

SD041 “KANG-GLAC” CRUISE
REPORT
KANGERLUSSUAQ TROUGH AND
EAST GREENLAND FJORDS
JULY-AUGUST 2024



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& the KANG-GLAC team

Cover photo: RRS *Sir David Attenborough* and the workboat *Erebus* working in Kivioq Fjord, East Greenland. Drone photo credit: Joe Laurence.

This unpublished report contains initial observations and conclusions. It is not to be cited without written permission of the Principal Scientists and the Director of the British Antarctic Survey.

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1 CRUISE SUMMARY: SD041 KANGERLUSSUAQ TROUGH AND CENTRAL EAST GREENLAND FJORDS

1.1 Acknowledgements

We thank the Master, Officers and Crew of the *RRS Sir David Attenborough* (SDA) for their truly excellent support during cruise SD041, July-August 2024. A total of 83 scientists, science support personnel, officers and crew were on board for SD041 and all worked extremely hard to carry out their tasks with dedication. We especially thank Captain Will Whatley and Night Master Matthew Neill for their professionalism during this complex cruise as well as their skills when exploring new territories in East Greenland where no bathymetry existed and sometimes in challenging ice conditions. We are grateful for the dedication and hard work of the deck crews (day and night), the ship's engineers, and all those who worked on board Erebus during the campaign. This first use of Erebus for science alongside the use of helicopters from the ship, represents a large step forward in the UK's capability to deliver more science per day from SDA in remote polar environments.

The work was funded by NERC as part of the "KANG-GLAC: Assessing ocean-forced, marine-terminating glacier change in Greenland during climatic warm periods and its impact on marine productivity" project (BAS grant number: NE/V006509/1). We are indebted to NERC for this funding, as well as for supporting the RRS SDA as a scientific platform.

1.2 Introduction, Scientific Aims and Approach

The overall aims of the KANG-GLAC project are to quantify the rates of ice loss from Greenland's marine-terminating outlet glaciers and their oceanic drivers on decadal to centennial timescales, and to assess the impacts on ocean circulation and marine productivity. We adopt a multi-disciplinary approach to achieve these goals, integrating observations from marine geology and geophysics, onshore studies of glacial geology, contemporary oceanography, as well as marine biological and biogeochemical approaches. Observational datasets acquired during SD041 will underpin numerical modelling to assess the rates and magnitude of ice-sheet change during Holocene warm periods as an analogue for future Greenland Ice Sheet (GrIS) change. Cruise SD041 on the *RRS Sir David Attenborough* to the fjords and continental shelf of central east Greenland in July-August 2024 was the main data collection phase for the project.

The underlying rationale for cruise SD041, and for the KANG-GLAC project overall, is that the GrIS is currently the largest contributor to global sea-level rise from the Earth's Cryosphere and is predicted to continue to be a major source of sea-level rise over the next century. Melt from the GrIS delivers large volumes of freshwater to the seas around Greenland and, along with riverine inputs, this freshwater has the potential to perturb the Atlantic Meridional Overturning Circulation, and thus Northern Hemisphere climate and weather systems (e.g., Straneo & Heimbach, 2013). Increasing freshwater delivery from the GrIS also perturbs marine ecosystems around Greenland, as well as further afield, because it alters nutrient fluxes to coastal seas. In turn, this affects marine productivity and biogeochemical cycling in the water column and at the seafloor (Straneo et al., 2019). Unfortunately, at present, we lack understanding about both the delivery of freshwater and nutrients to the ocean around Greenland and about the transport of oceanic heat towards Greenland's marine-terminating glaciers that is driving the increased melt.

This project focuses on the coastline and fjords near to the Kangerlussuaq Gletsjer system in central east Greenland plus the adjacent continental shelf. Kangerlussuaq Gletsjer (KG) is the largest outlet glacier in the region being responsible for about 5% of total GrIS ice discharge to the ocean (Rignot & Kanagaratnam, 2006). In the period 2000-2012, half the total ice loss from the GrIS was from four glaciers, one of which was Kangerlussuaq Gletsjer (Mouginot et al., 2019). Between 2016 and 2018, the calving front of KG retreated 5 km and since then it is thought to have been particularly vulnerable to rapid mass loss (via dynamic thinning and glacier acceleration) because its grounding line has retreated onto an inland-deepening bed (Brough et al., 2019). The glacier calves into the head of an 80-km long fjord that continues across the shelf for 270 km as a 400–800 m deep trough (Figure 1.2-1) (**Note:** we use the nomenclature Kangerlussuaq Trough as we do not know of any official Greenlandic placename for this depression). Marine sediment cores have documented an ice-tongue collapse and a 9-km retreat of KG in the 1930s after a local and regional increase in air and ocean temperatures (Vermassen et al., 2020). However, the longer-term behaviour of the glacier before the 20th century and the links to ocean temperatures, circulation, and marine productivity are unknown. This project combines oceanographic, biological, biogeochemical, geophysical, and geological observations to determine coupled rates of dynamic ice loss, oceanic forcing, biological productivity, and carbon storage in seafloor sediments through the Holocene, and in particular across the Holocene Thermal Maximum (HTM) (9-5 ka). At that time, enhanced radiative forcing meant that summer temperatures in Greenland were at least 2°C higher than present (Axford et al., 2021; Martin et al., 2024) and are, therefore, analogous to those predicted for 2100 under all SSP scenarios (at 2100 the predicted range of temperature increase over preindustrial is 3.2° to 8.2° C for SSP1-2.6 to SSP5-8.5, respectively; Bochow et al., 2024).

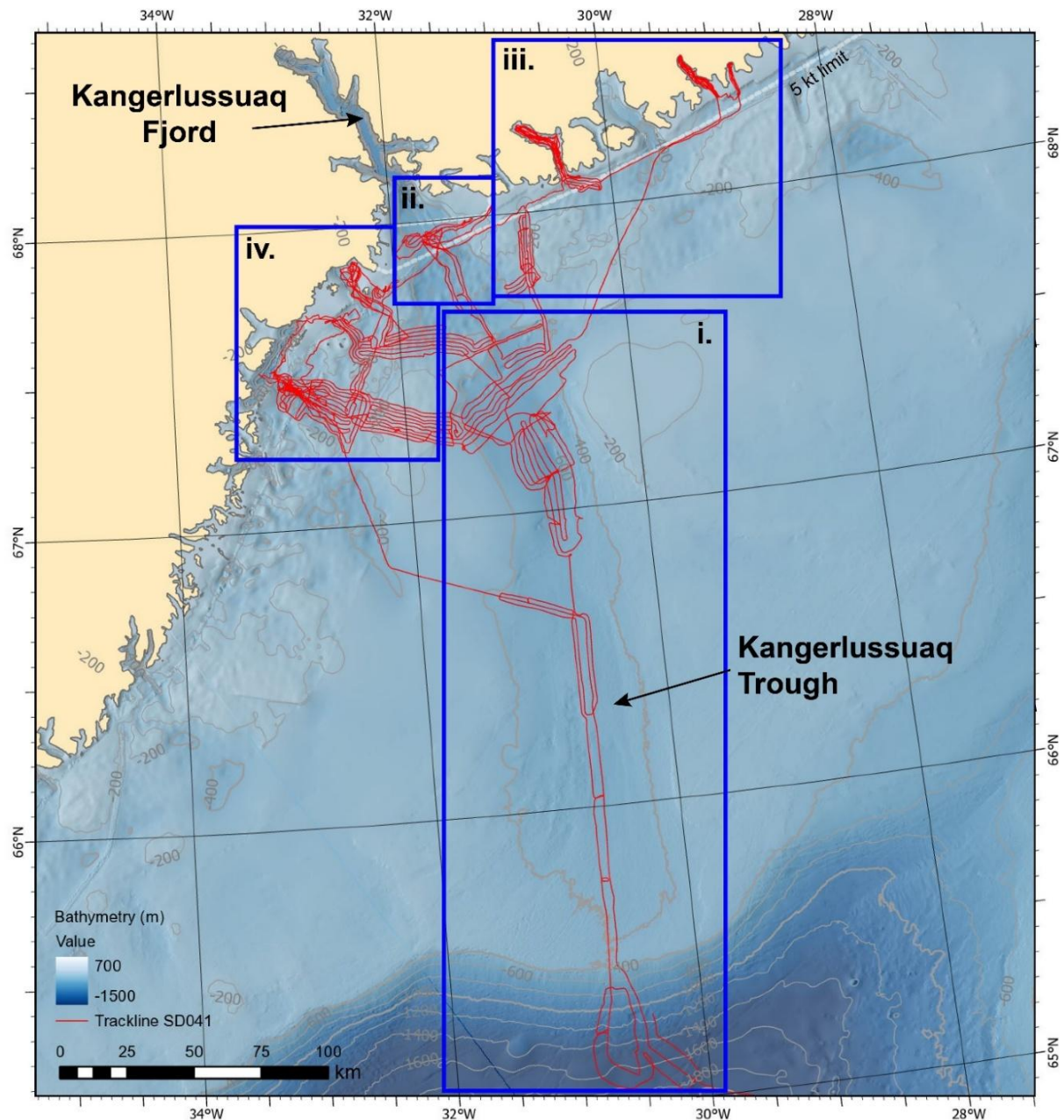


Figure 1.2-1. Location of Kangerlussuaq Fjord and trough in central East Greenland and SD041 ship track. Work areas are: (i) Kangerlussuaq Trough; (ii) the mouth of Kangerlussuaq Fjord (KF); (iii) the fjords and inner shelf areas north of KF; and (iv) the fjords and inner shelf areas south of KF. Restricted areas as per the diplomatic clearance document are shown by white-dashed lines.

Cruise SD041 of the RRS *Sir David Attenborough* (hereafter the 'SDA') to East Greenland was a multi-disciplinary science cruise making observations to address several major aspects of the KANG-GLAC project. These were: (i) contemporary oceanography to determine circulation patterns and dynamics of warm-water inflows as well as glacial freshwater outflows and fluxes; (ii) Holocene glaciology and oceanography to reconstruct central eastern GrIS dynamics (i.e., ice extent, thickness, calving/melt/sedimentation rates) and ocean temperatures from both marine and terrestrial data; and (iii) biology and biogeochemistry on both water column and seafloor

sediments to quantify modern carbon/nutrient fluxes, cycling, and marine productivity, and also to understand nutrient storage in seafloor sediments through the Holocene.

The cruise involved data collection in four main work areas: (i) in Kangerlussuaq Trough that extends south from the mouth of Kangerlussuaq Fjord (KF); (ii) the mouth of KF; (iii) the fjords and inner shelf areas to the north of KF; and (iv) the fjords and inner shelf areas south of KF (Figure 1.2-1). We used several approaches during SD041 which comprised:

- Data collection from the SDA using various shipboard instruments and equipment such as the CTD, MOCNESS and Bongo nets, a floating sediment trap, a tethered mooring, Lotus buoys, multibeam and single-beam echo sounders, a sub-bottom profiler, and seafloor corers including piston-, gravity and multi-corers.
- Use of the workboat 'Erebus' for seafloor mapping in areas that were inaccessible to the SDA, as well as for oceanographic measurements and instrument deployments close to marine-terminating glacier faces.
- The Gavia AUV for seafloor mapping and oceanographic measurements.
- An Air Greenland H155 twin-engine helicopter deployed from the SDA to put a terrestrial geology team onshore for the collection of lake sediment cores and bedrock samples.

We note that due to the Diplomatic Clearance issued by the Government of Greenland for this work, the SDA was not able to enter Kangerlussuaq Fjord itself and that work in fjords and nearshore areas along the Blosseville coast was restricted to 5 knots (see Figure 1.2-1 for restricted areas).

Cruise SD041 departed Rosyth 19.07.2024 and returned 30.08.2024. Project science was carried out within the permitted area (in the Greenland EEZ) between 23.07.2024 and 25.08.2024 (33 days total).

1.3 Placename Nomenclature

In this report, we follow the place names of The Language Secretariat of Greenland: <https://nunataqqi.gl/> (last accessed April 2026). An example of the coastline north of Kangerlussuaq Fjord is given in Figure 1.3-1 as an exemplar. A list of the most important placenames for this cruise report are as follows:

- Kangerlussuaq Gletsjer
- 3-miippugut Fjord (was Ryberg Fjord)
- Sorgenfri Gletsjer
- Kivioq Fjord
- Rosenborg Gletsjer
- Apuliliip Apusiia (glacier)
- Paattuulaajit Ikertivaat (embayment)
- Immikkeertigajik Takikkaagajik (was Deception Ø or Deception Island)

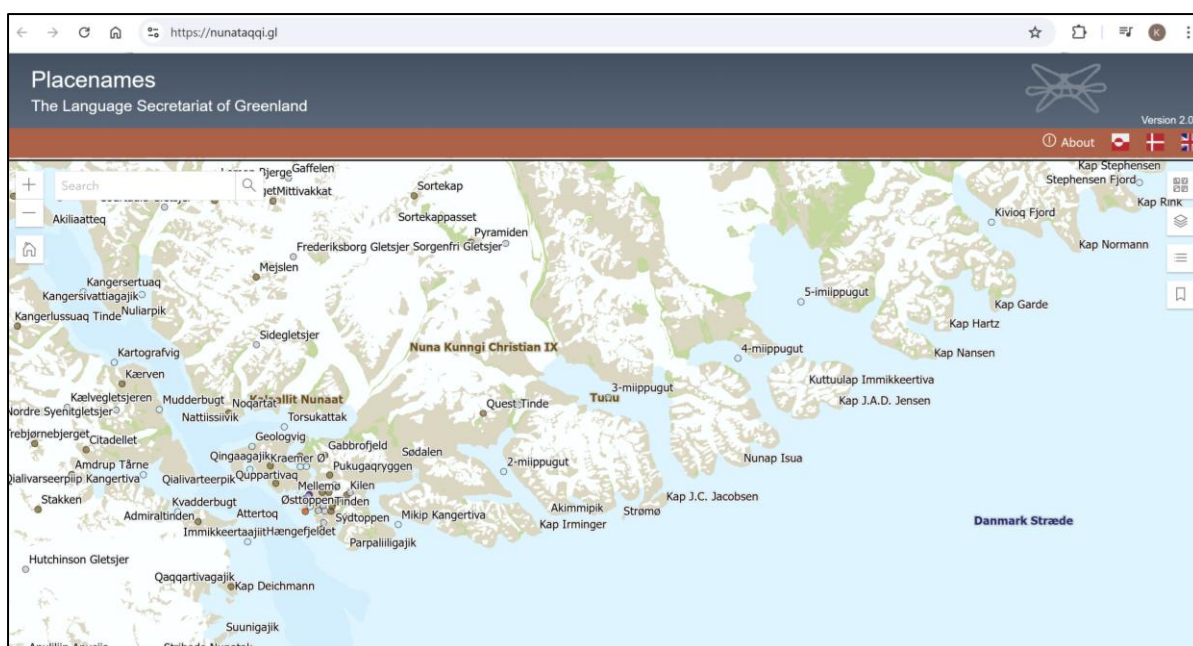


Figure 1.3-1. The area north of Kangerlussuaq Fjord (large fjord on the left) with place names as per The Language Secretariat of Greenland. Note 3-miippugut Fjord (centre of image) and Kivioq Fjord (right of image).

1.4 List of Personnel

Total Science Party: 42 (45 with Air Greenland personnel)

Kelly Hogan	BAS	Co-Principal Scientist/Marine Geophysicist
Colm Ó Cofaigh	Durham Univ.	Co-Principal Scientist/Marine Geologist
Matthew Hunt	Durham Univ.	Marine Geologist
Holly Jenkins	Durham Univ.	Marine Geologist
Jerry Lloyd	Durham Univ.	Marine Geologist
David Roberts	Durham Univ.	Glacial Geologist
Camilla Snowman Andresen	GEUS	Marine Geologist
Freja Strandlød	GEUS	Marine Geologist
Timothy Lane	LJMU	Glacial Geologist
Lev Tarasov	Memorial Univ.	Ice Sheet Modeller
Povl Abrahamsen	BAS	Physical Oceanographer
Florence Atherden	BAS	Marine Biologist
Bryony Freer	BAS	Glaciologist/Oceanographer
Rhiannon Jones	BAS	Marine Biogeochemist
Robert Larter	BAS	Marine Geophysicist
Joseph Metcalfe	BAS	Geologist
Clara Manno	BAS	Marine Biologist
Alena Sakovich	BAS	Marine Biologist
Gabriele Stowasser	BAS	Marine Ecologist
Geraint Tarling	BAS	Biological Oceanographer
Katrin Wagner	Univ. Bonn	Sediment Geochemist
Laura Castro de la Guardia	SAMS	Oceanographer

Lewis Drysdale	SAMS	AUV Operations Lead
John Howe	SAMS	Geologist/AUV Operator
Lea Riehn	SAMS	Oceanographer
Luisa Patrolecco	ISPRA	Marine Biologist
Martim Mas e Braga	St. Andrews	Oceanographer
Vincent Doñate Felipe	Stockholm Univ.	Marine Geophysicist
Kirsty Brooks	BAS	ICT (Computing Engineer)
Katy Cartlidge	BAS	AME (Mechanical Engineer)
Gareth Flint	BAS	AME (Mechanical Engineer)
Alice Fremand	BAS	Data Manager
Blair Fyffe	BAS	Field Guide
Chris Gray	BAS	AME (Electronic Engineer)
Eloise Littley	BAS	MSCL Technician
Alex Murphy	BAS	AME (Mechanical Engineer)
Nikita Petrov	BAS	AME (Electronic Engineer)
Maciej Pietrowski	BAS	ICT (Computing Engineer)
Iain Rudkin	BAS	Field Guide
Aisling Smith	BAS	Laboratory Manager
Joseph Hooper	BAS	Safety Systems Manager
Jonjo Knott	BASMU	Doctor (Helicopter Operations)

Joined SDA for the period 01.08.2024 – 22.08.2024:

Daniel Skoglund	Air Greenland	Helicopter Pilot
Hans Christian Sivertsen	Air Greenland	Helicopter Mechanic
Jógvan Viderø Olsen	Air Greenland	Helicopter Mechanic

Ship's Company: 38

William Whatley	Master	Arnis Macans	Motorman CPO
Matt Neill	Night Master	Lee Hafford	Motorman PO
Fergus Walker	Chief Officer	David Peck	CPO Science
Matthew Chapman	2nd Officer (safety)	Craig Lennon	CPO Deck
Josh Mcleod	2nd Officer (nav.)	Jack Wilmhurst	PO Deck
Elizabeth Coase	3rd Officer	Joseph Laurence	Launchman
Andris Kubulins	Chief Engineer	Paul Hirdau	Able Seaman
Geraldine Wythe	2nd Engineer	Daelyn Peck	Able Seaman
Christopher Henry	3rd Engineer	Alan Simmons	Able Seaman
Lewis Bumstead	3rd Engineer	Carlos Vargas	Able Seaman
Chris Summers	3rd Engineer	Bryn Foulkes	Able Seaman
Thomas King	3rd Engineer	Graham Waylett	Able Seaman
Lee Eccles	4th Engineer	Liam O'Brien	Doctor
Chris Walton	Purser	Micah Hendrick	2nd Cook
Aaron Harper	Chief Cook	Robert Sutton	Deck Engineer
Bryn Ferguson	Deck Engineer	Graham Raworth	Cook Steward

Nick Greenwood	Senior Steward	Anita Buttle	Steward
Desislava Fileva	Steward	Jake Wigley	ETO
Zachary Carelton-Green	Electronics Officer	Harrison Dorgan	ETO

Acronyms

BAS = British Antarctic Survey

GEUS = Geological Survey of Denmark and Greenland

ISPRA = Italian National Institute for Environmental Protection and Research

LJMU = Liverpool John Moores University

SAMS = Scottish Association of Marine Science

AME = BAS Antarctic & Marine Engineering Section

ICT = BAS Information Communications Technology Section

NP = Nurse Practitioner

ETO = Electro-Technical Officer

CPO = Chief Petty Officer

PO = Petty Officer

1.5 Cruise Narrative

Scientific party onboarded during the period 12.07.24-18.07.24.

Friday July 19. Safety briefing for scientific party followed by lifeboat drill. The ship was underway by 1300 UTC and the pilot was on board ~1400 UTC. Departure from Rosyth was via the Firth of Forth heading north to Scapa Flow. Sea state – slight.

Saturday July 20. Arrival Scapa Flow at 0630 UTC. Deployment of *Erebus* scientific workboat for EM2040 multibeam calibration, USBL testing, and A-frame testing. Departed Scapa Flow at 1100 UTC. Polar Abandonment drill followed by fire drill (ship's crew only). Ship's clock retarded by 1 hr from BST. Talk on science background and cruise plan to ship's company and scientific party.

Noon position: 003° 03.3 W, 58° 48.7 N. Sea state – slight, wind Force 3, dir. S.

Sunday July 21. Passage north-westwards over the Wyville-Thomson Ridge and Faroe Bank towards Keflavik, Iceland. Stopped for test CTD cast at 0900 but was aborted due to CTD boom problems. Transit restarted then a successful test CTD cast to 100 m was performed at 1152; no samples were collected as SDA was in the Faroes EEZ.

Noon position: 013° 39.2 W, 61° 11.8 N. Sea state – moderate, wind Force 6, dir. W.

Monday July 22. Passage westwards towards Keflavik, Iceland.

Noon position: 023° 26.5 W, 63° 27.3 N. Ship's clock retarded by 1 hr from UTC to Greenland time (UTC-2). Sea state – moderate, wind Force 6, dir. W.

Tuesday July 23. Entered Greenland EEZ and permitted work area at the base of the SE Greenland continental slope. Marine mammal observer (MMO) watch completed at 0918 (60 plus 20 minutes soft start; ~1800 m water depth). Started geophysical data collection (TOPAS sub-bottom profiler, EM122 multibeam). CTD deployed at 1104 (aborted, communications error) and redeployed successfully. Surveyed up trough-mouth fan and northwards along Kangerlussuaq Trough, then turning north-westwards towards the coast south of Kangerlussuaq Fjord. First night shifts for science party and commencement of 24-hour science operations.

Noon position: 030° 03.8 W, 65° 02.3 N. Sea state – slight, wind Force 2, dir. SSW.

Wednesday July 24. Arrived ice edge ~0330 and broke ice towards Greenland coast. Arrived at the planned mooring site in a deep basin (>800 m) on the inner continental shelf at ~1000. Unfortunately, a large floe was located over the site. A CTD deployment nearby in the same basin was partially successful (bottles did not fire). The SDA's mooring winch had a technical issue, so survey continued with the EM122 and TOPAS sub-bottom profiler looking for deeper water (>750 m) and good sea-ice conditions for mooring deployment. Overnight, the first sediment cores were taken in the deep basin showing ~50 m of stratified sediments. Deployments at the site were: MC, GC, CTD. The first attempt at deploying the mooring was aborted due to heavy sea-ice closing in on the mooring rope.

Noon position: 032° 54.5 W, 67° 27.8 N. Sea state – slight, wind Force 1, dir. variable.

Thursday July 25. We remained in the ice at the mooring site. A second attempt to deploy the mooring was successful with SDA cutting a lead in a large ice floe and then deploying the mooring whilst moving down the open lead. The first Arctic drone flight captured beautiful footage of the SDA in sea ice with mountains of coastal Kong Christian IX Land in the background. A trial Bongo net deployment (1 net only) was then carried out in a patch of more open water. SDA then left the ice, surveying with multibeam and sub-bottom profiler, to the mid-continental shelf area in Kangerlussuaq Trough. Overnight, station work was successful recovering a GC, MC, and a CTD.

Noon position: 033° 01.8 W, 67° 28.6 N. Sea state – slight, wind Force 1, dir. variable.

Friday July 26. Work continued in the mid-shelf part of Kangerlussuaq Trough with fog descending during the afternoon. A drifting sediment trap (DST) was deployed to drift freely for 12 hours, then a CTD and Bongo net (2 nets) station was completed. Unfortunately, the beacon communicating between the DST stopped sending position data to the ship at ~1345 UTC so we opted to carry out a multibeam and TOPAS survey past its last known location in the afternoon; a successful trial Mocness trawl took place after dinner. Around 2000 UTC, after a very short time of searching for the DST at its last known location, the DST was sighted from the Bridge with the science party helping; it was recovered to by 2245 UTC. One coring station was undertaken during the night (GC, MC) recovering more than 7 m of sediment in the GC. At a second coring station, the piston corer was set up and deployed twice. The first attempt was aborted due to a technical issue with the auxiliary wire (shackles not fitting through the sheave/block gap), on the second attempt the hydrostatic release on the trigger arm did not fire so a reduced sample was recovered (~2.2 m).

Noon position: 030° 42.9 W, 66° 54.5 N. Sea state - slight, wind Force 3, dir. NE.

Saturday July 27. During the morning, we continued our multibeam and TOPAS survey on the mid-shelf of Kangerlussuaq Trough over an area with glacial landforms possibly showing convergent flow into the trough. Then we headed north towards the coast to perform a CTD

transect running from SW to NE on a bathymetric sill in the trough. In total, the transect included 7 CTDs in water depths of 370-450 m and was complete by 0530 UTC (July 28). One GC was taken north of the bathymetric sill with the aim of getting a deglacial age from the inner part of the trough.

Noon position: 67° 25.6 N, 030° 58.4 W. Sea state – slight, wind Force 5, dir. ENE.

Sunday July 28. In cloudy conditions with some rain, we undertook a CTD and Bongo net deployment in the inner shelf basin of Kangerlussuaq Trough, inland of the sill (latitude ~67° 45 N). We then collected multibeam and TOPAS data transiting towards the mouth of Kangerlussuaq Fjord and in the fjord mouth entrance to look for core sites; strong ENE winds meant that we ran NW-SE oriented lines. At ~1700 UTC we commenced a transect of 9 CTDs across the fjord mouth, completing 4 of 9 before breaking off for 2 gravity core sites. The sites were selected to obtain deglacial ages and very little postglacial drape could be seen on the TOPAS records and no short cores (MC, BC) were taken. After coring, we resumed the CTD transect working towards the NE side between Kap Hammer and Kap Irminger.

Noon position: 67° 50.5 N, 031° 27.3 W. Sea state – slight, wind Force 6, dir. ENE.

Monday July 29. We started the day by acquiring the last two CTD casts on KF mouth transect. Then returned to CTD20 position to perform a Mocness trawl in the central part of KF mouth. One trigger failed (50 m to 5 m depth) so the net was redeployed for a short trawl to capture the ecosystem in the uppermost water column. We then undertook a multibeam and TOPAS survey, along the SE Greenland coast and existing Oceans Melting Greenland multibeam coverage, towards the entrance to 3-miippugut Fjord. Strong winds at the coast dropped off significantly as we entered the fjord in beautiful light and clear conditions. Overnight, we performed a multibeam and TOPAS survey in outer 3-miippugut Fjord and into the small tributary off the main fjord at 68° 15.74 N, 30° 25.79 W. The tributary terminates in a secondary unnamed glacier front that splits from Sorgenfri Gletsjer which is the main glacier in 3-miippugut Fjord. Unfortunately, there was a slight touchdown on the seafloor with the Farsounder pole that protrudes 2 m from the bottom of the SDA making its draft 9 m.

Noon position: 67° 55.8 N, 031° 28.9 W. Sea state – slight, wind Force 3, dir. SW.

Tuesday July 30. In extremely calm or “millpond” conditions Erebus plus the Gavia AUV team was deployed from the starboard side of SDA to undertake the first Gavia missions about 1 km from the ice front. After a few hours of work, they returned to remove the internal ballast from Gavia because the water was fresher (less dense) and more turbid (sediment laden) than expected. We did a CTD to determine water density and then redeployed Erebus with Gavia modified for the condition in the fjord. A second small boat was also launched to investigate the Farsounder pole, but visibility was too poor in the sediment-laden water to see anything. After internal and external investigations of the Farsounder pole and chamber whilst remaining on station at the CTD site, science recommenced at 1500 UTC. We performed a multibeam and TOPAS survey on the southern side of inner 3-miippugut Fjord then returned to a position ~1 km from the ice front of Sorgenfri Gletsjer to bring Erebus and the Gavia team back on board at ~1800 UTC. Overnight, coring was performed at four sites in inner and mid-3-miippugut Fjord, with a gravity core and multicore at each station and an additional CTD was taken in the innermost part of the fjord.

Noon position: 68° 16.5 N, 030° 46.7 W. Sea state – slight, variable wind direction.

Wednesday July 31. Erebus was launched from SDA just after 0700 UTC for its second (of three) seafloor mapping days in 3-miippugut Fjord. After a Bongo deployment (2 x nets) in the innermost fjord (at the site of CTD27), we returned to a bathymetric sill across the inner fjord via the northern side of existing multibeam coverage and completed a transect of five CTDs. At the third CTD site, in the centre of the fjord, we also deployed a Bongo net (1 x net). We then returned to close to the face of Sorgenfri Gletsjer to collect Erebus and the Gavia team. During the night another suite of gravity and multi-cores were acquired, this time in the mid to outer part of the fjord.

Noon position: 68° 14.9 N, 030° 34.9 W. Sea state – slight, variable wind direction.

Thursday August 01. Erebus was again launched shortly after 0900 UTC to undertake a series of CTDs and biological sampling stations along the calving front of Sorgenfri Gletsjer with Erebus also collecting multibeam bathymetry data in areas too shallow for SDA using its EM2040. Meanwhile, the SDA transited to the middle part of 3-miippugut Fjord for a station with CTD and Bongo deployments, followed by transit another hour southwards towards the outer fjord to deploy a floating sediment trap, CTD, and Bongo (2 x nets) at one station. In a lull between two severe low pressure systems outside of the fjords, we took the opportunity during the night shift to perform a multibeam and TOPAS survey beyond the fjord mouth tracing the fjord overdeepening out on to the inner continental shelf.

Noon position: 68° 13.4 N, 030° 28.6 W. Sea state – slight, variable wind direction.

Friday August 02. After an email exchange between PP Andresen and colleagues at the Greenland Centre for Climate Research (GCRC), it was noted that the Greenlandic name for “3-miippugut Fjord” is actually 3-miippugut and we will adopt this name from this point forwards. The Erebus workboat was again launched around 0900 UTC, with the Gavia AUV team on board, to perform a seafloor survey in front of the tributary glacier in 3-miippugut Fjord, inshore of an emergent moraine (LIA limit?) newly christened “Neil Moraine” during SD041. The SDA transited southwards and undertook a CTD transect across the fjord, completing four of five stations before returning to collect Erebus at the head of the fjord at 1900 UTC. The night was dedicated to trialling a new set-up of the piston corer on SDA following an issue during its first deployment on 27 July.

Noon position: 68° 08.7 N, 030° 25.8 W. Sea state – slight, wind Force 5, dir. SE.

Saturday August 03. The final day of Erebus deployments in 3-miippugut was dedicated to obtaining a series of turbulence profiles using a SAMS-owned MSS instrument across the face of Sorgenfri Gletsjer, including profiles within an extremely active meltwater plume (speeds >1.2 kt) at the western edge of the glacier. The SDA stayed on station in the innermost fjord for ~ 2 hours to investigate a technical issue with the coring warp (wire) and then moved to a shallow bathymetric sill (160-180 m) to carry out a MOCNESS trawl. This was followed by a Bongo plus “mini Bongo” deployment in the inner fjord; the mini Bongo is used to sample live forams. Overnight 2 x CTDs on way out of fjord, one to complete outer fjord transect and one with BIO and Bongo at the fjord mouth to complete station deployments in 3-miippugut Fjord. Transit to Kivioq Fjord to the northeast past Nansen Fjord.

Noon position: 68° 14.6 N, 030° 35.4 W. Sea state – slight, wind variable direction.

Sunday August 04. By 0900 the SDA had performed a seafloor survey (multibeam, TOPAS) up to the marine-terminating glacier face of Rosenborg Gletsjer in Kivioq Fjord. At 0950 UTC Erebus was launched to swath the shallowest parts of the fjord and in a bay on the northern side of the

fjord into which a small tributary glacier drains. At the same time the SDA continued its survey of the inner fjord. This was followed by several more Erebus trips to give crew and scientists not involved in Erebus science the chance to see the fjord from the smaller workboat. Seafloor surveying continued overnight with three additional Erebus trips made in the outer fjord for night-shift personnel.

Noon position: 68° 26.1 N, 029° 13.5 W. Sea state – slight, wind variable direction.

Monday August 05. On the second day in Kivioq Fjord, Erebus was launched at 0915 UTC with SAMS oceanographers and the Gavia team on board to complete turbulence profiles along the face of Rosenborg Gletsjer and Gavia AUV missions in the same area. This day also marked the start of SDA deployments in Kivioq Fjord that included: an along-fjord transect of CTDs and biological sampling stations (from inner to outer fjord), followed by a cross-fjord transect of 5 CTDs in the outer fjord.

Noon position: 68° 25.4 N, 029° 13.1 W. Sea state – slight, wind Force 2, dir. SW.

Tuesday August 06. At 0900 UTC Erebus + CTD + Bio samplers out. Continued deployments in Kivioq Fjord including: a floating sediment trap released in the inner fjord to sample the high density outflow (?) layer at ~80 m depth, a MOCNESS trawl in the mid-fjord, and 3 CTD stations in the outer fjord, one with Bongo net deployment in the outer part of the fjord. In the early afternoon, the SDA received some missing science equipment that was brought up from Tasiilaq. We broke before completing the final CTD cast of the outer-fjord transect to retrieve Erebus near the glacier face but then returned to perform the last CTD cast before exiting Kivioq Fjord and surveying with multibeam and TOPAS sub-bottom profiler instruments around Kap Norman into the next fjord along the coast. This fjord is unnamed (<https://nunataqqi.gl/>) but there is a second branch of Rosenborg Gletsjer draining into it.

Noon position: 68° 25.4 N, 029° 13.1 W. Sea state – slight, wind Force 2, dir. SW.

Wednesday August 07. Today was the final deployment for the Erebus workboat was in the fjords north of Kangerlussuaq Fjord. She was launched at ~0900 UTC with the Gavia AUV team on board to survey in the innermost fjord and along the face of Rosenborg Gletsjer. Water depths were deeper than expected in this fjord (>400 m) when compared with Kivioq Fjord (~230 m deep in deepest parts). A transect of four CTDs were taken across the innermost fjord with biological water sampling and a Bongo net deployment at the central station. There was a short delay to deployments whilst the open-close mechanism on the Bongo nets was checked. After this, two more CTDs were taken in the middle and outer parts of the fjord; Bongo nets were also deployed at the outer fjord site. After retrieving Erebus at ~1830 UTC, two Bongo casts were repeated at the innermost station. Overnight, samples were obtained from two core sites in the unnamed fjord including a short MC and a long (GC or PC) core at each location followed by a CTD at the fjord mouth to complete the along-fjord transect. By 0600 UTC, the SDA had departed the SE Greenland coastline heading southeastwards back to Kangerlussuaq Trough, acquiring multibeam bathymetry and TOPAS data during transit.

Noon position: 68° 25.0 N, 028° 48.7 W. Sea state – slight, wind Force 1, dir. variable.

Thursday August 08. The SDA reached the mid-continental shelf work area by ~1300 UTC then performed a multibeam and TOPAS survey adding to existing coverage in the area until 1800 UTC. At that time, a CTD was taken in a deep basin in the Kangerlussuaq glacial trough (>700 m water depth), followed by a MOCNESS trawl to assess the pelagic ecosystem (at approximately sunset)

on the mid-shelf. Overnight, three long cores were taken at sites on the mid-shelf targeting a 30-40 m thick stratified unit for an expanded Late Holocene record, and glacial till with overlying drape to obtain a deglacial age for the mid-shelf.

Noon position: 68° 31.7 N, 030° 38.9 W. Sea state – slight, wind Force 5, dir. WSW.

Friday August 09. At ~0930 UTC we deployed the MOCNESS net for a second time in the mid-shelf basin to capture the pelagic ecosystem around sunrise to compare with the sunset catch from 08 August. After that, SDA commenced transit to the NW back towards the Greenland coastline and the mouth of Kangerlussuaq Fjord in cloudy conditions. The vessel deviated out of Kangerlussuaq Trough, heading westwards to find an area with a higher cloud base so that the Air Greenland helicopter could land safely. The helicopter, which will be used to transport the geology land team to onshore sites to collect rock samples for cosmogenic dating, landed on SDA's helipad at ~1650 UTC. Overnight we carried out a swath survey moving gradually towards the mouth of Kangerlussuaq Fjord. We then commenced a 24-hour MOCNESS trawl programme (4 x trawls every 6 hours) at 0600 UTC, working west to east across the mouth of Kangerlussuaq Fjord. In between MOCNESS deployments we carried out swath and TOPAS surveys to expand our seafloor coverage in this area and assess potential coring sites.

Noon position: 67° 15.6 N, 031° 05.1 W. Sea state – slight, wind Force 3, dir. WSW.

Saturday August 10. Two more MOCNESS trawls were completed in the mouth of Kangerlussuaq Fjord with start times 1200 and 1800 UTC and a repeat CTD was taken at the site of the deepest CTD from a previous transect across the fjord mouth (496 m water depth). The weather was rainy and foggy to start with, clearing slightly through the day. Overnight we completed the 24-hour MOCNESS programme with the fourth deployment at 0000 UTC. We then collected gravity-(SD041-0039GC) and multi-cores SD041-0040MC in a till unit on the east side of the mouth of Kangerlussuaq Fjord. Following core recovery, we carried out a swath survey south and then west across the inner shelf towards 'Fladø Trough' (informal name for the narrow trough in the bay Paattuulaajit Ikertivaat at ~67° 45'N, 32° 15'W).

