieses Kapitels.

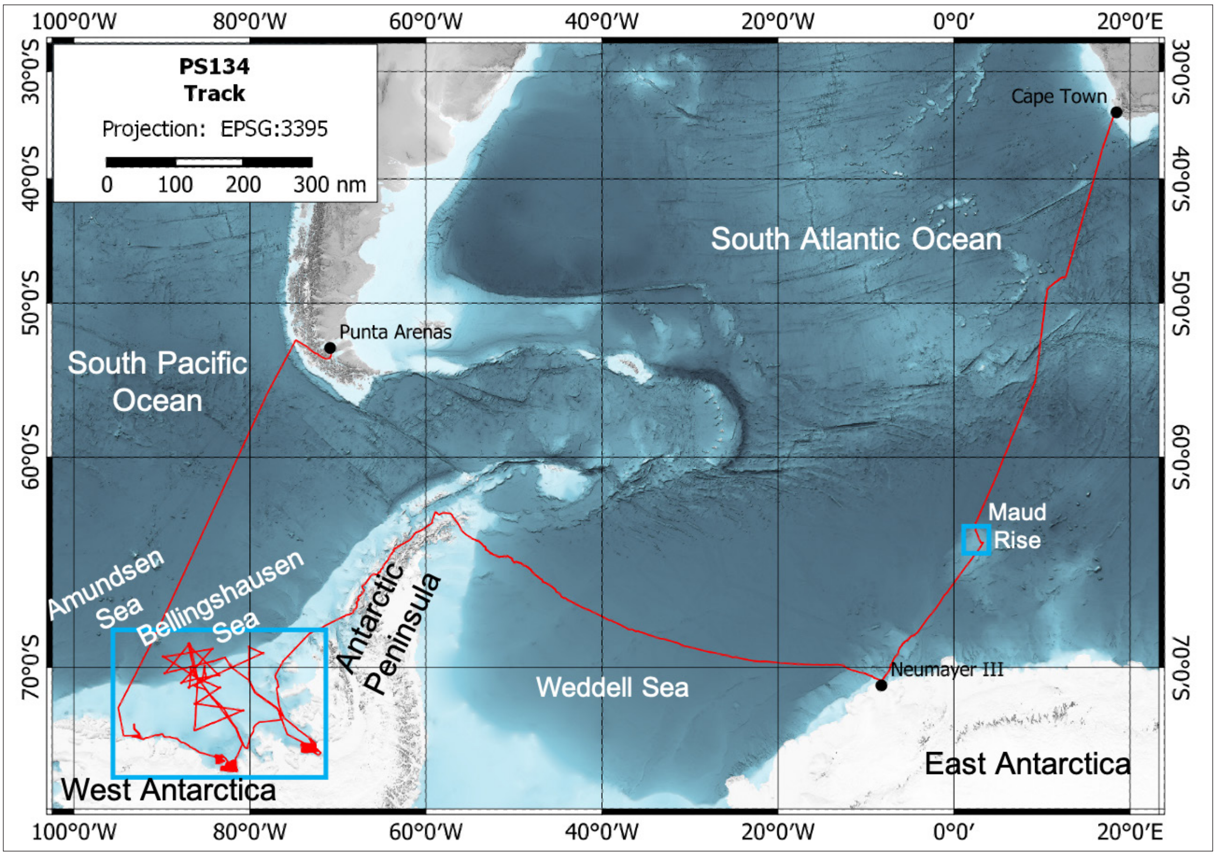

Abb. 1.1: Die Fahrtroute (rote Linien) und Untersuchungsgebiete (hellblaue Kästchen) der Polarstern-Expedition PS134. Siehe https://doi.pangaea.de/10.1594/PANGAEA.961184 für eine Darstellung des Master tracks in Verbindung mit der Stationsliste für PS134

Fig. 1.1: Ship track (red lines) and study areas (light blue boxes) of Polarstern expedition PS134. See https://doi.pangaea.de/10.1594/PANGAEA.961184 to display the master track in conjunction with the station list for PS134

SUMMARY AND ITINERARY

Karsten Gohl DE.AWI

Summary

The Expedition PS134 with the title „West Antarctic Ice Sheet history and processes in the Bellingshausen Sea (WAIS-BELL)“ is primarily aimed to assess the development and changes of the ice sheets in West Antarctica in various times of the past. The ice sheets of West Antarctica and the Antarctic Peninsula have been likely subject to highly dynamic activities during periods of climate warming as most of the base of the West Antarctic Ice Sheet is grounded below present sea-level and therefore prone to melting by intruding warm deep water. In addition, most of the Antarctic Peninsula Ice Sheet is exposed to surface warming. Knowing their contribution to sea-level during times when climate conditions were similar as expected of a future warming Earth, requires reconstruction of their glacial advance and retreat cycles in relationship to bathymetric, topographic and oceanographic conditions.

The data and samples collected during this expedition will help decipher the paleo-environmental processes of the southern Bellingshausen Sea as this region, together with its neighbouring Amundsen Sea sector, exhibits some of the most dramatic ice mass loss developments in modern times. Various hypotheses state that these sectors have always been the most vulnerable locations in Antarctica for early ice sheet retreat in most deglaciation periods. Data produced by using seismic reflection profiling, geothermal heat flow measurements, multibeam bathymetric surveying and sub-bottom profiling serve to study transport, depositional and erosional processes of glacially derived continental shelf sediments and the glacially controlled structural formation of the continental slope. Thermochronological data and analyses of cosmogenic isotopes from rock samples collected from the coastal mainland provide indications on uplift of the Earth’s crust as well as the retreat history of the ice sheet since the last glacial maximum. Antarctic jellyfish were sampled as part of a small biological programme to study their diversity, distribution and trophic role in the Southern Ocean. Further, a study on whales was conducted to validate the mitigation methods applied in conjunction with the hydroacoustic and seismic surveys.

The expedition began on 23 December 2022 in Cape Town, South Africa, with the transit across the Southern Atlantic Ocean, the first sampling stations for jellyfish research, and the recovery and deployment of some oceanographic moorings before arriving at *Neumayer Station III* in western Dronning Maud Land of East Antarctica for resupply. After the transit across Weddell Sea and along a new, storm-avoiding route through the island world of the western Antarctic Peninsula, the main work area in the Bellingshausen Sea was reached. Most of the scientific work projects took place here, before returning to Punta Arenas, Chile, where the expedition ended on 6 March 2023.

The extraordinary sea-ice situation with a circum-Antarctic record minimum distribution in this austral summer season led to unexpected ice-free conditions also in the Bellingshausen Sea. Therefore, all research projects of PS134 could be conducted nearly as planned. The more than 3,700 km of seismic profiles on the continental shelf and slope with excellent data quality, detailed bathymetric surveys of impressive glacial-morphological formations in several troughs

offshore of glaciers of Ronne Entrance, Eltanin Bay and eastern Abbot Ice Shelf, as well as 29 sediment coring stations and numerous geothermal heat flow measurements on the shelf amounted to outcomes that exceeded prior expectations. A total of 16 successful sampling stations and the discovery of some new species were achieved by the relatively small jellyfish research programme. The land geology team collected rock samples from 10 outcrop locations along the coast and some islands. However, frequent unfavourable flight weather conditions restricted the number of sampling areas. Although a research programme on whales, that accompanied the seismic survey project, suffered from a damage of their drone and the malfunctioning of the data logger of their hydroacoustic lander, it documented surprisingly large numbers of marine mammals, in particular whales, by systematic observations during helicopter reconnaissance flights.

A first glimpse of the collected data and samples on board already indicated how dynamic the West Antarctic Ice Sheet has behaved in the Bellingshausen Sea sector in the past. The rich data and sample material will enable for the first time a comprehensive analysis and reconstruction of the ice-dynamic processes in climate change-relevant periods of the past in this sector.

The projects of the expedition contribute directly to research objectives and challenges of Topic 2 “Ocean and Cryosphere in Climate” and its Subtopics 2.1 “Warming Climates”, 2.3 “Sea Level Change” as well as Topic 6 “Marine and Polar Life: Sustaining Biodiversity, Biotic Interactions and Biochemical Functions” and its Subtopics 6.1 “Future Ecosystem Functionality” and 6.2 “Adaptation of Marine Life: From Genes to Ecosystems” of the Helmholtz Research Programme “Changing Earth – Sustaining our Future”. The projects also enhance national and international cooperation with universities.

Tab. 1.1: Itinerary of *Polarstern* expedition PS134.

Day	Date (2022/2023)	Board time ca.	Science activities and other events	Weather, seastate, ice
Fr	23.12.	(UTC+2h) 22:00	**Departure from Cape Town;**	fine; low seastate
Sa	24.12.		Transit; Unpacking of equipment; Christmas Eve dinner;	fine; medium seastate
Su	25.12.	 10:30	Transit; CTD test deployment; Unpacking of equipment; Christmas Day lunch & dinner;	cloudy; medium to high seastate
Mo	26.12.		Transit; Unpacking of equipment;	cloudy; medium seastate
Tu	27.12.	 10:00	Transit; CTD, multi-net and bongo-net station; Unpacking and assembling of equipment;	Cloudy, medium seastate
We	28.12.	(UTC+1h)	Transit; Weathering storm;	cloudy, strong storm; high seastate

Day	Date (2022/2023)	Board time ca.	Science activities and other events	Weather, seastate, ice
Th	29.12.		Transit; Weathering storm;	cloudy, strong storm; high seastate
Fr	30.12.	 16:00	Transit; Unpacking and assembling of equipment; Seminar on Environm. Protection Antarctica	cloudy, stormy; seastate lowering
Sa	31.12.	 08:00	Transit; CTD, multi-net and bongo-net station; Unpacking and assembling of equipment; New Year's Eve celebration;	fine; low seastate
Su	01.01.	(UTC) 18:00	Transit; Assembling of equipment; CTD, multi-net and bongo-net station;	cloudy; low to medium seastate
Mo	02.01.		Transit; Assembling of equipment;	cloudy; low seastate
Tu	03.01.	from 00:30	CTD, oceanographic mooring deployment & recovery programme;	cloudy; low seastate
We	04.01.	01:00 08:00 16:30	CTD, multi-net and bongo-net station; Oceanographic mooring deployment & recovery programme; 1 mooring not recovered despite dredging attempt; Transit;	partly sunny & cloudy; low seastate
Th	05.01.	 10:00	Transit; Training course for marine mammal observers; First encounter of sea-ice;	partly sunny & cloudy; low seastate
Fr	06.01.	15:15	**Arrival at Neumayer Station**; Neumayer Station logistics;	cloudy; windy
Sa	07.01.		Neumayer Station logistics; Recovery of drifting sea-ice instruments by helicopter; Visit to Station;	cloudy; later partly sunny; low wind
Su	08.01.	 18:00 21:00	Neumayer Station logistics; Visit to Station; Farewell ceremony; **Departure from Neumayer Station**;	sunny; windy
Mo	09.01.		Transit across Weddell Sea;	cloudy; low wind; increasing sea-ice
Tu	10.01.		Transit across Weddell Sea;	cloudy; low wind; sea-ice
We	11.01.		Transit across Weddell Sea;	cloudy; low wind; dense sea-ice

Day	Date (2022/2023)	Board time ca.	Science activities and other events	Weather, seastate, ice
Th	12.01.		Transit across Weddell Sea;	cloudy; low wind; dense sea-ice
Fr	13.01.		Transit across Weddell Sea;	cloudy; low wind; dense sea-ice
Sa	14.01.		Transit across Weddell Sea;	cloudy; low wind; ice decreasing; foggy
Su	15.01.	03:00	Entry to Antarctic Sound of N. Ant. Peninsula; Transit along western Antarctic Peninsula; South Polar Baptism Ceremony;	Cloudy, strong winds; later sunny, medium wind;
Mo	16.01.	(UTC-1)	Transit along western Antarctic Peninsula through Gerlache Strait, Neumayer Channel, Lemaire Channel and route between islands; Bathymetric profiling;	Cloudy to sunny; some snow; low wind;
Tu	17.01.		Transit east of Adelaide Island; Passing by Rothera Station; Bathymetric profiling;	Cloudy, hazy, medium wind;
We	18.01.	afternoon	Transit along NW and west of Alexander Island, Charcot Island and Latady Island; Bathymetric profiling; Arrival in main work area of eastern Bellingshausen Sea Embayment shelf; Entering Ronne Entrance;	Cloudy, hazy, medium wind;
Th	19.01.	morning 10:00 19:30	Start of detailed bathymetric survey of innermost Ronne Entrance off George VI Ice Shelf; Geological sampling on land outcrops (transport by helicopter); CTD for sound velocity profile;	Cloudy to sunny; low wind;
Fr	20.01.		Continue bathymetric survey; Geological sampling on land outcrops (transport by helicopter); Ice-reconnaissance with whale observation by helicopter;	Cloudy to sunny; low wind;
Sa	21.01.	11:30 19:00	Continue bathymetric survey; Geothermal heat-flow stations; Ice-reconnaissance with whale observation by helicopter; Sediment coring stations;	Cloudy; low wind;

Day	Date (2022/2023)	Board time ca.	Science activities and other events	Weather, seastate, ice
Su	22.01.	 01:30	Geothermal heat-flow stations; CTD, multi-net and bongo-net station; Sediment coring stations; Geological sampling on land outcrops (transport by helicopter);	Cloudy; partly sunny; low wind;
Mo	23.01.	 08:30 10:40 13:30 23:30	Bathymetric survey in inner Ronne Entrance; Life-boat manoevre; Continue bathymetric survey; Deployment seismic streamer and airguns; Technical difficulties with streamer and recording system, partially solved; Geological sampling on land outcrops (transport by helicopter); Start seismic profile AWI-20230001;	Cloudy; low wind;
Tu	24.01.	03:00 04:40 09:30	End seismic profile AWI-20230001, turning; Start seismic profile AWI-20230002; Ice reconnaissance flights; Geological sampling on land outcrops (transport by helicopter);	Cloudy; partly sunny; medium wind;
We	25.01.		Continue seismic profile AWI-20230002; Numerous and long airgun shutdowns due to seals behind stern;	Cloudy, hazy; medium wind and swell;
Th	26.01.		Continue seismic profile AWI-20230002; Numerous and long airgun shutdowns due to seals behind stern;	Cloudy; low wind; medium swell;
Fr	27.01.	01:00 03:00 11:45 13:30	End seismic profile AWI-20230002; Start seismic profile AWI-20230003; End seismic profile AWI-20230003; Start seismic profile AWI-20230004;	Cloudy; low wind; low swell;
Sa	28.01.		Continue seismic profile AWI-20230004;	Cloudy; low wind; low swell;
Su	29.01.	(UTC-2) 04:30 05:30 15:00 16:00 23:00	 End seismic profile AWI-20230004; Start seismic profile AWI-20230005; End seismic profile AWI-20230005; Start seismic profile AWI-20230006; Hydroacoustic lander (ALTO) deployment;	Cloudy; medium wind and swell;
Mo	30.01.		Continue seismic profile AWI-20230006;	Cloudy; low wind and swell;
Tu	31.01.	16:00	End seismic profile AWI-20230006 in eastern Eltanin Bay, retrieval of airguns and streamer; Bathmetric transect to Ronne Entrance;	Cloudy; low wind and swell;
We	01.02.	06:00 11:00	CTD and multi-net station; Sediment coring stations;	Partly sunny; low wind and swell;

Day	Date (2022/2023)	Board time ca.	Science activities and other events	Weather, seastate, ice
Th	02.02.	06:30 21:30	CTD and multi-net station; Sediment coring stations; Magnetic compensation circle;	Cloudy; medium wind and swell;
Fr	03.02.	01:00 08:30 12:00	CTD, multi-net and bongo-net station; Deployment seismic streamer and airguns; Start seismic profile AWI-20230007;	Cloudy; low wind and swell;
Sa	04.02.	 14:00 15:00 16:30	Continue seismic profile AWI-20230007; Helicopter flight to Peter I Island: Installation of GPS recorder on geodetic marker PET1 failed due to Skua nesting on site; rock collection away from site was possible; End seismic profile AWI-20230007; Start seismic profile AWI-20230008;	Cloudy; medium wind and swell;
So	05.02.	10:00 12:00	End seismic profile AWI-20230008; Successful drone flights for whale observation after drone repair with live video transmission; Start seismic profile AWI-20230009;	Partly cloudy; low wind and swell;
Mo	06.02.	08:45 10:15 20:00	End seismic profile AWI-20230009; Start seismic profile AWI-20230010; Crossing ALTO lander station;	Cloudy; wind and swell increasing;
Tu	07.02.	04:30 06:30 15:30 17:30 21:30	End seismic profile AWI-20230010; Start seismic profile AWI-20230011; End seismic profile AWI-20230011; Start seismic profile AWI-20230012; Crossing ALTO lander station;	Cloudy; medium to strong wind and swell;
We	08.02.	 22:00 23:00	Continue seismic profile AWI-20230012; End seismic profile AWI-20230012; Start seismic profile AWI-20230013;	Cloudy; strong wind and swell; later storm;
Th	09.02.		Continue seismic profile AWI-20230013;	Cloudy; stormy conditions;
Fr	10.02.	01:00 02:30	End seismic profile AWI-20230013; Start seismic profile AWI-20230014;	Cloudy; stormy conditions;
Sa	11.02.	01:30 03:30 18:30 20:15	End seismic profile AWI-20230014; Start seismic profile AWI-20230015; End seismic profile AWI-20230015; Start seismic profile AWI-20230016;	Cloudy; stormy conditions; improving later;
So	12.02.	 08:30	Continue seismic profile AWI-20230016; Crossing ALTO lander station;	Cloudy; medium wind and swell
Mo	13.02.	05:00 07:00	End seismic profile AWI-20230016; Start seismic profile AWI-20230017;	Cloudy; low wind and swell
Tu	14.02.	08:30 10:00 23:50	End seismic profile AWI-20230017; Start seismic profile AWI-20230018; End seismic profile AWI-20230018;	Cloudy to partly sunny; low wind and swell

Day	Date (2022/2023)	Board time ca.	Science activities and other events	Weather, seastate, ice
We	15.02.	01:45 14:30	Start seismic profile AWI-20230019; End seismic profile AWI-20230019 and survey, retrieval of airguns and streamer;	Cloudy to sunny; low wind and swell, increasing later
Th	16.02.	02:30 03:00 21:00	Recovery of ALTO lander; CTD and multi-net station; Waiting and riding out storm; CTD and multi-net station;	Cloudy; medium wind and swell, increasing to major storm; later decreasing
Fr	17.02.	06:30 19:00	Sediment coring stations; CTD and multi-net station; Sediment coring stations; Bathymetric survey transit to Eltanin Bay;	Cloudy to partly sunny; strong wind and swell, decreasing later
Sa	18.02.	01:30 23:00	Sediment coring stations; Continue bathymetric survey transit to Eltanin Bay; Waiting and riding out storm; Sediment coring station;	Cloudy; medium to strong wind and swell; storm later
Su	19.02.	03:00 07:30 18:30	Sediment coring station; Start bathymetric survey in Eltanin Bay; Reconnaisance helicopter flight along S Eltanin Bay coast for rock outcrop search;	Cloudy; some snow showers; low wind and swell
Mo	20.02.	 09:30 12:30	Continue bathymetric survey in Eltanin Bay; CTD and multi-net station; Reconnaisance helicopter flight along S Eltanin Bay ice-stream margins; Continue bathymetric survey;	Cloudy, partly sunny; low wind and swell
Tu	21.02.	 18:00	Continue bathymetric survey; CTD and multi-net station; Geothermal heat-flow station; Sediment coring stations;	Cloudy; medium to strong to stormy wind and waves
We	22.02.	 23:15	Sediment coring stations; Geothermal heat-flow stations; Sediment coring station; Start bathymetric survey;	Cloudy, partly sunny; wind and swell decreasing
Th	23.02.	 09:30 13:00	Continue bathymetric survey; CTD and multi-net station; Geological sampling on land outcrops (transport by helicopter); Continue bathymetric survey;	Cloudy, partly sunny; low wind and swell

Day	**Date (2022/2023)**	**Board time ca.**	**Science activities and other events**	**Weather, seastate, ice**
Fr	24.02.	 10:30	Continue bathymetric survey; Sediment coring stations; Reconnaisance helicopter flight along Venable Ice Shelf margin; Geothermal heat-flow stations; Bathymetric transect to western inner shelf along Venable Ice Shelf;	Cloudy; low wind and swell
Sa	25.02.	 08:30	Continue bathymetric transect along eastern Abbot Ice Shelf; CTD and multi-net station; Reconnaisance helicopter flights along eastern Abbot Ice Shelf margins; Continue bathymetric transect along eastern Abbot Ice Shelf;	Cloudy; low to medium wind and swell
Su	26.02.	09:30 12:30	CTD and multi-net station; Sediment coring & geoth. heat-flow stations; Bathymetric transect along SW shelf; **Depart. from SW Bellingshausen Sea shelf;**	Cloudy; medium wind and swell
Mo	27.02.	(UTC-3h) 21:00	Transit; Helicopter flight to western Peter I Island coast for geol. Sampling, but no landing pads found; Continue transit;	Cloudy; strong to medium wind and swell
Tu	28.02.		Transit;	Cloudy; medium wind and swell
We	01.03.		Transit;	Cloudy to sunny; medium wind and swell
Th	02.03.	 19:00	Transit; End of Expedition & Farewell Ceremony;	Cloudy to sunny; medium wind and swell
Fr	03.03.		Transit;	Cloudy to sunny; medium wind and swell
Sa	04.03.		Transit;	Cloudy to sunny; medium to low wind and swell
Su	05.03.		Transit through western Strait of Magellan	Cloudy; low wind and swell
Mo	06.03.	08:00	**Arrival in Punta Arenas.**	Cloudy; medium wind

2. WEATHER CONDITIONS DURING PS134

Jens Kieser[1], Christian Rohleder[1]   [1]DE.DWD

Friday 23 December – Friday 30 December 2022:

In calm and mild weather *Polarstern* started from Cape Town on the evening of 23 December for expedition PS134 – “WAIS-BELL”. Under the command of Captain Langhinrichs the ship steered a south-southwesterly course towards the first destination of the expedition, the edge of the Ekström Ice Shelf near *Neumayer Station III*.

During the first week of the expedition, the cruising area lay between the South Atlantic subtropical anticyclone and an intense low pressure system north of Dronning Maud Land. Westerly winds prevailed, which initially often blew with strengths between 5 and 7 Beaufort (Bft). Significant wave heights between 3 and 5 m were often recorded, with swell directions between southwest and northwest predominating. In the area south of 40° southern latitude *Polarstern* increasingly entered the sphere of influence of powerful secondary lows and their storm fields after Christmas, which were guided northwards around the steering centre of the low-pressure system mentioned above. One such intense low brought us the first storm between the evening of 27 December and the morning of 28 December, with mean wind speeds around 50 knots and gusts over 60 knots recorded at maximum in the morning of the 28. The significant wave height was temporarily estimated at 8 to 9 m. The troughs of another intense low affected the cruising area on 29 and 30 December, with mean wind speeds of 9 Bft recorded. Sea state again built up to a significant wave height of more than 6 m, which only began to decrease in the afternoon of 30 December. Whereas the air temperature had been around 20°C at the beginning of the voyage, on 26 December it dropped by about 10 K in a short time, with a simultaneous marked decrease in the water temperature. By 30 December the air temperature had dropped further to values just above the freezing point. The passages of the secondary lows with their troughs caused unsettled weather with showers, some of which fell in the form of snow or snow grain from 28 December. In the vicinity of precipitation, visibility dropped to 1 to 2 km at times, otherwise visibility was mostly between 10 and 20 km.

Saturday 31 December 2022 – Wednesday 4 January 2023:

During this period *Polarstern* continued to move in a south-southwesterly direction between 55° and 65° southern latitude and between the 10 and 3 eastern meridians. North of Dronning Maud Land at this time a low-pressure system was located, on whose northern flank several secondary lows and troughs were led around eastwards, which temporarily influenced the cruising area. The winds in the cruising area blew mainly from westerly directions, with wind forces of 6 to 7 Bft being recorded temporarily. It was not until 4 January that the wind shifted to the east and abated, while one of the aforementioned secondary lows passed to the north of our cruising area. Air temperatures ranged between -3°C and 0°C, water temperatures around -1°C.

Poor visibility was recorded more frequently at the beginning. Especially on 1 January, there was fog for a longer period of time with visibility between 300 and 600 metres. After New Year’s Day visibility improved and poor visibility was observed only briefly in snow showers, which occurred occasionally. Periods of nearly overcast or cloudy skies predominated, with mostly stratocumulus clouds over the cruising area. Significant wave height decreased from 3-4 m to 1-2 m.

Thursday 5 January 2023:

On its course in a south-southwesterly direction, *Polarstern* moved between 66° south, 0° west and 69° south, 4° west. The cruising area was initially on the back side of an intense low-pressure system, which drifted eastwards along 60° of southern latitude, moving away from the cruising area. Before *Polarstern* entered the sphere of influence of the next cyclonic system approaching from the west in the second half of the day, it was crossed eastwards by a weak high-pressure ridge around midday.

At first glance, the described constellation of pressure systems and the weather development to be expected here does not seem very spectacular and actually not worthy of a detailed description in the context of this report. However, the sighting of several funnel clouds (see Fig. 2.1) and at least one “waterspout” in the immediate vicinity of *Polarstern* on this day can be considered a remarkable event, at least from a meteorological point of view, which should be acknowledged here in a separate section.

On this day, below a marked temperature inversion, an almost overcast and quite uniform stratocumulus cloud layer lay in the altitude range between 4,000 and 5,000 FT AMSL (feet above mean sea level) above the cruising area until the afternoon. Below the inversion the air mass was characterised by unstable stratification. In the morning a brief and spatially limited drop in the cloud base to about 2,000 FT AMSL was observed. In the area of these lower cloud bases, several “funnel clouds” could be observed, at least one of which briefly made contact with the sea surface. The air temperature ranged between -2°C and -1°C on this day, the water temperature around -1°C. The wind blew at 2 to 4 Bft until noon, shifting from southeast to west. During the period of occurrence of the “Funnel Clouds”, an abrupt and temporary wind increase of about 6 knots could be observed, although 15 knots (4 Bft) were hardly exceeded even in gusts. Later in the day, mean wind speeds between 10 and 18 knots (around 4 Bft) were recorded, with the wind continuing to shift to the northeast. Before light snow began to fall in the evening and visibility dropped to the medium range between 5 and 10 km, it was initially mostly in the good to very good range. In the evening *Polarstern* reached an area with denser sea ice.

Friday 6 January – Sunday 8 January 2023:

On the afternoon of 6 January *Polarstern* reached the ice shelf edge at 70°30’ South, 008°12’ West to stay in the “ice harbour” in Atka Bay until the evening of 8 January. During this period, the weather was initially dominated by a depression north of Dronning Maud Land. Later, a shallow trough of low pressure formed over the extreme northern and northwestern part of the ice shelf. The wind, which was strong at times (6 Bft), shifted from east to southwest in our area and increasingly brought in somewhat drier and colder air. Not only visibility improved. The cloud cover also slowly lifted and dispersed, so that it was sunny for a long time on 8 January. Temperatures ranged between -4°C and -1°C. The swell coming in from the north was weakened by the sea ice lying to the north and hardly reached more than 1m.

Monday 9 January - Saturday 14 January 2023:

During this period, *Polarstern* moved from Atka Bay along the Great Circle towards the northern tip of the Antarctic Peninsula. In the area traversed in the northern Weddell Sea large ice-covered areas alternated with open water areas. A series of low-pressure troughs and high-pressure ridges swinging eastwards, as well as an intense low passing through to the north of the area, caused unsettled weather with intermittent snowfall, fog patches but also sunny phases. Visibility was repeatedly below 1 km for long periods. Temperatures ranged between -4°C and 0°C. They only rose to +2°C as we approached to the Antarctic Sound in the evening of 14 January. The wind blew from different directions, on 10 and 11 January temporarily with strengths around 7 Bft. As a result of the ice situation in the wider vicinity of the cruising area, the sea state remained moderate. The significant wave height only temporarily exceeded 2 m by a little. Most of the time it was lower than 1 m.

Sunday 15 January – Friday 20 January 2023:

The cruise now guided us southwards along the eastern edge of the Bellingshausen Sea. We mostly sailed close to the coast, at times also through narrow sounds lined by mountains and glaciers, between the Antarctic Peninsula and the offshore islands. Apart from icebergs the waters were mostly iceless. In the area of influence of two successive intense lows over the Bellingshausen Sea the weather was unsettled and sometimes very windy. Particularly in the night of 15 January and in the night of 17 to 18 January gales of 10 Bft occurred, with the maximum gusts even reaching gale force (12 Bft, > 63 knots). Westerly to northerly wind directions predominated. Temporary weak winds and variable wind directions were recorded in the area of the islands. Temperatures ranged from -2°C to +3°C during this period. While the significant wave heights in the shelter of the islands were seldom more than 1 m, we initially encountered frequently waves with significant heights around 4 m in open areas of the Bellingshausen Sea. There were repeated snow showers or longer lasting snowfalls, which reduced the visibility considerably, during heavier snowfall temporarily below 1 km. Away from snowfall, visibility was moderate to good, but visibility of 20 km was rarely exceeded.

Saturday 21 January – Tuesday 24 January 2023:

The working area during this period was in the Ronne Entrance in the southeasternmost part of the Bellingshausen Sea. At first, weak air pressure differences dominated in the area of local pressure systems. Later, the working area lay on the southern edge of a low-pressure system over the Bellingshausen Sea, whereby the pressure differences increased somewhat. A nearly overcast stratocumulus or altocumulus clouding characterised the cloud picture these days. Temporarily, some snow fell. The wind blew mainly weak to moderate from different directions. Only on 24 January did a fresh to strong south-easterly wind set in temporarily, with the cloud cover described above disappearing or being replaced by high cirrus. Air temperatures ranged between -3°C and +3°C during this period, and water temperatures between 0°C and 3°C. During snowfall visibility temporarily diminished to about 5 km, otherwise visibility mostly exceeded 30 km. However, white-out conditions occurred at times over the ice shelf, which limited the possibilities for helicopter flights here. The significant wave height was mostly well below 1 m, rising to about 2 m only on 24 January.

Wednesday 25 January – Wednesday 1 February 2023:

During this period the cruising and research area continued to lie in the south-eastern part of the Bellingshausen Sea, with *Polarstern* temporarily moving slightly to the north-west and thus away from the ice shelf. Partly quite powerful lows were located over the northern Bellingshausen Sea. Within a southward reaching trough, small-scale low-pressure cores developed at times in the vicinity of our sailing area, so that weak low-pressure influence prevailed with mostly moderate pressure gradient. Low level clouds and intermittent precipitation, which mostly fell as snow, characterised the weather during these days. At times, the cloud cover lay on the sea surface and thus caused fog. As a result, poor visibility prevailed temporarily. Poor visibility was also recorded at times in light to moderate snowfall or snow showers, which occurred daily. The wind blew from different directions often with 4 to 5 Bft, temporarily also with slightly deviating wind speeds. Air temperatures between -2°C and +2°C were recorded, water temperatures between 0 and +3°C. The significant wave height was often between 1 and

2 m, at times reaching 3 m. The main swell often came from northerly directions, with other swells coming from different directions at times.

Thursday 2 February – Friday 10 February 2023:

Repeatedly intense low-pressure areas moved from the northwest to the Bellingshausen Sea, where they weakened. The low-pressure activity reached its peak for the time being with a severe gale, which reached the Bellingshausen Sea from the north on 9 February with a central pressure lower than 940 hPa and remained there for several days, weakening only slowly. Unsettled and often windy, at times stormy weather characterised this period, during which *Polarstern* moved in the area of the "Belgica Trough" to the south of the Bellingshausen Sea. The wind blew predominantly from northerly or easterly directions. The maximum with average wind speeds of 8 to 9 Bft (around 40 knots) was recorded on the morning of 9 February. The air temperatures ranged between -2°C and +2°C, the water temperatures between 0°C and +2°C. Cloudy conditions dominated, with intermittent light or moderate snow. Temporarily the precipitation changed to light freezing drizzle. Particularly in the vicinity of precipitation, visibility repeatedly dropped into the poor range between 1 and 4 km, in fog below 1 km. Otherwise, visibility of more than 20 km was frequently recorded in the beginning, later not often more than 20 km. With predominantly northerly swell directions, the significant wave height was initially only seldom above 3 m, from 7 February between 4 and 6 m, with the maximum on early 9 February.

Saturday 11 February – Saturday 18 February 2023:

The former intense depression, which had reached the Bellingshausen Sea on 9 February, weakened over the southern Bellingshausen Sea and initially influenced the weather pattern in the cruising and working area, which was largely in the vicinity of the "Belgica Trough". After the passage of a high-pressure ridge on 15 February, the cruising area again came under the influence of intense low-pressure areas. Thus, cloudy weather with intermittent precipitation, which fell temporarily as rain or drizzle, but mostly as snow, characterised the weather in this period. Particularly in the vicinity of the low centres, fog also occurred. Accordingly, poor visibility below 5 km was repeatedly recorded, while visibility above 20 km was observed only occasionally. Strong winds of 6 to 7 Bft occurred repeatedly, on the morning of 16 February also gale force with mean wind speeds above 40 knots (9 Bft). In phases with wind forces above 5 Bft, northerly or easterly wind directions dominated. At times, the cruising and working area was in the central area of the lows, where weak winds from variable directions were recorded. While the significant wave height was 1 to 2 m in the meantime, 5 to 6 m were observed at times on 11, 16 and 18 February. The swells came predominantly from northerly directions. Air temperatures continued to hover around freezing point, with water temperatures measured between 0°C and 2°C.

Sunday 19 February – Sunday 26 February 2023:

During this period, the cruising and working area was in Eltanin Bay and later between it and Thurston Island, in the southernmost part of the Bellingshausen Sea. Here initially northerly winds blew between low-pressure areas located to the north and a high-pressure ridge over Ellsworth Land, but otherwise predominantly southeasterly to northeasterly winds. Temporarily, marked pressure differences in conjunction with the "guard rail effect" caused by the nearby coast or ice edge and additional katabatic effects caused the wind to increase to 10 Bft on the evening of 21 February. On the following day, the wind continued to blow strongly, partly with gale force, before decreasing considerably and only freshening up again towards the end of the period. Significant wave heights of around 3 m were observed during the period of strong winds and gales on 21, 22 and 26 February. Otherwise, the significant wave height was mostly below 2 m, whereby the part of the swell coming in from northerly directions predominated.

Around snowfall, which occurred intermittently until 20 February, visibility temporarily decreased to below 1 km. From 21 February onwards, temporarily no precipitation was observed and visibility was almost continuously above 10 km, mostly even around or above 30 km, before precipitation in the form of snow and freezing drizzle with poor visibility set in again from 25 February onwards. In the meantime, visibility was temporarily somewhat reduced only near the coast and in the vicinity of icebergs due to blowing snow. In the relatively dry air brought in from the ice in the meantime, the low stratocumulus clouds disappeared for some time. Temperatures dropped somewhat. They were between -6°C and 0°C during this period. Water temperatures hovered around 0°C.

Monday 27 February – Monday 6 March 2023:

During this period the passage from the southern Bellingshausen Sea to Punta Arenas was on the expedition's schedule. On the evening of 26 February, we had already left the working area at the southern edge of the Bellingshausen Sea to head for the western entrance of the Strait of Magellan on a north-northeasterly course. Initially, we were still sailing in the southern area of an extensive low-pressure system, which was located over the Bellingshausen Sea and the adjacent sea areas. The wind blew predominantly from easterly directions, reaching strengths of 6 to 7 Bft at times. Significant wave heights were 3-4 m, briefly slightly above. The swell continued to come from northerly directions. Under mostly cloudy skies, there were initially intermittent poor visibility between 1 and 5 km associated with light snowfall. Later, visibility above 10 km predominated.

From 1 March *Polarstern* sailed in the northern part of the aforementioned low-pressure system, later increasingly between the lows to the south of the cruising area and high air pressure over the subtropical South Pacific. The wind direction now had a westerly component, with pressure differences increasing again, at least temporarily. As a result, near gale-force winds (7 Bft) blew from southwesterly directions in the cruising area, especially on 3 March. The significant wave height during these days was often around 4 m, at times also close to 5 m, whereby the direction from which the swell came in changed from northwest to west-southwest. The weather changed its character fundamentally during these days. The atmosphere was now highly unstable stratified and sunny phases alternated with convective clouds, which brought snow, rain and sleet showers with brief poor visibility. Otherwise, visibility ranged between 10 and 40 km. While the water temperature was still at 0°C at the end of February, it gradually rose from the turn of the month and reached 10°C in the entrance area of the Strait of Magellan. While the air temperature was still near freezing point in the last days of February, it gradually climbed to around 8°C at the beginning of March, measured during the passage through the Strait of Magellan on the evening of 5 March. The passage of the western Strait of Magellan on 5 and 6 March until reaching Punta Arenas was accompanied by a low-pressure system moving eastwards over southern Patagonia, which at times caused rain and average visibility between 5 and 10 km. The wind blew mostly with 4 to 5 Bft from northwest to north, briefly with 6 Bft. While the significant wave height before entering the Strait of Magellan was still 2 m, later hardly any wave heights above 1 m were observed. With a fresh northerly wind and a temperature around 7°C, the research cruise PS134 "WAIS-BELL" ended off Punta Arenas in the morning of 6 March 2023.

Fig. 2.1: Funnel cloud in the vicinity of Polarstern *in the late morning of 5 January 2023 over the sea area north of Dronning Maud Land, East Antarctica (photo by Christian Rohleder)*

3. MARINE GEOPHYSICS: WEST ANTARCTIC ICE SHEET HISTORY AND PROCESSES IN THE BELLINGSHAUSEN SEA SECTOR (WAIS-BELL)

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Grant-No. AWI_PS134_01

Objectives

The ice sheets of West Antarctica and the Antarctic Peninsula are likely subject to highly dynamic activities during periods of climate warming as most of the base of the West Antarctic Ice Sheet is grounded below present sea-level, and most of the Antarctic Peninsula Ice Sheet is exposed to surface warming. Knowing their contribution to sea-level during times when climate conditions were similar as expected for the future of a warming Earth requires reconstruction of their glacial advance and retreat cycles in relationship to bathymetric, topographic and oceanographic conditions. The scientific aim of this main expedition project was to decipher the paleo-environmental and paleo-ice sheet processes of the southern Bellingshausen Sea and easternmost Amundsen Sea (Figs. 1.1 and 3.1) as this region exhibits some of the most dramatic ice mass loss developments in modern times. It is hypothesized that this sector has always been the most vulnerable location in Antarctica for early ice sheet retreat in most deglaciation periods of the past and will act similarly, if not more rapidly, with present day and future climate change.

The data produced by using seismic reflection profiling, multibeam bathymetric surveying, sub-bottom profiling and geothermal heat flow measurements will serve to study transport, depositional and erosional processes of glacially derived inner to outer shelf sediments and their structural properties of the variable slopes from the continental shelf to the continental rise along the southern Bellingshausen Sea sector.

The extensive seismic and hydroacoustic surveys in this project offer a unique opportunity to test observation methods as part of an extensive mitigation validation study project of marine mammals.

This WAIS-BELL project contributes directly to research objectives and challenges of Topic 2 “Ocean and Cryosphere in Climate” and its Subtopics 2.1 “Warming Climates” and 2.3 “Sea Level Change” of the AWI Research Programme, and will enhance cooperation with universities.

Work at sea

The austral summer season 2022/23 was characterised by a record sea-ice minimum for Antarctica in general and for the Bellingshausen Sea in particular (Fig. 3.1). This unusual situation of lacking sea-ice made it possible that PS134 projects could be conducted over an unexpected large part of the continental shelf and slope. With more than 3,700 km of seismic profiles across the shelf and, in particular, in the glacially formed Belgica Trough and its large trough mouth fan on the slope, densely spaced bathymetric surveying of inner shelf glacimorphological formations in Ronne Entrance, Eltanin Bay and off eastern Abbot Ice Shelf, numerous geothermal heat flow measurements in the same regions as well as high-quality sub-bottom profiling along the entire ship-track, the extent of the geophysical data acquisition exceeded expectations. These datasets will form the base for analyses on glacially derived sedimentation processes, the reconstruction of past ice-sheet advances and retreat periods and tectonic processes relevant for ice-sheet dynamics of the Bellingshausen Sea sector.

Details of the seismic, bathymetric and sub-bottom surveys, the geothermal heat flow measurements as well as the marine mammal observation and mitigation validation project of this main expedition programme, including preliminary results, are described in Sub-Chapters 3.1 to 3.5.

References

Dorschel et al. (2022) The International Bathymetric Chart of the Southern Ocean Version 2. Scientific Data 9:275. https//doi.org/10.1038/s41597-022-01366-7

Morlighem M and 37 co-authors (2020) Deep glacial troughs and stabilizing ridges unveiled beneath the margins of the Antarctic ice sheet. Nature Geoscience 13:132–137, https://doi.org/10.1038/s41561-019-0510-8

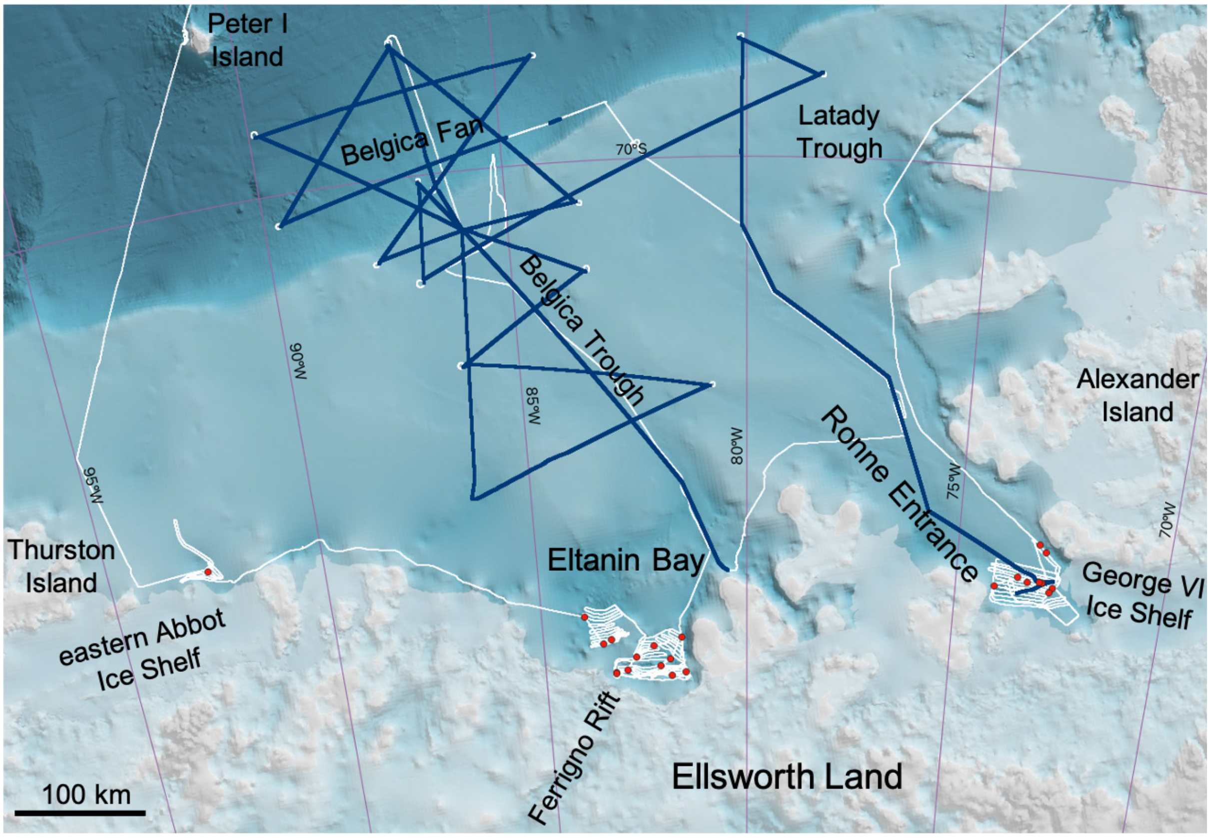

Fig. 3.1: PS134 work area of marine geophysical surveys and measurements in the Bellingshausen Sea sector of West Antarctica with seismic profiles (blue lines) acquired on the continental shelf and slope as well as geothermal heat flow measurement stations (red dots) on the inner continental shelf. Whites lines denote the ship track. Dedicated densely spaced multi-beam bathymetric surveys were conducted in inner Ronne Entrance, Eltanin Bay and off eastern Abbot Ice Shelf. Sub-bottom Parasound profiling continued along the entire ship track. Background bathymetry is from IBCSO Version 2 (Dorschel et al., 2022) with embedded subglacial topography from BEDMACHINE (Morlighem et al., 2020).

3.1 Seismic Profiling

Gabriele Uenzelmann-Neben[1], Karsten Gohl[1], Pascal Daub[1], Thorsten Eggers[1], Johanna Gille-Petzoldt[1], Benedikt Haimerl[1], Jakob Hamann[1], Sven Hoffmann[1], Ingra Malucelli Barbosa[1], Christina Paul[1], Alejandro Cammareri[2], Juan Manuel Salazar[2], Hugo Manuel Santos Lopes[2]

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Grant-No. AWI_PS134_01

Objectives

The behaviour of the polar ice sheets in relation to climatic changes and their contribution to global sea-level change are poorly understood. The latest Intergovernmental Panel for Climate Change (IPCC) report (IPCC, 2018) explicitly flags this deficiency in knowledge. In contrast to most of the East Antarctic Ice Sheet, the West Antarctic Ice Sheet (WAIS) and the Antarctic Peninsula Ice sheet (APIS) are likely to have been subject of a very dynamic activity during their history. Most of the bases of the WAIS and the southern APIS are grounded below present sea level and dip landward. Thus, both WAIS and APIS are sensitive to changes in global sea level and regional oceanographic conditions as well as atmospheric conditions. Their collapses would result in a global sea-level rise of 3-5 m (Fretwell et al., 2013). Satellite observations of the last decades have shown that the negative ice mass balance of Antarctica is highest along the Pacific margins of West Antarctica and the Antarctic Peninsula, in particular in the Amundsen Sea Embayment (Pine Island, Thwaites, Smith and Pope Glaciers) and Eltanin Bay (Ferrigno Ice Stream) of the Bellingshausen Sea (e.g. Rignot et al., 2019; Schröder et al., 2019). Significant sub-ice shelf melting by relatively warm modified Circumpolar Deep Water (CDW) spreading across the shelves through deep paleo-ice stream troughs towards the grounding zones of the WAIS and APIS has been identified as the most likely cause for today's ice sheet retreat (e.g. Rignot et al., 2019).

Largely unknown are the processes of WAIS and APIS dynamics, the oceanographic conditions leading to melting processes, and the ice sheet's contribution to sea-level during times with climate conditions similar to today or expected for the near future of a warming Earth. The challenges are (1) to identify the locations of former glacial troughs and paleo-pathways of CDW across the shelves, which have a strong relationship to tectonic features of the basement and pre-glacial consolidated sediments (examples in Gohl et al., 2013a,b; Klages et al., 2014, Uenzelmann-Neben et al., 2022), (2) to identify and quantify the former advance and retreat cycles of the WAIS and APIS across the shelves (e.g. Gohl et al., 2013b; Gohl et al., 2021a) and thus the conditions for their partial and total collapses, and (3) link these ice- and coast-proximal records to more distal deep-sea records of the continental rise and its sediment drifts (e.g. Uenzelmann-Neben & Gohl, 2012, 2014; Lindeque et al., 2016a,b; Uenzelmann-Neben, 2006, 2019; Gohl et al., 2021a,b).

Modified warm CDW, circulating onto the shelves mainly through deeply incised glacial troughs, has been recognized as the main culprit for subglacial melt processes of ice shelves close to the grounding zones. This seems to be at least the modern process along the shelves of Pacific West Antarctica, mainly in the Amundsen Sea Embayment but also on the Bellingshausen Sea shelf. A recent study based on the analysis of a sediment drift patched to the eastern flank of Pine Island Trough using seismic data showed that inflow of warm deep water slowed the offshore expansion of the WAIS in late Eocene/early Oligocene times (Uenzelmann-Neben et al., 2022). Seismic records from the Pine Island Trough of the Amundsen Sea shelf further show that the location of this trough has been relatively stationary since glacial onset (Gohl et al., 2013a) because of constraints by basement flanks along its eastern margin. We speculate that such stationary trough positions are not necessarily the case on the Bellingshausen Sea shelf, for instance for the Belgica Trough.

The collected network of seismic profiles (Fig. 3.1.1) provides a dataset for mapping the extent of former glacial troughs and identifying documents of deep water activity on the shelf as well as the interaction of down- and along-slope sediment transport processes in the area of the Belgica Fan. This provides the means to analyse past CDW incursions and their possible effects on past subglacial melting mechanisms and conclusions on ice advances and the development of the circulation system.

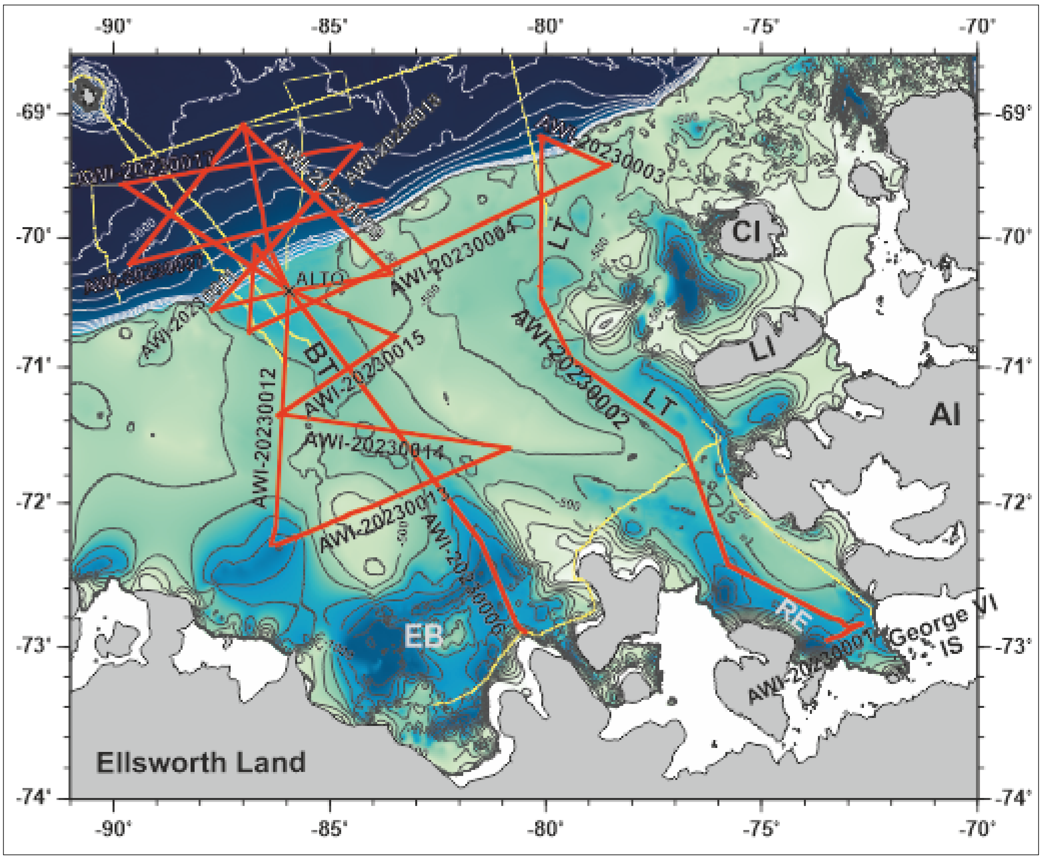

Fig. 3.1.1: Map of the Bellingshausen Sea showing the location of seismic lines collected during expedition PS134 (red lines). Yellow lines show pre-existing seismic lines. Bathymetry from Dorschel et a. (2022). AI= Alexander Island, CI= Charcot Island, BT= Belgica Trough, EB= Eltanin Bay, George VI IS= George VI Ice Shelf, LI= Latady Island, LT= Latady Trough, RE= Ronne Entrance.

Differences in the dynamics of WAIS evolution between the Amundsen and Bellingshausen Seas have been hypothesized. A west-east trend was inferred with an early Miocene ice advance in the Amundsen Sea, while a glacial advance in the Bellingshausen Sea occurred only post-15 Ma (Uenzelmann-Neben, 2019). At LGM (about 20 ka) grounded ice reached the continental shelf breaks along most Antarctic margins. The Bellingshausen Sea sector shows a dominant anomaly, well constrained by data (Hillenbrand et al., 2010), implying that grounded ice did not reach the shelf break above the Belgica Trough. With warming oceanic conditions, this situation would likely enable a more rapid retreat from the shelf, because major buttressing areas are missing and warm deep water can ‘bite’ into the grounding zones close to the inner shelf already in the early stages of deglaciation periods. It remains to be tested whether this phenomenon existed through the earlier glacial periods back to the Pliocene, thus making the Bellingshausen Sea Embayment a vulnerable spot. Our extensive seismic survey, linked with the pre-existing seismic lines and drill records, provides a seismostratigraphic record of past glacial advances such as progradational sequences, truncation surfaces and buried grounding zone wedges as seen in parts of the Amundsen Sea shelf sediment sequences by Gohl et al. (2021a).

Seismic Equipment

Seismic Sources, Activation and Timing

We used an airgun cluster of 4 GI-Guns to resolve the sedimentary layers (Fig. 3.1.2). A single GI-Gun™ is made up of two independent air guns within the same body. The first air gun ("Generator") produces the primary pulse, while the second air gun ("Injector") is used to control the oscillation of the bubble produced by the "Generator". We used the "Generator" with a volume of 0.72 liters (45 in^3) and fired the "Injector" (1.68 liters = 105 in^3) with a delay of 33 ms. This leads to an almost bubble-free signal. The guns were towed 7 m behind the vessel in 2 m depth and fired every 25 m (~10 s shot interval).

The activation of the airguns occurs through a gun controller (Teledyne BigShot™). The controller provides the power necessary to activate the valves of the guns. With an optional feedback signal from extra hydrophones, the controller is capable of synchronizing the activation of each gun automatically. This ensures that the complete gun array fires at the same time. The gun controller itself waits for the fire order (TTL signal) of the navigation system.

Seismic data acquisition requires a very precise timing system, because seismic sources and recordings systems must be synchronised. All the systems are synchronised through a dedicated GPS clock with an accuracy of 1µs.

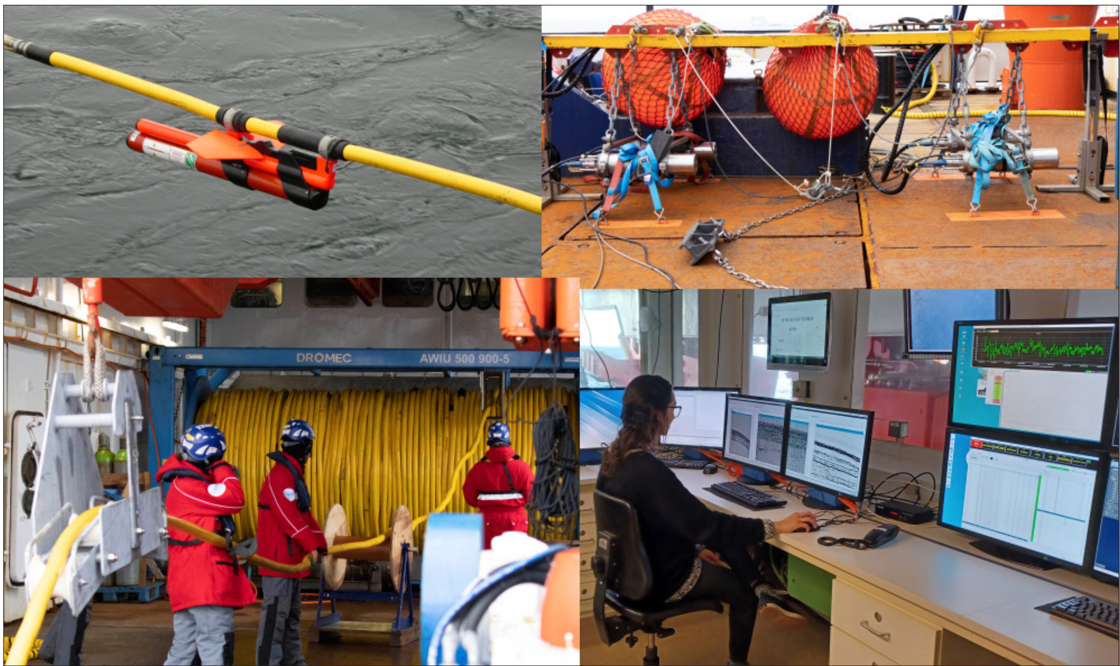

Fig. 3.1.2: Photos show a depth-control "bird" mounted on the streamer (upper left), the GI-Gun configuration (upper right), the 3,000 m long hydrophone streamer during deployment (lower left), and the seismic recording system monitors in the seismic lab (lower right).

Navigation and Triggering

For planning the lines and performing the line shooting, we used a separate navigation system (Sercel SeaPro Nav™). From ship side, we received NMEA strings for the ship position, heading, water depth and speed through water. Depending on the actual plan, the navigation system calculates the next shot point as defined by the shot parameters (shot distance, time or a combination of both) and generates the fire order for the air guns. After each successfully performed shot, the navigation system generates a navigation header file and transfers it to the acquisition system. This file uses the SEAL™ acquisition system to generate the final SEGD-formatted file for this shot point.

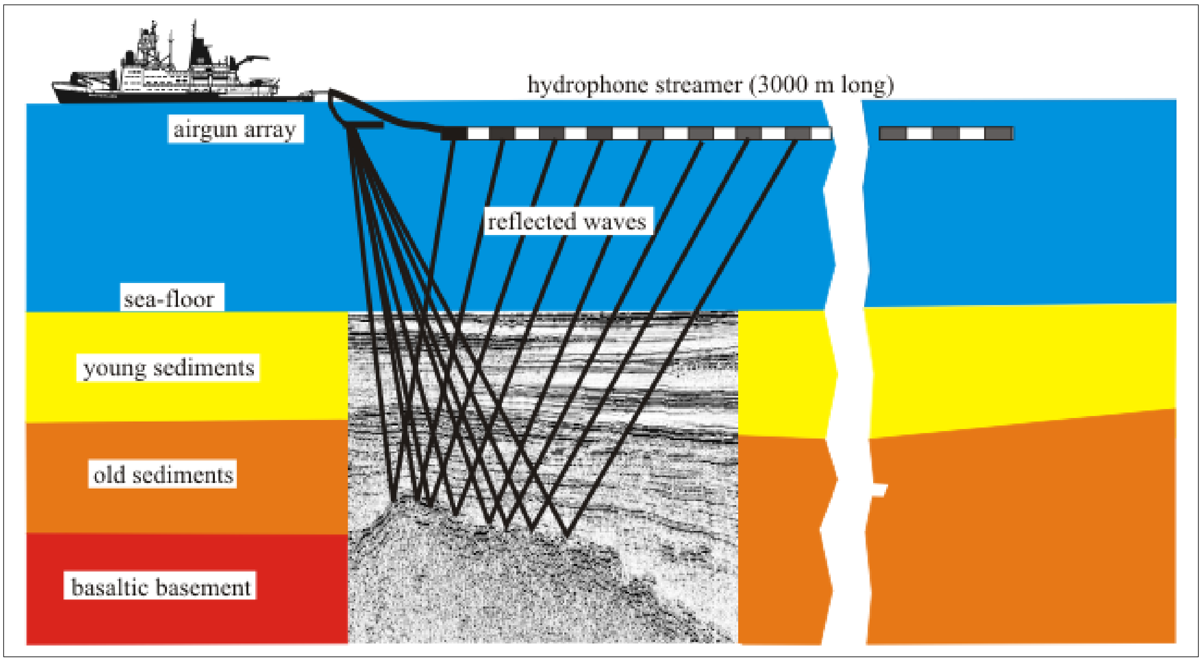

Fig. 3.1.3: Principle of marine seismic reflection surveying.

Multi-channel Seismic Reflection Recording System

For multi-channel seismic reflection data acquisition (Figs. 3.1.2 and 3.1.3), a digital seismic hydrophone streamer and recording system was used. The system consists of a large capacity, fully integrated, high resolution marine seismic data acquisition system (Sercel SEAL 428™) (Fig. 3.1.4). The solid Sercel SENTINEL™ streamer (Fig. 3.1.4) is a 240-channel hydrophone array, composed of 20 active sections with 12 channels each. Each channels consists of 8 hydrophones placed in an array. The spacing of each hydrophone array is 12.5 m (Table 3.1.1).

The streamer is coupled to the on-board recording system via a fiber-optic tow leader and a deck lead. The data collected by the hydrophone array is firstly converted from an analogue signal to digital via a Field Digitizing Unit (FDU2F). The data is available as a 24-Bit word with a sample rate of 1, 2 or 4 ms and then routed through a Line Acquisition Unit Marine (LAUM). After filtering and compressing the data, the LAUM sends them to the on-board equipment. The LAUM also supplies power for the FDU2F, and they are located after every 5 active sections. The interface to the on-board equipment is the Deck Cable Crossing Unit (DCXU). It has a build-in high-voltage power supply for powering all the streamer modules and acts as a LAUM for first 60 channels.

During expedition PS134, the lead-in cable of the streamer was malfunctioning. The deck cable from the seismic recording system was thus directly connected to the HESA unit, sidestepping the lead-in cable and the HAU unit (Fig. 3.1.4).

To avoid damage by the risk of ice, the tail-buoy was not connected. Instead we used an inflatable floating buoy.

The main control and recording software is installed on a server running Linux Operating System mounted with the other components in a mobile rack. It manages the flow of acquired data from the streamer and auxiliary channels. It also manages processing of the data and export to various peripherals (FC-AL tape drives, NFS disks, plotters, QC tools). Communications and synchronization with the navigation system are ensured via Ethernet links or a T0 signal. Communications with DCXU-428s are ensured via Ethernet links too, therefore the server can manage a virtually unlimited number of DCXU-428s (streamers). The system and all parameters for acquisition are displayed and controlled on a separate client pc with a graphical user interface (GUI).

The acquisition runs in continuous mode and the final SEGD file for a shot point will be generated according to the navigation header file, received from the navigation system. The final SEGD file is stored on the server and exported simultaneously to two Network Attached Storage (NAS) with a capacity of 5 TB each. The actual SEGD for the last shot point is also available for the QC-Software running on a separate client. With this software, it is possible to have a first look on the data for quality control.

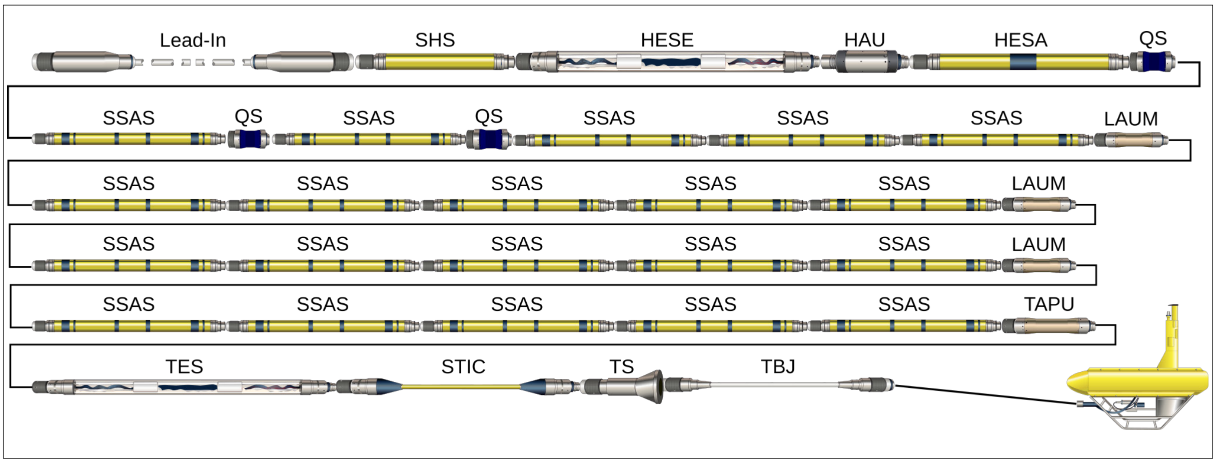

Fig. 3.1.4: Regular setup of the seismic data acquisition. Due to malfunctioning of the lead-in cable during PS134, the deck cable was directly connected to the HESA unit. The tail-buoy was replaced by an inflatable buoy to avoid damage by ice risk.

Depth Control and Positioning

With depth-control units, so called “birds” (Fig. 3.1.2), we controlled the depth of the streamer cable during the operation. We used Model 5010/5011 DigiBIRD™ and CompassBIRD™ II from ION, controlled by Digicourse™ software, for this purpose. Nominal depth of the streamer cable in calm weather conditions was 10 m. The depth can be changed during operation by setting new target depths for each bird through the controller software. The actual depths and headings (only Model 5011 DigiBIRD™ and CompassBIRD™ II) of each bird are transferred to the navigation system and stored for every shot-point.

Passive Acoustic Monitoring

We used the Sercel QuietSea™ system for passive acoustic monitoring. The system can detect vocalizations emitted by marine mammals. These signals are of two types: whistles and click trains. The whistles are particular vocalizations emitted to communicate between marine mammals in the same group or are parts of a song call emitted by specific baleen whale males.

The clicks are impulsive signals (from approximately ten microseconds to few milliseconds) and so cover a great bandwidth. The bandwidth covered by clicks can be highly variable depending on the species.

The system uses the seismic data (using the SEAL™ interface) to detect vocalizations in the seismic bandwidth (from 10 Hz to 200 Hz with usual seismic sampling frequency of 2 ms). It also uses dedicated streamer modules and auxiliary modules to detect localizations in the [200 Hz-96 kHz] bandwidth.

Tab. 3.1.1: Specification of a SENTINEL™ active streamer section (SSAS) of 12.5 m spacing.

Field Digitizing Units (FDUs).	
Arrangement	One per receiver point (2 channels)
Functions	A/D conversion, data digitizing, and tests
FDUs per active section	6 (2 per location)
Spacing	50 m
Hydrophones	
Standard model	Sercel Flexible Hydrophone (SFH)
Nominal capacitance	32.5 nF ± 10% @ 20º C
Nominal sensitivity	–192.9 dB ref to 1 V/µPa ± 1.5 dB (22.65 V/bar) @ 20º C
Hydrophone Array	
Cut off frequency	2 Hz
Groups per section	12
Hydrophones per group	8
Group capacitance (nominal)	260 nF ± 10% @ 20° C
Group sensitivity	–194.1 dB ref to 1 V/µPa ± 1.0 dB (19.7 V/bar) @20° C
Field Digitizing Units (FDUs).	
Arrangement	One per receiver point (2 channels)
Functions	A/D conversion, data digitizing, and tests

Seismic Recording Parameters

All seismic profiles were recorded with the following parameter settings: 33.5 m lead-in length, 7 m distance to G-Guns, 9 s record length, 1 ms sample interval, 25 m shot interval (nominal). The seismic profile summary list can be found in Appendix A.4.

Mitigation for Marine Mammals

The mitigation regulations for seismic operations in Antarctic waters require the visual observations for marine mammals within a predefined safety zone by marine mammal observers (MMOs). The MMOs of PS134 followed the mitigation protocol according to the permit issued by Germany's Federal Environment Agency (Umweltbundesamt – UBA).

The marine mammal observation was coordinated and conducted by the three professional and experienced JNCC-PSO qualified MMOs, Alejandro Cammareri, Juan Manuel Salazar Sierra and Hugo Santos Lopes (from Marybio Foundation) with the support of 19 additional observers drafted from the various science teams of PS134 and trained by A. Cammareri and J.M. Salazar during the expedition. During seismic operations, a constant visual watch for marine mammals was conducted by four marine mammal observers (MMOs) per shift to detect any marine mammals within the predefined safety zone of 1,000 m for whales and 500 m for seals, around the ship (no defined max. distance for beaked whales and southern elephant seals). After a modified permit was issued by UBA on 27 January, up to 5 crabeater seals within the safety zone were excluded from mitigation due to their unexpected high abundance and the risk of jeopardizing the entire seismic survey. Visual observations were conducted by one MMO from the bridge deck, two MMOs from the winds of the port and starboard sides, respectively scanning 360° around the vessel, and one MMO monitoring the shipboard infrared (IR) camera system. The trained observers changed every 2 hours, shifting observation positions every 30 minutes, with one professional MMO always on watch.

The primary observation technique to spot marine mammals was to scan the sea around the vessel and within the safety zone using the naked eye and scanning with reticulated binoculars (Fujinon 7x50) continuously. Areas of interest on the water (breaking wave crests, splashes, blows, footprints, dark shapes, bird activity, etc.) were used as visual cues to investigate. To ensure that most of the perimeter of the seismic sources were observed continuously, an IR thermal imaging sensor (FIRST Navy), installed in the crow's nest of *Polarstern* (Zitterbart et al., 2013), was used. The IR sensor constantly monitors its environment within a field of view of 360° horizontally (approximately 100° to the stern obstructed by the crow's nest) by 28.8° vertically. The recorded image shows the thermographic signatures of marine mammals (e.g. blow) and provides the observer in the IR observation room with detected cues on the monitor to give further assistance to the MMOs in a potential shut-down situation.

Pre-watch observations started at least 60 minutes before scheduled seismic operations were to begin to ensure that no marine mammal was detected within the safety zone when seismic operations were due to start. Clearance for the 30 minutes soft-start procedure (a gradual increase of energy and number of the air pulsers) was given when there was no detection of marine mammals in the water of the mitigation area for a safety period of time (30 min for whales and seals, and 60 min for beaked whales and southern elephant seals). Airgun shutdown occurred when a marine mammal was detected in the water within the respectively safety zone.

During seismic operations, MMOs performed continuous watch during all the seismic survey, totalling 466:14 hours (20 days) of visual and IR monitoring efforts. During that period, 231 detections of marine mammals were recorded (Tab. 3.1.2), of which 161 were within the safety zone. In 60 of these encounters, shut-downs (SD) of airguns were conducted, the others were crabeater seal encounters for which mitigation did not apply after 27 January (modified permit issued) if there were less than 6 animals detected within the safety zone.

Tab. 3.1.2: Summary of airgun shut-downs due to detection of marine mammals within the safety zone during seismic surveys.

Date	Sighting number	Visual or IR camera	Species	Mitigation action
24/01/2023	8	Visual	Whale, not identified	Shut-down
24/01/2023	9	Visual	Seals, poss. Crabeater	Shut-down
24/01/2023	10	Visual	Seals, poss. Crabeater	Shut-down

Date	Sighting number	Visual or IR camera	Species	Mitigation action
24/01/2023	11	Visual	Minke whale	Shut-down
24/01/2023	12	Visual	Crabeater seal	Shut-down
24/01/2023	16	Visual	Crabeater seal	Shut-down
24/01/2023	17	Visual	Crabeater seal	Shut-down
24/01/2023	19	Visual	Crabeater seal	Shut-down
24/01/2023	21	Visual	Seals, poss. Crabeater	Shut-down
25/01/2023	26	Visual	Crabeater seal	Shut-down
25/01/2023	29	Visual	Crabeater seal	Shut-down
25/01/2023	30	Visual	Crabeater seal	Shut-down
25/01/2023	31	Visual	Crabeater seal	Shut-down
25/01/2023	32	Visual	Crabeater seal	Shut-down
25/01/2023	34	Visual	Crabeater seal	Shut-down
26/01/2023	43	Both	Humpback whale	Shut-down
26/01/2023	44	Both	Humpback whale	Shut-down
26/01/2023	47	Visual	Crabeater seal	Shut-down
26/01/2023	48	Visual	Crabeater seal	Shut-down
27/01/2023	52	Visual	Crabeater seal	Shut-down
27/01/2023	54	Visual	Crabeater seal	Shut-down
27/01/2023	55	Both	Crabeater seal	Shut-down
27/01/2023	56	Visual	Crabeater seal	Shut-down
28/01/2023	64	Visual	Humpback whale	Shut-down
28/01/2023	65	Visual	Humpback whale	Shut-down
30/01/2023	75	Visual	Humpback whale	Shut-down
30/01/2023	79	Visual	Humpback whale	Shut-down
30/01/2023	81	Both	Humpback whale	Shut-down
30/01/2023	83	Visual	Humpback whale	Shut-down
30/01/2023	97	Both	Minke whale	Shut-down
30/01/2023	100	Visual	Humpback whale	Shut-down
31/01/2023	104	Visual	Humpback whale	Shut-down
31/01/2023	114	Visual	Possibly Minke whale	Shut-down
31/01/2023	117	Visual	Minke whale	Shut-down
31/01/2023	118	Visual	Humpback whale	Shut-down
04/02/2023	136	Visual	Humpback whale	Shut-down
05/02/2023	138	Visual	Orca	Shut-down
05/02/2023	139	Visual	Humpback whale	Shut-down
07/02/2023	156	Visual	Humpback whale	Shut-down
07/02/2023	157	Visual	Humpback whale	Shut-down
07/02/2023	158	Visual	Humpback whale	Shut-down
10/02/2023	166	Both	Humpback whale	Shut-down
10/02/2023	167	Visual	Humpback whale	Shut-down
10/02/2023	170	IR	Humpback whale	Shut-down
10/02/2023	174	Visual	Humpback whale	Shut-down

Date	Sighting number	Visual or IR camera	Species	Mitigation action
10/02/2023	175	Both	Humpback whale	Shut-down
10/02/2023	177	Both	Humpback whale	Shut-down
11/02/2023	182	Visual	Humpback whale	Shut-down
12/02/2023	184	Both	Minke whale	Shut-down
12/02/2023	187	Both	Humpback whale	Shut-down
13/02/2023	194	Visual	Humpback whale	Shut-down
13/02/2023	195	Both	Humpback whale	Shut-down
13/02/2023	206	Visual	Humpback whale	Shut-down
13/02/2023	208	Both	Humpback whale	Shut-down
13/02/2023	212	Visual	Humpback whale	Shut-down
14/02/2023	218	Visual	Antarctic fur seal	Shut-down
15/02/2023	223	Visual	Humpback whale	Shut-down
15/02/2023	225	Visual	Humpback whale	Shut-down
15/02/2023	227	Visual	Humpback whale	Shut-down
15/02/2023	231	Visual	Humpback whale	Shut-down

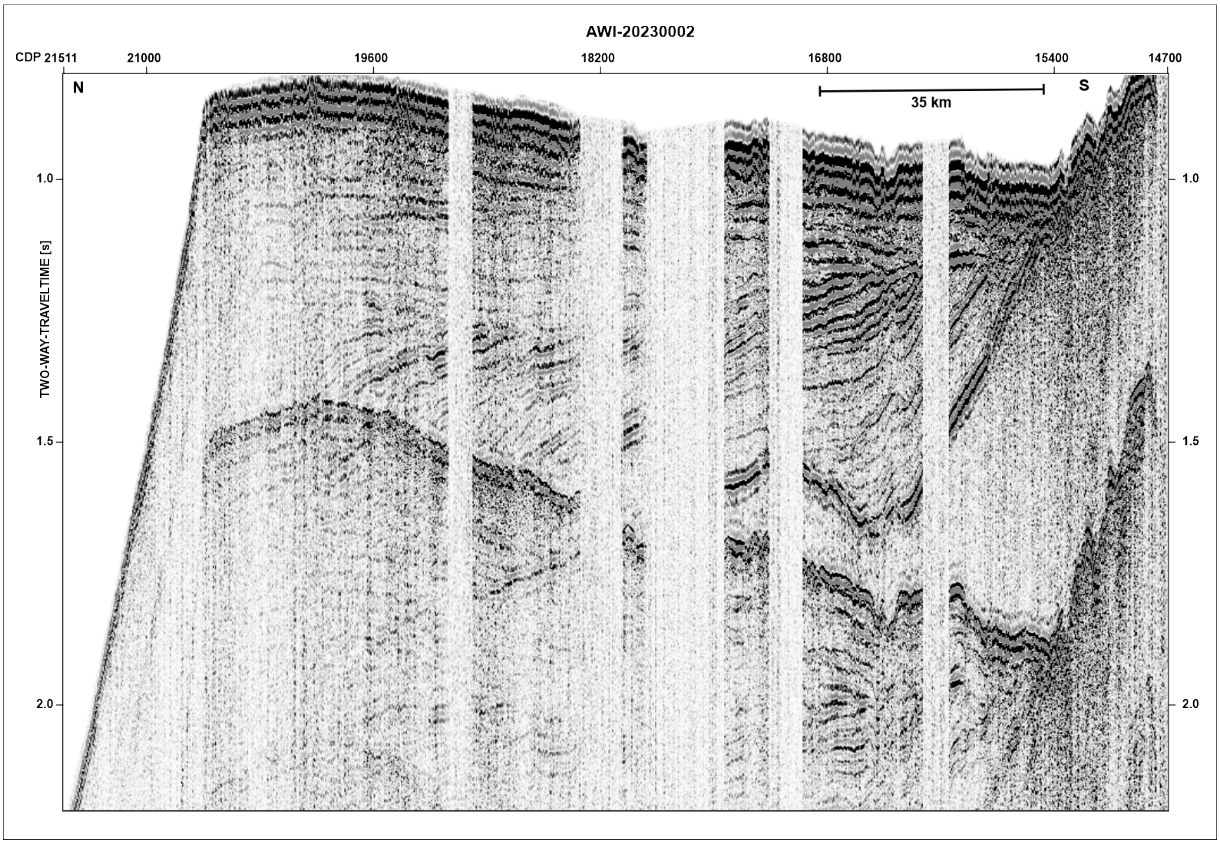

Fig. 3.1.5: Northern part of unprocessed seismic profile AWI-20230002 (single-channel quality control plot) showing northward dipping and aggrading sedimentary sequences. Strong-amplitude seafloor multiples will be removed in complete data processing. The data gaps are due to the presence of marine mammals in the safety zone and, thus, shut-downs or airgun operations.

Preliminary results

In total, 2,014 nm (3,730 km) of seismic reflection profiles were collected (Appendix A.4). These 19 profiles cover the Latady Trough from the Ronne Entrance towards the shelf break on the eastern Bellingshausen Sea shelf, and the Belgica Trough and Belgica Trough-Mouth Fan on the central Bellingshausen Sea shelf (Fig. 3.1.1).

In the Ronne Entrance, the seismic penetration was very low indicating shallow acoustic basement, possibly meta-sedimentary rocks. Near the vicinity of Latady Island, the sedimentary sequences start to dip northwards with different inclinations pointing towards several phases of ice sheet advance (Fig. 3.1.5).

These sets of northward dipping sequences can also be observed on the central Bellingshausen Sea shelf. Closer to the shelf break, aggrading sequences further characterise the seismic data (Fig. 3.1.6). The seismic data resolve the migrating location of the Belgica Trough, whose formation appears to be closely linked to the dynamics of the ice sheet in the Bellingshausen Sea sector.

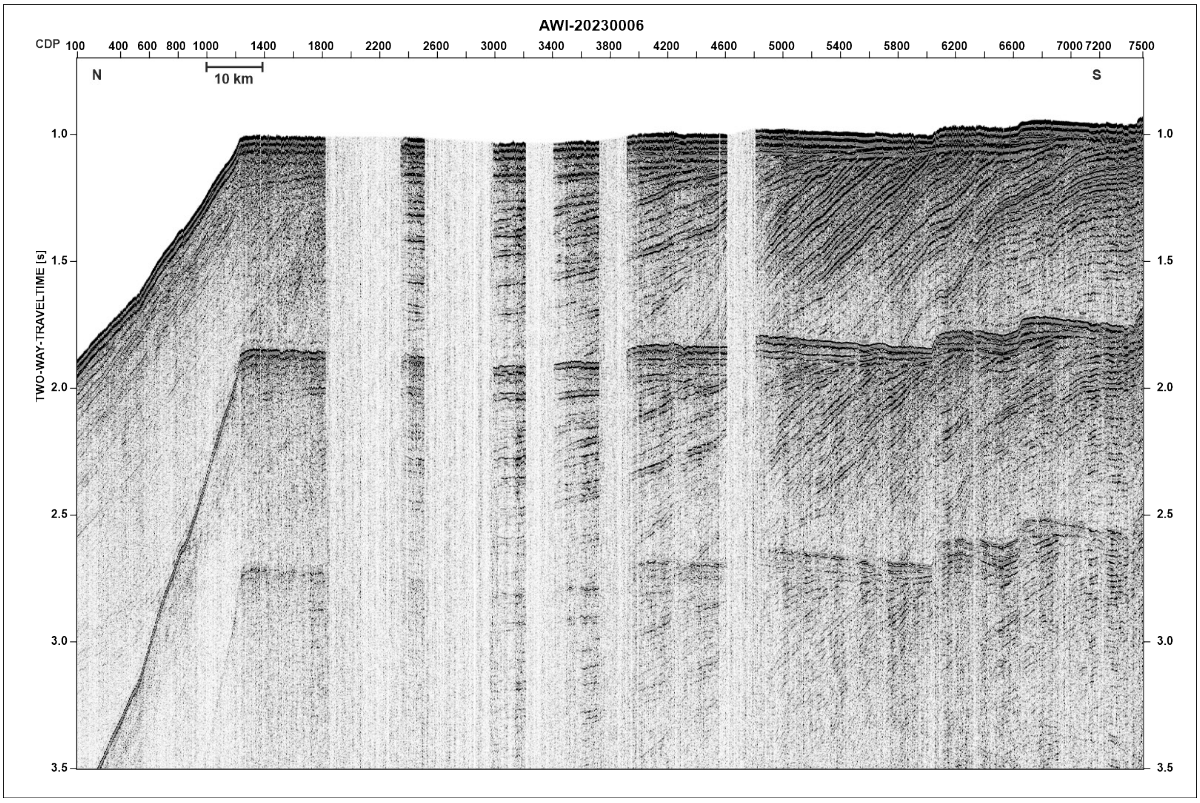

Fig. 3.1.6: Northern part of unprocessed seismic profile AWI-20230006 (single-channel quality control plot) showing northward dipping and aggrading sedimentary sequences. Strong-amplitude seafloor multiples will be removed in complete data processing. The data gaps are due to the presence of marine mammals in the safety zone and, thus, shut-downs of airgun operations.

The seismic profiles across the Belgica Trough-Mouth Fan will allow a detailed reconstruction of the formation of this fan. Down-slope sediment transport appears to have strongly interacted with along-slope sediment transport (Fig. 3.1.7). Via the seismic data we will be able to unravel different phases related to ice sheet dynamics (waxing/waning of the ice sheet) and intensified oceanic circulation (erosion and re-deposition).

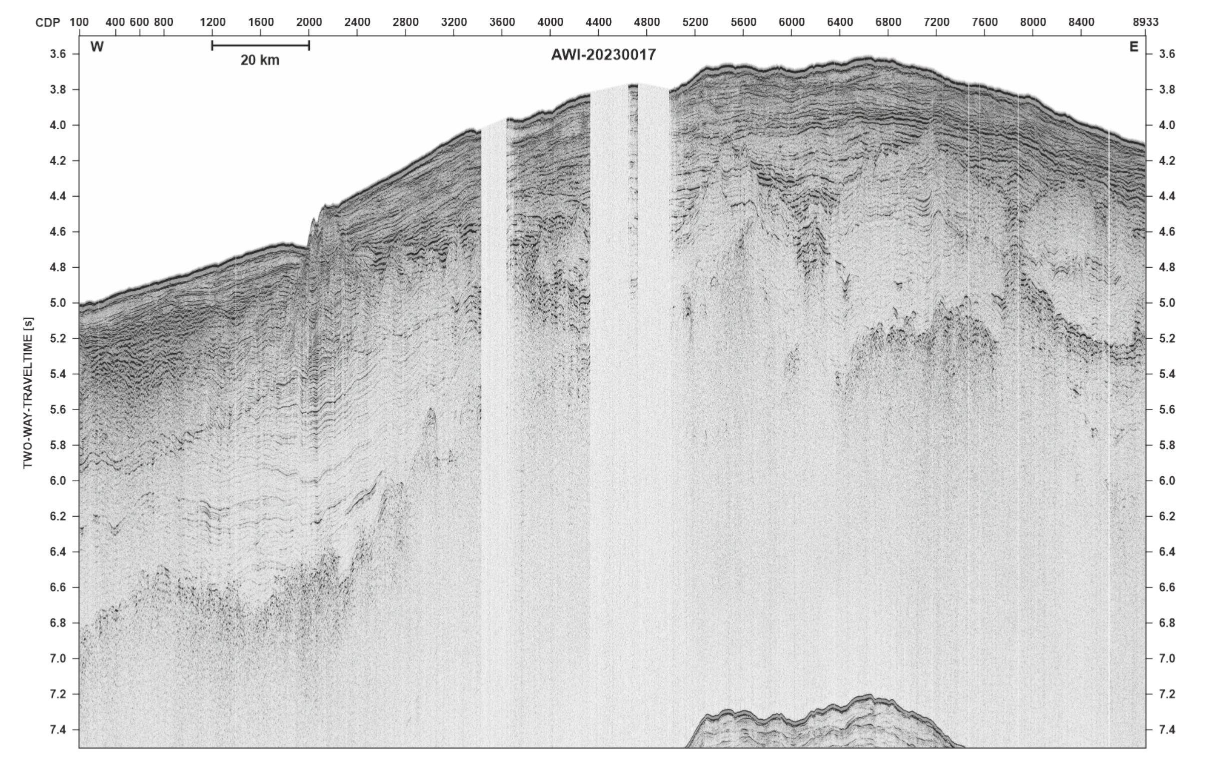

Fig. 3.1.7: Part of unprocessed seismic profile AWI-20230017 (single-channel quality control plot) showing down-slope as well bottom-current sediment transport features of the Belgica Trough-Mouth Fan. The data gaps are due to the presence of marine mammals in the safety zone and, thus, shut-downs of airgun operations.

Data management

Metadata and a short report will be submitted to DOD and PANGAEA. A full cruise report will be made available from PANGAEA within six months after the cruise. Seismic data will be submitted to the SCAR Antarctic Seismic Data Library System (SDLS) from which they will be made available to interested collaboration partners two years after data acquisition and as open access four years after data acquisition according to the SDLS guidelines. Access for the science community will also be provided according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within four years after the end of the cruise (or after an extended moratorium period). By default, the CC-BY license will be applied.

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In all publications based on this expedition, the Grant No. AWI_PS134_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.

References

Fretwell P & 59 co-authors (2013) Bedmap2: improved ice bed, surface and thickness datasets for Antarctica. The Cryosphere 7:375-393. https://www.the-cryosphere.net/7/375/2013/

Dorschel B, Hehemann L, Viquerat S, Warnke F, Dreutter S, Tenberge YS, Accettella D, An L, Barrios F, Bazhenova E, Black J, Bohoyo F, Davey C, De Santis L, Dotti CE, Fremand AC, Fretwell PT, Gales J, Gao J, Gasperini L, Greenbaum JS, Jencks JH, Hogan K, Hong JK, Jakobsson M, Jensen L, Kool J, Larin S, Larter RD, Leitchenkov G, Loubrieu B, Mackay K, Mayer L, Millan R, Morlighem M, Navidad F, Nitsche FO, Nogi Y, Pertuisot C, Post AL, Pritchard HD, Purser A, Rebesco M, RignotE, Roberts JL, Rovere M, Ryzhov I, Sauli C, Schmitt T, Silvano A, Smith J, Snaith H, Tate AJ, Tinto K, Vandenbossche P, Weatherall P, Wintersteller P, Yang C, Zhang T, Arndt JE (2022) The International Bathymetric Chart of the Southern Ocean Version 2. Scientific Data 9, 275. https://doi.org/10.1038/s41597-022-01366-7

Gohl K, Denk A, Wobbe F, Eagles G (2013a) Deciphering tectonic phases of the Amundsen Sea Embayment shelf, West Antarctica, from a magnetic anomaly grid. Tectonophysics 585:113–123. http://dx.doi.org/10.1016/j.tecto.2012.06.036

Gohl K, Uenzelmann-Neben G, Gille-Petzold J, Hillenbrand C-D, Klages J, Bohaty SM, Passchier S, Frederichs T, Wellner J, Lamb R, Leitchenkov G, IODP Expedition 379 Scientists (2021a) Evidence for a highly dynamic West Antarctic Ice Sheet during the Pliocene. Geophysical Research Letters 48:e2021GL093103. https://doi.org/10.1029/2021GL093103

Gohl K, Wellner JS, Klaus A, Expedition 379 Scientists (2021b) *Amundsen Sea West Antarctic Ice Sheet History.* Proceedings of the International Ocean Discovery Program, 379: College Station, TX (International Ocean Discovery Program). https:// doi.org/ 10.14379/iodp.proc.379.2021

Gohl K, Uenzelmann-Neben G, Larter RD, Hillenbrand C-D, Hochmuth K, Kalberg T, Weigelt E, Davy B, Kuhn G, Nitsche FO (2013b) Seismic stratigraphic record of the Amundsen Sea Embayment shelf from pre-glacial to recent times: Evidence for a dynamic West Antarctic ice sheet. Marine Geology 344:115–131. https://doi.org/10.1016/j.margeo.2013.06.011

Hillenbrand C-D, Larter RD, Dowdeswell JA, Ehrmann W, Ó Cofaigh C, Benetti S, Graham AGC, Grobe H, (2010) The sedimentary legacy of a palaeo-ice stream on the shelf of the southern Bellingshausen Sea: Clues to West Antarctic glacial history during the Late Quaternary. Quaternary Science Reviews 29:2741–2763. https://doi.org/10.1016/j.quascirev.2010.06.028

Intergovernmental Panel on Climate Change – IPCC (2018) Special Report: Global Warming of 1.5°C, Geneva. https://www.ipcc.ch/sr15

Klages JP, Kuhn G, Hillenbrand C-D, Graham AGC, Smith JA, Larter RD, Gohl K, Wacker L (2014) Retreat of the West Antarctic Ice Sheet from the western Amundsen Sea shelf at a pre- or early LGM stage. Quaternary Science Reviews 91:1–15. http://doi.org/10.1016/j.quascirev.2014.02.017

Lindeque A, Gohl K, Henrys S, Wobbe F, Davy B (2016a) Seismic stratigraphy along the Amundsen Sea to Ross Sea continental rise: A cross-regional record of pre-glacial to glacial processes of the West Antarctic margin. Palaeogeography, Palaeoclimatology, Palaeoecology 443:183–202. https://doi.org/ 10.1016/j.palaeo.2015.11.017

Lindeque A, Gohl K, Wobbe F, Uenzelmann-Neben G (2016b) Preglacial to glacial sediment thickness grids for the Southern Pacific margin of West Antarctica. Geochemistry, Geophysics, Geosystems 17. https://doi.org/10.1002/2016GC006401

Rignot E, Mouginot J, Scheuchl B, van den Broeke M, van Wessem MJ, Morlighem M (2019) Four decades of Antarctic Ice Sheet mass balance from 1979–2017. Proceedings National Academy Science 116:1095–1103. https://doi.org/10.1073/pnas.1812883116

Schröder L, Horwath M, Dietrich R, Helm V, van den Broeke MR, Ligtenberg SRM (2019) Four decades of Antarctic surface elevation changes from multi-mission satellite altimetry. The Cryosphere 13:427–449. https://doi.org/10.5194/tc-13-427-2019

Uenzelmann-Neben G (2006) Depositional patterns at Drift 7, Antarctic Peninsula: Along-slope versus down-slope sediment transport as indicators for oceanic currents and climatic conditions. Marine Geology 233:49–62. https://doi.org/10.1016/j.margeo.2006.08.008

Uenzelmann-Neben G (2019) Variations in ice-sheet dynamics along the Amundsen Sea and Bellingshausen Sea West Antarctic Ice Sheet margin. Geol. Soc. America Bulletin 131:479–498. https://doi.org/10.1130/b31744.1

Uenzelmann-Neben G, Gohl K (2012) Amundsen Sea sediment drifts: Archives of modifications in oceanographic and climatic conditions. Marine Geology 299–302:51–62. https://doi.org/10.1016/j.margeo.2011.12.007

Uenzelmann-Neben G, Gohl K (2014) Early glaciation already during the Early Miocene in the Amundsen Sea, Southern Pacific: Indications from the distribution of sedimentary sequences. Global and Planetary Change 120:92–104. https://doi.org/10.1016/j.gloplacha.2014.06.004

Uenzelmann-Neben G, Gohl K, Hochmuth K, Salzmann U, Larter RD, Hillenbrand C-D, Klages JP, Science Team of Expedition PS104 (2022) Deep water inflow slowed offshore expansion of the West Antarctic Ice Sheet at the Eocene-Oligocene transition. Communications Earth & Environment 3:36. https://doi.org/10.1038/s43247-022-00369-x

Zitterbart DP, Kindermann L, Burkhardt E, Boebel O (2013) Automatic round-the-clock detection of whales for mitigation from underwater noise impacts. PLoS ONE 8. https://doi.org/10.1371/journal.pone.0071217

3.2 Bathymetry

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Grant-No. AWI_PS134_04

Objectives

Accurate knowledge of the seafloor topography, hence high-resolution bathymetry data, is a basic key information and necessary to understand many marine processes. It is of particular importance for the interpretation of scientific data in a spatial context. Bathymetry, hence geomorphology, is furthermore a fundamental parameter for understanding the general geological setting of an area and geological processes such as erosion, sediment transport and deposition. Even information about tectonic processes can be inferred from bathymetry.

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. Satellite-altimetry derived bathymetry therefore lack the resolution necessary to resolve small- to meso-scale geomorphological features (e.g. sediment waves, glaciogenic features and small seamounts). Ship-borne multibeam data provide bathymetric information at a resolution sufficient to resolve these features and enable site selection for the other scientific working groups on board.

Glacigenic landforms preserved at the seafloor can form the basis for the reconstruction of the dynamic history of Antarctic Ice Sheets. In particular, these landforms can shed light on its retreat since its maximum extent during the Last Glacial Maximum. Understanding the processes that led to this ice sheet retreat in the past can provide important information for predicting future responses of Antarctic Ice Sheets to changing climate conditions and oceanographic settings. Glacigenic landforms can only be determined in high-resolution bathymetric data sets. Therefore, detailed bathymetric surveys were planned together with the marine geological working group to acquire data of these areas with the ship's hydroacoustic instruments (see Chapter 4).

Furthermore, the collection of underway data during PS134 will contribute to the bathymetry data archive at the AWI and thus to bathymetric world datasets such as IBCSO (International Bathymetric Chart of the Southern Ocean) GEBCO (General Bathymetric Chart of the Ocean).

Work at sea

The main task of the bathymetry group was to plan and run bathymetric surveys in the study areas and during the transit. The raw bathymetric data was corrected for sound velocity changes in the water column, processed and cleaned for erroneous soundings and artefacts. Detailed seabed maps derived from the data were provided to other working groups for station planning, for example combined palaeo-glaciological interpretation and geological core site planning (see Chapter 4). During the survey, the acoustic measurements were conducted by three operators working 24/7-hour shifts (except for periods of stationary work).

Technical description

During the PS134 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 Processing Unit (PU) 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 PU 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. In shallower shelf areas, the angle could be opened up to ~60° from nadir on both sides to get an overall swath width of approximately 3.5 times the water depth.

Data acquisition and processing

Data acquisition was carried out throughout the entire cruise between Cape Town, South Africa, and Punta Arenas, Chile, while the ship was in international waters. In the Southern Ocean (south of 60° S) the surveying was conducted in accordance to the Antarctic Treaty regulation set by the German Environmental Agency (Umweltbundesamt).

The MBES was operated with Hydromap Control and for online data visualization, Teledyne PDS was used. The collected bathymetry was redundantly logged in ASD and 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 and to correct HYDROSWEEP depths for changes of the sound velocity (SV) in the water column, SV profiles were generated from CTD data that were collected and provided by the SO-JELLY group. SV correlates with the density of a water mass and thus is depending on pressure, temperature and salinity of the seawater in a given location at a given depth. Wrong or outdated SV profiles lead to refraction errors and reduced data quality and faulty depth measurements.

During PS134, a total of 43 SV profiles were applied to the MBES. They include 19 SV profiles from the CTD data. The remaining 24 profiles were purely synthetic profiles generated using the WOA18 (World Ocean Atlas 2018).

Stations

Data collection with the Hydrosweep received the number PS134_0_Underway-13 throughout the expedition. All additional stations relevant for bathymetry are listed in Table 3.2.1.

Tab. 3.2.1: List of bathymetric stations during PS134.

Station Number	Description	Device	Start (UTC)	End (UTC)
PS134_1-1	SO-JELLY station	CTD_SBE9plus_485	2022-12-25 08:28:52	2022-12-25 09:26:29
PS134_2-1	SO-JELLY station	CTD_SBE9plus_485	2022-12-27 07:31:05	2022-12-27 09:42:04
PS134_3-4	SO-JELLY station	CTD_SBE9plus_485	2022-12-31 11:50:45	2022-12-31 13:56:34
PS134_4-4	SO-JELLY station	CTD_SBE9plus_485	2023-01-01 23:56:03	2023-01-02 01:57:18
PS134_5-1	SO-JELLY station	CTD_SBE9plus_485	2023-01-03 00:58:40	2023-01-03 02:53:35

Station Number	Description	Device	Start (UTC)	End (UTC)
PS134_10-2	SO-JELLY station	CTD_SBE9plus_485	2023-01-04 02:08:37	2023-01-04 04:08:06
PS134_14-1	Ronne Entrance geological survey	Hydrosweep DS3	2023-01-19 11:05:00	2023-01-21 12:15:20
PS134_15-1	CTD station for SV	CTD_SBE9plus_485	2023-01-19 20:34:18	2023-01-19 21:40:37
PS134_20-1	SO-JELLY station	CTD_SBE9plus_485	2023-01-22 02:21:28	2023-01-22 03:20:54
PS134_36-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-01 08:00:50	2023-02-01 09:05:35
PS134_40-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-02 08:18:36	2023-02-02 09:18:59
PS134_44-3	SO-JELLY station	CTD_SBE9plus_485	2023-02-03 06:35:30	2023-02-03 08:00:53
PS134_59-3	SO-JELLY station	CTD_SBE9plus_485	2023-02-16 09:03:02	2023-02-16 10:16:27
PS134_60-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-16 23:05:21	2023-02-17 00:16:41
PS134_63-4	SO-JELLY station	CTD_SBE9plus_485	2023-02-17 23:55:28	2023-02-18 00:41:14
PS134_68-1	Eltanin Bay geological survey	Hydrosweep DS3	2023-02-19 09:40:49	2023-02-24 11:31:12
PS134_69-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-20 11:39:59	2023-02-20 12:48:37
PS134_70_1	SO-JELLY station	CTD_SBE9plus_485	2023-02-21 15:51:54	2023-02-21 16:48:59
PS134_84-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-23 11:40:03	2023-02-23 12:49:21
PS134_89-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-25 10:33:13	2023-02-25 11:38:46
PS134_90-1	SO-JELLY station	CTD_SBE9plus_485	2023-02-26 11:39:48	2023-02-26 12:31:40

PS134_14-1 – Ronne Entrance

For geological site selection and to get comprehensive information on the seabed topography for palaeo-glaciological interpretation (see Chapter 4), a systematic bathymetric survey has been conducted in Ronne Entrance (Fig. 4.3). Parallel survey lines with a total track length of 695 nm (1,287 km) have been sailed with ~20 % overlap to efficiently cover an area of 2,235 km^2. The survey was complemented by two CTD casts for SV correction (*PS134_15-1* and *PS134_20-1*). The depth in the survey area ranges from ~1,300 m in the south western corner up to ~130 m in the south eastern inner bay.

PS134_68-1 – Eltanin Bay

Another systematic survey hast been conducted in Eltanin Bay, again for geological site selection and to get comprehensive information on the seabed topography for palaeo-glaciological interpretation (see Chapter 4). Separated in four blocks to follow the slope direction of the seabed topography, parallel survey lines with a total track length of 867 nm (1,606 km) have been sailed with ~20 % overlap to efficiently cover an area of 2,629 km^2 (Fig. 4.5). The survey was complemented by three CTD casts for SV correction (*PS134_69-1*, *PS134_70-1* and *PS134_84-1*). The depth in the survey area ranges from ~1,200 m in the north western corner up to ~120 m in the south.

Preliminary Results

During 69 days of survey, a track length of 10,254 nm (18,989 km) was surveyed by the swath bathymetry system, resulting in an area of 199,775 km^2 of mapped seafloor. Fig. 3.2.1 shows the generated bathymetry grid. The raw data volume of bathymetric data (S7K format only) was 306 GB broken up in 1,455 separated data files.

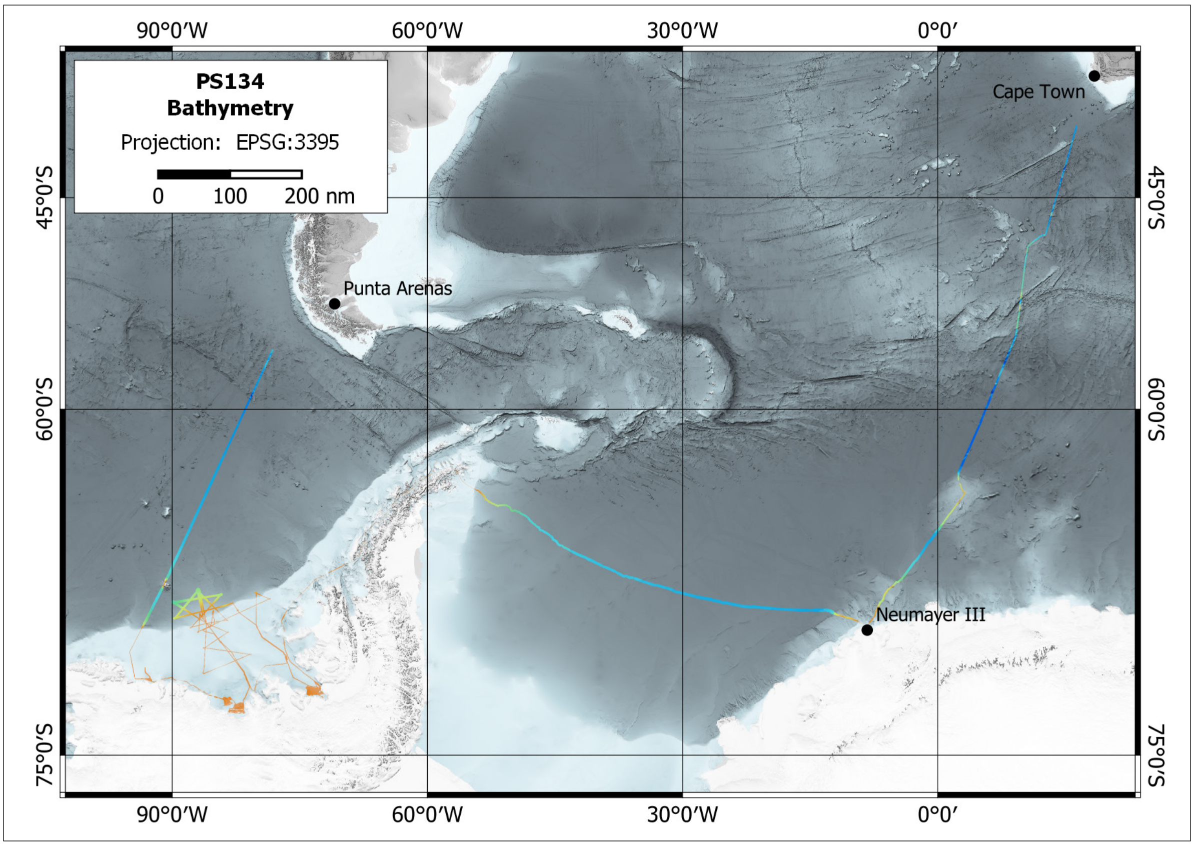

Fig. 3.2.1: Overview on the bathymetric data acquired during PS134 (background digital elevation model is the AWI Basemap for Antarctica, based IBCSO v2, Dorschel et al. 2022, and GEBCO 2022)

Data management

Geophysical and oceanographic 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 cruise at the latest. By default, the CC-BY license will be applied.

Furthermore, the data will be included in regional data compilations such as IBCSO (International Bathymetric Chart of the Southern Ocean) 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 2.1 and 2.3.

In all publications based on this expedition, the **Grant No. AWI_PS134_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

References

Dorschel et al. (2022) The International Bathymetric Chart of the Southern Ocean Version 2. Scientific Data, 9:275 https//doi.org/10.1038/s41597-022-01366-7

GEBCO Compilation Group (2022) GEBCO_2022 Grid. https//doi.org/10.5285/e0f0bb80-ab44-2739-e053-6c86abc0289c

3.3 Parasound Sub-Bottom Profiling

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Grant-No. AWI_PS134_01

Objectives

For the PS134 study area, the sub-bottom profiling or sediment echosounding system Parasound P70 was used as a method to image the upper meters of the ocean floor's subsurface for understanding glacial and geological processes such as erosion, sediment transport and deposition, or even tectonic processes of the younger past. Especially, the identification of glacially formed structures is essential to reconstruct the advance, extension and retreat pattern of ice sheets e.g. by mapping the distribution of megascale glacial lineations, moraines, or grounding zone wedges (e.g. Evans et al., 2005; Ó Cofaigh et al., 2008; Jakobsson et al., 2011; Livingstone et al., 2012). In turn, understanding the processes of this past ice sheet dynamics can provide important information for predictions of future responses of the West Antarctic Ice Sheet (WAIS) and the Antarctic Peninsula Ice Sheet (APIS) to changing climate conditions and oceanographic settings. The correct identification and interpretation of a subglacial bedform crucially depends on the detailed recording of its internal architecture, which can be achieved by acoustic sub-bottom profiling with the "Parasound" system.

Furthermore, by imaging the upper few tens of meters, sediment echography is an important link between bathymetry (mapping the surface morphology) and reflection seismics (imaging deeper structures down to several km depth). The integration of these three data sets is of particular importance for interpreting geological data in a wider spatial context, whereas coring results provide crucial information about chronology as well as structural and lithological components of the imaged features.

Generally, sediment echography surveys with "Parasound" are essential to define ideal geological coring locations (see Chapter 4).