Noon position: 67° 57.6 N, 031° 38.8 W. Sea state – slight, wind Force 5, dir. ENE.

Sunday August 11. We commenced coring in Fladø Trough overnight in 300-400 water depth. The trough contains thick sequences of acoustically stratified sediments which provided excellent targets for coring. We collected cores SD041-0041MC and SD041-0042 PC behind a moraine ridge in the outer trough, and then SD041-0043MC and SD044-0044 PC in the inner trough and closer to the glacier front. Following collection of the cores the ship collected a swath line in inner Fladø Trough and was on station in the inner shelf for Erebus/Gavia and helicopter deployments starting at 08.00 hrs.

Noon position: 67° 49.3 N, 032° 25.1 W. Sea state – slight, wind Force 2, dir. WNW.

Monday August 12. By 0930 UTC the workboat Erebus had been launched to perform seafloor mapping and oceanographic surveys along the eastern front of glacier Apuliliip Apusiia with the Gavia AUV. The next few hours were taken up with helicopter operations (lift-off and touchdowns, loading) prior to its first departure for science with the terrestrial geology team on board to work at site KG8 at the head of Kangerlussuaq Fjord. During the afternoon, the SDA acquired multibeam and TOPAS data in the northern part of Paattuulaajit Ikertivaat (colloquially called the "Fladø Trough" work area during the cruise) and did two CTD and Bongo net stations. Erebus and the helicopter returned to SDA by 2000 UTC.

Noon position: 67° 52.7 N, 032° 21.2 W. Sea state – slight, wind Force 2, dir. E.

Tuesday August 13. This was another day with a triple science programme: the helicopter deployed the terrestrial geology team to KG8, Erebus was launched with oceanographers and biologists on board to collect MSS turbulence profiles, CTD profiles and biological samples along the front of Apuliliip Apusiia, and SDA performed a multibeam bathymetry and TOPAS survey in the outer part of the bay. By 1930 UTC both Erebus and the land team had been recovered to SDA which then transited to the inner shelf SE of Paattuulaajiit Ikertivaat for coring and CTD station work. Overnight we collected two gravity cores (SD041-045GC and SD041-046GC) as well as two CTDs before proceeding with a swath survey south, and then west, to the area of the mooring.

Noon position: 67° 47.4 N, 032° 01.6 W. Sea state – slight, wind Force 4, dir. SW.

Wednesday August 14. By 1030 UTC the helicopter had transported the land team to site KG5, in the mid-fjord area of Kangerlussuaq Fjord. After this the floating sediment trap was deployed close to the mooring site, and the SDA undertook exploratory multibeam and TOPAS surveys looking for open water and workable conditions in the fjords south of 67° 45' N on the SE Greenland coast. An accumulation of large icebergs and sea ice floes between Immikkeertigajik Takikkattagajik (this is named Deception Ø on some maps) and Uunartaajiit islands at approximately 33°W, 66° 30 N may be grounded on a shallow bank running between the two sets of islands. Two flights with the SDA drone and aerial photographs taken by the helicopter, on its flights were extremely useful in terms of spotting more open water. Swath survey overnight to northern end of inner coastal trough in heavy fog and ice, as well as recovery of a floating sediment trap.

Noon position: 67° 47.4 N, 032° 01.6 W. Sea state – slight, wind Force 4, dir. SW.

Thursday August 15. After a grey and murky start there was a question of whether the visibility was good enough for helicopter deployments. However, improving conditions meant that the land team and helicopter were away from SDA by 0940 UTC to work at KG2 site (a low elevation coastal site at the mouth of Kangerlussuaq Fjord). The SDA began a series of deployments in the coastal trough beginning with a transect of three CTDs across the northern entrance to the trough at a latitude of ~67° 42 N. At the middle CTD (two of three) there were technical issues with the CTD wire (1.5-hour delay) as well as the hydro wire (used for Bongo nets). Overnight we attempted to access a coring site in the inner coastal trough to deploy a piston corer but were unable to access the core site due to extensive ice. We therefore proceeded east to collect multi- and gravity cores SD041-0046MC and SD041-0047GC, checking ice conditions en-route for a second MOCNESS trawl. Following core recovery, we commenced a 24-hour Mocness trawl at 0600 hrs UTC Friday morning.

Noon position: 67° 28.5' N, 032° 48.0' W. Sea state – slight, wind Force 2, dir. SW.

Friday August 16. In glorious sunny weather, MCh of the day was spent doing repeat MOCNESS trawls in the narrow but deep basin (>800 m deep) where the mooring was deployed on July 25. The MOCNESS was deployed at 0600, 1200, 0600 and 2400 UTC and lasted around 2 hours each time. Between trawls we added to our multibeam and TOPAS coverage east of the mooring/MOCNESS area to map any deeper water connections across the continental shelf. After the final MOCNESS trawl, we then continued a swath survey to the east of the mooring site, finishing the survey back at the mooring location by 0900 UTC.

Noon position: 68° 28.3' N, 032° 57.8' W. Sea state – slight, wind Force 3, dir. SW.

Saturday August 17. The helicopter plus land team were away from SDA by 0930 UTC, after which we monitored ice conditions at the mooring location and took a CTD (#074) to compare with the mooring instrument data. After the CTD, there was a large iceberg (>25 m above the waterline) close to the mooring location but the mooring itself was clearly visible on the EK80 and water column display of the EM122 (these data were recorded). An hour-long test of the starboard lifeboat davit mechanism was performed, and was successful, following a small smoke incident on Friday 16 August. After this the mooring site was clear of icebergs and recovery began in bright sunshine; the mooring was successfully recovered by 1415 UTC. Of note were the sediment trap tubes (closed at 2-day intervals over 20 days) which contained abundant samples suggesting this is a highly productive area. Two more CTD stations, one with Bongo samples, were completed during the afternoon. Overnight, we collected four cores along a transect east of the mooring site: SD041-0048GC, SD041-0049GC, SD041-0050GC and SD041-0051GC. Upon completion of the final core, we then commenced a swath survey northwards, in foggy conditions to the northern end of the inner shelf deep trough so as to be position for helicopter, Erebus and Gavia deployments on Sunday.

Noon position: 68° 28.8' N, 033° 01.9' W. Sea state – slight, wind Force 3, dir. S.

Sunday August 18. Visibility (fog and low cloud) was too poor for helicopter deployments in the morning although it was forecast to brighten/clear in the early afternoon. The SDA spent a few hours swath surveying east of the northern entrance to the deep coastal trough (informally “Deception Trough” from now on) to wait for weather conditions to improve. The helicopter took off at 1415 UTC, and the land team was able to complete a half-day of sampling returning to the vessel at 2100 UTC. After this, a second CTD cast and Bongo station was carried out beyond the northern entrance to Deception Trough. Overnight we carried out a swath survey south from the mouth of Kang Fjord to the mid-shelf where we carried a out series of east-west lines imaging impressive bedrock structure in the seafloor.

Noon position: 67° 41.5 N, 032° 34.4 W. Sea state – slight, wind Force 4, dir. NNE.

Monday August 19. The morning began in heavy fog on the inner-mid continental shelf south of Kangerlussuaq Trough. Daytime deployments included a FST (complete by 1030 UTC), three CTD casts and two Bongo net sampling stations (at the same locations as two of the CTD casts). The aim of this work was to connect oceanographic and biological sampling stations on the inner shelf in the Deception Trough area with existing samples from the mid-shelf area of Kangerluusuaq Trough. Overnight we recovered the FST and then proceeded eastwards across the mid-shelf to start a transect of four cores at three stations, heading back west to the mooring site. These cores targeted sediment drapes over bedrock highs and comprised SD041-0052MC and SD041-0053GC at the first station, followed by cores SD041-0054GC and SD041-0055GC further west. Upon completion of the final core, we proceeded westwards swathing to the mooring site for arrival at 08.00 hrs on Tuesday morning.

Noon position: 67° 20.6 N, 031° 47.6 W. Sea state – slight, wind Force 1, dir. variable.

Tuesday August 20. Contrary to the weather forecast, visibility in the morning was better than expected and good enough for both helicopter and Erebus operations from the SDA. The helicopter plus land team was deployed by 0945 UTC and Erebus was moving away from SDA towards their work area just east of the Uunartaajit islands by 1045 UTC. Their targets were some small troughs that trend E-W to SE-NW and appear to connect to the deep where the mooring was deployed. The Gavia AUV completed her deepest missions of the cruise here, working well

in 435 m water depth. The land team visited the low elevation site KG4 to obtain rock samples for cosmogenic dating and fill a gap in their “dipstick” profile of the deglacial ice sheet thinning through Kangerlussuaq Fjord. The SDA then tried to sail into the southern part of Deception Trough to see if a piston-core site was accessible, and a CTD cast was taken in mobile ice conditions. After this, the SDA returned to the deep basin east of Deception Trough (the previous mooring site) to redeploy the instrumented mooring and take another CTD. The mooring will remain for a period of 1 year, thus sampling a full winter-summer cycle. Overnight we collected a multicore and piston core (SD041-MC056 and SD041-PC057) in heavy ice from a stratified basin west of the mooring site. Upon completion of the piston core, we proceed swath eastwards and then north towards the inner shelf to the east of Kangerlussuaq Trough.

Noon position: 67° 31.9 N, 33° 07.2 W. Sea state – slight, wind Force 1, dir. variable.

Wednesday August 21. The SDA transited northeastwards acquiring multibeam and TOPAS sub-bottom profiler data, arriving on the inner shelf NE of Kangerlussuaq Trough by 1130 UTC. Shortly after, in beautiful sunny weather, the helicopter took off for the final day of terrestrial geology work. It took the land team to site KG8 at the head of Kangerlussuaq Fjord to collect a lake core with a full Holocene record. Erebus was also deployed with the Gavia AUV team on board; they carried out two successful seafloor AUV missions (>25 line-km) on the inner shelf outside of 2-miippgut fjord. The SDA planned to do a MOCNESS trawl and to take a CTD cast but there was a short delay due to technical issues with the CTD winch and communications to the MOCNESS device. We then performed the MOCNESS trawl in 360 m water depth collecting Atlantic Water species as well as the very rare *Megacalanus* mesopelagic copepod. Overnight we deployed a floating sediment trap and then proceeded swath and collecting CTDs in a smaller trough east of inner Kangerlussuaq Trough and aligned with the mouth of 2-miippugut Fjord (previously known as I.C Jacobsen Fjord). We completed two CTDs, but a problem developed with the wire spooler and so we switched to gravity coring, collecting core SD041-GC058 which recovered over 4 m of sediment. Continuing technical problems meant the CTD stations had to be abandoned while repairs were carried out on the CTD spooler.

Noon position: 67° 57.0 N, 30° 47.8 W. Sea state – slight, wind Force 3, dir. W.

Thursday August 22. After an extremely successful 12-day work period with the Air Greenland helicopter, they took off from the SDA helipad for the final time at 1020 UTC. The science party is exceptionally grateful to the pilot and two mechanics (Daniel, Hans Christian, and Jogvan) for their hard work and support during helicopter operations on KANG-GLAC. After their departure, the SDA transited SW to retrieve the FST in calm conditions on the inner shelf outside of 2-miippugutt Fjord. Two Bongo nets were deployed at the same station to look for Atlantic Water species as had been found in the nearby MOCNESS but unfortunately the nets came up almost empty. The rest of the day was spent doing a multibeam and TOPAS survey to map out convergent glacial landforms on the mid-shelf in Kangerlussuaq Trough. Overnight we deployed a Lotus Buoy and then proceeded to collect swath and TOPAS data from the mid-shelf working first westwards and then southwards, adding to our block of multibeam data showing convergent glacial lineations in Kangerlussuaq Trough. We collected three cores, SD041-MC059 (at the site of SD041-PC038) from the deepest part of a thick stratified basin on the mid-shelf, and SD041-MC060 and SD041-PC061 towards the margins of the same basin ten miles further south. Following completion of the latter core we proceed southwards along Kangerlussuaq Trough towards a CTD station.

Noon position: 67° 45.9 N, 31° 01.9 W. Sea state – slight, wind Force 3, dir. SSE.

Friday August 23. After a technical issue with the CTD winch a test cast was performed followed by a full CTD cast on the mid to outer shelf in the trough. This was followed by two Bongo nets and a second CTD cast. The rest of the day was spent mapping the seafloor in the mid-to-outer shelf area of Kangerlussuaq Trough on the way back up to a core site. Overnight on Friday we collected a gravity core SD041-GC062 from the mid-shelf, before commencing a long transit of 40 miles out to the outer shelf. MCh of the terrain imaged in the swath from the outer shelf shows extensive iceberg scouring but we collected a piston- (SD041-PC062) from an acoustically stratified basin in 500 m of water, as well as a CTD from the same site. A multi-core from the same location was unsuccessful but was not repeated due to time constraints.

Noon position: 66° 38.6 N, 030° 36.7 W. Sea state – slight, wind Force 4, dir. N.

Saturday August 24. Today was spent on the outermost continental shelf in Kangerlussuaq Trough and on the continental slope further south. The latter is the glacial trough-mouth fan (TMF) built by repeated growth of the Greenland Ice Sheet during Quaternary glacial cycles when it extended across the continental shelf. This was the final day of deployments for the cruise, and it began in sunshine with a CTD cast and two Bongo net deployments. The SDA then proceeded southwards on to the continental slope to survey the trough-mouth fan and to perform a MOCNESS trawl and CTD in deeper water (~1500 m). These were complete by 1845 and 2115 UTC, respectively. Overnight on Saturday we carried out three deployments on the slope in front of the mouth of Kangerlussuaq Trough. A final CTD station from the upper slope was followed by 6 m gravity cores in 1200 m (SD041-GC063) and 1300 m (SD041-GC064) water depth. This completed the deployments on cruise SD041. The remainder of the night shift was spent on a swath survey of the slope (the 'Kangerlussuaq Trough-Mouth Fan').

Noon position: 65° 42.6' N, 030° 42.6' W. Sea state – slight, wind Force 3, dir. SE.

Sunday August 25. After the final deployments overnight, the SDA continued a multibeam and TOPAS survey on the Kangerlussuaq TMF. End of cruise dinner. We stopped recording and pinging on all the acoustic instruments (EM122, TOPAS, EK80, VM-ADCP) at 2247 UTC as SDA passed out of the Greenland EEZ.

Noon position: 65° 28.3 N, 030° 22.0 W. Sea state – slight, wind Force 3, dir. ESE.

Monday August 26. On passage eastwards towards Keflavik, Iceland in calm seas. 15 personnel departed SDA at Keflavik by small boat transfer at 1900 UTC. SDA departed Keflavik at ~2015.

Noon position: 64° 24.2 N, 024° 32.1 W. Sea state – slight, wind Force 2, dir. ENE.

Tuesday August 27. On passage southeastwards towards northern Scotland.

Noon position: 62° 44.2 N, 020° 19.4 W. Sea state – slight, wind Force 2, dir. E.

Wednesday August 28. On passage southeastwards towards northern Scotland.

Noon position: 60° 45.3 N, 011° 51.6 W. Sea state – rough, wind Force 7, dir. NE.

Thursday August 29. On passage east and south around the northern tip of Scotland to Rosyth.

Noon position: 58° 50.1 N, 004° 0.1 W. Sea state – moderate, wind Force 5, dir. E.

Friday August 30. Under the Firth of Forth bridges ~1230 UTC. SDA tied up by ~1600 UTC.

Noon position: 56° 01.2 N, 003° 26.8 W. Sea state – moderate, wind Force 5, dir. NNW.

2 ACTIVITY REPORT: MARINE GEOPHYSICS AND GEOLOGICAL SAMPLING

2.1 Marine Geophysics – SDA Multibeam and Sub-bottom Profiling

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Four sonar systems were used primarily to survey the seafloor, and another was used to survey the water column during cruise SD041. Seafloor surveys from the SDA were conducted with the Kongsberg EM122 (~12 kHz) and EM712 (40–100 kHz) multibeam echo-sounding systems and the Kongsberg TOPAS PS018 parametric sub-bottom profiling system, all of which use hull-mounted transducers. Additional seafloor surveys were conducted in shallow water areas from the Erebus workboat using the Kongsberg EM2040 (200–400 kHz) multibeam echo-sounding system, the transducers for which are mounted in a pod attached to the hull. Water column surveys were conducted from the SDA using the Kongsberg EK80 high-precision scientific echo sounder, which uses hull-mounted transducers transmitting at 6 different frequencies ranging from 18 to 333 kHz. The water column recording option on the EM122 and EM712 systems was also used on a few occasions during the cruise.

Table 2.1-1. SDA multibeam echo-sounder systems used during SD041.

Model	Angle	Depth Range	Acquisition Software
EM122	1°x 1°	50 – 7000 m	Seafloor Information System (SIS) – version 4.3.2
EM712	1°x 1°	5 – 800 m	Seafloor Information System (SIS) – version 5.12.2

Before starting to transmit on any of these systems marine mammal watches were conducted by members of the scientific party who had completed a Joint Nature Conservancy Committee-approved training course, following the recommendations in the NERC Marine Environment Interaction Policy. A new marine mammal watch was conducted before restarting transmission on occasions when pinging was interrupted for more than 10 minutes. When starting transmissions on the multibeam and TOPAS systems the mammal protection options were used so that the initial transmissions were at a low power and transmission power levels were gradually ramped up to the normal operating level. Each time the workboat Erebus was deployed, transmission on the EM2040 system was started while still close to the SDA, from which sonar systems were already transmitting.

All times mentioned in the text below are in UTC.

The TOPAS and EM712 systems were operated on transit in the UK EEZ after departing from Rosyth, TOPAS being started at 16:47 and EM712 at 18:05 on July 19. Logging of data from the TOPAS system was started at 20:21 on July 19, but EM712 data were not logged on transit. Both systems were stopped at 19:58 on July 20 before crossing from the UK EEZ into the Faroese EEZ.

Erebus was deployed in Scapa Flow between 07:39 and 10:30 on July 20 to collect some data on the EM2040 system for calibration purposes.

After crossing from Iceland's EEZ into the Greenland EEZ in the Denmark Strait on July 23, the TOPAS system was started at 10:20 and the EM122 was started at 10:56, in water depths around 1800 m. These systems were then operated almost continuously until leaving the Greenland EEZ on August 25, apart from brief interruptions due to technical problems. The EM712 system was started at 16:37 on July 23, but it was only operated intermittently during the cruise due to recurring technical problems. No data were logged from the EM712 system until 15:33 on July 28. During the cruise, data logging on EM122, EM712, and TOPAS systems was paused during work on stations (however, pinging continued) and was restarted as the vessel got underway again.

Table 2.1-2 Summary of the sound-velocity profiles (SVPs) used during SD041.

File name (SVP)	CTD / Rapidcast	Lat. Active (dd)	Long. Active (dd)	Date / time active
SD041_003_SSsvp_fixed_thinned	CTD	65.04650	-30.08968	13:04 23/07/24
rapidcast_ctd_004	Rapidcast	66.26120	-30.62513	21:34 23/07/24
SD041_008_SSsvp_fixed_thinned	CTD	66.90488	-30.71218	12:07 26/07/24
SD041_009_SSsvp_fixed_thinned	CTD	67.52151	-31.51685	20:35 27/07/24
SD041_010_SSsvp_fixed_thinned	CTD	67.54149	-31.36603	22:36 27/07/24
SD041_016_SSsvp_fixed_thinned	CTD	67.74701	-31.44494	11:11 28/07/24
SD041_026_SSsvp_fixed_thinned	CTD	68.01377	-30.79818	21:22 29/07/24
SD041_027_SSsvp_fixed_thinned	CTD	68.27617	-30.77627	16:09 30/07/24
SD041_035_SSsvp_fixed_thinned	CTD	68.15918	-30.46596	08:09 02/08/24
SD041_045_SSsvp_fixed_thinned	CTD	68.40068	-29.16841	03:27 06/08/24
SD041_053_SSsvp_fixed_thinned	CTD	68.41223	-28.81595	15:13 07/08/24
SD041_058_SSsvp_fixed_thinned	CTD	67.55152	-31.79932	21:37 09/08/24
SD041_060_SSsvp_fixed_thinned	CTD	67.94883	-31.65142	18:46 10/08/24
SD041_067_SSsvp_fixed_thinned	CTD	67.59361	-32.17944	02:20 14/08/24
SD041_068_SSsvp_fixed_thinned	CTD	67.63612	-32.63355	00:14 15/08/24
SD041_074_SSsvp_fixed_thinned	CTD	67.69628	-32.55468	17:31 18/08/24
SD041_082_SSsvp_fixed_thinned	CTD	67.50294	-32.88488	03:51 21/08/24
SD041_075_SSsvp_fixed_thinned	CTD	67.72756	-30.97497	15:48 22/08/24
SD041_086_SSsvp_fixed_thinned	CTD	66.30799	-30.65934	17:43 23/08/24
SD041_003_SSsvp_fixed_thinned	CTD	65.28493	-30.76070	15:35 24/08/24
SD041_090_SSsvp_fixed_thinned	CTD	65.38162	-30.48595	11:45 25/08/24
SD041_089_SSsvp_fixed_thinned	CTD	65.45437	-30.23655	15:29 25/08/24

Sound velocity profiles (SVPs) from CTD casts conducted during the cruise were imported into the EM122 and EM712 systems using the SVP editor in the SIS software to enable these systems to calculate ray paths and depths accurately (see Table 2.1-2). The frequency of CTD casts during the cruise meant that there was only one occasion on which it was considered necessary to collect an SVP specifically for use in the multibeam echo sounding systems. This Rapidcast CTD was conducted starting at 19:30 on July 23, and the resulting SVP was loaded and used in the EM122 system from 21:34 the same day.

Data collected on the Greenland continental slope and shelf using the EM122 system from the start of its operation until 20:36 on July 29 were logged in survey SD041_b (see Table 2.11). Data collected between 15:33 on July 28 and 20:38 on July 29 on the EM712 system were also logged to a survey assigned the same name in its data storage structure. This survey includes data collected on the trough mouth fan at the mouth of the Kangerlussuaq Trough, along the trough and on the inner continental shelf to its west (see Figure 1.2-1). Survey SD041_b was reactivated on the EM122 system when the SDA returned to this region at 12:21 on August 08 and data collected from then until the system was stopped on August 25 before leaving Greenland's EEZ were added to this survey. Survey SD041_b was reactivated on the EM712 system at 13:45 on August 10 and data were logged intermittently to this survey until 17:10 on August 13, with several interruptions due to technical problems. Depths of areas surveyed in Kangerlussuaq Trough ranged from about 400 m at the shelf break to more than 700 m in a depression near the inner-mid shelf transition, whereas depths surveyed on inner shelf areas to the west ranged from shallower than 40 m on some shallow banks to more than 800 m in the deep trough near the coast where the mooring was deployed. Coverage in shallower areas near the front of Apuliliip Apusiia glacier and on the flank of the trough where the mooring was deployed was augmented by data collected using the EM2040 system on Erebus missions. Water-column data logging during recording of EM122 Survey SD041_b data was active from around 18:00 on July 23 to 09:48 on July 24, from 11:51 on July 25 to 01:24 on July 27, and from 14:51 to about 15:30 on August 20. Water column logging was not activated on the EM712 system during recording of Survey SD041_b data.

New surveys, named SD041_c, were started on the EM122 and EM712 systems on the approach to 3-Miippugut Fjord at 20:40 on July 29. Data collected on the EM122 system were logged to this survey until 06:00 on August 04. Data logging on the EM712 system was fairly continuous, except for times it was interrupted during station work, until early on August 01. On August 01 the EM712 system reported pinging errors and stopped pinging on several occasions. After the PC running the control software and the transceiver units had been rebooted several times to restart the system and the errors had returned, it was shutdown at 20:20 on August 01. The EM712 system was restarted once more at 04:09 on August 04 but only ran for a few minutes before reporting errors, and it was shutdown again at 04:16.

The SD041_c survey data were collected almost entirely within 3-miippugut Fjord, except for an hour of data collection along the approach and departure tracks to and from this area (Figure 2.1-1). Water depths in the fjord were up to 425 m near the mouth of the fjord but all of the inner part of the fjord was shallower than 270 m. Coverage in shallower parts and around the coasts of the fjord was augmented by data collected using the EM2040 system on Erebus missions. EM20240 data collected on an Erebus mission to the front of a glacier that terminates on the north side of the fjord were particularly valuable as the SDA was unable to reach that area due to the presence of a moraine on which the deepest part of the crest is only a few metres below sea level. No water column logging was activated on either the EM122 or EM712 system during

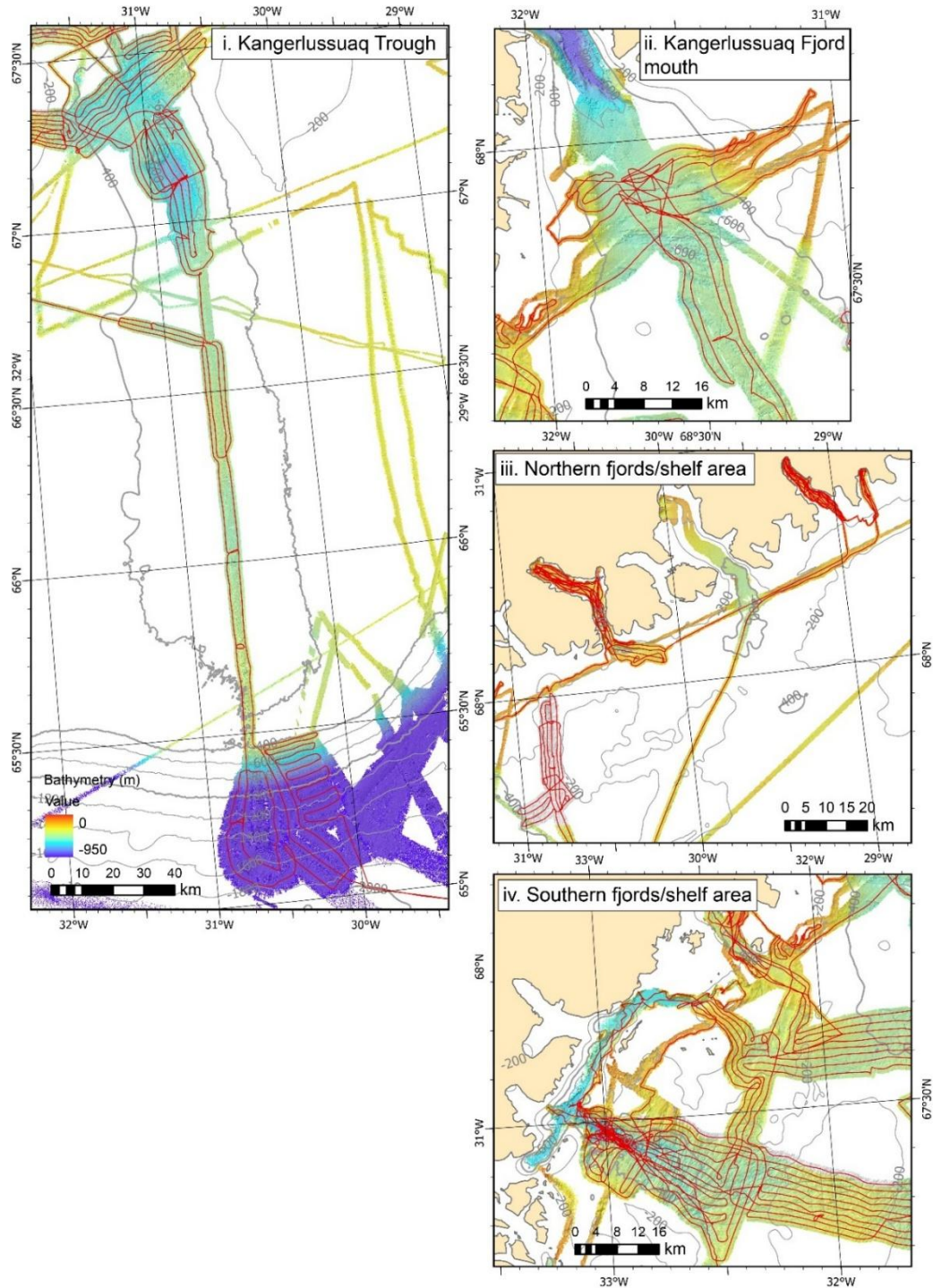


Figure 2.1-1. SD041 tracklines (red) and multibeam data coverage in the four working areas of the cruise. TOPAS sub-bottom profiles were also collected along the trackline.

recording of Survey SD041_c data. Another new survey, named SD041_d, was started on the EM122 system while transiting between 3-Miippugut and Kivioq Fjords at 06:04 on August 04. Data collected on the EM122 system were logged to this survey until 12:20 on August 08. An SD041_d survey was also created on the EM712 system, and it was started at 09:22 on August 04. However, the system again reported errors, had stopped pinging by 09:45 and no data appear to have been logged from this interval. The EM712 system was started again at 15:36 on August

07 and data were logged from it until 08:40 on August 08. The SD041_d survey data were collected almost entirely in Kivioq Fjord and the bay in front of Rosenberg Gletsjer, except for a few hours of data collection along the approach and departure tracks to and from this area (Figure 1.2). Both the fjord and the bay generally get deeper towards the inner part of the fjord or bay, with the greatest water depths being about 230 m in Kivioq Fjord and about 440 m in front of Rosenberg Gletsjer. Coverage in shallower parts and around the coasts of the fjord and the bay was augmented by data collected using the EM2040 system on Erebus missions. Water column data logging on both the EM122 and EM712 systems during recording of Survey SD041_d data was active from 15:51 to 17:25 on August 07.

Data logging on the EK80 system was started at 12:53 on 25th July and continued for most of time the SDA was in the Greenland EEZ.

2.1.1 SDA Multibeam: Equipment Information and Performance

2.1.1.1 Installation Parameters

The installation parameters were set up following the information from the Anko Maritime AS (2020) reference survey as follows:

EM122	Forward (X)	Starboard (Y)	Downward (Z)
TX transducer	21.457	-0.711	7.975
RX transducer	16.425	-0.006	8.004

Table 2.1-3. EM122 installation parameters.

EM122	Roll	Pitch	Heading
TX transducer	0.04	-0.02	0.01
RX transducer	-0.06	-0.25	0.08

Table 2.1-4. EM122 offset angle parameters.

No calibration was undertaken on either the EM122 or EM712 during the cruise due to time constraints. Positioning system used was the Seapath 320+ with a precision of 0.8 m. The last calibration of both multibeam echo sounders was undertaken on 27-28/08/2022 north of the Butt of Lewis (NW Scotland). These following angular offsets from that cruise were added into SIS in the installation parameters and used during SD041.

Table 2.1-5. EM122 angular offset from 2022 calibration.

Roll	Pitch	Heading
0.11	0.00	-0.1

The comparable parameters for the EM712 are:

Table 2.1-6. EM712 installation parameters.

EM712	Forward (X)	Starboard (Y)	Downward (Z)
TX transducer	19.926	0.263	8.093
RX transducer	18.699	0.965	8.085

Table 2.1-7. EM712 offset angle parameters.

EM712	Roll	Pitch	Heading
TX transducer	0.13	-0.32	359.83

RX transducer	-0.21	-0.13	359.79
---------------	-------	-------	--------

Table 2.1-8. EM712 angular offsets from previous calibration.

Roll	Pitch	Heading
0.08	0.25	0.15

2.1.1.2 Operational Settings

The equipment was operated using Kongsberg Information System (SIS) and Helmsman software. Table 2.1-9 gives the different parameters used during the cruise.

Table 2.1-9. Runtime parameters used during SD041.

Option	EM122 Settings	EM712 settings
Angular coverage *	AUTO or MANUAL: port: 45° - 70°/ Starboard: 45° - 70°	AUTO or MANUAL: port: 45° - 70°/ Starboard: 45° - 70°
Depth *	Force depth and range depth frequently used	Force depth and range depth frequently used
Beam spacing	HD EQDST	HD EQDST
Dual swath mode	DYNAMIC	OFF
Ping mode *	AUTO or MANUAL	AUTO or MANUAL
Pitch stabilization	ON	ON
Auto tilt	3 deg.	NA
Along direction (deg.)	NA	0
Yaw stabilization	Mode: REL. MEAN HEADING	REL. MEAN HEADING
Heading filter	MEDIUM	MEDIUM
External trigger	ON (K-SYNC)	ON (K-SYNC)
Filtering and gain	Spike Filter Strength: MEDIUM Range gate: SMALL Phase ramp: NORMAL Penetration Filter strength: STRONG Slope: ON Aeration: OFF Sector tracking: ON Interference: ON	Spike Filter Strength: STRONG Range gate: NORMAL Phase ramp: NORMAL Penetration Filter strength: STRONG Slope: ON Aeration: OFF Interference: OFF Normal incidence corr.: 10deg Use Lambert's law: ON Enable scope: ON
Absorption Coefficient	Source: Salinity Salinity (parts per thousand): 35	Salinity Salinity (parts per thousand): 35
Mammal protection */Transmit power level	-20 dB to Max	-20 dB to Max
Water Column	30 log R 20 dB offset	30 log R 30 dB offset
* Parameters regularly changed while running the EM122 or EM712		

The EM122 and EM712 were always operated in external trigger mode via K-Sync allowing multiple acoustic instruments to be operated at the same time. **Error! Reference source not found.** shows the trigger group schedule used most of the time during SD041.

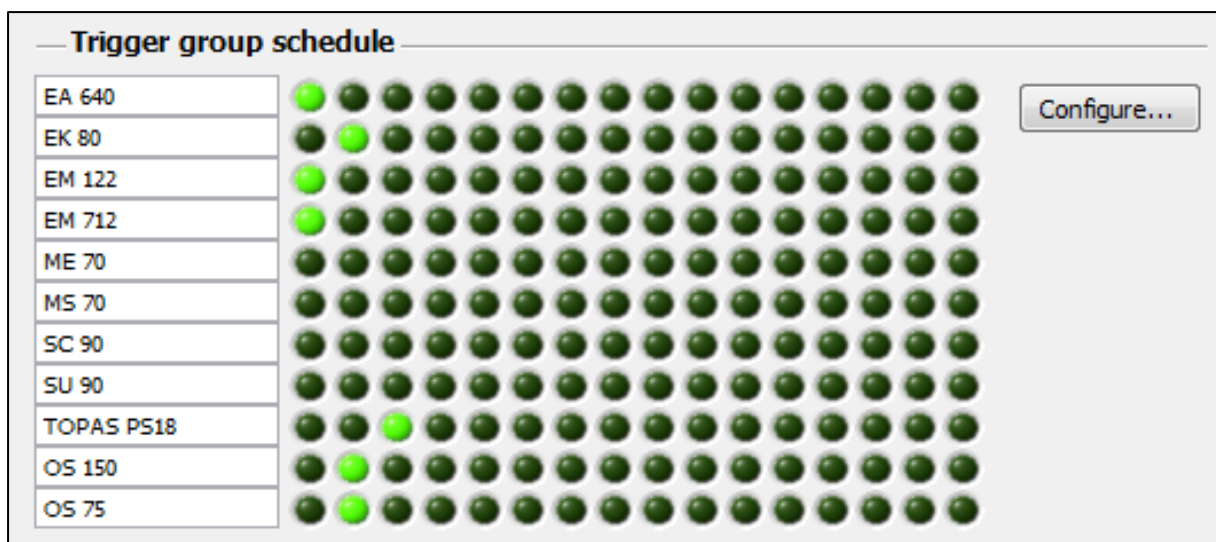


Figure 2.1-2 Trigger group schedule (on K-Sync) used during SD041.

The multibeam systems were monitored and the ‘angular coverage’, ‘depth’, ‘ping mode’ and ‘mammal protection’ parameters changed regularly to adapt to the water depth and sea conditions. In bad weather, to increase the quality of the data, the beam angles were reduced and the power set to maximum. The dual swath mode was enabled for the EM122 and set to ‘DYNAMIC’. It means that the alongship angle between the two transmit fans is determined based on vessel speed, ping rate and depth, in order to provide uniform alongship sampling of the seafloor. However, this mode was set to OFF for the EM712. Default values were used for the ‘water column’, ‘absorption coefficient’, ‘auto tilt’, and ‘along direction’ parameters.

2.1.1.3 BIST and Noise Tests

Built In Self Tests (BIST) were carried out several times during the cruise. An initial BIST test was run on 19/07/2024 for both the EM122 and the EM712. They were both successful, but it is to be noted that:

- The TX channel BIST for the EM712 was showing a warning: there was a single spike (~10k) in the impedance test and then failures across the board in the phase values (all around -25). Looking back at previous EM712 BISTs, the same single impedance spike was present right back to the HATs in 2021. Phase values in previous tests in SIS4 were all around -25 and the phase limits were -50 to 50 whereas the SIS5 limits are currently -10 to 50, hence the test failures. This was thus deemed a normal behaviour. Additional information is available within the Kongsberg EM712 Hydrographic Workstation replacement and upgrade to SIS5 acquisition software report.
- The first BIST test of the EM122 was faulty. The multibeam transceiver unit was restarted following a strict order as updated in the AME Standard Operating Procedure.

2.1.1.4 Survey Information and Processing Summary

EM122/EM712 survey periods and geographical coverage are summarised in Table 2.1-10 and Table 2.1-11 and Figure 2.1-1. SD041 tracklines (red) and multibeam data coverage in the four working areas of the cruise. TOPAS sub-bottom profiles were also collected along the trackline below. There were breaks in the logging of multibeam data between the timeframes listed due to the vessel being stationary (e.g., during scientific deployments, vessel hove to), or for periods where data quality was deemed too poor to keep. Additional details on these periods

can be found in the dedicated multibeam event log. Files consist of a maximum of one hour of data.

Table 2.1-10. EM122 surveys and survey periods.

Survey name	Start time (UTC)	End time (UTC)	No. of files	Description
SD041_a	NA	NA	0	Transit from UK up to Icelandic EEZ
SD041_b	23/07/2024 14:03:56	25/08/2024 22:08:39	504	Greenland EEZ, continental shelf to mooring site, Kangerlussuaq Trough
SD041_c	29/07/2024 20:40:12	04/08/2024 06:00:38	101	3-miippugut Fjord
SD041_d	04/08/2024 06:02:49	08/08/2024 12:20:36	89	Transit from 3-miippugut Fjord to Kivioq Fjord, Kivioq Fjord and bay in front of Rosenborg Gletsjer

Table 2.1-11. EM712 surveys and survey periods.

Survey name	Start time (UTC)	End time (UTC)	No. of files	Description
SD041_a	NA	NA	0	Transit from UK up to Icelandic EEZ
SD041_b	28/07/2024 16:03:51	13/08/2024 16:55:31	126	Greenland EEZ, continental shelf to mooring site, Kangerlussuaq Trough
SD041_c	29/07/2024 20:40:06	04/08/2024 09:39:54	93	3-miippugut Fjord
SD041_d	07/08/2024 16:06:56	08/08/2024 08:56:36	23	Transit from 3-Miippugut Fjord to Kivioq fjord, Kivioq Fjord and bay in front of Rosenborg Gletcher

Only EM122 multibeam data were processed during the cruise. Table 2.1-12 provides the number of processed files in each multibeam survey.

Table 2.1-12. EM122 processed data summary.

Survey name	No. of files	No. of processed files	Description
SD041_b	504	184	Partially processed: File 0000 to 0189 and from 0203 to 0219 processed.
SD041_c	101	101	Fully processed
SD041_d	89	89	Fully processed

2.1.1.5 Multibeam Data Processing and File Structure

Raw data were automatically written to the local data drive (D:/sisdata/raw/'survey name') on the EM122 and EM712 acquisition machines on SDA. These data were synchronised using "rsync" every 10 minutes to the SDA Storage Area Network and were symbolically hard-linked to the following paths:

/data/cruise/sda/current/system/multibeam_kongsberg_em122/acquisition/raw/'survey name'
/data/cruise/sda/current/system/multibeam_kongsberg_em712/acquisition/raw/'survey name'

Data were processed with MB System v5.7.8 using workstation sdl-ws-v1.

Data cleaning was done manually using the `mbedit` graphical interface. This allowed the users to manually flag data in either a ping-by-ping view or as a waterfall view where multiple pings can

be viewed together. Detailed editing was done using the ping-by-ping view for each hour file followed by a quick look using the waterfall view to check for any erroneous depth values missed.

A common file structure was created to hold all the MB-System data located under:

```
/data/cruise/sda/current/work/multibeam_em122/processing/'survey_name'
```

The 'survey_name' directory holds all the copied mb59 raw files, the edits and the processed mb59 files, plus symbolic links to the original raw .all files. A single folder one level up (e.g., .../multibeam_em122/grd/) holds all the gridded outputs. An identical structure exists for the EM712.

2.1.1.6 Observations, Issues, and Recommendations

EM712 “ping status is faulty” error

On several occasions during the cruise, the EM712 had to be restarted after a faulty ping error. The issue became more apparent during the cruise. While it first appeared only every 72 hours, it happened several times a day while in 3-miippugut fjord. The only solution we had found to this issue was to restart both the computer and processing unit. Kongsberg has been contacted regarding this issue.

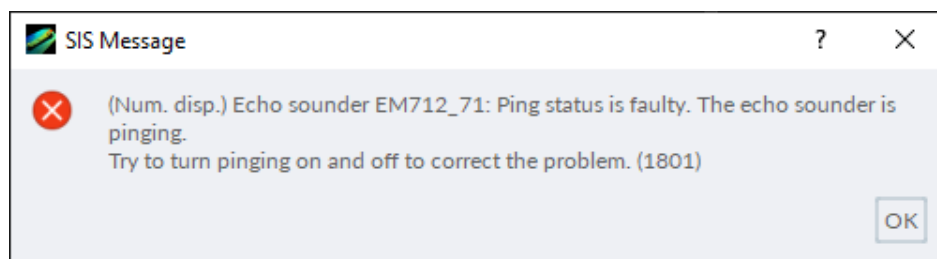


Figure 2.1-3. Screenshot of EM712 faulty ping error.

It should be noted that the RVDAS messages were not always picked up by RVDAS during the cruise. At the beginning of the cruise, the message ID was not set up correctly. This has been rectified from 23/07/2024 with the KODPT message ID. It was also noticed that after one of the restarts on 01/08/2024, the depth from the EM712 was not picked up at all; this was probably due to a wrong IP address of the EM712 computer (this is unconfirmed). At restart, the messages were picked up again.

EM122 Time Issue 09-10/08/2024

On 10 August at 09:39 UTC, the two GNSS systems (Seapath 1 and Seapath 2) were rebooted unexpectedly by the bridge. The EM122 system crashed as it had lost both location and time information. While the location was back after the first EM122 reboot, the Seapath drop out led to several time issues which unfortunately were not picked up right away. At the time of the first restart, from ~10:00 to 15:34 UTC, the date/time set in the PU was one day and several hours before the expected date/time. Files number 170 to 175 from survey SD041_b thus show approximately 31-hour difference from the real UTC date time. At 15:34 UTC on 10.08.2024, the time was set right after a restart of the computer, but the date of the PU was still set one day early: 09.08.2024 instead of 10.08.2024. Files 176 (file 175 does not exist) to 202 of survey SD041_b are thus affected by a 24-hour difference between their time stamps and the UTC date/time. The issue was fixed on 11.08.2024 at 20:46 UTC. Table 2.1-13 summarises the time issues.

Because of this issue, we have several datasets from different locations collected at the same time. This was not handled very well by MB-system, and files 170 to 202 from survey SD041_b had to be pre-processed separately (in folder named SD041_b_170-202).

2.1.1.7 Recommendations

It is recommended to check the EM712 crash issue with Kongsberg. The crash seemed to happen only when the EM712 was run through K-Sync. A finer tuning of K-Sync might be necessary for the smooth running of the EM712.

Numerical display ▼	
N 67.74327	North DD.DD
W 32.22369	East DD.DD
---	Head used
3.57	Ping interval
0.09	Roll
0.16	Heave
0.10	Speed kn
2024 08 11	Ext. Date
20:12:33	Ext. Time
2024 08 10	PU Date
20:12:32	PU Time
86400997	PU - ZDA
962	PU - POS
355.53	Depth
MEDIUM	Mode
HD EQDST	Beam sp.
432/432	Beams
60/60	Cover. (deg.)
626/617	Cover. (m)
1446.90	SV Profile
1446.90	SV Used
1446.6	SV sensor
0.28	Ping Hz
30843	Pingno.
---	Det. mode
On	PPS
0.00	Height
N 67.74327	North DD.DD
-20.00	TX pow.
1446.6	SV sensor
0.00	Tide
0.00	Geo. und.
0.00	Depth Sens.
0.16	Yaw stab.
0.05	AttVel downw
☐ Satellites	

Table 2.1-13. EM122 time issues that occurred during SD041.

File number	Time stamp of the files	Real date/time (UTC)	Time difference
170	2024/08/09 03:17:30	2024/08/10 ~10:00	~ 31hours
171	2024/08/09 04:17:30	2024/08/10 ~11:00	
172	2024/08/09 05:17:30	2024/08/10 ~12:00	
173	2024/08/09 06:17:30	2024/08/10 ~13:00	
174	2024/08/09 07:17:30	2024/08/10 ~14:00	
175	Does not exist		24 hours
176	2024/08/09 15:34:27	2024/08/10 15:34:27	
177	2024/08/09 16:34:27	2024/08/10 16:34:27	
178	2024/08/09 17:34:28	2024/08/10 17:34:28	
179 - 201	...	...	
202	2024/08/10 19:39:13	2024/08/11 19:39:13	

2.1.2 Workboat *Erebus* Multibeam Surveys

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EM2040 survey periods and geographical areas are summarised in Table 2.1-14 below. There were breaks in the logging of multibeam data for periods where data quality was particularly bad. Files consist of a maximum of 30 minutes of data. Note that data were collected opportunistically without a specialist always onboard.

Table 2.1-14. EM122 surveys acquired during SD041.

Survey name	Start time (UTC)	End time (UTC)	No. of files	Description
ER041_a	20/07/2024 08:18:23	03/08/2024 18:32:56	100	Includes calibration lines in Scapa Flow and sorties in 3-Miippugut Fjord
ER041_d	04/08/2024 10:40:26	21/08/2024 19:07:10	88	Includes Erebus surveys in front of Rosenborg Gletsjer and Kivioq Fjord as well as work in Fladø, Kangerlussuaq and Deception Troughs

2.1.3 Erebus Multibeam: Equipment Information and Performance

2.1.3.1 Installation Parameters

Erebus is set up with the Kongsberg EM2040 echosounder. The EM2040 equipment was operated using Kongsberg Information System (SIS) – version 4.3.2.

Table 2.1-15. Echo-sounder characteristics on workboat *Erebus*.

Model	Angle	Frequency range	Depth Range	Acquisition Software
EM2040	1°x 1°	200 – 400 kHz	0 – 1000 m	Seafloor Information System (SIS) – version 4.3.2

Prior to SD041, a survey was undertaken on 04/07/2024 by Anko AS to check the installation parameters for the EM2040. However, the installation parameters were wrongly entered to the initial parameter in SIS (on *Erebus*). The issue was discovered on 04/08/2024 and although, instructions were given to apply the changes, we discovered at the end of the cruise that these were not applied. The installation parameters used during the cruise are given in Table 2.1-16. Note that the RX transducer downward value should have been 1.086 instead of -1.086.

Table 2.1-16. EM2040 installation parameters (in metres).

EM2040	Forward (X)	Starboard (Y)	Downward (Z)
RX transducer	-0.003	6.017	-1.086
TX transducer	0.1	5.714	1.109

Table 2.1-17. EM2040 offset angle parameters as entered into SIS (on *Erebus*).

EM2040	Roll	Pitch	Heading
RX transducer	0.14	1.63	-0.01
TX transducer	0.23	1.64	-0.17

Table 2.1-18. EM2040 transducer orientation as entered into SIS (on *Erebus*).

EM2040	Orientation
--------	-------------

TX transducer	Port
RX transducer	Aft

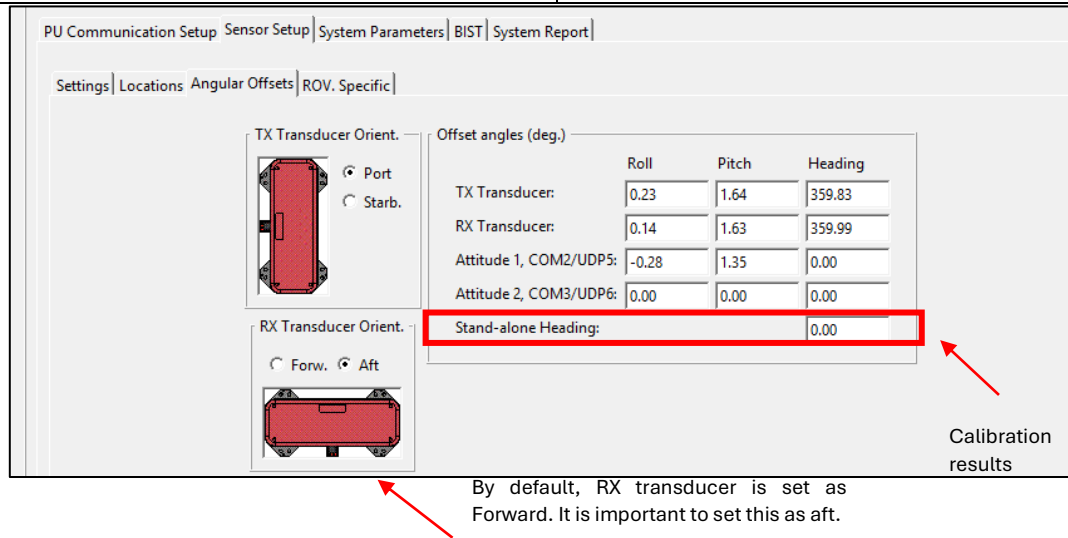


Figure 2.1-4. Installation parameters as entered into SIS (on Erebus).

2.1.3.2 BIST Tests and Calibration

A BIST test was conducted in SIS prior to the calibration and no errors were identified. A patch test was performed on 20.07.2024 to calibrate the EM2040 under the survey name: ER041_a. The calibration was undertaken over four parallel lines (see Calibration lines parameters in Table 2.1-18) in Scapa Flow. To ensure that the multibeam echosounder system was fully calibrated, the Sound Velocity Profile (SVP) was updated with new values from a CastAway CTD undertaken shortly before the calibration. Lines were run at 2 knots and 5-6 knots to check for latency, pitch, roll and heading errors; the calibration had to be undertaken in only two hours of survey due to constraints on time. The calibration results are given in Table 2.1-19.

Table 2.1-19. EM2040 angular offsets from calibration performed on SD041.

Element	Offset prior to calibration	Correction	
Roll MRU (deg)	-0.19	-0.09	
Pitch MRU (deg)	1.35	0.00	
Heading MRU (deg)	0.00	0.00	
Time (sec)	0.00	0.00	

Table 2.1-20. EM2040 calibration lines.

MB line count	Date	Time start	Lat start (decimal degrees)	Lon start (decimal degrees)	Time end	Lat end (decimal degrees)	Lon end (decimal degrees)	Speed	Comments
0002	20/07/2024	08:28:55	58.8710614	-3.0425169	08:40:14	58.8572109	-3.0386827	5 kts	Roll line
0003		08:40:14	58.8572089	-3.0386823	08:53:43	58.8464536	-3.0363516	2.5 kts	Latency line
0005		08:57:00	58.8469835	-3.0367574	09:07:13	58.86176935	-3.0399976	5 kts	Roll, heading and pitch line

0008		09:13:21	58.8547664	-3.0382028	09:18:57	58.84654325	-3.0359039	5 kts	Roll, pitch and latency line
0010		09:21:01	58.84807645	-3.0356253	09:26:16	58.85610285	-3.0375504	5 kts	Heading line

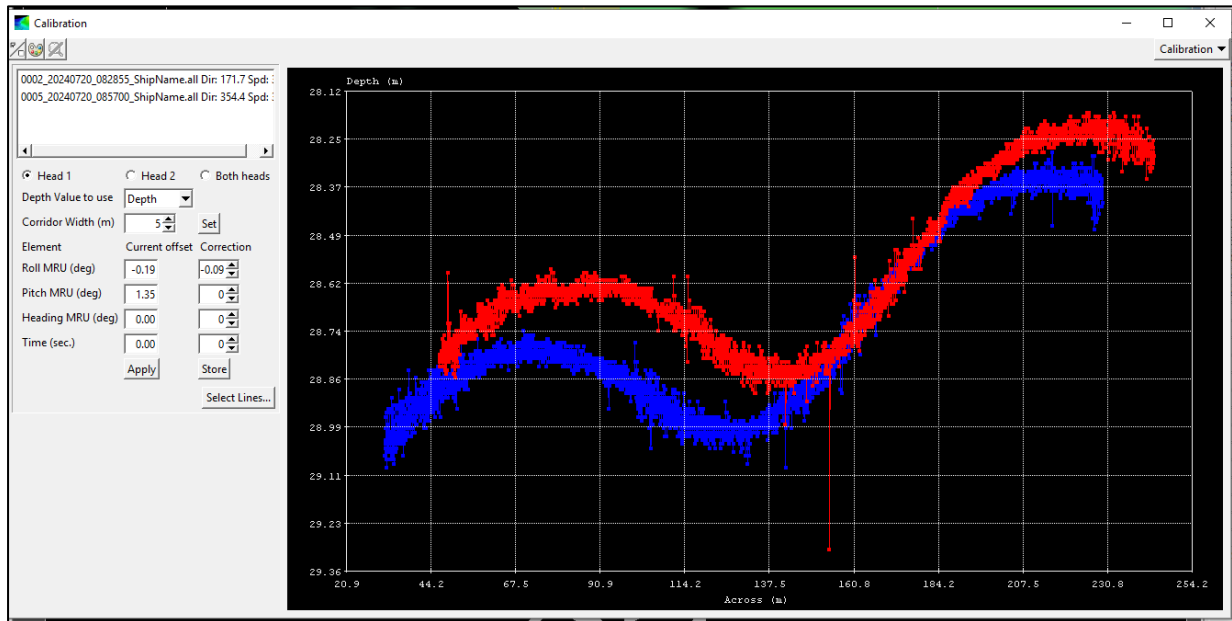


Figure 2.1-5. EM2040 roll calibration results.

A 20-cm difference was observed during the roll calibration. The two lines were surveyed in opposite direction and it was hypothesised that the difference is linked to the way Erebus behaves in and against the weather regarding the draft or the incorrect parameters entered for the sensor set up at the time of the calibration.

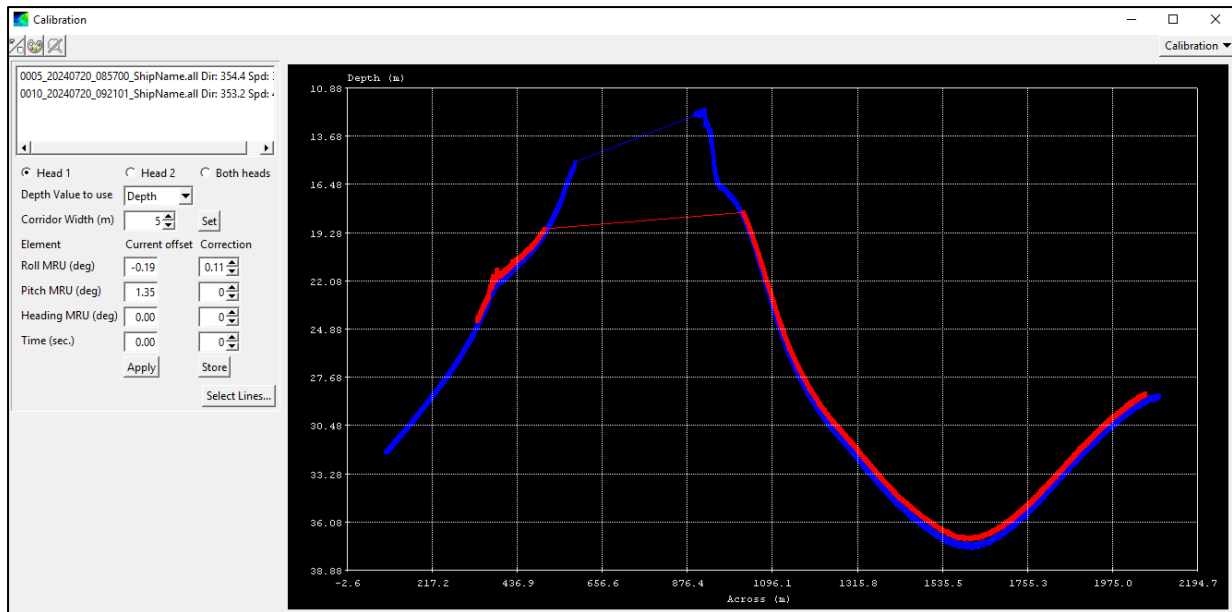


Figure 2.1-6. EM2040 pitch calibration results.

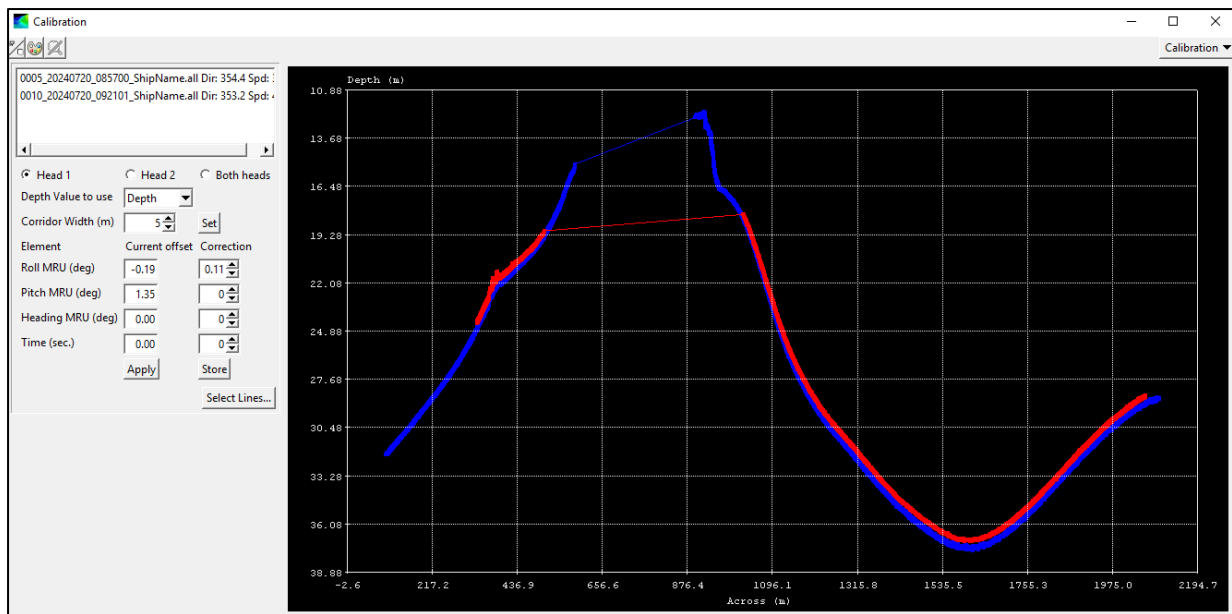


Figure 2.1-7. EM2040 heading calibration results.

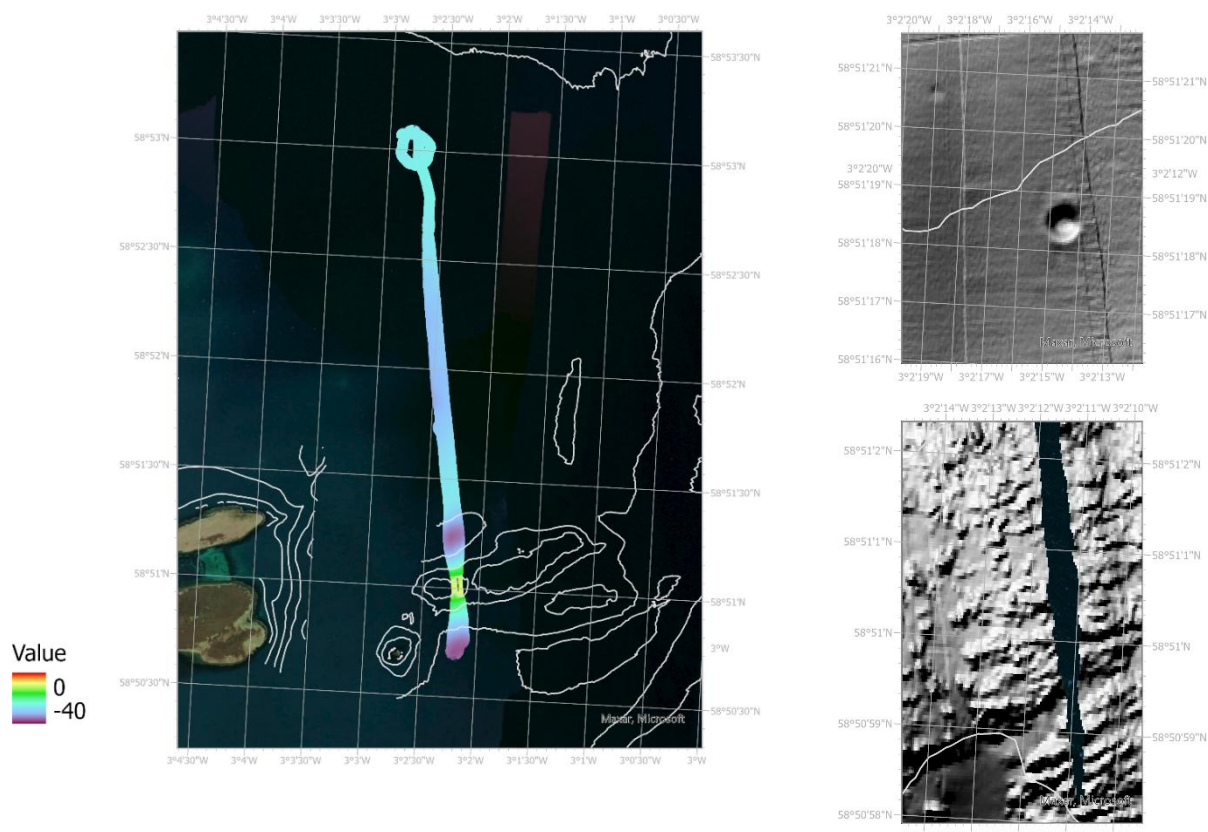


Figure 2.1-8. EM2040 calibration lines in Scapa Flow; "value" is water depth in metres.

2.1.3.3 Operational Settings

The equipment was operated using Kongsberg Information System (SIS) and Helmsman software. Table 2.1-21 shows the different parameters used during cruise SD041.

Table 2.1-21. Runtime parameters used during ER030 trial cruise and SD041 multibeam surveys.

Option	EM2040 Settings
Angular coverage *	AUTO or MANUAL: port: 70°/ Starboard: 70°
Depth *	Force depth and range depth frequently used
Angular coverage mode	AUTO
Sector mode	NORMAL
Beam spacing	HD EQDST
Ping mode	Changed depending on water depth
Pulse type	AUTO
FM disable	Yes
Detector mode	NORMAL
Pitch stabilisation	ON
Along Direction (deg.)	0.0
Yaw stabilisation	Mode: OFF Heading: 0.0 Heading filter: MEDIUM
Max. Ping Freq (Hz)	50.00
Min swath distance (m)	0.0
External trigger	OFF
3D scanning	OFF

2.1.3.4 Observations, Issues, and Recommendations

It is recommended to revise the initial parameters in SIS before the next EM2040 survey and to make sure that the initial parameters are set as per Table 2.1-22.

Table 2.1-22. Initial parameters for the EM2040 on Erebus.

	Forward (X)	Starboard (Y)	Downward (Z)
RX transducer	-0.003	6.017	1.086
TX transducer	0.1	5.714	1.109

2.2 Sub-bottom Profiler: TOPAS

Authors: Rob Larter (BAS), Alice Fremand (BAS)

Acquisition: Rob Larter (BAS), Alice Fremand (BAS), Kelly Hogan (BAS), Vicent Doñate (Stockholm University), Joe Metcalfe (BAS), Colm Ó Cofaigh (Durham University), John Howe (SAMS), Holly Jenkins (Durham University), Matthew Hunt (Durham University)

Sub-bottom profile data gives information on the seabed immediately beneath the seafloor. It was collected in using the hull-mounted Kongsberg Marine TOPAS (PS18) sub-bottom profiler. The TOPAS equipment was operated primarily using Kongsberg TOPAS version 3.3 software (very rarely version 3.2). The TOPAS sub-bottom profiler was used in conjunction with the multibeam echo sounders as an essential tool for identifying sediment core sites and was therefore used extensively during the cruise. To avoid interferences with the other acoustic instruments (ADCP, EK80, EM122 and EM712), the system was running through an external trigger managed by K-SYNC (see Figure 2.1-2 for K-sync configuration).

2.2.1 Acquisition

TOPAS transmission was first started at 16:47 UTC on 19th July 2024. The system was then stopped before entering the Icelandic EEZ at 19:58UTC on 20th July 2024 and turned back on when entering the Greenlandic waters at 10:20UTC on 23rd July. From then, the system was run continuously apart from the multiple instances where it stopped for unknown reasons but rapidly restarted by the watchkeeper.

The list of parameters used are summarised in the table below:

Table 2.2-1. List of parameters used for TOPAS data acquisition.

	Parameter	values
TRANSMITTER	Transmit mode	Normal
	Trigger mode	External
	Ping interval	Managed by K-sync with a minimum ping interval of 1s in shallow water
	Pulse form	Chirp (LFM)
	Start frequency (kHz)	2
	Stop frequency (kHz)	6
	Chirp length	10
	Output level (dB)	Between -9 and 0 depending on depth and environmental noise
	HRP stabilization	On
	Beam control	AUTO
	Transducer sound speed (m/s)	1500 m/s
RECEIVER	Delay control	Manual
	Master trig delay (ms)	Set manually depending on depth
	Delay offset (ms)	0

	Sample rate	32
	Trace length (ms)	400
	HP-filter (kHz)	1.0
	Bottom tracker	ON
PORCESSING	Bottom tracker	ON
	TVG	Enabled Offset: 0 to -35 TVG control: Manual or tracking
	Filters	Enabled Filter type: Matched Corner frequencies: Low sidelobe

Changes in the different parameters or details about when the system crashed can be found in the dedicated sub-bottom profiler TOPAS log.

2.2.2 Performance

The main problem with TOPAS was encountered on 10/08/2024. After a bridge reboot of Seapath between 09:36 and 09:49 UTC, TOPAS crashed and was not responding or pinging anymore. It has been only possible to restart TOPAS after 8 hours spent trying to fix the system. During that time, all the fuses were checked, the cables disconnected and reconnected, and the software uninstalled and reinstalled (see AME report for further information).

In addition, it is to be noted that the system stopped at more or less regular intervals (on some days every 30-60min) for no apparent reason. It was usually restarted again by rebooting the computer, mostly by an operating system restart but on a few occasions with a hard reboot of the server.

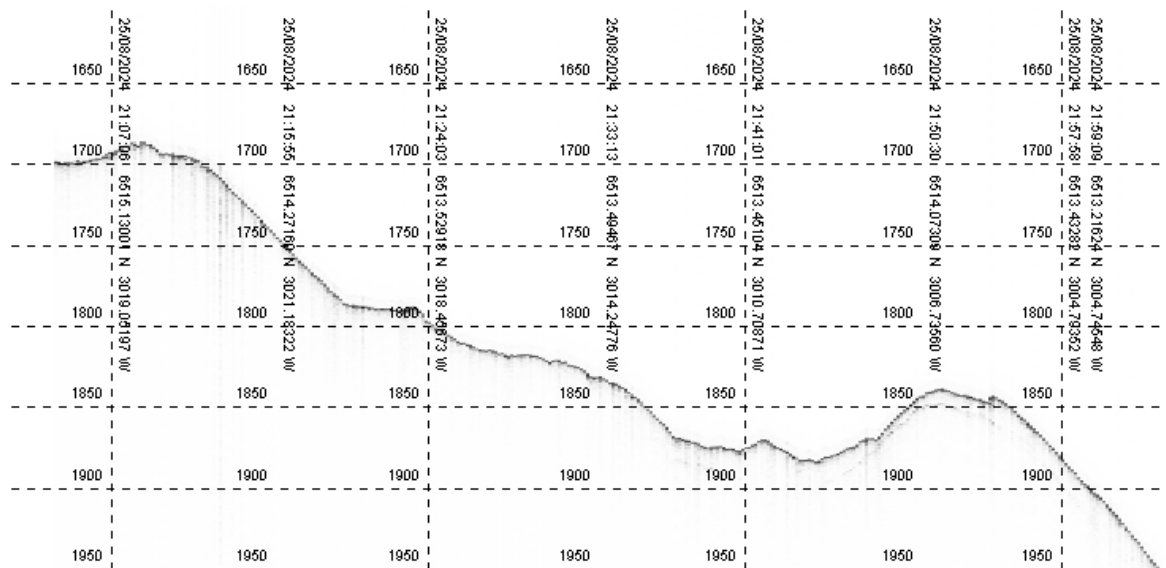


Figure 2.2-1. Example of TOPAS data collected during the cruise.

2.3 Gravity Meter

Author: Alice Fremand (BAS)

The ship's Dynamic Gravity Systems AT1M gravity meter was activated in Rosyth and data started to be recorded on the tablet PC in the Gravity Meter Room on 19th July 2024 12:23 UTC. The gravity meter worked well during the cruise but it is to be noted that the gravity data were not logged via

RVDAS part of the cruise. Indeed, the COM port 1 of the MOXA unit corresponding to the QC gravity were not in the expected format until 04th August 2024 21:22 UTC, time we resolved the issue by uninstalling the Apcupsd software which was used to monitor the UPS status. A short interruption to the RVDAS system also happened on 18/08/2024 from 11:39 to 11:52 UTC due to a Windows update trying to be uploaded.

On 29/08/2024 at 10:45 UTC, the computer tablet stopped logging without warning. It was restarted at 13:00 UTC. The log shows some errors, but this will need to be further investigated as the cause is still unknown.

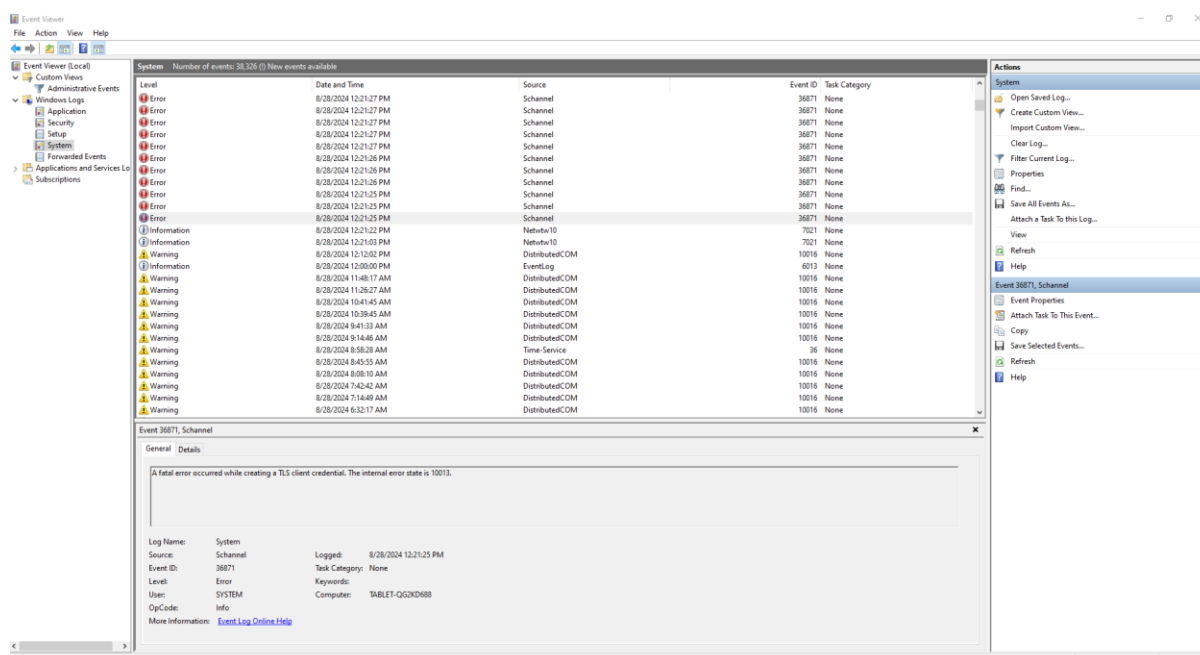


Figure 2.3-1. Log error recorded on 29/08/2024.

The last base tie was conducted in Harwich prior to the cruise on 17th June 2024 using a Lacoste and Rambert land gravity meter provided by the BAS aerogeophysics group (meter G-784). The gravity bias calculated then was of **968965.65 mGal with a drift of -0.001mGal/day**.

2.4 Marine Geology – Seafloor Sediment Coring

Author: Jerry Lloyd (Durham)

Acquisition: Jerry Lloyd (Durham), Matthew Hunt (Durham), Holly Jenkins (Durham University), Camilla Andreassen (GEUS), Freja Strandhof (GEUS), Rhiannon Jones (BAS), Katrin Wagner (Bonn), Martim Mas e Braga (St Andrews), Bryony Freer (BAS), Eloise Littey (BAS), Colm O’Cofaigh (Durham University)

2.4.1 Introduction and Aims

The sediment coring program of the KANG-GLAC project aimed to collect sedimentary material from the East Greenland continental shelf through the fjord systems for two main purposes. Firstly, the core material will help understand the timing of retreat of the Kangerlussuaq Gletsjer system across the continental shelf and back into the fjord systems. Secondly, detailed analyses of the core material will provide information on the variability in ocean conditions through time

to assess the potential role of ocean forcing on glacier dynamics, both retreat and re-advances, through the Holocene. A particular focus is on the Holocene Thermal Maximum (9-5 ka) to try to better understand the role of ocean forcing on ice-margin dynamics during a period of warmer than present conditions.

2.4.2 Sampling Strategy and Core Deployment

To address the aims of the project, three coring systems were used during cruise SD041: gravity corer (GC), piston corer (PC), and multicorer (MC). Details of GC and PC deployment sites are in Table 2.4-1 while Figure 2.4-1 shows location of core sites. Details of MC deployment sites are in

Table 2.4-2 and location of core sites shown in Figure 2.4-2 superimposed on multibeam bathymetry of the region. Cores were collected from a transect starting at the upper continental slope, through the main palaeo-Kangerlussuaq Gletsjer trough system across the outer continental shelf to the inner mouth of Kangerlussuaq Fjord. Additionally, a series of cores were collected from troughs and fjords immediately north and south of Kangerlussuaq Fjord (Figure 2.4-1).