Work at Sea

Instruments

Sub-bottom profiles were recorded with the hull-mounted Deep-Sea Sediment Echosounder PARASOUND (Teledyne Reson, Bremen, Germany), system PS3-P70. This system generates two primary, high-frequency acoustic signals with slightly differing frequencies selectable in a range of 18-24 kHz (PLF, PHF). Due to the non-linear acoustic behaviour of water, the so-called "Parametric Effect", two secondary harmonic frequencies (SLF, SHF) are generated in the water column of which one is the difference (SLF) and the other the sum (SHF), respectively. As a result of the longer wavelength, the secondary low frequency signal (SLF) is able to penetrate the sediment column as deep as for example a 4 kHz signal (up to 100 m depending on sediment conditions), whereas the vertical resolution still corresponds to the primary high frequency signal (PHF), and thus about some decimeters in sediments. The secondary high frequency (SH) can be used for detection of bubbles in the water column.

The primary signals are emitted in a narrow beam of 4°, but at high power. That has the advantage that the sediment-penetrating pulse is generated within the narrow beam of the primary frequencies, and thereby providing a very high lateral resolution.

The system, however, has its limitations in imaging rough sea floor topographies or submarine ridges with slopes steeper than 4°. Here, the signal energy reflected from the small inclined footprint on the seafloor is scattered out of the lateral range of the receiving transducers in the hull of the vessel. As a consequence, only few reflections from the seafloor are recorded, i.e., even fewer from the sub-bottom.

Survey settings

During expedition PS134, a 22 kHz setting was used as the Primary High Frequency (PHF), to avoid interferences with the Hydrosweep (Bathymetry) system (see Chapter 3.2). The Secondary Low Frequency (SLF) was set to 4 kHz. Depending on the properties of the sea-floor surface and sediments our settings enabled an imaging of the sub-bottom down to more than 100 m, and with a vertical resolution of about 30 cm. The combined signal has a beam width of ~4°. The resulting beam's footprint on the sea bottom is about 7 % of the water depth.

Concerning signal frequencies, a deviation was noted between the auxiliary log-files (PHF=18 kHz before 19.1.23; 22 kHz after 19.1.23) and values selected in the "Control PARASOUND Sensor" > "Basic settings" (PHF=20 kHz before 19.1.23; and 20.5 kHz after 19.1.23).

The system was controlled using the programme Hydromap Control. Live data visualisation and data storage was performed with the Parastore software. Every hour, screenshots of the profiles were stored and made directly accessible on a public directory.

Sub-bottom profiling

During expedition PS134, digital data acquisition and storage were switched on after *Polarstern* left the EEZ of South Africa on 24 December 2023 at 23:39 h UTC, and was switched off on 04 March 2023 at 01:50 h UTC when the ship reached the EEZ of Chile at the end of the expedition.

Data acquisition took place during all times on transit, even while surveying in the main study area to provide information for station planning and sediment coring sites. For some specific surveys, and throughout seismic reflection measurements, the ship's speed was reduced from 10 kn on average to only 5 kn, to achieve undisturbed and high-resolution profiles. "Parasound" profiling was carried out in a 24-hour/7-day shift mode, and the data recorded were promptly made available for site selection and cruise planning. All actions and reasons concerning switching on and off the system, system parameters, actions on stations, and events concerning MMO calls are documented in Appendix A.5 (PS134 Parasound Log).

The daily routine included the subsequent processing steps that are meanwhile established as a standardised workflow consisting of (a) acquisition of data in the internal PARASOUND ASD and PS3 formats, (b) conversion of PS3 to standard SGY format, (c) extraction of navigation data and conversion to standard UKOOA format, (d) preparation for storage in Pangaea, and (e) performance of a preliminary processing of data and visualisation with Kingdom software (Appendix A.6, PS134 Parasound Profiles and Stations).

Mitigation for marine mammals

The mitigation regulations for profiling operations consisted of visual observations for marine mammals by observers, following the mitigation protocol predefined by Germany's Federal Environment Agency (Umweltbundesamt – UBA).

In detail, the mitigation actions comprised:

1. Start of sounding only after at least 15 min. marine mammal observer (MMO) watch without sightings of marine mammals.

2. After interruptions of more than 30 min, the Parasound P70 sediment echosounder has to be restarted with reduced pulse rate ("Whale Warning Mode") after 15 min.

3. When sounding is needed **on station**, continuous MMO watches by two persons has to be performed. Sounding has to be stopped whenever marine mammals were sighted in the water closer than 100 m to the ship. Restart only after 15 min. without sightings of marine mammals.

4. Pulse rate and sounding operations have to be reduced appropriate to a scientific necessary level and water depth.

5. During the operation of the sediment echosounder **on stations** closer than 500 m to icebergs, shelf-ice edges, and coasts, and whales are observed in between, sounding has to be stopped. Sounding can be restarted after 15 min without sightings.

6. If opportunistic sightings of whales between ship's course and icebergs, shelf-ice edges, and coasts, the ship has to keep a distance of > 500 m.

7. Every exception of following this mitigation regulations will have to be documented in a report.

All actions and reasons concerning switching on and off the system, and events concerning MMO calls are documented in Appendix A.5 (PS134 Parasound Log).

Preliminary results

In total ~18,989 km (~10,254 nm) of sub-bottom profiles were acquired during 69 days of operation. South of 60° our working comprised 61 days of sub-bottom profiling (Chapter 1, Fig. 1.1: Track of *Polarstern* expedition PS134). The profile names, sub-bottom penetration range, sub-seafloor characterisation for geological sampling, and other notes are listed in Appendix A.6 (PS134 Parasound Profiles and Stations).

The acquired dataset provides both, subsurface and geomorphological information of the upper ~50 m of the substrate of the research area. The "Parasound" records serve as a compilation of high-resolution sub-bottom profiles along the cruise track, and at the target sites for coring and heat-flow measurements. These sub-bottom profiles image the surfaces and internal architectures of glacial-geomorphological features (e.g. iceberg plough marks (Fig. 3.3.1) and grounding zone wedges (Fig. 3.3.2), erosional structures, and depositional features (e.g. slumps, slides, fans). Linked to the results from multi-beam mapping and sediment coring, the network of sub-bottom profiles offers an important tool for the interpretation of geological data in a spatial context. Expected outcomes aim towards a better understanding of ice-sheet dynamics and geological processes in the research area.

For the selection of sites and locations of heat-flow measurements, the sub-bottom profiles enabled to identify areas of high and low sedimentation rates, outcrops, and to avoid areas of sediment re-deposition or erosion.

At a first glance, numerous glacial-geomorphological features were imaged on the sub-bottom profiles of the Bellingshausen Sea shelf. Abundant presence of subglacial lineations, such as iceberg plough marks, grounding-zone wedges and corrugation ridges indicate the former presence of grounded ice sheets and icebergs extending across the continental shelf off Ellsworth Land, and furrowing deep through the seabed surface (Fig. 3.3.1). Sinus-like ripples are interpreted as corrugation ridges observed for the first time in the study area. Because of their high regularity, they are supposed to be generated by the bouncing of either grounded former icebergs or the grounding zone of a retreating ice stream into the seabed due to tidal fluctuations (e.g. Jakobsson et al., 2011).

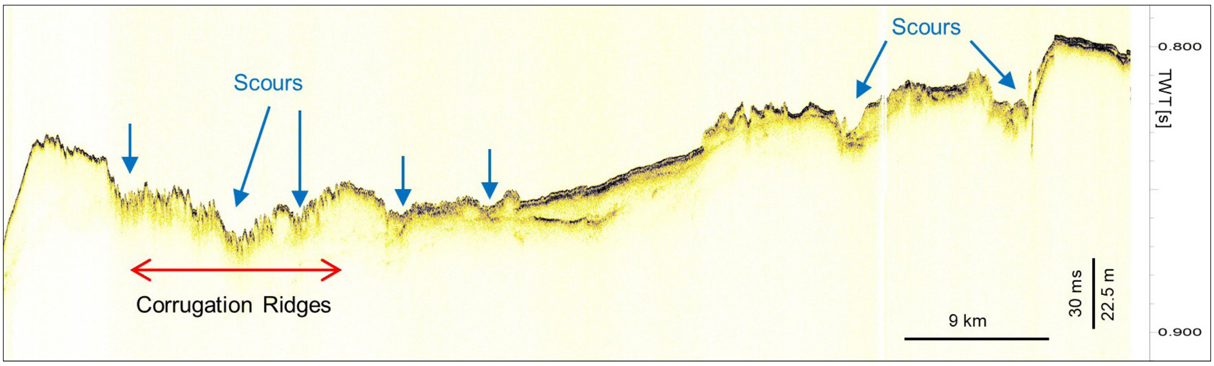

Fig. 3.3.1: Section of a sub-bottom profile imaging corrugation ridges (red arrow area), plough marks and scours (blue arrows) of icebergs.

In the Bellingshausen See, on several transects from the inner to outer continental shelf, successions of crag-and-tail features and grounding zone wedges were imaged. The formation of the crag-and-tails and of the grounding-zone wedge build-ups indicate strong interaction of ice sheets and icebergs with the geological substrate. On the basis of the sub-bottom profiles obtained with the "Parasound" system, geological sampling along the transects was performed to 1) acquire information about the substrate, 2) constrain chronological context and 3) construct a spatiotemporal context for imaged features across the continental shelf (Fig. 3.3.2; and in Chapter 4).

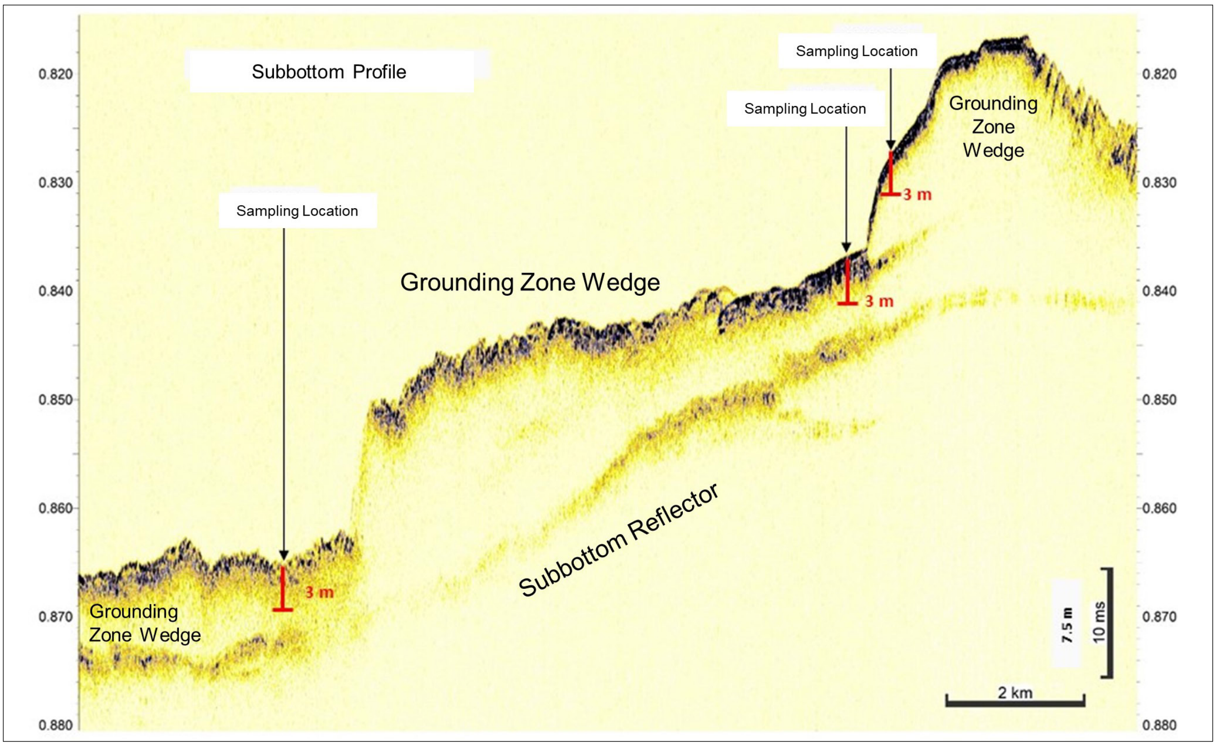

Fig. 3.3.2: Sub-bottom profile imaging grounding zone wedges and sampling locations.

Data management

Sub-bottom profiling data collected during PS134 were copied to the *Polarstern* data base, from where they will be transferred to the data mass storage at AWI Bremerhaven and linked to the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) at AWI.

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

In all publications based on this expedition, the **Grant No. AWI_PS134_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.

References

Evans J, Pudsey CJ, Ó Cofaigh C, Morris P, Domack EW (2005) Late Quaternary glacial history, flow dynamics and sedimentation along the eastern margin of the Antarctic Peninsula Ice Sheet. Quaternary Science Reviews 24:741–774.

Jakobsson M, Anderson JB, Nitsche FO, Dowdeswell JA, Gyllencreutz R, Kirchner N, Mohammad R, O'Regan M, Alley RB, Anandakrishnan S, Eriksson B, Kirshner A, Fernandez R, Stolldorf T, Minzoni R, Majewski W (2011) Geological record of ice shelf break-up and grounding line retreat, Pine Island Bay, West Antarctica. Geology 39:691–694.

Livingstone SJ, Ó Cofaigh C, Stokes CR, Hillenbrand C-D, Vieli A, Jamieson SSR (2012) Antarctic palaeo-ice streams. Earth-Science Reviews 111:90–128.

Ó Cofaigh C, Dowdeswell JA, Evans J, Larter RD (2008) Geological constraints on Antarctic palaeo-ice-stream retreat. Earth Surface Processes and Landforms 33:513–525.

3.4 Geothermal Heat Flow Measurements

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Grant-No. AWI_PS134_04

Objectives

The West Antarctic Ice Sheet (WAIS) currently shows increasing retreat dynamics, combined with concerns that it could partially collapse, leading to rapid sea-level rise. Glaciers are subject to changes that affect them from the outside. We currently know of three processes that have a significant influence on the stability of the ice sheets: (1) air temperature and solar radiation acting from above, (2) oceanic water acting from below the ice shelves and at the grounding zones, and (3) geothermal heat flow (GHF) acting from the sub-surface below. This has been the case in the past, with varying effectiveness of the different compartments, as much of the base of the West Antarctic Ice Sheet lies below sea level. We suspect that the ice sheets in the southern Bellingshausen Sea have been particularly sensitive in warm times. This marginal region of Antarctica seems to react particularly sensitive to climate changes, especially in interaction with the ocean. Although first studies have indicated regionally high geothermal heat flow in some parts of the Amundsen Sea Embayment sector (Dziadek et al., 2017, 2019, 2021), there is still little known on the effect that geothermal heat flow has had on sliding conditions of grounded ice. Knowledge of geothermal heat flow will contribute to the ice sheet energy budget. Our contributions are focused on processes of two time scales: The identification and long-term effect of the tectonically generated West Antarctic Rift System arms extending onto the Bellingshausen Sea shelf, and the detection of short-term seasonal water mass movements. On this cruise, we focused on two different regions, the Ronne Entrance and the Eltanin Bay. Both are characterized by elongated glacial troughs formed by ice streams draining the WAIS in this sector (Ó Cofaigh et al., 2005; Graham et al., 2011). The seafloor of Eltanin Bay is the upstream part of the dominant Belgica Trough on the Bellingshausen Sea shelf. Understanding to which extent the Circumpolar Deep Water (CDW) and geothermal heat flow influenced this rapid ice mass loss is crucial for accurate ice sheet modelling and future sea-level predictions. Further, the acquired data can improve our understanding of local heat flow variations due to topographic depressions and small-scale geological variability. Eltanin Bay is located at the end of the Ferrigno Rift on the mainland (Bingham et al., 2012) and, therefore, subject to possibly elevated heat flow. A profile of heat flow measurements across the suggested rift axis could potentially help to verify its existence and orientation, and improve our understanding of the extent of CDW in this region.

In-situ temperature measurements

We use 12 Miniaturized Temperature Data-Loggers (MTL), precision thermometers for deep sea operations, to autonomously measure the temperature of the subsurface of the seafloor on the Bellingshausen Sea shelf. The loggers can withstand water depths to 6,000 m and are able to penetrate into marine sediment layers. They have a resolution of 0.001°C, an accuracy of 0.1°C (Pfender and Villinger, 2002), and were programmed to record the temperature with a frequency of 1 Hz. Up to 6 loggers were mounted with fins on a 5 m long lance that is designed with a pointy tip to penetrate effortless into the sediment. One of the sensors, the water MTL, is attached to the weight head to measure the temperature of the overlying water layer (Fig. 3.4.1). The weight head is 850 kg, which ensures a deep penetration.

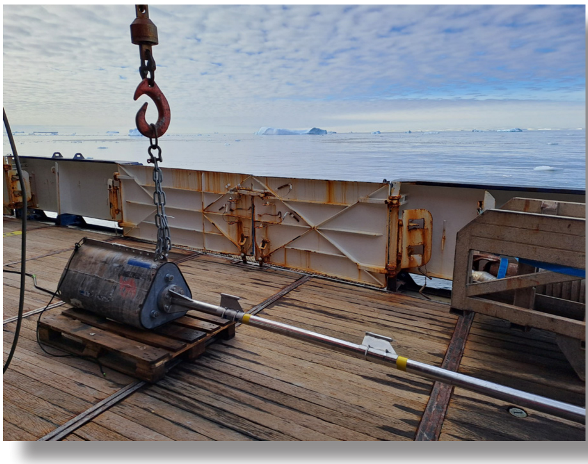

Fig. 3.4.1: Left: Geothermal heat flow lance (5 m) with weight head (850 kg), five mounted fins, and MTLs on deck. Right: Water MTL attached with four cable ties to the weight head.

At station, the lance with MTLs is lowered into the water column with a rope speed of 1 m/s while continuously measuring the water temperatures. From the rope tension printer in the winch control room, it can be inferred when the lance is entering the sediment where it remains for 7-12 minutes to allow for the decay of frictional heating. After this time, the sensor measurements have stabilized and should represent the true temperatures of the sediment. The lance is then pulled out of the sea floor with a speed of 0.2 m/s and after release again with a speed of 1 m/s up to the deck. The data from the loggers are finally exported and saved, and newly programmed for the next stations. The target areas are small basins and troughs on the continental shelf where sediments have accumulated and water column temperatures likely show less variations (Dziadek et al., 2017), and were ideally located near seismic profile lines for knowledge of the structure of the basins and troughs.

Thermal Conductivity Measurements

For accurate geothermal heat flow calculations, the thermal conductivity of several sediment cores is taken on the same cruise in the vicinity of, or at the same location as the temperature measurements. For this, the KD2PRO (www.decagon.com) is used providing three types of needle probes that are inserted into the archive or working halves of the split cores (Fig. 3.4.2). For the cores from this cruise, two needle types, a double needle of 30 mm with an outer diameter of 1 mm and a single needle of 60 mm with an outer diameter of 1.2 mm are compared and used interchangeably in the first core. The measured thermal conductivity is then given with an absolute accuracy of 5 % and taken from cores equilibrated to the ambient laboratory temperatures (~21 °C).

Fig. 3.4.2: Left: Two needle types – a double and single needle – are used for thermal conductivity measurements. Right: Split core and thermal conductivity instrument KD2PRO with the double needle

Preliminary results

Prior to using the lance, a calibration was performed by mounting the MTLs onto the conductivity-temperature-depth rosette system (CTD). The temperatures at 1,000 m and 2,000 m depths are compared and if necessary the differences between MTL temperature reading and CTD are saved for later correction. The differences range between 0.001 K to 2 K (Fig. 3.4.3) which is mostly due to the lack of appropriate calibration files for some of the MTLs.

In total, 23 vertical temperature measurements could be conducted (Tab. 3.4.1, Figs. 3.4.4 to 3.4.6) with 9 in Ronne Entrance, 13 in Eltanin Bay, and 1 close to the Abbot Ice Shelf. The measured sediment temperatures range from 1.14 to 1.54° C and the uncorrected heat flow estimations yield values from 17.4 to 89.6 mW/m^2 (e.g. Fig. 3.4.7) with the thermal conductivities from Table 3.4.2. Especially, the extremely low preliminary heat flow estimations need to be looked at in detail and probably corrected for warm water influence and disturbances in the upper sediment layer from chaotic debris flow and deep water penetration. Five MTLs were bent due to the impact of a hard sediment layer or drop stones and one of them is still readable at the end of the cruise. Two MTLs were lost because the access rope was wrapped around the lance and tear them off while disentangling or they got stuck in the sediment.

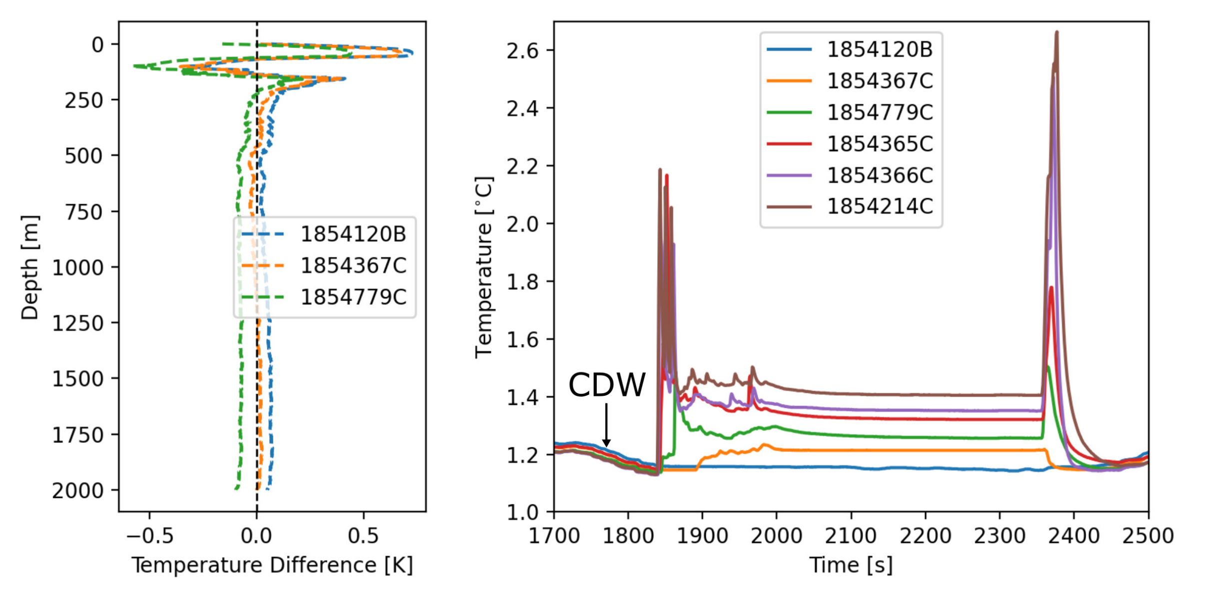

Fig. 3.4.3. Left: Differences between CTD profile temperatures and three exemplary MTL temperature measurements down the water column. Right: Temperatures with measurement time for station PS134_17-1. The first peak marks the temperature disturbance due to penetration into the sediment after which the measurement continued for an equilibration time of about 8 minutes before the lance was pulled out of the sediment. CDW – Circumpolar Deep Water.

Tab. 3.4.1: Overview and details of the geothermal heat flow measurement sites of PS134.

Station N°	Name of Site	Longitude [deg]	Latitude [deg]	Water Depth	Penetration Depth [m]	Comment
PS134_16-1	HF2320	-72.67535	-72.894	680 m	~ 4	MTL at deepest position was lost
PS134_17-1	HF2321	-72.91706	-72.65163	768 m	~ 5	/
PS134_18-1	HF2322	-73.09123	-72.60052	657 m	~ 6	Weight head covered in sediment
PS134_20-7	HF2323	-72.946733	-72.868616	674 m	~ 3	/
PS134_21-1	HF2324	-73.008616	-72.865866	667 m	~ 0.5	One MTL + one fin were lost
PS134_24-1	HF2325	-72.7431	-72.928916	723 m	~ 4.5	One MTL was bent but still readable
PS134_25-1	HF2326	-73.28743	-72.87536	752 m	~ 6	Weight head completely covered in sediment, one MTLs was bent but still readable
PS134_26-1	HF2327	-73.52236	-72.84683	761 m	~ 3	/
PS134_27-1	HF2328	-74.05783	-72.9214	1099 m	~ 3.5	/

Station N°	Name of Site	Longitude [deg]	Latitude [deg]	Water Depth	Penetration Depth [m]	Comment
PS134_70-4	HF2329	-83.25315	-73.59876	798 m	~ 6	Weight head completely covered with sediment
PS134_74-1	HF2330	-81.522	-73.61595	605 m	~ 5	/
PS134_75-1	HF2331	-81.8706	-73.63713	752 m	~ 5	/
PS134_76-1	HF2332	-82.13742	-73.56512	920 m	~ 5	/
PS134_77-1	HF2333	-81.90375	-73.52102	1016 m	~ 2	/
PS134_78-1	HF2334	-81.60818	-73.36883	931 m	~ 2	/
PS134_79-1	HF2335	-82.30288	-73.42358	695 m	~ 4	/
PS134_80-1	HF2336	-82.7445	-73.4961	559 m	~ 3	/
PS134_81-1	HF2337	-82.95883	-73.5881	852 m	~ 5	/
PS134_82-1	HF2338	-83.2425	-73.60762	824 m	~ 6	Station close to PS134_70. Again, weight head completely covered in sediment. One already bent MTL bent further and not readable
PS134_86-1	HF2339	-83.32263	-73.36315	711	~ 5	/
PS134_87-3	HF2340	-83.534716	-73.39346	639	~ 4	/
PS134_88-1	HF2341	-83.95275	-73.1944	1148	~ 4	One MTL not readable
PS134_91-2	HF2342	-92.69216	-72.49243	734	~ 6	Weight head completely covered with sediment. Three loggers bent and two readable.

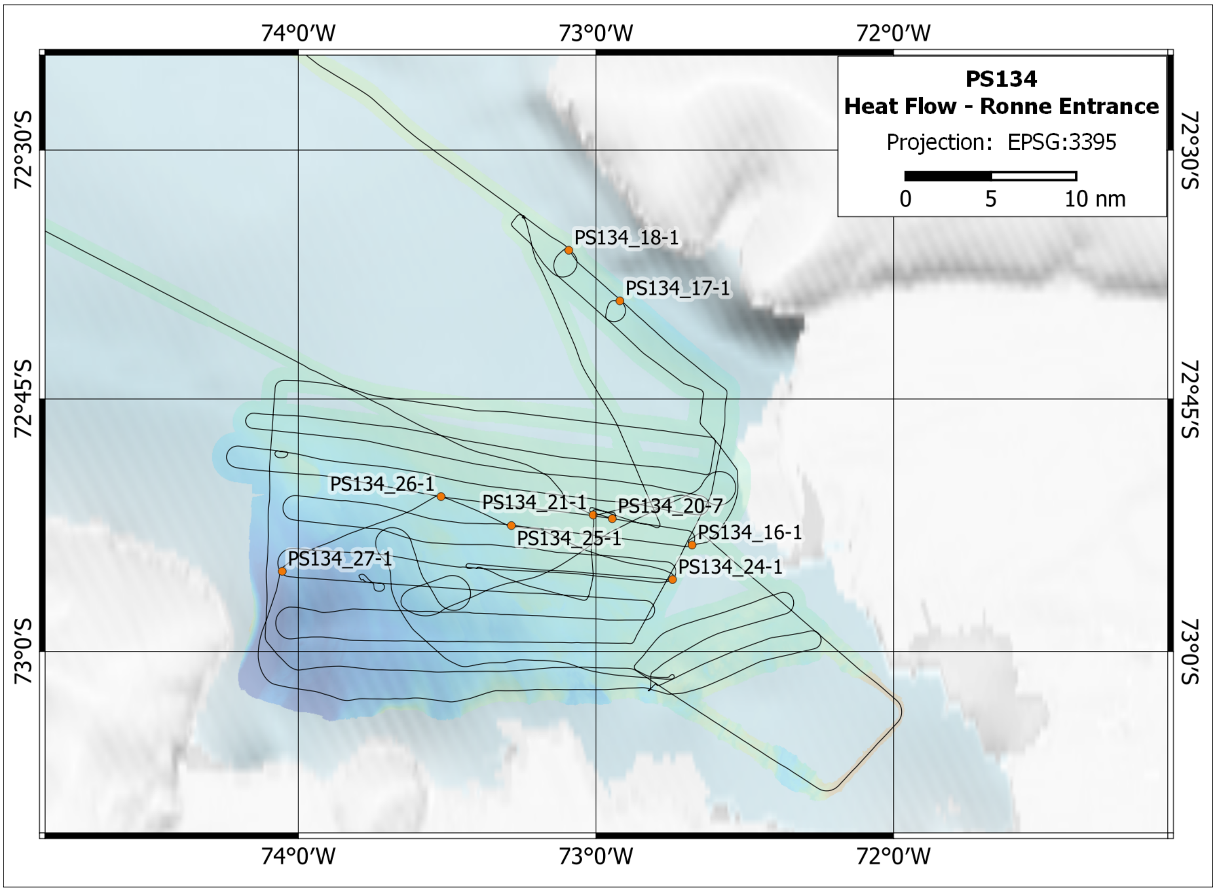

Fig. 3.4.4. Map of ship track lines and heat flow stations in the Ronne Entrance working area underlain with bathymetric survey data.

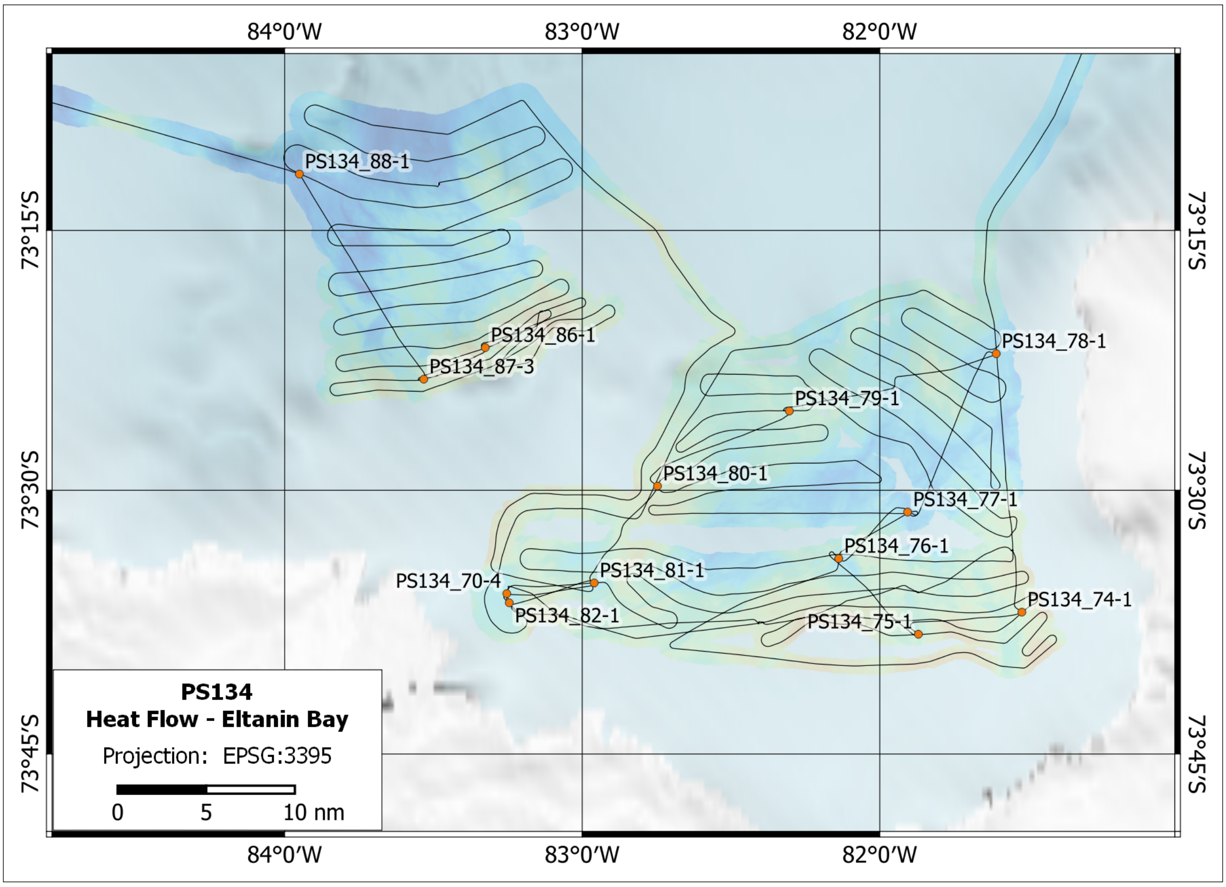

Fig. 3.4.5. Map of ship track lines and heat flow stations in the Eltanin Bay working area underlain with bathymetric survey data.

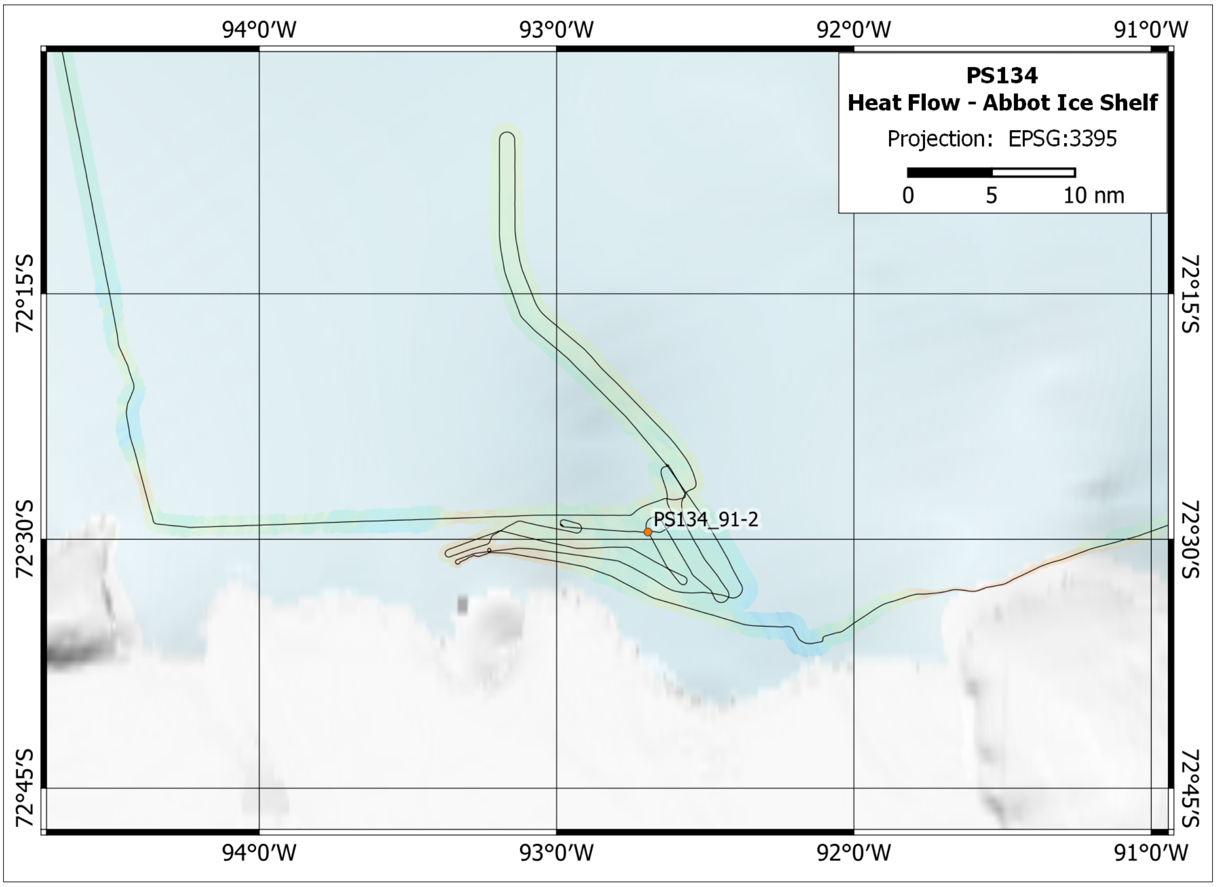

Fig. 3.4.6. Map of ship track lines and heat flow stations off the eastern Abbot Ice Shelf working area underlain with bathymetric survey data.

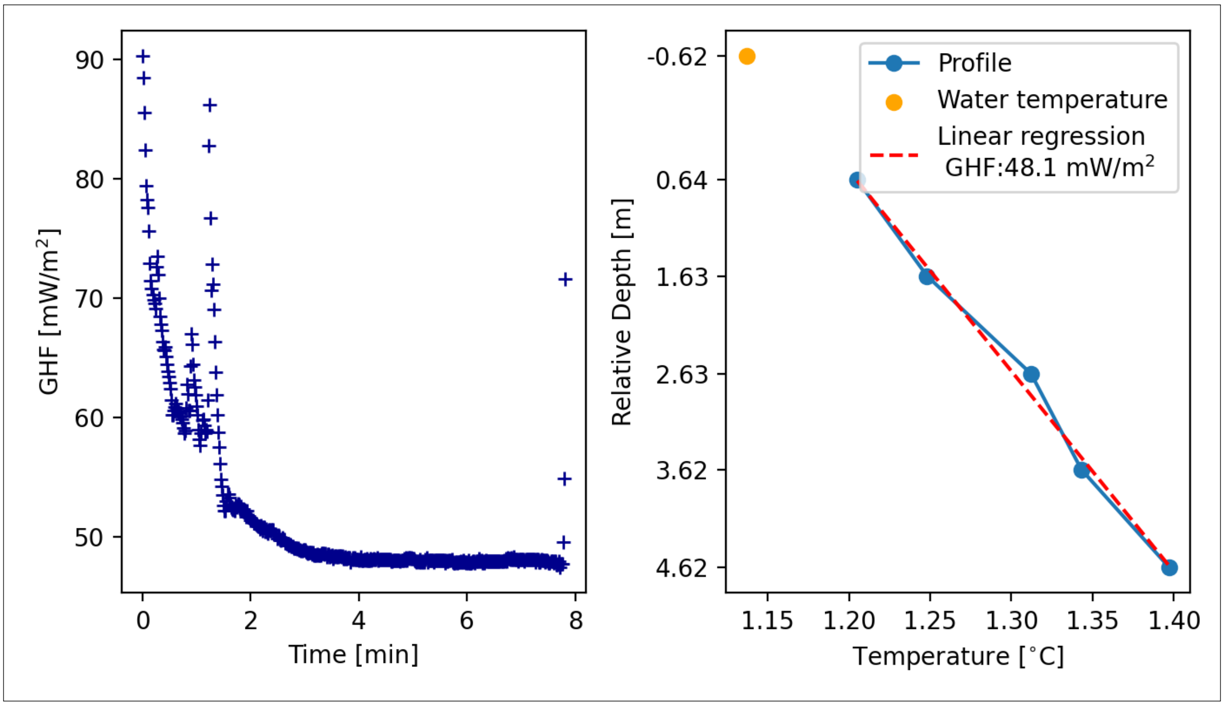

Fig. 3.4.7. Left: Thermal gradient and inferred geothermal heat flow (GHF) with time after sediment penetration for station PS134_17-1. Right: Temperature profile with linear regression after about 7.5 minutes of thermal equilibration. The GHF is calculated with an assumed mean thermal conductivity of 0.99 W/mK.

The marine geologists collected several sediment cores during the cruise (see Chapter 4). Of 43 cores in total, 11 cores were split during the cruise and were be used to measure thermal conductivities. For sites without an accompanying direct measurement of thermal conductivity from a sediment core, the mean thermal conductivity of all measured cores of 0.99 W/mK is used to calculate the geothermal heat flow. In general, the thermal conductivity is highly spatially variable depending on the lithology of the prevailing sediment. From the cores, we inferred values between 0.79 and 1.18 W/mK. The vertically averaged and temperature corrected value of every core is listed in Table 3.4.2.

Tab. 3.4.2: Vertical averaged thermal conductivity of archive or working halves of split sediment cores.

Station N°	Longitude [deg]	Latitude [deg]	Water Depth [m]	Core Length [cm]	Needle	Ø Thermal Conductivity [W/mK]
PS134_19-3	-73.2434	-72.5665	620	254	dual	0.81
PS134_20-5	-72.9466	-72.8688	675	239	dual + single	1.04
PS134_21-2	-73.0088	-72.8661	668	95	dual	1.01
PS134_22-2	-73.0271	-72.9458	752	66	dual	0.81
PS134_23-1	-73.3996	-72.9175	850	132	dual	0.79
PS134_27-2	-74.0595	-72.9215	1102	209	dual	0.99
PS134_38-1	-77.7467	-71.3200	641	234	dual	1.15

Station N°	Longitude [deg]	Latitude [deg]	Water Depth [m]	Core Length [cm]	Needle	Ø Thermal Conductivity [W/mK]
PS134_39-1	-71.2836	-77.9063	662	241	dual	1.04
PS134_41-1	-80.0884	-70.4872	642	244	dual	1.01
PS134_42-1	-82.0984	-69.9901	568	299	dual	1.18
PS134_42-2	-82.0985	-69.9902	568	120	dual	1.09

In each of the temperature logs, the CDW could be detected as gradual increase in temperature of the bottom-water layer (e.g. Fig. 3.4.3). The temperatures reach up to 1.28 °C which could significantly influence the thermal gradient of the upper sedimentary layers and, therefore, the actual geothermal heat flow could be higher than the uncorrected value. In order to estimate the depth down to which the CDW has an influence, the temporal variation will have to be taken into account from continuous measurements or oceanographic mooring stations as it has been done by Dziadek et al. (2019).

Data management

Measured temperature and derived geothermal heat flow 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.

In all publications based on this expedition, the **Grant No. AWI_PS134_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.

References

Bingham RG, Ferraccioli F, King EC, Larter RD, Pritchard HD, Smith AM, Vaughan, DG, 2012. Inland thinning of West Antarctic Ice Sheet steered along subglacial rifts. Nature 487:468–471. https://doi.org/10.1038/nature11292

Dziadek R, Ferraccioli F, Gohl K (2021) High geothermal heat flow beneath Thwaites Glacier in West Antarctica inferred from aeromagnetic data. Communications Earth & Environment 2:162.

Dziadek R, Gohl K, Diehl A, Kaul N (2017) Geothermal heat flux in the Amundsen Sea sector of West Antarctica: New insights from temperature measurements, depth to the bottom of the magnetic source estimation and thermal modelling. Geochemistry Geophysics Geosystems 18.

Dziadek R, Gohl K, Kaul N, Science Team of Expedition PS104 (2019) Elevated geothermal surface heat flow in the Amundsen Sea Embayment, West Antarctica. Earth and Planetary Science Letters 506:530–539.

Graham AGC, Nitsche FO, Larter RD, 2011. An improved bathymetry compilation for the Bellingshausen Sea, Antarctica, to inform ice-sheet and ocean models. Cryosphere 5:95–106.

Ó Cofaigh C, Larter RD, Dowdeswell J.A, Hillenbrand C-D, Pudsey CJ, Evans J, Morris P, 2005. Flow of the West Antarctic Ice Sheet on the continental margin of the Bellingshausen Sea at the last glacial maximum. J. Geophys. Res. 110:B11103.

Pfender M, Villinger H (2002) Miniaturized data loggers for deep sea sediment temperature gradient meurements. Marine Geology 186:557–570.

3.5 Marine Mammal Observations and Mitigation Methods

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Objectives

The aim of the marine mammal observation studies is to validate different visual and acoustic monitoring methods, which can be used to mitigate the effects of hydroacoustic studies on marine mammals. Hydroacoustic methods include seismic airguns, Parasound, Hydrosweep as well as other acoustic systems.

Six different monitoring methods are included in the studies:

1. Visual observations from different platforms on *Polarstern*, to compare the effort of two vs. three marine mammal observers
2. Infrared-camera system (IR) installed on board of the vessel, to support visual detections and possibly allow autonomous detection of marine mammals
3. Drone equipped with high-resolution video cameras to support the long-distance observations of marine mammals and monitor the behaviour of whales (individuals or groups)
4. Acoustic monitoring with a stationary deep-water recording device to record vocalisations of whales
5. Hydrophone array integrated in the seismic streamer towed behind the vessel to acoustically detect marine mammals during the seismic surveys
6. Opportunistic aerial surveys from a helicopter in combination with ice-recognisance flights are performed, to extend the radius of the visual monitoring beyond the area visible from the ship

The effectiveness and application of the different monitoring methods differ depending on the function of the hydroacoustic methods (moving or stationary) and environmental parameters (visibility, natural acoustic background noise level etc.). The aim of the validation is a comprehensive quantitative and qualitative comparison of the current and newly tested monitoring methods.

Furthermore, the methods will be applied in different scenarios during the cruise to study the relative abundance of marine mammals in relation to ongoing hydroacoustic surveys. The aim is to detect possible effects of underwater noise by the hydroacoustic systems on marine mammal abundance before, during and after the surveys. The ability of the drone to follow animals for a longer time will also allow collecting data on the individual behaviour of whales in response to the underwater sound emitted by *Polarstern* and the hydroacoustic methods. This footage can be used to give insight into the onset, severity and duration of behavioural responses and establish a method to study these responses of marine mammals to underwater sound on a larger spatial scale.

Ship visual observations

The mitigation regulations for seismic profiling according to the German Federal Environmental Agency (Umweltbundesamt – UBA) protocol are described in detail in Chapter 3.1.

The objective of replicating the visual observations by the marine mammal observers (MMO) from a different platform (observer deck versus bridge) was to compare the sighting rate of two versus three visual observers. The results are intended to verify the number of required observers and provide a recommendation for the mitigation regulations of UBA based on the validation results.

Infrared-camera system

These observations were complemented by the infrared (IR) camera system (FIRST Navy by Rheinmetall and Tashtego imaging software), which is installed on *Polarstern* for the seismic surveys. The IR-system is part of the mitigation regulations implemented by UBA and is therefore explained in detail in Chapter 3.1. In general, the system allows the detection of marine mammals under poor sighting conditions (e.g. low light or in high sea states).

Drone-based video monitoring

For PS134, MAUI63 provided an electrically powered quad-plane called the ROC (Fig. 3.5.1) manufactured by the Hungarian firm ARACE and an artificial intelligence (AI) detection system for post flight detection of cetaceans and a dataset of 20,000 images of whale footage gathered in 2019 to 2020 in New Zealand waters to assist in retraining. The drone has a number of adaptations for the Antarctic environment such as a homing beacon system that enabled autonomous take-offs and landings from a moving vessel, and a differential GPS system that negated the need for a magnetic compass for navigation. The drone also has a live video link from a controllable camera that allowed operators to track wildlife in real time. Normally, for quantitative surveys a high resolution camera (24 or 63 megapixel) would also be used. However, this was not fitted as it is would not be useful for behavioural monitoring and would heavily reduce flight times. Besides complementing the quantitative detection of whales at a wider range around the vessel, the objective of the drone was therefore to detect and follow individual animals or groups and observe their behaviour and possible reactions towards the hydroacoustic emissions.

Fig. 3.5.1: The ARACE drone used for visual observations of marine mammals; the white sphere installed underneath the drone body is the 360° video camera system (photo: Robert Larter).

During the transit from Cape Town a real-time automatic AI detection pipeline training was built, its detection model (YOLO4) retrained with a set of NZ sourced whale images, and the detector made ready for testing. A custom GPS waypoint generator was also built that allows on the fly survey missions to be planned from a moving ship. This enabled the drone and ship speeds and headings to be entered and other survey parameters to be allocated thus keeping the drone ahead of the ship at all times. In practice, ad hoc ‘fly to here’ waypoints can also be entered at any time and new flight plans uploaded to the drone while in air.

Aerial surveys

Opportunistic aerial surveys for marine mammals were conducted using one of the on-board helicopters and performed in close cooperation with the planned geophysical and ice recognisance activities. These observations will help to obtain a baseline of cetacean density and distribution in relation to habitat characteristics without any underwater noise input (‘pre-exposure phase’) and with seismic work (‘exposure phase’), especially in relation to the distance to the vessel, i.e., the sound source.

Bottom-mounted acoustic recorder (Passive Acoustic Monitoring)

An Autonomous Long-Term Observatory (ALTO, see Fig. 3.5.2), a mooring system designed by JASCO Applied Sciences for deploying multiple oceanographic instruments at the bottom of the ocean was used as a platform for deploying an underwater sound recording system in the study area. The main objectives of the acoustic monitoring were to determine:

- the occurrence, species and number of vocalising marine mammals (mainly baleen and toothed whales) by applying automated and manual analysis methods;
- direction and distance of vocalising whales relative to the recorder;
- the sound level of *Polarstern* and of all hydroacoustic survey methods; and
- the acoustic characteristics of other animals and all environmental sounds in Antarctic waters.

The recorder, an Autonomous Multichannel Acoustic Recorder (AMAR G4 UD), manufactured by JASCO Applied Sciences was equipped with four highly sensitive, broadband hydrophones, capable of recording sounds in the frequency range between 10 Hz – 256 kHz. With 2 TB of data storage and sufficient battery power supply, the system was scheduled to record sound continuously for up to 48 days from its position at the seafloor.

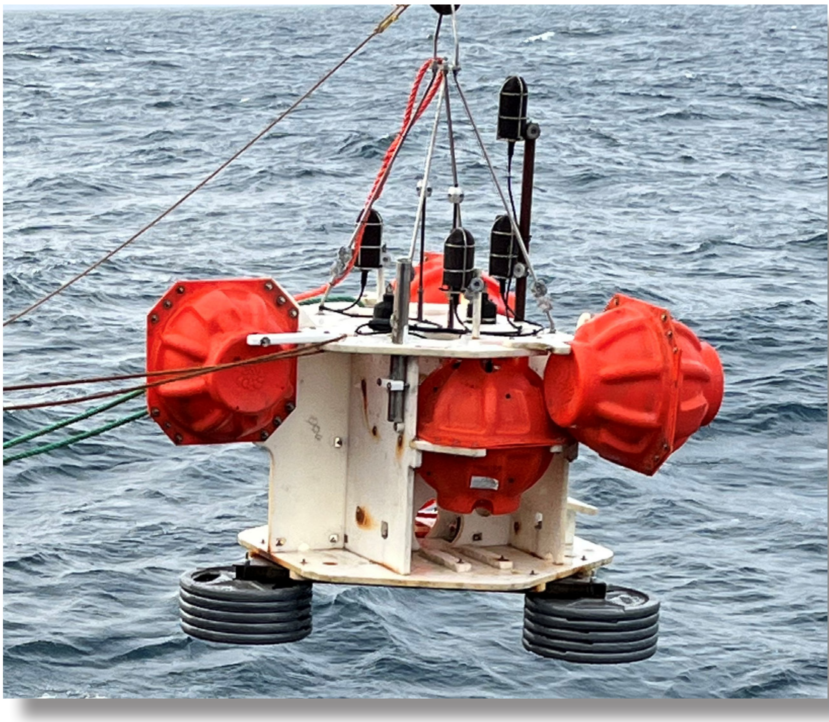

Fig. 3.5.2: Underwater sound recording system (ALTO) during deployment in the Bellingshausen Sea. The four-hydrophone array (black foam cones inside metal protection cages) is mounted on top of the ALTO's main body (photo: Karsten Gohl).

Towed hydrophone array (Passive Acoustic Monitoring)

The QuietSea™ system by Sercel is a passive acoustic monitoring system integrated in the seismic streamer system designed to detect the presence of cetaceans during seismic operations. The QuietSea software system is designed to automatically detect and identify vocalisations emitted by cetaceans and localise their positions. A detailed description is given in Chapter 3.1.

Work at Sea

Ship observations

Visual monitoring of the area surrounding *Polarstern* was conducted by constantly scanning the area for marine mammals by naked eye or with binoculars (20x magnification). In addition to the MMO personnel and the IR system, two observers were visually monitoring the area around *Polarstern* from the observation platform above the bridge (higher platform than MMO personnel) as part of the validation project. Due to weather restrictions, a limited number of observers and a necessary shut-down of the internet antennas installed on the observation platform for the time of these watches, a maximum of 5 hours per day were covered. A total of 50.25 hours were completed.

Drone operations

The drone was used for both quantitative and qualitative surveys of whales in the area around the *Polarstern*. The video footage was recorded for post-flight review and analysis. GPS coordinates and time were imprinted on the video via the on-screen display. While performing test flights when *Polarstern* was positioned at the ice shelf (north pier) at *Neumayer III Station*, a software problem resulted in the drone being damaged in a collision with the superstructure of *Polarstern* on 7 January 2023. The successful repairs to the drone and solving the software issue took several weeks and the drone was unavailable for the first seismic survey. For the second seismic survey, consistent bad weather and the prioritization of helicopter flights severely limited the time available for drone flights. During the second seismic survey, the drone was flown for a total of just over 13 hours, covering a total distance of just over 1,000 km. No sightings of marine mammals were recorded during this time. However, during the three flights immediately following the cessation of seismic surveys, the team detected four separate groups of whales.

In practice, drone flights averaged about 1.5 hours each due to concerns about reduced battery capacity due to the low temperatures. For surveying, the preferred altitude was 300 meters, with the camera angled between 45-60 degrees downward and facing forward.

Aerial surveys

The surveys followed line-transect distance sampling methodology (Buckland et al. 2001), however, surveys were planned and conducted in an ad hoc manner given suitable weather conditions and helicopter availability (Lehnert et al. 2012; Scheidat et al. 2011). Transect lines were designed around the position of *Polarstern*, following basic principles of good survey design as performed during previous cruises (Williams et al. 2014). A rectangular or rhomboid survey design was used to maintain a safe distance to the vessel as defined by the maximum endurance of the helicopters and weather conditions (Kock et al. 2009; Scheidat et al. 2011). The same experienced observers participated in all the surveys. The maximum distance of the ice survey flights, which were used opportunistically for the marine mammal observations, was 80 nm.