Coring locations were identified using a combination of multibeam bathymetry and TOPAS sub-bottom profiler data. Sites interpreted to have relatively thick sediment sequences based on TOPAS sub-bottom profiler imagery were sampled using a 12-m core barrel (either GC or PC). For sites identified with potentially thinner sedimentary sequences the GC was deployed with a 6-m barrel. The MC was deployed at approximately half of the PC and GC coring sites (22 out of a total of 40 PC and GC sites). The MC was not deployed at sites interpreted as having thinner and potentially stiff or gravelly sediment sequences, nor at continental slope sites.

2.4.3 Material Collected and Initial Analyses

A total of 65 successful core deployments were made: 32 GC, 10 PC, and 22 MC deployments (see Table 2.4-1 and

Table 2.4-2). Core recovery was generally good with core lengths ranging from 0.46 m to 9.92 m (not including core shoe samples); average PC length was 8.32 m, 3.42 m for GC. Once retrieved GC and PC cores were cut into 1-m sections and passed through the Multi-Sensor Core Logger (MSCL; see section 2.5 for full details). Selected GC and PC cores (19 total) were also split onboard, photographed, and described. For MC deployments, typically 12 tubes were used and then a selection of sample tubes were sub-sampled for further analysis (see sections 2.6 for further details). For marine geology, at each MC location one tube was sliced at 1- or 2-cm resolution into bags for post-cruise analysis (benthic foraminifera and Pb²¹⁰ profiling).

During the cruise, a selection of samples from the base of GC and PC cores and surface of MC cores were processed to investigate qualitative foraminiferal assemblages. Approximately 5 ml of sediment per sample analysed was soaked in Milli-Q water to aid sediment disaggregation. Samples were then sieved through 500 µm and 63 µm sieves with the residue retained on the 63-µm sieve collected for analysis. Samples were viewed using a Leica binocular microscope and selected specimens were picked out onto cardboard slides using a fine paint brush. All surface MC samples analysed contained relatively abundant foraminiferal assemblages, abundance decreased from the open continental shelf into the glacially-proximal fjord sites. Within the fjords, foraminiferal diversity was also reduced at sites closer to tidewater glacier margins. Foraminiferal abundance and diversity varied significantly in the basal PC and GC samples, though most contained at least some foraminifera. In general, foraminiferal assemblages were

dominated by calcareous specimens, though some samples also contained significant numbers of agglutinated tests. Samples from the outer to mid-shelf also contained significant proportions of planktic foraminifera. A representative selection of foraminiferal specimens were imaged using the shipboard scanning electron microscope (SEM; see Section 2.7 for details and image examples).

2.4.4 Equipment Performance

In general, coring deployments on SD041 were very successful with good core recovery. During the early part of the cruise, the GC was deployed with either a 6-m or 12-m barrel using the core cradle from Deck 3, mid-ship, starboard side. Technical issues made deployment of the PC problematic at the start of the cruise. However, these were overcome by mid-cruise and the PC could be deployed with up to a 12-m barrel. From this point onwards, the PC was deployed with a 12-m barrel using the core cradle from Deck 3, mid-ship, starboard side. For sites identified with potentially thinner sedimentary sequences (based on TOPAS data), the GC was deployed with a 6-m barrel. This was deployed mid-ship, Deck 3, starboard side without use of the cradle.

The multicorer or MC was also deployed from mid-ship starboard side on Deck 3, usually with 12 sample tubes. In general, the MC performed well with good sediment recovery ranging from approximately 20 to 50 cm. Occasionally, one or two tubes did not sample. This was most likely due to cobbles blocking the closing mechanism. At one location the MC did not trip, potentially due to poor sediment penetration. At this site the MC was re-deployed with 4 tubes to enable increased sediment penetration and to allow tripping of the sampling mechanism. This was successful and the MC was deployed twice at this location with 4 tubes on each deployment (site SD041_046MC). Syringes and rhizons were cleaned and reused for multiple sites. Rhizons and syringes were cleaned first using milli-Q, then 5% HCl, and then rinsed with Milli-Q and left to dry. Equipment performed well and the cleaning method has previously shown reproducible results.

Table 2.4-1. Gravity and piston core sites sampled during SD041. “Shoe” is the additional sample from the core shoe and catcher in a separate core liner or bag. Mud Fjord refers to the bay or small fjord north of Kivioq Fjord between Kap Normann and Kap Rink (see <https://nunataqqi.gl/>); Fladø Trough refers to a glacially-eroded trough running NW-SE in Paattuulaajit Ikertivaat bay (near what was Fladø Ø or Fladø Island).

Core ID	Latitude °N	Longitude °E	Water depth (m)	Location	Date collected	Core recovery (m) + no. sections
SD041_002GC	67.47284	-32.98381	816	Inner shelf, south	25/07/2024	7.75 (8 sections + shoe)
SD041_003GC	67.32417	-30.90022	580	Mid shelf trough	26/07/2024	3.05 (3 sections + shoe)
SD041_005GC	67.24533	-30.80173	565	Mid shelf trough	27/07/2024	7.03 (7 sections + shoe)
SD041_008GC	67.67459	-31.3518	457	Inner shelf trough	28/07/2024	2.23 (3 sections + shoe)
SD041_009GC	67.90936	-31.64358	480	Inner shelf trough	29/07/2024	1.53 (2 sections + shoe)
SD041_010GC	67.96516	-31.69379	497	Inner shelf trough	29/07/2024	0.46 (1 section + shoe)
SD041_011GC	68.17675	-30.45852	377	Mid 3-miippugut Fjord	30/07/2024	3.6 (4 sections + shoe)

SD041_013GC	68.23822	-30.65866	182	Inner 3-miippugut Fjord	31/07/2024	3.89 (4 sections + shoe)
SD041_015GC	68.2573	-30.71504	257	Inner 3-miippugut Fjord	31/07/2024	3.66 (4 sections + shoe)
SD041_017GC	68.28493	-30.77868	256	Inner 3-miippugut Fjord	31/07/2024	1.43 (2 sections)
SD041_019GC	68.25147	-30.62129	192	Inner 3-miippugut Fjord	31/07/2024	2.75 (3 sections + shoe)
SD041_021GC	68.22269	-30.47496	300	Mid 3-miippugut Fjord	01/08/2024	7.56 (8 sections + shoe)
SD041_023GC	68.13139	-30.43263	420	Outer 3-miippugut Fjord	01/08/2024	4.3 (5 sections + shoe)
SD041_030GC	68.39616	-29.16275	226	Kivioq Fjord mid	06/08/2024	4.84 (5 sections + shoe)
SD041_031GC	68.41004	-29.17736	222	Kivioq Fjord mid	06/08/2024	4.43 (5 sections + shoe)
SD041_033GC	68.35622	-28.7848	185	Mud Fjord 1	08/08/2024	4.7 (6 sections + shoe)
SD041_037GC	67.13483	-30.66546	569	Mid shelf trough	09/08/2024	2.42 (3 sections + shoe)
SD041_039GC	67.95334	-31.61614	490	Inner shelf trough	11/08/2024	2.64 (3 sections + shoe)
SD041_044GC	67.69198	-32.05416	281	Mid Shelf, south	13/08/2024	1.91 (2 sections)
SD041_045GC	67.59266	-32.24747	412	Mid Shelf, south	14/08/2024	4.14 (5 sections + shoe)
SD041_047GC	67.43026	-32.41754	438	Mid Shelf, south	16/08/2024	3.49 (5 sections + shoe)
SD041_048GC	67.46942	-32.80804	453	Inner Shelf south	17/08/2024	0.54 (1 sections)
SD041-049GC	67.43213	-32.83702	508	Inner Shelf south	17/08/2024	3.21 (4 sections)
SD041-050GC	67.38292	-32.70343	492	Inner Shelf south	18/08/2024	4.28 (5 sections + shoe)
SD041-051GC	67.3155	-32.54951	401	Inner Shelf south	18/08/2024	1.64 (2 sections)
SD041_053GC	67.30099	-31.6397	489	Mid shelf south	20/08/2024	3.83 (5 sections + shoe)
SD041_054GC	67.29905	-31.7785	394	Mid shelf south	20/08/2024	1.52 (2 sections + shoe)
SD041_055GC	67.37101	-32.33263	457	Mid shelf south	20/08/2024	3.53 (4 sections + shoe)
SD041_058GC	67.98376	-30.79563	296	Inner Shelf North	22/08/2024	4.37 (6 sections + shoe)
SD041_062GC	66.69804	-31.08653	503	Outer Shelf	23/08/2024	3.33 4 sections + shoe)
SD041_064GC	65.25528	-30.77416	1217	Continental slope	25/08/2024	3.18 (4 sections + shoe)
SD041_065GC	65.24405	-30.7889	1274	Continental slope	25/08/2024	2.24 (3 sections)
SD041_007PC	67.32428	-30.89844	585	Mid shelf trough	27/07/2024	2.3 (3 sections)
SD041-025PC	68.25761	-30.7148	258	3-miippugut Fjord, inner	03/08/2024	8.52 (9 sections + shoe)
SD041_028PC	68.35039	-29.0466	91	Kivioq Fjord outer	05/08/2024	8.67 (9 sections + shoe)

SD041_035PC	68.36656	-28.8086	216	Mud Fjord	08/08/2024	9 (9 sections + shoe)
SD041_036PC	67.32398	-30.90032	581	Mid Shelf Trough	09/08/2024	9.61 (10 sections + shoe)
SD041_038PC	67.11949	-30.78462	734	Mid Shelf Trough	09/08/2024	9.56 (10 sections + shoe)
SD041_042PC	67.76762	-32.28144	408	Fladø Trough	12/08/2024	9.59 (10 sections + shoe)
SD041_057PC	67.5112	-33.09482	668	Inner Shelf South	21/08/2024	9.92 (10 sections + shoe)
SD041_061PC	66.9492	-30.75649	572	Outer Shelf	23/08/2024	8.4 (9 sections + shoe)
SD014_063PC	66.03411	-30.62253	494	Outer Shelf	24/08/2024	7.64 (8 sections + shoe)

Table 2.4-2. Multicore sites sampled during SD041 cruise.

Core ID	Latitude	Longitude	Water depth (m)	Location	Date collected	Core recovery
SD041-001MC	67.47399	-32.9901	824.23	Inner shelf, south	25/07/2024	26 cm
SD041-004MC	67.32533	-30.89603	576.22	Mid shelf, trough	26/07/2024	28 cm
SD041-006MC	67.24533	-30.80173	565.07	Mid shelf, trough	27/07/2024	30 cm
SD041_012MC	68.17674	-30.45852	372.87	Mid 3-miippugut	31/07/2024	40 cm
SD041_014MC	68.23822	-30.65866	180.1	Inner 3-miippugut	31/07/2024	50 cm
SD041_016MC	68.2573	-30.71505	257.55	Inner 3-miippugut	31/07/2024	40 cm
SD041_018MC	68.28493	-30.77867	256.05	Inner 3-miippugut	31/07/2024	40 cm
SD041_020MC	68.25148	-30.62129	192.58	Inner 3-miippugut	31/07/2024	40 cm
SD041_022MC	68.22332	-30.47714	300.37	Mid 3-miippugut	01/08/2024	40 cm
SD041_024MC	68.13232	-30.43315	417.64	Outer 3-miippugut	01/08/2024	40 cm
SD041_026MC	68.10732	-30.42318	426.03	Outer 3-miippugut	04/08/2024	40 cm
SD041_027MC	68.35051	-29.04719	92.92	Outer 3-miippugut	05/08/2024	44 cm
SD041_029MC	68.39496	-29.1635	227.64	Kivioq Fjord mid	06/08/2024	40 cm
SD041_032MC	68.35622	-28.7848	193.15	Mud Fjord 1	07/08/2024	40 cm
SD041_034MC	68.36722	-28.81313	215.44	Mud Fjord 2	08/08/2024	40 cm
SD041_040MC	67.95334	-31.61614	490.66	Inner shelf, trough	11/08/2024	30 cm
SD041_041MC	67.76762	-32.28143	411.93	Fladø Trough	11/08/2024	44 cm
SD041_043MC	67.85177	-32.46151	347.68	Fladø Trough inner	12/08/2024	44 cm
SD041-046MC	67.43025	-32.41754	435.97	Mid Shelf, South	16/08/2024	27 cm
SD041_052MC	67.30099	-31.6397	488.06	Mid Shelf, South	20/08/2024	28 cm
SD041_056MC	67.51129	-33.09528	667.35	Inner Shelf, South	20/08/2024	43 cm
SD041_059MC	67.1195	-30.78461	735.48	Mid Shelf, Trough	23/08/2024	35 cm
SD041_060MC	66.9492	-30.75649	570.15	Outer Shelf	23/08/2024	35 cm

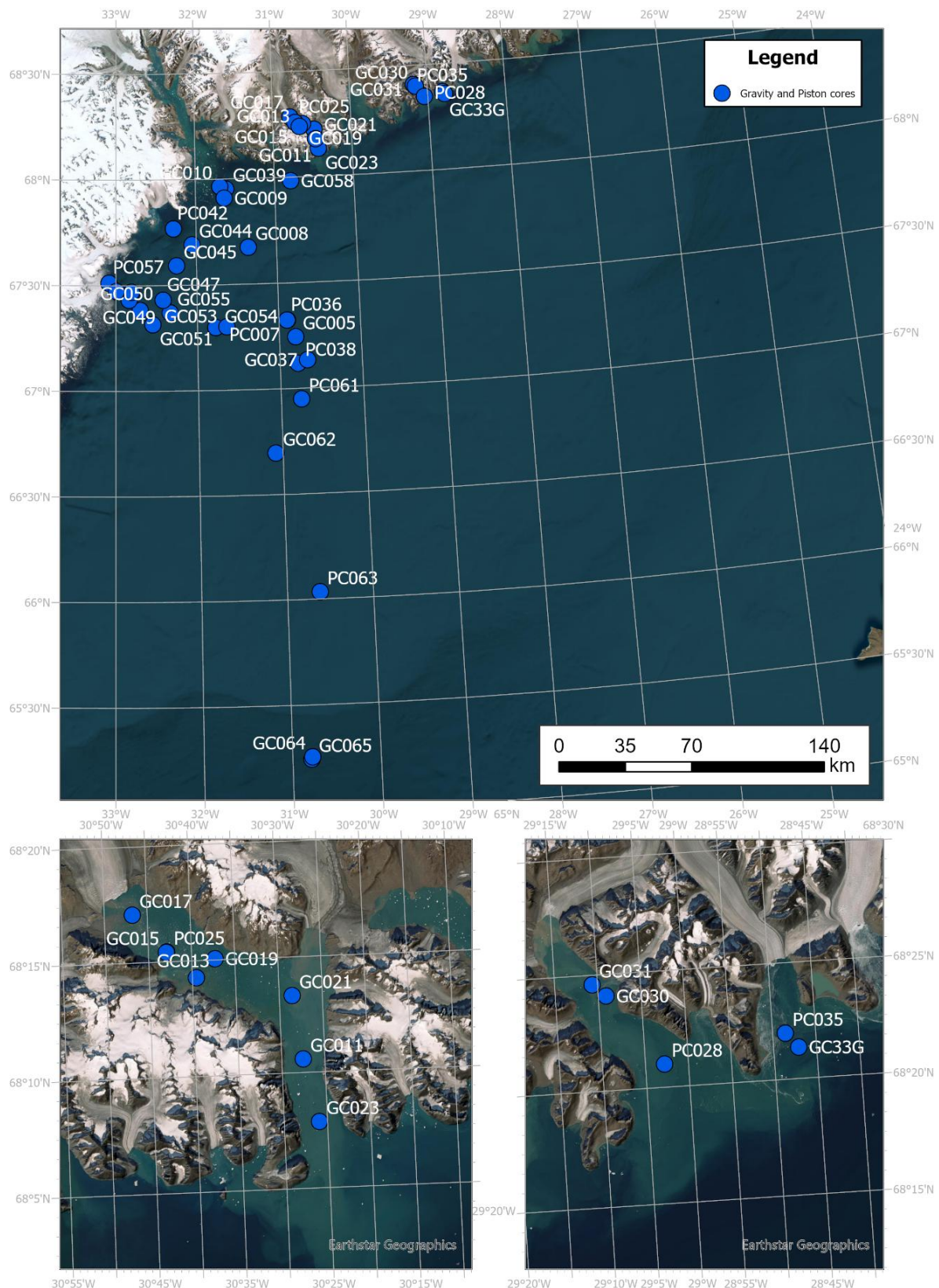


Figure 2.4-1. Map of Kangerlussuaq continental shelf showing location of gravity core (prefix GC) and piston core (prefix PC) sites. Inset of 3-miippugut and Kivioq Fjords showing location of cores taken.

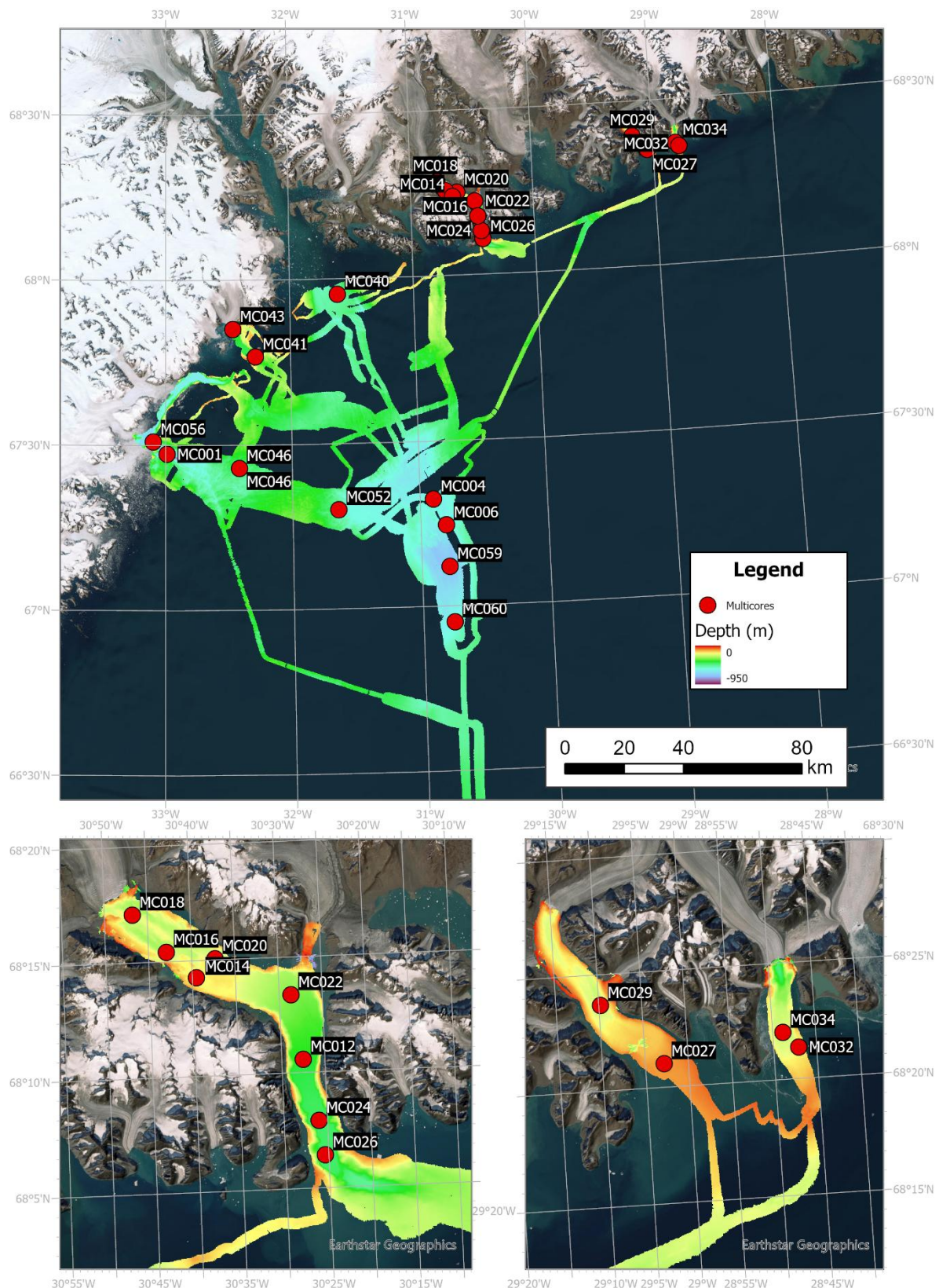


Figure 2.4-2. Map of Kangerlussuaq continental shelf showing location of multicore stations (prefix MC) underlain by the multibeam bathymetry from SD041 and previous cruises. Inset of 3-miippugut and Kivioq Fjords showing location of cores within the fjords.

2.5 Marine Geology - Multi-Sensor Core Logging

Author: Eloise Littey (BAS)

2.5.1 Introduction and Aims

The Geotek multi-sensor core logger (MSCL-S) is an automated core scanner which can be configured with a series of sensors to measure the properties of whole and split lengths of core (PC or GC type). When onboard the RRS *SDA*, the MSCL is housed in a containerised laboratory which can be temperature regulated and provides storage for up to 30 sections of core. For SD041, core sections were measured whole and three sensors: attenuated gamma density, p-wave velocity, and magnetic susceptibility were set up in sequence for analysis at 1-cm resolution. The system is entirely non-destructive allowing for the measurement of sediment physical properties from which an indication of lithology can be derived. Cores were analysed within 12-24 hours of acquisition, facilitating comparison of recovered cores from different locations, and guiding the direction of further core deployments.

2.5.2 Summary of Activities

2.5.2.1 Instrument Setup

Prior to commencing science onboard, the MSCL container was configured to maintain a constant temperature inside of 19-21°C to ensure optimal performance of the mounted sensors. The rails on the MSCL were adjusted to their widest setting to accommodate GC and PC liners with a diameter of 110 mm and the source plate was levelled to ensure that ionising radiation from the sealed source would pass directly through the widest point of the cores.

2.5.2.2 Calibration

Each sensor on the MSCL-S requires calibration with varying regularity. The Bartington magnetic susceptibility (MS) loop sensor is factory calibrated but requires zeroing and checks with a manufacturer-supplied standard at the start of every new core log. This standard is held in the centre of a section of core liner and passed directly through the centre of the MS loop. The p-wave sensors, which also measure core thickness, are also checked at the start and end of every core log. A reference core thickness piece of gravity or PC liner (as required) filled with deionised water has an expected p-wave velocity of 1476 ± 5 m/s. If this was measured to be outside the accepted error on the pre-core checks, minor adjustments were applied in processing settings by taking into account ambient temperature and the total travel time of the p-wave passing through the liner. Both MS and p-wave velocity measurements are sensitive to temperature, and a Platinum Resistance Thermometer provided ambient temperature data to correct p-wave velocity and monitor drift over the logging period.

Attenuated gamma density was calibrated for both GC and PC liners on 24.07.24, the night before the first sections were logged. A stepped aluminium piece of known diameter was mounted centrally inside a section of representative GC and PC liner and filled with deionised water, leaving no air space. This calibration section was then logged at 0.2-mm resolution and the average gamma count values recorded against the known diameter. R^2 values (i.e., fit to modelled values) exceeded 0.999 for both calibrations. Values of the resultant correlation line were input into the Geotek software and must be re-entered every time there is a change between GC or PC. The lifetime of a gamma calibration is up to 30 days, so the same calibration was used for the whole project to ensure consistency on all cores. Expected density of water is 1.026 ± 0.01 g/cc and this was monitored at the start and end of every core with the reference core thickness section to ensure that values were within error. Over the course of the cruise, GC values drifted

down to the lower end of the accepted range but were still deemed acceptable. Had they fallen outside the range, a new calibration would have been performed.

2.5.2.3 Core Scanning

During SD041, the MSCL was operated on the night shift to align with the sediment coring activity. Following core cutting and labelling, 1-m sections were brought directly into the container to allow for acclimatisation to (19-21°C), the necessary temperatures for -wave and MS sensors. Cores were scanned within 12-48 hours of collection. Every core log was bracketed by a sequence of check pieces consisting of the reference core-thickness piece, MS-check piece, and a second water filled section of liner at 17.5 ppt salinity. Quality assurance and quality control was monitored on these sections at the start and end of every core. If values at the start of a log fell outside the accepted range, adjustments could be made to the p-wave settings. If MS, Gamma density or temperature were outside of their range, core logging was stopped, adjustments made (e.g. rezero the MS), and the session restarted. If values fell outside the accepted range at the end of a log, this was noted and some cores were rerun (i.e., SD041_002GC and SD041_019GC). Over each night of core scanning, at least 10% of the total core length to be analysed was run in replicate after the end check pieces. This data may be found in the processed data folder.

2.5.2.4 Data Processing

After each core was logged in the MSCL, the raw data was preserved in a *.raw file and in a *_RAW.out file. The data was then cleaned to remove spurious points (outliers) and artefacts. This was done cautiously, as large rocks in each core could look like outlier points whereas they in fact represent a true feature of the recovered sediments. At the interface between 1 m core sections, 3-4 cm of data points were removed consistently from both the gamma density and MS data as the values dropped out of range due to the absence of sediment. Up to 10 cm of p-wave data was also removed at the end caps as the sediment thickness variations affect p-wave transmission and false velocities are recorded. P-wave was closely monitored throughout core logging to ensure that the correct part of the wave form was being measured. After logging, every waveform was checked and any data points that had measured too early or too late were removed; these could also be identified easily as the values spiked above the rest of the data. A cleaned data file *_CLEANED.out was exported. Finally, depths were edited to those written on the liners. This was a minor alteration to remove decimal places and to ensure that the data correspond with descriptive logs. The data were exported as *_EDITEDDEPTHS.out.

2.5.3 Results

Almost 200 m of core was collected over the course of the KANG-GLAC cruise (see Section 2.4). All cores were successfully scanned using the MSCL and the resultant physical property data provided a “first look” into the sediments, from cores taken close to glacier fronts to those from across the Greenland continental shelf and onto the slope. Cores typically showed a gradual increase in density with depth due to natural compaction, but peaks and troughs highlighted internal layers and changes in grain size (e.g., turbidites and sand layers). These typically correspond with both p-wave and MS curves as p-waves pass more quickly when there is less air space to impede their travel and magnetic susceptibility reflects the amount of lithic material as opposed to organic. For example, SD041_036PC (Figure 2.5-1) is a 9.61-m long PC from the mid shelf which exhibits this natural density increase with depth. However, at ~8.5 m core depth, a distinct density decrease followed more dense material at ~9.3 m is shown, with a similar feature in both the MS and p-wave velocity curves. These suggest a sudden change in sediment type to

one of less compact material resting on top of a harder surface. A similar, density decrease above a harder surface also appears in SD041_053GC (Figure 2.5-2) on the inner shelf (Figure 2.4-1).

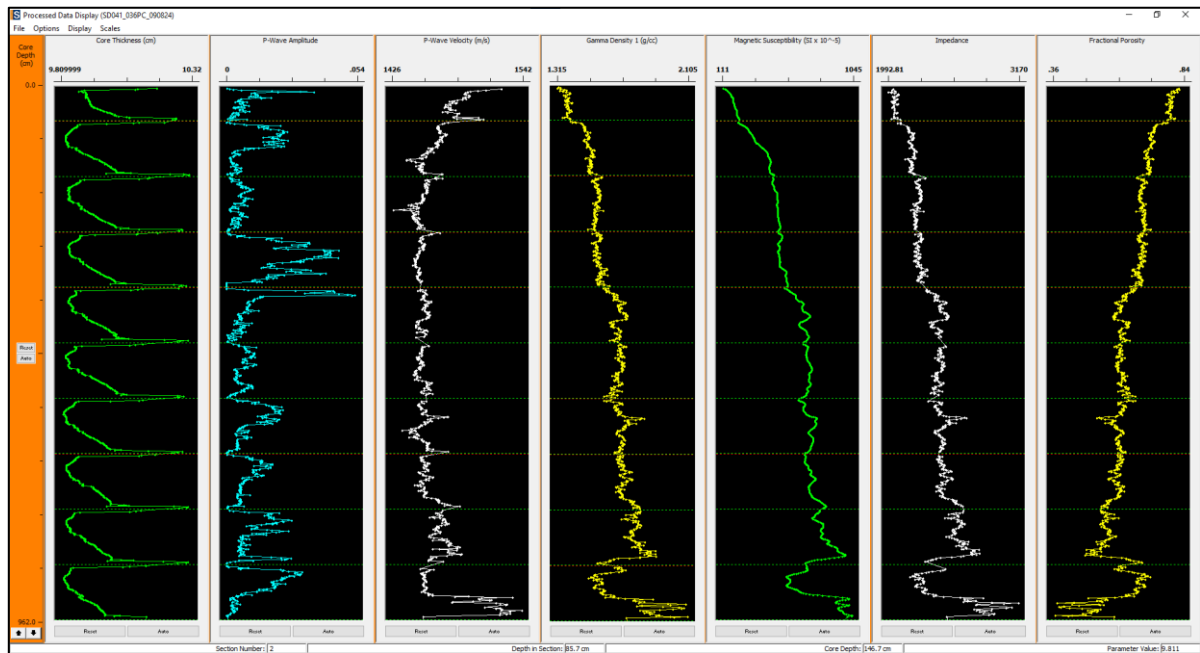


Figure 2.5-1. Screenshot of processed SD041_036PC. A change in density, MS and p-wave velocity at 8.5 m core depth indicates a change in sediment character with a harder material below 8.5 m. Panels from left to right: core thickness (cm), p-wave amplitude (p-wave transmission through the core; this is not relevant for sediment interpretation but shows that a p-wave successfully passed through the core), p-wave velocity (m/s), Gamma Density (g/cc), MS (SI x 10⁻⁵), Impedance (calculated from Gamma density and p-wave velocity), fractional porosity.

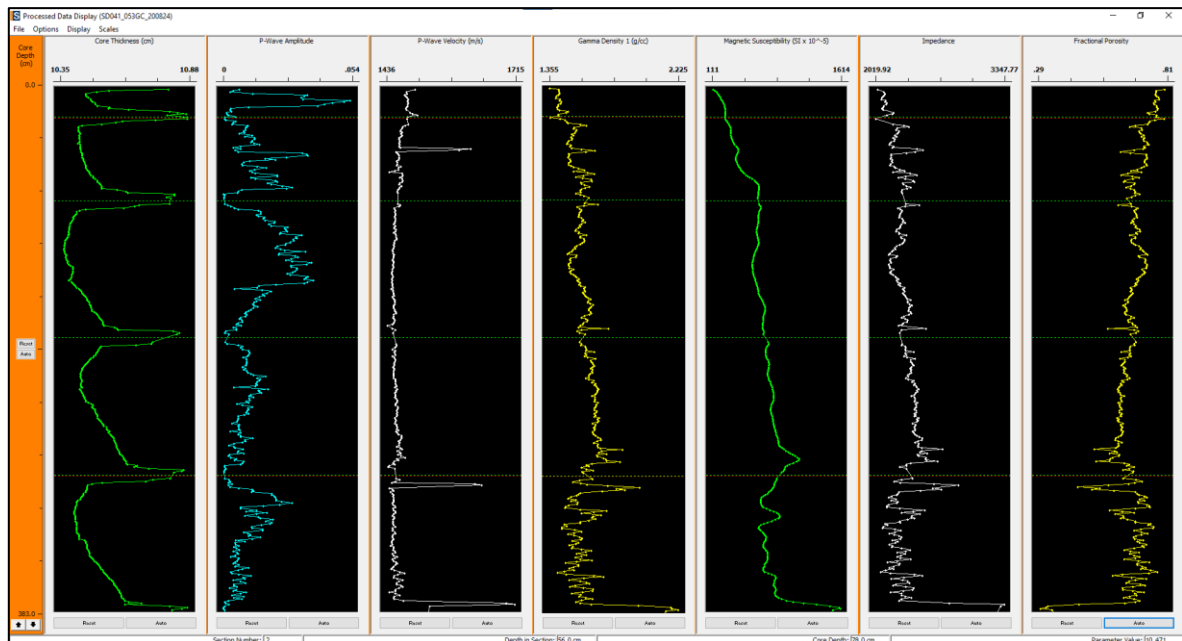


Figure 2.5-2. Screenshot of processed SD041_053GC. A change in density, MS and p-wave velocity at 2.5 m indicates a change in sediment character with a hard till layer in the bottom 10 cm of the core. Panels from left to right: core thickness (cm), p-wave amplitude (p-wave transmission through the core – this is not relevant for data interpretation but shows that a p-wave was successfully passed through the core), p-

wave velocity (m/s), gamma density (g/cc), MS ($\text{SI} \times 10^{-5}$), Impedance (calculated from gamma density and p-wave velocity), fractional porosity.

2.5.4 Equipment Performance

Core thickness and deviation datasets as recorded by the p-wave transducers consistently showed a sloped (decreasing) effect after the half-way point of each 1-m section of core. The effect of this is much stronger in cores acquired earlier in the cruise, which also have a half-way inflection point. It was determined that this artefact had resulted from a slight “twisting effect” as the endcaps of each core section dropped into the space between the rails at the MS loop and p-wave transducers. The effect was slightly reduced by raising the leg beneath the MS loop but it also reduced as the rails shifted and expanded over the course of SD041. The effect of this decreasing trend did not affect the MSCL data, but it is recommended that a solution is found for the rail gaps to try to prevent this effect in future.

In the final days of SD041, the MS data on the check pieces began to indicate drift over the course of a core log. MS at the start of the sequence was consistently 238 ± 5 ($\text{SI} \times 10^{-5}$) but would fall outside this range to ~ 231 ($\text{SI} \times 10^{-5}$). This is not enough drift to necessitate rerunning the cores. The drift was inconsistent, as it did not happen on all the cores but it was noticeably more frequent at the end of the cruise. SD041_061PC, SD041_062GC and SD041_065GC were affected; the data can be seen in the quality assurance/quality check excel document ('QAQC_check_TWICE_DAILY').

2.6 Marine Geology – Multicore Sampling

Authors: Rhiannon Jones (BAS), Katrin Wagner (Bonn)

Acquisition: Jerry Lloyd (Durham), Matthew Hunt (Durham), Holly Jenkins (Durham University), Camilla Andreassen (GEUS), Freja Strandhof (GEUS), Rhiannon Jones (BAS), Katrin Wagner (Bonn), Martim Mas e Braga (St Andrews), Bryony Freer (BAS), Eloise Littey (BAS), Colm Ó Cofaigh (Durham University)

2.6.1 Introduction and Aims

The objectives of the multicore (MC) sampling and inorganic geochemical studies during SD041 were to sample and conserve pore waters and sediments for the determination of dissolved and sedimentary concentrations of major and minor elements and element species. In the pore waters, a particular interest is in dissolved nutrients (e.g., PO_4^{3-} , NO_3^- , NH_4^+ , H_4SiO_4) and metals (e.g., Fe^{2+} , Mn^{2+} , Mg^{2+} , Ba^{2+}), as well as in dissolved Si and Si isotopes. In the sediments, bulk content of major (e.g., Al, Si, Fe, Ca, Mg) and minor (e.g., Mn, Co, Mo, Ba, Sr) elements will be investigated as part of the KANG-GLAC project. These analyses will provide insights into sediment depositional processes and transport energies, terrigenous sediment provenance from Greenland, primary productivity and nutrient availability, as well as early diagenetic processes including the benthic recycling of nutrients to the bottom waters.

2.6.2 Summary of Activities

At sea, pore water and sediment samples were taken for shore-based inorganic-geochemical analyses. Pore waters were extracted in the laboratory at room temperature from pre-drilled MC tubes using rhizon samplers (0.15- to 0.18- μm filter size) and 20 mL plastic syringes. Samples from the bottom waters close to the sediment-water interface were taken from the multicore (MC) tubes and split for:

- (i) Nutrients
- (ii) Trace metals (TM)
- (iii) Dissolved Si and Si isotope analyses

Pore-water extractions were started immediately after retrieving samples from the MC at 1-cm intervals between 0 and 10 cm core depth, 2-cm resolution between 10 and 20 cm depth, and 5-cm intervals below 20 cm core depth. After inserting the rhizons and syringes, the first extracted drop was discarded to avoid contamination and to rinse the filter. Pore waters were samples from 2-3 MC tubes simultaneously, and samples from both tubes were pooled to reach sufficient volumes for nutrient, trace metal and dissolved Si/Si isotope analyses. Pore water samples for TM and Si/Si isotope analyses were acidified with ultra-pure, concentrated Nitric acid (1 µl acid per 1 ml sample) on the same day and stored at room temperature. Pore water samples for nutrients were frozen at -20 °C immediately after sampling. All MC stations are listed in Table 2.6-1 and sampled parameters are indicated. See Figure 2.4-2 in Section 2.4 for a map of MC sampling locations. Sediment cores retrieved using the MC were also sampled for foraminiferal analyses. In total, during SD041, 17 stations were sampled for trace metal and dissolved Si/Si isotope analyses, 5 stations were sampled for nutrients, and 21 stations were sampled for the BIOPOLE project.

Parallel to pore water sampling, MC cores were sliced for sediment samples using plastic and steel devices. MC tubes (from the same cast as the pore water tubes) were sub-sampled within one hour of recovery (to deck) at 1-cm resolution down to 10 cm core depth, then at 2-cm resolution down to a maximum of 30 cm core depth for Si analyses and a maximum of 40 cm core depth for trace metals/mineral composition. At one station per sampling area, an additional core from the same cast was sliced for nutrient analyses at the same resolution as for silicon analyses. In addition, the top 10 cm (0 – 5 cm, 5 – 10 cm) were sampled for the BIOPOLE project. Sediment samples for KANG-GLAC were stored in the -20 °C freezer immediately after sampling; samples taken for BIOPOLE were stored at 4 °C.

Table 2.6-1 List of all multicore stations. Sampled parameters are indicated.

Station	Latitude [deg/min]	Longitude [deg/min]	Si, TM and solid sediment	Nutrient solid sediment	Si, TM, Nutrient pore-water	BIOPOLE
SD041_001MC	67°28.439	-32°59.405				
SD041_004MC	67°19.519	-30°53.761	X			X
SD041_006MC	67°14.719	-30°48.103	X	X		X
SD041_012MC	68°10.604	-30°27.511	X			X
SD041_014MC	68°14.293	-30°39.519				X
SD041_016MC	68°15.438	-30°42.903				X
SD041_018MC	68°17.095	-30°46.720	X	X		X
SD041_020MC	68°15.088	-30°37.277	X	X		X
SD041_022MC	68°13.399	-30°28.628				X
SD041_024MC	68°7.9392	-30°25.989				X

SD041_026MC	68°6.4392	-30°25.390	X			X
SD041_027MC	68°21.030	-29°2.8314	X	X		X
SD041_029MC	68°23.697	-29°9.8099	X			X
SD041_032MC	68°21.373	-28°47.088	X	X	X	X
SD041_034MC	68°22.033	-28°48.787	X		X	X
SD041_040MC	67°57.200	-31°36.968	X		X	
SD041_041MC	67°46.057	-32°16.885	X		X	X
SD041_043MC	67°51.106	-32°27.690	X		X	X
SD041_046MC	67°25.815	-32°25.052	X		X	X
SD041_052MC	67°18.059	-31°38.382	X		X	X
SD041_056MC	67°30.677	-33°5.7168	X		X	X
SD041_059MC	67°7.1700	-30°47.076				X
SD041_060MC	66°56.952	-30°45.389	X		X	X

2.6.3 Sediment Incubation Experiments

To determine the release of nutrients in sediments to the overlying water column over time, incubation experiments were performed at four MC stations. The experiments consisted of collecting sediment from the multicore deployments, and bottom water from the CTD rosette (5–10 m above the seafloor) at the same or nearby sites, where possible. Sediment collection corresponded with sites where full multicore biogeochemistry sampling was also taken. Around 1.5 - 2 L of bottom water was collected through an AcroPak 1000 filter and acid-cleaned tubing directly inline from the niskin into 500 mL acid-cleaned Nalgene HDPE bottles and put into a +3 incubator. Sediment was collected as the top 0 – 1 cm slice from one multicore tube and bagged and placed in the fridge. When both parameters were collected, two 500 mL bottles were filled with 50% seawater and 50% Milli-Q, and two 500 mL bottles contained just seawater. To one of each 50/50% and 100% SW, 20 – 25 mL of sediment was added and the bottles were returned to the incubator with the lids loose. Timestamp sampling was done after 1 hour, 24 h, 3 d and 6 d. Water was filtered through an 0.18 µm rhizon filter and subsampled into vials for total alkalinity, trace metals, silicon isotopes, and nutrients. From the two 500 mL bottles without sediment, a blank filtered sample was taken at each timestep. In total, each timestep had 10 subsamples, and each incubation took 40 samples. The blank and trace metal samples were sampled into acid-cleaned vials (10 % HCl).

Incubation experiments were performed at stations SD041_020, 026, 032 and 043. Samples will be analysed at BAS and University of Bonn for the parameters listed above.

2.7 Scanning Electron Microscope

Author: Joe Metcalfe (BAS)

2.7.1 Introduction and Aims

A scanning electron microscope (SEM) was used to collect backscatter electron images of foraminifera shells separated from the soft sediment cores acquired from the seafloor substrate (Table 2.4-1 and

Table 2.4-2 provide a full list). Such high magnification (up to 100 000x for photographic magnification) and high-resolution imagery assists with foraminiferal species identification, which in turn can be used as a proxy to reconstructing palaeo-environmental conditions during sediment deposition.

The Hitachi TM4000Plus tabletop microscope performed well throughout all analytical sessions, producing high-quality images and encountering no serious faults. During SD041, 10 sample stubs were imaged in total encompassing a wide range of species, many of which have not been imaged at this level of detail in the existing literature. The following sections detail methods of sample preparation and image acquisition, a summary of any issues encountered during analysis, and preliminary findings.

2.7.1.1 Sample Preparation

Sample preparation was undertaken by the coring team. Foraminifera shells were wet-sieved and washed, then air dried prior to mounting. Individual shells were then hand-picked using a fine paint brush and placed onto universal 25-mm or 12.5-mm aluminium screwed stubs topped by carbon double-sided adhesive tabs (Figure 2.7-1). Mounted stubs were then put into a desiccator for ~24 hours to rid of any excess moisture. Finally, sample stubs were looked at under a light microscope to check for any loose debris or salt.

2.7.1.2 Image Acquisition

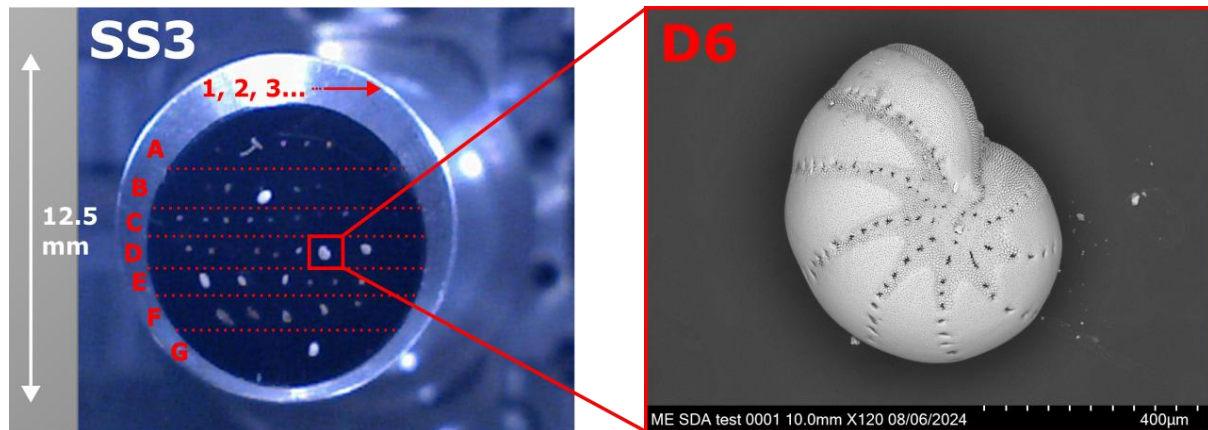
10 sample stubs were imaged across 9 imaging sessions during the cruise. Imaging was undertaken in 2–3-hour sessions and usually during periods of calm water/weather to ensure stability of the instrument and thus to minimize roll/pitch/heave effects on image quality, which was typically of a very high quality. Table 2.7-1 lists the instrument parameters selected for all imaging sessions.

Table 2.7-1. Hitachi TM4000Plus instrument settings used for SEM image collection.

Parameter	Mode/value
Detector	Backscatter electron (BSE)
Accelerating voltage	15 kV, Mode 3
Vacuum	Standard (M)
Scanning speed capture	“Slow”

Figure 2.7-1. 'SS3' mounted on a 12.5 mm aluminium stub topped with a double-sided carbon adhesive tab. The typical gridded layout and positioning of individual foraminifera is shown (lettered rows, numbered left to right). Blown up inset (right) is a captured backscattered electrons (BSE) image of 'D6' (SD041_SS3_D6), an example of an *Elphidium* sp..

Images were obtained incrementally for single foraminifera at a time and were taken in order of position on sample stubs. Individual forams were arranged into a gridded layout and given a



designated position to simplify navigation and labelling (i.e., D6; see Figure 2.7-1). Image names were provided in the format of “CRUISE ID_STUB ID_POSITION ID”, i.e., SD041_SS3_D6. For some forams which showed particularly complex structure, additional images of high magnification were obtained, in which “_zoomed” was added to the end of the image file name.

2.7.2 Equipment Performance

The SEM performed optimally throughout all imaging sessions and only encountered one minor fault during the pilot session of the cruise on 31.07.2024. Upon switching on the SEM, air evacuation of the specimen chamber is automatically initiated. The Hitashi TM software on the companion PC was started during air evacuation, which is believed to have interrupted the evacuation process, causing it to fail to reach vacuum. All instrumentation was shut down and switched back on accordingly and the start-up procedure was repeated, although this time the software was not opened until the blue LED light under ‘EVAC/AIR’ had stopped blinking, indicating that vacuum had been achieved. From thereon, the SEM performed without fault with no evidence of any hardware or software complications caused by the initial issue.

During the session on 02.08.2024, it was noted during imaging that that sample 2824 contained several clusters of cubic/rhombic crystals of generally bright reflectance under backscattered electrons (BSE). They were typically formed on and/or around individual forams and were interpreted as salt crystals likely precipitated from residual moisture during the drying process. It was hereon ensured that all foraminifera were washed using distilled or Milli-Q water and emplaced into a desiccator for at least 24 hours prior to imaging. All stubs were then checked for salt or debris under a light microscope before SEM imaging to mitigate against unintentionally introducing salt or debris into the specimen chamber. No damage or impact to instrumentation or image quality was reported after the session on 02.08.2024.

All common foraminiferal species recorded in MC surface samples examined during the cruise were imaged. In addition, several less common species that have hitherto received less attention in the literature were also imaged, revealing greater detail of morphological aspects such as aperture location and shape.

2.8 Terrestrial Geology

Author: David Roberts

Acquisition: David Roberts (Durham), Tim Lane (LJMU), Iain Rudkin (BAS), Blair Fyffe (BAS), Lev Tarasov (Memorial), Jonjo Knott (BASMU)

2.8.1 Introduction and Aims

Understanding the long-term behaviour of Kangerlussuaq Gletsjer (KG) is a primary aim of this project. The time window between deglaciation at the end of the Last Glacial Maximum and the mid Holocene being critical for understanding the ice-sheet response to increases in both atmospheric and ocean temperatures on millennial to centennial timescales. Recent (20th Century) changes to the KG margin suggest it is vulnerable to rapid mass loss (via dynamic thinning and glacier acceleration), but its longer-term behaviour before the C20th and through the Holocene are unconstrained. In particular, understanding KG response to the Holocene Thermal Maximum (HTM) (8-5 ka) is a key goal for the project, as this period is analogous to temperatures predicted for 2100 and beyond.

The key aims of the onshore terrestrial work were three-fold:

- i. Constrain ice extent (geomorphology)
- ii. Constrain rates of KG fluctuation (geochronology)
- iii. Understand drivers of KG fluctuation (ice sheet reconstruction)

To constrain patterns and rates of KG retreat the project targeted coastal to inner fjord sectors of KG fjord and investigated eight pre-determined field areas to provide horizontal and vertical (spatial) and temporal control on glacial retreat and thinning.

The fjord terrain peripheral to KG is steep and mountainous with arêtes and pyramidal peaks bordering the main fjord (1500-2000 m asl). This is challenging terrain to undertake field mapping and sample collection in a short time window and, thus, an Air Greenland helicopter was deployed from the SDA to put the terrestrial geology team onshore for the collection of rock samples and lake sediment cores. The rock samples were collected to provide surface exposure ages (e.g. Roberts et al 2024) and the lake samples to provide deglacial ages and a Holocene climate history (e.g. Bennike and Weidick, 2001).

2.8.2 Field Area

KG fjord is ~90 km long, over 1 km in depth and has peripheral mountainous terrain which extends to 2000 m a.s.l. (above sea level). The geology of the fjord is dominated by three geological terrains. On the coast, the Palaeogene North Atlantic Igneous Province forms the East Greenland Vandsfaldsdalen and Mikis formations dominated by tholeiitic, picritic and basaltic lava flows. Through the mid and upper fjords Neoarchaen - MesoArchaen intrusive and metamorphosed rocks dominate (orthogneiss). These are intruded by Palaeogene, gabbroic, syenite and quartz syenite complexes associated with the Skaergaard Formation (**Error! Reference source not found.**). The areas underlain by Neoarchaen-Mesoarchaen orthogneiss in particular are rich in quartz which provides abundant ¹⁰Be and ²⁶Al isotopes for surface exposure dating (Roberts et al. 2009; Young et al., 2011).

Eight field sites were identified prior to field work (KG 1- 8). These were designated to provide spatial (horizontal and vertical) and temporal data with which to reconstruct ice retreat and thinning through KG fjord from early deglaciation into the Holocene.

KG 8 and KG 7 cover the inner most fjord adjacent to the contemporary ice margin between 600 and 900m asl. KG5 and KG4 cover the mid fjord from 50 to 1350m asl. KG 2 and the supplementary site of KG Village cover the outer fjord between 50 and 400m asl (Figure 2.8-2)

2.8.3 Safety and Logistics

The field expedition operated under the Greenlandic *Ministry for Agriculture, Self-Sufficiency, Energy and Environment* Expedition Permit C-24-06.

Durham University chartered Air Greenland for the period Aug 9th and 22nd for this operation. An EC 155 twin-engined helicopter was deployed to the ship from Tasiilaq in SE Greenland on Aug 9th. This included the pilot (Daniel Skoglund) and two mechanics (Hans Christian Sivitsen and Jogvan Videro Olsen). Working together with the SDA heli-deck and bridge teams, the onshore field party were delivered into the field area on Aug 12, 13, 14, 15, 16, 17, 18, 20 and 21 August for 9 days of fieldwork. Aug 10th and 11th were not conducive to flying due to low cloud and fog. Aug 19th was a scheduled break for the helicopter team.

Personnel and equipment were deployed into the field between 08.00 - 09.00 hrs and retrieved between 18.00 - 20.00hrs. Provision for overnight camps was provided but not required. Two field rangers with rifles were deployed as part of the team in order to provide polar bear protection.

2.8.4 Field Site Information

In all, 52 samples were collected from six sites for surface exposure dating between altitudes of 1350 m to 50 m a.s.l. Three rock-drill cores were also collected to explore complex exposure and burial histories on two high altitude surfaces. These were supplemented by lakes cores from four sites (see Figures. 2.16-2.20; Table 2.8-1)

2.8.4.1 KG8

Description: Abraded gneissic terrain with gabbro to the west. This area was characterised geomorphologically by ‘cnoc n lochan’ terrain with well-developed roches moutonnée. This area may record Early Holocene deglaciation of the upper KG fjord. Deglacial/Holocene lakes were present and as was a clear Little Ice Age re-advance moraine with moraine-dammed lakes along its south boundary. Multiple surface exposure and lake samples taken at this site (Table 2.8-1; Figure 2.8-3, Figure 2.8-4, Figure 2.8-6). **Elevation range: 600 – 850 m a.s.l.**

2.8.4.2 KG7

Description: Steep, gneissic terrain on the northern side of upper fjord. Lower slopes mantled in Little Ice Age moraines with moraine-dammed lakes. Upper slopes (above 150 m asl) exhibited abraded gneissic terrain with lateral moraine staircases and lateral meltwater channels. This site was also chosen as a drill core site as the terrain above 800m asl was largely unaffected by scour, instead being highly fractured and weathered, potentially indicating cold-based ice. KG RD3 recovered a 39 cm drill core in banded gneiss (Figure 2.8-5). Multiple surface exposure samples were also taken (Table 2.8-1). **Elevation range: 0 – 1000 m a.s.l.**

2.8.4.3 KG5

Description: Overridden, abraded gneissic terrain on south side of fjord. Granitic, syenite and quartz syenite outcrops at higher elevations. This transect exhibited evidence for warm-based ice abrading the landscape up to 1350 m asl. Multiple surface exposure samples taken from bedrock and erratic sites (Table 2.8-1). The upper plateau surface at 1350 m asl maybe part of the *Lower Planation Surface* as mapped by Bonow et al. (2014). As such the landscape ‘surface’

maybe several million years old. Two rock drills were taken on this surface. KG RD 1 was 55 cm long and KG RD 2 was 42cm long. **Elevation range: range 0 – 1350 m a.s.l.**

2.8.4.4 KG4

Description: Heavily abraded gneissic terrain with multiple bedrock and erratic sites in the mid fjord area. This small peninsula also harbours a clear marine limit (perched boulder/wash limit) measured to ~ 50 m asl in the northwest and ~ 85m asl in the southeast. It also exhibits a clear lateral moraine between ~60 and 100m asl thought to predate the Little Ice Age. Multiple surface exposure samples were taken (Table 2.8-1). **Elevation range: 0 – 150 m a.s.l.**

2.8.4.5 KG2

Description: Gneissic and gabbroic terrain on southeast end of fjord. This peninsula protrudes northeast into the fjord and would have been overrun by warm-based ice during the LGM. It has classic 'cnoc and lochan' terrain with excellent roche moutonnée sites and perched erratics. Multiple surface exposure samples taken (Table 2.8-1). At ~ 400m asl a discrete debris assemblage rests at the break in slope at 68°08'29"N 32°04'45"W. This may be the remnant of a lateral moraine but its morphology appears more like a protalus rampart and it may be rock-glacierized. **Elevation range: 0 – 450 m a.s.l.**

2.8.4.6 KG Village

Description: Abraded gneissic and gabbroic terrain on northeast end of fjord. This area has a staircase of lakes from 55 to 110 m asl that are situated just above the marine limit at ~ 49 - 51 m asl. The two lowest lakes were cored, with Lake 1 recovering up to 80cm of sediment that may cover the complete Holocene record. Multiple surface exposure samples were also taken (Table 2.8-1). **Elevation range: 0 – 300 m a.s.l.**

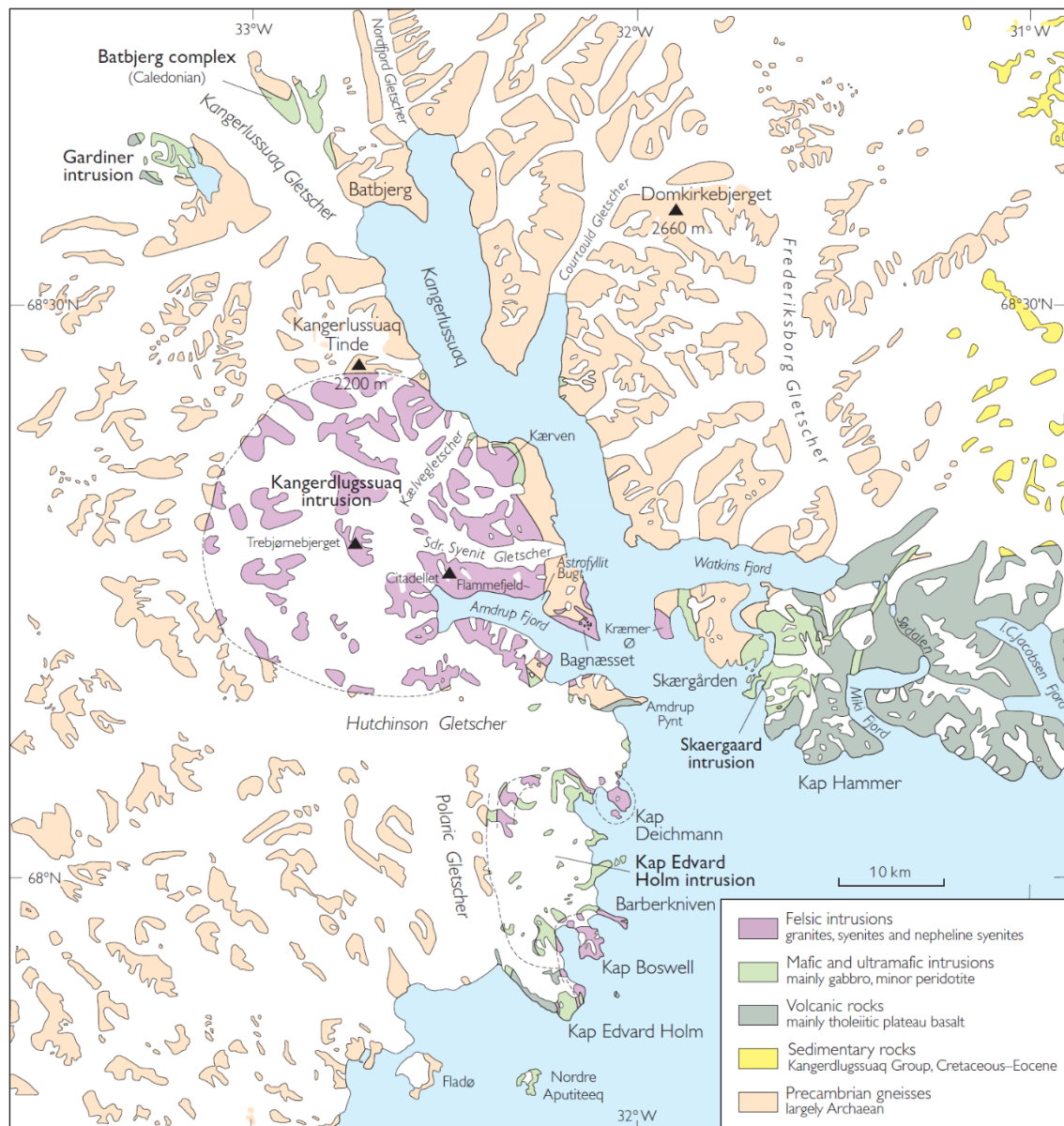


Figure 2.8-1. Geological map of the Kangerlussuaq Fjord area (from Kent Brooks, 2011).

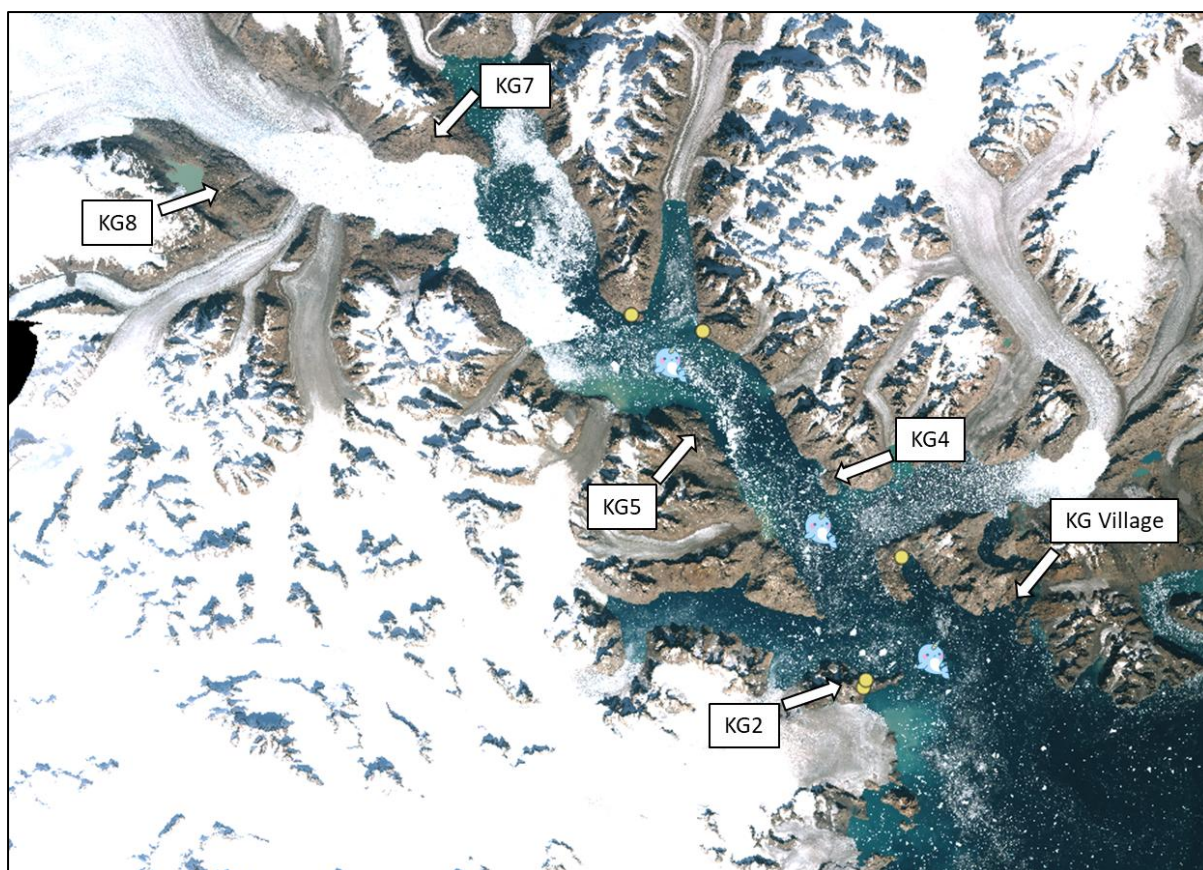


Figure 2.8-2. Overview map of the Kangerlussuaq Fjord field area showing the key fieldwork sampling areas; previous samples (Dyke et al. 2014) in yellow.



Figure 2.8-3. Examples of bedrock sampling for surface exposure ages in Kangerlussuaq Fjord.



Figure 2.8-4. Examples of erratic sampling for surface exposure ages in Kangerlussuaq Fjord.



Figure 2.8-5. Examples of bedrock rock drilling for complex burial/surface exposure ages in Kangerlussuaq Fjord.



Figure 2.8-6. Examples of lake coring in Kangerlussuaq Fjord.

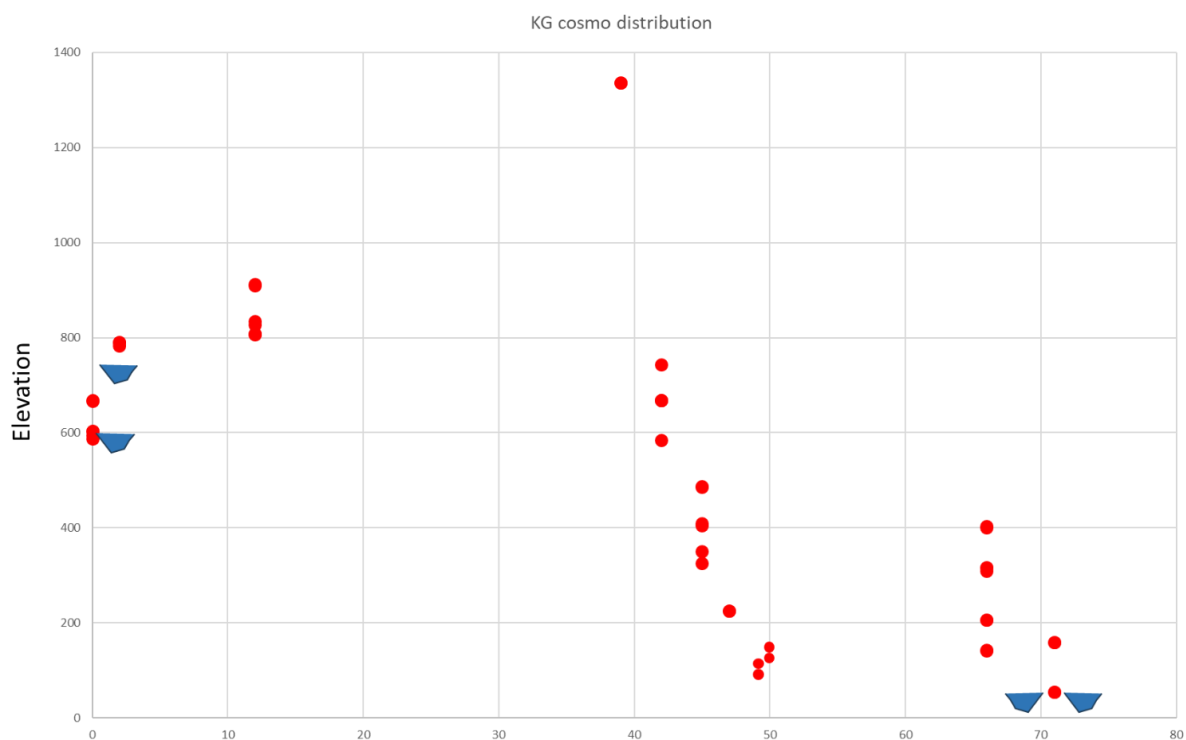


Figure 2.8-7. The spatial distribution of surface exposure age and lake samples taken between August 12 and 21st 2024 in Kangerlussuaq Fjord. X-axis is distance along KF with fjord mouth on the RHS.



Figure 2.8-8. The terrestrial geology ("onshore") field team and Air Greenland team, KANG-GLAC project 2024.

Table 2.8-1 Surface exposure age, rock drill and lake samples taken in Kangerlussuaq Fjord between August 12 and 21st 24 during cruise SD041.

Event No.	Date	Site Name	Sample Name	Sample Type	Lat. N (DDDM)	Long. W (DDDM)	Alt. (m)	Time UTC	Sample notes
SD041-187	12/08/24	KG8	KG-C1	Erratic sample	68° 34.389	33° 03.300	791	1600	
SD041-187	12/08/24	KG8	KG-C2	Erratic sample	68° 34.345	33° 03.279	783	1645	

SD041-187	12/08/24	KG8	KG-C3	Bedrock sample	68° 34.390	33° 03.294	791	1745	
SD041-187	12/08/24	KG8	KG-Lake1-Beeker1	Lake core	68° 34.4167	33° 03.800	740	1645	c.35cm
SD041-187	12/08/24	KG8	KG-Lake1-Beeker1-CoreShoe	Lake core	68° 34.4167	33° 03.800	740	1645	Bag of mud
SD041-187	12/08/24	KG8	KG-Lake1-Beeker2	Lake core	68° 34.4167	33° 03.800	740	1645	c.35cm
SD041-187	12/08/24	KG8	KG-Lake1-Beeker2-CoreShoe	Lake core	68° 34.4167	33° 03.800	740	1645	Bag of mud
SD041-193	13/08/24	KG8	KG-C4	Erratic sample	68° 36.020	33° 02.940	588	1135	
SD041-193	13/08/24	KG8	KG-C5	Erratic sample	68° 36.002	33° 02.897	595	1205	
SD041-193	13/08/24	KG8	KG-C6	Bedrock sample	68° 35.978	33° 02.645	603	1400	
SD041-193	13/08/24	KG8	KG-C7	Bedrock sample	68° 35.971	33° 02.667	604	1500	
SD041-193	13/08/24	KG8	KG-C8	Erratic sample	68° 35.797	33° 02.475	668	1400	
SD041-193	13/08/24	KG8	KG-C9	Bedrock sample	68° 35.744	33° 02.282	667	1500	
SD041-193	13/08/24	KG8	KG-Lake2-Core1	Lake core	68° 35.95	33° 02.967	610	1600	c.10cm
SD041-193	13/08/24	KG8	KG-Lake2-Core Catcher	Lake core	68° 35.95	33° 02.967	610	1600	Bag of mud
SD041-199	14/08/24	KG5	KG-C10	Erratic sample	68° 18.653	32° 13.747	225	1300	
SD041-199	14/08/24	KG5	KG-C11	Bedrock sample	68° 18.653	32° 13.747	226	1345	
SD041-199	14/08/24	KG5	KG-C12	Erratic sample	68° 19.189	32° 15.011	325	1635	
SD041-199	14/08/24	KG5	KG-C13	Bedrock sample	68° 19.189	32° 14.989	350	1700	
SD041-199	14/08/24	KG5	KG-C14	NO SAMPLE					
SD041-199	14/08/24	KG5	KG-C15	NO SAMPLE					
SD041-199	14/08/24	KG5	KG-C16	Erratic sample	68° 19.255	32° 14.829	410		
SD041-199	14/08/24	KG5	KG-C17	Bedrock sample	68° 19.270	32° 14.802	405		
SD041-199	14/08/24	KG5	KG-C18	Erratic sample	68° 19.530	32° 15.193	487		
SD041-199	14/08/24	KG5	KG-C19	Bedrock sample	68° 19.530	32° 15.193	486		
SD041-204	15/08/24	KG5	KG-C20	Bedrock sample	68° 20.561	32° 18.303	744	1245	
SD041-204	15/08/24	KG5	KG-C21	Erratic sample	68° 20.542	32° 17.984	669	1400	
SD041-204	15/08/24	KG5	KG-C22	Bedrock sample	68° 20.542	32° 17.984	669	1415	
SD041-204	15/08/24	KG5	KG-C23	Bedrock sample	68° 20.545	32° 17.933	669	1430	
SD041-204	15/08/24	KG5	KG-C24	Bedrock sample	68° 20.427	32° 17.667	584	1625	
SD041-204	15/08/24	KG5	KG-C25	NO SAMPLE					

SD041-204	15/08/24	KG5	KG-C26	Bedrock sample	68° 20.497	32° 21.288	1337	1400	
SD041-204	15/08/24	KG5	KG-C27	Bedrock sample	68° 20.482	32° 21.260	1337	1500	
SD041-204	15/08/24	KG5	KG-RD-1	Rock drill	68° 20.497	32° 21.288	1337	1400	
SD041-204	15/08/24	KG5	KG-RD-2	Rock drill	68° 20.497	32° 21.288	1337	1400	
SD041-215	16/08/24	KG2	KG-C28	Erratic sample	68° 08.524	32° 02.693	141	1330	
SD041-215	16/08/24	KG2	KG-C29	Bedrock sample	68° 08.524	32° 02.693	143	1400	
SD041-215	16/08/24	KG2	KG-C30	Erratic sample	68° 08.471	32° 03.390	206	1515	
SD041-215	16/08/24	KG2	KG-C31	Bedrock sample	68° 08.461	32° 03.400	207	1545	
SD041-215	16/08/24	KG2	KG-C32	Bedrock sample	68° 08.604	32° 04.493	403	1515	
SD041-215	16/08/24	KG2	KG-C33	Bedrock sample	68° 08.558	32° 04.482	400	1545	
SD041-215	16/08/24	KG2	KG-C34	Bedrock sample	68° 08.587	32° 04.025	317	1600	
SD041-215	16/08/24	KG2	KG-C35	Erratic sample	68° 08.587	32° 04.025	317	1630	
SD041-215	16/08/24	KG2	KG-C36	Bedrock sample	68° 08.596	32° 03.843	310	1645	
SD041-219	17/08/24	KGV	KG-C37	Erratic sample	68° 10.502	31° 46.255	55	1130	
SD041-219	17/08/24	KGV	KG-C38	Erratic sample	68° 10.497	31° 46.218	55	1200	
SD041-219	17/08/24	KGV	KG-C39	Bedrock sample	68° 10.816	31° 45.798	159	1400	
SD041-219	17/08/24	KGV	KG-C40	Erratic sample	68° 10.854	31° 45.752	159	1500	
SD041-219	17/08/24	KGV	KGV Lake 1 Russian 1	Lake core	68° 10.628	31° 46.3043	54	1200	Depth 689 - 739cm
SD041-219	17/08/24	KGV	KGV Lake 1 Beeker 1	Lake core	68° 10.628	31° 46.3043	54	1230	Base 760cm
SD041-219	17/08/24	KGV	KGV Lake 1 Beeker 2	Lake core	68° 10.628	31° 46.3043	54	1300	Base 780cm
SD041-219	17/08/24	KGV	KGV Lake 1 Beeker 2 CoreShoe	Lake core	68° 10.628	31° 46.3043	54	1300	
SD041-219	17/08/24	KGV	KGV Lake 2 Russian 1	Lake core	68° 10.4593	31° 45.9582	56	1500	Depth 830 - 880cm. WD 770cm
SD041-219	17/08/24	KGV	KGV Lake 2 Russian 2	Lake core	68° 10.4593	31° 45.9582	56	1530	Depth 830 - 880cm. WD 770cm
SD041-231	18/08/24	KG7	KG-C41	Erratic sample	68° 34.969	32° 36.798	808	1545	
SD041-231	18/08/24	KG7	KG-C42	Erratic sample	68° 34.969	32° 36.798	807	1615	
SD041-231	18/08/24	KG7	KG-C43	Bedrock sample	68° 34.964	32° 36.8 19	808	1645	

SD041-231	18/08/24	KG7	KG-C44	Bedrock sample	68° 35.104	32° 36.926	834	1700	
SD041-231	18/08/24	KG7	KG-C45	Bedrock sample	68° 35.104	32° 36.966	827	1730	
SD041-231	18/08/24	KG7	KG-C46	Bedrock sample	68° 35.370	32° 37.143	909	1805	
SD041-231	18/08/24	KG7	KG-C47	Bedrock sample	68° 35.380	32° 37.158	912	1835	
SD041-231	18/08/24	KG7	KG-RD-3	Rock drill	68° 35.100	32° 36.939	833		
SD041-250	20/08/24	KG4	KG-C48	Erratic sample	68° 16.767	32° 02.230	92	1200	
SD041-250	20/08/24	KG4	KG-C49	Erratic sample	68° 16.777	32° 02.329	104	1230	
SD041-250	20/08/24	KG4	KG-C50	Erratic sample	68° 16.904	32° 02.564	109	1200	
SD041-250	20/08/24	KG4	KG-C51	Erratic sample	68° 16.909	32° 02.566	111	1230	
SD041-250	20/08/24	KG4	KG-C52	Bedrock sample	68° 16.909	32° 02.566	111	1300	
SD041-250	20/08/24	KG4	KG-C53	Bedrock sample	68° 16.773	32° 02.340	100	1330	
SD041-250	20/08/24	KG4	KG-C54	NO SAMPLE					
SD041-250	20/08/24	KG4	KG-C55	NO SAMPLE					
SD041-250	20/08/24	KG4	KG-C56	Bedrock sample	68° 17.364	32° 03.041	58	1500	
SD041-250	20/08/24	KG4	KG-C57	Erratic sample	68° 17.354	32° 03.036	59	1530	
SD041-258	21/08/24	KG8	KG-Lake1-Beeker3-Section A	Lake core	68° 34.4167	33° 03.800	740		Depth 1051 - 1095cm. WD 1040cm
SD041-258	21/08/24	KG8	KG-Lake1-Beeker3-Section B	Lake core	68° 34.4167	33° 03.800	740		Depth 1095 - 1105cm
SD041-258	21/08/24	KG8	KG-Lake1-Beeker4-Section A	Lake core	68° 34.4167	33° 03.800	740		Depth 1085 - 1128cm. WD 1060cm
SD041-258	21/08/24	KG8	KG-Lake1-Beeker4-Section B	Lake core	68° 34.4167	33° 03.800	740		Depth 1128 - 1138cm
SD041-258	21/08/24	KG8	KG-Lake1-Russian1	Lake core	68° 34.4167	33° 03.800	740		Depth 1010 - 1060cm. WD 1000cm
SD041-258	21/08/24	KG8	KG-Lake1-Russian2	Lake core	68° 34.4167	33° 03.800	740		Depth 1055 - 1105cm. WD 1040cm
SD041-258	21/08/24	KG8	KG-Lake1-Russian3	Lake core	68° 34.4167	33° 03.800	740		Depth 1030 - 1080cm. WD 1010cm

3 ACTIVITY REPORT: OCEAN MEASUREMENTS AND SAMPLING

3.1 Conductivity-Temperature Depth Profiles

Author: Povl Abrahamsen (BAS), Martim Mas e Braga (BAS)

A Conductivity-Temperature-Depth (CTD) unit was deployed attached to a Rosette carrying 24 x 24L Niskin bottles. The CTD unit (Sea-Bird SBE911plus) was equipped with the following sensors: one pressure sensor, two temperature sensors (plus an SBE35 Deep Ocean Standard Thermometer, see below), two conductivity sensors, two submersible pumps, two dissolved oxygen sensors, one transmissometer, two fluorometers (chlorophyll-a and coloured-dissolved organic matter, CDOM), one altimeter, one backscatter sensor, and one PAR sensor. The CDOM, backscatter, and photosynthetically active radiation (PAR) sensors were mounted on the vane of the rosette. Finally, the rosette held two lowered acoustic Doppler current profilers (L-ADCP), which have their own chapter in this report (see Section 3.2). For details on each instrument, please see the AME and data management reports. In total, there were 90 CTD casts during the cruise, including 4 test casts (1, 2, 84), and 1 aborted cast due to winch problems (83), which were later fixed, leading to a shorter cast (84) prior to resuming normal activities (85–90). Figure 3.1-1 shows the distribution of all CTD deployments from SDA in Greenlandic waters (3–90).