Survey flights were conducted at a constant altitude of 600 ft (except in few cases to avoid the low clouds) and a speed of 100 kn approximately (Gilles et al. 2016). Two observers were positioned in the back of the helicopter and covered the left and right side, respectively (Scheidat et al. 2011). A third person was seated further back than the observers as the navigator recording the data. All data were entered directly into a computer using the customised survey software 'SAMMOA' (Observatoire Pelagis 2022). SAMMOA is linked to an external GPS device storing GPS locations in 4 s intervals. Environmental conditions (sea state, cloud cover, glare, ice coverage, water turbidity) were assessed by the observers and entered into SAMMOA. Additionally, each observer reports on subjective sightings conditions (good, moderate or poor), which shall reflect the likelihood of sighting a cetacean given the prevailing environmental conditions. Any changes in the environmental or sighting conditions were immediately reported by the observers and consequently updated in the software programme.

For each cetacean sighting, detailed information was recorded, including species, declination angle (used to calculate distance from the transect line) and group size. Ancillary information on the behaviour, swimming direction, cue and presence/absence of calves were also noted.

For each seal sighting, the same detail information was collected; however, it was also indicated in the comments, if the seal was observed swimming or over ice. More details on aerial surveys and field protocols are available in the literature (Herr et al. 2016, 2019; Scheidat et al. 2011; Williams et al. 2014).

Given the days with optimal flying conditions, flights during none-seismic and seismic work were possible. The transects covered a distance of 18 to 50 km per survey and in total 3,709 km of observation effort was completed in 27.3 hours.

Passive acoustic monitoring – ALTO

The acoustic mooring was deployed during the ongoing seismic survey on 30 January 2023 at a speed of approximately two knots by dropping it from a height of ~0.5 m above the surface into the water. While the ALTO was not designed for deploying it in free fall onto the water surface while the vessel was sailing, the risk was considered acceptable. An important factor in assessing the risk was that the chosen deployment location was considered ideal, but the ongoing seismic survey could not be interrupted, with a major time loss of about 6 hours, while passing over this location.

In order to record the sounds produced by *Polarstern* and all hydroacoustic systems operated during the surveys, *Polarstern* crossed the ALTO position four times over the duration of its deployment. During the first two passages, the seismic airguns, Hydrosweep, and Parasound were operated. In the third passage, only the seismic airguns were active and in the last one, all hydroacoustic sources were shut down. The different scenarios were intended to allow analysing and determining the acoustic footprint of each sound source (*Polarstern* and the three main hydroacoustic sources).

In the early morning of 16 February 2023, the acoustic releases of the ALTO were triggered to send the lander back to the surface. With several members of the scientific and ship's crew on watch, the mooring was spotted 10 minutes later and at 02:30 (UTC) the mooring was successfully recovered back onto the deck of *Polarstern*.

Passive acoustic monitoring – QuietSea

The QuietSea system, which is integrated in the seismic streamer system and airgun cluster, suffered from a malfunction during the first seismic survey, but operated continuously during the second survey from 3 to 15 February 2023.

Preliminary results

Ship observations

The professional MMOs and trained observers detected 455 marine mammals in 231 sightings over the course of the seismic surveys. The infrared system and sightings by other people (not MMO, i.e., *Polarstern*- and scientific crew) added 13 sightings with 24 animals to this total.

The validation project resulted in 50.25 hours of comparative visual effort from the two platforms. The overall sighting performance of the MMO/volunteer team working with three observers and the whale team working with two observers was almost identical (MMO-team: 63 sightings; whale team: 62 sightings). However, there were numerous sightings that either team missed in comparison (22 for the MMO team versus 23 of the whale team). This result will allow the regulatory agency to reconsider the number of visual observers required as part of the mitigation measures during the hydroacoustic surveys. However, to provide a final decision in the quantity and arrangement of the MMO, it must be taken into account that the result of this comparison is not considering important aspects which can influence the observer performance, such as the differences in platform height, observers experience, weather conditions and the distance at which animals were sighted.

Humpback whales were sighted the most by both teams and accounted for most of the differences in sightings. Seals approaching and following *Polarstern* behind the vessel, however, also accounted for a substantial part of the differences in sightings. From the bridge or observation deck, it is impossible to visually observe the area behind the vessel and the two teams differed in their frequency of visually checking the back area. Recommendations will be made to optimise the observation of this area.

Drone operations

The drone creates detailed logs for each flight. A kml file could be created from these logs, showing the drone's flightpath (Fig. 3.5.3).

The drone video telemetry channel is limited to 2 MB/s resulting in 30 frames per second (fps) at low 720-pixel (p) resolution coupled with high H264 compression of the video footage. This works fine for terrestrial surveys but fails under ocean scenarios. This made observations very difficult, and more flights are needed to determine the best altitude and zoom settings. Using a higher bit rate channel allowing the cameras full resolution at lower frame rates would offer a large improvement. Preliminary experiments have shown that H264 encoding at 5 fps 1080 p at 2 MB per second gives a large improvement. In the three flights (at ~ 4 hours total with ~50 % on effort) when the MMO where actually detecting whales, 4 groups (six humpback whales) where found in real time. Post flight view of all the 13 hours of recordings showed two more low resolution whale fin signatures. This is very tedious work and due to the lack of data no AI training was able to be performed to enable automatic real time and post flight analysis.

Further flights are needed to adjust flight altitudes, camera angles and focus settings, and to get familiar with the gimbal camera control parameters such as setting control pitch and yaw angles and zoom levels as controlling the camera is not a trivial matter. For quantitative survey a light weight, nadir facing, high resolution mapping camera is recommended, which with post flight analysis, will give excellent fidelity and pixel position resolution to within 15 cm.

The drone and ground control system, once updated, proved reliable and easy to land with the drone able to automatically track the ship speed and heading land on the ship even when travelling at or near full speed of 13 kn.

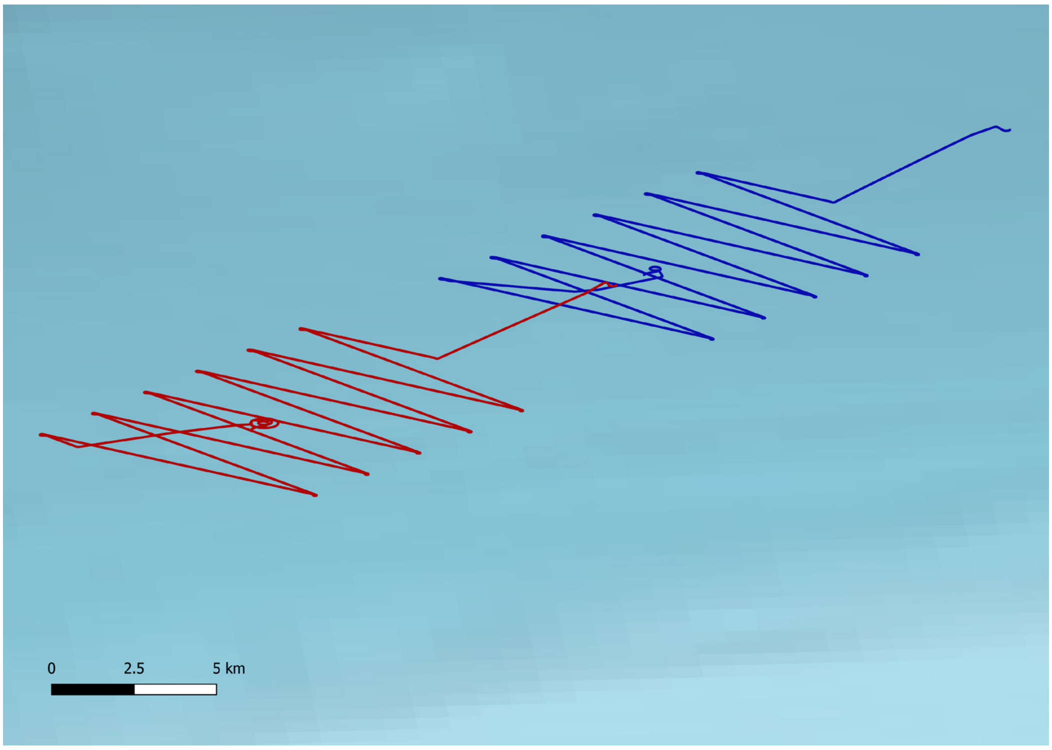

Fig. 3.5.3: Compilation of flight paths from two drone flights (colour-coded in red and blue) conducted on 14 Feb 2023

Aerial surveys

A total of 228 sightings of marine mammals were recorded. We observed 373 animals, including Antarctic minke whales, humpback whales, pinnipeds (over ice or swimming), killer whales and southern bottlenose whales (Fig. 3.5.4, Tab. 3.5.1). Animals were observed in a radius of 136 m to 90 km around the ship.

The results of the aerial surveys will allow us to give a first impression of marine mammal occurrence in the Bellingshausen Sea. The area was almost continuously covered by sea ice until recently, so this will be a first report of species composition, distribution and relative abundance.

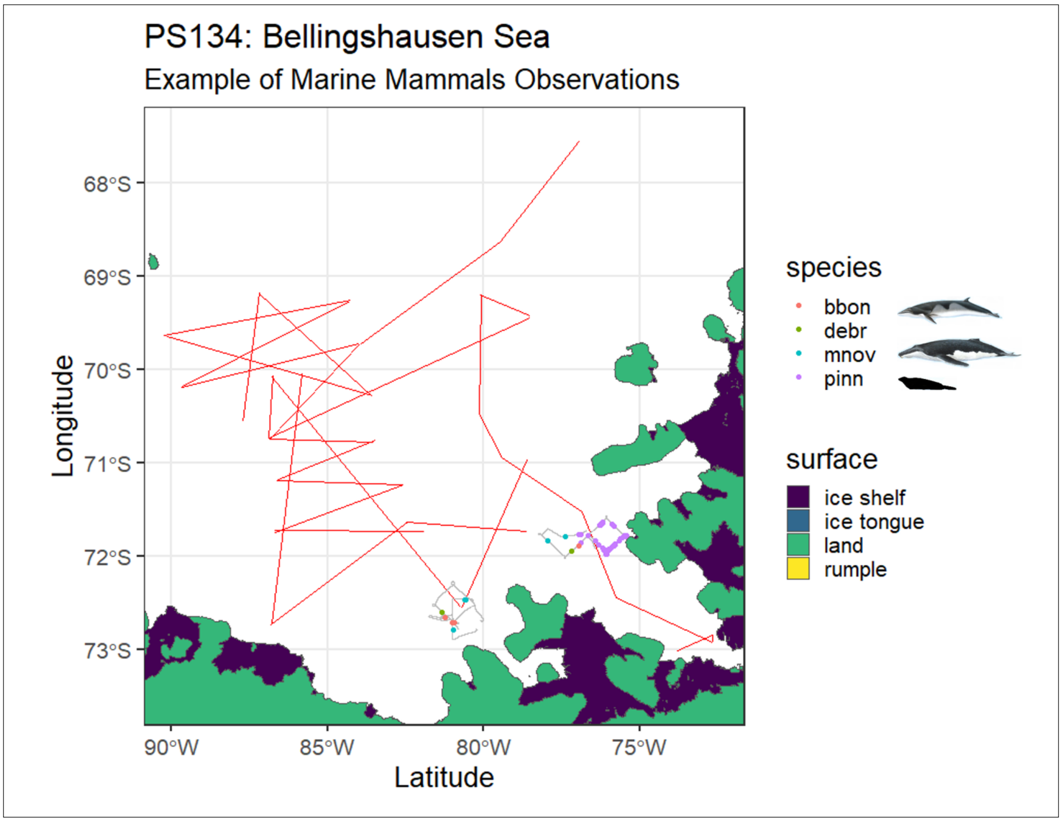

Fig. 3.5.4: Example map with sightings from the helicopter at Bellingshausen Sea, overlay with the planned seismic tracks in red. The marine mammal species observed were Antarctic minke whale (bbon), humpback whale (mnov) and seal (pinn); marine debris (debr) was also observed. Illustrations Uko Gorter.

Tab. 3.5.1: Total effort and number of sightings during the different scenarios of seismic activity. The numbers in brackets show the total number of animals observed.

	Distance covered (km)	**Antarctic minke whales**	**Humpback whales**	**Southern bottlenose whales**	**Killer whales**	**Pinnipeds**	**Other whales**	**Marine debris**
Total	3,709	15 (33)	32 (56)	1 (6)	1 (11)	174 (260)	4 (6)	3 (3)

Bottom-mounted acoustic recorder

Due to an unforeseeable and still unexplained malfunction of the system, no acoustic data were recorded, rendering the efforts related to the acoustic mooring futile. The system had been tested and calibrated prior to its deployment and was working normally. Similar tests were conducted after its retrieval, also showing no aberrant functions. It remains unclear what triggered the system malfunction. A possible explanation is that an electronic fault, possibly due to electric statics, was triggered within the recorder system.

Passive acoustic monitoring system

The QuietSea system was recording during the second seismic survey before, during and after the streamer and seismic airguns were deployed and activated. During the first survey, the system did not function. The system recorded acoustic events with many false positives. However, 39 events were identified by the system's algorithm as acoustic detections of marine mammal vocalisations. Of these, three detections were classified by the automatic detection software as baleen whale sounds ('whistles') while all remaining 36 detections were identified as toothed whale echolocation signals ('clicks').

The visual analysis of all detection data by an experienced analyst, however, revealed that only one acoustic detection, a whistle emitted by a baleen whale (species unknown), was showing a true vocalisation of a whale (Fig. 3.5.5) while all other detections were falsely identified by the QuietSea system. The vocalisation was recorded on 5 hydrophone elements located in the first part of the seismic streamer. The localisation software revealed that the sounds were arriving at the streamer from behind.

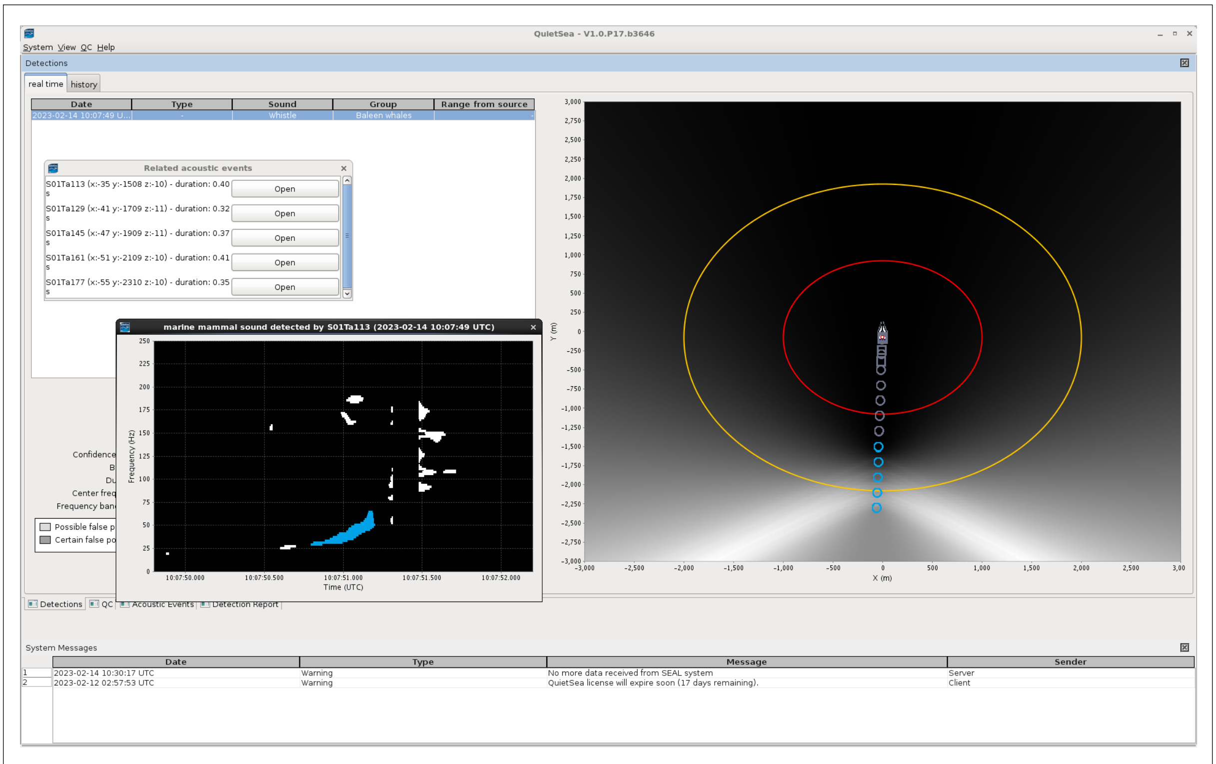

Fig. 3.5.5: Screenshot of the QuietSea analysis screen showing the spectrogram of an identified whale vocalisation (blue shape in left figure) and the bearing analysis (white lines in right figure). Blue dots in the right figure indicate the low-frequency streamer modules that received the vocalisation signal, red and yellow circles indicate the extent of the safety zone around Polarstern which is situated in the middle of the figure.

Data management

Upon publication or approximately after 3 years, preliminary data will be made available on appropriate platforms, such as PANGAEA, GBIF (http://www.gbif.org, Global Biodiversity Information Facility) or ANTABIF (http://www.biodiversity.aq).

References

Buckland ST, Borchers DL and Thomas L (2001) *I*ntroduction to Distance Sampling. Estimating Abundance of Biological Populations*.* New York.

Gilles A,Viquera S, Becker EA, Forney KA, Geelhoed SCV, Haelters J, Nabe-Nielsen J, Scheidat M, Siebert U, Sveegaard S, van Beest F M, van Bemmelen R and Aarts G (2016) Seasonal Habitat-Based Density Models for a Marine Top Predator, the Harbor Porpoise, in a Dynamic Environment. Ecosphere 7(6):e01367.

Herr H, Kelly N, Dorschel B, Huntemann M, Kock K, Lehnert LS, Siebert U, Viquerat S, Williams R and Scheidat M (2019) Aerial Surveys for Antarctic Minke Whales (*Balaenoptera Bonaerensis*) Reveal Sea Ice Dependent Distribution Patterns. Ecology and Evolution (January) ece3.5149.

Herr H, Viquerat S, Siegel V, Kock K-H, Dorschel B, Huneke WGC, Bracher A, Schröder M and Gutt J (2016) Horizontal Niche Partitioning of Humpback and Fin Whales around the West Antarctic Peninsula: Evidence from a Concurrent Whale and Krill Survey. Polar Biology 39(5):799–818.

Kock K,Scheidat M, Boebel O, Bräger S, Herr H, Lehnert K, Lehnert LS, Verdaat H and Williams R (2009) The Occurrence of Cetaceans along Two Transects from 57° S to Atka Bay (70°29.6’ S/07°57.6’ W). (SC/61/IA11):1–20.

Lehnert LS, Geelhoed S, Gray I, Lehnert K, Plön S, Verdaat H, Gilles A, Herr H and Siebert U (2012) Distance Sampling Surveys for Cetaceans in Antarctic Waters - Berichte Zur Polar- Und Meeresforschung. Berichte Zur Polar- Und Meeresforschung 646:51–55.

Observatoire Pelagis U L R (2022) SAMMOA 2.1.3. Retrieved (https://www.observatoire-pelagis.cnrs.fr/tools/sammoa/?lang=en).

Scheidat M, Friedlaender A, Kock K-H, Lehnert L, Boebel O, Roberts J and Williams R (2011) Cetacean Surveys in the Southern Ocean Using Icebreaker-Supported Helicopters. Polar Biology 34(10):1513–22.

Williams R, Kelly N, Boebel O, Friedlaender AS, Herr H, Kock K-H, Lehnert L S, Maksym T, Roberts J, Scheidat M, Siebert U and Brierley AS (2014) Counting Whales in a Challenging, Changing Environment. Scientific Reports 4:4170.

4. MARINE GEOLOGY – ICE SHEET VARIABILITY AND ITS COASTAL RESPONSE IN THE BELLINGSHAUSEN AND AMUNDSEN SEAS (COREBELL)

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Grant-No. AWI_PS134_05

Objectives

The West Antarctic Ice Sheet (WAIS) and the Antarctic Peninsula Ice Sheet (APIS) have undergone major ice loss for decades. In the case of the WAIS this mass loss may kick start even faster retreat into subglacial basins in its interior, where ice is grounded as deep as ~2.5 km below sea level. Scenarios of such WAIS collapses are simulated for environmental conditions that are predicted to occur over the next few centuries. Marine geological archives provide valuable insight into both previous configurations of ice sheet and sea-ice cover as well as the mechanisms triggering retreat. They, therefore, help to elucidate the significance of recent rapid ice-sheet changes for future mass loss from the WAIS and APIS and resulting global sea-level rise. High-resolution marine geological archives are also required for reliably constraining previous retreat rates of ice sheet margins and sea-ice limits. Therefore, the following objectives guided us during our work in the study area:

- Provide reliable spatiotemporal information about the maximum ice-sheet extent on the Bellingshausen Sea continental shelf and reveal past ice-drainage pathways during the Last Glacial Maximum (LGM)
- Constrain the style and timing of post-LGM grounded ice retreat towards the modern ice front by mapping morphological features that mark ice marginal positions (e.g., grounding-zone wedges, moraines) on the shelf and by developing detailed facies models and reliable age models for sedimentary sequences recovered from these features in cores
- Reconstruct changes in sea-ice cover in the southern Bellingshausen Sea during the Holocene and over the last two centuries using biomarker-based proxies and diatom assemblages
- Deliver detailed information about past and current meltwater dynamics by bathymetric mapping of inner-shelf channel networks and targeted sampling including detailed analysis of meltwater plumites
- Test the hypothesis of a WAIS collapse during the last interglacial by recovering and investigating a record from a selected core site on the outer Amundsen Sea shelf that was not overridden by grounded ice during the last glacial period
- Collate a seafloor surface sediment data set for the further development and evaluation of a range of various palaeoenvironmental proxies (biomarkers, trace metals on calcareous foraminifera, proxies for sediment provenance and meltwater deposition).

Guided by the aforementioned objectives, our combined strategy including multibeam bathymetry and sediment echography surveys as well as sediment coring on the Bellingshausen Sea shelf is outlined in Fig. 4.1 below.

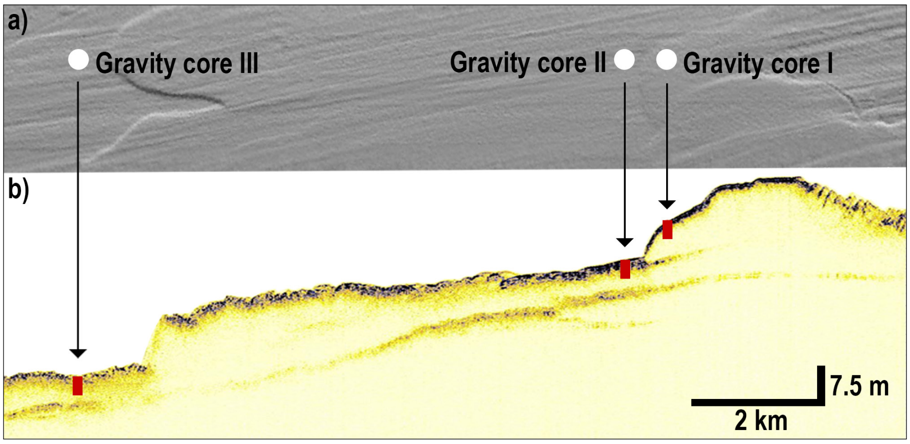

Fig. 4.1: Strategy for recovering sediment cores from the seabed in the working area: 1) Analysis of high-resolution bathymetry (a) and sediment echography (b) data to 2) define most ideal locations for sediment coring (locations in panel a) including deployed core lengths (see panel b). The shown example is from stacked and lineated grounding-zone wedges on the Bellingshausen Sea shelf.

Work at sea

Together with the bathymetry and sediment acoustics groups, we directed systematic swath bathymetry and sediment echography surveys on inner shelf areas in Ronne Entrance, Eltanin Bay and offshore from the Eastern Abbot Ice Shelf as well as along major palaeo-ice stream troughs extending seaward from two of these areas – i.e., Latady and Belgica troughs – to characterize the seafloor morphology and structural geometry of pro- and subglacial landforms (Figs. 4.2, 4.3, 4.5; see also Chapters 3.2 and 3.3). Based on these combined data, we identified locations for giant box and gravity coring. In total, we recovered 43 cores from 30 sites (Fig. 4.2; Table 4.1). Most of the sediment records provide *in-situ* characteristics of past ice flow, e.g., past ice-sheet bed conditions, and allow to date the (minimum) age of grounding-line retreat from each core location along past ice-stream trajectories and from innermost parts of the continental shelf in Ronne Entrance, Eltanin Bay and offshore from the Eastern Abbot Ice Shelf.

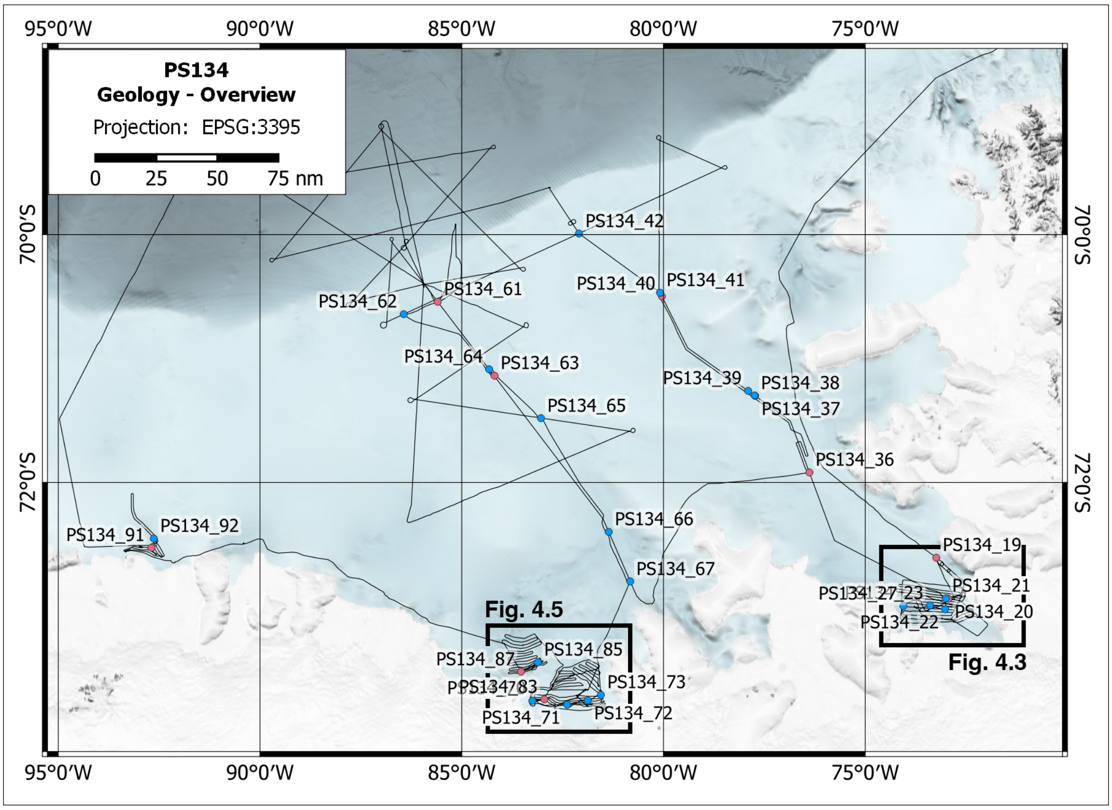

Fig. 4.2: Study area on the Bellingshausen Sea continental shelf with specific survey areas indicated by black frames; red dots indicate combined giant box and gravity coring sites. Blue dots indicate gravity coring sites. Multibeam bathymetry and sediment echography survey areas directed by us are indicated by black frames (background bathymetry is from IBCSO v2; Dorschel et al., 2022) and presented in more detail in Figs. 4.3 and 4.5.

Ronne Entrance

Due to the unusual absence of sea ice on the Bellingshausen Sea shelf at the time of the cruise, we were able to survey a ~2,300 km^2 large area (PS134_14-1; see Table 4.1) in the inner Ronne Entrance in between the George VI Ice Shelf front and Spaatz Island (Fig. 4.3) with the hull-mounted multibeam and sediment echosounders to 1) map past ice flow trajectories, 2) reveal the interaction between subglacial substrate and past overlying ice cover (see example in Fig. 4.4a), and 3) determine thickness variations in post-LGM sediment cover. Guided by those high-resolution multibeam bathymetry and sediment echography data, we recovered 10 giant box and gravity cores from six sites (Fig. 4.3; Table 4.1). Together with the seismic team, we further recorded a short seismic profile across the inner Ronne Entrance for revealing subglacial substrate control of the imaged bathymetric features (profile AWI-20230001, see Chapter 3.1).

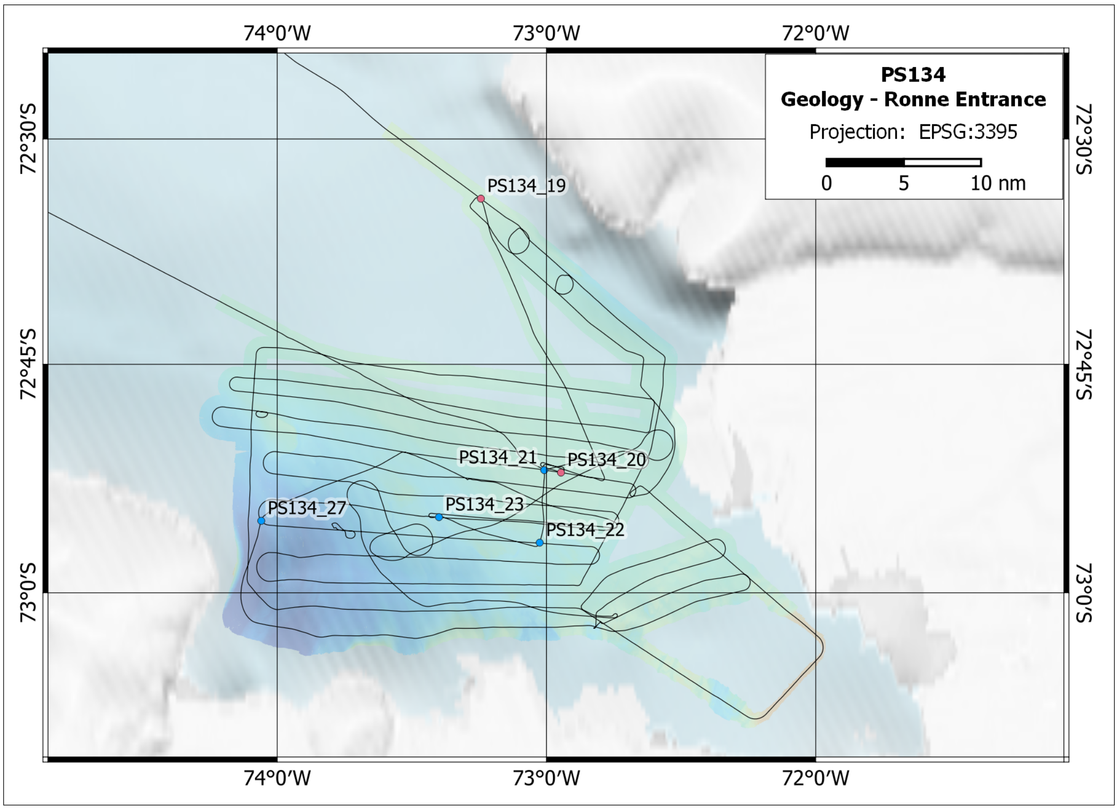

Fig. 4.3: Multibeam bathymetry and sediment echography survey area in inner Ronne Entrance; red dots indicate combined giant box and gravity coring sites. Blue dots indicate gravity coring sites (background bathymetry is from IBCSO v2; Dorschel et al., 2022).

Latady Trough

The Latady palaeo-ice stream trough on the easternmost Bellingshausen Sea shelf drained western Palmer Land (southern Antarctic Peninsula) and Alexander Island and extends from the Ronne Entrance along the western margin of Alexander Island, i.e., Monteverdi and Beethoven peninsulas and Latady Island, towards the continental shelf break (Fig. 4.2). We selected giant box and gravity coring sites along seismic survey line AWI-20230002 (see Chapter 3.1) in the central axis of this trough on the basis of synchronously collected multi-beam bathymetry and sediment echography data (Fig. 4.2). In total, we recovered 10 cores from seven sites (see Table 4.1), mainly from trough sections that remained undisturbed from iceberg scouring and revealed pristine subglacial bedforms, such as mega-scale glacial lineations (MSGLs), sometimes preserved on the upper surfaces of grounding-zone wedges (Fig. 4.4b). These features are usually covered by a thin drape of postglacial strata potentially allowing to constrain minimum grounding line retreat ages from the different portions of this largely unstudied palaeo-ice stream trough (*cf*. Hillenbrand et al., 2010; Larter et al., 2014).

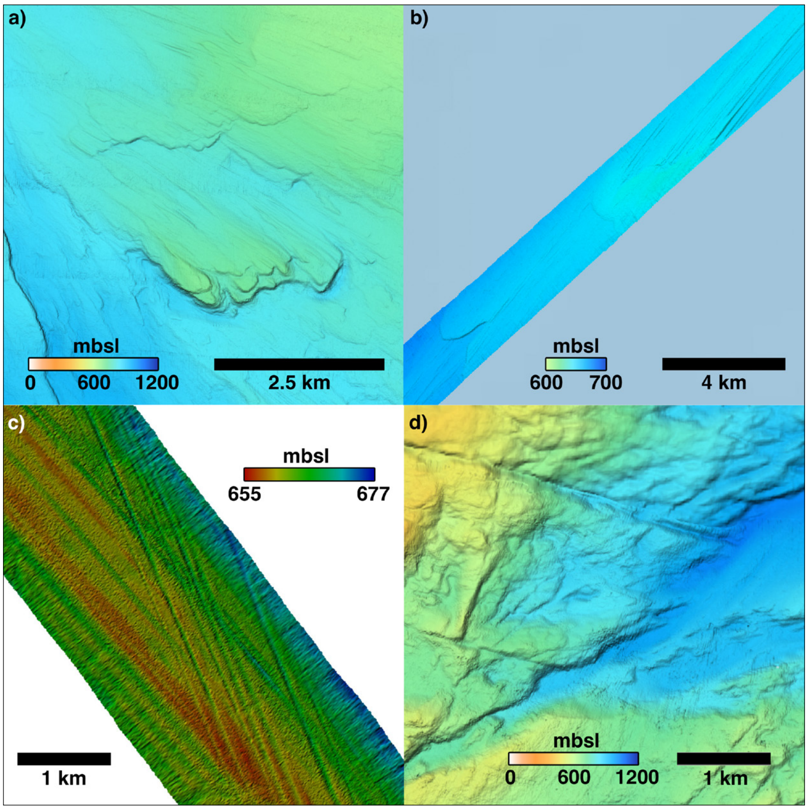

Fig. 4.4: Examples for seafloor features imaged with multibeam bathymetry in a) Ronne Entrance with many present crag-and-tail features, b) Latady Trough showing lineated stacked grounding-zone wedges, c) Belgica Trough with cross-cutting mega-scale glacial lineations, and d) Eltanin Bay revealing tectonically controlled seafloor topography overprinted by past meltwater erosion.

Belgica Trough

During the acquisition of six seismic lines (see Chapter 3.1) along and across one of the most prominent palaeo-ice stream troughs along the West Antarctic margin (e.g., Hillenbrand et al., 2010; Graham et al., 2011; Larter et al., 2014), we investigated the seafloor morphology and subbottom stratigraphy of Belgica Trough for identifying the most ideal sites for sediment coring (Figs. 4.1, 4.2). We mostly focused on seafloor features that indicate stillstand phases during past grounding line retreat – i.e., grounding-zone wedges – and chose sites where glacial lineations (Fig. 4.4c) and overlying postglacial sediments remained undisturbed from later iceberg scouring, therefore providing promising locations not only for constraining minimum grounding line retreat ages but also for characterising the internal composition of such features. Furthermore, we recovered sediment records from 1) debris flow deposits covering MSGLs at the outer trough margin, 2) dipping reflectors of potentially pre-Quaternary sedimentary strata only covered by a thin drape of (post-)glacial deposits, and 3) a crag-and-tail feature at the transition from rough bedrock terrain to sedimentary substrate on the inner trough section. In total, we recovered 10 cores from seven sites along Belgica Trough (Table 4.1).

Eltanin Bay

Led by only sparse existing bathymetric data in the inner part of Eltanin Bay, mainly collected on an expedition by the Korean Polar Research Institute (KOPRI), we directed a ~2,700 km^2 large survey (PS134_68-1; see Table 4.1) together with the bathymetry group in between Wirth Peninsula in the east and the Ferrigno Ice Stream front in the west with our multibeam and sediment echosounders (Fig. 4.5; see also Chapters 3.2 and 3.3). The seafloor topography appears to be largely tectonically-controlled with prominent ice-flow overprinting indicated by e.g., crag-and-tail features and past subglacial meltwater flow (Fig. 4.4d). For revealing past-ice sheet bed conditions and internal composition of subglacial features as well as for reconstructing the history of the last ice advance and retreat, we recovered 10 cores from seven sites in Eltanin Bay (Table 4.1).

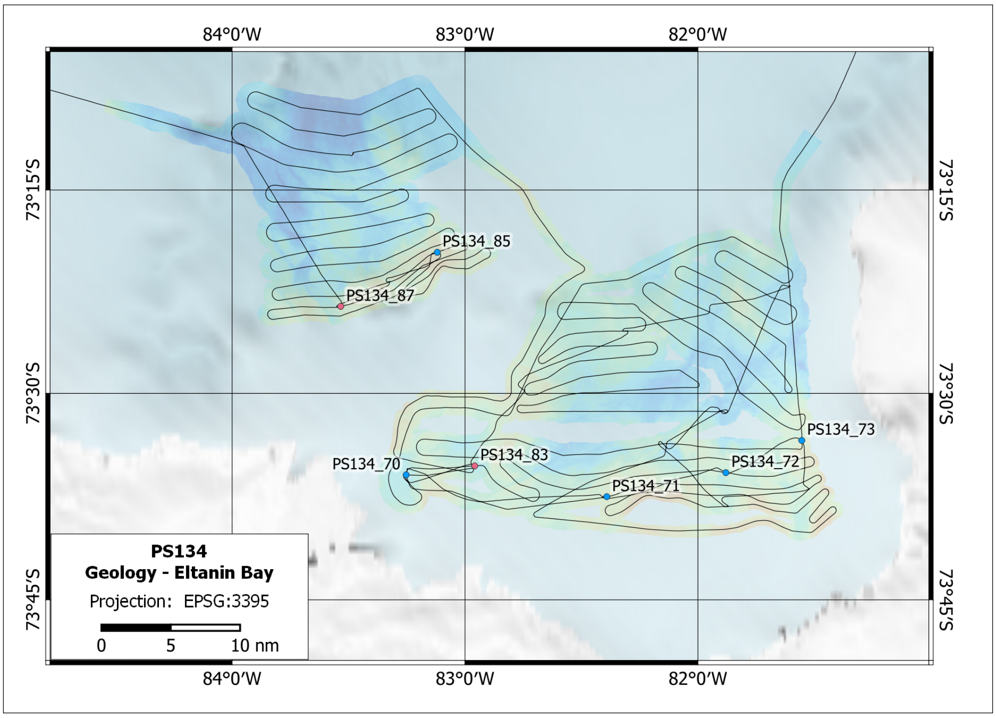

Fig. 4.5: Multibeam bathymetry and sediment echography survey area in Eltanin Bay; red dots indicate combined giant box and gravity coring sites. Blue dots indicate gravity coring sites (background bathymetry is from IBCSO v2; Dorschel et al., 2022).

Offshore eastern Abbot Ice Shelf

Just offshore from the easternmost Abbot Ice Shelf, we imaged the innermost portion of a bathymetric trough that extends in a seaward direction (Fig. 4.2). Pristine glacial lineations as well as crag-and-tail features allow for defining 1) past ice flow directions and 2) the transition between rough bedrock topography and sedimentary substrate along the former flow pathway of the glacier occupying this trough. In order to obtain more detailed information on past ice sheet bed conditions and constrain the timing of past ice sheet cover, we recovered three sediment cores from two sites (Table 4.1).

On-board documentation, scanning, and sampling of sediment cores and seawater

Giant box cores (50 x 50 x 60 cm): Directly after recovery, excess water was siphoned off from the top of the acquired seabed sediment sample, with retaining the lowermost ~2 cm of the water column for analysis of the presence of the most recently settled diatom species. Subsequently, the box core surfaces were photographed and described for documenting their lithological composition, presence of benthic fauna and dropstones, coring disturbance etc. before sub-sampling surface sediment (0-1 cm depth) from a defined area using metal frames for sedimentological and micropalaeontological analyses. Three ~60 cm-long gravity core liners with 12.5 cm diameter were then slowly pushed into the sediment for collecting one subcore for sedimentological analyses and two subcores for archiving at +4 °C and -20 °C, respectively. Another subcore was collected with a multi-core liner with 10 cm diameter and immediately cut into 1 cm slices down-core toits base for further sedimentological analyses, and the upper 5 cm of another subcore retrieved with a multi-core liner with 6.7 cm diameter were immediately sampled at 1 cm depth resolution for biomarker analyses. The jellyfish research group subsampled a ca, 10 cm^2 large area from the surface for eDNA analyses (see Chapter 6).

Gravity cores: After core recovery, plastic liners with the recovered sediment were pulled out of the core barrels, labelled, and cut into 1 m-long sections directly on deck. After cleaning, capping, and sealing them in the lab, the sections were measured and properly labelled, including the end caps. After warming up for ~24 hours, all whole-core sections were scanned with a GEOTEK Multi-Sensor Core Logger (MSCL-S) on board. Based on the magnetic susceptibility, gamma-ray attenuation density and p-wave velocity data collected with the MSCL-S, we split sections from 38 cores, which were photographed and visually described (supplemented by information from lithological smear slides) before we measured the shear strengths of the sediment with a handheld shear vane at pre-defined depths led by lithologic and/or structural variations. The same depth intervals were subsequently sampled using 10 cm^2 syringes for post-cruise analysis of bulk parameters (TOC, TN, water content, etc.) before the entire 1 cm-thick sediment slices were removed as a coarse fraction sample, on which the grain size distribution and microfossil content will be determined by post-cruise analyses. At selected sites, we additionally took water samples from a conductivity-temperature-depth (CTD) rosette system (see Chapter 6) for sampling potential meltwater plume detritus suspended in the water column.

Dating and proxy development

We focused coring mainly on shallow shelf areas adjacent to the troughs above the local Carbonate Compensation Depth (CCD) to recover sediments that bear sufficient amounts of calcareous microfossils, a critical requirement not only for reliable radiocarbon dating of post-LGM ice-sheet retreat but also for utilizing trace element and stable carbon and oxygen isotope compositions of fossil calcareous shells to reconstruct past water mass variability and seawater temperatures. At these shallow water depths, we avoided coring sites heavily scoured by iceberg keels, which would have resulted in the obliteration of the original geomorphological and geological record.

Tab. 4.1: Marine-geological sampling stations on the Bellingshausen Sea continental shelf with colours referring to different study areas – dark blue: Ronne Entrance; orange: Latady Trough; green: Belgica Trough; red: Eltanin Bay; light blue: Trough offshore eastern Abbot Ice Shelf (GBC: Giant Box Corer; GC: Gravity Corer; CTD: Water sampler with associated Conductivity Temperature Depth sensor).

Station	Gear	Lat [deg]	Lon [deg]	Water depth HS [m]	Core recovery/ Deployed length [m]
PS134_14-1	Bathymetric survey				
PS134_19-1	GBC	-72.5665	-73.2440	619	0,38/0,6
PS134_19-2	GC	-72.5666	-73.2434	619	0,2/5
PS134_19-3	GC	-72.5665	-73.2434	620	2,54/5
PS134_20-5	GC	-72.8688	-72.9466	675	2,39/5
PS134_20-6	GBC	-72.8687	-72.9466	674	0,41/0,6

Station	Gear	Lat [deg]	Lon [deg]	Water depth HS [m]	Core recovery/ Deployed length [m]
PS134_21-2	GC	-72.8661	-73.0088	668	0,95/8
PS134_22-1	GC	-72.9453	-73.0257	752	0/5
PS134_22-2	GC	-72.9458	-73.0271	752	0,66/5
PS134_23-1	GC	-72.9175	-73.3996	850	1,32/10
PS134_27-2	GC	-72.9215	-74.0595	1102	2,09/10
PS134_36-1	CTD	-71.9218	-76.3884	612	n/a
PS134_36-4	GBC	-71.9219	-76.3883	611	0,43/0,6
PS134_36-5	GC	-71.9217	-76.3881	611	2,66/5
PS134_37-1	GC	-71.3230	-77.7335	634	2,83/3
PS134_38-1	GC	-71.3200	-77.7467	641	2,34/3
PS134_39-1	GC	-71.2836	-77.9063	662	2,41/3
PS134_40-4	GC	-70.5168	-80.0430	641	2,77/3
PS134_40-5	GBC	-70.5166	-80.0422	642	0,39/0,6
PS134_41-1	GC	-70.4872	-80.0884	642	2,44/3
PS134_42-1	GC	-69.9901	-82.0984	568	2,99/3
PS134_42-2	GC	-69.9902	-82.0985	568	1,2/5
PS134_61-1	GBC	-70.5616	-85.5996	660	0,33/0,6
PS134_61-2	GC	-70.5615	-85.5981	661	0,62/3
PS134_62-1	GC	-70.6636	-86.4413	676	2,9/3
PS134_62-2	GC	-70.6638	-86.4395	676	3,6/5
PS134_63-5	GBC	-71.1629	-84.1897	612	0,38/0,6
PS134_63-6	GC	-71.1631	-84.1903	612	1,1/3
PS134_64-1	GC	-71.1109	-84.3252	637	2,73/3
PS134_65-1	GC	-71.4996	-83.0401	593	2,57/3
PS134_66-1	GC	-72.3738	-81.3605	907	1,0/3
PS134_67-1	GC	-72.7418	-80.8285	794	0,62/3
PS134_68-1	Bathymetric survey				
PS134_69-1	CTD	-73.5215	-81.9035	990	n/a
PS134_70-1	CTD	-73.5989	-83.2543	798	n/a
PS134_70-5	GBC	-73.5989	-83.2532	798	0,7/0,6
PS134_71-1	GC	-73.6254	-82.3919	528	2,06/3
PS134_72-1	GC	-73.5963	-81.8809	644	0,68/3
PS134_73-1	GC	-73.5572	-81.5550	588	2,95/3
PS134_73-2	GC	-73.5572	-81.5545	589	3,96/5
PS134_83-1	GBC	-73.5881	-82.9587	853	0,2/0,6
PS134_83-2	GC	-73.5880	-82.9600	852	3,85/5
PS134_84-1	CTD	-73.2035	-83.4798	1075	n/a
PS134_85-1	GC	-73.3269	-83.1196	498	2,5/3

Station	Gear	Lat [deg]	Lon [deg]	Water depth HS [m]	Core recovery/ Deployed length [m]
PS134_87-1	GBC	-73.3934	-83.5340	664	0,26/0,6
PS104_87-2	GC	-73.3934	-83.5336	663	3,89/5
PS134_91-1	GBC	-72.4925	-92.6927	734	0,24/0,6
PS134_91-3	GC	-72.4923	-92.6915	732	4,27/5
PS134_92-1	GC	-72.4241	-92.6311	635	2,64/5

Preliminary results

In close collaboration with the seafloor and sediment acoustics groups (Chapters 3.2 and 3.3), we carried out bathymetric and sediment echography surveys in Ronne Entrance, Latady Trough, Belgica Trough, Eltanin Bay, and offshore from the easternmost Abbot Ice Shelf (Fig. 3.1) and additionally recovered 43 cores from 30 sites (Table 3.1) in these areas. Absence of sea ice allowed for extensive and coherent multibeam bathymetry and sediment echography surveys (examples in Fig. 3.3; see also Chapters 3.2 and 3.3), which reveal strong substrate control of past ice flow in all surveyed areas. The integration of geophysical and geological data will allow us to define past ice-sheet bed conditions, establish the timing of past glacier advance and retreat, constrain the mechanisms forcing ice-sheet retreat, reconstruct past sea-ice cover, and identify variability of meltwater discharge and its role for past ice-sheet dynamics. Together, the knowledge from the geophysical and geological archives retrieved on the Bellingshausen Sea shelf is urgently needed not only to understand the previous WAIS and APIS dynamics on different time scales, but also to improve models that attempt to accurately predict the future behaviour of these ice sheets.

Data management

National and international partners involved in the expedition will have immediate and preferential access to the cruise report, shipboard data, and retrieved samples. The availability of expedition data and samples will initially remain restricted to these scientists and their collaborators directly involved in the project. After a moratorium period that protects the interests of the project partners, the scientific community will have open access to all data and samples.

In principle, AWI's research data policy follows the principles for the responsible handling of research data, which are based on the recommendations of the Helmholtz Association for guidelines on the management of research data, on the Guidelines of the European Commission on Data Management according to the FAIR principles, and the guidelines of the German Research Foundation (DFG) on handling research data.

AWI aims to publish the primary scientific cruise data as soon as possible. All data will be archived in a publicly accessible, citable long-term repository two years after collection. The archived data may be under moratorium for a maximum of two additional years. In addition, appropriate moratorium periods will be applied for and recorded in the data management plan. After the embargo periods have expired, the data must be made public immediately and actively using the FAIR principles. All data will be stored in international data bases (e.g., PANGAEA, DOD, SCAR SDLS), preferably in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) operated as an open-access library by the AWI and the Center for Marine Environmental Sciences, University of Bremen (MARUM), within two years after the end of the cruise at the latest. By default, the CC-BY license will be applied.

Sediment samples and cores collected during *Polarstern* expeditions will be archived in the AWI Core Repository, which is operated by the marine geology department since 1983. Cores are stored as whole core sections or split core halves in sealed D-tubes at 4° C and at an air humidity limited at 35 %. The repository is open to the scientific community for sampling but subject to ongoing work at AWI, including national and international collaborations.

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 project is supported by the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopics 1 and 3.

In all publications based on this expedition, the **Grant No. AWI_PS134_05** will be quoted and the following publication will be cited:

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

References

Dorschel B, Hehemann L, Viquerat S, Warnke F, Dreutter S, Tenberge YS, Accettella D, An L, Barrios F, Bazhenova E, Black J, Bohoyo F, Davey C, De Santis L, Dotti CE, Fremand AC, Fretwell PT, Gales J., Gao J, Gasperini L, Greenbaum JS, Jencks JH, Hogan K, Hong JK, Jakobsson M, Jensen L, Kool J, Larin S, Larter RD, Leitchenkov G, Loubrieu B, Mackay K, Mayer L, Millan R, Morlighem M, Navidad F, Nitsche FO, Nogi Y, Pertuisot C, Post AL, Pritchard HD, Purser A, Rebesco M, RignotE, Roberts JL, Rovere M, Ryzhov I, Sauli C, Schmitt T, Silvano A, Smith J, Snaith H, Tate AJ, Tinto K, Vandenbossche P, Weatherall P, Wintersteller P, Yang C, Zhang T, Arndt JE (2022) The International Bathymetric Chart of the Southern Ocean Version 2. Scientific Data 9:275. https//doi.org/10.1038/s41597-022-01366-7

Graham AGC, Nitsche FO, Larter RD (2011) An improved bathymetry compilation for the Bellingshausen Sea, Antarctica, to inform ice-sheet and ocean models. The Cryosphere 5:95–106. https://doi.org/10.5194/tc-5-95-2011

Hillenbrand C-D, Larter RD, Dowdeswell JA, Ehrmann W, Ó Cofaigh C, Benetti S, Graham AGC, Grobe H (2010) The sedimentary legacy of a palaeo-ice stream on the shelf of the southern Bellingshausen Sea: Clues to West Antarctic glacial history during the Late Quaternary. Quaternary Science Reviews 29:2741–2763. https://doi.org/10.1016/j.quascirev.2010.06.028

Larter RD, Anderson JB, Graham AGC, Gohl K, Hillenbrand C-D, Jakobsson M, Johnson JS, Kuhn G, Nitsche FO, Smith JA, Witus AE, Bentley MJ, Dowdeswell JA, Ehrmann W, Klages JP, Lindow J, Ó Cofaigh C, Spiegel C (2014) Reconstruction of changes in the Amundsen Sea and Bellingshausen Sea sector of the West Antarctic Ice Sheet since the Last Glacial Maximum. Quaternary Science Reviews 100:55–86. https://doi.org/10.1016/j.quascirev.2013.10.016

5. TERRESTRIAL GEOLOGY: TECTONIC AND GLACIAL HISTORY ALONG THE BELLINGSHAUSEN SEA (TEC-GLA-BELL)

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Grant-No. AWI_PS134_04

Objectives

The Bellingshausen Sea sector of West Antarctica is assumed to host the youngest part of the West Antarctic Rift System, although exact timing is still poorly constrained (Granot et al., 2018). Along with the Amundsen Sea sector, it is among the areas most affected by glacial mass loss in Antarctica (Smith et al., 2020). Although the modern record of thinning rates indicates that glacial bed topography exerts a major control on present-day ice sheet dynamics, knowledge on past tectonics and geomorphology is very deficient. In particular in the Bellingshausen Sea area, palaeotopographic reconstructions mostly rely on data from the Amundsen and Ross Sea sectors (e.g., Paxman et al., 2019). Relief evolution, however, is important for understanding the glaciation history of West Antarctica. It serves as a boundary condition for correctly modelling ice sheet behaviour which, in turn, is required for predicting the future of the West Antarctic Ice Sheet.