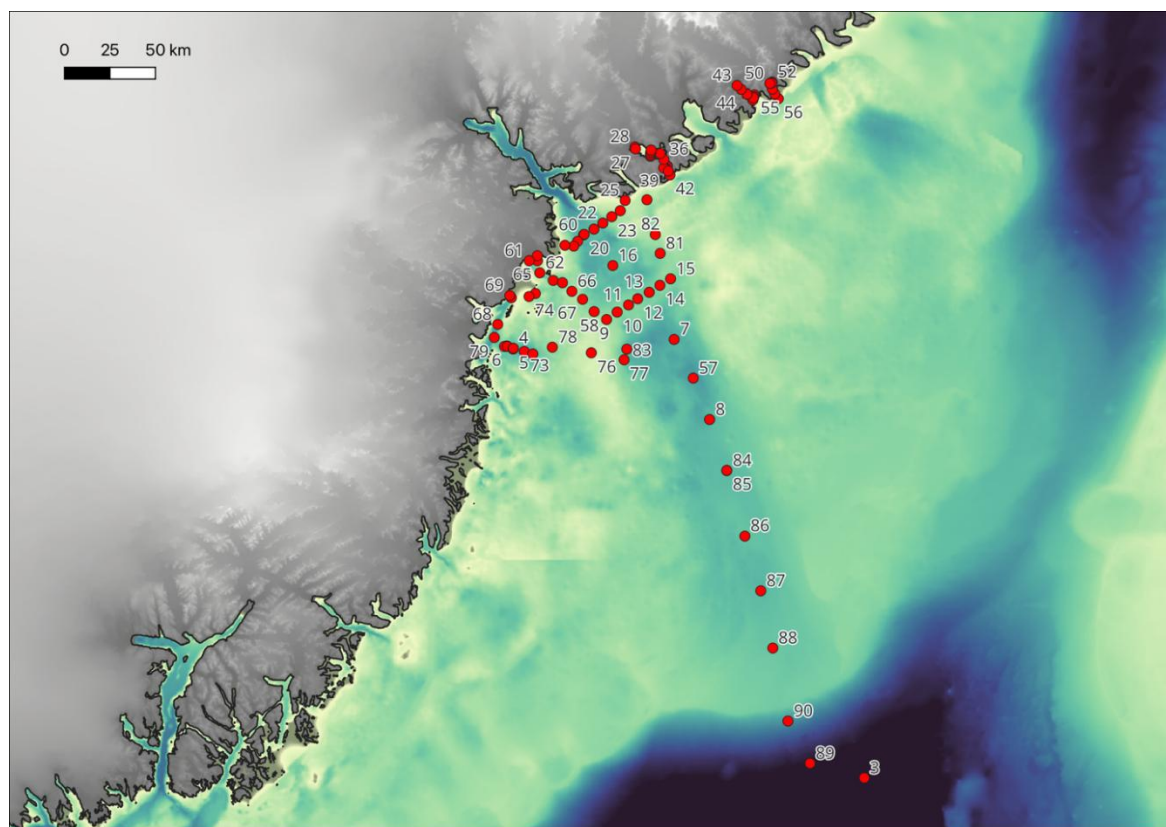


Figure 3.1-1. All CTD stations (red points, some with their numbers for reference) during the KangGlac cruise. BedMachine_v5 ice-sheet surface (grey shading) and ocean bathymetry (colours) for reference.

Table 3.1-1. Locations of CTD casts taken from SDA during SD063.

CTD cast number	Date and Time (UTC)	Latitude (dd)	Longitude (dd)	Depth EA640 (m)	Biological sampling
001	21/07/2024 11:51	61.19739	-13.65341	1656.14	
002	21/07/2024 12:55	61.20219	-13.68168	1664	
003	23/07/2024 11:04	65.02841	-30.00548	1845	
004	24/07/2024 12:15	67.46166	-32.91174	821.94	
005	24/07/2024 13:57	67.45804	-32.91567	672.95	
006	25/07/2024 02:53	67.4766	-32.98226	842.73	x
007	26/07/2024 06:18	67.32533	-30.89602	597.91	x
008	26/07/2024 10:57	66.90406	-30.71041	515.66	
009	27/07/2024 19:17	67.49823	-31.66982	393.34	
010	27/07/2024 20:41	67.52151	-31.51685	391.53	
011	27/07/2024 22:07	67.54226	-31.35442	408.11	x
012	28/07/2024 00:02	67.56093	-31.22169	432.86	
013	28/07/2024 02:06	67.57842	-31.05829	471.11	
014	28/07/2024 03:32	67.59871	-30.90369	473.7	
015	28/07/2024 05:01	67.61674	-30.75067	408.02	
016	28/07/2024 09:55	67.74784	-31.43129	471.76	x
017	28/07/2024 17:03	67.89804	-31.97485	81.82	x
018	28/07/2024 19:07	67.88416	-31.86607	213.53	
019	28/07/2024 20:13	67.90302	-31.80198	390.38	
020	28/07/2024 21:51	67.92851	-31.69977	505.98	x
021	29/07/2024 03:55	67.94249	-31.55919	472.67	
022	29/07/2024 05:49	67.96104	-31.42878	313.39	
023	29/07/2024 07:19	67.98105	-31.29536	168.06	
024	29/07/2024 08:50	67.99973	-31.16865	163.64	
025	29/07/2024 10:05	68.04259	-31.07456	103.73	x
026	29/07/2024 20:35	68.02017	-30.79649	222.19	x
027	30/07/2024 14:09	68.27519	-30.77785	256.41	
028	31/07/2024 06:25	68.28473	-30.77878	252.63	
029	31/07/2024 13:25	68.251	-30.58203	99.53	
030	31/07/2024 14:16	68.24246	-30.59063	167.19	
031	31/07/2024 15:06	68.23486	-30.60223	159.08	x
032	31/07/2024 16:41	68.22659	-30.60885	175.89	
033	31/07/2024 17:46	68.22277	-30.61183	89.71	
034	01/08/2024 03:20	68.13045	-30.43109	420.48	
035	01/08/2024 11:33	68.22332	-30.47678	297.9	x
036	01/08/2024 15:07	68.19051	-30.45027	356.43	x
037	02/08/2024 14:10	68.15106	-30.4799	101.62	
038	02/08/2024 15:16	68.15191	-30.47058	246.9	
039	02/08/2024 16:10	68.15257	-30.46126	407.47	
040	02/08/2024 17:09	68.1548	-30.43117	250.01	
041	03/08/2024 22:08	68.15603	-30.42763	141.54	
042	03/08/2024 23:45	68.10946	-30.42351	428.67	
043	05/08/2024 10:38	68.44684	-29.25635	0.02	

044	05/08/2024 12:26	68.42268	-29.21776	164.12	
045	05/08/2024 15:04	68.39229	-29.16014	205.6	
046	06/08/2024 15:03	68.36631	-29.0929	112.18	
047	06/08/2024 17:17	68.3572	-29.10714	69.41	
048	06/08/2024 17:59	68.37117	-29.08191	117.31	
049	07/08/2024 00:21	68.3793	-29.07113	103.12	
050	07/08/2024 10:31	68.41218	-28.82901	162.75	
051	07/08/2024 11:21	68.41171	-28.80226	244.71	
052	07/08/2024 12:20	68.41565	-28.79399	81.52	
053	07/08/2024 13:38	68.41217	-28.81699	411.05	
054	07/08/2024 17:23	68.38164	-28.8181	229.89	
055	07/08/2024 21:35	68.35657	-28.80429	200.69	
056	08/08/2024 05:10	68.32879	-28.77768	101.41	
057	08/08/2024 18:23	67.11928	-30.7813	750.12	
058	09/08/2024 19:42	67.54974	-31.80188	442.67	
059	10/08/2024 02:20	67.72258	-32.11478	330.17	
060	10/08/2024 14:41	67.92675	-31.70795	498.42	
061	11/08/2024 15:30	67.86336	-32.47139	308.83	
062	11/08/2024 18:04	67.79404	-32.3719	406.85	
063	11/08/2024 19:41	67.7431	-32.22389	357.43	
064	12/08/2024 13:36	67.87833	-32.35397	100.88	
065	12/08/2024 16:20	67.85423	-32.36772	216.04	
066	13/08/2024 23:39	67.67096	-32.02149	246.31	
067	14/08/2024 00:54	67.62107	-31.91002	379.41	
068	14/08/2024 17:17	67.59158	-33.04231	616.56	
069	15/08/2024 10:18	67.71721	-32.81353	190.78	
070	15/08/2024 11:26	67.70455	-32.80022	617.88	
071	17/08/2024 10:21	67.47903	-33.01674	789.54	
072	17/08/2024 15:35	67.41437	-32.68333	583.73	
073	17/08/2024 18:16	67.43508	-32.78311	581.6	
074	18/08/2024 13:12	67.69231	-32.57369	540.79	
075	18/08/2024 20:41	67.69996	-32.48582	425.03	
076	19/08/2024 10:51	67.35676	-31.95598	399.85	
077	19/08/2024 13:54	67.28708	-31.57198	551.59	
078	19/08/2024 18:08	67.42572	-32.42276	471.47	
079	20/08/2024 12:23	67.53238	-33.12005	673.27	
080	20/08/2024 17:00	67.47897	-32.98518	845.39	
081	21/08/2024 21:21	67.74982	-30.80036	354.11	
082	22/08/2024 00:24	67.84469	-30.80182	277.98	
083	22/08/2024 07:37	67.33469	-31.50717	677.37	
084	23/08/2024 09:45	66.64243	-30.6608	474.07	
085	23/08/2024 11:16	66.64243	-30.66079	482.09	
086	23/08/2024 16:08	66.31102	-30.6455	431.2	
087	24/08/2024 06:51	66.03407	-30.62283	501.97	
088	24/08/2024 10:34	65.75046	-30.653	417.26	
089	24/08/2024 19:38	65.16352	-30.56623	1499.62	

090	24/08/2024 23:11	65.38892	-30.69308	703.26	
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3.1.1 Data Acquisition and Initial Processing

All CTD data are saved in the onboard storage systems (see data management document and "Data output structure" section below) in hexadecimal (.hex) format, which is then (i) converted to engineering units in a human-readable ".cnv" format, (ii) aligned (oxygen advanced by 5 s), and (iii) corrected for the conductivity cells' thermal mass using Sea-Bird's proprietary software SBE Data Processing. All CTD sensors measured continuously during deployment at a frequency of 24 Hz, whereas the SBE35 sensor only took measurements once a bottle was closed, for calibration purposes (see below).

3.1.2 In-house Processing Algorithm

1. Run SBE batch process routine, that does the following:

- Convert from hexadecimal (deck unit output) to ".cnv" files
- Align casts
- Correct for conductivity cell's thermal mass

2. Setup paths in *CTDvarn.m* (constantly read by processing subroutines)

3. Run *ctdreadGEN.m* (converts SBE batch processing output to a matlab file)

4. Run *editctdGEN.m* (manual filtering of bad data)

5. Run *batch_ctdGEN.m* (several routines are called within):

- *deriveGEN*: derives variables, saved as *SD041_ctd_XXX.var*
- *onehzctdGEN*: gets casts in 1Hz sampling (for L-ADCP processing), saved as *SD041_ctd_XXX.1hz*
- *splitcastGEN*: divides cast into down & up casts, saved as *SD041_ctd_XXX.var.dn* and *SD041_ctd_XXX.var.up* respectively
- *fallrateGEN*: removes data for depths above already reached during downcast and when being lowered at < 0.25 m/s, overwriting the downcast file
- *gridctdGEN*: bins data to 2dbar pressure levels, saved as *SD041_ctd_XXX.2db.mat*

6. Run *ctdplotGEN* for plotting figures as a preliminary visual check

3.1.3 In-house Calibration Algorithm

batch_botGEN.m wraps the following calibration routines:

1. *makebotGEN*: reads Seabird data and creates bottle file
2. *sb35readGEN*: reads SB35 file
3. *readsalGEN*: reads salinity from excel spreadsheet and adds to mat file
4. *addsalGEN*: reads in bottle file and adds salinity data
5. *salcalGEN*: calculates offsets between CTD and salinometer salinities to correct/calibrate CTD data
6. *mergebotGEN*: merges salinity and oxygen calibration

batch_calGEN.m: reprocesses all CTD data with the respective calibrations applied.

3.1.4 CTD Calibration

For calibration, reference measurements were taken from SBE35 for temperature (measures when bottle is closed), and from bottled seawater salinometer analysis for conductivity. No independent laboratory analyses were performed for dissolved oxygen, so the calibrations obtained on the previous cruise (SD035, PICCOLO), were applied instead. Oxygen data were also compared against the casts made with the SBE19plusV2 CTD, showing good correspondence with the primary sensor. Further offsets were applied to the secondary sensor, which appeared to jump after station 55. Throughout the cruise, both before and after the secondary sensor was replaced, the secondary oxygen showed higher noise than the primary. Given the apparent drift of both secondary sensors, the data should be treated as suspect, but the primary sensor calibration was deemed to be appropriate for this cruise (Figure 3.1-2).

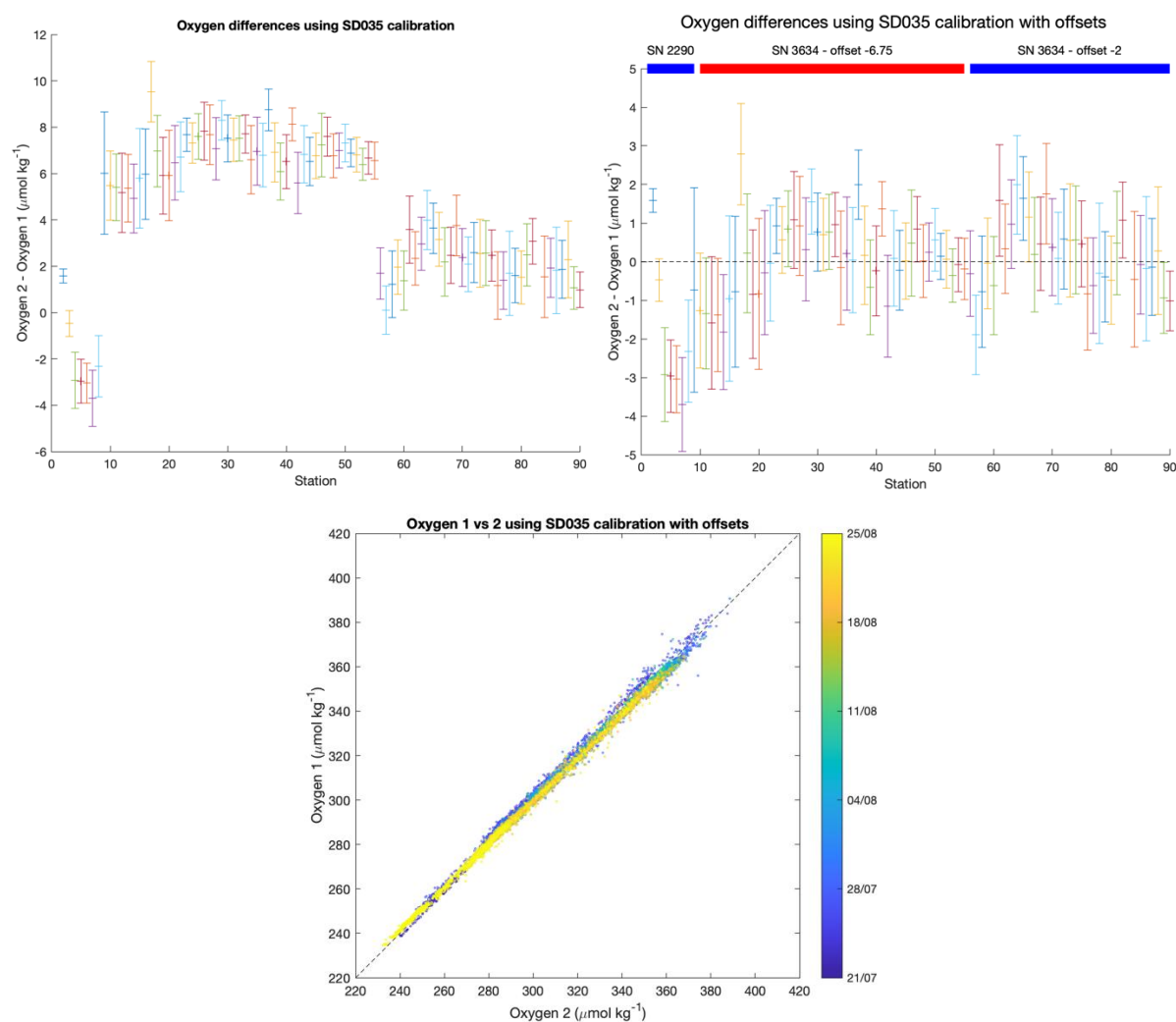


Figure 3.1-2. Differences between primary and secondary oxygen sensors with SD035 calibrations applied, and with additional offsets applied. The third panel shows the primary vs secondary sensor readings with offsets applied.

Table 3.1-2 Calibrations applied to the dissolved oxygen sensors.

Stations	Primary oxygen sensor	Secondary oxygen sensor
CTD 1-8	s/n 0245 $DO_{cal}=DO_{factory}*0.9944-7.8717$	s/n 2290 $DO_{cal}=DO_{factory}*0.9955-6.7469$
CTD 9-55		s/n 3634 $DO_{cal}=DO_{factory}*1.0702-21.787$
CTD 56-90		s/n 3634 $DO_{cal}=DO_{factory}*1.0702-17.037$

For conductivity and temperature, the offsets between the respective reference and CTD sensors were computed for depths from which salinity samples were taken. Since we opted for using a single, depth-independent offset for correcting the CTD measurements, the final offset applied to each sensor was the median along the water column, considering all stations, of all measurements after applying a filter. The option for using the median instead of the mean was to prevent results from being biased towards the larger deviations that are observed in the surface layers when strong gradients exist. The latter also partially motivated the choice of filtering the measurements. When computing the median offset, we discarded all measurements with a standard deviation above $0.0025 \text{ mS cm}^{-1}$ and $0.0025 \text{ }^{\circ}\text{C}$, and all measurements where vertical gradients exceeded $0.1 \text{ mS cm}^{-1} \text{ dbar}^{-1}$ and $0.15 \text{ }^{\circ}\text{C dbar}^{-1}$ for conductivity and temperature, respectively.

Error! Reference source not found. shows the temperature (upper panels) and conductivity (lower panels) offsets for all casts in each station (left panels), as well as the original values for each sensor (open circles) compared to the calibrated values (filled circles) for sensors 1 and 2 (blue and red, respectively), at each depth (right panels). Applied offsets are $-9\text{e-}4 \text{ }^{\circ}\text{C}$ and $-2\text{e-}3 \text{ }^{\circ}\text{C}$ for temperature sensors 1 and 2, respectively, and 0.0013 mS/cm and 0.0074 mS/cm for conductivity sensors 1 and 2, respectively.

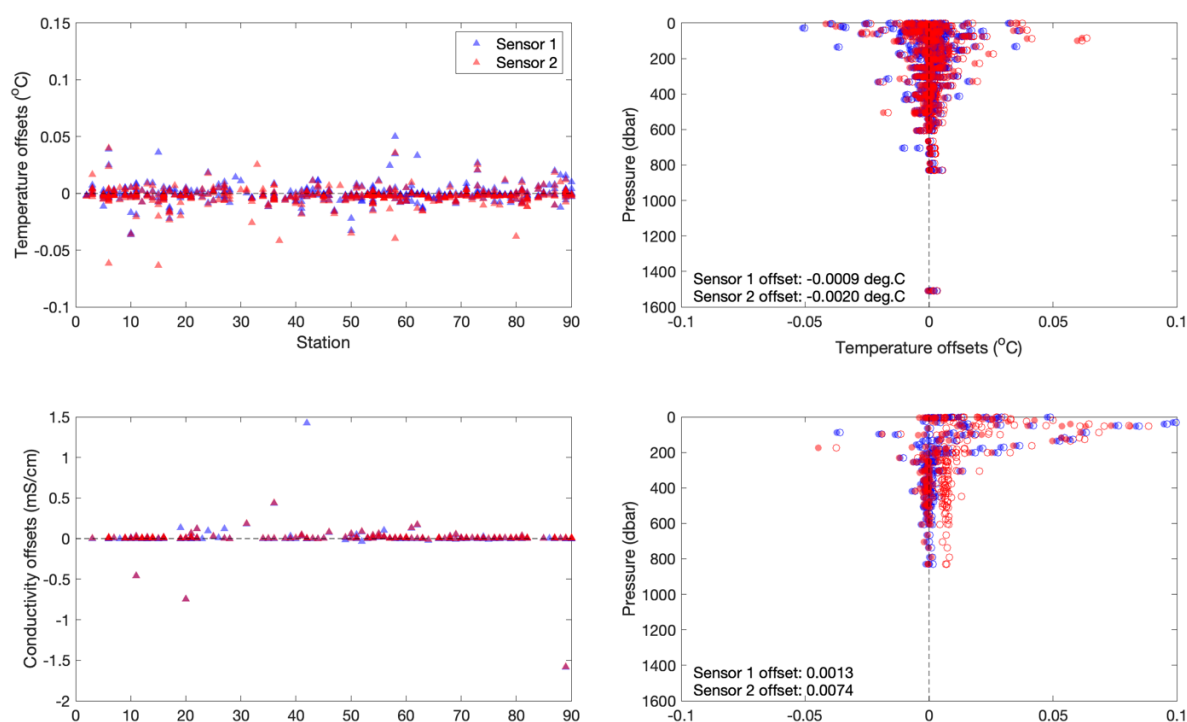


Figure 3.1-3. Temperature (upper panels) and conductivity (lower panels) offsets for sensors 1 (blue) and 2 (red). Offsets are plotted per station (left panels) and depth (right panels).

3.1.5 Data Output Structure

All raw cruise CTD data is stored in:

`/leg/system/ctd_seabird_sbe911plus/acquisition/data/SD041/CTD`

All processed cruise data including the calibrated files is stored in:

`/leg/work/scientific_work_areas/ctd/BASproc`

All in-house BAS scripts, including the L-ADCP processing, are available in their private Github repository. Processing and plotting scripts developed specific for this cruise can be found in https://github.com/martimmas/cruise_work.

3.1.6 Preliminary Results

Figure 3.1-4 shows a compilation of all CTD stations in the cruise in θ -S space, coloured by station number. Figure 3.1-5 shows example profiles taken at ice fronts, compared with a mid-shelf profile (85), so that the difference between the environments can be appreciated.

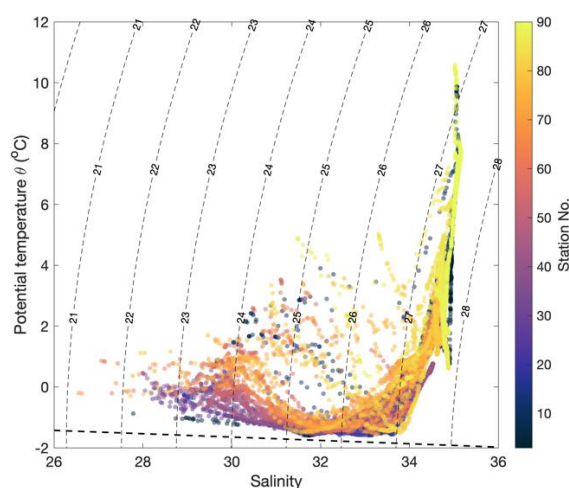


Figure 3.1-4. Potential temperature-salinity diagram showing all CTD profiles taken during the KangGlac cruise. Colours show the station. Number, thin dashed lines show the potential density (σ) curves, and bold dashed line shows the freezing point of seawater at the sea surface.

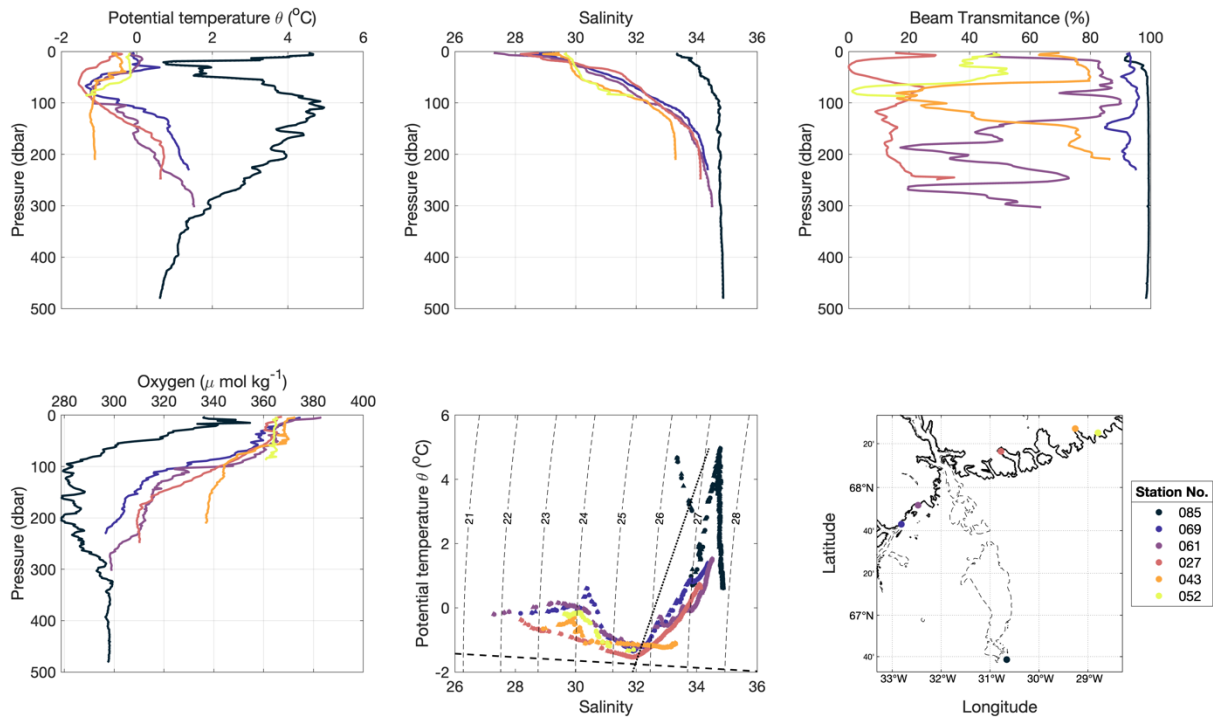


Figure 3.1-5. Example characteristic profiles of mid-shelf in the Kangerlussuaq trough (85) compared with profiles taken at the ice front.

3.1.7 Example Sections

Below are some examples of characteristic sections, along Kangerlussuaq Trough (Figure 3.1-6), and for 3-miipuggut (was Ryberg) and Kivioq Fjords, both along (Figure 3.1-7 and Figure 3.1-8), and across (Figure 3.1-9 and Figure 3.1-10) their main axes. It is worth noting that these are not necessarily synoptic, as they are a compilation of all casts along a certain section. Inside the fjords, most of the casts were taken within a 6h window, whereas in Kangerlussuaq Trough the time between casts was up to a few weeks apart.

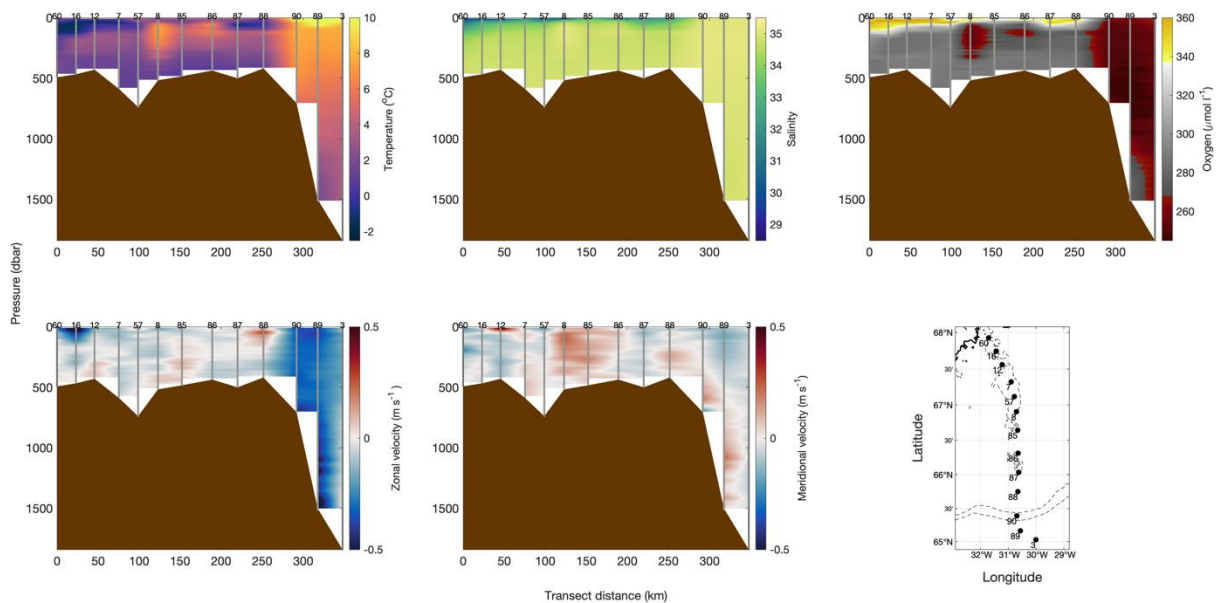


Figure 3.1-6. Previous page. CTD transect along Kangerlussuaq Trough for temperature, salinity, dissolved oxygen (upper panels), and zonal and meridional L-ADCP velocities (lower panels). Bottom right panel shows cast locations. Grey lines show cast locations, which are numbered at the top.

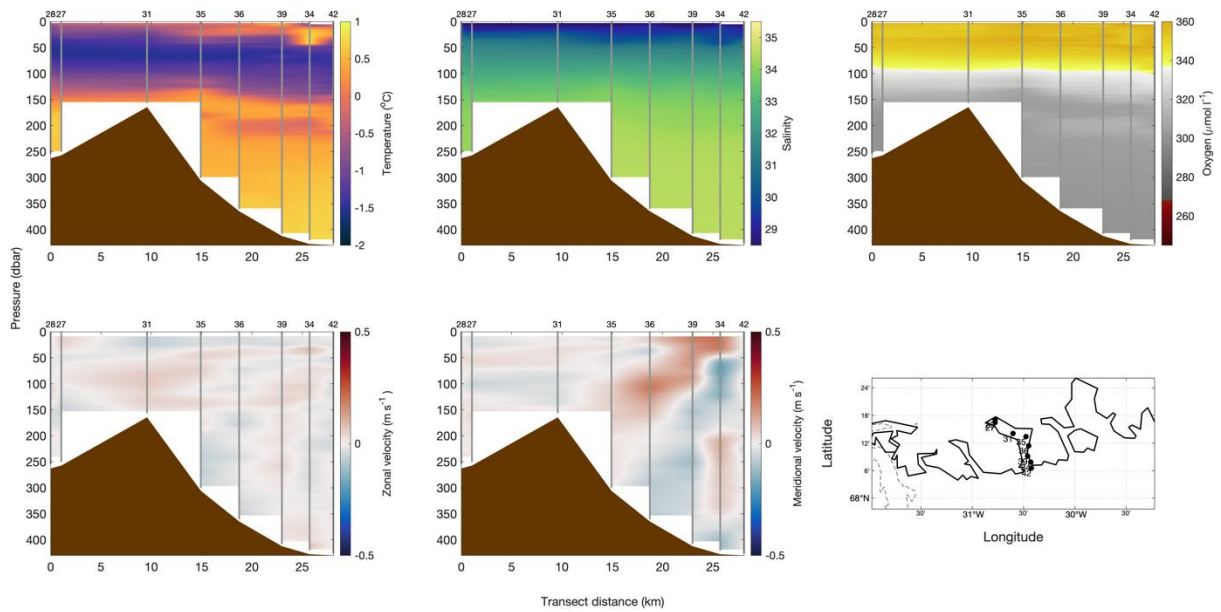


Figure 3.1-7. As in Figure 3.1-6, but for 3-miipuggut Fjord. Note the coarse resolution coastline, which is not accurate.

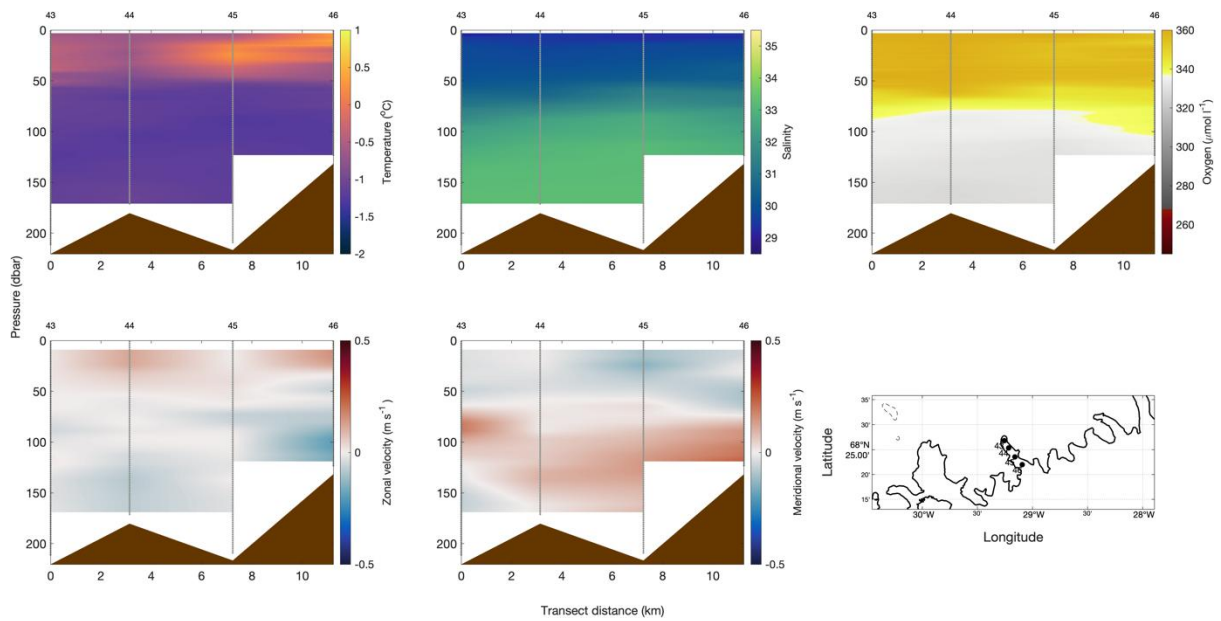


Figure 3.1-8. As in Figure 3.1-6, but for Kivioq Fjord. Note the coarse resolution coastline, which is not accurate.