A major target of this project is to gain information on timing, location, and extent of tectonic activity along the West Antarctic Rift System, along with information on the palaeotopographic evolution of West Antarctica. Furthermore, we plan to obtain information on coastal deglaciation processes in response to past climate change.

For achieving these goals, we will apply (1) low-temperature radiogenic dating methods to rocks collected from onshore exposures as well as to glacially transported clastic sediment deposited in the Bellingshausen Sea. The latter provides age signatures indicative for erosion and exhumation processes integrated over the sediment source area. For better characterizing the subglacial source area, we will (2) additionally study the petrography of lithoclasts and pebbles contained in the sediment as well as the heavy mineral composition. We (3) collected glacial erratics and glacially eroded bedrock to analyse them for their ^{10}Be contents. The resulting exposure ages provide information since when the sampled areas are free of ice. Data from this part of the project complement the offshore-based work of the Marine Geology and Geophysics groups carried out during cruise PS134.

Onshore sampling

The initial reconnaissance of exposed rock outcrops relied largely on satellite imagery (LIMA). Whenever distance to land, the scheduled research programme and weather conditions allowed, these identified sites were visited using the board helicopters. Accessibility, however, was commonly restricted by local turbulence, steep terrain, ice cover and residential wildlife which limited our sampling campaign down to ten locations (Table 5.1).

In the eastern part of the Bellingshausen Sea, metasedimentary sequences were sampled at two locations on Alexander Island (Fig. 5.1). BEL23-04 comprises quartzitic sandstone from a thinly bedded unit cropping out on the east coast of Ronne Entrance. Further towards the northeast, massive slate was sampled at Staccato Peaks (BEL23-05). The steep cliffs were locally cut by aplitic dykes and overlain by intrusive bodies of granitic to dioritic composition. Both lithologies could not be accessed *in-situ* but specimens were collected from scree.

In the inner Ronne Entrance, three sampling locations were selected on Eklund Islands (Fig. 5.1). While BEL23-01 and BEL23-02 were recovered from flat islands near sea level, BEL23-03 was collected from a nunatak at 312 m elevation. BEL23-01K includes complementary bedrock material for cosmogenic surface exposure dating. All samples are of granitic to granodioritic composition. Additional subsamples were taken from sharply cutting N-S trending basaltic dykes.

The nunataka and accessible outcrops between Ronne Entrance and Eltanin Bay are widely characterised by Cenozoic volcanic edifices. Corresponding basaltic and pyroclastic lithologies were sampled on the east coast of Rydberg Peninsula and the inner Wirth Peninsula (Fig. 5.1, BEL23-06, BEL23-09). A variety of granitic to dioritic and metasedimentary glacial erratics was observed in both locations. On Wirth Peninsula, five erratic boulders were recovered for cosmogenic exposure dating (BEL23-09K). Intrusive complexes underlying the Cenozoic volcanics crop out at sea level approximately 2 km west of Smyley Island and on the northwesternmost point of Wirth Peninsula. They comprise granitic to locally pegmatitic lithologies with aplitic veins (BEL23-07, BEL23-10).

Finally, the attempted deployment of a GPS reference station allowed us to sample exposed sequences of vesicular basalt at Michajlovodden in the southeast of Peter I Island (Fig. 5.1, BEL23-08).

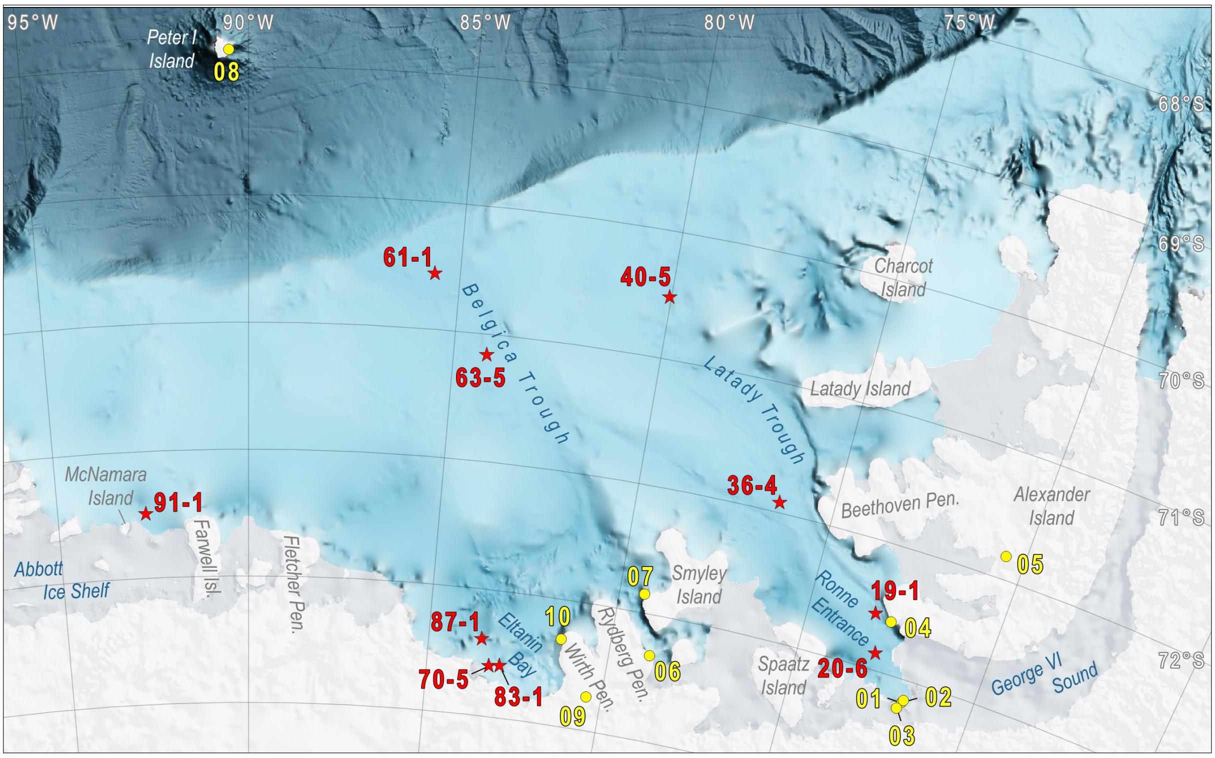

Fig. 5.1: The Bellingshausen Sea sector with onshore rock sampling sites (yellow dots, BEL23-…) and locations of marine box cores (red stars, PS134_...) during PS134.

Offshore sampling

Given the widely inaccessible landsites in the Bellingshausen Sea area, valuable complementary information on the hinterland‘s geology can be derived from terrigenous lithoclasts in the glaciomarine record. Ten giant box cores were recovered in close cooperation with the Marine Geology group (see Chapter 4, Fig. 5.1) and sieved for ice-rafted debris (IRD) greater than 20, 5 and 2 mm. The respective IRD content varied in absolute amount, size distribution and petrography (Table 5.2). From east to west, the relative abundance of volcanic and metasedimentary lithoclasts was significantly reduced while the proportion of intrusive components gradually increased. Large dropstones of 20 to 30 cm in diameter occurred nearshore but also in the mid and outer shelf area along the Belgica Trough.

Tab. 5.1: Onshore field sites of terrestrial geology with sampled lithology on PS134.

Sample-ID	Location	Lat [deg]	Long [deg]	Elevation [m]	Description
BEL23-01	Ronne Entrance, Eklund Islands	-73.1718	-71.8573	6	granite
BEL23-01A	Ronne Entrance, Eklund Islands	-73.1718	-71.8573	6	basalt
BEL23-01B	Ronne Entrance, Eklund Islands	-73.1718	-71.8573	6	diorite
BEL23-01K	Ronne Entrance, Eklund Islands	-73.1718	-71.8573	6	bedrock cosmo: granite
BEL23-02	Ronne Entrance, Eklund Islands	-73.1568	-71.8338	4	granite
BEL23-02A	Ronne Entrance, Eklund Islands	-73.1568	-71.8338	4	basalt
BEL23-03	Ronne Entrance, Eklund Islands	-73.2312	-71.9521	312	granite
BEL23-04	Ronne Entrance, eastern shore	-72.5958	-72.7895	10	metapsammite
BEL23-05	Alexander Island, Staccato Peaks	-71.8200	-70.5031	275	slate
BEL23-05L	Alexander Island, Staccato Peaks	-71.8200	-70.5031	275	scree: aplite, granodiorite
BEL23-06	Rydberg Peninsula, eastern shore	-73.3222	-78.8830	300	basalt
BEL23-06L	Rydberg Peninsula, eastern shore	-73.3222	-78.8830	300	glacial erratics: granite, meta-sediment, tuffite
BEL23-07	Small islands west of Smyley Island	-72.8518	-79.3297	0	granite, pegmatite
BEL23-08	Peter I Island, Michajlovodden	-68.8633	-90.4267	46	basalt
BEL23-09	Wirth Peninsula, Nunatak	-73.7336	-80.4214	796	pyroclastic breccia, tuffite
BEL23-09K	Wirth Peninsula, Nunatak	-73.7336	-80.4214	796	erratics cosmo: granite, diorite
BEL23-10	Small island west of Wirth Peninsula	-73.3134	-81.3574	0	granite

Tab. 5.2: Box coring stations on PS134 (see Chapter 4) with trends in IRD composition. v = volcanics, s = (meta)sediments, i = intrusives; relative abundance: ***high, **moderate, *low.

Station	Location	Lat [deg]	Long [deg]	Depth [m]	IRD content
PS134_19-1	Inner Ronne Entrance, east	-72.5665	-73.2440	619	moderate (v***, s*)
PS134_20-6	Inner Ronne Entrance, central	-72.8687	-72.9466	674	low (v***, s**, i*)
PS134_36-4	Latady Trough, inner shelf	-71.9219	-76.3883	611	high (v**, i**, s*)
PS134_40-5	Latady Trough, mid shelf	-70.5166	-80.0422	642	moderate (v**, s**, i*)
PS134_61-1	Belgica Trough, outer shelf	-70.5616	-85.5996	660	high (s**, i**, v*)
PS134_63-5	Belgica Trough, mid shelf	-71.1629	-84.1897	612	high (s***, i**, v*)
PS134_70-5	Eltanin Bay, near Ferrigno Ice Stream	-73.5989	-83.2532	798	low (s**, i**)
PS134_83-1	Eltanin Bay, near Ferrigno Ice Stream	-73.5881	-82.9587	853	high (s**, i**)
PS134_87-1	Eltanin Bay, near Ferrigno Ice Stream	-73.3934	-83.534	664	high (s**, i**, v*)
PS134_91-1	East of Abbott Ice Shelf	-72.4925	-92.6927	734	high (i***, s**)

Perspectives

The sampled material will be processed and analysed in the frame of a DFG-funded project. Obtained thermochronology and surface exposure dates will provide important new insights in the tectonic evolution as well as glaciation and de-glaciation history of the Bellingshausen Sea sector of West Antarctica.

Data management

Data generated for this project 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.

This project contributes to the Helmholtz Research Programme "Changing Earth – Sustaining our Future" Topic 2, Subtopic 1.

In all publications based on this expedition, the **Grant No. AWI_PS134_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.

References

Granot R, Dyment J (2018) Late Cenozoic unification of East and WestAntarctica. Nature Communications 9:3189.

Paxman G, Jamieson S, Hochmuth K, Gohl K, Bentley M, Leitchenkov G, Ferraccioli F (2019) Reconstructions of Antarctic topography since the Eocene-Oligocene boundary. Palaeogeography, Palaeoclimatology, Palaeoecology 5535:109346.

Smith B, Fricker H, Gardner A., Medley B, Nilsson J, Paolo F, Holschuh N, Adusumilli S, Brunt K, Csatho B, Harbeck K, Markus T, Neumann T, Siegfrie M, Zwally H (2020) Pervasive ice sheet mass loss reflects competing ocean and atmospheric processes. Science 368:1239–1242.

6. MARINE BIOLOGY: CHARACTERIZING JELLYFISH DIVERSITY, DISTRIBUTION AND TROPHIC ROLE ACROSS A LATITUDINAL GRADIENT AND IN UNDEREXPLORED REGIONS OF THE SOUTHERN OCEAN (SO-JELLY)

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Objectives

Southern Ocean (SO) ecosystems have experienced increasing environmental and anthropogenic changes over the last decades. Measurable consequences are particularly evident in, but not limited to, the Antarctic Peninsula, where some ice shelves have already lost up to 18 % of their thickness in less than 20 years (Paolo et al., 2015). These growing impacts have urged scientists to extensively report on SO marine biodiversity and biogeography (e.g., De Broyer et al., 2014), as well as to investigate how these changes may affect its marine biota, food webs, and ecosystem services (e.g., Constable et al., 2014).

Gelatinous zooplankton (hereafter GZP), jellyfish and allies, are a major taxonomically and ecologically diverse group comprising cnidarians (i.e., medusae and siphonophores), ctenophores, and chordates (e.g., salps and pyrosomes). Ubiquitous in all oceans, GZP play a key trophic role in planktonic communities (Hays et al., 2018) and have the potential to form large blooms. GZP are also reputed to be climate change winners and are believed to have significantly increased in numbers over recent decades in many marine ecosystems (e.g., Richardson et al., 2009). This paradigm of “ocean jellification” is supported by the growing evidence of negative impacts of GZP aggregations on human enterprises, such as fisheries and hydropower plants (reviewed in Purcell, 2012). Nonetheless, even though evidence is accumulating, the jellification paradigm is still under heavy debate (*cf*. Pitt et al., 2018). The reason for our inability to confirm recent increases in GZP populations is the critical scarcity of data, and the lack of a reliable baseline (Pauly et al., 2009).

Studies assessing the impact of changing GZP abundance and/or composition in the SO have exclusively been focusing on salps, more easily quantifiable with nets due to their strong tunica, and due to their ongoing range expansion in the rapidly warming Southwest Atlantic sector of the SO (e.g., Plum et al., 2020). Here, the pelagic realm has undergone an ecological shift from a krill-based to a salp-based ecosystem (Atkinson et al., 2004, 2019). Therefore, strong impacts on higher trophic levels such as marine mammals and seabirds, particularly species that depend on Antarctic krill (*Euphausia superba*) as their lipid-rich prey (e.g., Trathan & Hill, 2016) are expected. These changes will also have major biogeochemical implications, influencing local productivity and phytoplankton communities (Cavan et al., 2019; Plum et al., 2020). Besides salps, other GZP groups are prone to increase (or decrease) in biomass due to environmental changes, but so far remain unstudied. Periods dominated by krill and/or salps may alternate regionally with periods dominated by pelagic cnidarians and ctenophores, e.g., in the Antarctic Polar Frontal Zone near South Georgia (Pagès et al., 1996).

Data scarcity on GZP is due to two major reasons. The first is because GZP species, especially ctenophores, are extremely difficult to chemically fix and preserve. Second, the extreme fragility of these soft-bodied organisms, easily fragmented or destroyed with traditional net sampling (Licandro et al., 2015), has led to the underestimation of their biomass and diversity (e.g., Hosia et al., 2017). The use of alternative methods for GZP studies in the SO, such as environmental DNA (eDNA) studies and optical methods, remained extremely rare or non-existent. eDNA studies, targeting macro-organism DNA in environmental samples (water, sediment), without the animal itself having to be present in the sample, represent a major scientific breakthrough of the last years (Thomsen & Willerslev, 2015). This method has shown high potential to characterize the aquatic diversity of different taxa (e.g., Valentini et al., 2016; Thomsen et al., 2016, Bakker et al., 2019, De Jonge et al., 2021), including GZP (Govindarajan et al., 2021). It has also been proven to be a promising tool for assessing polar biodiversity, allowing the detection of non-indigenous species and monitoring both open water and under-ice environments (e.g., Lacoursière-Roussel et al., 2018). Besides detecting presence of GZP in the water column, eDNA can also be used in diet studies. Metabarcoding studies to identify DNA of prey items in predators' stomachs are in the case of rapidly digested gelatinous tissues, the most cost-effective way to detect this otherwise overlooked prey (e.g., Günther et al., 2021). Studies on SO pelagic *Themisto* amphipods have shown that ctenophores and other jellies make up an important part of their diet, which was hitherto not recognized with traditional microscopy of stomach contents (Havermans et al., unpublished results). Since a large proportion of the obtained sequences is not available in existing databases, eDNA analyses should be combined with specimen collection and traditional taxonomy.

With the proposed SO-Jelly programme, we aimed to establish a baseline knowledge on SO GZP, combining traditional net catches for specimen collection with non-invasive eDNA studies to reliably assess GZP diversity and community composition. This was done across a latitudinal gradient in the SO on the transect from Cape Town to the Antarctic Ekström Ice Shelf near *Neumayer Station III*, hereafter referred to as "latitudinal transect", including stations at each side of the Antarctic Polar Front. Furthermore, we sampled GZP in regions for which virtually no GZP studies have been carried out, i.e., the coastal areas and shelves of the Bellingshausen Sea (Lindsay et al., 2014).

We aim to accomplish the following objectives:

- Study GZP species diversity. We will perform an integrative taxonomic study combining morphological and molecular tools. The main outcome includes a reference DNA database covering the molecular diversity of the species encountered in the different water masses, which will serve further eDNA and molecular diet studies. The obtained sequences from different regions will allow us to study genetic connectivity of widespread GZP species – using net catches, DNA barcoding and phylogeographic analyses;
- Assess distributions and abundances of GZP species and link these to environmental parameters. Species distributions were assessed vertically from the surface across the midwater zone and along a latitudinal gradient covering different water masses. These data allowed us to study distributional patterns of different species in different regions, by sampling along a latitudinal transect across the Antarctic Front, and sections across the shelf break in the Bellingshausen Sea, – using net catches, eDNA metabarcoding of water and sediment samples, phylogeographic analyses, 3D ecological niche modelling;

- Study speciation processes and test population connectivity at oceanic scale. The presence of the same species in both poles, also known as bipolarity, constitutes a major speciation process over oceanic scale. For a subset of selected bipolar species, we will compare our previously obtained samples from the Arctic and sub-Arctic/boreal regions with the ones we obtained during this expedition. Species delimitation based on Sanger sequencing, and divergence time based on High-Throughput Sequencing will be then overlapped with life cycle history and character evolution to obtain a novel and more complete perspective of the origin and evolutionary consequences of bipolarity – using net catches, DNA barcoding, phylogeographic analyses, genomics;
- Elucidate the trophic role of dominant jellies in the SO food webs. The importance of different jelly species as prey for pelagic amphipods will be evaluated – using net catches, molecular diet analyses.

This baseline knowledge will pave the way for future studies exploring the consequences of potential increases (or decreases) in jelly biomass and distributional shifts for the rapidly changing SO pelagic ecosystems.

Work at sea

CTD casts were conducted at 17 stations. At 16 of these stations, various net deployments, including vertical net casts with the Midi-Multinet and towed Bongo nets, were conducted (see Fig. 6.1, Table 6.1, and Appendix A.7). Sediment was also sampled from giant box core deployments at eight stations.

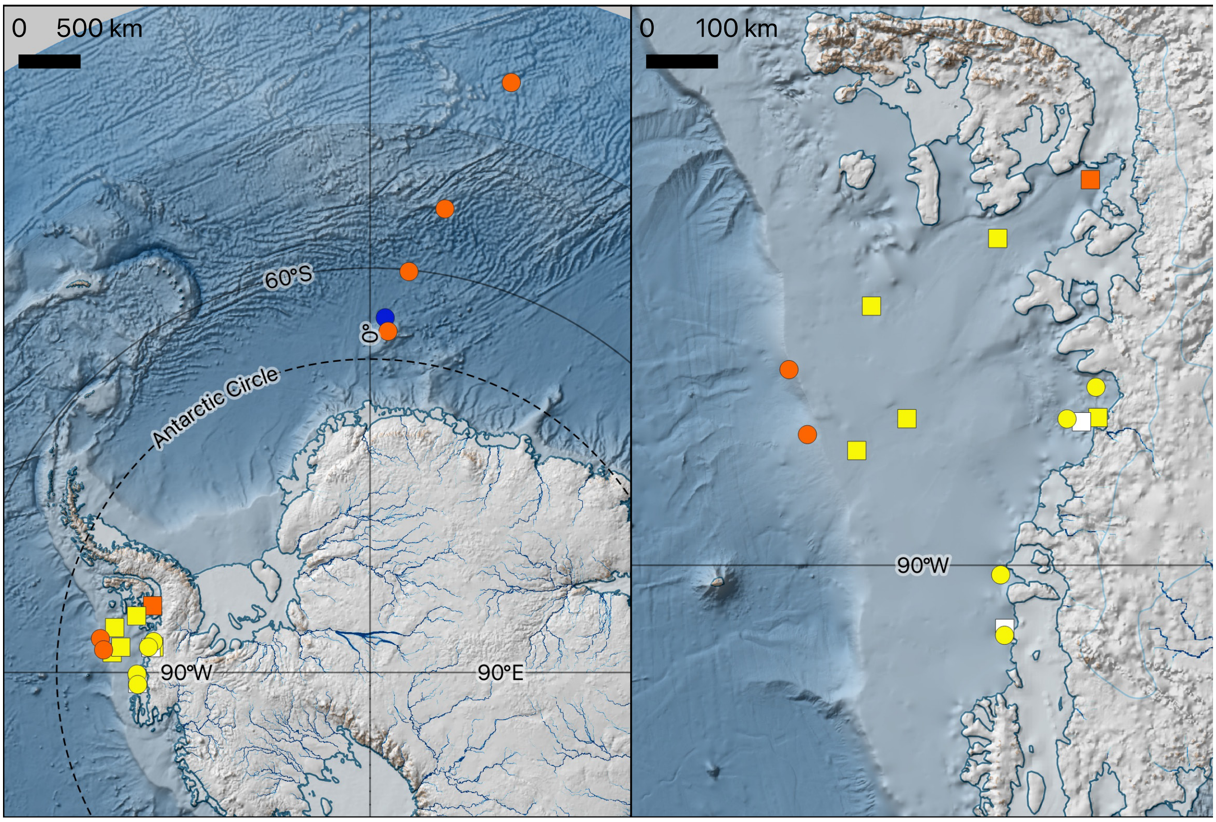

Fig. 6.1: Sampling stations. Circles = pelagic deployments, rectangle = pelagic deployments + boxcorer; blue = CTD cast only, yellow = CTD + Midi-Multinet (MN), orange = CTD + MN + Bongo net, and white = only sediments collected.

Tab. 6.1: SO-JELLY deployments and sampling during PS134.

		Station	Coordinates	Water depth (m)	CTD (Maximum depth, m)	Multinet (Maximum depth, m)	Bongo (Wire length, m)	Sediment (Depth, m; number of cores)
LATITUDINAL TRANSECT		PS-134-2	46°10.319´S 13°27.618´E	4876	2000	2000	450	-
		PS134-3	55°25.903´S 9°10.434´E	5025	2000	2000	450	-
		PS134-4	60°07.162´S 5°32.542´E	5171	1800	2000	450	-
		PS134-5	63°31.956´S 2°26.593´E	4304	2000	-	-	-
		PS134-10	64°30.067´S 3°00.453´E	2087	2000	2000	450	-
Bellingshausen Sea	Transect A	PS134-20	72°52.14´S 72°56.89´W	675	640	600	450	674; 1
		PS134-36	71°55.31´S 76°23.28´W	612	585	550	-	611; 1
		PS134-40	70°30.99´S 80°02.52´W	642	600	600	-	642; 1
		PS134-44	69°35.82´S 82°50.69´W	1133	1000	1000	330	-
	Transect B	PS134-59	70°33.66´S 85°35.95´W	661	600	600	-	660; 1
		PS134-60	69°55.02´S 85°8.99´W	1148	1000	1000	450	-
		PS134-63	71°09.77´S 84°11.42´W	612	580	580	-	611; 1
		PS134-70	73°35.88´S 83°15.41´W	798	760	760	-	664; 1
	Transect C	PS134-69	73°31.30´S 81°54.11´W	983	950	950	-	-
		PS134-84	73°12.27´S 83°28.87´W	1070	1000	1000	-	-
		PS134-89	72°27.53´S 90°24.38´W	915	900	890	-	-
		PS134-90	72°20.102´S 92°59.130´W	617	560	550	-	-

CTD profiles and in-situ water sampling for eDNA studies

At each station, the CTD rosette cast was carried out, preceding, or following net sampling. One CTD cast along the latitudinal transect was carried out without net sampling. Depth distribution of water masses will be determined based on the vertical profiles of temperature, salinity, dissolved oxygen, and fluorescence measurements (as a proxy for chlorophyll-*a* concentration). The rosette was used to sample water at different depth intervals. A total of 17 CTD casts were conducted, resulting in 482 eDNA samples from filtered sea water. During the latitudinal transect, five CTD casts up to 2,000 m deep were carried out, resulting in 328 L of filtered water (164 filtered eDNA samples), sampled from up to 11 depth layers. In the Bellingshausen Sea, water was collected from 12 different stations, from up to 1,000 m deep, resulting in 636 L of filtered water (318 filtered eDNA samples), sampled from up to 11 depth layers.

Water samples of 2 L were collected in triplicates, corresponding to the depth layers sampled with the stratified Midi-Multinet hauls. At first, an extraction blank (Milli-Q water) was filtered at each station to monitor cross-contamination between samples. Sea water was then filtered through Sterivex cellulose filters of 0.2 µm average pore size. Filters containing eDNA were frozen at -80° C until further analyses (DNA extraction and sequencing) at the AWI home laboratories.

Net sampling

Meso- and macrozooplankton, including GZP, were collected using net deployments. Stratified vertical hauls with the Midi-Multinet provided information on vertical distribution patterns and will be compared with the results of our planned eDNA studies. The Midi-MN has a 0.25 m^2 mouth opening and an opening-closing mechanism with 5 net bags with a 150 µm mesh size. It was vertically lowered at 0.5 m/s and hauled at 0.3 m/s. The volume of water sampled was obtained through flowmeters attached to the frame of the Midi-MN. The Bongo net consisted of two nets, with a mouth opening of 60 cm diameter and a 300 µm mesh size. It was equipped with non-filtering cod ends and a V-fin depressor attached to the net frame. Oblique tows with the Bongo net allowed us to catch the larger-sized, fast-swimming macrozooplankton (e.g., larger jellies and hyperiid amphipods) and small nekton (e.g., fish juveniles). The net was towed sideways at a ship's speed up to two knots while being lowered and hauled at 0.5 m/s.

Sample preparation for molecular analyses

After retrieving the nets, GZP species abundances were calculated based on the volume of water sampled on the MN deployments. For all nets, freshly caught individual GZP were photographed with particular attention to identification features (e.g., gonads, manubrium, umbrellar marginal structures, tentacles, and oral arms) depending on the taxonomic group. A ruler was added when photographing the specimens so that their size can be obtained from the photographs. If taxonomically/ecologically interesting specimens were damaged during collection (e.g., *ctenophores* or delicate *hydrozoan medusae*), short-term maintenance in Kreisel aquariums was performed to facilitate regeneration and further characterization. Three preservation methods were used, allowing us to maximize the usage of samples for a large set of analyses. Most specimens were preserved in ethanol (96 %) for posterior DNA barcoding and reference library construction. For some large/delicate specimens a small piece of tissue was removed and preserved in 96 % ethanol or frozen at -80 °C for subsequent molecular studies. The remaining specimens were preserved in 10 % formalin for subsequent morphological analyses. *Hyperiid amphipods* were preserved in 96 % ethanol for molecular diet analyses of their stomach contents. Tunicates and fish juveniles were preserved in -80 °C. Other zooplankton groups, like polychaetes, krill, chaetognaths, pteropods and bulk rest content of the nets were preserved in 96 % ethanol.

Sediment sampling for eDNA studies

No sediment was sampled during the latitudinal transect. In the Bellingshausen Sea, sediment was collected from eight box corer deployments, in collaboration with the Marine Geology working group on board, led by Johann P. Klages. Triplicate surface sediment samples (first millimetres) were taken for eDNA metabarcoding analyses. Sediment samples were stored at -80° C until further analyses (DNA extraction and sequencing) in the AWI home laboratories.

Preliminary and expected results

GZP species composition and other zooplankton based on net catches

We sampled gelatinous zooplankton using two types of nets at 16 different stations. The total number of individuals caught during the different net deployments carried out at each station and species richness based on our preliminary morphological identification are listed in Tab. 6.2. After confirming species identification with molecular analyses at our home facilities, we will calculate abundances for all the species sampled based on the number of individuals per volumes of water filtered with the different nets. GZP species composition and abundances will be determined for each net haul and linked with oceanographic data identified in the CTD profiles. Vertical distribution and diversity will be assessed based on the depth-stratified Multinet hauls. This will allow us to infer regional and bathymetric differences in GZP community composition and distributions. These data will also be used to validate the obtained eDNA results on GZP distribution.

Tab. 6.2: Gelatinous zooplankton sampled with net deployments at the different PS134 stations. The number of specimens recovered at each station and the species richness are listed.

Station	Number of specimens	Species richness
PS134-2	82	11
PS134-3	46	9
PS134-4	136	18
PS134-5	0	0
PS134-10	198	20
PS134-20	249	17
PS134-36	103	8
PS134-40	115	10
PS134-44	196	15
PS134-59	64	4
PS134-60	18	2
PS134-63	142	6
PS134-70	270	15
PS134-69	368	14
PS134-84	129	17
PS134-89	423	18
PS134-90	304	16
Total	**2843**	**56**

A total of 2,843 specimens of gelatinous zooplankton have been collected (Tab. 6.2) during PS134. Fifty-six species/morphospecies have been identified, including several potentially undescribed species and rare deep-sea jellies. The species number is expected to rise after further in-depth morphological and molecular work is performed. A great majority of the specimens found (ca. 80 %) were photographed using high-resolution extreme-macro photography, which will facilitate subsequent taxonomic analyses. In some cases, the animals were acclimatized and/or recovered in Kreisel tanks for several hours, prior to be photographed. This allowed us to obtain pictures of individuals in very good conditions and displaying more natural positions/behaviours (Fig. 6.2).

Fig. 6.2: Selection of some gelatinous zooplankton species obtained during PS134. A Amphinema rubrum; B Heteropyramis cristallina; C Crossota brunea; D Callianira cristata; E Diphyes antarctica, F Pyrostephos vanhoeffeni, G Zanclonia weldoni; H Beroe sp.; I Solmundella bitentaculata; J Mitrocomidae; K Dimophyes arctica. Images taken by Joan J. Soto- Àngel

The siphonophore *Dimophyes arctica* (N = 634), the hydromedusae *Solmundella bitentaculata* (N = 548) and *Arctapodema ampla* (N = 213), and the comb jelly *Callianira cristata* (N = 244) were the most abundant GZP sampled. Locally, the density of *Solmundella bitentaculata* reached values of 2 specimens per cubic meter for some of the depth ranges surveyed in the Bellingshausen Sea, which constitutes the highest densities ever reported in Antarctic waters (*cf*. Pagès & Kurbjeweit, 1994; Pagès & Schnack-Shield, 1996). Our preliminary data show a higher proportion of holoplanktonic species (including *siphonophores* and *Trachymedusae*) in open-water regions, but a higher GZP abundance and diversity in coastal areas. This is particularly true for the comb jelly *Callianira cristata,* with extraordinarily high abundances (> 1 individual per cubic meter) observed in the vicinity of the ice shelf in the Bellingshausen Sea stations. Species composition and abundance data will be linked to the different oceanographic variables surveyed (temperature, salinity, dissolved oxygen, primary productivity) in order to determine the key drivers for GZP distribution.

As an example, the depth distribution of different GZP taxa at the two southernmost stations (PS134_4 and PS134_10) of the latitudinal transect are given in Fig. 6.3. Although these two stations had same depths and similar temperature, salinity, and dissolved oxygen profiles (Fig. 6.4), the number and vertical distributions of the different taxa strongly varied. As observed through all our survey, siphonophores were the most abundant taxa, followed by hydromedusae. Both taxa were present at all depths except at the surface (0-20 m) depth. Ctenophores and tunicates were less commonly found at those two stations, but they were present at different depths including the shallowest waters.

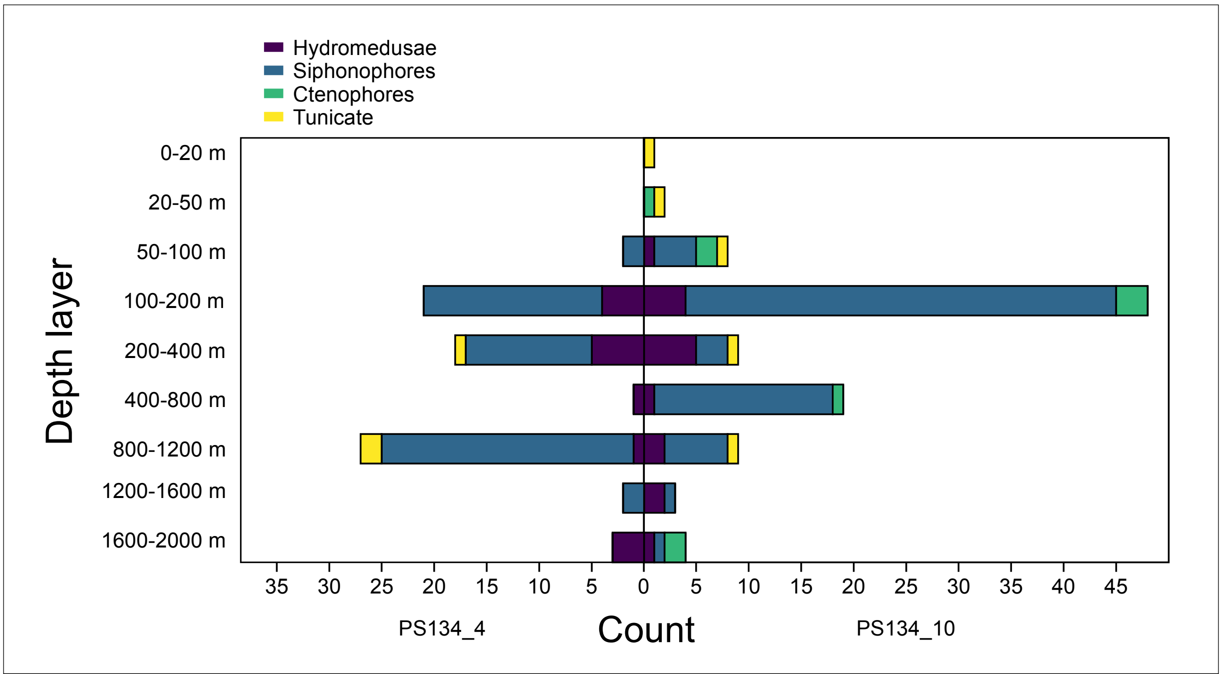

Fig.6.3: Vertical distribution of the main gelatinous zooplankton groups collected by Midi-MN at the two southernmost stations of the latitudinal transect, namely PS134_4 and PS134_10.

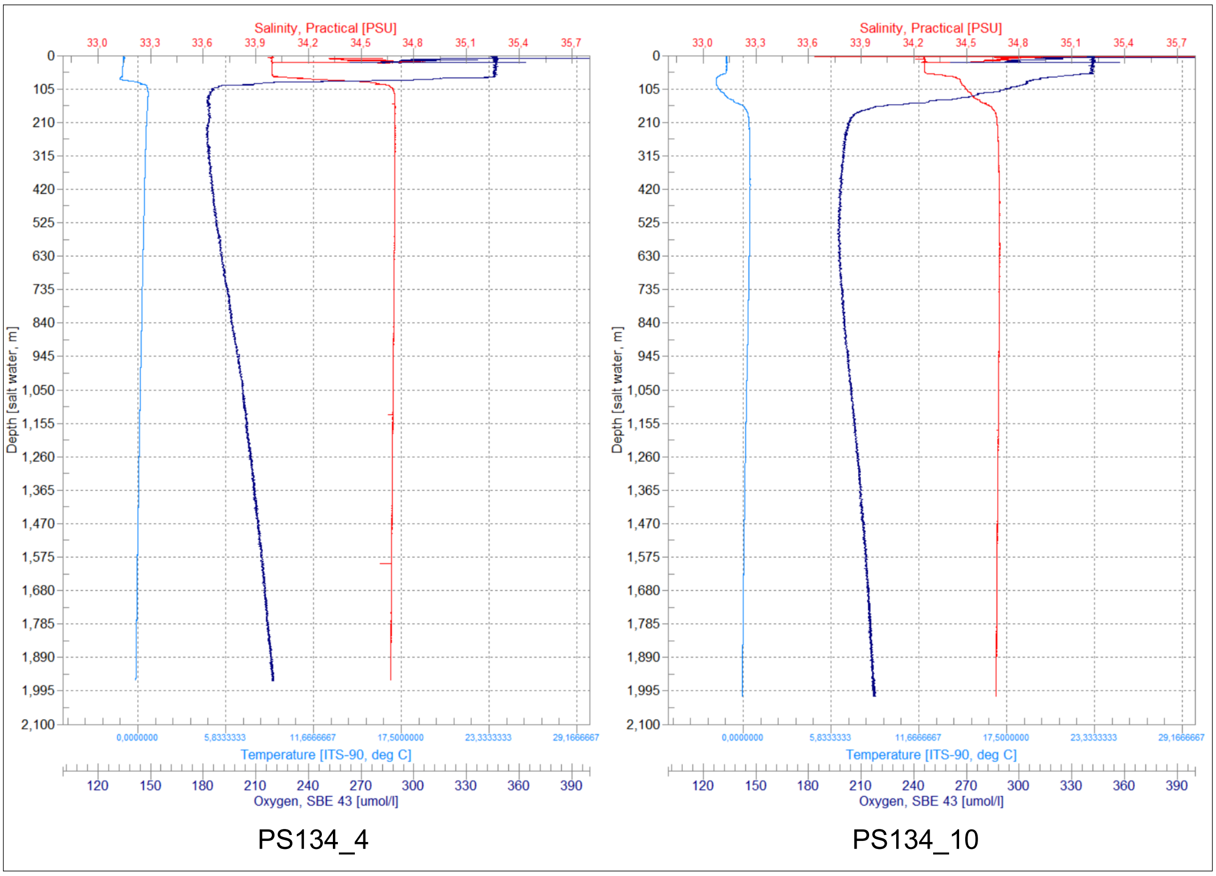

Fig. 6.4: CTD profiles of stations PS134_4 and PS134_10

We sampled zooplankton using the Midi-Multinet and Bongo net in 16 stations during the latitudinal transect, and in the Bellingshausen Sea. Midi-Multinet catches were counted for further analysis. The most abundant macrozooplankton groups encountered during this expedition were polychaetes, krill, chaetognaths, and copepods (Fig.6.5).

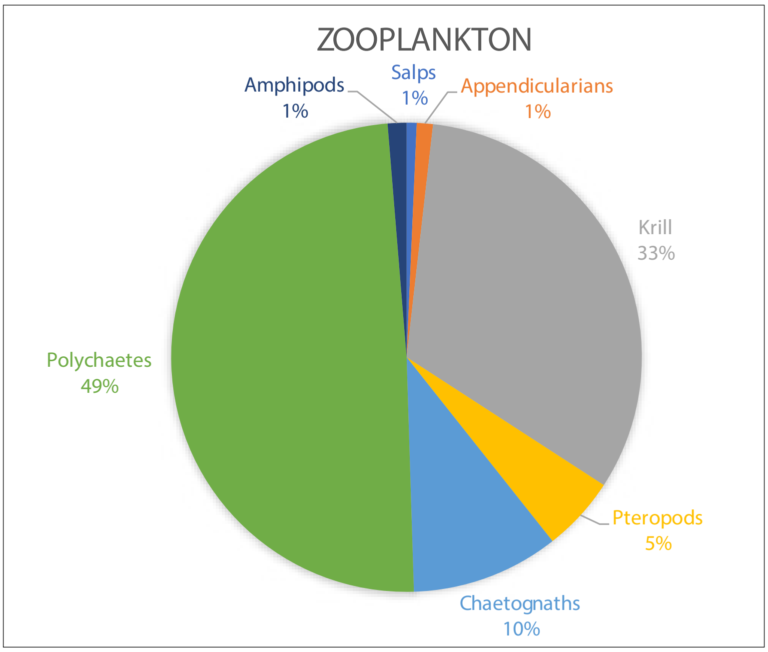

Fig. 6.5: Proportions of macrozooplankton groups (excluding copepods) in the Midi-Multinet catches during PS134.

Integrative reference database

A main outcome of this project is the establishment of a reference DNA database of GZP for the Southern Ocean, covering the molecular diversity of the species encountered in the expedition. To do so, we will integrate the morphological identifications of the specimens collected with their DNA sequences, targeting the same genetic markers that will be used for eDNA metabarcoding, DNA barcoding, and molecular diet analyses.

DNA barcoding, systematics, and phylogeographic analyses

All samples collected during SO-Jelly will be barcoded for the cytochrome *c* oxidase subunit I gene (COI) as well as the 16S and 18S ribosomal RNA genes (16S and 18S). Taxonomic descriptions and revisions will be conducted by describing, photographing, and keeping vouchers for relevant specimens, including barcoding information. Based on the barcoding information from the latitudinal transect, the variation in GZP communities will be tested multivariate analyses of community composition. We will test whether GZP species' populations are homogenous, and likely connected with gene flow, or are, geographically structured or composed of distinct genetic lineages.

Species delimitation, speciation, and bipolarity

Antarctic waters are home to several GZP endemic species (e.g., Ronowicz et al., 2019). Among them, some are known to display a bipolar distribution. Bipolarity, or the presence of the same species in both poles (Stepanjants et al., 2006), is a major speciation process over oceanic scale, and the greatest disjunct distribution pattern on earth (Crame, 1993). Even though bipolarity was documented nearly two centuries ago, it has been rarely evaluated in an evolutionary context (Allcock & Griffiths, 2014). The evolutionary origin and diversification of bipolar taxa is still mostly unknown for most groups. Species delimitation methods (using COI, 16S and 18S genes) will allow to determine potential bipolar taxa (i.e., whether or not our case studies represent the same lineage in both poles). Double digest restriction-site associated DNA sequencing (ddRADseq) will be performed on particular taxa to reconstruct the evolutionary history of selected morphological traits and evaluate the origin of bipolarity between the northern taxa (sampled during previous Arctic expeditions) and the southern taxa. The comparison between species with different life cycles (e.g., with or without a medusa stage) will reveal if the different strategies (i.e., different dispersal capabilities) condition the divergence time between the northern and southern clades. Two good holoplanktonic candidates for these studies collected in sufficient number during PS134 and present at both poles were the species *Dimophyes arctica* and *Solmundella bitentaculata.*

Environmental DNA (eDNA) metabarcoding analyses for assessing GZP communities

Environmental DNA metabarcoding analysis can provide detailed and accurate biodiversity assessments of marine zooplankton communities. We will use this method to investigate GZP diversity based on water and sediment samples from different depths of the CTD casts and box corer deployments. DNA will be extracted and library preparation with PCR technical triplicates per sample will be carried out. Universal and GZP group-specific primers will be implemented. The universal primers include the V4 region (450 bp) of 18S rRNA (Balzano et al., 2015) and a 313-bp fragment of COI (Leray et al., 2013). This variable 18S rRNA V4 region is known to perform well in both community clustering and taxonomic assignments across a very wide taxonomic range of eukaryotes (e.g., Blanco-Bercial, 2020; Questel et al., 2021) whereas the barcode region of mitochondrial COI will provide a finer assay of metazoan community diversity in general (Questel et al., 2021). Whereas the 18S rRNA fragment appears to be more efficient in detecting tunicates and ctenophores, the Leray COI primers have been proven useful for discriminating a wide range of cnidarian species (Rathnayake, 2022). Reads generated with an Illumina NovaSeq sequencing platform will be processed and clustered into operational taxonomic units using bioinformatic pipelines. Non-metric multidimensional scaling (nMDS) will be used to evaluate the differences in taxonomic composition as well as regional differences in GZP communities and species richness.

Molecular diet analyses

Stomach contents of hyperiid amphipods will be studied with DNA metabarcoding in order to assess GZP predation. We will apply a similar combination of universal primers (COI, 18S) as for the aforementioned eDNA analyses to detect the occurrence of jelly DNA reads in predators' stomachs. The workflow is similar to the one described above for eDNA analyses, from DNA extraction to NovaSeq sequencing and taxonomic assignments. Prey compositions will be analysed using multivariate analyses and diversity indexes. MOTU richness will be calculated by rarefying to the number of reads corresponding to the sample with the least reads to allow for statistical comparison among predator species and sampling sites.

Data management

Zooplankton and eDNA samples, as well as eDNA extracts, will be archived and stored at the AWI. GZP, both specimens and DNA extracts, will be stored either at the AWI or the University Museum of Bergen (Norway). DNA extracts will be stored at -80° C for up to 10 years after publication of the results (according to the DFG guidelines for good scientific practice). A voucher collection of ethanol preserved jelly specimens, linked to their DNA extracts, will be kept in a repository at the AWI and/or the University Museum of Bergen. Geo-referenced environmental data sets such as GZP distribution records and species inventories from net catches 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.

Biogeographic datasets will also feed other databases (e.g., OBIS, GBIF). Molecular 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. Results on eDNA metabarcoding analyses will be published in peer-reviewed journals within three years after the cruise. 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_PS134_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.

References

Allcock AL, Griffiths HJ (2015) Bipolarity. In De Broyer C, Koubbi P, Griffiths HJ et al (eds), Biogeographic Atlas of the Southern Ocean. Scientific Committee on Antarctic Research, Cambridge: 431–436.

Atkinson A, Siegel V, Pakhomov E, Rothery P (2004) Long-term decline in krill stock and increase in salps within the Southern Ocean. Nature 432:100–103. https://doi.org/10.1038/nature02950.1.

Atkinson A, Hill SL, Pakhomov EA, et al (2019) Krill (*Euphausia superba*) distribution contracts southward during rapid regional warming. Nature Climate Change 9:142–147. https://doi.org/10.1038/s41558-018-0370-z

Balzano SEA, Leterme S (2015). Protist diversity along a salinity gradient in a coastal lagoon. Aquatic Microbial Ecology 74: 263–277. doi:10.3354/ame01740

Bakker J, Wangensteen OS, Baillie C, et al (2019) Biodiversity assessment of tropical shelf eukaryotic communities via pelagic eDNA metabarcoding. Ecology and Evolution 9:14341–14355. https://doi.org/10.1002/ece3.5871

Blanco-Bercial L (2020) Metabarcoding Analyses and Seasonality of the Zooplankton Community at BATS. Frontiers in Marine Science 7:1–16. https://doi.org/10.3389/fmars.2020.00173

Cavan EL, Laurenceau-Cornec EC, Bressac M, Boyd PW (2019) Exploring the ecology of the mesopelagic biological pump. Progress in Oceanography 176:102125. https://doi.org/10.1016/j.pocean.2019.102125

Constable AJ, Melbourne-Thomas J, Corney SP, et al (2014) Climate change and Southern Ocean ecosystems I: How changes in physical habitats directly affect marine biota. Global Change Biology 20:3004–3025. https://doi.org/10.1111/gcb.12623

Crame JA (1993) Bipolar molluscs and their evolutionary implications. Journal of Biogeography 20: 145–161. https://doi.org/10.2307/2845668

De Broyer C, Koubbi P, Griffiths HJ, et al (eds) (2014) Biogeographic Atlas of the Southern Ocean. Scientific Committee on Antarctic Research, Cambridge

De Jonge DSW, Merten V, Bayer T, et al (2021) A novel metabarcoding primer pair for environmental DNA analysis of Cephalopoda (Mollusca) targeting the nuclear 18S rRNA region. Royal Society Open Science 8:201388. https://doi.org/10.1098/rsos.201388

Govindarajan A, Francolini R, Jech JM, Lavery AC, Llopiz J, Wiebe PH, Zhang WG (2021). Exploring the use of environmental DNA (eDNA) to detect animal taxa in the mesopelagic zone. Frontiers in Ecology and Evolution 9(146).

Günther B, Fromentin JM, Metral L, Arnaud-Haond S (2021) Metabarcoding confirms the opportunistic foraging behavior of Atlantic bluefin tuna and reveals the importance of gelatinous prey. PeerJ 9:e11757. https://doi.org/10.7717/peerj.11757

Hays GC, Doyle TK, Houghton JDR (2018) A Paradigm Shift in the Trophic Importance of Jellyfish? Trends in Ecology and Evolution 33:874–884. https://doi.org/10.1016/j.tree.2018.09.001

Hosia A, Falkenhaug T, Baxter EJ, Pagès F (2017) Abundance, distribution and diversity of gelatinous predators along the northern Mid-Atlantic Ridge: A comparison of different sampling methodologies. PLoS ONE 12:1–18. https://doi.org/10.1371/journal.pone.0187491

Lacoursière-Roussel A, Howland K, Normandeau E, et al (2018) EDNA metabarcoding as a new surveillance approach for coastal Arctic biodiversity. International Journal of Business Innovation and Research 17:7763–7777. https://doi.org/10.1002/ece3.4213

Leray M, Yang JY, Meyer CP, et al (2013) A new versatile primer set targeting a short fragment of the mitochondrial COI region for metabarcoding metazoan diversity: Application for characterizing coral reef fish gut contents. Frontiers in Zoology 10:1–14. https://doi.org/10.1186/1742-9994-10-34

Licandro P, Blackett M, Fischer A, et al (2015) Biogeography of jellyfish in the North Atlantic, by traditional and genomic methods. Earth System Science Data 7:173–191. https://doi.org/10.5194/essd-7-173-2015

Lindsay D, Guerrero E, Grossmann M, Fuentes V (2014) Southern Ocean gelatinous zooplankton. In: De Broyer C, Koubbi P, Griffiths HJ, et al. (eds) Biogeographic Atlas of the Southern Ocean. Cambridge, pp 266–275

Pagès F, Kurbjeweit (1994) Vertical distribution and abundance of mesoplanktonic medusae and siphonophores from the Weddell Sea, Antarctica. Polar biology 14:243–251

Pagès F, Schnack-Schiel SB (1996) Distribution patterns of the mesozooplankton, principally siphonophores and medusae, in the vicinity of the Antarctic Slope Front (Eastern Weddell Sea). Journal of Marine Systems 9: 231–248

Pagès F, White MG, Rodhouse PG (1996) Abundance of gelatinous carnivores in the nekton community of the Antarctic Polar Front Zone in summer 1994. Marine Ecology Progress Series 141: 139–247

Paolo FS, Fricker HA, Padman L (2015) Volume loss from Antarctic ice shelves is accelerating. Science 348:327–331. https://doi.org/10.1126/science.aaa0940

Pauly D, Graham W, Libralato S, et al (2009) Jellyfish in ecosystems, online databases, and ecosystem models. Hydrobiologia 616:67–85. https://doi.org/10.1007/s10750-008-9583-x

Pitt KA, Lucas CH, Condon RH, et al (2018) Claims That Anthropogenic Stressors Facilitate Jellyfish Blooms Have Been Amplified Beyond the Available Evidence: A Systematic Review. Frontiers in Marine Science 5:1–11. https://doi.org/10.3389/fmars.2018.00451

Plum C, Hillebrand H, Moorthi S (2020) Krill vs salps: dominance shift from krill to salps is associated with higher dissolved N:P ratios. Scientific reports 10:5911. https://doi.org/10.1038/s41598-020-62829-8

Purcell JE (2012) Jellyfish and ctenophore blooms coincide with human proliferations and environmental perturbations. Annual Review of Marine Science 4:209–235. https://doi.org/10.1146/annurev-marine-120709-142751

Questel JM, Hopcroft RR, DeHart HM, et al (2021) Metabarcoding of zooplankton diversity within the Chukchi Borderland, Arctic Ocean: improved resolution from multi-gene markers and region-specific DNA databases. Marine Biodiversity 51:1–19

Rathnayake PKWIN (2022) Diet analysis of two hyperiid amphipods in the southern Benguela Upwelling System using DNA metabarcoding. MSc thesis, University of Bremen, 89 pp.