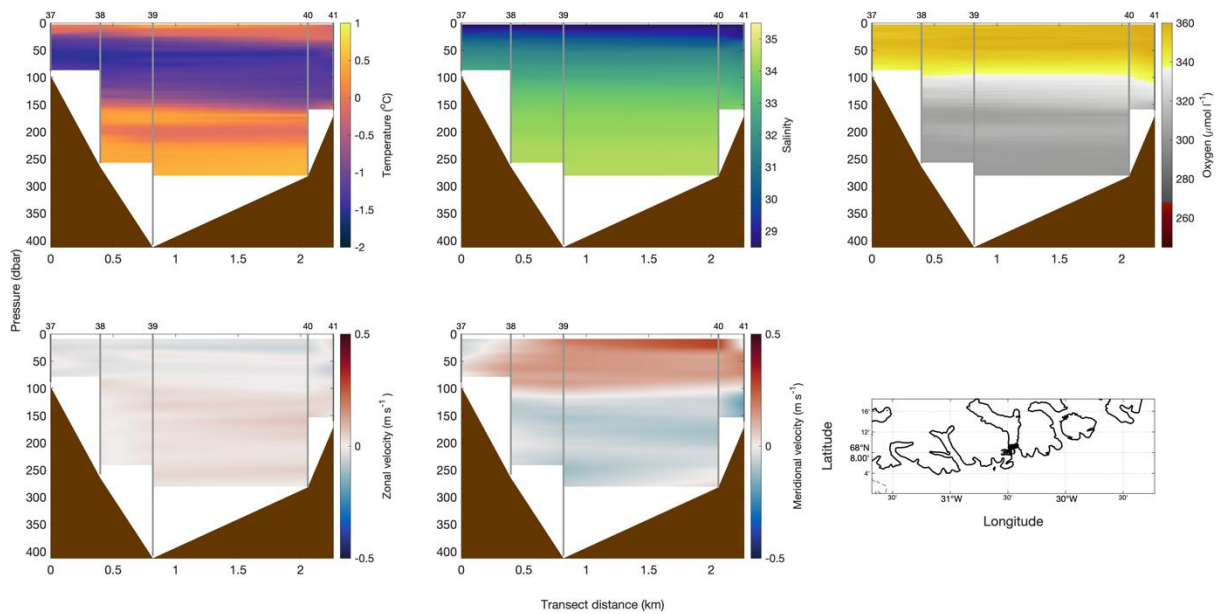


Figure 3.1-9. As in Figure 3.1-6 but across 3-miupgugut Fjord. Note the coarse resolution coastline, which is not accurate.

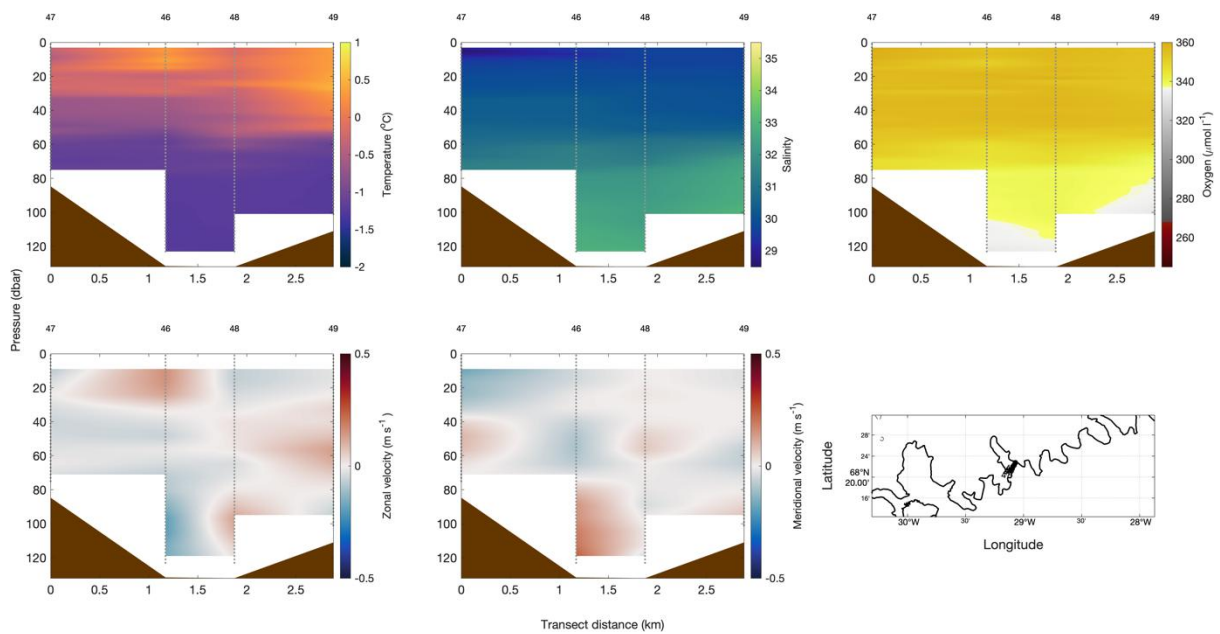


Figure 3.1-10. As in Figure 3.1-6, but across Kivioq Fjord. Note the coarse resolution coastline, which is not accurate.

3.2 Lowered Acoustic Doppler Current Profiler (L-ADCP)

Author: Laura Castro de la Guardia (SAMS)

3.2.1 Summary

Ocean current profiling was carried out using a pair of Teledyne RDI Workhorse Monitor 300-kHz L-ADCPs mounted on a stainless-steel rosette. The L-ADCPs are identified as MASTER looking down and SLAVE looking up. Technical problems with the MASTER L-ADCP resulted in no data from this L-ADCP on CTDs 4 and 5. The MASTER L-ADCP was replaced from CTD 6 onwards. No

further technical problems with the L-ADCPs were encountered. After processing the data with the MATLAB based LDEO software (version IX 15beta) the data looked reasonably good.

Table 3.2-1. Glossary of ocean instruments.

Acronym	Meaning
CTD	Conductivity, temperature, depth. Here it refers to the CTD rosette
L-ADCP	Lowered Acoustic Doppler Current Profiler
COM	Serial communication port to connect to the instrument using a software.

3.2.2 Instrument Details

Christopher Gray and Nikita Petrov, the BAS CTD operators, managed the execution of pre- and post-deployment scripts and data backups. They also dealt with any software requirements or technical issues relating to these matters.

Table 3.2-2. Instrument details.

Instrument	Make	Serial Number	CTD cast numbers	comments
L-ADCP master down	Teledyne WHM300	14443	01-03	Technical problems
L-ADCP master down	Teledyne WHM300	15060	06 - end	Replacement
L-ADCP slave up	Teledyne WHM300	14897	01 – end	

3.2.3 Pre-deployment Scripts

In the pre-deployment scripts, the first step was to awaken the L-ADCPs. To avoid issues, the SLAVE was awakened before the MASTER. Pre-deployment scripts then continued simultaneously on both L-ADCPs. Chris noted that it is good practice to start the scripts on the SLAVE first to avoid freezing of the software.

Table 3.2-3. Pre-deployment scripts.

	Open BBTalk Terminals
	Connect and awake the L-ADCPs: COM7 connects to MASTER and COM8 connects to SLAVE
Output Code lines:	Load and run pre-deployment tests. Checked for:
PA	PASS and FAIL outputs, the transmit test should be the only one with FAIL (it is normal for it to fail on air)
PT200	Moisture level must start with 8 or 9 (any other value is unacceptable for deployment)
PC2	Make sure sensor output is working
RS	Record memory card free and use space
	Load L-ADCP scripts and start recording immediately prior to CTD launch to avoid recording data on air and filling memory.

3.2.4 Deployment Scripts

Table 3.2-4. Deployment scripts.

Commands MASTER	for	Meaning	Commands SLAVE
>WM15		Water mode 15	>WM15
>TC2		Log date and time	>TC2
>LP1		Pings per ensembles 1	>LP1
>TB 00:00:02.80		Time per burst 2.8s	
>TE 00:00:01.30		Time per ensemble 1.3 seconds Time per ensemble 0 seconds	>TE 00:00:00.00
>TP 00:00.00		Time between pings	>TP 00:00.00
>LN25		Number of depth bins 25	>LN25
>LS0800		Bin size 8m	>LS0800
>LF0		Blank time after transmitting 0 seconds	>LF0
		Set narrow bandwidth (redundant comment)	>WB1
>LW1		Narrow bandwidth mode	>LW1
>LV400		Ambiguity velocity 4m/s	>LV400
>SM1		Set as DOWN looking Set as UP looking	>SM2
>SA011		Send 1 synchronization pin before each ensemble	>SA011
>SB0		Writing Channel B Break State [DISABLED]. Disable hardware-break detection on Channel B	>SB0
>SW5500		Delay of 550 milli seconds after synchronisation pulse	
>SI0		Send synchronisation pulse after each ensemble	
>EZ0011101		Sensor settings: manual speed of sound 1500 m/s; manual transducer depth 0m; measured heading; measured pitch; measured roll; manual salinity 35psu; measured temperature	>EZ0011101
>EX00100		Use beam coordinates	>EX00100
>CF11101		Flow settings: enable automatic ensemble cycling; enable automatic ping cycling; enable binary data output; disable serial output, enable data recorded.	>CF11101
>CK		Save as user default	>CK

>CS	Begin pinging	>CS
-----	---------------	-----

3.2.5 Post-deployment Procedure

Upload data to the computer using a specific naming system that includes cruise number (SD041), CTD cast, CTD frame SS for stainless steel, and L-ADCP output M or S for MASTER or SLAVE, respectively. An example raw file name is: SD041_080_SS_M.000

3.2.6 Technical Problems

No data for L-ADCP on CTD 04 and CTD 05. The MASTER L-ADCP stopped working. When the MASTER L-ADCP was opened, Chris confirmed water has made its way inside, burning the circuits. The MASTER L-ADCP was changed on the 24/07/2024.

CTD cable had to be re-terminated on 15.08.2024 after CTD 70 and there was a 12h wait until the CTD could be deployed again. On the 21.08.2024 upon arriving to CTD 81, the CTD winch was not turning, and the deployment was delayed.

3.2.7 Data Processing

Processing of the L-ADCP raw data was performed using MATLAB-based scripts of the velocity inversion method, LDEO L-ADCP processing Software version IX 15beta (Thurnherr 2021). The scripts were provided by Povl Abrahamsen and made available in the sda legwork drive (path: legwork/scientific_work_areas/L-ADCP/LDEO_IX_15beta/). The LDEO software incorporated the measured CTD temperature and salinity. The main MATLAB function is process_cast.m. This function requires the input of the CTD cast number and the processed CTD data. The processing of the L-ADCP data was therefore performed shortly after the processing of the CTD data.

After calibrating the CTD conductivity measurements with salt bottle samples, the L-ADCP data were re-processed with the corrected salinity.

For most CTD casts process_cast.m ran smoothly and gave reasonable results. However, some CTD casts required specific parameter adjustments. These adjustments have been included in a separate script called: set_cast_params_prelim_sd041.m and set_cast_params.m. This script can be found at /legwork/scientific_work_areas/L-ADCP/.

Figure 3.2-1 shows an example where the standard data processing did not recognise the seafloor (Figure 1a). This was fixed by adding a case to set_cast_params.m that forced the processing tools to delete the seabed data (Figure 3.2-1b). This was done on CTD 17, 37, 52, 52 and 84. In addition to forcing the removal of bottom we defined the search for the bottom on CTD 17 between 100 and 10 m, and CTD 69 between 300 and 1m. The 1m on CTD 69 was because this cast almost touched the bottom.

Table 3.2-5. Processing scripts.

Scripts	Comments
process_cast.m	% LIST OF STEPS FOR begin step: % 0: LOAD CAST PARAMETERS % 1: LOAD L-ADCP DATA % 2: FIX L-ADCP-DATA PROBLEMS % 3: LOAD GPS DATA % 4: GET BOTTOM-TRACK DATA % 5: LOAD CTD PROFILE % 6: LOAD CTD TIME SERIES

	% 7: FIND SURFACE & SEA BED % 8: APPLY PITCH/ROLL CORRECTIONS % 9: EDIT DATA % 10: FORM SUPER ENSEMBLES % 11: REMOVE SUPER-ENSEMBLE OUTLIERS % 12: RE-FORM SUPER ENSEMBLES % 13: (RE-)LOAD SADC DATA % 14: CALCULATE INVERSE SOLUTION % 15: CALCULATE SHEAR SOLUTION % 16: PLOT RESULTS & SHOW WARNINGS % 17: SAVE OUTPUT
set_cast_params_prelim_sd041.m & set_cast_params.m	Step 0 – explanation This script specifies special parameters for individual cast where processing yields an error or look wrong. During the SD041 research cruise we had to force/specify parameters for CTD 1, 2, 4, 17, 37, 51, 52, 69 and 84. CTD 1 2 and 4 did not reach the bottom – so we force NO bottom track: p.btrk_mode=0 CTD 17, 37, 51, 52, 84 - initial processing did not pick up the bottom signal, so we forced the bottom to be cleared by setting p.btrk_mode = 2. For CTD 17, bottom track range was also reduced with p.btrk_range=[100 10] CTD 69 - CTD was very close to bottom, so bottom track range was modified with p.btrk_range=[300 1] and p.btrk_mode=2
Data removed	All Velocities exceeding 4 m/s were considered outliers and removed. It is unrealistic for the ocean to have such high flows
Depth bins	25 bins 8 m thick
Pings per Ensemble	1

Persisting processing problems. CTD 9, 10, 11 shows strong reflection of the bottom that may persist. However, noting that the strongest reflection was removed (Figure 3.2-2a), and the vertical profile looked good for the most part, except surface values that look unconstrained (Figure 3.2-2b).

3.2.8 Science Objectives

To elucidate the ocean circulation within the fjords in southeast Greenland, as well as the total volume, heat and freshwater exchange between the shelf and the fjords. L-ADCP data will also support the marine geology team and CTD data will support the sampling of MOCNESS. Thus there are also CTD casts following or preceding the coring MOCNESS sites.

3.2.9 Sampling Strategy and Areas

Focus areas and sampling strategy had to be decided based on sea ice conditions. The general research focus was southeast Greenland on the inner and outer shelf. Therefore, most of the CTDs were deployed around the Kangerlussuaq Trough on the inner and outer shelf.

The coastal areas immediately to the south and north of Kangerlussuaq Fjord were examined for possible entrances to the fjords. The north was identified as having safer ice conditions in late July. Two fjords in the north with marine glaciers, 3-miippugut (pronounced pingasut miippugut)

and Kivioq, were identified as safe to enter. In mid-August, ice conditions in the south allowed access the marine terminus of Apuliip Apusiia glacier near Fladø Island. The region near the glacier has the name Paattuulaajik Kertivaat. At these three glacier sites, the SDA carried out CTD transects to help elucidate glacier-ocean interactions.

Additional CTD casts were made to investigate the connection between the mooring site and a coastal trough. Several CTDs were also deployed around the mooring site and during the previous mooring sampling. Some CTDs linked to bathymetric data were taken along the deep trough to search for the connection between this deep trough and the main Kangerlussuaq Trough.

3.2.10 Future Work

To quantify the heat, volume and freshwater exchange between the Kangerlussuaq fjord and the shelf, a box was closed around Kangerlussuaq fjord entrance make budget calculations (Table 3.2-6). By combining hydrography and ocean velocities we will be able to estimate the exchange of heat, salt and volume between the shelf and the fjord.

Table 3.2-6. SD041 research focus areas for CTDs. CTD casts are grouped into interest areas, and sections that can aid quantification/mapping of the shelf-fjord exchanges.

<i>Focus area/Sections</i>	<i>CTD casts numbers</i>	<i>Comments</i>
Outer Kanger trough	9, 10, 11, 12, 13, 14, 15	~ 7 km spacing between CTDs
Inner Kanger trough	17, 18, 19, 20, 21, 22, 23, 24, 25	Arch closing the mouth of Kangerlussuaq fjord 3 to 7 km spacing between CTDs
Along Kanger trough	20, 16, 12, 7, 57, 8, 84-90	60 is at the same location at a 20 but a later day 23 to 30 km spacing between CTDs 84 and 85 are on the same station but 84 was used after repairing the cable/winch and no water was collected.
Northeast bound Kanger box	26, 82, 81, 15	
Southwest bound Kanger box	61, 65, 63, 59, 66, 67, 58 9	
Kivioq Fjord & Rosenborg glacier		
Kivioq Fjord entrance	47, 46, 48, 49	
Kivioq Fjord along	43, 44, 45, 46	
Chocolate Bay glacier Front	50, 53, 51, 52	
Chocolate Bay along	53, 54, 55, 56	
3-Miippugut fjord & Sorgenfri glacier		
3-miippugut inner	33, 32, 32, 30, 29	
3-miippugut outer	37, 38, 39, 40, 41	
3-miippugut along	28, 31, 35, 36, 39, 34, 42	
	26	Can be used to address connectivity between 3- mippugut and Kangerlussuaq fjord/trough
Fladø bay & Apuliip Apusiia glacier		
Fladø trough	61, 62, 63, 59, 66, 67, 58, 9	~5 to 9km spacing between CTDs
Mooring site and coastal trough		
Mooring site	6, 4, 5,	
Mooring trough along	79, 71, 6, 5, 73, 72	
Coastal trough along	68, 70, 79	
Coastal trough north entrance	69, 70,	
Coastal trough connection to Fladø	70, 74, 75, 63 or 59	

3.2.11 Preliminary Observations

CTDs 7 and 8 were taken in the Kangerlussuaq Trough (Figure 3.2-3); cast 7 is downstream of cast 8. These two casts show an inflow into the Kangerlussuaq Trough (e.g., northwest flow). CTD 8 shows the strong inflow in the upper 300m while CTD 7 has the strongest inflow below 300m.

The temporal changes in the ocean currents at the entrance to Kangerlussuaq fjord can be addressed to some extent using CTD 20 (28.07.2024 at 22h) and CTD 60 (10.08.2024 at 15h). These two CTDs will be deployed at approximately the same location in the Inner Kangerlussuaq Trough section (Figure 3.2-4).

A total of 90 CTD casts were made along the East Greenland coast and the shelf area (Figure 5). The processed fields of the three velocity components (u east and west, v north and south, w up and down) are of reasonable magnitude (Figure 3.2-6, Figure 3.2-7, Figure 3.2-8). Although difficult to see in Figures 3.2.6-8, the general flow direction is as expected. Future plots should aim to combine stations within the same section and look at sections individually to address the more interesting science questions.

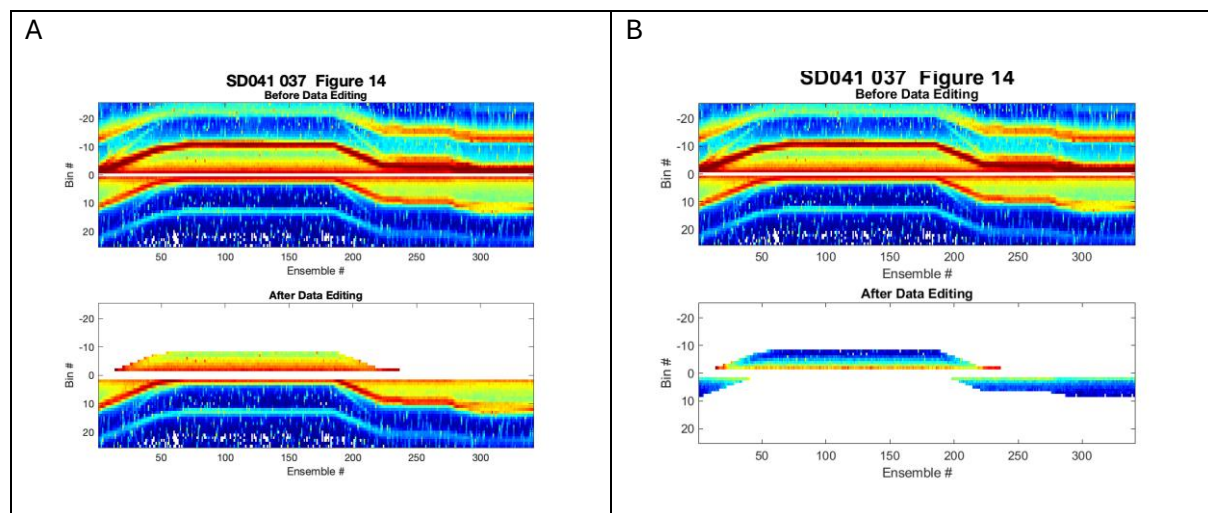


Figure 3.2-1. Example of the use of set parameters to fix the processing of CTD 37. (a) Without specifying `p.btrk_mode` (b) forcing `p.btrk_mode = 2`

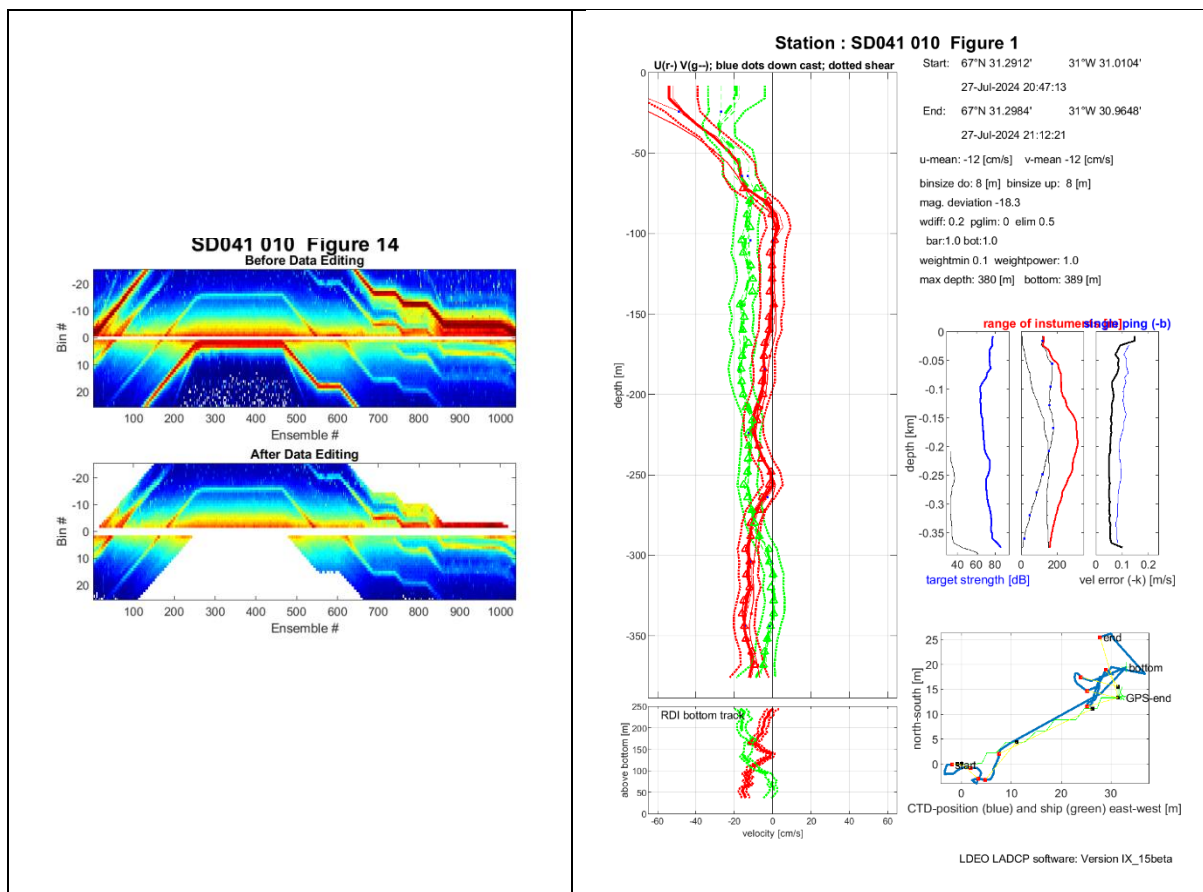


Figure 3.2-2. Persisting problems of stations 09, 10, 11. Using the example of station 10.

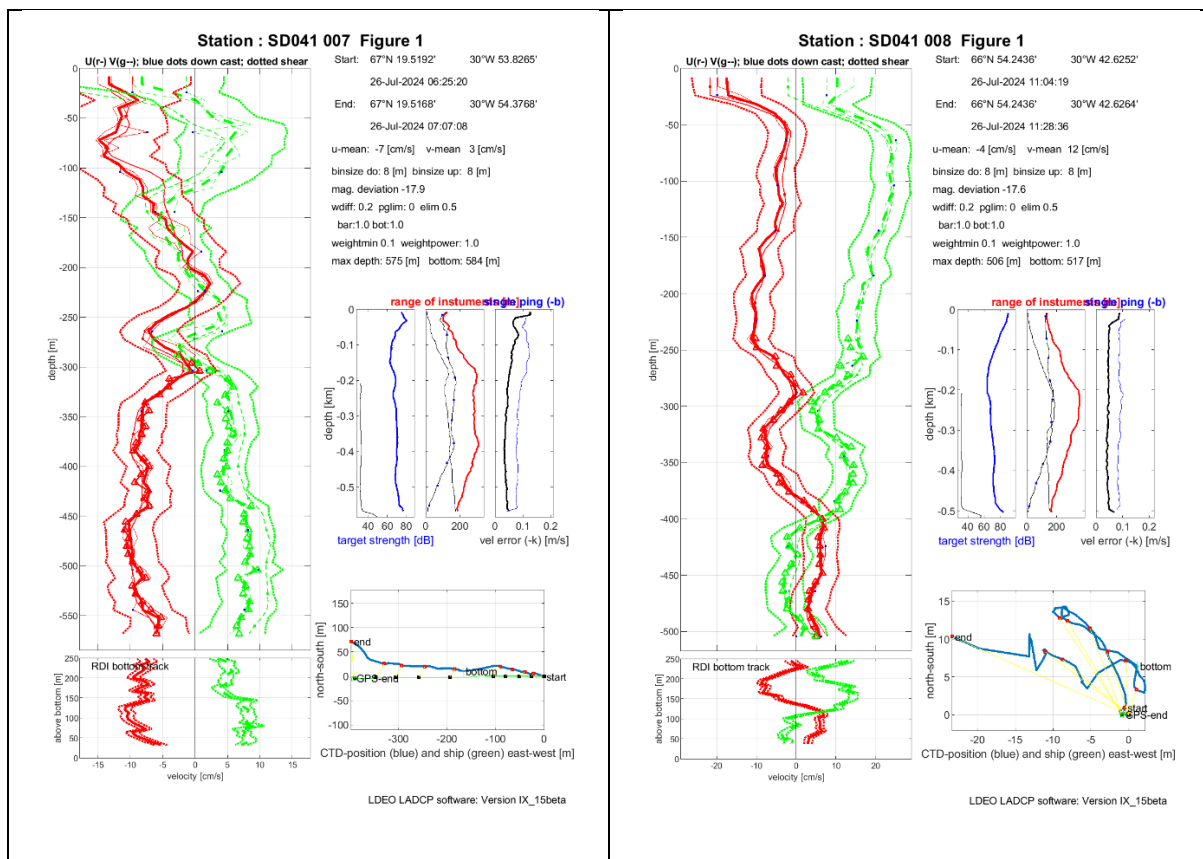


Figure 3.2-3. Potential inflow of Atlantic water into Kangerlussuaq Fjord. (a) CTD 7 is located in the middle of the shelf and closer to the entrance to Kangerlussuaq fjord than (b) CTD 8, which is located near the shelf break.

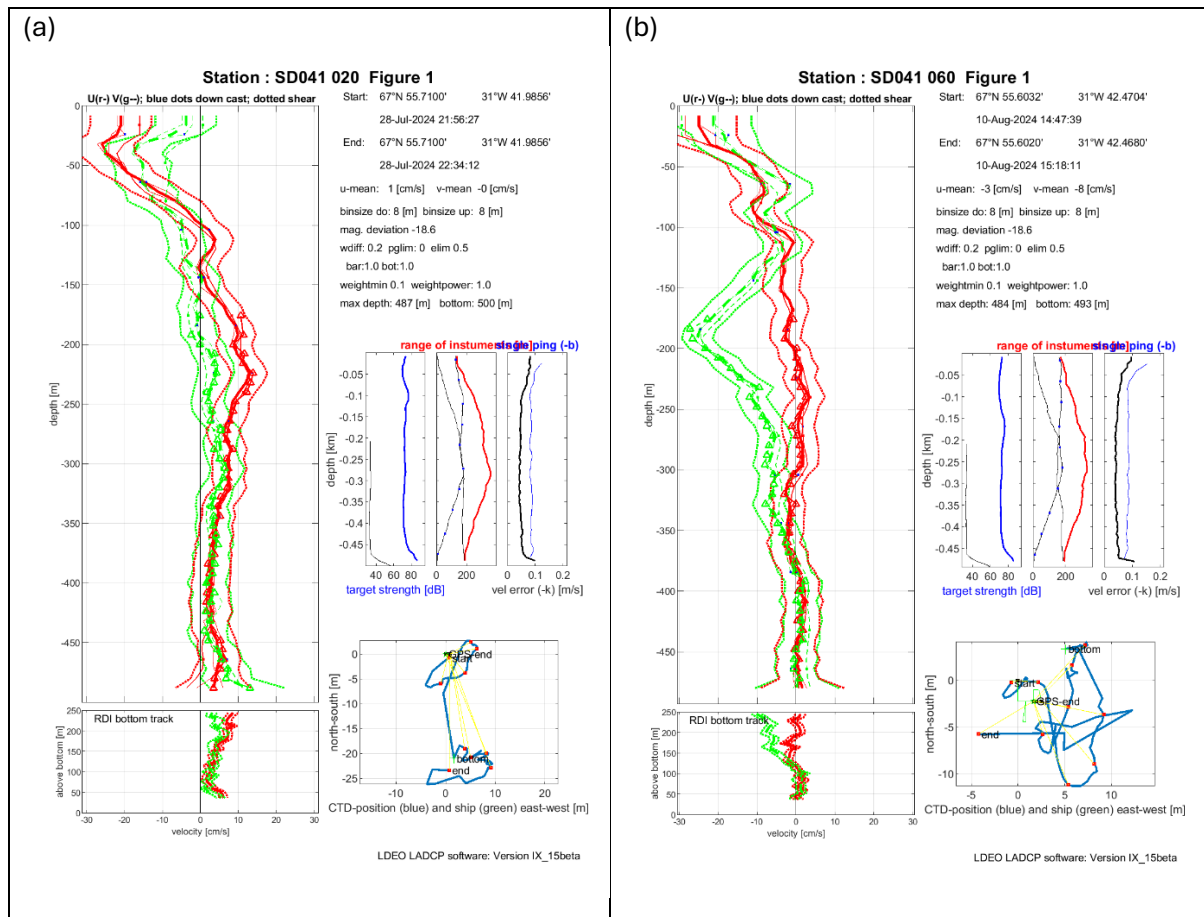


Figure 3.2-4. Different snapshots of the currents at the entrance to Kangerlussuaq. (a) CTD 20 captures an outflow (southwest) at the surface and an inflow (northeast) at depth on 20 July. (b) Twenty days later, on

10 August, CTD 60 records a weaker outflow at the surface, no inflow at depth, but a strong easterly current at mid-depth (150 to 250m), possibly the East Greenland Coastal Current.

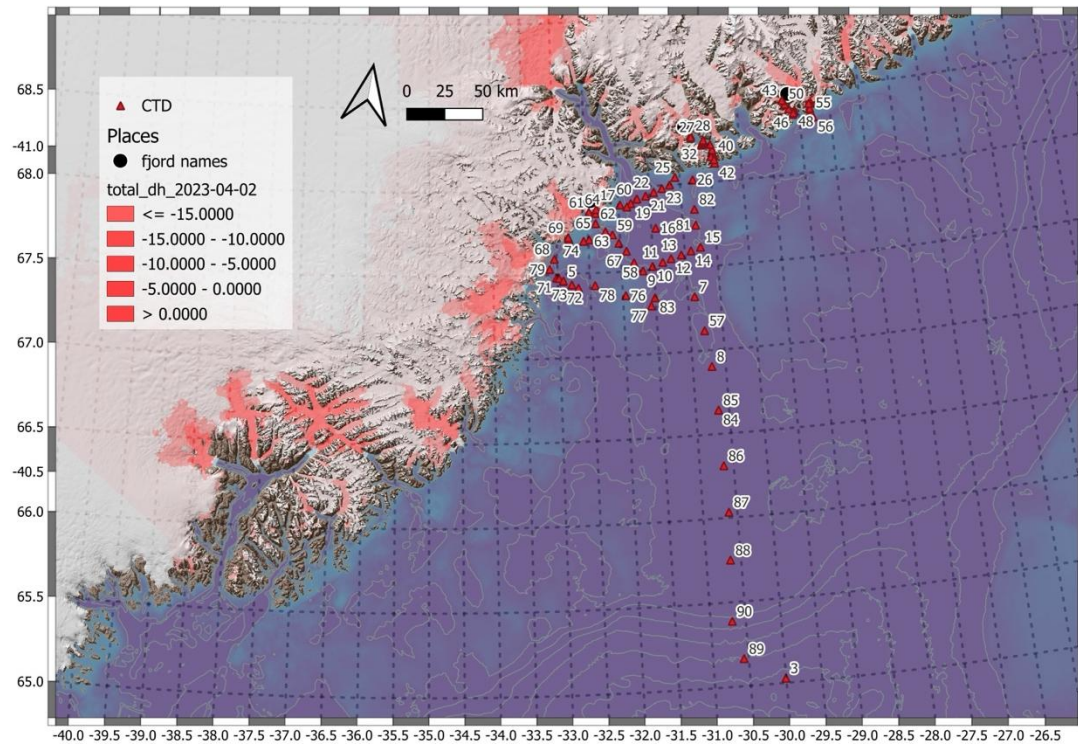


Figure 3.2-5. CTD stations around eastern Greenland.

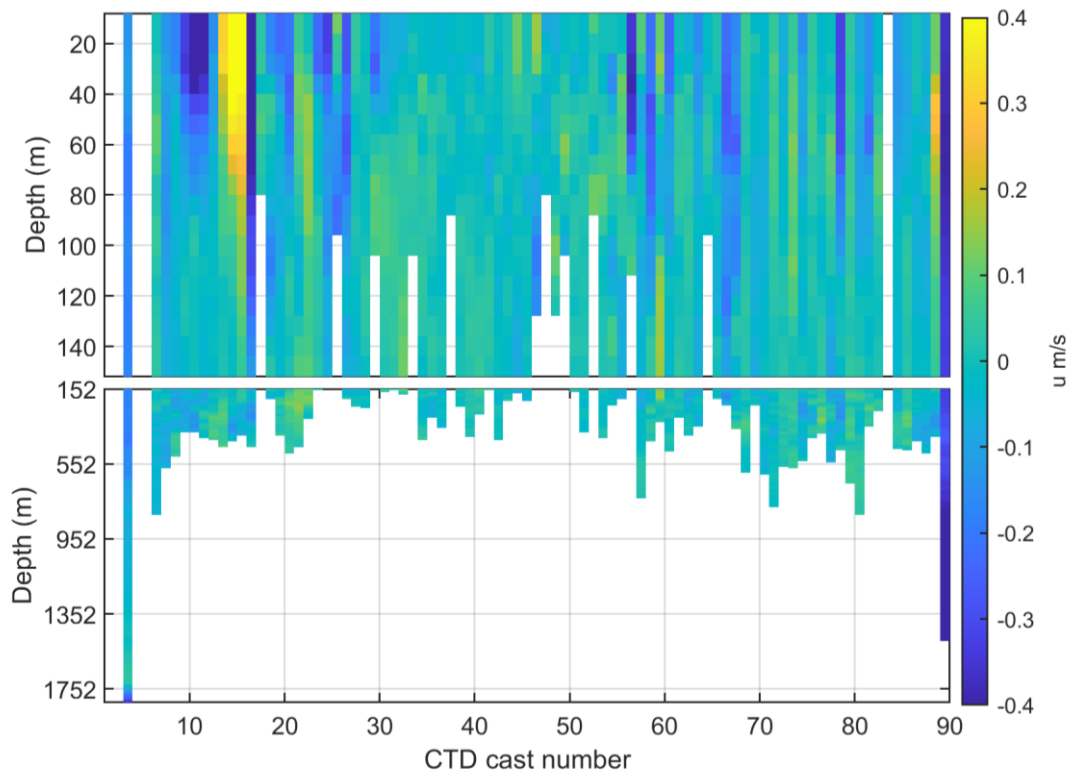


Figure 3.2-6. East-West component of the velocity at each station. Top panel zooms on the top 15m of the water column. Sign convention indicates direction positive to the east and negative to the west

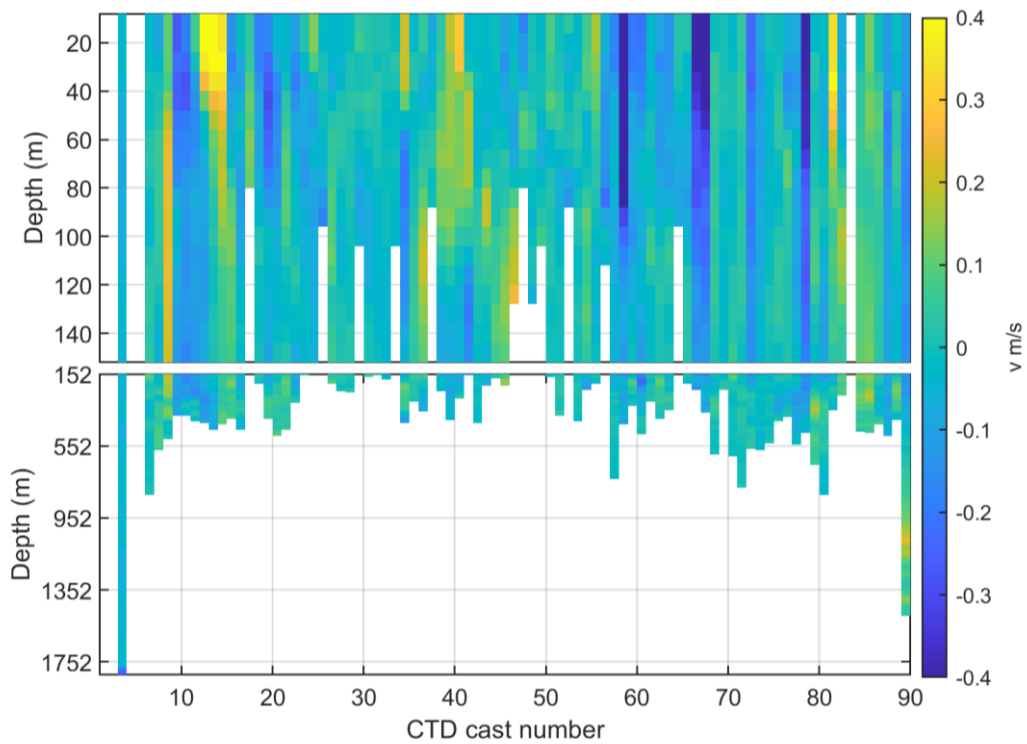


Figure 3.2-7. North-South component of the velocity at each station. Top panel zooms on the top 15m of the water column. Sign convention indicates direction positive to north and negative to the south.