Richardson AJ, Bakun A, Hays GC, Gibbons MJ (2009) The jellyfish joyride: causes, consequences and management responses to a more gelatinous future. Trends in Ecology and Evolution 24:312–322. https://doi.org/10.1016/j.tree.2009.01.010

Ronowicz M, Peña Cantero ÁL, Mercado Casares B, Soto-Angel JJ (2019) Assessing patterns of diversity, bathymetry and distribution at the poles using Hydrozoa (Cnidaria) as a model group. Hydrobiologia 833:25–51. https://doi.org/10.1007/s10750-018-3876-5

Stepanjants SD, Cortese G, Kruglikova SB, Bjørklund KR (2006). A review of bipolarity concepts: history and examples from Radiolaria and Medusozoa (Cnidaria). Marine Biology Research 2: 200–241. https://doi.org/10.1080/17451000600781767

Thomsen PF, Møller PR, Sigsgaard EE, et al (2016) Environmental DNA from Seawater Samples Correlate with Trawl Catches of Subarctic, Deepwater Fishes. PLoS ONE 11:e0165252. https://doi.org/10.1371/journal.pone.0165252

Thomsen PF, Willerslev E (2015) Environmental DNA - An emerging tool in conservation for monitoring past and present biodiversity. Biological Conservation 183:4–18. https://doi.org/10.1016/j.biocon.2014.11.019

Valentini A, P T, C M, et al (2016) Next-generation monitoring of aquatic biodiversity using environmental DNA metabarcoding. Molecular Ecology 25:929–942

7. OCEANOGRAPHY: SOUTHERN OCEAN CARBON AND HEAT IMPACT ON CLIMATE – RECOVERY CRUISE (SO-CHIC-RECOVERY)

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Grant-No. AWI_PS134_07

Objectives

The present programme enters within the framework of the wider European project H2020 SO-CHIC (Southern Ocean Carbon and Heat on Climate). The overall objective of SO-CHIC is to understand and quantify variability of heat and carbon budgets in the Southern Ocean through an investigation of the key processes controlling exchanges between the atmosphere, ocean and sea ice. The Southern Ocean regulates the global climate by controlling heat and carbon exchanges between the atmosphere and the ocean. It is responsible for about 60-90 % of the excess heat (i.e. associated with anthropogenic climate change) absorbed by the World Oceans each year, and is also recognised to largely control decadal scale variability of Earth carbon budget, with key implications for decision makers and regular global stocktake agreed as part of the Paris agreement. Despite such pivotal climate importance, its representation in global climate model represents one of the main weaknesses of climate simulation and projection. Limitations come both from the lack of observations in this extreme environment and its inherent sensitivity to intermittent small-scale processes that are not captured in current Earth system models.

The present programme aims at recovering three mooring lines deployed in 2021-2022 from the *SA Agulhas II* (https://doi.org/10.5281/zenodo.6948850), and to deploy 4 new mooring lines and 1 float.

Work at sea

The main working area was in the Maud Rise region, where we attempted to recover 3 mooring lines (ASFAR, ULS, PROPOL) and deployed 4 new mooring lines (UK1-4) as ell as 1 APEX float (Table 7.1).

Moorings and float deployment

All four moorings were deployed anchor first, following the common practice in sea-ice covered areas. The depth accuracy of the mooring locations was crucial as the top of each of the four lines was supposed to be only 50 m below the surface. On the UK1 location, the bathymetry profile from the ship's multibeam echo sounder (Atlas Hydrosweep DS3, 13.6-16.4 kHz) was therefore analysed and corrected, based on the local CTD density profile. Despite this accurate depth measurement, the line was still too long. The anchor reached the bottom when the top part of the line was still a few meters above the surface. Consequently, 35 m of rope were cut from the mooring line.

We suspect that this issue was due to an error on rope length measurement rather than on depth measurement. The 1 % error on the ~4,251-m long rope length is consistent with an excess of 35 m. All the following moorings were consequently deployed 50 meters deeper than originally planned, the top of UK2-4 reaching 100 m below surface. No corrected bathymetry measurements were needed for the deployment of UK2-4.

Finally, following the four moorings deployment, we successfully deployed the APEX float.

Moorings recovery

The ASFAR and ULS moorings were successfully recovered. They were easily released using a remote acoustic deck unit.

The PROPOL mooring release, however, did not respond to the acoustic deck unit nor to the ship integrated Posidonia system. Based on the Parasound profile of the mooring location, which shows a 25-m thick layer of soft sediments to which the PROPOL line is anchored, we suspect that the release might have been buried in the ocean floor, which would explain this lack of response. Following the detection of the PROPOL mooring line by the ship's sonar (Simrad EK80), we still attempted a last and more direct recovery, based on a fishing method involving two ropes, with one end attached to the ship and the other to a Zodiac (*Luisa*). This attempt was also unsuccessful.

Tab. 7.1: List of oceanographic mooring stations.

Date and time (UTC)	Station name	Latitude	Longitude	Operation	Depth
03.01.2023 03:45	UK1	63°31.969'S	02°26.593'E	Deployment	4.361 m
03.01.2023 12:54	UK2	63°41.223'S	02°25.899'E	Deployment	3.417 m
03.01.2023 08:44	ASFAR	63°39.316'S	02°26.808'E	Recovery	3.845 m
03.01.2023 15:45	UK3	63°41.835'S	02°23.861'E	Deployment	3.312 m
03.01.2023 19:45	UK4	63°55.058'S	02°26.772'E	Deployment	2.812 m
04.01.2023 10:20	ULS	64°32.884'S	03°12.994'E	Recovery	2.092 m
04.01.2023 13:37	PROPOL	64°31.664'S	03°14.824'E	Recovery	2.092 m
04.01.2023 17:50	APEX	64°41.947'S	03°02.156'E	Deployment	

Preliminary results

Settings of deployed instruments

The deployed measuring instruments (RBR – SoloT, SBE37, Aquadopp-DW, Workhorse Long Ranger) were all started at their required sampling rate prior to their deployment. The releases of the four deployed moorings responses were also successfully tested.

Expected results

After the expedition, the collection of measurements obtained with the recovered mooring lines will be rigorously analysed to document and quantify the processes governing open ocean Polynya development. This analysis will hopefully be completed with the Propol measurements, if the mooring line is successfully recovered during a later expedition. This analysis will entail three complementary stages focussing on classes of processes of distinct scales.

First, the processes preconditioning the emergence of Polynyas via a reduction of ambient stratification over Maud Rise will be assessed. Two types of processes will be targeted here:

(i) the generation of a Taylor cap circulation over the Rise, and of slowly-evolving mesoscale meanders around the Rise, by the impingement of the Weddell Gyre's southern limb on the local topography; and (ii) the generation of small-scale turbulent mixing associated with e.g., the breaking of internal tides radiated from the Rise. To document the contribution of (i) to reducing regional stratification, the measurements of the mesoscale circulation obtained by satellite altimetry, Deep-Argo floats and moorings will be examined concurrently, using proven analytical techniques previously developed and applied by our team. To document the contribution of (ii), the distribution of the turbulent dissipation rate will be quantified, and the fine-scale motions underpinning turbulence (e.g., internal waves) will be characterised from the mooring measurements.

Second, the impact of intermittent de-stratifying processes (sea-ice formation, small-scale turbulent mixing events, and instabilities linked to the nonlinear equation of state of seawater) in reducing upper-ocean stratification and promoting oceanic heat loss and Polynya growth will be assessed, in the context of the evolving atmospheric and sea ice conditions (e.g., storm events and wind-forced sea-ice divergence). The atmospheric forcing of de-stratification events will be evaluated from air-sea fluxes of heat, freshwater and momentum provided by a state-of-the-art atmospheric reanalysis (e.g., the ECMWF ERA-Interim product), constrained locally by our observations. Daily satellite measurements of sea ice concentration and motion will be utilised to document the relationship between evolving sea ice conditions and the unfolding of de-stratification events.

Third, the role of re-stratifying processes (specifically, sub-mesoscale instabilities and mesoscale baroclinic instability of the frontal system encircling Maud Rise) in enhancing upper-ocean stratification and arresting Polynya growth will be assessed. This will be achieved by evaluating the occurrence of sub-mesoscale symmetric and baroclinic instabilities in the upper ocean through a potential vorticity-based instability analysis of the glider observations; by calculating the upward buoyancy flux associated with both sub-mesoscale and mesoscale instabilities from the mooring measurements; and by evaluating the mesoscale circulation and atmosphere / sea-ice conditions in which each instability occurs, and the impacts of each instability on upper- ocean stratification.

The outcomes of these three lines of analysis will be synthesised and contextualised within a sea-ice concentration budget of the Maud Rise region for the period of the experiment. This exercise will enable us to attribute events of significant change in regional sea ice concentration (such as e.g., the opening or closing of a Polynya) to mechanical and thermodynamic drivers. By contrasting this information with our preceding diagnostics of atmospheric forcing and de-stratifying and re-stratifying processes, the processes governing the Polynya's development will be identified and quantified.

Data management

The present project is part of the wider SO-CHIC project which has an entire work package (and associated budget) dedicated to data handling. In particular, we will enable discovery, open access, view and download of the data generated and collected during the SO-CHIC project. Data management is developed in coordination and collaboration with already existing infrastructures and integrators (e.g. EMODnet, CMEMS, SOOS) to avoid the duplication of effort and to facilitate a fast adoption and availability of the produced data.

During the Targeted Operation Period, the SO-CHIC observations will be provided to the European and international marine and ocean data management infrastructures. For SO-CHIC-Recovery, data will be provided to SISMER (the French national oceanographic data repository): The data will be made publicly available either after the first scientific peer-reviewed publication using the dataset, or after a maximum of 2 years after the end of the expedition. We expect a total data volume of about 50 GB for the SO-CHIC-Recovery cruise, including all raw, postprocessed, and calibrated datasets.

In all publications based on this expedition, the **Grant No. AWI_PS134_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.

APPENDIX

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A.2 EXPEDITIONSTEILNEHMER:INNEN / EXPEDITION PARTICIPANTS

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Brand	Caroline	DE.UNI-BREMEN	Student	Geophysics
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Burkhalter-Castro	Rosemary	US.USF	PhD student	Oceanography
Cammareri	Alejandro	AR.MARYBIO	Scientist	Biology
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Gille-Petzoldt	Johanna	DE.AWI	PhD student	Geophysics
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Klages	Johann	DE.AWI	Scientist	Geology
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Lensch	Norbert	DE.AWI	Technician	Geology
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Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Salazar Sierra	Juan Manuel	AR.MARYBIO	Scientist	Biology
Santos Lopes	Hugo Manuel	AR.MARYBIO	Scientist	Biology
Schick	Luca	DE.TIHO	Scientist	Biology
Seifert	Michael	DE.DRF	Technician	Helicopter service
Soto Àngel	Joan	NO.UIB	Scientist	Biology
Stevenson	Christopher	NZL.MAUI63	Pilot	Biology
Troch	Matthias	BE.UGENT	PhD student	Geology
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Van Coillie	Meltse	BE.MEDIA	Journalist	Media
Vaupel	Lars	DE.NHC	Pilot	Helicopter service
Verhaegen	Gerlien	DE.AWI	Scientist	Biology
Weich	Zelna	UK.BAS	PhD student	Geology
Weigelt	Estella	DE.AWI	Scientist	Geophysics

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW

No.	Name	Vorname	Position
1	Langhinrichs	Moritz	Master
2	Langhinrichs	Jacob	Chief Mate
3	Ziemann	Olaf	Chief Engineer
4	Eckenfels	Hannes	2nd Mate
5	Strauß	Erik	2nd Mate
6	Peine	Lutz	2nd Mate
7	Hofmann	Jörg	Comm. Officer
8	Pliet	Johannes	Comm. Officer
9	Guba	Klaus	Ships Doctor
10	Ehrke	Tom	2nd Engineer
11	Krinfeld	Oleksandre	2nd Engineer
12	Rusch	Torben	2nd Engineer
13	Pommerencke	Bernd	SET
14	Frank	Gerhard	ELO
15	Krüger	Lars	ELO
16	Schwedka	Thorsten	ELO
17	Winter	Andreas	ELO
18	Brück	Sebastian	Bosun
19	Keller	Eugen	Carpenter
20	Buchholz	Joscha	Decksmate
21	Decker	Jens	Decksmate
22	Fink	Anna-Maria	Decksmate
23	Lutz	Johannes	Decksmate
24	Möller	Falko	Decksmate
25	Schade	Tom	Decksmate
26	Stellamanns	Thies	Decksmate
27	Weiß	Daniel	Decksmate
28	Niebuhr	Tim	Decksmate
30	Plehn	Markus	Storekeeper
30	Arnold-Becker	André	MP Rat.
31	Clasen	Nils	MP Rat.
32	Jassmann	Marvin	MP Rat.

No.	Name	Vorname	Position
33	Probst	Lorenz	MP Rat.
34	Waterstradt	Felix	MP Rat.
35	Schnieder	Sven	Cook
36	Bogner	Christoph	Cooksmate
37	Martens	Michael	Cooksmate
38	Witusch	Petra	Chief Stewardess
39	Ilk	Romy	2nd Stewardess, Nurse
40	Chen	Quan	2nd Steward
41	Dupont	Erik	2nd Steward
42	Fehrenbach	Martina	2nd Stewardess
43	Golla	Gerald	2nd Steward
44	Shi	Wubo	2nd Steward
45	Hu	Guoyong	Laundrymate

A.4 SEISMIC PROFILE SUMMARY

PROFILE # AWI-…	Start/ End	DATE	TIME (UTC)	LATITUDE	LONGITUDE	File #, # of SHOT	PROFILE LENGTH (nm)	GI-gun array set-up, volume	COMMENT
20230001	start end	24.01.23 24.01.23	01:23 05:01	-72.959147 -72.842567	-73.516647 -72.6726694	1-1222, 1222	17	4 GI-guns, true GI mode (45 + 105 in³), 33 ms delay	Start of ramp-up 1:23, full power 1:53 MM shut down: #00000390-#00000580 #00000623-#00000785
20230002	start end	24.01.23 27.01.23	06:31 02:06	-72.848844 -69.185533	-72.669203 -80.090097	1223-22636, 21414	289	3 GI-guns, true GI mode (45 + 105 in³), 33 ms delay	MM shut down: #00001257-#00001606 #00001617-#00001787 #00001816-#00002143 #00002627-#00002872 #00004776-#00005073 #00007240-#00008316 #00009620-#00009795 #00009933-#00010213 #00010457-#00010658 #00010839-#00011261 #00011326-#00015581 #00016861-#00017022 #00017749-#00017943 #00018906-#00019119 #00019810-#00019997 #00022335-
20230003	start end	27.01.23 27.01.23	03:44 13:25	-69.171342 -69.425586	-80.166794 -78.568947	22637-25403, 2767	37	3 GI-guns, true GI mode (45 + 105 in³), 33 ms delay	MM shut down: #00023560- #00023763 #00024911-#00025257 #00025306-

PROFILE # AWI-…	Start/ End	DATE	TIME (UTC)	LATITUDE	LONGITUDE	File #, # of SHOT	PROFILE LENGTH (nm)	GI-gun array set-up, volume	COMMENT
20230004	start end	27.01.23 29.01.23	14:01 06:28	-69.406136 -70.727914	-78.4880278 -86.8615861	25404-39379, 13976	187	3 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: -#00025662 #00025825-#00026026 #00036633-#00036837 #00037137-#00037373
20230005	start end	29.01.23 29.01.23	08:23 17:02	-70.752594 -70.065344	-86.866606 -86.729683	39380-42450, 3071	42	4 (3) GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	
20230006	start end	29.01.23 31.01.23	18:12 18:12	-70.049450 -72.903297	-86.764992 -80.448511	42451-58064, 15614	211	3 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	gun repairs: #00044251-#00044760 Gun #3 turned off #00045611 MM shut down: #00044609-#00044760 #00044925-#00045405 #00045632-#00045823 #00046139-#00046329 #00047024-#00047227 #00050893- #00051125 #00051182-#00051577 #00052175 #00052400 #00055098-#00055399 #00056252-#00056499 #00056534-#00057408
20230007	start end	03.02.23 04.02.23	13:59 17:02	-69.696469 -70.205306	-69.696469 -89.622267	58065-65820, 7756	105	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	#58409 activation of three bird retrieval systems – interruption of profile for 6 hrs

PROFILE # AWI-…	Start/ End	DATE	TIME (UTC)	LATITUDE	LONGITUDE	File #, # of SHOT	PROFILE LENGTH (nm)	GI-gun array set-up, volume	COMMENT
20230008	start end	04.02.20 05.02.23	18:16 12:08	-70.217611 -69.093681	-89.655581 -86.996081	65823-72122, 6300	85	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00065823-#00065982 #00068704-#00068922 #00069722-#00069932 Technical problems #00069268-#00069279
20230009	start end	05.02.23 06.02.23	13:48 10:50	-69.078547 -70.283036	-87.036114 -83.570742	72123-79601, 7478	101	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	
20230010	start end	06.02.23 07.02.23	12:11 06:23	-70.279197 -70.561069	-83.532175 -87.711178	79602-85946, 6345	86	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00085610-#00085909 WP ALTO #00083211
20230011	start end	07.02.23 07:02:23	08:06 17:23	-70.580469 -87.756458	-87.756458 -86.395736	85947-88954, 3008	41	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00086363-#00086575 #00086744-#00086992
20230012	start end	07.02.23 09.02.23	19:29 00:28	-70.121058 -72.298044	-86.348636 -86.343311	88955-98792, 9838	133	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	#00090374 ALTO
20230013	start end	09.02.23 10.02.23	00:49 03:01	-72.301133 -71.600903	-86.280742 -80.838686	98793-107209, 8417	114	4 (3) GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	Gun #1 turned off #00101769
20230014	start end	10.02.23 11.02.23	04:26 03:27	-71.605478 -71.351403	-80.812989 -86.152100	107210-114866, 7656	103	3 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00109076-#00109283 #00109480-#00109748 #00110216 #00110602 #00111124-#00111367 #00112087-#00112300 #00112822-#00113070

PROFILE # AWI-…	Start/ End	DATE	TIME (UTC)	LATITUDE	LONGITUDE	File #, # of SHOT	PROFILE LENGTH (nm)	GI-gun array set-up, volume	COMMENT
20230015	start end	11.02.23 11:02.23	05:07 20:31	-71.371253 -70.767147	-86.231961 -83.479003	114867-119681, 4814	65	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00117390-#00117612
20230016	start end	11.02.23 13.02.23	22:01 07:00	-70.774356 -69.574444	-83.420072 -89.788100	119682-130703, 11022	149	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	WP ALTO #00123636 MM shut down: #00123003-#00123291 #00124046-#00124231 #00128873-#00129138 #00129705-#00129925
20230017	start end	13.02.23 14.02.23	08:37 10:29	-69.578156 -69.255886	-89.881450 -84.307444	130704-139560, 8857	120	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00134170-#00134281 #00134969-#00135288 #00135365-#00135622
20230018	start end	14.02.23 15.02.23	11:53 01:57	-69.239439 -70.084831	-84.265269 -86.394975	139567-144556, 4990	67	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00141265-#00141515
20230019	start end	15.02.23 15.02.23	03:38 16:26	-70.106478 -69.073297	-86.379058 -86.994778	144557-149164, 4608	62	4 GI-guns, true GI mode (45 + 105 in^3), 33 ms delay	MM shut down: #00146883-#00147154 #00147707-#00147975 #00148090-#00148387 #00148555-#00148791
						149164	2014 nm 3730 km		

A.5 PARASOUND LOGS

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2022	Dec	24	23:39	n/a	Generell start of Parasound subbottom profiling for PS134	ew	Single Pulse	100	manual	Start sounding and logging when out off EEZ of South Africa, Long: 16.79089°E Lat: -37.43228°S, Speed~9Kn, Depth~4300m, Storage Disk Fill: 59%
2022	Dec	24	23:45	n/a	Automatic depth controll: Ctr. Paras. PHF	ew	Single Pulse	100	Ctr. Paras. PHF	
2022	Dec	25	08:30	Start PS134_01	Reduced pulse rate (30s) during station for exact positioning for sampling	ew	Single Pulse	30000	Ctr. Paras. PHF	Start Station PS134_01 work at 08:28, Long: 16.317310, Lat: -38.769134, WD=4747, test CTD, Speed < 1 Kn, Depth: 4743M
2022	Dec	25	09:33	End PS134_01	Resume sounding with 100ms pulse rate after station end	ew	Single Pulse	100	Ctr. Paras. PHF	End of station PS134_01 work at 09:26. Speed ~9-10 Kn, Depth: 4743M
2022	Dec	26	ab 15:00 bis 17:30		several starts and stops of sounding and recording because of training	ew	Single Pulse	100	Ctr. Paras. PHF	
2022	Dec	26	17:35		resume normal sounding and recording after test	ew	Single Pulse	100	Ctr. Paras. PHF	100ms Pulse rate in Transmission sequence (before 1200 ms)
2022	Dec	26	18:00		Reduced pulse rate (30s), as test if appropriate during stations	ew	Single Pulse	30000ms = 30 s	Ctr. Paras. PHF	Test if 30s pulse rate in Transmission sequence is appropriate on station. Fazit: pulse rate is too low, system takes long time to find sea floor reflector.

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2022	Dec	26	18:20		Resume sounding with higher Pulse rate after test	ew	Single Pulse	100	Ctr. Paras. PHF	normal: 100 ms pulse rate
2022	Dec	26	18:50		QED, Water depth = ~5000m, Min Time Interval between Pulses = 3000ms (system: ~2500ms) Max. Number of Pulses= 6 (system: 3)	ew	QED (3 pulses)	3000	Ctr. Paras. PHF	Test mit QED
2022	Dec	27	04:44		Back to single pulse for transit	ew	Single Pulse	100	Ctr. Paras. PHF	back to single pulse for transit
2022	Dec	27	07:28	Start PS134_02	Reduced pulse rate (20s) during station	mg	Single Pulse	20000	Ctr. Paras. PHF	Start Station PS134_02 work at 07:31, Long: 13.460235, Lat: -46.172656, WD=4872m
2022	Dec	27	11:38		several changes for testing	rl	Single Pulse	20000	Ctr. Paras. PHF	on station: 20 s pulse rate in Transmission sequence
2022	Dec	27	17:50	End PS134_02	Resume sounding with 200ms pulse rate after station end	ew	Single Pulse	200	Ctr. Paras. PHF	End of station PS134_02 work at 15:48.
2022	Dec	28	03:25		ship reduced speed and turned into wind because of 7-8 m wave height	ew	Single Pulse	200	Ctr. Paras. PHF	ship reduced speed and turned into wind because of high waves
2022	Dec	28	05:30		Reduce Pulse Rate to 20 s	ew	Single Pulse	20000	Ctr. Paras. PHF	ship reduced speed <5 Kn and turned into wind because of high waves
2022	Dec	28	10:30		Reduce Pulse Rate to 30 s	ew	Single Pulse	30000	Ctr. Paras. PHF	ship reduced speed < 5 Kn and turned into wind because of high waves

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2022	Dec	29	8:00 - 10:00		Parasound training, changing various parameters, by mistake from 29.12.22 09:37 to 30.12.22 06:30 SLF was recorded in sgy instead of ps3 format	cp				ship reduced speed < 5 Kn and turned into wind because of high waves
2022	Dec	29	10:00		Resume sounding with 30 s pulse rate, end of test, by mistake SLF was recorded in sgy format	kl	single pulse	30000	Ctr. Paras. PHF	end of test, by mistake SLF was recorded in sgy format, ship reduced speed < 5 Kn and turned into wind because of high waves
2022	Dec	29	00:00		Resume sounding with 500 ms pulse rate, by mistake SLF was recorded in sgy format	ew	Single Pulse	500	Ctr. Paras. PHF	ship speed resumed between 5-10 Kn
2022	Dec	30	06:35		Record of SLF in PS3 Format again , by mistake from 29.12.22 09:37 to 30.12.22 06:30 SLF was recorded in sgy instead of ps3 format	ew	Single Pulse	500	Ctr. Paras. PHF	during training by mistake SLF was recorded in sgy format, since 06:35 record SLF in PS3 Format again
2022	Dec	31	07:05	Start PS134_03	Reduce Pulse Rate to 30 s during station	ew	Single Pulse	30000	Ctr. Paras. PHF	Start Station PS134_03 work at 07:00, Long: 9.174319, Lat: -55.422845, WD=5007m
2022	Dec	31	13:56	End PS134_03	Resumed sounding with 500 ms pulse rate after station end	mg	Single Pulse	500	Ctr. Paras. PHF	End of station PS134_03 work at 13:56
2023					2023					2023

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	1	18:17		Start Continuous Parasound Watch because south of 60° S and entering area of Antarctic Treaty System	ew	Single Pulse	500	Ctr. Paras. PHF	Start of MMO-watches because south of 60°S, and entering area of Antarctic Treaty System. MMO opportunistic during moving, MMO-watch continous during stations. System settings: Frequencies: PHF/ SLF=20kHz/4kHz Pulse Rate >/= 500ms
2023	Jan	1	18:56	Start PS134_4-1	Stop sounding because on Station	ew	no pulse			Start Station PS134_4-1, Long: 5.551088°E, Lat: -60.108898°S, WD=3001m (Hydro)
2023	Jan	2	01:57	End PS134_4-4	Resumed sounding with soft start after station end	mg	Single Pulse	soft start	Ctr. Paras. PHF	End Station PS134_4-4, 1:56 - 2:01 - 20000 ms; till 2:06 - 10000 ms; till 2:11 - 5000 ms; till 2:16 - 1000 ms; from 2:16 500 ms
2023	Jan	2	02:16		Sounding with normal pulse rate	mg	Single Pulse	500	Ctr. Paras. PHF	
2023	Jan	3	00:48	Start PS134_5	Stop sounding on station	mg	no pulse			Parasound was stopped because of a sequence of closely spaced stations (PS134_6 - PS134_8). Start Station PS134_5, Long: 2.439996°E, Lat: -63.530085°S, WD=4306.2 m (Fishlot).

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	3	07:03		Start Sounding because of serious problems detecting water depth (MMO watch by chance present on bridge)	ew	Single Pulse	500		Serious problems in detection of waterdepth. Bathymetrie and EK80 show different waterdepths. Correct water depth is essential for sampling (rope length of winch). For security reasons Parasound was switched on without a softstart, but whale watch by chance was present on bridge at least 30 min. before sounding and during sounding.
2023	Jan	3	07:10		Stop Sounding	ew				Stop sounding because Parasound not neccessary anymore. Problem of water depth deviation between Hydrosweep and EK80 solved.
2023	Jan	3	21:23	End PS134_9	Softstart after Stations end, after 15 min. MMO watch minimum	ew	Single Pulse	20000, 10000, 5000, 1000, each for 5 min.	Ctr. Paras. PHF	End PS134_9 at 21:16, Long: 2.445911°E, Long: -63.917879°S, WD=2700m. Resume sounding at 21:23 with softstart after a sequence of stations and short transits without sounding. After 15 min. MMO watch.
2023	Jan	3	21:45		Normal Pulse rate of 500 ms after softstart	ew	Single Pulse	500	Ctr. Paras. PHF	Normal Pulse Rate of 500 ms after Sofstart
2023	Jan	3	21:56		QED	ew	QED	2000 ms 3 Pulses	Ctr. Paras. PHF	Water Depth ~ 2700m
2023	Jan	4	01:03	Start PS134_10	Stop sounding	mg	no pulse			Start Station PS134_10, Long: 3° 0.297‘ E, Lat: -64° 30.026‘ S, WD = 2093.3 m (Hydro)

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	4	08:07	End PS134_10	Softstart after Stations end, after 15 min. MMO watch minimum	ew	Single Pulse	10000, 5000, 1000, each for 5 min.	Ctr. Paras. PHF	End PS134_10 at 08:00, Long: 2.999434°E, Long: -64.500267°S, WD= 2087m. Resume sounding at 08:07 with softstart after a sequence of stations and short transits without sounding. After 15 min. MMO watch minimum.
2023	Jan	4	08:23		QED , Normal Pulse Rate of 500 ms after softstart	ew	QED	2000 ms 3 Pulses	Ctr. Paras. PHF	Water Depth ~ 2100m
2023	Jan	4	08:51	Start PS134_11	Stop sounding	ew	no pulse			Start Station PS134_11, Long: 3.244858‘ E, Lat: -64.528788‘ S, WD = 2075 m (Hydro)
2023	Jan	4	16:32	End PS134_11 PS134_12	Softstart after Stations end, after 15 min. MMO watch minimum	ew	Single Pulse	20000, 10000, 5000 - each for 5 min.	Ctr. Paras. PHF	End Station, Long: 3.247366°E, Lat: -64.526285, Water Depth ~ 2085m. Resume sounding at 16:32 with softstart after a sequence of stations and short transits without sounding. After 15 min. MMO watch minimum.
2023	Jan	4	16:47		QED , Normal Pulse Rate of 500 ms after softstart	ew	QED	2000 ms 3 Pulses	Ctr. Paras. PHF	
2023	Jan	4	17:47	Start PS134_13 End		ew				Station PS134_13, Long: 3.037478, Lat: -64.699236, WD=2185m, Speed reduced (deployed en-passant)
2023	Jan	5	10:00		Single Pulse, 500 ms Pulse rate	ew	Single Pulse	500	Ctr. Paras. PHF	end of Maud Rise = no interesting layers

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	5	22.20		-	JK	Single Pulse	500	Ctr. Paras. PHF	Entered sea ice - poor data quality
2023	Jan	6	14:21		Reduce Pulse rate to 10000 ms	ew	Single Pulse	10000	Ctr. Paras. PHF	Reduce Pulse rate to 10000 ms, because in shallow water off Neumayer
2023	Jan	6	14:30	Station Neumayer	Stop Sounding	ew				Shelf ice edge off Neumayer Station reached
2023	Jan	8	16:26		System shut down	mg				For traning
2023	Jan									
2023	Jan	9	22:23	End Neumayer	Soft start after 15 min MMO watch at minimum, leaving Neumayer	mg	Single Pulse	20000, 10000, 5000, 1000 (jeweils 5 min)	External Hydrosweep DS PHF (first 4 min), Cont. Parasound PHF	Started sounding after leaving Neumayer, after 15 min MMO watch at minimum, Disk Fill: 54 %
2023	Jan	9	22:45		Final pulse rate	mg	Single Pulse	500	Cont. Parasound PHF	
2023	Jan	9	23:12		Reduce pulse rate to 10s, test	bh	Single Pulse	10000	Cont. Parasound PHF	23:12-04:30, tests if pulse rate could be reduced reasonable
2023	Jan	10	00:21		Resume of puls rate to 1s , test	mg	Single Pulse	1000	Cont. Parasound PHF	
2023	Jan	10	04:30		Reduce of puls rate to 5s, test	ew	Single Pulse	5000	Cont. Parasound PHF	
2023	Jan	14	4 _6	N/A	old projects copied from „Mcpc1ps3/g“ to Lacie „Parasound-I „, and deleted afterwards from „g“.	ew				space on „g“ very full, now Disk Fill again 53%

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	14	11:53		copied data to MDM	mg				
2023	Jan	16	14:14		Resume pulse rate to 1s, unknown waters	mg	Single Pulse	1000	Cont. Parasound PHF	entered area which is not yet recorded by Polarstern
2023	Jan	16	14:15		Reduce pulse rate to 3s	mg	Single Pulse	3000	Cont. Parasound PHF	pluse rate 1000 was too high
2023	Jan	16	17:01		Reduce pulse rate to 5s, back in known waters	mg	Single Pulse	5000	Cont. Parasound PHF	back in known waters
2023	Jan	16	19:45		change to Hydro PHF	ew			External Hydrosweep DS PHF	often parasound signal loss due to rugged topography
2023	Jan	17	08:15		Resume of puls rate to 4s	ew	Single Pulse	4000	External Hydrosweep DS PHF	Sedimentpocket of ~25 m thickness between islands
2023	Jan	17	23:24		System depth source changed to External Hydrosweep DS PHF	rbc	Single Pulse	4000	External Hydrosweep DS PHF	When I started my shift, the depth source was on External Hydrosweep MD PHF and the PHF and SLF bottom depths were not correct, so I changed it to Hydrosweep DS. I am not sure how long the depth source was MD Hydrosweep.
2023	Jan	18	02:13		changed system depth source back to controlled Parasound PHF	mg	Single Pulse	4000	Cont. Parasound PHF	
2023	Jan	18			changed system depth source to External Hydrosweep DS PHF	mg	Single Pulse	4000	External Hydrosweep DS PHF	Rough topography - automatic delay more stable with hydrosweep data

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	18	11:38		changed system depth source back to controlled Parasound PHF	ew	Single Pulse	4000	Cont. Parasound PHF	controlled Parasound depth, because good signals from Parasound PHF
2023	Jan	18	17:30		Reduce puls rate to 1.5 s	ew	Single Pulse	1500	Cont. Parasound PHF	reduce time interval to 1500ms for better lateral resolution, because area of interest reached
2023	Jan	18	19:50		Change puls rate to 1 s	ew	Single Pulse	1000	Cont. Parasound PHF	shallow water ~150m
2023	Jan	19	02:18		Changed storage from SGY+ PS3 back to PS3	mg				
2023	Jan	19	05:29	survey 1	Resume of puls rate to 500, because of survey	ew	Single Pulse	500	Cont. Parasound PHF	start of Bathymetric Survey , pulse rate 100ms (~950ms) at about 500m waterdepth, Long: 74°51.485'W, Lat: 72°10.813' S
2023	Jan	19	06:43		Change of puls rate	ew	QED, 4Pulses	500	Cont. Parasound PHF	water depth well below 500 m
2023	Jan	19	10:43		PHF frequency set to 20.5 kHz	rdla	QED, 4Pulses	500	Cont. Parasound PHF	Change because of interference with Hydrosweep
2023	Jan	19	11:05	Start PS134_14	Start bathymetric and geological survey	ew	QED, 4Pulses	500	Cont. Parasound PHF	Start of PS134_14 work at 11:05; bathymetric and geological survey, Long: -72.579398°W, Lat: -72.737083°S, WD= 747m
2023	Jan	19	12:58		change of heading (COH)	mg				change of ship heading from 208° to 272°
2023	Jan	19	15:26:00 - 15:36		COH	mg				change of ship heading from to ~ 272° to ~ 92°
2023	Jan	19	18:24 - 18:38		COH	ew				change of ship heading from to ~ 92° to ~ 272°

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	19	20:38	Start PS134_15	reduce pulse rate, approaching Station, MMO watch all station time	ew	Single Pulse	20000	Cont. Parasound PHF	Start station PS134_15 work at 20:43, Approaching CTD-Station, Long: -73.779913°W, Lat: -72.930148°S, WD = 1036m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	19	21:44	Stop PS134_15	Resumed sounding with 500 ms pulse rate after station end	CD	QED, 4Pulses	500	Cont. Parasound PHF	Stop Station PS134_15 work at 21:40; MMO watch all station time
2023	Jan	19	22:05		different pulse rate changes and depth source changes	ew	QED, 4Pulses	500	Cont. Parasound PHF	after station end complete loss of depths. Trying different pulse rates, Now sytem recording again, all ok
2023	Jan	20	2:04 - 2:14			mg				COH from 94° to 277°
2023	Jan	20	04:47 - 05:04			mg				COH from 275° to ~99°
2023	Jan	20	07:53 - 08:07		COH	ew				COH from 99° to 278°
2023	Jan	20	08:00		Resume pulse rate to 8 pulses to improve resolution	ew	QED, 8 Pulses	500	Cont. Parasound PHF	change of pulse rate from 4 to 8 pulses, try to improve resolution
2023	Jan	20	11:20 - 11:28		COH	ew				COH from ~278° to ~96°
2023	Jan	20	from 15:13:00		COH	mg				COH from 100° to 280°
2023	Jan	20	~19:00-??		COH	ew				COH from 280° to 96°
2023	Jan	21	from 01:52		COH	mg				COH to 187°

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	21	02:38 - 2:43		Restart sounding due to error message	mg	QED, 4Pulses	500		error message, briefly no data was recorded. Set no. Of pulses to 4, this didn‘t helped. Once sounding was stopped and restarted, recording worked again
2023	Jan	21	02:48		Reduce number of pulses back to 8	mg	QED, 8 Pulses	500		
2023	Jan	21	from 3:52 to 4:25		COH	mg				COH to 126° anf finally 87
2023	Jan	21	08:29 to 08:44		COH	ew				COH from ~87° to ~42°
2023	Jan	21	09:50 to 10:18		COH	jh				COH from ~42° to ~312°
2023	Jan	21	11:08		copied data to MDM	ew				
2023	Jan	21	12:29	Start PS134_16	Continued sounding during approache to Station for exact positioning	ew	QED, 8 Pulses	500		approaching PS134_16, still high pulse rate for exact positioning
2023	Jan	21	12:34	PS134_16	Reduced pulse rate (20000ms=20s) when Station reached for exact positioning for sampling with whale watch during station	ew	Single Pulse	20000	Cont. Parasound PHF	Start Station PS134_16 work at 12:36, Long: -72.6754°W, Lat: -72.893999°S, WD = 680 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	21	13:28	End PS134_16	Resumed sounding with 500 ms pulse rate after station end	mg	QED, 8 Pulses	500	Cont. Parasound PHF	Stop Station PS134_16 work at 13:20 , resume sounding after 15 min MMO watch
2023	Jan	21			problems after sounding	mg	QED, 4 Pulses	500		Changed QED
2023	Jan	21	13:35		Changed pulse rate	mg	QED, 8 Pulses	500	Cont. Parasound PHF	Everything back to normal

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	21	15:51	Start PS134_17	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	20000	Cont. Parasound PHF	Start Station PS134_17 work at 15:57, Heatflow-Station, Long: -72.918066°W, Lat: -72.651756°S, WD = 767 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	21	16:50	End PS134_17	Resumed sounding with 500 ms pulse rate after station end	mg	Single Pulse	500	External Hydrosweep DS PHF	End of Station PS134_17 work at 16:46; Lost signal when applying QED, 8 pulses
2023	Jan	21	16:52		Changed pulse rate	mg	QED, 8 Pulses	500	Cont. Parasound PHF	
2023	Jan	21	17:55	Start PS134_18	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	20000	Cont. Parasound PHF	Start Station PS134_18 work at 17:50, Heatflow-Station, Long: -73.091268°W, Lat:-72.600575 °S, WD = 658 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	21	18:49	End PS134_18	Resume sounding after station end; MMO watch during station	ew	QED, 8 Pulses	500	Cont. Parasound PHF	Stop Station PS134_18 work at 18:43, Resume sounding after station end, with MMO watch all time
2023	Jan	21	19:50	Start PS134_19	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	20000	Cont. Parasound PHF	Start Station PS134_19 work at 19:53, Long:-73.245471°W, Lat:-72.567228 °S, WD = 622 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	21	23:51	End PS134_19	Resumed sounding with 500 ms pulse rate after station end	Johannes	QED, 8 Pulses	500	Cont. Parasound PHF	Stop Station PS134_19 work at 23:00, Resume sounding with normal ping rate after station end, with MMO watch all time move the window depth at 23:24, at 23:42 automatic 5%

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	22	02:16	Start PS134_20	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	20000	Cont. Parasound PHF	Start station PS134_20 work at 02:21, Long:-72.86797°W, Lat:-72.94675 °S, WD = 675 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	22	10:33	End PS134_20	Resumed sounding with 500 ms pulse rate after station end	Benedikt	QED, 8 Pulses	500	Cont. Parasound PHF	Stop Station PS134_20 work at 10:30, Resume sounding with normal ping rate after station end, with MMO watch all time
2023	Jan	22	10:54	Start PS134_21	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	Benedikt	Single Pulse	20000	Cont. Parasound PHF	Start station PS134_21 work at 10:55, Long:-73.010058°W, Lat:-72.865109 °S, WD = 669 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	22	13:04	End PS134_21	Resumed sounding with 500 ms pulse rate after station end	mg	QED, 8 Pulses	500	Cont. Parasound PHF	Stop Station PS134_21 work at 13:00, pulse rate: first increased to 0.5 s singel pulse and afterwards to final setting
2023	Jan	22	13:45	Start PS134_22	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	20000	Cont. Parasound PHF	Start Station PS134_22 work at 13:43, Long:-73.025717 ° W, Lat:-72.94565° S, WD = 752 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	22	15:10		Stop sounding because MMs in mitigation zone (2 seals)	mg				Stop sounding after telefon call of MMO, because of MM approach < 100m

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	22	15:28		Start sounding with reduced pulse rate (20s) after MMs retreat, after MMO call from Bridge	mg	Single Pulse	20000	Cont. Parasound PHF	Start sounding after MMO call from Bridge, MMs were less than 30 min in mitigation zone
2023	Jan	22	15:38	End PS134_22	Resume sounding with 500 ms pulse rate after station end	mg	QED, 8 Pulses	500	Cont. Parasound PHF	Stop Station PS134_22 work at 15:22 , pulse rate: first increased to 0.5 s singel pulse and afterwards to final setting
2023	Jan	22	16:09	Start PS134_23	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	20000	Cont. Parasound PHF	Start station PS134_23 work at 16:18, Lat:-72.917767° S, Long:-73.40015 ° W, WD = 852 m, MMO-watch all station time, pulse rate reduced to 20s during station time
2023	Jan	22	17:17	End PS134_23	Resume sounding with 500 ms pulse rate after station end	ew	QED, 8 Pulses	500	Cont. Parasound PHF	End of station PS134_23 work at 17:12, pulse rate: first increased to 0.5 s singel pulse and afterwards to final setting with QED
2023	Jan	22	17:58		testing pulse rates	ew	Singele Pulse	500	Cont. Parasound PHF	system didn't accept 500 ms time interval and QED, shows a lot of errors
2023	Jan	22	18:08		Resume sounding with 500 ms pulse rate after test	ew	QED, 8 Pulses	500	Cont. Parasound PHF	system stabil again with 500 ms time interval and QED
2023	Jan	22	18:54	Start PS134_24	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	500	Cont. Parasound PHF	Start station PS134_24 work at 19:05, Lat:-72.928929° S, Long:-72743119 ° W, WD = 724 m, MMO-watch all station time, pulse rate reduced to 20s during station time

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	22	19:07		Stop sounding because MMs in mitigation zone (2 seals)	ew				Stop sounding after telefon call of MMO, because of MM approach < 100m
2023	Jan	22	19:28		Resume sounding after call from MMO - no seals sighted for at least 15 min.	ew	Single Pulse	20000	Cont. Parasound PHF	Resume sounding after call from MMO - no seals sighted for at least 15 min. Severe problems to restart sounding after the standby. System did not accept „ sounding“ again. After several tries sounding finally started.
2023	Jan	22	19:32		Stop sounding because seals and whales in mittigation zone	ew				Stopped sounding, call from MMO - seals and later whales in mittigation zone. Inbetween end of station PS-134_24 work at 19:48.
2023	Jan	22	20:10 - 20:25		Softstart to restart system after call from MMO - no MMs sighted in mitgation zone for at least 15 min.	ew	Single Pulse	20000, 10000, 5000 - each for 5 min.	External Hydrosweep DS PHF	softstart after shut down and total system restart for training voluteers
2023	Jan	22	21:13		Stop sounding, call from MMO - seals in mittigation zone	cp				call from MMO, seals closer than 100m
2023	Jan	22	21:16	Start PS134_25		cp				no sounding because of seals in mitigation zone, during station PS134_25, Lat: -72.875633, Lon: -73.284675, water depth = 751.5m, MMO watch all station time
2023	Jan	22	21:38		Resume sounding after call from MMO - no seals sighted for at least 15 min.	cp	single Pulse	20000	Cont. Parasound PHF	start sounding with 20 s pulse rate for exact positioning on station

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	22	22:10		Resume sounding with 500 ms pulse rate after station end	cp	single Pulse	500	Cont. Parasound PHF	end of station PS134_25 work at 22:10 , increase pulse rate to 500ms
2023	Jan	22	22:51	Start PS134_26	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	cp	single Pulse	20000	Cont. Parasound PHF	Start station PS134_26 work at 22:51; Lat: -72.846924, Lon: -73.520903, water depth = 761.9m, MMO watch all station time
2023	Jan	22	23:39	PS134_26-1	Resume sounding with 500 ms pulse rate after station end	Benedikt	Single Pulse	500	Cont. Parasound PHF	end of Station work at 23:37, Resume sounding 0.5 s pulse rate after station end, with MMO watch all time
2023	Jan	23	00:53	Start PS134_27	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	Benedikt	single Pulse	20000	Cont. Parasound PHF	Start of station PS134_27 work at 00:54; Lat: -72.920849, Lon: -73.054608, water depth = 1099.2m, MMO watch all station time
2023	Jan	23	03:22	End PS134_27	Resume sounding with 500 ms pulse rate after station end	mg	QED, 8 pulses	500	Cont. Parasound PHF	End of station PS134_27 work at 03:19 , Resume sounding with 0.5 s pulse rate after station end, with MMO watch all time
2023	Jan	23	09:34		Stop sounding, because of life boat safety drill, Parasound system shut down for training	ew				Stop sounding, because of life boat safety drill. Interruption during safety drill used for Parasound training of volunteers.
2023	Jan	23	11:44 - 11:59		Softstart after training end, after 15 min. MMO watch minimum	Benedikt	Single Pulse	10000, 5000, 1000, 500	External Hydrosweep DS PHF	softstart after shut down, 11:44 10000 Pulses, 11:49 5000 Pulses, 11:54 Pulses 1000, 11:59 500Pulses

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	23	~ 12:00		-	Benedikt				Storage springt selbstständig von ps3 auf sgy und muss nochmals gesetzt werden. Diese Fehler ist schon zwei weiter Male aufgetreten.
2023	Jan	23	12:13		Change Pulse modus to QED	Benedikt	QED, 8 Pulses	500	Cont. Parasound PHF	QED modus
	Jan	23	14:33	Start PS134_28		ew				Start of seismic survey with MMO watch all time
2023	Jan	23	15:49	Streamer Deployment PS134_28	change pulse rate, MMO watch during whole seismic survey.	mg	QED, 8 pulses	1000	Cont. Parasound PHF	Reduce pulse rate, as vessel speed is only 4 - 5 kn (because of streamer deployment for seismic survey)
2023	Jan	23	17:49-17:58		test with different constellations of pulse rates and transmission sequences	ew	QED, 8 pulses	1000	Cont. Parasound PHF	after some constellation tests of pulse rate and transmission sequences back to QED, 8Pulses, 1000ms interval
2023	Jan	23	19:22		reduce pulse rate, due to low ship speed during Streamer Recocery	ew	Single Pulse	10000	Cont. Parasound PHF	reduce pulse rate, due to low ship speed during Streamer Recocery
2023	Jan	23	23:40		change pulse rate	Benedikt	Single Pulse	500	Cont. Parasound PHF	Changed speed back to 5kn--> Higher Ping Rate
2023	Jan	24	00:03		change pulse rate	Benedikt	Single Pulse	1000	Cont. Parasound PHF	Changed speed to 3kn for deployment of Airguns--> Slower Ping Rate, System runs stable
2023	Jan	24	00:38		change pulse rate	Luca	Single Pulse	500	Cont. Parasound PHF	Changed speed back to 5kn--> Higher Ping Rate
2023	Jan	24	00:55		change pulse rate	mg	QED, 8 pulses	1000	Cont. Parasound PHF	

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	24	01:33	Start PS134_29		mg				Start seismic line 20230001, Long: -73.485122, Lat: -72.954622, WD=865
2023	Jan	24	06:38	Start PS134_30	continue with QED, 8 pulses, Time Interval 1000ms	ew				Start seismic line 20230002, Long: -72.702222°W, Lat: -72.845839°S
2023	Jan	24	16:41		changed number of pulses to 4	mg	QED, 4 pulses	1000	Cont. Parasound PHF	Current number of pulses is only 1 --> 8 pulses are not necessary
2023	Jan	27	04:11	Start PS134_31		ew				Start Seismic Line 20230003, Long: -80.088821, Lat: -69.185525, WD=1615
2023	Jan	27	14:29	Start PS134_32						Start Seismic Line 20230004, Long: -78.573887, Lat: -69.426289, WD=547
2023	Jan	28	03:37		Copied data to MDM	mg				
2023	Jan		08:00		Update of LaCie II	ew				
2023	Jan	29	08:27	Start PS134_33		ew				Start Seismic Line 20230005, Long:-86.864119, Lat: -70.747011, WD=571m
2023	Jan		18:05	Start PS134_34		ew				Start Seismic Line 20230006, Long:-86.777143, Lat: -70.044114, WD=1372m
2023	Jan	30	01:05 - 01:15	PS134_35		ew				Lander ausgesetzt, Lon: -85.957094, Lat: -70.404478, WD= 640
2023	Jan	31	18:17 - 18:23		change of pulse modus and reduce pulse rate because of low speed during streamer recovery	ew	Single Pulse	500 - 2000	Cont. Parasound PHF	End of station PS134_34, last seismic line at 18:12, reduce pulse rate because of shallow water depth <300 m, close to coast, low speed < 2Kn due to streamer recovery. MMO watch during whole seismic survey.

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Jan	31	22:10	End PS134_34	Resume pulse modus QED, 4 Pulses, 1000ms rate,	ew	QED, 4 Pulses	1000	Cont. Parasound PHF	End of Station PS134_34 work at 21:45 (seismic survey), end streamer recocery, back to >500 m water depth, 10 Kn
2023	Feb	1	07:56	Start PS134_36	Stop sounding, because on station with minor penetration	ew				Start of station PS134_36 work at 08:00 , Long:-76.387948, Lat: -71.922592, WD=612m
2023	Feb	1	11:14-12:00		Shuthdown and restart of system for training	ew				Parasound training for Johanna
2023	Feb	1	13:48	End PS134_36	Softstart before Station end, to controll exact positioning of sampling location; after 15 min. MMO watch minimum	mg	Single Pulse	10000, 5000, 1000, 500	Cont. PARASOUND PHF	End of station PS134_36 work at 13:54. Start sounding with reduced pulse rate: 13:48 - 14:04 10 s; 14:04 - 14:11 5 s; 14:11 - 14:17 1s; 14:17 - 14: 0.5 s
2023	Feb	1	14:23		Final Pulse rate reached	mg	QED, 4 pulses	1000	Cont. PARASOUND PHF	
2023	Feb	1	21:20	Start PS134_37	Reduced pulse rate (20s); slow approach to station; continued sounding for exact positioning for sampling; with MMO watch during all station time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Start of station PS134_37 work at 21:25, Long:-77.732458, Lat: -71.322810, WD=634m
2023	Feb	1	22:34	Start PS134_38	Reduced pulse rate (20s) during station for exact positioning for sampling With MMO watch during all station time	cb	Single Pulse	20000	Cont. PARASOUND PHF	2 min transfer from PS134_37 to PS134_38 while staying on reduced (20000) single pulse rate

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	1	23:17		Stop sounding because MMs in mitigation zone (2 seals)	cb				Telefon call of MMO
2023	Feb	1	23:32		Start sounding after MMs retreat and stations end, after MMO call from Bridge	cb	Single Pulse	1000	Cont. PARASOUND PHF	No MMs observed for at least 15 Min.; resume sounding with pulse rate of 1000ms ; No softstart neccessary because interruption < 30 min.
2023	Feb	2	00:15	Start PS134_39	Reduced pulse rate (20s); slow approach to station; continued sounding for exact positioning for sampling; with MMO watch during all station time	jh	Single Pulse	20000	Cont. PARASOUND PHF	Start of Station PS134_39 work at 00:15, Long:-77.908436, Lat: -71.284599, WD=640 m
2023	Feb	2	01:03		Resume sounding with pulse rate 10s after station end; with MMO watch during all station time	jh	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_39 at 01:03
2023	Feb	2	08:18	Start PS134_40	Stop sounding, because on station with minor penetration	ew				Start of Station PS134_40 work at 08:18, Long:-80.42888, Lat: -70.516608, WD=642m
2023	Feb	2	13:37	End PS134_40	No sounding during short transit	ew				End of Station PS134_40 work 13:37, no sounding during short transit (< 2nm) to next Station (PS134_41)
2023	Feb	2	14:10	Start PS134_41	No sounding during station time	mg				Start of Station PS134_41 work 14:10, Long: -80.091240, Lat: -70.487424, WD=643

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	2	14:59		Softstart before Station end, to controll exact positioning of sampling location; after 15 min. MMO watch minimum	mg	Single Pulse	10000, 5000, 1000, 500	Cont. PARASOUND PHF	Softstart before station end to controll sampling position after long interruption of sounding. Start sounding with reduced pulse rate: 14:59 - 15:05: 10 s pulse rate; 15:05 -15:10: 5 s pulse rate; from 15:10 1 s pulse rate
2023	Feb	2	15:04	End PS134_41	Resume sounding with pulse rate 10s after station end; with MMO watch during all station time	mg	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_41 at 15:04
2023	Feb	2	20:28	Start PS134_42	Reduced pulse rate (20s) during station for exact positioning for sampling With MMO watch during all station time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Start of Station PS134_42 work at 20:32, Long: -82.099806, Lat: -69.990003, WD=550
2023	Feb	2	22:35	End PS134_42	Resumed sounding with 1000 ms pulse rate after station end, after MMO watch during whole station time	ew	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_42 at 22:32
2023	Feb	3	03:40	Start PS134_44	Stop sounding approaching station	mg				Slow approach (< 1 kn) to final Station location; Start of station work at 03:44; Long: -82.840465, Lat: -69.598061, WD=1110m
2023	Feb	3	09:24	End PS134_44	Softstart after Station end, after 15 min. MMO watch minimum	ew	Single Pulse	10000, 5000, 1000, 500	Cont. PARASOUND PHF	End of station PS134_44 work at 09:19. Start sounding with reduced pulse rate: 09:24 10 s, 9:30 5 s, 09:35 1s, 09:40 0.5 s

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	3	09:40		Final Pulse rate reached	ew	Single Pulse	500	Cont. PARASOUND PHF	
2023	Feb	3	10:17		Reduce pulse rate to 5 s, low speed for streamer deployment	ew	Single Pulse	5000	Cont. PARASOUND PHF	
2023	Feb	3	14:01		Increased pulse rate	mg	Single Pulse	1000	Cont. PARASOUND PHF	Ships speed > 4 kn
2023	Feb	3	14:01		Changed Transmission Sequence	mg	QED, 4 pulses	1000	Cont. PARASOUND PHF	
2023	Feb	3	14:02		Increased pulse rate	mg	QED, 4 pulses	500	Cont. PARASOUND PHF	
2023	Feb	3	14:02		Changed Max. Number of Pulses	mg	QED, 8 pulses	500	Cont. PARASOUND PHF	
2023	Feb	3	15:20		Changed Max. Number of Pulses	mg	QED, 4 pulses	500	Cont. PARASOUND PHF	Current number of pulses only 3
2023	Feb	3	16:17		Changed Transmission Sequence and decreased pule rate	mg	Single Pulse	1000	Cont. PARASOUND PHF	Ships speed < 4 kn
2023	Feb	3	20:13	PS134_45	Changed Transmission Sequence and decreased pule rate	ew	QED, 8 pulses	1000	Cont. PARASOUND PHF	Start Seismic Survey, on line 20230007
2023	Feb	4	08:55		Reduced pulse rate, lower resolution sufficient	ew	QED, 4 pulses	1000	Cont. PARASOUND PHF	Lower resolution is sufficient for seismic survey
2023	Feb	4	12:03		Reduced pulse rate, lower resolution sufficient	ew	QED, 4 pulses	1500	Cont. PARASOUND PHF	Lower resolution is sufficient for seismic survey

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	4	12:10		copy PS134 to MDM	ew				
2023	Feb	4	21:54		change Pulse rate because of much noise	ew	Single Pulse	1000	Cont. PARASOUND PHF	much noise due to rough seafloor topography
2023	Feb	4	18:27	PS134_46	no action					Start Seismic Line 20230008, no changes
2023	Feb	5	13:59	PS134_47	no action					Start Seismic Line 20230009, no changes
2023	Feb	6	12:17	PS134_48	no action					Start Seismic Line 20230010, no changes
2023	Feb	6	~22:13:00		no action					Passing Lander Station PS134_35, on seismic line 20230010
2023	Feb	7	08:13	PS134_49	no action					Start Seismic Line 20230011, no changes
2023	Feb	7	19:28	PS134_50	no action					Start Seismic Line 20230012, no changes
2023	Feb	7	23:22		Stop sounding for noise test	ew				Start of noise test passing Lander Station PS134_35, with MMO all time
2023	Feb	7	23:44		Start sounding after noise test	ew	Single Pulse	1,000	Cont. PARASOUND PHF	End of noise test at Lander Station PS134_35, with MMO all time
2023	Feb	8	06:55		C-Keel: In the window „Sounder Environment“ Source „System C-Keel“ changed to „Manual“ .	ew				Bevor a value of 1449 m/s was displayed in „Survey status“ as C-Keel velocity. After change to „Manual“ a value of 1500 m/s is displayed in „Survey status“ as C-Keel velocity.

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	9	006:06	PS134_51	no action	mg				Start Seismic Line 20230013, no changes
2023	Feb	9	08:18		Stop sounding. Fehlermeldung: Parasound is not sending telegrams, Restart Hydromap Control	ew				very strong seastate, high waves might be possible reason for system failure
2023	Feb	9	08:30		Kompletter Neustart des Hydromap Servers	ew				keine Verbindung zum Parasound Sensor beim ersten Neustart aufgebaut
2023	Feb	9	08:54		Sounding again after second restart	ew	Single Pulse	1500	Cont. PARASOUND PHF	sytem is running again, after twice time restarted
2023	Feb	9	22:51		wieder Fehlermeldungen: Parasound DS PS70 is not sending telegram	ew				system beruhight sich von selbst wieder
2023	Feb	10	04:34	PS134_52	no action	ew				Start Seismic Line 20230014, no changes
2023	Feb	11	05:34	PS134_53	no action	ew				Start Seismic Line 20230015, no changes
2023	Feb	11	07:15		copy to MDM	ew				
2023	Feb	11	22:18	PS134_54	no action	ew				Start Seismic Line 20230016, no changes
2023	Feb	12	14:57		Changed system depth source	mg	Single Pulse	1500	External Hydrosweep DS PHF	System had problems finding the depth
2023	Feb	12	15:01		Stopped sounding for 30 sec	mg				Data quality is very bad
2023	Feb	12	15:05		Changed system depth source	mg	Single Pulse	1500	Cont. PARASOUND PHF	Data quality back to normal

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	12	20:55-21:00		Störung Parasound, danach viele gleichmäßige Sinusschwingungen = Störung von pitch und heave -control	ew				Pitch-Roll-Heave Control ok? Aufschaukeln von Sinusschwingungen
2023	Feb	12	21:27		shuthdown of system, because sinus signal increases in amplitude	ew		off		
2023	Feb	12	21:35		restart of system, MMO watch during all interrupted time (seismic)	ew	Single Pulse	500	Cont. PARASOUND PHF	signal ok, reasonable surface and depth, no wiggels anymore, MMO watch all time present (because of seismic profiling).
2023	Feb	13	02:21		Changed system depth source	mg	Single Pulse	1500	External Hydrosweep DS PHF	
2023	Feb	13	06:14 - 06:37		change transmission sequence	ew	QED, 4 Pulses	1000 , 1500	Cont. PARASOUND PHF	WD > 3000 m
2023	Feb	13	09:00	PS134_55	no action	ew	QED, 4 Pulses	1500	Cont. PARASOUND PHF	Start Seismic Line 20230017, no changes
2023	Feb	14	12:02	PS134_56	no action	ew	QED, 4 Pulses	1500	Cont. PARASOUND PHF	Start Seismic Line 20230018, no changes
2023	Feb	15	03:48	PS134_57	no action	ew	QED, 4 Pulses	1500	Cont. PARASOUND PHF	Start Seismic Line 20230019, no changes
2023	Feb	15	16:26	end PS134_57	no action	ew				End of seismic survey, end of line 20230019, no changes
2023	Feb	16	00:42		stopped sounding	mg				System didn‘t find depth

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	16	00:43		Resumed sounding	mg	QED, 4 Pulses	1500	Cont. PARASOUND PHF	
2023	Feb	16	00:46		Changed depth control	mg	QED, 4 Pulses	1500	External Hydrosweep DS PHF	System is happy again
2023	Feb	16	01:42	Start PS134_58	Stop sounding and system shutdown	mg				Stop Sounding because of sound-test approaching of ALTO (Station PS134_58)
2023	Feb	16	03:42		Resumed sounding	mg	Single Pulse	20000	Cont. PARASOUND PHF	Resumed sounding after 15 min MMO, continous MMO during station
2023	Feb	16	03:50		Changed pulse rate	mg	Single Pulse	10000	Cont. PARASOUND PHF	Needed for meassurements of the „sounding cone““??
2023	Feb	16	04:15		Stopped sounding	mg		off		On Station PS134_58, no Parasound needed
2023	Feb	16	04:38	end PS134_58		mg		off		End of Station PS134_58 work at 04:38, Lander (Alto) recovered
2023	Feb	16	04:48		Softstart, Station end, no MMO watch due to darkness	mg	Single Pulse	20000	Cont. PARASOUND PHF	End Station PS134_58 work at 04:38, Softstart with pulse rates: 20s, 10 s, 5 s, 1s, each 5 min. Sounding needed for depth control - MMO not possible because it is too dark, UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.
2023	Feb	16	04:53		Increased pulse rate	mg	Single Pulse	10000	Cont. PARASOUND PHF	Increased pulse rate after 5 min - for depth controll
2023	Feb	16	05:20		Increased pulse rate	mg	Single Pulse	5000	Cont. PARASOUND PHF	leaving Station PS134_58

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	16	05:27		Increased pulse rate	mg	Single Pulse	1000	Cont. PARASOUND PHF	Final pulse rate
2023	Feb	16	06:36	Start PS134_59	Stop sounding, sequence of Stations with no or only minor penetration	ew		off		Start Station Work PS134_59 at 06:40, Long.: -85.601107, Lat: -70.561816, WD= 659m., no sounding necessary because Stations with no or only minor penetration,
2023	Feb	16	10:52 - 11:07	End PS134_59	Softstart, Station end, no MMO watch because of bad weather and sea state conditions	ew	Single Pulse	20000, 10000, 5000, 1500	Cont. PARASOUND PHF	End station work at 10:16, Softstart with pulse rates: 20s, 10s, 5s, 1.5s each 5 min. Sounding needed for depth controll. MMO watch as tried, but did not make sense due to bad weather conditions, high waves, heavy seastate, and fog . UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.
2023	Feb	16	12:27		reduce pulse rate to 5 s, low speedbecause of heavy sea state	ew	Single Pulse	5000	Cont. PARASOUND PHF	reduced pulse rate beacuse of bad weather and very low speed >4kn during transit to next station
2023	Feb	16	23:08	Start PS134_60	Stop sounding, sequence of Stations with no or only minor penetration	ew		off	Cont. PARASOUND PHF	Start Station Work PS134_60 at 23:05, Long.: -85.149574, Lat: -69.916047, WD= 1154m., no sounding necessary because Stations with no or only minor penetration,

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	17	03:42	End PS134_60	Softstart, Station end, no MMO watch due to darkness	mg	Single Pulse	20000	Cont. PARASOUND PHF	End Station PS134_60 work at 03:29, Softstart with pulse rates: 20s, 10 s, 5 s, 1s, each 5 min. Sounding needed for depth control; MMO not possible as it is to dark and foggy --> UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.
2023	Feb	17	03:59		Reached final pulse rate	mg	Single Pulse	5000	Cont. PARASOUND PHF	Changes of pulse rate: 03:49 - 10 s, 03:54 - 5 s, 03:59 - 1 s
2023	Feb	17	04:23		Increased pulse rate	mg	Single Pulse	1000	Cont. PARASOUND PHF	
2023	Feb	17	06:21		SLF Storage format set from PS3/SGY to PS3	ew				SLF Storage format was set on PS3/SGY before, now changed to PS3
2023	Feb	17	08:29	Start PS134_61	Stop sounding, because on station with minor penetration	ew		off		Start Station Work PS134_61 at 08:28, Long.: -85.599311, Lat: -70.561186, WD= 682m, no sounding necessary because Stations with no or only minor penetration,
2023	Feb	17	10:54 - 11:09	End PS134_61	Softstart, Station end, after 15 min. MMO watch minimum	ew	Single Pulse	20000, 10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_61 at 10:48. Softstart, resume sounding with reduced pulse rate, after 15 min. MMO watch minimum
2023	Feb	17	13:00	Start PS134_62	Stop sounding, approaching station with minor penetration	ew		off		Start Station Work PS134_62 at 12:58, Long.: -86.440953, Lat: -70.664033, WD= 677 m, no sounding necessary because Stations with no or only minor penetration,

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	17	15:26	End PS134_62	Resumed sounding	mg	Single Pulse	20000	Cont. PARASOUND PHF	Resumed sounding with a soft start after 15 min of MMO, no marine mammels sighted
2023	Feb	17	15:42		Reached final pulse rate	mg	Single Pulse	1000	Cont. PARASOUND PHF	Continuing with soft start; pulse rate: 15:32 - 10 s, 15:37 - 5 s, 15:42 - 1 s
2023	Feb	17	21:10	Start PS134_63	Stop sounding, because on station with no or minor penetration	ew		off		Start Station Work PS134_63 at 21:20, Long.: -84.190634, Lat: -71.164297, WD= 611 m, no sounding necessary because Stations with no or only minor penetration.
2023	Feb	18	03:06	End PS134_63	Resumed sounding with soft start	mg	Single Pulse	20000	Cont. PARASOUND PHF	MMO not possible as it was too dark and foggy. In visible area no MM spotted for > 15 min before sounding was resumed.
2023	Feb	18	03:26		Increased pulse rate - soft start	mg	Single Pulse	1000	Cont. PARASOUND PHF	Soft start, pulse rate: 03:14 - 10 s, 03:19 - 5 s, 03:26 - 1 s
2023	Feb	18	03:50	Start PS134_64	Stopped sounding	mg		off		Start Station Work PS134_64 at 03:55, Long.: -84.328066, Lat: -71.110600, WD= 636 m, no sounding necessary because Stations with no or only minor penetration.
2023	Feb	18	04:47 - 09:59		Copy to MDM	mg				
2023	Feb	18	05:01	End PS134_64	Resumed sounding with soft start	mg	Single Pulse	20000	Cont. PARASOUND PHF	MMO not possible as it was too dark, fog and snowfall decreased visibility further. UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop…") - and Reason (e.g. „Station reached; Whale Stop;…")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	18	05:26		Increased pulse rate - soft start	mg	Single Pulse	1000	Cont. PARASOUND PHF	Soft start, pulse rate: 05:06 - 10 s, 05:20 - 5 s, 05:26 - 1 s
2023	Feb	18	08:49	Start PS134_65	Stop sounding, because on station with no or minor penetration	ew		off		Start Station Work PS134_65 at 08:50, Long.: -83.043471, Lat: -71.7500225, WD= 611 m, no sounding necessary because Stations with no or only minor penetration.
2023	Feb	18	09:42-09:57	End PS134_65	Softstart, Station end, after 15 min. MMO watch minimum	ew	Single Pulse	20000, 10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_65 at 09:40. Softstart with pulse rates: 20s, 10 s, 5 s, 1s, each 5 min. After 15 min. MMO watch minimum
2023	Feb	18	14:05		Stopped sounding , Storage error, Storage PHF and SLF low	mg				Stopped sounding because of full data storage. Deleted data of December and January: Before: 1.81 TB - after: 1.43 TB
2023	Feb	18								Folder „Hydrosweep DS3" from 19.12.2022 comprising 1 TB, deleted from g. In Parastore: Disk Fill is now on 18%
2023	Feb	18	14:16	End PS134_65	Start sounding, system restarted	mg	Single Pulse	1000	Cont. PARASOUND PHF	Start sounding with pulse rate 1 s because interruption was less than 30 min.
2023	Feb	18	16:18		Stop sounding, abwettern after Station ???	mg		off		???
2023	Feb	18	20:50		copied G/DATA back to g/DATA	ew		off		Parasotire Window: Disk Fill 32%

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	19	00:54	Start PS134_66	no sounding	ew		off		Start Station Work PS134_66 at 0054, Long.: -81.358338, Lat: -72.373511, WD= 907 m, no sounding continued due to bad weather, and during all station time because only minor penetration.
2023	Feb	19	02:16 - 02:36	End PS134_66	Softstart, Station end, after 15 min. MMO watch minimum	ew	Single Pulse	20000, 10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_66 at 02:20. Softstart with pulse rates: 20s, 10 s, 5 s, 1s, each 5 min. After 15 min. MMO watch minimum
2023	Feb	19	05:10	Start PS134_67	Stopped sounding	mg		off		
2023	Feb	19	06:01 - 06:16	End PS134_67	Softstart, Station end after call from Bridge. No MMO watch possible	ew	Single Pulse	20000, 10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_67 at 05:44. After call from Bridge Softstart, resume sounding with reduced pulse rate. MMO not possible as it was too dark. UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.
2023	Feb	19	09:40	Start PS134_68	Change Pulse Modus for Bathymetry Survey	ew	QED, 4 Pulses	1000	Cont. PARASOUND PHF	Start of Bathymetric Survey
2023	Feb	19	16:05		Changed pulse mode and rate	mg	Single Pulse	500	Cont. PARASOUND PHF	System had problems finding the depth
2023	Feb	19	16:11		Changed pulse mode and rate back to previous settings	mg	QED, 4 Pulses	1000	Cont. PARASOUND PHF	

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	20	11:47	Start PS134_69	Stop sounding, because on station with minor penetration	ingra		off		Start of station PS134_69 work at 11:39 , Long:-73.521503, Lat: -81.903461, WD=989m, No sounding because Station with no or only minor Penetration
2023	Feb	20	14:31	End PS134_69	Resumed sounding - soft start	mg	Single Pulse	20000	Cont. PARASOUND PHF	Resumed sounding after 15 min MMO
2023	Feb	20	14:47		Final Pulse rate reached	mg	Single Pulse	1000	Cont. PARASOUND PHF	Soft start: 14:36 - 10 s, 14:42 - 5 s, 14:47 - 1 s
2023	Feb	20	14:53		Changed pulse mode	mg	QED, 4 pulses	1000	Cont. PARASOUND PHF	
2023	Feb	21	15:41	Start PS134_70	Stop sounding, because on station with minor penetration	mg		off		Start of station PS134_70 work at 15:51, Long:-73.598873, Lat: -83.254285, WD=798m, No sounding because Station with no or only minor Penetration
2023	Feb	21	21:10 -21:25	End PS134_70	Softstart, Station end, after 15 min. MMO watch minimum	ew	Single Pulse QED,4pulses	20000, 10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_70 at 21:04. Softstart with pulse rates: 20s, 10 s, 5 s, 1s, each 5 min. After 15 min. MMO watch minimum
2023	Feb	21	23:11	Start PS134_71-1	Stop sounding, because on station with minor penetration	bh		off		Start of station PS134_71-1 work at 23:11, Long:-73.626764, Lat: -82.407964, WD=518m, No sounding because Station with no or only minor Penetration

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	22	00:11		Start sounding with 1000 ms pulse rate, because right position urgently needed. MMO watch on bride, no sightings of MMs.	ew	Single Pulse	1000	Cont. PARASOUND PHF	Sounding had urgently to be resumed with 1000 ms pulse rate and has to be continued during station time to define a small sampling location. MMO watch on bridge all time. The softstart was shortened to get the right position in appropriate time. UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.
2023	Feb	22	00:52	End PS134_71	Station end, after MMO watch on the bridge during all time.	jh	Single Pulse	1000	Cont. PARASOUND PHF	End of station PS134_71 at 00:51, after MMO watch on the bridge during all time.
2023	Feb	22	02:02	Start PS134_72	Reduced pulse rate (20s) ; continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	20000	Cont. PARASOUND PHF	Start of station PS134_72 work at 01:57, Long:-73.626211, Lat: -82.391413, WD=527m, Parasound needed on station for positioning of the ship, MMO watch during all station time
2023	Feb	22	02:50 - 03:00	End PS134_72	Resumed sounding with reduced pulse rate after station end, after 15 min. MMO watch minimum	mg	Single Pulse	10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_72 at 02:52. Softstart, pulse rate: 10 s, 5 s, 1s , each 5 min.; after 15 min. MMO watch
2023	Feb	22	03:06		change transmission sequence for use on station	mg	QED, 4 pulses	1000	Cont. PARASOUND PHF	
2023	Feb	22	03:33	Start PS134_73	Reduced ping rate (20s), continued sounding for exact positioning for sampling; no MMO watch possible due to darkness	mg	Single Pulse	20000	Cont. PARASOUND PHF	Start of station work PS134_73 at 03:36, Long: -81557846°W , Lat:-73.557459 °S, WD 562m. MMO watch on bridge until 5:00. From 5:00 to dark to continue MMO. UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	22	05:56	End PS134_73	Resumed sounding with 5s pulse rate after station end	mg	Single Pulse	5000	Cont. PARASOUND PHF	End of station work PS134_73 at 05:46
2023	Feb	22	05:58		Resumed sounding with 1s pulse rate	mg	Single Pulse	1000	Cont. PARASOUND PHF	
2023	Feb	22	06:19	Start PS134_74	Reduced ping rate (20s), continued sounding for exact positioning for sampling; no MMO watch possible due to darkness	ew	Single Pulse	20000	Cont. PARASOUND PHF	Start of station work PS134_74 at 06:18, Long: -81.523410°W , Lat:-73.615855 °S, WD 586m. MMO not possible as it is to dark --> UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)1.)) applied.
2023	Feb	22	07:07	End PS134_74	Resumed sounding with 1 s pulse rate after station end	ew	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_74 at 07:06
2023	Feb	22	07:57	Start PS134_75	Reduced pulse rate (20s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Start Station PS134_75 work at 07:58, Long: -81.870921, Lat: -73.636776, WD=753m; with MMO watch during all station time
2023	Feb	22	08:50 - 09:09	End PS134_75	Resumed sounding with reduced pulse rate after station end; with MMO watch during all station time	ew	Single Pulse	10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_75 at 08:52
2023	Feb	22	09:39		Reduced pulse rate (20s) approaching Station PS134_75, with MMO watch all time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Slow approach (< 1 kn) to final Station location

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	22	09:45		Resume sounding with pulse rate 1s to find exactly sampling location ; with MMO watch during all station time	ew	Single Pulse	1000	Cont. PARASOUND PHF	Higher Pulse rate 1s needed during slow approach (< 1 kn) to Station location PS134_76, looking for final Station location
2023	Feb	22	09:54	Start PS134_76	Reduced pulse rate (20s) approaching Station PS134_76, with MMO watch all time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Start Station PS134_76 work at 09:51, Long: -82.138814, Lat: -73.564947, WD=919m; with MMO watch during all station time
2023	Feb	22	10:54	End PS134_76	Resumed sounding with reduced pulse rate after station end; with MMO watch during all station time	ingra	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_76 at 10:53
2023	Feb	22	11:35	Start PS134_77	Reduced pulse rate (20s) approaching Station PS134_77, with MMO watch all time	ingra	Single Pulse	20000	Cont. PARASOUND PHF	Start Station PS134_77 work at 11:34, Long: -81.907309, Lat: -73.520649, WD=1007.1m; with MMO watch during all station time
2023	Feb	22	12:43 - 12:53	End PS134_77	Resumed sounding with reduced pulse rate after station end; with MMO watch during all station time	ew	Single Pulse	10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_77 at 12:40
2023	Feb	22	14:00	Start PS134_78	Reduced pulse rate (20s) approaching Station PS134_78, with MMO watch all time	mg	Single Pulse	20000	Cont. PARASOUND PHF	Begin of station work PS134_78 at 14:02, Long: -81.609551 W, Lat: -73.368993 S, WD = 903.2 m; Parasound needed for positioning - MMO watch during all station time
2023	Feb	22	15:06	End PS134_78	Resumed sounding with 1 s pulse rate after station end	mg	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_78 at 15:03

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	22	16:22	Start PS134_79	Reduced pulse rate (20s) approaching Station PS134_78, with MMO watch all time	mg	Single Pulse	20000	Cont. PARASOUND PHF	Begin of station work PS134_79 at 16:19, Long: -82.305464 W, Lat: -73.420285 S, WD = 695.4 m; Parasound needed for positioning - MMO watch during all station time
2023	Feb	22	17:25	End PS134_79	Resumed sounding with 1 s pulse rate after station end	mg	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_79at 17:25
2023	Feb	22	18:37	Start PS134_80	Reduced pulse rate (20s) approaching Station PS134_78, with MMO watch all time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Begin of station work PS134_80 at 18:31, Long: -82.747515 W, Lat: -73.495911 S, WD = 563 m; Parasound needed for positioning - MMO watch during all station time
2023	Feb	22	19:09	End PS134_80	Resumed sounding with 1 s pulse rate after station end	ew	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_80 at 19:07
2023	Feb	22	20:01	Start PS134_81	Reduced pulse rate (10s) approaching Station PS134_78, with MMO watch all time	ew	Single Pulse	10000	Cont. PARASOUND PHF	Begin of station work PS134_81 at 20:00, Long: -82.960236W, Lat: -73.588132 S, WD = 569 m; Parasound needed for positioning on very narrow sampling location - MMO watch during all station time
2023	Feb	22	20:48	End PS134_81	Resumed sounding with 1 s pulse rate after station end	ew	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_81 at 20:48
2023	Feb	22	21:26	Start PS134_82	Reduced pulse rate (20s) approaching Station PS134_78, with MMO watch all time	ew	Single Pulse	20000	Cont. PARASOUND PHF	Begin of station work PS134_82 at 21:30,Long: -83.245464 W, Lat: -73.606978 S, WD = 825 m; Parasound needed for positioning - MMO watch during all station time

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	22	22:22	End PS134_82	Resumed sounding with 1 s pulse rate after station end	bh	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_82 at 22:22
2023	Feb	22	23:02	Start PS134_83	Reduced pulse rate (20s) approaching Station PS134_78, with MMO watch all time	bh	Single Pulse	20000	Cont. PARASOUND PHF	Begin of station work PS134_83 at 23:02,Long: -82.964893 W, Lat: -73.587678 S, WD = 823 m; Parasound needed for positioning - MMO watch during all station time
2023	Feb	23	01:18	End PS134_83	Resumed sounding with 1 s pulse rate after station end	sh	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_83 at 01:14
2023	Feb	23	02:08	Continue PS134_68	Changed transmission sequence for Bathymetry Survey	mg	QED, 4 Pulses	1000	Cont. PARASOUND PHF	Continuation of Bathymetric Survey named as Station PS134_68
2023	Feb	23	11:03	Continue PS134_83	Speed decreased to 5 kn	ingra	QED, 4 Pulses	1000	Cont. PARASOUND PHF	Speed decreased to try to better view the sediments layers in the Parasound due to top soft sediments coverage.
2023	Feb	23	11:41	Start PS134_84	Stop sounding, because on station with minor penetration	ingra	off			Start of station PS134_84 work at 11:40 , Long:-83.479759, Lat: -73.203534, WD=1074.5m. No sounding because Station with no or only minor Penetration
2023	Feb	23	14:53	End PS134_84	Start sounding with soft start	mg	Single Pulse	20000	Cont. PARASOUND PHF	End of station work PS134_84 at 14:48. Softstart with pulse rates: 20s, 10 s, 5 s, 1s, each 5 min. After 15 min. MMO watch minimum
2023	Feb	23	15:10		Final Pulse rate reached	mg	Single Pulse	1000	Cont. PARASOUND PHF	Soft start, pulse rate: 14:49 - 10 s, 15:04 - 5 s, 15:10 - 1 s

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	23	15:15		Changed transmission sequence	mg	QED, 4 Pulses	1000	Cont. PARASOUND PHF	
2023	Feb	23	22:37		Stop Sounding	bh	off			Stopped souding because of Whales in mitigation zone
2023	Feb	23	22:52		Start sounding, MMO watch during all interrupted time	bh	QED, 4 Pulses	1000	Cont. PARASOUND PHF	Resume sounding after call from MMO - no marine mammals sigthed in mitigation zone since shutdown, no softstart neccessary because interruption < 30 min.
2023	Feb	24	08:30		change pulse rate and transmission sequence for test	ew	Single Pulse	500		test if PHF signal can be made less scattered
2023	Feb	24	09:10		test finished, back to previous settings	ew	QED, 4 Pulses	1000	Cont. PARASOUND PHF	tested: differnet pulse rates, amplificaion, gain settings… result: no improvement of scattered PHF signal
2023	Feb	24	12:19	Start PS134_85	Reduced pulse rate (10s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	10000	Cont. PARASOUND PHF	Start Station PS134_85 work at 12:19, Long: -83.121576, Lat: -73.327449, WD=478m; with MMO watch during all station time
2023	Feb	24	13:10		Resumed sounding with 1 s pulse rate after station end	ew	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_85 at 13:06
2023	Feb	24	13:44	Start PS134_86	Reduced pulse rate (10s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	10000	Cont. PARASOUND PHF	Start Station PS134_86 work at 13:47, Long: -83.326256, Lat: -73.363143, WD=691m; with MMO watch during all station time

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	24	14:36	End PS134_86	Resumed sounding	mg	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_86 at 14:36
2023	Feb	24	15:05	Start PS134_87	Reduced pulse rate (10s); continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	10000	Cont. PARASOUND PHF	Start station PS134_87 work at 15:10 , Lat: -73.393439, Long: -83.537310, WD = 654.3 m; MMO watch during all station time
2023	Feb	24	16:53	n/a	Stopped sounding and shut down system, strange PHF signal	mg		off		PHF signal shows a ~5m thick scattered stripe with undulations on top - restart sytem
2023	Feb	24	17:21	n/a	Start sounding with reduced pulse rate (10s); continued sounding for exact sampling position; with MMO watch during all station time	mg	Single Pulse	10000	Cont. PARASOUND PHF	PHF signal still looks the same
2023	Feb	24	18:09	End PS134_87	Resumed sounding with 1 s pulse rate after station end	mg	Single Pulse	1000	Cont. PARASOUND PHF	End of station work PS134_87 at 18:08
2023	Feb	24	19:33	Start PS134_88	Reduced pulse rate (10s); continued sounding for exact sampling position; with MMO watch during all station time	ew	Single Pulse	10000	Cont. PARASOUND PHF	Start station PS134_88 work at 19:30 , Lat: -73.195304, Long: -83.950774, WD = 1117 m; MMO watch during all station time

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop…") - and Reason (e.g. „Station reached; Whale Stop;…")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	24	19:40		MMO call: seal in mitigation zone, but continue sounding with reduced pulse rate for safe positioning on station	ew	Single Pulse	10000	Cont. PARASOUND PHF	Sounding had urgently to be continued with reduced pulse rate (10s) for a safe deployment of gear and positioning on station. MMO watch on bridge all time. --> UBA Ausnahmegenehmigung (§17,Abs.2 Satz 1 AUG, IV.)3.)) applied.
2023	Feb	24	19:45		Stop sounding for seal in mitigation zone was possible now	ew		off		Stop souding during seal in mitigation zone was possible now. Sampling location and gear were safely positioned. Bridge was informed. MMO watch on bride all time. Later a whale approached.
2023	Feb	24	20:39 - 20:50	End PS134_88	Softstart, after Station end, and retreat of MMs , after 15 min. MMO watch minimum	ew	Single Pulse	10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_88 at 20:26. Sofsstart after call from MMO: seal and whale were out of mitigation zone for > 15 min.
2023	Feb	24	22:55		Changed system depth source	bh	QED, 4 pulses	1000	External Hydrosweep DS PHF	Waterdepth around 150 meters --> Changed to external Hydrosweep DS PHF after manual change due to problems with Cont. PARASOUND PHF Changed Depth Search Window to 100 - 2000 Meters
2023	Feb	24	23:10		Changed system depth source	bh	QED, 4 pulses	1000	Cont. PARASOUND PHF	Controlled PARASOUND PHF depth is good again
2023	Feb	25	07:54	n/a	Copy to MDM	ew				
2023	Feb	25	10:34	Start PS134_89	Stop sounding, because on station with minor penetration	ingra		off		Start of station PS134_89 work at 10:33 , Long:-90.405443, Lat: -72.458411, WD=916m

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	25	13:38 - 13:55		Softstart, Station end, after 15 min. MMO watch minimum	ew	Single Pulse QED, 4 pulses	20000, 10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_89 at 13:32. Softstart, pulse rate: 20s, 10 s, 5 s, 1s , each 5 min.; after 15 min. MMO watch minimum
2023	Feb	25	20:15	n/a	no action	ml				Turn around to pick up buoy ,
2023	Feb	26	11:41	Start PS134_90	Stop sounding, because on station with no penetration.	jh		off		Start of station PS134_90 work at 11:39 , Lon:-92.977805, Lat: -72.486372, WD=587m
2023	Feb	26	13:37 - 13:47		Softstart, Station end, after 15 min. MMO watch minimum	ew	Single Pulse QED, 4 pulses	10000, 5000, 1000	Cont. PARASOUND PHF	End of station work PS134_90 at 13:32. Shortened Softstart because close to next Station; pulse rate: 10 s, 5 s, 1s , each 5 min.; after 15 min. MMO watch minimum
2023	Feb	26	14:16	Start PS134_91	Reduce pulse rate and transmission sequence for station work	mg	Single Pulse	10000	Cont. PARASOUND PHF	Start station work at 14:39. Lat: -72.492496, Lon: -92.692810, WD = 734.7 m. Parasound needed for positioning on station - MMO during all station time
2023	Feb	26	17:10	End PS134_91	Resumed sounding with 5 s pulse rate after station end	mg	Single Pulse	5000	Cont. PARASOUND PHF	End of station work PS134_91 at 17:09
2023	Feb	26	17:15		Changed transmission sequence	mg	QED, 4 pulses	1000	Cont. PARASOUND PHF	
2023	Feb	26	18:07	Start PS134_92	Reduce pulse rate after long and complicated approach to station	ew	Single Pulse	10000	Cont. PARASOUND PHF	Start station PS134_92 work at 18:05 , Lat: -72.424597, Long: -92.630544, WD = 640 m; MMO watch during all station time
2023	Feb	26	18:46-18:53	End PS134_92	Resumed sounding with 5 s pulse rate after station end	ew	Single Pulse	5000	Cont. PARASOUND PHF	End of station work PS134_92 at 18:45

Year	Month	Day	Time UTC	Station	Action (e.g. “Start; Stop...”) - and Reason (e.g. „Station reached; Whale Stop;...“)	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Feb	26	19:01		Changed transmission sequence	ew	Single Pulse	1000	Cont. PARASOUND PHF	
2023	Feb	27	18:45		no action	ew				Transit to Punta Arenas
2023	Feb	27	evening		several changes of transmission, sequence, pulse rates, depth window due to very rough topography	ew	Single Pulse, QED 4 pulses	1000, 500	Cont. Parassound PHF, external Hydro DS PHF	Very rough topography approching and around Peter 1 Island, often seafloor detection lost
2023	Feb	28	03:11		Changed transmission sequence	mg	QED, 4 pulses	1000	Cont. PARASOUND PHF	
2023	Feb	28	05:26		Changed pulse rate	mg	QED, 4 pulses	1500	Cont. PARASOUND PHF	
2023	Feb	28	07:30 - 12:00		copy to MDM	ew				
2023	Feb	28	08:00 - 13:00		copy to MDM	ew				
2023	Mar	1	08:00 - 13:00		copy to MDM	ew				
2023	Mar	1	23:59		Changed transmission sequence	ew	Single Pulse	1000	External Hydrosweep DS PHF	because of bad seafloor detection in Cont.Paras.
2023	Mar	2	10:00-14:00		copy to MDM	ew				

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop…") - and Reason (e.g. „Station reached; Whale Stop;…")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
2023	Mar	2	19:08	n/a	Stop MMO watches north of 60°S. Continued sounding and logging with normal ping rate.	ew				Stop MMO watches north of 60°S. Continued sounding and logging with normal ping rate but stop watch keeping because leaving area of Antarctic Treaty System; Lon:-81.391'W, Lat: -60.00°' S, WD=5040m.
2023	Mar	3	10:10		copy to MDM	ew				
2023	Mar	4	01:59	n/a	Generell Stop of Parasound subbottom profiling for PS134	mg,ew		off		Stop sounding and logging when entering EEZ of Chile, Long: -78.151°W Lat: -56.305°S, Depth~4516m, Storage Disk Fill: 37%
					Responsible Observer (Watch-Keeper): ew = Estella Weigelt, mg = Marie Gärtner					
					Voluntary Observer (Watch-Keeper): bh = Benedikt Haimerl, cb = Carolin Brand, CD = Claus-Dieter Hillenbrand, cp = Christina Paul, imb = Ingra Malucelli Barbosa, jb = Johannes Baltzer, jh = Jakob Hamann, rdla = Rob Larter					
					Files Summary	No. Of Files				

Year	Month	Day	Time UTC	Station	Action (e.g. "Start; Stop...") - and Reason (e.g. „Station reached; Whale Stop;...")	Observer	Modus [Single Pulse or QED (# Pulses)]	Puls rate (ms)	System Depth Source	Comments
					PHF*.ps3	8900				
					SLF*.ps3	8916				
					ps32sgy	8916				
					CONV	767				
					NAV	381				
					UKOOA	381				
					SGY	381				

A.6 PARASOUND PROFILES AND STATIONS

File name	min [s]	max [s]	Depth	Plot	Comment
2022_1224_233911.sgy	5.15	6.40	ok	-	
2022_1225_033914.sgy	6.10	6.65	ok	y	Test CTD
2022_1225_073927.sgy	6.30	6.70	ok	y	PS134_01
2022_1225_113936.sgy	5.80	6.75	ok	-	AgulhasRidge
2022_1225_153944.sgy	4.20	6.75	ok	-	AgulhasRidge+Slope
2022_1225_193956.sgy	5.65	7.05	ok	-	AgulhasRidge
2022_1225_234006.sgy	5.25	7.20	ok	-	
2022_1226_034015.sgy	5.60	7.30	ok	-	
2022_1226_074027.sgy	5.80	7.70	ok	-	
2022_1226_114037.sgy	5.30	7.35	ok	-	
2022_1226_154047.sgy	3.20	7.35	ok	-	Sea mount, often parameter changes due to Parasound Training
2022_1226_194057.sgy	6.20	7.30	ok	-	QED, 3, 2500ms
2022_1226_234101.sgy	5.60	7.10	ok	-	QED, 3, 2500ms
2022_1227_034106.sgy	5.45	7.05	ok	y	PS134_02
2022_1227_074117.sgy	6.30	6.60	ok	-	on station PS134_
2022_1227_114541.sgy	6.30	6.80	ok	-	on station PS134_
2022_1227_154602.sgy	4.70	7.00	ok	-	ParasoundTraining: Change of sounding parameters
2022_1227_194625.sgy	6.00	7.00	ok	-	
2022_1227_234636.sgy	5.15	6.60	ok	-	Weather stand by at end of profil
2022_1228_034641.sgy	4.90	6.30	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1228_074700.sgy	5.70	6.50	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1228_114740.sgy	5.60	6.10	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1228_154826.sgy	5.40	6.10	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1228_194926.sgy	5.05	5.80	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1228_235026.sgy	4.70	5.50	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1229_035126.sgy	4.50	5.70	ok	-	Weather stand by and Parasound-training (often change of parameters)
2022_1229_075157.sgy	4.20	5.40	ok	-	Weather stand by and Parasound-training (often change of parameters)
					gap segy was recorded instead of ps3
				-	
2022_1230_063547.sgy	4.50	5.40	ok	-	
2022_1230_103549.sgy	3.30	5.50	ok	-	
2022_1230_143556.sgy	3.20	7.10	ok	-	
2022_1230_183602.sgy	3.20	5.70	ok	-	

File name	min [s]	max [s]	Depth	Plot	Comment
2022_1230_223611.sgy	4.00	5.80	ok	-	
2022_1231_023617.sgy	3.90	6.70	ok	-	
2022_1231_063623.sgy	6.20	6.90	ok	y	PS134_03
2022_1231_103630.sgy	4.90	7.40	ok	-	PS134_03 , depth jumps
2022_1231_143704.sgy	5.30	7.03	ok	-	
2022_1231_183720.sgy	5.05	7.90	ok	-	
2022_1231_223733.sgy	5.90	7.70	ok	-	
2023					
2023_0101_023742.sgy	5.80	7.50	ok	-	
2023_0101_063757.sgy	4.10	7.30	ok	-	
2023_0101_103808.sgy	6.20	7.90	ok	-	
2023_0101_143822.sgy	6.60	7.40	ok	-	
2023_0101_183829.sgy	7.00	7.40	ok	y	PS134_04
2023_0102_015715.sgy	6.70	7.50	ok	-	PS134_04
2023_0102_055742.sgy	6.10	7.40	ok	-	
2023_0102_095758.sgy	7.00	7.40	ok	-	
2023_0102_135807.sgy	5.90	7.40	ok	-	
2023_0102_175822.sgy	6.20	7.40	ok	-	
2023_0102_215838.sgy	5.80	7.40	ok	y	PS134_05, MaudRise northernSlope
2023_0103_070316.sgy	5.70	6.15	ok	-	Short Profile (8m) MaudRiseSlope
					Gap because of Stations with short transit times inbetween, Stations PS134_06 to 09 no profiles
2023_0103_212409-080703.sgy	2.75	4.00	ok	y	Test file to join lines 2023_0103_212409 and 2023_0104_080703
2023_0103_212409.sgy	2.75	3.95	ok	y	PS134_09 at start, PS134_10 at end, MaudRise northern slope, QED
2023_0104_080703.sgy	2.81	3.04	ok	y	PS134_10 at start, PS134_11 at end, MaudRise, QED
2023_0104_163211.sgy	1.40	3.30	ok	y	PS134_11, PS134_12, PS134_13, Mau-dRise, SouthesternSlope
2023_0104_203232.sgy	2.60	4.00	ok	y	
2023_0105_003236.sgy	3.30	5.10	ok	y	
2023_0105_043241.sgy	4.50	6.60	ok		MaudRise, southwestern slope
2023_0105_083244.sgy	6.05	6.55	ok		UKOOA file kann nicht in KINGDOM eingelesen werden
2023_0105_123249.sgy	5.25	6.35	ok		
2023_0105_163256.sgy	4.75	5.75	ok		
2023_0105_203306.sgy	3.65	5.10	ok		
2023_0106_003315.sgy	2.50	4.10	ok		gap due to heavy ice
2023_0106_043321.sgy	2.60	4.30	ok		
2023_0106_083327.sgy	1.00	2.95	ok		
2023_0106_123331.sgy	0.20	2.60	ok		shelf edge off Neumayer

File name	min [s]	max [s]	Depth	Plot	Comment
					at Neumayer Station
2023_0108_222327.sgy	0.40	2.80	ok		shelf edge off Neumayer
2023_0109_022348.sgy	0.50	3.50	ok		jumps in depth
2023_0109_062354.sgy	2.95	6.10	ok		shelf edge off Neumayer
2023_0109_102402.sgy	5.75	6.50	ok		
2023_0109_142410.sgy	6.10	6.50	ok		eastern WeddellSea, gaps because of collisions with ice floes
2023_0109_182422.sgy	6.10	6.50	ok		eastern WeddellSea, gaps because of collisions with ice floes
2023_0109_222430.sgy	6.00	6.40	ok		eastern WeddellSea, channel+drift
2023_0110_022433.sgy	6.00	6.40	ok		eastern WeddellSea, little drift
2023_0110_062442.sgy	6.00	6.40	ok		
2023_0110_102452.sgy	6.00	6.40	ok		channel+drift
2023_0110_142503.sgy	6.00	6.40	ok		slump
2023_0110_182515.sgy	6.00	6.40	ok		
2023_0110_222523.sgy	6.00	6.40	ok		
2023_0111_022537.sgy	6.00	6.20	ok		channel-levee system
2023_0111_062545.sgy	5.90	6.10	ok		sediment waves
2023_0111_102558.sgy	5.70	6.10	ok		channel-levee
2023_0111_142606.sgy	5.80	6.00	ok		
2023_0111_182618.sgy	5.80	6.00	ok		sediment waves
2023_0111_222625.sgy	5.80	6.00	ok		
2023_0112_022636.sgy	5.80	6.00	ok		very nice channel -levee
2023_0112_062647.sgy	5.60	6.00	ok		
2023_0112_102652.sgy	5.30	5.70	ok		
2023_0112_142659.sgy	5.40	5.80	ok		
2023_0112_182709.sgy	5.60	5.80	ok		
2023_0112_222716.sgy	5.30	5.70	ok		
2023_0113_022720.sgy	5.30	5.60	ok		
2023_0113_062727.sgy	5.30	5.50	ok		WeddellSea, ~50m SedimentLayers
2023_0113_102737.sgy	5.10	5.50	ok		
2023_0113_142747.sgy	4.70	5.20	ok		Western WeddellSea, rise+ Sediment-Waves
2023_0113_182755.sgy	4.50	4.90	ok		western WeddellSea, SedimentWaves
2023_0113_222801.sgy	4.20	4.70	ok		Western WeddellSea, rise+ Transparen-tUpperLayer
2023_0114_022805.sgy	3.80	4.40	ok		
2023_0114_062812.sgy	3.30	4.00	ok		
2023_0114_102821.sgy	2.70	3.60	ok		gap: jump in depth, likely ice under sensor or ice-breaking
2023_0114_142831.sgy	1.00	2.90	ok		
2023_0114_182840.sgy	0.30	1.20	ok		Shelf of Peninsula off Antarctic Sound Rosamel
2023_0114_222849.sgy	0.30	0.70	ok		Shelf of Peninsula off Antarctic Sound Rosamel
2023_0115_022859.sgy	0.20	1.60	ok		

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0115_062909.sgy	0.00	1.30	ok		
2023_0115_102919.sgy	0.10	1.30	ok		
2023_0115_142929.sgy	0.20	0.90	ok		
2023_0115_182939.sgy	0.00	1.30	ok		
2023_0115_222946.sgy	0.10	1.30	ok		
2023_0116_022951.sgy	0.20	1.30	ok		
2023_0116_063001.sgy	0.10	1.50	ok		Channel-Levee System
2023_0116_103011.sgy	0.10	1.00	ok		
2023_0116_143017.sgy	0.10	0.80	ok		Sedimentpokets
2023_0116_183021.sgy	0.10	1.00	ok		tests change of pulse rate
2023_0116_223026.sgy	0.10	1.20	ok		
2023_0117_023032.sgy	0.10	1.50	ok		
2023_0117_063042.sgy	0.10	1.10	ok		
2023_0117_103049.sgy	0.00	1.20	ok		
2023_0117_143057.sgy	0.00	1.30	ok		
2023_0117_183105.sgy	0.40	1.30	ok		
2023_0117_223109.sgy	0.00	1.20	ok		
2023_0118_023117.sgy	0.00	1.10	ok		
2023_0118_063125.sgy	0.20	1.20	ok		
2023_0118_103133.sgy	0.10	1.20	ok		
2023_0118_143141.sgy	0.20	1.60	ok	y	NorthEastern leg of Entrance to Ronne Channel
2023_0118_183146.sgy	0.10	1.10	ok	y	
2023_0118_223149.sgy	0.70	1.00	ok	y	Small Sediment Basin off Latady Island
2023_0119_023150.sgy	0.60	0.90	ok	y	
2023_0119_063153.sgy	0.70	1.10	ok	y	PS134_17, PS134_18, PS134_19
2023_0119_103155.sgy	0.80	1.50	ok	y	Begin PS134_14-1 (BathySurvey 11:05)
2023_0119_143158.sgy	0.90	1.80	ok	y	
2023_0119_183200.sgy	0.90	1.60	ok	y	PS134_15, PS134-22, gap and strange jump in data
2023_0119_223203.sgy	0.80	1.60	ok	y	PS134_23, PS134_24, PS134_27, jump in data
2023_0120_023204.sgy	0.80	1.40	ok	y	
2023_0120_063206.sgy	0.80	1.20	ok	y	PS134_16, PS134_20, PS134_21, PS134_25, PS134_26
2023_0120_103209.sgy	0.80	1.40	ok	y	
2023_0120_143211.sgy	0.80	1.10	ok	y	sediment basin ~10m
2023_0120_183214.sgy	0.80	1.10	ok	y	thickening of upper transparent reflector from thin drape to ~8m thick layer
2023_0120_223216.sgy	0.80	1.10	ok	y	
2023_0121_023218.sgy	0.90	1.80	ok	y	strong topography
2023_0121_063221.sgy	0.00	1.30	ok	y	innermost profile inRonne Entrance
2023_0121_103225.sgy	0.20	1.10	ok	y	PS134_16
2023_0121_143227.sgy	0.80	1.10	ok	y	PS134_17, PS134_18
2023_0121_183240.sgy	0.80	1.10	ok	y	PS134_18. PS134_19

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0121_223248.sgy	0.80	1.10	ok	y	PS134_19, PS134_20, PS134_21
2023_0122_023250.sgy	0.80	1.00	ok	y	PS134_20
2023_0122_063330.sgy	0.80	1.00	ok	y	PS134_20
2023_0122_103419.sgy	0.80	1.10	ok	y	PS134_21, PS134_22
2023_0122_143421.sgy	0.80	1.20	ok	y	PS134_22, PS134_23
2023_0122_183442.sgy	0.80	1.20	ok	y	PS134_24, PS134_25
2023_0122_223446.sgy	0.90	1.60	ok	y	PS134_26, PS134-27
2023_0123_023500.sgy	0.70	1.90	ok	y	PS134_27
2023_0123_063522.sgy	0.70	1.50	ok	y	
2023_0123_114437.sgy	0.70	1.50	ok	y	
2023_0123_154448.sgy	0.80	1.60	ok	y	
2023_0123_194452.sgy	0.80	1.60	ok	y	
2023_0123_234503.sgy	0.80	1.60	ok	y	start seismic line 20230001 (PS134_29) at 01:33
2023_0124_034504.sgy	0.80	1.10	ok	y	start seismic line 20230002 (PS134_30) at 06:38
2023_0124_074507.sgy	0.80	1.00	ok	y	PS134_21 on seismic line 20230002
2023_0124_114509.sgy	0.80	1.00	ok	y	on seismic line 20230002
2023_0124_154512.sgy	0.80	1.20	ok	y	on seismic line 20230002
2023_0124_194515.sgy	0.80	1.20	ok	y	on seismic line 20230002
2023_0124_234516.sgy	0.70	1.00	ok	y	on seismic line 20230002
2023_0125_034518.sgy	0.70	1.00	ok	y	on seismic line 20230002
2023_0125_074522.sgy	0.60	1.10	ok	y	on seismic line 20230002
2023_0125_114524.sgy	0.80	0.90	ok	y	PS134_37, PS134_38, PS134_39, on seismic line 20230002
2023_0125_154527.sgy	0.80	0.90	ok	y	on seismic line 20230002
2023_0125_194529.sgy	0.70	1.00	ok	y	on seismic line 20230002
2023_0125_234531.sgy	0.50	0.90	ok	y	on seismic line 20230002
2023_0126_034533.sgy	0.60	1.00	ok	y	PS134_40-5, PS134_41, on seismic line 20230002
2023_0126_074535.sgy	0.70	0.90	ok	y	on seismic line 20230002
2023_0126_114538.sgy	0.60	0.90	ok	y	on seismic line 20230002
2023_0126_154540.sgy	0.60	0.80	ok	y	on seismic line 20230002
2023_0126_194542.sgy	0.60	1.20	ok	y	on seismic line 20230002
2023_0126_234543.sgy	1.00	2.60	ok	y	start seismic line 2023003 (PS134_31) at 03:23:57
2023_0127_034545.sgy	1.00	2.40	ok	y	on seismic line 20230003
2023_0127_074547.sgy	0.50	1.20	ok	y	on seismic line 20230003
2023_0127_114549.sgy	0.60	0.90	ok	y	start seismic line 2023004 (PS134_32) at 14:29:22
2023_0127_154551.sgy	0.60	0.90	ok	y	on seismic line 20230004
2023_0127_194553.sgy	0.60	0.80	ok	y	on seismic line 20230004
2023_0127_234554.sgy	0.60	0.90	ok	y	on seismic line 20230004
2023_0128_034556.sgy	0.65	0.95	ok	y	on seismic line 20230004

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0128_074558.sgy	0.60	0.90	ok	y	PS134_42, on seismic line 20230004
2023_0128_114600.sgy	0.50	0.80	ok	y	on seismic line 20230004
2023_0128_154602.sgy	0.55	0.85	ok	y	on seismic line 20230004
2023_0128_194604.sgy	0.75	1.05	ok	y	on seismic line 20230004
2023_0128_234607.sgy	0.80	1.00	ok	y	on seismic line 20230004
2023_0129_034608.sgy	0.60	1.00	ok	y	on seismic line 20230004, wedges on scours
2023_0129_074611.sgy	0.70	1.00	ok	y	start seismic line 20230005, shelf edge
2023_0129_114613.sgy	0.80	1.60	ok	y	on seismic line 20230005
2023_0129_154615.sgy	1.40	2.00	ok	y	seismic lines 20230005 to 20230006
2023_0129_194617.sgy	0.80	1.60	ok	y	seismic line 20230006
2023_0129_234619.sgy	0.80	1.00	ok	y	PS134_35(Lander) on seismic line 20230006
2023_0130_034620.sgy	0.80	0.95	ok	y	seismic line 20230006
2023_0130_074622.sgy	0.80	0.90	ok	y	seismic line 20230006
2023_0130_114625.sgy	0.80	0.90	ok	y	PS134_64 on seismic line 20230006
2023_0130_154627.sgy	0.70	0.85	ok	y	seismic line 20230006
2023_0130_194629.sgy	0.70	0.85	ok	y	seismic line 20230006
2023_0130_234631.sgy	0.75	0.95	ok	y	seismic line 20230006
2023_0131_034632.sgy	0.90	1.10	ok	y	seismic line 20230006
2023_0131_074635.sgy	1.00	1.35	ok	y	Dipping Reflectors on seismic line 20230006, PS134_66
2023_0131_114638.sgy	0.95	1.30	ok	y	seismic line 20230006, PS134_67
2023_0131_154641.sgy	0.30	1.35	ok	y	seismic line 20230006
2023_0131_194644.sgy	0.35	1.25	ok	y	end seismic line 20230006
2023_0131_234645.sgy	0.15	0.85	ok	y	
2023_0201_034646.sgy	0.75	0.95	ok	y	
2023_0201_074648.sgy	0.80	0.90	ok	y	system shut down between 11:14 and 12:00
2023_0201_135813.sgy	0.75	1.05	ok	y	
2023_0201_175825.sgy	0.75	0.95	ok	y	
2023_0201_215835.sgy	0.80	0.90	ok	y	PS134_37, PS134_38, PS134_39
2023_0202_015836.sgy	0.75	1.00	ok	y	
2023_0202_055838.sgy	0.60	0.95	ok	y	PS134_40-5
2023_0202_145944.sgy	0.65	0.95	ok	y	
2023_0202_185955.sgy	0.60	0.80	ok	y	PS134_42
2023_0202_225956.sgy	0.65	0.80	ok	y	
2023_0203_025958.sgy	0.60	1.70	ok	y	PS134_44
2023_0203_092457.sgy	1.40	3.05	ok	y	PS134_44
2023_0203_132501.sgy	2.50	3.10	ok	y	
2023_0203_172508.sgy	1.80	2.65	ok	y	PS134_45 start seismic line 20230007
2023_0203_212512.sgy	1.85	2.00	ok	y	on seismic line 20230007
2023_0204_012514.sgy	1.90	2.20	ok	y	on seismic line 20230007
2023_0204_052516.sgy	2.15	2.50	ok	y	on seismic line 20230007
2023_0204_092519.sgy	2.40	3.05	ok	y	on seismic line 20230007

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0204_132521.sgy	2.95	3.60	ok	y	on seismic line 20230007
2023_0204_172523.sgy	3.20	3.80	ok	y	on seismic line 20230008
2023_0204_212526.sgy	3.40	3.80	ok	y	on seismic line 20230008
2023_0205_012528.sgy	3.60	4.20	ok	y	on seismic line 20230008
2023_0205_052534.sgy	3.95	4.25	ok	y	on seismic line 20230008
2023_0205_092542.sgy	4.15	4.45	ok	y	on end of seismic line 20230008
2023_0205_132551.sgy	3.90	4.45	ok	y	start seismic line 20230009
2023_0205_172600.sgy	3.10	4.00	ok	y	on seismic line 20230009
2023_0205_212608.sgy	2.25	3.20	ok	y	on seismic line 20230009
2023_0206_012611.sgy	0.75	2.40	ok	y	seismic line 20230009
2023_0206_052614.sgy	0.45	0.90	ok	y	seismic line 20230009
2023_0206_092616.sgy	0.60	0.75	ok	y	seismic line 20230009 and 20230010
2023_0206_132618.sgy	0.50	0.90	ok	y	seismic line 20230010
2023_0206_172620.sgy	0.80	0.95	ok	y	seismic line 20230010
2023_0206_212622.sgy	0.80	0.95	ok	y	seismic line 20230010 close to PS134_35 Lander
2023_0207_012623.sgy	0.80	1.00	ok	y	seismic line 20230010
2023_0207_052625.sgy	0.65	0.95	ok	y	seismic line 20230010 and 20230011
2023_0207_092627.sgy	0.85	1.25	ok	y	seismic line 20230011
2023_0207_132629.sgy	1.15	1.60	ok	y	seismic line 20230011
2023_0207_172632.sgy	0.80	1.75	ok	y	seismic line 20230012
2023_0207_212636.sgy	0.80	0.95	ok	y	seismic line 20230012
2023_0208_012637.sgy	0.80	0.95	ok	y	seismic line 20230012
2023_0208_052639.sgy	0.70	0.90	ok	y	seismic line 20230012, outcropping reflectors
2023_0208_092642.sgy	0.70	0.80	ok	y	seismic line 20230012
2023_0208_132644.sgy	0.65	0.85	ok	y	seismic line 20230012
2023_0208_172646.sgy	0.65	1.00	ok	y	seismic line 20230012
2023_0208_212648.sgy	0.90	1.30	ok	y	seismic line 20230012 and 20230013
2023_0209_012650.sgy	0.75	1.25	ok	y	seismic line 20230013
2023_0209_052652.sgy	0.40	0.80	ok	y	seismic line 20130013, system failure and restart
2023_0209_092654.sgy	0.45	0.65	ok	y	seismic line 20230013
2023_0209_132657.sgy	0.55	0.90	ok	y	seismic line 20230013
2023_0209_172700.sgy	0.75	0.95	ok	y	seismic line 20230013
2023_0209_212704.sgy	0.65	0.90	ok	y	seismic line 20230013
2023_0210_012706.sgy	0.55	0.75	ok	y	seismic line 20230013 and 20230014
2023_0210_052709.sgy	0.60	0.75	ok	y	seismic line 20230014 Dipping Reflector
2023_0210_092712.sgy	0.65	0.85	ok	y	seismic line 20230014
2023_0210_132715.sgy	0.70	0.85	ok	y	seismic line 20230014
2023_0210_172718.sgy	0.75	0.90	ok	y	seismic line 20230014 Dipping Reflector
2023_0210_212720.sgy	0.65	0.85	ok	y	seismic line 20230014 Dipping Reflector
2023_0211_012721.sgy	0.65	0.85	ok	y	seismic line 20230014 - 20230015
2023_0211_052724.sgy	0.65	0.85	ok	y	seismic line 20230015
2023_0211_092727.sgy	0.70	0.90	ok	y	seismic line 20230015

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0211_132730.sgy	0.70	0.90	ok	y	seismic line 20230015
2023_0211_172734.sgy	0.60	0.90	ok	y	seismic line 20230015, Shelf edge
2023_0211_212737.sgy	0.60	0.80	ok	y	seismic line 20230015 and 20230016, Shelf edge
2023_0212_012738.sgy	0.65	0.90	ok	y	seismic line 20230016
2023_0212_052740.sgy	0.80	0.95	ok	y	seismic line 20230016
2023_0212_092743.sgy	0.80	0.95	ok	y	seismic line 20230016
2023_0212_132746.sgy	0.90	2.00	ok	y	seismic line 20230016 - shelf slope, Sedimentlayers > 10m
2023_0212_172748.sgy	1.10	2.70	ok	y	seismic line 20230016 - line shows unexpected jump
2023_0212_214753.sgy	2.75	3.95	ok	y	seismic line 20230016
2023_0213_014756.sgy	3.80	4.90	ok	y	seismic line 20230016
2023_0213_054804.sgy	4.80	5.10	ok	y	turn seismic line 20230016 to 20230017
2023_0213_094810.sgy	4.60	4.95	ok	y	seismic line 20230017 - shelf slope -20m deep reflector
2023_0213_134812.sgy	4.00	4.70	ok	y	seismic line 20230017 - sediment layers > 15m
2023_0213_174814.sgy	3.70	4.15	ok	y	seismic line 20230017
2023_0213_214817.sgy	3.60	3.85	ok	y	seismic line 20230017
2023_0214_014819.sgy	3.55	3.80	ok	y	seismic line 20230017
2023_0214_054822.sgy	3.65	4.10	ok	y	seismic line 20230017, 30m Sediments
2023_0214_094824.sgy	3.75	4.20	ok	y	seismic line 20230017 and 20230018
2023_0214_134827.sgy	2.80	3.90	ok	y	seismic line 20230018
2023_0214_174830.sgy	2.00	2.90	ok	y	seismic line 20230018
2023_0214_214834.sgy	1.50	2.10	ok	y	seismic line 20230018 - > 15m sediment on slope
2023_0215_014835.sgy	1.35	2.15	ok	y	seismic line 20230018 and 202320019
2023_0215_054837.sgy	2.00	3.15	ok	y	seismic line 20230019
2023_0215_094840.sgy	3.05	4.00	ok	y	seismic line 20230019
2023_0215_134842.sgy	3.90	4.50	ok	y	end of seismic line 20230019 (16:26:03)
2023_0215_174845.sgy	3.15	4.50	ok	y	
2023_0215_214846.sgy	0.80	3.30	ok	y	
2023_0216_034300.sgy	0.80	0.95	ok	y	Station PS134_59 and PS134_61
2023_0216_105308.sgy	0.80	0.95	ok	y	Station PS134_59 and PS134_61
2023_0216_145329.sgy	0.80	0.90	ok	y	
2023_0216_185339.sgy	0.80	1.55	ok	y	Shelf edge, ~10m subbottom reflector on shelf
2023_0217_034237.sgy	0.80	1.70	ok	y	StationPS134_60, shelf edge with scours, and shelf slope
2023_0217_074243.sgy	0.80	0.95	ok	y	Station PS134_59 and PS134_61
2023_0217_114246.sgy	0.85	0.95	ok	y	Station PS134_62
2023_0217_154248.sgy	0.80	0.95	ok	y	Station PS134_62
2023_0217_194249.sgy	0.80	0.90	ok	y	close to Stations PS134_63, PS134_64
2023_0218_030745.sgy	0.75	0.90	ok	y	Station PS134_63, PS134_64
2023_0218_070806.sgy	0.75	0.85	ok	y	Station PS134_65

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0218_110809.sgy	0.80	1.15	ok	y	interruption because system failure: storage low/out
2023_0218_150811.sgy	1.10	1.30	ok	y	PS134_66
2023_0219_021641.sgy	1.00	1.40	ok	y	PS134_67
2023_0219_061703.sgy	0.80	1.35	ok	y	sediment on slope 10 m
2023_0219_101705.sgy	0.50	1.50	ok	y	PS134_73_rough Topography - soft Sedimentcover
2023_0219_141708.sgy	0.50	1.35	ok	y	rough Topography - soft Sedimentcover
2023_0219_181710.sgy	0.45	1.10	ok	y	rough Topography - soft Sedimentcover
2023_0219_221712.sgy	0.45	1.20	ok	y	Sediment Pocket Long: -83.253132 W , Lat: -73.59993 S, and Long: -82.942563 W, Lat: -73.58786 S
2023_0220_021713.sgy	0.25	1.10	ok	y	PS134_74, PS134_75, multiple troughs with sediment filling
2023_0220_061716.sgy	0.35	1.15	ok	y	
2023_0220_101718.sgy	0.60	1.40	ok	y	~20m trough infill: Long. -82.13747 W, Lat. -73.56537 S, 20.02.23 11:02-11:05, PS134_69
2023_0220_143143.sgy	0.50	1.50	ok	y	PS134_69
2023_0220_183205.sgy	0.55	1.20	ok	y	Sediment Pocket: -73.49797 S, -82.74255 W
2023_0220_223207.sgy	0.60	1.50	ok	y	Channel filling: -73.42358 S, -82.297842 W (TWT: 0.025 s/ ~19 m)
2023_0221_023208.sgy	0.80	1.45	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0221_063210.sgy	0.65	1.35	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0221_103212.sgy	0.55	1.25	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0221_143215.sgy	0.60	1.20	ok	y	PS134_70
2023_0221_211058.sgy	0.45	1.10	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0222_011059.sgy	0.35	1.10	ok	y	PS134_72, PS134_73_rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0222_051101.sgy	0.50	1.05	ok	y	PS134_73, PS134_74, PS134_75 Rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0222_091122.sgy	0.70	1.45	ok	y	PS134_69, PS134_77, PS134_78_rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0222_131124.sgy	0.65	1.45	ok	y	PS134_78_rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0222_171128.sgy	0.55	1.20	ok	y	PS134_79-80-81-83_rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0222_211149.sgy	0.60	1.15	ok	y	PS134_70-81-82-833_rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0223_011203.sgy	0.45	1.15	ok	y	PS134_83end_rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0223_051224.sgy	0.50	1.70	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0223_091225.sgy	0.85	1.70	ok	y	PS134_84 rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0223_145226.sgy	0.80	1.60	ok	y	PS134_84 rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0223_185230.sgy	0.80	1.65	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0223_225245.sgy	0.65	1.60	ok	y	rough Topography - soft Sedimentcover? Or thin hard cover?
2023_0224_025246.sgy	0.40	1.30	ok	y	PS134_85, PS134_86, both in troughs between rough Topograpy
2023_0224_065248.sgy	0.30	1.15	ok	y	PS134_87 in trough between rough Topograpy
2023_0224_105250.sgy	0.30	1.00	ok	y	PS134_85, PS134_86, both in troughs between rough Topograpy
2023_0224_145252.sgy	0.50	1.65	ok	y	PS134_87 in trough between rough Topograpy
2023_0224_185255.sgy	0.15	1.75	ok	y	PS134_88 in trough between rough Topograpy
2023_0224_225259.sgy	0.15	1.35	ok	y	rough Topography , thin sediment cover
2023_0203_100052_PHF	1.90	3.15	ok	-	for amplitude tests
2023_0222_171128_PHF	0.50	1.20	ok	-	for amplitude tests
2023_0222_221747_PHF	0.45	1.25	ok	-	for amplitude tests
2023_0225_025300.sgy	0.40	1.10	ok	y	Transit 2
2023_0225_065302.sgy	0.15	1.35	ok	y	Transit 2
2023_0225_133830.sgy	0.10	1.25	ok	y	Transit 2
2023_0225_173834.sgy	0.20	1.35	ok	y	Transit 2
2023_0225_213836.sgy	0.50	1.15	ok	y	Transit 2
2023_0226_013837.sgy	0.50	1.10	ok	y	Transit2 ---> PS134_92
2023_0226_053839.sgy	0.50	1.10	ok	y	PS134_91
2023_0226_093841.sgy	0.30	1.10	ok	y	PS134_90
2023_0226_133847.sgy	0.50	1.10	ok	y	PS134_91
2023_0226_173858.sgy	0.40	1.20	ok	y	PS134_92
2023_0226_213900.sgy	0.40	1.30	ok	y	RoughTopography close to coast, than gently rising towards shelf edge
2023_0227_013902.sgy	0.60	1.10	ok	y	Bellingshausen Sea Shelf, Seafloor gently rising towards shelf edge
2023_0227_053903.sgy	0.50	0.75	ok	y	Middle Bellingshausen Sea Shelf, Corrugation Ridges
2023_0227_093905.sgy	0.55	4.40	ok	y	Shelf Edge Bellingshausen Sea
2023_0227_133907.sgy	4.20	5.55	ok	y	Shelf Rise Bellingshausen Sea, hummocky in deep part
2023_0227_173910.sgy	4.55	5.65	ok	y	Bellingshausen Sea, close to Peter-I Island
2023_0227_213915.sgy	0.30	4.70	ok	y	Around Peter-I Island, search for LandGeology Station
2023_0228_013916.sgy	1.25	5.60	ok	y	North of Peter-I Island Transit Back
2023_0228_053920.sgy	5.30	5.75	ok	y	Transit Back, West Antarctic Shelf Rise
2023_0228_093922.sgy	5.60	6.00	ok	y	Transit Back, West Antarctic Shelf Rise

File name	min [s]	max [s]	Depth	Plot	Comment
2023_0228_133925.sgy	5.85	6.15	ok	y	Transit Back, West Antarctic Shelf Rise, channels
2023_0228_173929.sgy	6.00	6.20	ok	y	Transit Back, > 30m Deep Sea Sediments
2023_0228_213933.sgy	6.05	6.25	ok	-	Transit Back
2023_0301_013936.sgy	6.10	6.30	ok	y	Transit Back, >20 m Deep Sea Sediments, Channels
2023_0301_053940.sgy	6.20	6.35	ok	-	Transit Back
2023_0301_093943.sgy	6.25	6.35	ok	y	Transit Back, >20 m Deep Sea Sediments, Transparent Layer
2023_0301_133946.sgy	6.25	6.40	ok	-	Transit Back
2023_0301_173949.sgy	6.30	6.45	ok	-	Transit Back
2023_0301_213952.sgy	6.35	6.50	ok	-	Transit Back
2023_0302_014000.sgy	6.40	6.55	ok	y	Transit Back, Deep Sea Basin, > 30m Sediments
2023_0302_054011.sgy	6.45	6.55	ok	-	Transit Back
2023_0302_094020.sgy	6.50	6.70	ok	-	Transit Back
2023_0302_134026.sgy	6.55	6.75	ok	y	Transit Back, Rise
2023_0302_174038.sgy	6.65	6.80	ok	-	Transit Back
2023_0302_214051.sgy	5.90	7.75	ok	-	Transit Back
2023_0303_014100.sgy	5.95	7.70	ok	y	Transit Back, Rise, rough Topography
2023_0303_054114.sgy	6.20	7.00	ok	-	Transit Back, Rise, rough Topography
2023_0303_094123.sgy	5.90	7.50	ok	-	Transit Back, Rise, rough Topography
2023_0303_134130.sgy	5.70	6.85	ok	-	Transit Back, Rise, rough Topography
2023_0303_174139.sgy	5.30	6.80	ok	-	Transit Back, Rise, rough Topography
2023_0303_214152.sgy	5.35	6.75	ok	-	Transit Back, Rise, rough Topography
2023_0304_014201.sgy	5.50	6.20	ok	-	Transit Back, stop Parasouns at 04.03.2023 at 01:50 UTC

A.7 SO-JELLY DEPLOYMENTS AND SAMPLING DURING PS134

	Station	Coordinates	CTD (Depths sampled, m)	Midi-Multinet (Depth intervals, m)	Bongo (Wire length, m)	Sediment (Depth, m; number of cores)
LATITUDINAL TRANSECT	PS-134-2	46°10.319´S	2000	2000 – 1600	450	-
		13°27.618´E	1800	1600 – 1200		
			1400	1200 – 800		
			1000	800 – 400		
			600	400 – 0		
			300			
			150	400 – 200		
			75	200 – 100		
			55	100 – 50		
			35	50 – 20		
			8	20 – 00		
	PS134-3	55°25.903´S	2000	2000 – 1600	450	-
		9°10.434´E	1800	1600 – 1200		
			1400	1200 – 800		
			1000	800 – 400		
			600	400 – 0		
			300			
			150	400 – 200		
			75	200 – 100		
			55	100 – 50		
			35	50 – 20		
			3	20 – 00		
	PS134-4	60°07.162´S	1800	2000 – 1600	450	-
		5°32.542´E	1400	1600 – 1200		
			1000	1200 – 800		
			600	800 – 400		
			300	400 – 0		
			150			
			75	400 – 200		
			65	200 – 100		
			35	100 – 50		
			3	50 – 20		
				20 – 00		
	PS134-5	63°31.956´S	2000	-	-	-
		2°26.593´E	1800			
			1400			
			1000			
			600			
			300			

					50 – 20 20 – 0		
		PS134-44	69°35.82´S 82°50.69´W	1000 900 750 600 500 400 300 150 75 35 0	1000 – 800 800 – 650 650 – 450 450 – 300 300 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	330?	-
	Transect B	PS134-59	70°33.66´S 85°35.95´W	600 500 400 300 150 75 50 35 0	600 – 300 300 – 200 200 – 100 100 – 50 50 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	-	660; 1
		PS134-60	69°55.02´S 85°8.99´W	1000 900 750 600 500 400 300 150 75 35 0	1000 – 800 800 – 650 650 – 450 450 – 300 300 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	450	-
		PS134-63	71°09.77´S 84°11.42´W	580 500 400 300 150 75 35 0	580 – 300 300 – 200 200 – 100 100 – 50 50 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	-	611; 1

		PS134-70	73°35.88´S 83°15.41´W	760 650 550 450 300 150 75 35 0	760 – 700 700 – 600 600 – 500 500 – 400 400 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	-	664; 1
	Transect C	PS134-69	73°31.30´S 81°54.11´W	950 900 750 600 300 150 75 35 0	950 – 800 800 – 650 650 – 450 450 – 350 350 – 0	-	-
		PS134-84	73°12.27´S 83°28.87´W	1000 900 750 600 300 150 75 35 0	1000 – 800 800 – 650 650 – 450 450 – 350 350 – 0	-	-
		PS134-89	72°27.53´S 90°24.38´W	900 750 600 300 150 75 35 0	890 – 700 700 – 350 350 – 200 200 – 100 100 – 0	-	-
		PS134-90	72°20.102´S 92°59.130´W	560 400 300 150 75 35 0	550 – 300 300 – 200 200 – 100 100 – 50 50 – 0	-	-

				150 75 35 3			
		PS134-10	64°30.067´S 3°00.453´E	2000 1800 1400 1000 600 300 150 75 35 2	2000 – 1600 1600 – 1200 1200 – 800 800 – 400 400 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	450	-
Bellinghausen Sea	Transect A	PS134-20	72°52.14´S 72°56.89´W	640 500 400 300 150 75 35 0	600 – 300 300 – 200 200 – 100 100 – 50 50 – 0 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	450	674; 1
		PS134-36	71°55.31´S 76°23.28´W	585 500 400 300 150 75 35 0	550 – 300 300 – 200 200 – 100 100 – 50 50 – 00 400 – 200 200 – 100 100 – 50 50 – 20 20 – 0	-	611; 1
		PS134-40	70°30.99´S 80°02.52´W	600 500 400 300 150 75 35 0	600 – 300 300 – 200 200 – 100 100 – 50 50 – 0 400 – 200 200 – 100 100 – 50	-	642; 1

A.8 STATIONSLISTE / STATION LIST PS134

Station list of expedition PS134 from Cape Town to Punta Arenas; the list details the action log for all stations along the cruise track.

See https://www.pangaea.de/expeditions/events/PS134 to display the station (event) list for expedition PS134.
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

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134-track		2022-12-22T00:00:00	-33.90680	18.43370		CT	Station start	Capetown - Punta Arenas
PS134-track		2023-03-06T00:00:00	-53.14470	-70.90910		CT	Station end	Capetown - Punta Arenas
PS134_0_Underway-1		2022-12-24T06:58:15	-35.35692	17.65066	3130.8	ADCP	Station start	
PS134_0_Underway-1		2023-03-04T01:30:34	-56.34330	-78.18296	4304.5	ADCP	Station end	
PS134_0_Underway-6		2022-12-24T07:00:41	-35.36281	17.64877	3130.6	MYON	Station start	
PS134_0_Underway-6		2023-03-04T01:34:30	-56.33596	-78.17571	4179.7	MYON	Station end	
PS134_0_Underway-7		2022-12-24T06:58:34	-35.35766	17.65041	3131.2	FBOX	Station start	
PS134_0_Underway-7		2023-03-04T01:31:50	-56.34082	-78.18058	4286.1	FBOX	Station end	
PS134_0_Underway-11		2022-12-24T07:12:35	-35.39121	17.63953	3149.2	MAG	Station start	
PS134_0_Underway-11		2023-03-04T01:29:49	-56.34476	-78.18425	4290.2	MAG	Station end	
PS134_0_Underway-12		2022-12-24T07:12:08	-35.39013	17.63986	3148.3	GRAV	Station start	
PS134_0_Underway-12		2023-03-04T01:36:32	-56.33188	-78.17307	4088.8	GRAV	Station end	
PS134_0_Underway-13		2022-12-25T07:54:30	-38.68208	16.34875	4500.5	MBES	Station start	
PS134_0_Underway-13		2023-03-04T01:41:26	-56.32249	-78.16535	4238.3	MBES	Station end	
PS134_0_Underway-14		2022-12-24T07:00:01	-35.36114	17.64925	3130.8	NEUMON	Station start	

** Comments are limited to 130 characters. See https://www.pangaea.de/expeditions/events/PS134 to show full comments in conjunction with the station (event) list for expedition PS134.*

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_0_Underway-14		2023-03-04T01:34:04	-56.33678	-78.17643	4217.2	NEUMON	Station end	
PS134_0_Underway-17		2022-12-24T06:59:31	-35.35992	17.64965	3131.2	pCO2	Station start	
PS134_0_Underway-17		2023-03-04T01:32:26	-56.33973	-78.17950	4276.6	pCO2	Station end	
PS134_0_Underway-18		2022-12-24T06:59:09	-35.35900	17.64997	3131.7	pCO2	Station start	
PS134_0_Underway-18		2023-03-04T01:33:19	-56.33812	-78.17774	4228.2	pCO2	Station end	
PS134_0_Underway-20		2022-12-24T23:30:00	-37.41132	16.79813	3040.1	PS	Station start	
PS134_0_Underway-20		2023-03-04T01:42:12	-56.32103	-78.16415	4263.8	PS	Station end	
PS134_0_Underway-22		2022-12-24T07:14:44	-35.39630	17.63790	3150.4	SNDVELPR	Station start	
PS134_0_Underway-22		2023-03-04T01:37:44	-56.32948	-78.17154	4121.3	SNDVELPR	Station end	
PS134_0_Underway-23		2022-12-24T07:09:12	-35.38308	17.64212	3143.0	TSG	Station start	
PS134_0_Underway-23		2023-03-04T01:35:14	-56.33452	-78.17467	4113.8	TSG	Station end	
PS134_0_Underway-24		2022-12-24T07:10:12	-35.38541	17.64137	3143.8	TSG	Station start	
PS134_0_Underway-24		2023-03-04T01:35:51	-56.33329	-78.17389	4077.4	TSG	Station end	
PS134_0_Underway-28		2022-12-23T12:00:00	-33.91542	18.43350		SWEAS	Station start	Precipitation sensor gives invalid values
PS134_0_Underway-28		2023-03-06T09:23:16	-53.17406	-70.88646	18.2	SWEAS	Station end	Precipitation sensor gives invalid values
PS134_1-1		2022-12-25T08:50:00	-38.77474	16.31897	4741.8	CTD-RO	max depth	
PS134_2-1		2022-12-27T08:35:23	-46.17198	13.46030	4875.9	CTD-RO	max depth	
PS134_2-2		2022-12-27T11:00:45	-46.17023	13.45977	4889.0	BONGO	Station start	
PS134_2-2		2022-12-27T11:40:18	-46.17559	13.46510	4821.5	BONGO	Station end	
PS134_2-3		2022-12-27T11:51:36	-46.17515	13.46757	4839.0	MSN	Station start	
PS134_2-3		2022-12-27T14:33:24	-46.16407	13.48064	4975.0	MSN	Station end	
PS134_2-4		2022-12-27T14:49:00	-46.16453	13.47843	4960.8	MSN	Station start	
PS134_2-4		2022-12-27T15:48:02	-46.15375	13.47543	4978.4	MSN	Station end	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_3-1		2022-12-31T07:07:28	-55.42377	9.17538	5002.2	BONGO	Station start	
PS134_3-1		2022-12-31T07:50:38	-55.43367	9.17606	5060.1	BONGO	Station end	
PS134_3-2		2022-12-31T07:56:47	-55.43395	9.17584	5067.9	MSN	Station start	
PS134_3-2		2022-12-31T10:52:21	-55.43276	9.17398	5036.8	MSN	Station end	
PS134_3-3		2022-12-31T10:52:55	-55.43276	9.17394	5044.6	MSN	Station start	
PS134_3-3		2022-12-31T11:44:45	-55.43120	9.17531	5021.5	MSN	Station end	
PS134_3-4		2022-12-31T12:45:10	-55.43176	9.17386	5021.5	CTD-RO	max depth	
PS134_4-1		2023-01-01T19:07:50	-60.10970	5.55024		BONGO	Station start	
PS134_4-1		2023-01-01T19:53:55	-60.12054	5.56044	3000.8	BONGO	Station end	
PS134_4-2		2023-01-01T20:00:08	-60.12070	5.56130	5001.0	MSN	Station start	
PS134_4-2		2023-01-01T22:55:59	-60.12026	5.55299		MSN	Station end	
PS134_4-3		2023-01-01T22:56:40	-60.12025	5.55300		MSN	Station start	
PS134_4-3		2023-01-01T23:47:18	-60.12010	5.55295		MSN	Station end	
PS134_4-4		2023-01-02T00:02:36	-60.12041	5.55243		CTD-RO	Station start	
PS134_4-4		2023-01-02T00:49:59	-60.11935	5.54212		CTD-RO	Station end	
PS134_5-1		2023-01-03T01:45:57	-63.53258	2.44322	4294.6	CTD-RO	max depth	
PS134_5-2	SO-CHIC-UK1	2023-01-03T03:39:38	-63.53257	2.44361	4294.7	MOOR	Station start	Deployment
PS134_5-2	SO-CHIC-UK1	2023-01-03T07:46:18	-63.53295	2.44248	4293.0	MOOR	Station end	Deployment
PS134_6-1	ASFAR	2023-01-03T08:44:29	-63.65661	2.44261	3716.0	MOOR	Station start	Recovery
PS134_6-1	ASFAR	2023-01-03T11:47:04	-63.65470	2.43538		MOOR	Station end	Recovery
PS134_7-1	SO-CHIC UK2	2023-01-03T12:48:41	-63.68694	2.43189	3413.6	MOOR	Station start	Deployment
PS134_7-1	SO-CHIC UK2	2023-01-03T14:46:36	-63.68741	2.43201	3412.3	MOOR	Station end	Deployment
PS134_8-1	SO-CHIC-UK3	2023-01-03T15:24:31	-63.69700	2.39863	3306.7	MOOR	Station start	Deployment

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_8-1	SO-CHIC-UK3	2023-01-03T17:29:30	-63.69731	2.39766	3314.6	MOOR	Station end	Deployment
PS134_9-1	SO-CHIC-UK4	2023-01-03T19:19:59	-63.91779	2.44618	2812.0	MOOR	Station start	Deployment
PS134_9-1	SO-CHIC-UK4	2023-01-03T21:16:30	-63.91788	2.44591		MOOR	Station end	Deployment
PS134_10-1		2023-01-04T01:12:23	-64.50115	2.99974	2087.3	BONGO	Station start	
PS134_10-1		2023-01-04T01:59:38	-64.50838	3.02124	2081.5	BONGO	Station end	
PS134_10-2		2023-01-04T03:01:39	-64.50115	3.00744	2087.3	CTD-RO	max depth	
PS134_10-3		2023-01-04T04:16:34	-64.50083	3.00703	2087.4	MSN	Station start	
PS134_10-3		2023-01-04T07:04:32	-64.50010	2.99971	2087.5	MSN	Station end	
PS134_10-4		2023-01-04T07:14:46	-64.50011	2.99954	2087.4	MSN	Station start	
PS134_10-4		2023-01-04T08:00:13	-64.50027	2.99943	2087.2	MSN	Station end	
PS134_12-1	ULS	2023-01-04T10:25:38	-64.54740	3.22042		MOOR	Station start	Recovery
PS134_12-1	ULS	2023-01-04T10:49:24	-64.54836	3.21314		MOOR	Station end	Recovery
PS134_11-1	PROPOL	2023-01-04T11:02:34	-64.53439	3.23100		MOOR	Station start	Station aborted
PS134_11-1	PROPOL	2023-01-04T16:29:53	-64.52625	3.24729	559.6	MOOR	Station end	Station aborted
PS134_13-1	APEX	2023-01-04T17:47:35	-64.69924	3.03748	2184.5	ARGOFL	Station start	
PS134_13-1	APEX	2023-01-04T17:50:15	-64.69817	3.03276	2183.1	ARGOFL	Station end	
PS134_14-1		2023-01-19T11:05:05	-72.73708	-72.57881	747.5	MBES	Station start	
PS134_14-1		2023-01-21T12:15:09	-72.88562	-72.63801	689.2	MBES	Station end	
PS134_15-1		2023-01-19T21:14:24	-72.92812	-73.79181	1031.2	CTD-RO	max depth	
PS134_16-1		2023-01-21T12:29:36	-72.89485	-72.67754	680.6	GradT	Station start	
PS134_16-1		2023-01-21T13:20:38	-72.89437	-72.67303	680.3	GradT	Station end	
PS134_17-1		2023-01-21T15:57:19	-72.65178	-72.92014	765.8	GradT	Station start	
PS134_17-1		2023-01-21T16:46:35	-72.65179	-72.91807	766.4	GradT	Station end	
PS134_18-1		2023-01-21T17:50:52	-72.60097	-73.09187	660.8	GradT	Station start	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_18-1		2023-01-21T18:43:26	-72.60059	-73.09129	657.5	GradT	Station end	
PS134_19-1		2023-01-21T20:08:59	-72.56650	-73.24402	619.0	GKG	max depth	
PS134_19-2		2023-01-21T21:36:52	-72.56656	-73.24334	619.6	GC	max depth	5m
PS134_19-3		2023-01-21T22:40:34	-72.56651	-73.24432	619.6	GC	max depth	5m
PS134_20-1		2023-01-22T02:47:13	-72.86907	-72.94814	674.3	CTD-RO	max depth	
PS134_20-2		2023-01-22T03:23:17	-72.86917	-72.94785	674.7	MSN	Station start	
PS134_20-2		2023-01-22T04:25:24	-72.86965	-72.94480	674.0	MSN	Station end	
PS134_20-3		2023-01-22T04:26:24	-72.86964	-72.94503	673.9	MSN	Station start	
PS134_20-3		2023-01-22T05:56:58	-72.86839	-72.94699	675.0	MSN	Station end	
PS134_20-4		2023-01-22T06:19:43	-72.86888	-72.94576	675.5	BONGO	Station start	
PS134_20-4		2023-01-22T07:11:49	-72.86690	-72.95699	676.1	BONGO	Station end	
PS134_20-5		2023-01-22T07:43:17	-72.86880	-72.94654	674.6	GC	max depth	5m
PS134_20-6		2023-01-22T08:49:58	-72.86872	-72.94655	674.4	GKG	max depth	
PS134_20-7		2023-01-22T09:40:05	-72.86881	-72.94572	674.3	GradT	Station start	
PS134_20-7		2023-01-22T10:30:29	-72.86884	-72.94547	674.3	GradT	Station end	
PS134_21-1		2023-01-22T10:55:41	-72.86511	-73.01006	669.2	GradT	Station start	
PS134_21-1		2023-01-22T11:59:47	-72.86643	-73.00769	667.8	GradT	Station end	
PS134_21-2		2023-01-22T12:34:14	-72.86606	-73.00874	667.9	GC	max depth	8m
PS134_22-1		2023-01-22T13:59:53	-72.94529	-73.02573	752.6	GC	max depth	5m
PS134_22-2		2023-01-22T14:59:04	-72.94575	-73.02706	751.9	GC	max depth	5m
PS134_23-1		2023-01-22T16:41:17	-72.91751	-73.39962	849.8	GC	max depth	10m
PS134_24-1		2023-01-22T19:05:41	-72.92896	-72.74323	724.0	GradT	Station start	
PS134_24-1		2023-01-22T19:48:28	-72.92893	-72.74190		GradT	Station end	
PS134_25-1		2023-01-22T21:16:45	-72.87563	-73.28467	751.5	GradT	Station start	
PS134_25-1		2023-01-22T22:10:05	-72.87643	-73.29471	756.6	GradT	Station end	
PS134_26-1		2023-01-22T22:51:21	-72.84692	-73.52090	761.9	GradT	Station start	
PS134_26-1		2023-01-22T23:37:03	-72.84669	-73.52396	761.5	GradT	Station end	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_27-1		2023-01-23T00:54:11	-72.92085	-74.05461	1094.7	GradT	Station start	
PS134_27-1		2023-01-23T02:09:16	-72.92161	-74.06249	1104.5	GradT	Station end	
PS134_27-2		2023-01-23T02:42:48	-72.92153	-74.05953	1101.8	GC	max depth	10m
PS134_28-1		2023-01-23T14:33:06	-73.02669	-72.77933	637.4	SEISREFL	Station start	
PS134_28-1		2023-01-24T00:32:23	-72.93794	-73.62030	923.6	SEISREFL	Station end	
PS134_29-1	AWI-20230001	2023-01-24T01:33:52	-72.95462	-73.48512	865.8	SEISREFL	Station start	
PS134_29-1	AWI-20230001	2023-01-24T05:00:51	-72.84249	-72.67171	693.8	SEISREFL	Station end	
PS134_30-1	AWI-20230002	2023-01-24T06:38:24	-72.84584	-72.70222	682.5	SEISREFL	Station start	
PS134_30-1	AWI-20230002	2023-01-27T02:06:00	-69.18553	-80.09010		SEISREFL	Station end	
PS134_31-1	AWI-20230003	2023-01-27T03:23:57	-69.14728	-80.16012	1825.9	SEISREFL	Station start	
PS134_31-1	AWI-20230003	2023-01-27T12:45:28	-69.42627	-78.56555	546.1	SEISREFL	Station end	
PS134_32-1	AWI-20230004	2023-01-27T14:29:22	-69.42629	-78.57389	547.1	SEISREFL	Station start	
PS134_32-1	AWI-20230004	2023-01-29T06:29:59	-70.72926	-86.86959	594.1	SEISREFL	Station end	
PS134_33-1	AWI-20230005	2023-01-29T08:27:29	-70.74701	-86.86412	571.3	SEISREFL	Station start	
PS134_33-1	AWI-20230005	2023-01-29T17:02:56	-70.06302	-86.72913	1310.5	SEISREFL	Station end	
PS134_34-1	AWI-20230006	2023-01-29T18:05:45	-70.04411	-86.77714	1372.1	SEISREFL	Station start	
PS134_34-1	AWI-20230006	2023-01-31T21:45:04	-72.77200	-80.20157	853.7	SEISREFL	Station end	
PS134_35-1		2023-01-30T01:05:30	-70.40448	-85.95709	640.6	B_LANDER	Station start	
PS134_35-1		2023-01-30T01:15:52	-70.41012	-85.94695	634.9	B_LANDER	Station end	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_36-1		2023-02-01T08:29:26	-71.92184	-76.38835	611.5	CTD-RO	max depth	
PS134_36-2		2023-02-01T09:05:59	-71.92185	-76.38885	611.5	MSN	Station start	
PS134_36-2		2023-02-01T10:11:28	-71.92175	-76.38838	611.3	MSN	Station end	
PS134_36-3		2023-02-01T10:10:13	-71.92180	-76.38843	611.2	MSN	Station start	
PS134_36-3		2023-02-01T11:55:18	-71.92181	-76.38888	611.0	MSN	Station end	
PS134_36-4		2023-02-01T12:02:01	-71.92232	-76.38898	611.6	GKG	max depth	
PS134_36-5		2023-02-01T13:32:20	-71.92170	-76.38804	611.0	GC	max depth	5m
PS134_37-1		2023-02-01T21:39:59	-71.32298	-77.73343	634.3	GC	max depth	3m
PS134_38-1		2023-02-01T22:51:27	-71.32003	-77.74660	640.8	GC	max depth	3m
PS134_39-1		2023-02-02T00:30:39	-71.28363	-77.90632	661.5	GC	max depth	3m
PS134_40-1		2023-02-02T08:46:10	-70.51666	-80.04207	642.3	CTD-RO	max depth	
PS134_40-2		2023-02-02T09:20:06	-70.51651	-80.04210	642.2	MSN	Station start	
PS134_40-2		2023-02-02T10:21:03	-70.51656	-80.04237	641.9	MSN	Station end	
PS134_40-3		2023-02-02T10:27:37	-70.51639	-80.04206	642.3	MSN	Station start	
PS134_40-3		2023-02-02T11:43:36	-70.51682	-80.04296	641.1	MSN	Station end	
PS134_40-4		2023-02-02T12:10:42	-70.51682	-80.04294	641.3	GC	max depth	3m
PS134_40-5		2023-02-02T13:14:24	-70.51660	-80.04224	641.8	GKG	max depth	
PS134_41-1		2023-02-02T14:29:16	-70.48722	-80.08842	642.0	GC	max depth	3m
PS134_42-1		2023-02-02T20:46:57	-69.99008	-82.09839	568.3	GC	max depth	3m
PS134_42-2		2023-02-02T21:46:47	-69.99015	-82.09837	567.8	GC	max depth	5m
PS134_43-1		2023-02-02T23:20:44	-69.89912	-82.27208	535.3	MAG	Station start	
PS134_43-1		2023-02-03T01:26:29	-69.89716	-82.27381	531.4	MAG	Station end	
PS134_44-1		2023-02-03T03:44:06	-69.59717	-82.84299	1138.0	MSN	Station start	
PS134_44-1		2023-02-03T04:35:29	-69.59795	-82.84065	1111.2	MSN	Station end	
PS134_44-2		2023-02-03T04:36:04	-69.59806	-82.84046	1109.9	MSN	Station start	
PS134_44-2		2023-02-03T06:30:09	-69.59662	-82.84419	1134.4	MSN	Station end	
PS134_44-3		2023-02-03T07:12:51	-69.59698	-82.84539	1135.6	CTD-RO	max depth	
PS134_44-4		2023-02-03T08:14:38	-69.59692	-82.84439	1132.6	BONGO	Station start	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_44-4		2023-02-03T09:19:52	-69.59716	-82.80647	1042.0	BONGO	Station end	
PS134_45-1	AWI-20230007	2023-02-03T10:40:56	-69.65363	-83.36297	1775.5	SEISREFL	Station start	
PS134_45-1	AWI-20230007	2023-02-04T17:03:33	-70.20578	-89.62837	2557.1	SEISREFL	Station end	
PS134_46-1	AWI-20230008	2023-02-04T18:09:26	-70.22387	-89.67099	2548.2	SEISREFL	Station start	
PS134_46-1	AWI-20230008	2023-02-05T12:08:15	-69.09318	-86.99497	3232.9	SEISREFL	Station end	
PS134_47-1	AWI-20230009	2023-02-05T13:59:24	-69.08992	-87.00406	3235.2	SEISREFL	Station start	
PS134_47-1	AWI-20230009	2023-02-06T10:51:24	-70.28430	-83.56684	482.1	SEISREFL	Station end	
PS134_48-1	AWI-20230010	2023-02-06T12:17:29	-70.28129	-83.55895	478.0	SEISREFL	Station start	
PS134_48-1	AWI-20230010	2023-02-07T06:37:26	-70.56390	-87.74432	545.0	SEISREFL	Station end	
PS134_49-1	AWI-20230011	2023-02-07T08:13:20	-70.57228	-87.74086	540.7	SEISREFL	Station start	
PS134_49-1	AWI-20230011	2023-02-07T17:24:25	-70.08228	-86.39070	1131.3	SEISREFL	Station end	
PS134_50-1	AWI-20230012	2023-02-07T18:56:39	-70.08524	-86.39633	1127.6	SEISREFL	Station start	
PS134_50-1	AWI-20230012	2023-02-08T23:59:55	-72.26825	-86.34103	815.2	SEISREFL	Station end	
PS134_51-1	AWI-20230013	2023-02-09T00:06:54	-72.27667	-86.34824	817.1	SEISREFL	Station start	
PS134_51-1	AWI-20230013	2023-02-10T03:06:21	-71.59797	-80.82120	467.8	SEISREFL	Station end	
PS134_52-1	AWI-20230014	2023-02-10T04:34:07	-71.60116	-80.84434	476.6	SEISREFL	Station start	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_52-1	AWI-20230014	2023-02-11T03:27:18	-71.35116	-86.15444	554.8	SEISREFL	Station end	
PS134_53-1	AWI-20230015	2023-02-11T05:34:45	-71.35156	-86.15603	555.1	SEISREFL	Station start	
PS134_53-1	AWI-20230015	2023-02-11T20:31:41	-70.76645	-83.47636	466.3	SEISREFL	Station end	
PS134_54-1	AWI-20230016	2023-02-11T22:18:12	-70.76695	-83.47389	464.5	SEISREFL	Station start	
PS134_54-1	AWI-20230016	2023-02-13T07:00:48	-69.57380	-89.79080	3699.7	SEISREFL	Station end	
PS134_55-1	AWI-20230017	2023-02-13T09:00:11	-69.57479	-89.79982	3696.4	SEISREFL	Station start	
PS134_55-1	AWI-20230017	2023-02-14T10:28:04	-69.25597	-84.30886	3032.4	SEISREFL	Station end	
PS134_56-1	AWI-20230018	2023-02-14T12:02:46	-69.24952	-84.28997	3037.5	SEISREFL	Station start	
PS134_56-1	AWI-20230018	2023-02-15T01:55:36	-70.08462	-86.39469	1129.3	SEISREFL	Station end	
PS134_57-1	AWI-20230019	2023-02-15T03:48:12	-70.08177	-86.39692	1137.7	SEISREFL	Station start	
PS134_57-1	AWI-20230019	2023-02-15T16:26:00	-69.07330	-86.99478		SEISREFL	Station end	
PS134_58-1		2023-02-16T01:50:18	-70.37828	-85.96791		B_LANDER	Station start	
PS134_58-1		2023-02-16T04:38:35	-70.42055	-85.93679		B_LANDER	Station end	
PS134_59-1		2023-02-16T06:40:38	-70.56182	-85.60111	658.8	MSN	Station start	
PS134_59-1		2023-02-16T07:46:50	-70.56323	-85.59671	658.6	MSN	Station end	
PS134_59-2		2023-02-16T07:50:50	-70.56312	-85.59650	659.7	MSN	Station start	
PS134_59-2		2023-02-16T09:02:09	-70.56224	-85.59858	659.9	MSN	Station end	
PS134_59-3		2023-02-16T09:45:58	-70.56105	-85.59948	661.3	CTD-RO	max depth	
PS134_60-1		2023-02-16T23:38:15	-69.91706	-85.14978	1147.7	CTD-RO	max depth	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_60-2		2023-02-17T00:18:29	-69.91722	-85.15086	1147.8	MSN	Station start	
PS134_60-2		2023-02-17T02:26:31	-69.91657	-85.14879	1148.3	MSN	Station end	
PS134_60-3		2023-02-17T02:27:52	-69.91665	-85.14883	1148.1	MSN	Station start	
PS134_60-3		2023-02-17T03:29:20	-69.91516	-85.15073	1153.2	MSN	Station end	
PS134_61-1		2023-02-17T08:52:50	-70.56156	-85.59954	660.3	GKG	max depth	
PS134_61-2		2023-02-17T10:16:42	-70.56145	-85.59812	661.2	GC	max depth	3m
PS134_62-1		2023-02-17T13:17:31	-70.66361	-86.44133	676.3	GC	max depth	3m
PS134_62-2		2023-02-17T14:32:20	-70.66379	-86.43945	676.4	GC	max depth	3m
PS134_63-1		2023-02-17T21:22:21	-71.16428	-84.19030	610.7	BONGO	Station start	
PS134_63-1		2023-02-17T22:01:19	-71.16750	-84.20750		BONGO	Station end	
PS134_63-2		2023-02-17T22:08:16	-71.16708	-84.20320		MSN	Station start	
PS134_63-2		2023-02-17T22:54:55	-71.16347	-84.18955	611.3	MSN	Station end	
PS134_63-3		2023-02-17T22:55:24	-71.16342	-84.18943	611.6	MSN	Station start	
PS134_63-3		2023-02-17T23:50:46	-71.16270	-84.19007	611.8	MSN	Station end	
PS134_63-4		2023-02-18T00:16:03	-71.16285	-84.19036	612.2	CTD-RO	max depth	
PS134_63-5		2023-02-18T01:21:41	-71.16291	-84.18971	612.4	GKG	max depth	
PS134_63-6		2023-02-18T02:27:58	-71.16310	-84.19024	612.3	GC	max depth	3m
PS134_64-1		2023-02-18T04:12:02	-71.11085	-84.32519	637.0	GC	max depth	3m
PS134_65-1		2023-02-18T09:09:01	-71.49960	-83.04010	592.6	GC	max depth	3m
PS134_66-1		2023-02-19T01:24:34	-72.37383	-81.36055	907.5	GC	max depth	3m
PS134_67-1		2023-02-19T05:26:48	-72.74178	-80.82850	794.3	GC	max depth	3m
PS134_68-1		2023-02-19T09:40:58	-73.27791	-81.64590	655.0	MBES	Station start	
PS134_68-1		2023-02-24T11:30:53	-73.37706	-83.17967	468.5	MBES	Station end	
PS134_69-1		2023-02-20T12:09:37	-73.52168	-81.90139	981.5	CTD-RO	max depth	
PS134_69-2		2023-02-20T12:51:49	-73.52154	-81.90258	984.0	MSN	Station start	
PS134_69-2		2023-02-20T14:29:44	-73.52185	-81.89296	960.9	MSN	Station end	
PS134_70-1		2023-02-21T16:12:24	-73.59809	-83.25683	798.4	CTD-RO	max depth	
PS134_70-2		2023-02-21T16:54:54	-73.59669	-83.25487	798.6	MSN	Station start	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_70-2		2023-02-21T17:48:01	-73.59816	-83.25294	798.5	MSN	Station end	
PS134_70-3		2023-02-21T17:48:49	-73.59845	-83.25226	798.2	MSN	Station start	
PS134_70-3		2023-02-21T19:05:54	-73.59814	-83.25371	798.2	MSN	Station end	
PS134_70-4		2023-02-21T19:06:51	-73.59824	-83.25388	798.4	GradT	Station start	
PS134_70-4		2023-02-21T20:08:10	-73.59888	-83.25361	798.1	GradT	Station end	
PS134_70-5		2023-02-21T20:40:31	-73.59893	-83.25320	798.4	GKG	max depth	
PS134_71-1		2023-02-22T00:24:02	-73.62541	-82.39184	527.9	GC	max depth	3m
PS134_72-1		2023-02-22T02:18:35	-73.59623	-81.88092	643.5	GC	max depth	3m
PS134_73-1		2023-02-22T03:53:16	-73.55715	-81.55496	588.5	GC	max depth	3m
PS134_73-2		2023-02-22T04:58:15	-73.55716	-81.55446	588.8	GC	max depth	5m
PS134_74-1		2023-02-22T06:18:35	-73.61585	-81.52341	586.4	GradT	Station start	
PS134_74-1		2023-02-22T07:06:01	-73.61578	-81.52528	586.1	GradT	Station end	
PS134_75-1		2023-02-22T07:58:14	-73.63678	-81.87092	753.5	GradT	Station start	
PS134_75-1		2023-02-22T08:52:00	-73.63708	-81.87464	718.3	GradT	Station end	
PS134_76-1		2023-02-22T09:51:14	-73.56495	-82.13881	919.6	GradT	Station start	
PS134_76-1		2023-02-22T10:53:38	-73.56525	-82.13756	920.2	GradT	Station end	
PS134_77-1		2023-02-22T11:34:52	-73.52065	-81.90731	1007.1	GradT	Station start	
PS134_77-1		2023-02-22T12:40:09	-73.52127	-81.90215	1016.3	GradT	Station end	
PS134_78-1		2023-02-22T14:02:24	-73.36899	-81.60955	903.2	GradT	Station start	
PS134_78-1		2023-02-22T15:03:28	-73.36995	-81.61096	902.2	GradT	Station end	
PS134_79-1		2023-02-22T16:32:33	-73.42406	-82.30454	675.3	GradT	Station start	
PS134_79-1		2023-02-22T17:26:24	-73.42371	-82.30274	688.9	GradT	Station end	
PS134_80-1		2023-02-22T18:31:02	-73.49591	-82.74752	563.5	GradT	Station start	
PS134_80-1		2023-02-22T19:07:42	-73.49653	-82.74385	569.2	GradT	Station end	
PS134_81-1		2023-02-22T20:00:04	-73.58813	-82.96024	853.4	GradT	Station start	
PS134_81-1		2023-02-22T20:48:33	-73.58810	-82.95749	827.2	GradT	Station end	
PS134_82-1		2023-02-22T21:30:36	-73.60698	-83.24546	824.7	GradT	Station start	
PS134_82-1		2023-02-22T22:21:58	-73.60767	-83.24238	824.3	GradT	Station end	

Event label	Optional label	Date/Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS134_83-1		2023-02-22T23:33:17	-73.58807	-82.95870	853.3	GKG	max depth	
PS134_83-2		2023-02-23T00:38:21	-73.58795	-82.96004	852.6	GC	max depth	5m
PS134_84-1		2023-02-23T12:11:51	-73.20446	-83.48104	1070.0	CTD-RO	max depth	
PS134_84-2		2023-02-23T12:53:39	-73.20462	-83.48117	1069.9	MSN	Station start	
PS134_84-2		2023-02-23T14:48:22	-73.20690	-83.48456	1026.1	MSN	Station end	
PS134_85-1		2023-02-24T12:36:34	-73.32688	-83.11954	497.6	GC	max depth	3m
PS134_86-1		2023-02-24T13:47:22	-73.36314	-83.32626	690.8	GradT	Station start	
PS134_86-1		2023-02-24T14:36:26	-73.36571	-83.32582	528.0	GradT	Station end	
PS134_87-1		2023-02-24T15:26:02	-73.39332	-83.53413	664.5	GKG	max depth	
PS134_87-2		2023-02-24T16:42:48	-73.39341	-83.53366	664.0	GC	max depth	5m
PS134_87-3		2023-02-24T17:26:29	-73.39354	-83.53283	634.2	GradT	Station start	
PS134_87-3		2023-02-24T18:08:12	-73.39218	-83.53341	574.8	GradT	Station end	
PS134_88-1		2023-02-24T19:30:04	-73.19530	-83.95077	1116.7	GradT	Station start	
PS134_88-1		2023-02-24T20:26:21	-73.19502	-83.95528	1090.2	GradT	Station end	
PS134_89-1		2023-02-25T11:03:27	-72.45875	-90.40638	915.1	CTD-RO	max depth	
PS134_89-2		2023-02-25T11:39:14	-72.45866	-90.40558	913.4	MSN	Station start	
PS134_89-2		2023-02-25T13:32:24	-72.46182	-90.40447	905.3	MSN	Station end	
PS134_90-1		2023-02-26T12:05:57	-72.48502	-92.98553	618.1	CTD-RO	max depth	
PS134_90-2		2023-02-26T12:32:40	-72.48512	-92.98621	614.0	MSN	Station start	
PS134_90-2		2023-02-26T13:32:21	-72.48582	-92.98564	566.7	MSN	Station end	
PS134_91-1		2023-02-26T14:39:05	-72.49247	-92.69264	734.3	GKG	max depth	
PS134_91-2		2023-02-26T15:08:33	-72.49255	-92.69323	735.4	GradT	Station start	
PS134_91-2		2023-02-26T16:17:57	-72.49202	-92.68990	731.3	GradT	Station end	
PS134_91-3		2023-02-26T16:45:44	-72.49231	-92.69153	731.9	GC	max depth	5m
PS134_92-1		2023-02-26T18:18:20	-72.42408	-92.63108	635.3	GC	max depth	5m

** Comments are limited to 130 characters. See https://www.pangaea.de/expeditions/events/PS134 to show full comments in conjunction with the station (event) list for expedition PS134.*

Abbreviation	Method/Device
ADCP	Acoustic Doppler Current Profiler
ARGOFL	Argo float
BONGO	Bongo net
B_LANDER	Bottom lander
CT	Underway cruise track measurements
CTD-RO	CTD/Rosette
FBOX	FerryBox
GC	Gravity corer
GKG	Giant box corer
GRAV	Gravimetry
GradT	Temperature gradient probe
MAG	Magnetometer
MBES	Multibeam echosounder
MOOR	Mooring
MSN	Multiple opening/closing net
MYON	DESY Myon Detector
NEUMON	Neutron monitor
PS	ParaSound
SEISREFL	Seismic reflection profile
SNDVELPR	Sound velocity probe
SWEAS	Ship Weather Station
TSG	Thermosalinograph
pCO2	pCO2 sensor

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