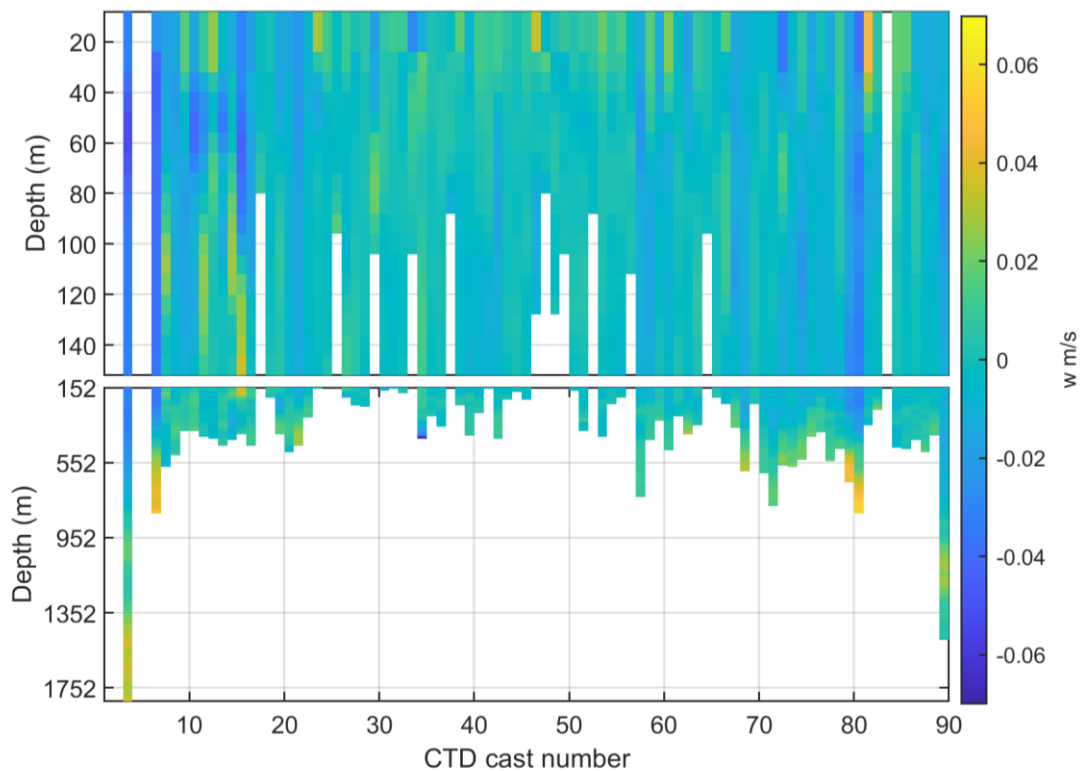


Figure 3.2-8. Vertical component of the velocity at each station. Top panel zooms on the top 15m of the water column. Sign convention indicates direction positive is up and negative is down south.

3.3 Vessel mounted Acoustic Doppler Current Profiler (VM-ADCP)

Author: Lea Riehn (SAMS)

3.3.1 Introduction

Ocean current velocities from 8 m to 880 m depth were measured with a 75-KHz and a 150kHz Teledyne RDI Ocean Surveyor vessel-mounted acoustic Doppler current profiler (VM-ADCP). Data were acquired, displayed and logged via the RDI VmDas software (version 1.42) and subsequently processed via a series of bespoke Matlab routines developed from previous cruises.

3.3.2 Set-up

Throughout the cruise, 2 VM-ADCP's were set to run in narrowband mode with 1 ping per ensemble. They were run through Ksync, a sonar synchronisation unit, to prevent interference from the TOPAS sub-bottom profiler, and with bottom track disabled, to prevent interference with other acoustic systems such as the EK80. One of the VM-ADCPs runs at 75 kHz with 16-m bins down to 880m. The blanking distance below the instrument is 8 m. There are 55 bins in total and bottom track is disabled. The rotation angle is set to 45° nominal angle. A salinity of 35 was assumed, and it was set to use the measured temperature to calculate the speed of sound. The second VM-ADCP runs at 150 kHz with 8-m bins down to 450 m. The blanking distance below the instrument is 4m. There are 55 bins in total and bottom track is disabled. The rotation angle is set to 45° nominal angle. A salinity of 35 was assumed, and it was set to use the measured temperature to calculate the speed of sound.

Although VmDas was set to switch to a new file whenever the files reach 10 MB in size, the VM-ADCPs were manually stopped daily and restarted, starting a new file sequence. This was done to prevent the VmDas from crashing, based on prior experience. The start and stop times associated with each file sequence were recorded in the VM-ADCP log.

3.3.3 Data Output

The Teledyne RDI VmDas software saved the data files with the file naming nomenclature of "sd041_os75nb_yyyymmddTHHMMYY_xxx_000nnn.aaa" where os75nb or os150nb designates the frequency of the ADCP (and narrowband mode), yyyymmddTHHMMYY is the date-/time-stamp of the start of the file sequence, xxx = the file sequence number starting at 000, nnn = the file number within that sequence and aaa = the file type. For each sequence, 9 different file types were made:

Table 3.3-1. ADCP file type created

Extension	Description	Type
*.ENR	Raw ADCP data file	Binary
*.ENS	ADCP data screened (by VmDas or user) with *.NMS navigation data added.	Binary
*.ENX	ADCP single-ping data and navigation data after bin-mapping and transform to Earth coordinates. Screened for error velocity, vertical velocity and false targets.	Binary
*.LOG	All output logging and error messages	ASCII
*.LTA	Long-time average of ADCP data (averaging time period specified in VmDas software options – in this case, 600 seconds).	Binary
*.N1R	Raw National Marine Electronics Association (NMEA) navigation data from Seatex GPS system.	ASCII
.NMS	Navigation data after screening and pre-averaging.	Binary
*.STA	Short-time average of ADCP data (averaging period specified in VmDas software options – in this case, 120 seconds)	Binary

*.VMO	Options settings for data collection	ASCII
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3.3.4 Post-processing

Raw VM-ADCP files were processed via a series of Matlab scripts originally written in Kiel and obtained from RV Poseidon cruise 328, where they were used by Mark Inall. They were subsequently adapted for the OS75 on James Clark Ross in November 2005 and for the ADCPs on SDA in 2022, and edited by countless researchers from BAS and other institutions in the intervening years.

1. The file location of the raw VM-ADCP output files [RAWPATH] and the location of the processed files [PATH].
2. The filename prefix 'sd041_os150nb_yyyymmddThhmmss_xxx_000000 and the cruise name 'SD041'.
3. All data files were selected, but a few lines couldn't be processed:
 - o Line 38,39,40 of the 75-kHz ADCP
4. There was an issue in the VmDas software with the input of GPS data, which is needed for the post-processing. Povl Abrahamsen revised the scripts remove_bad_navigation.m and subst_bad_seatex.m for any files where this was a problem, substituting GPS data from the port SeaPath system (logged with RVDAS) where data are missing in the NMEA streams logged by VmDas. An additional fix was added to subst_bad_seatex.m to fix problems with missing heading data in 150-kHz ADCP line 15 that initially prevented this from processing.
5. The narrowband misalignment angle and amplitude scaling factor corrections (misalignment_nb and amplitude_nb) were set to 0 and 1 respectively for the initial run. The alignment and amplitude offsets were identified during the initial run. Once the actual offsets were generated, they were substituted in and the script re-ran thus applying this offset to the SADC files.
6. Once these values were decided on, the VM-ADCP were reprocessed with these offsets in place changing misalignment_nb from 0 to -2 for the 75-kHz ADCP and -0.6 for the 150-kHz ADCP. The scale factor, amplitude_nb, was kept at 1.
7. Once reprocessed, these data were then used to produce vertical time profiles as well as quiver vector plots using the various mapping and figure plotting codes used on previous cruises, and in QGIS.

The computer running the VmDas software crashed 9 times at which point the software stops recording, which results in some data loss. The crash was noticed and the computer rebooted at

1. 24.07.24 07:42
2. 29.07.24 09:32
3. 04.08.24 10:05
4. 06.08.24 18:43
5. 07.08.24 14:09
6. 11.08.24 15:22
7. 14.08.24 20:14
8. 20.08.24 00:17
9. 25.08.24 21:30

Data acquisition was not resumed after the final crash, as it was immediately before leaving the Greenland EEZ.

3.3.5 VM-ADCP Performance

The 75-kHz ADCP exhibited strong near-surface biases in the direction of the ship's movement, occasionally affecting all bins down to 100 m. While MCh of SD041 was conducted in shallow

water, the maximum range was rarely over 550 m. The 150-kHz ADCP achieved a range of 400-450 m and did not appear to have the same problems near the surface, resulting in a MCh better dataset in the upper ocean.

The 75-kHz ADCP would regularly time out during data acquisition, resulting in fewer pings collected within each data file, about 3% fewer than the 150-kHz ADCP.

VmDas was running on a single computer, with separate instances of VmDas for each ADCP. Separate serial ports provided the NMEA position/velocity feeds to the two ADCPs, while both obtained attitude data via UDP on the network. After some varying amount of time one of the ADCPs would stop logging the position/velocity data; attitude data would still be collected and embedded in the data files. The other ADCP would continue collecting NMEA data. The time before these dropouts started were variable, and both ADCPs exhibited this same (software?) problem. The lack of position and velocity data were solved in post-processing by obtaining these data from the underway feeds logged through RVDAS and substituting these data for the missing values.

The data acquisition computer froze on multiple occasions, as listed above. Each crash would necessitate IT going to the server room to reboot the computer. All of the software problems above will hopefully be solved by moving from a Windows/VmDas acquisition system to a Linux/UHDAS system in the refit immediately following this cruise.

The problem with the poor near-surface performance and limited range of the 75-kHz ADCP should be investigated further, as should the timeouts, if they continue with the new data acquisition system. The 150-kHz ADCP appears to be performing well.

3.3.6 Data Overview

23-Aug-2024 11:56:00

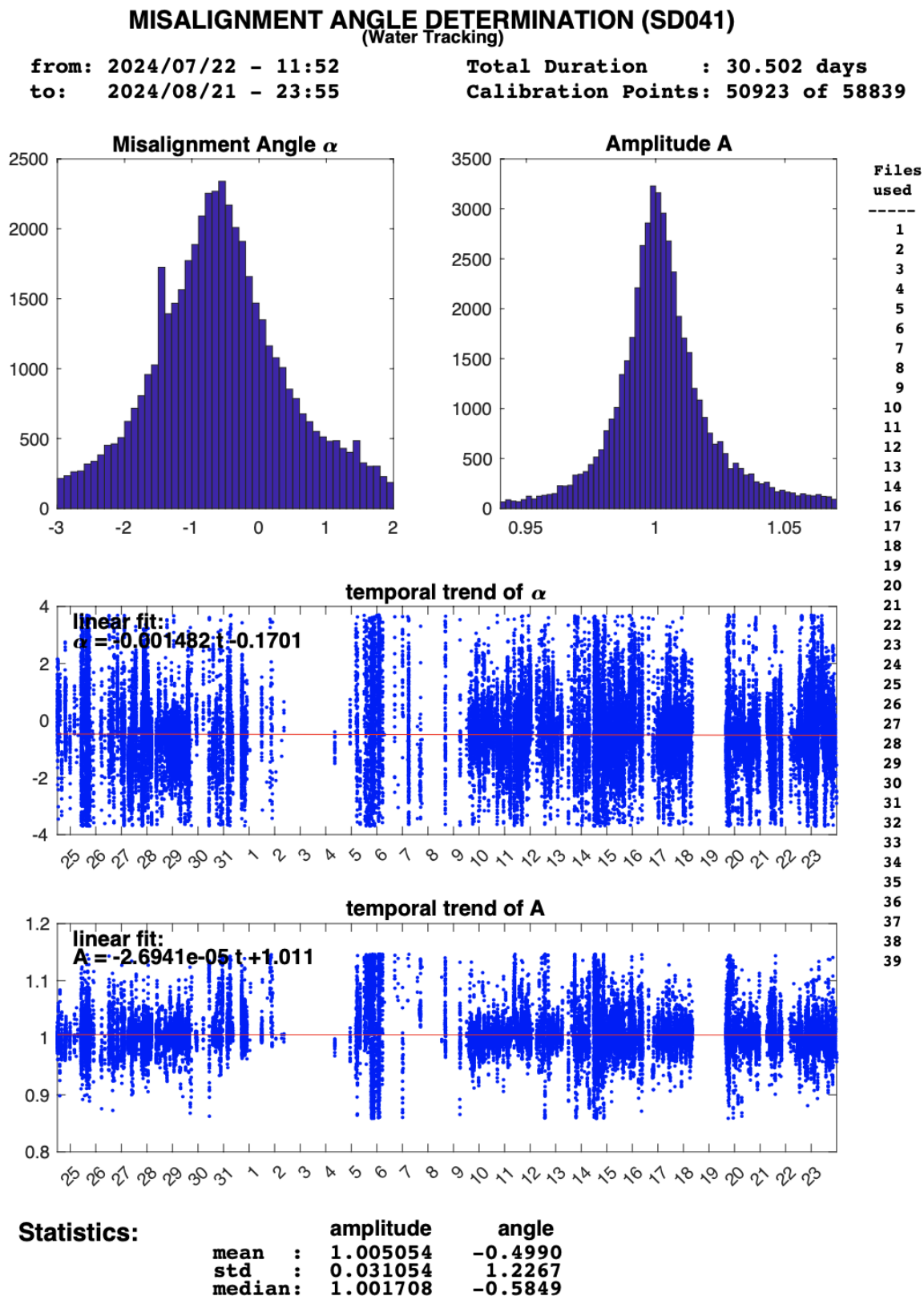


Figure 3.3-1. Initial processing of 150kHz VM-ADCP.

MISALIGNMENT ANGLE DETERMINATION (SD041) (Water Tracking)

from: 2024/07/22 - 11:52
to: 2024/08/21 - 23:55

Total Duration : 30.502 days
Calibration Points: 52224 of 55514

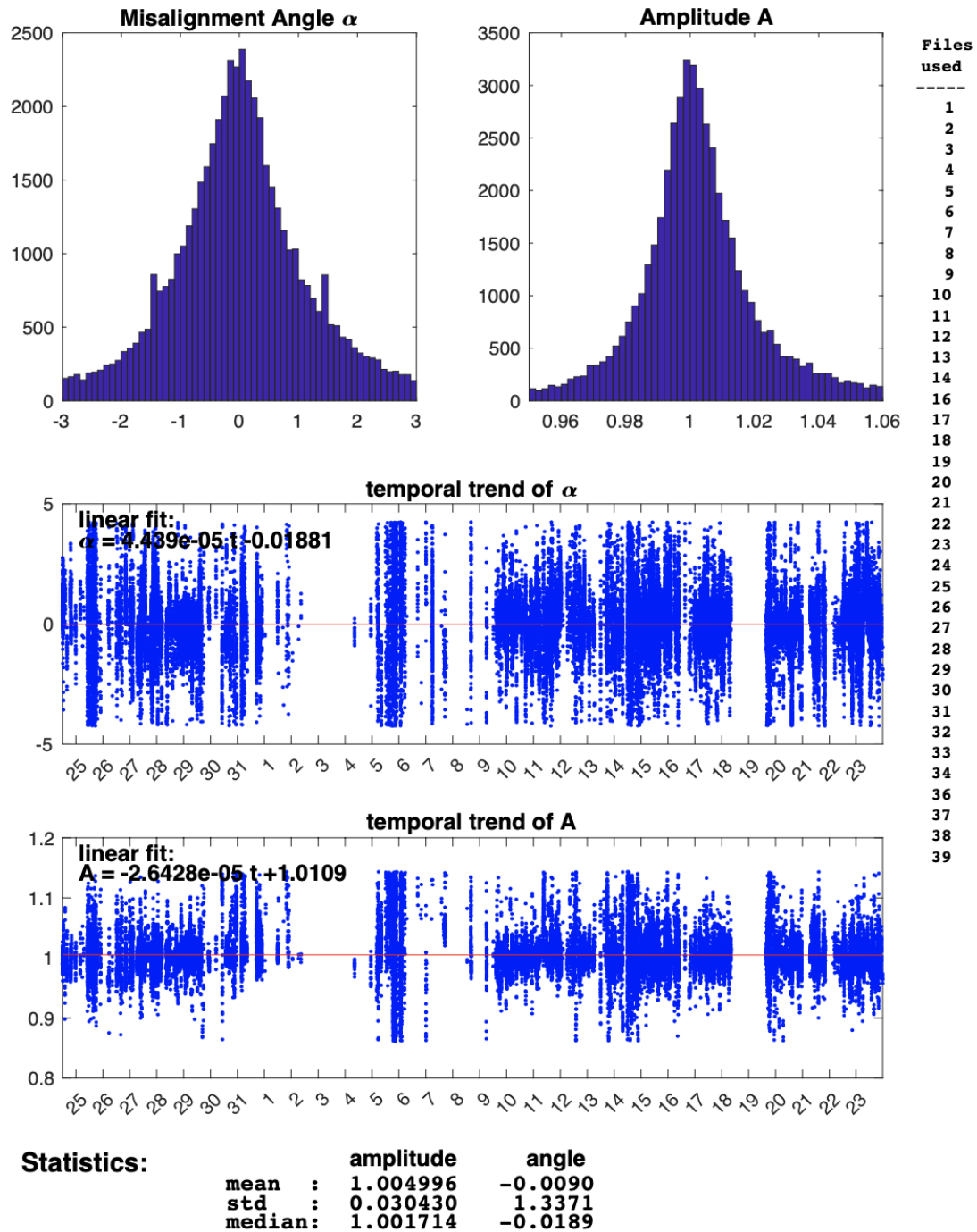
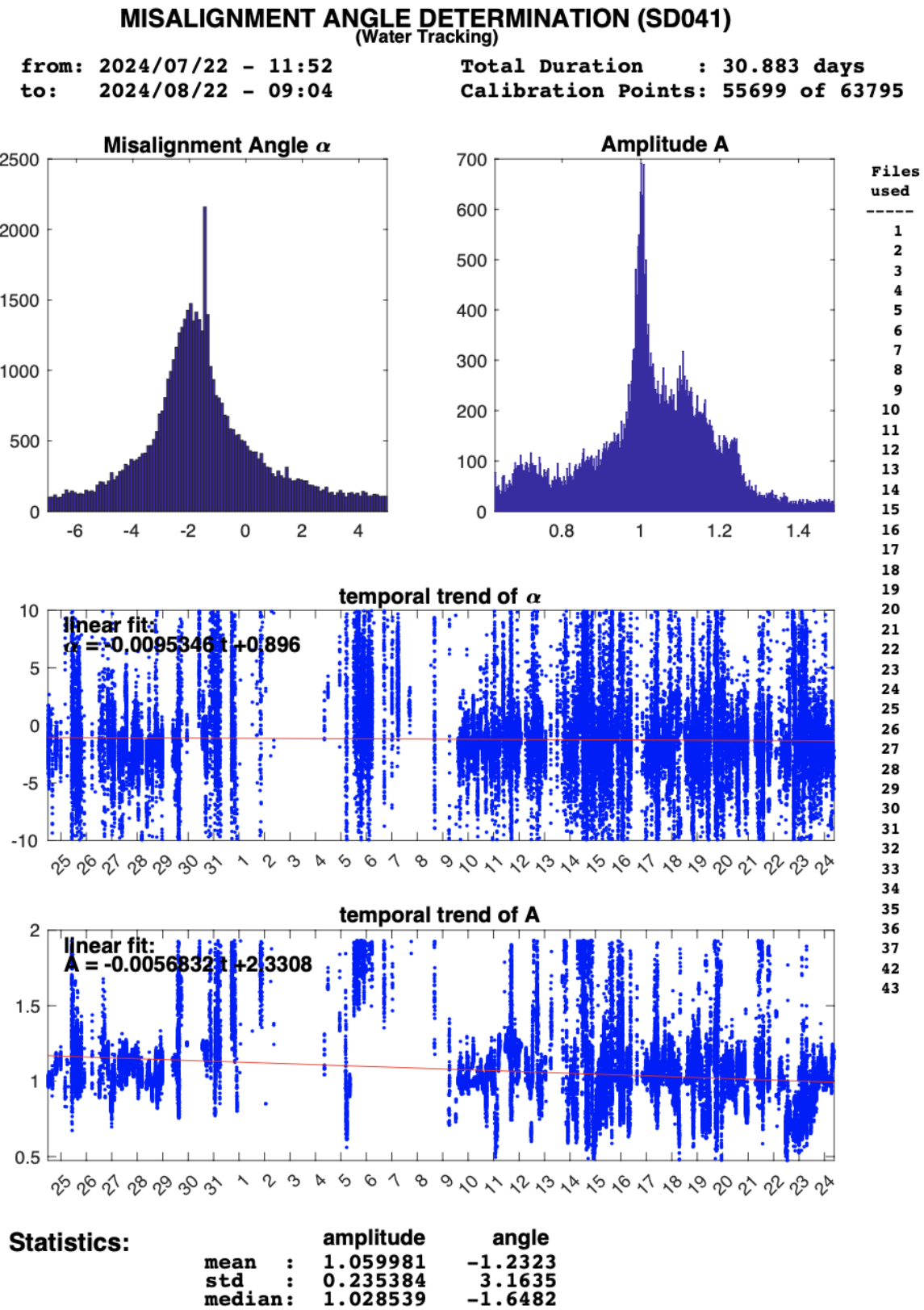


Figure 3.3-2 Corrected 150kHz VM-ADCP.



MISALIGNMENT ANGLE DETERMINATION (SD041) (Water Tracking)

from: 2024/07/22 - 11:52
to: 2024/08/22 - 09:04

Total Duration : 30.883 days
Calibration Points: 58630 of 63513

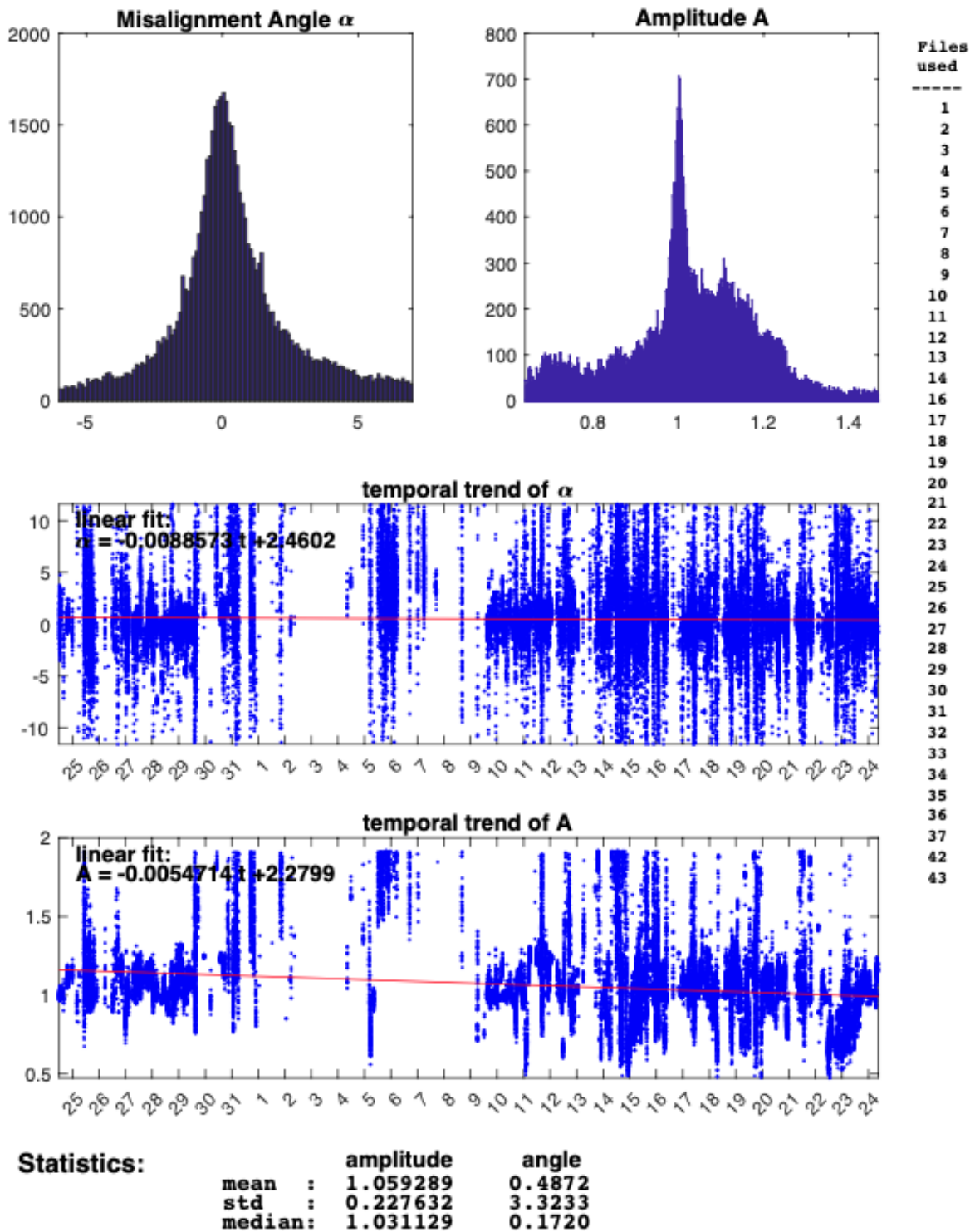


Figure 3.3-4. Corrected 75kHz VM-ADCP.

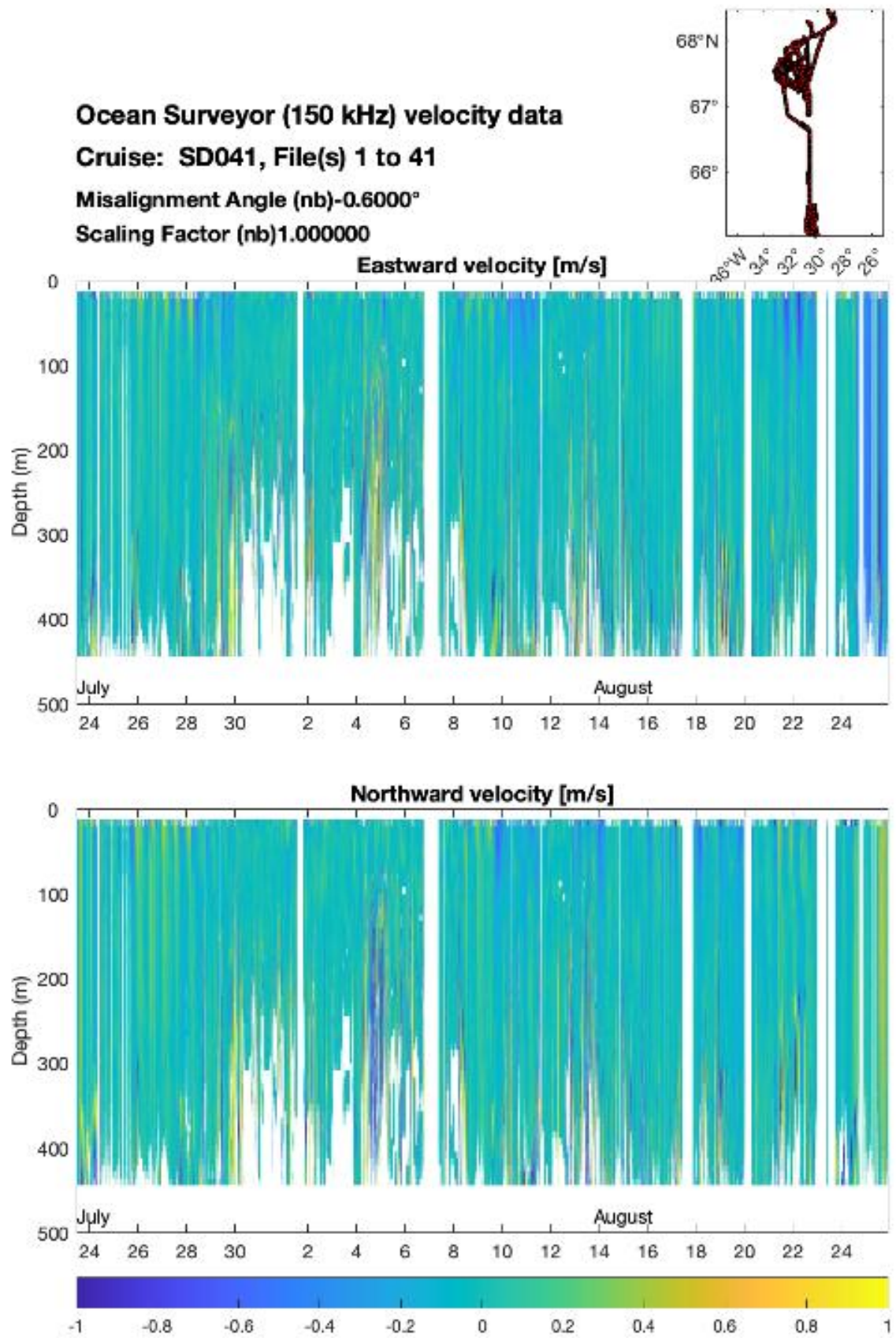


Figure 3.3-5. *u* and *v* velocity components of the 150 kHz VM-ADCP.

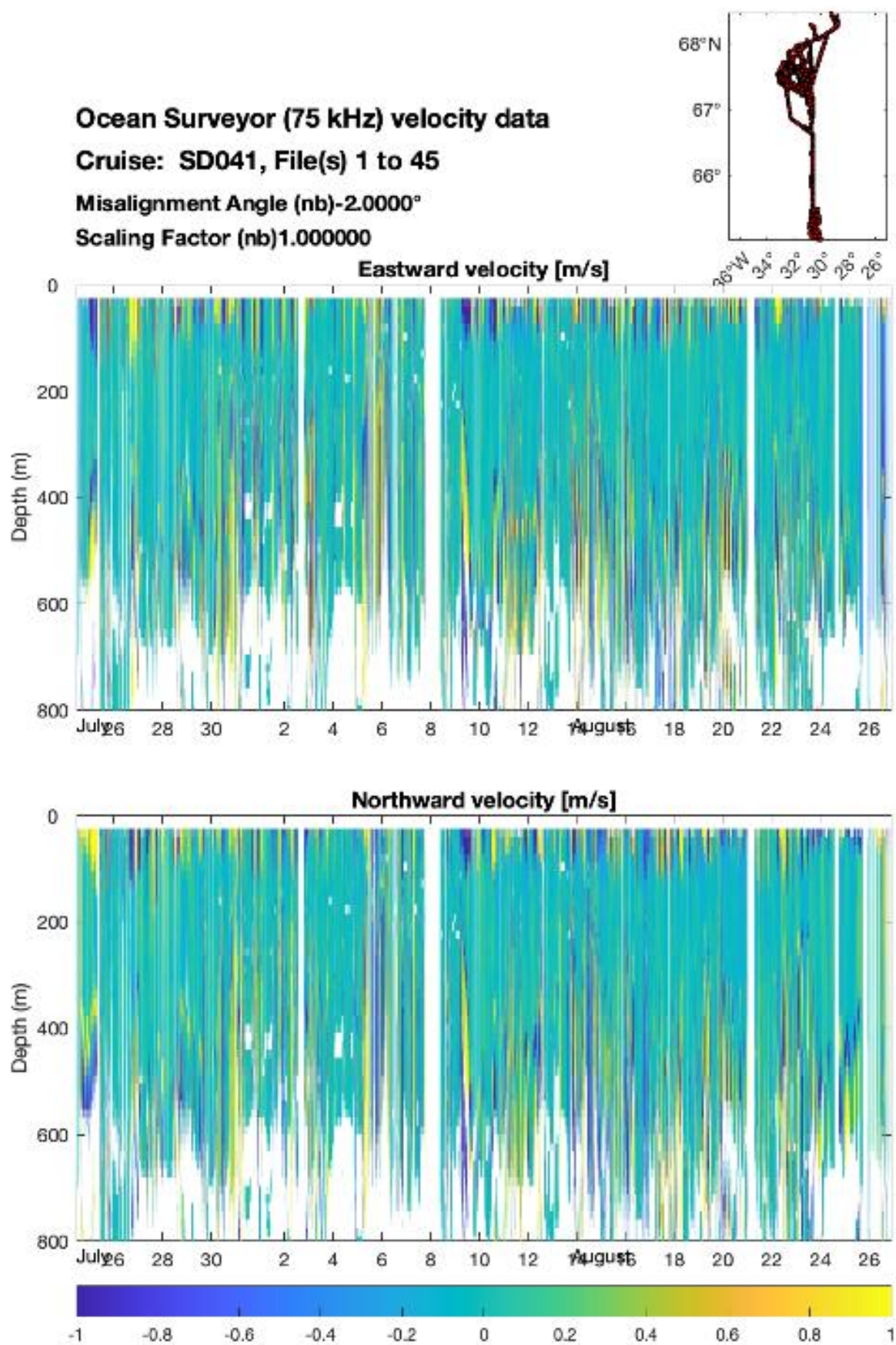


Figure 3.3-6. *u* and *v* velocity components of the 75 kHz VM-ADCP.

3.3.7 Example Sections

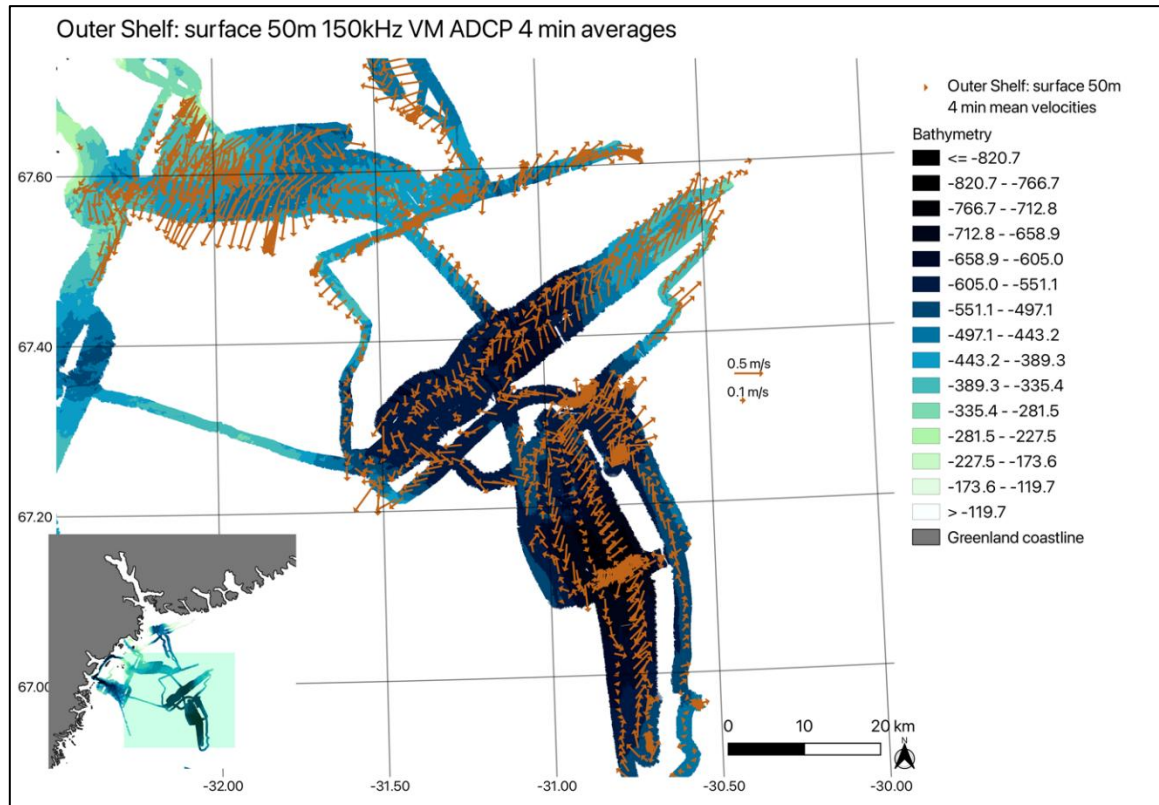


Figure 3.3-7. Outer shelf area showing the top 50 m of the 150 kHz VM-ADCP averaged in 4-minute ensembles.

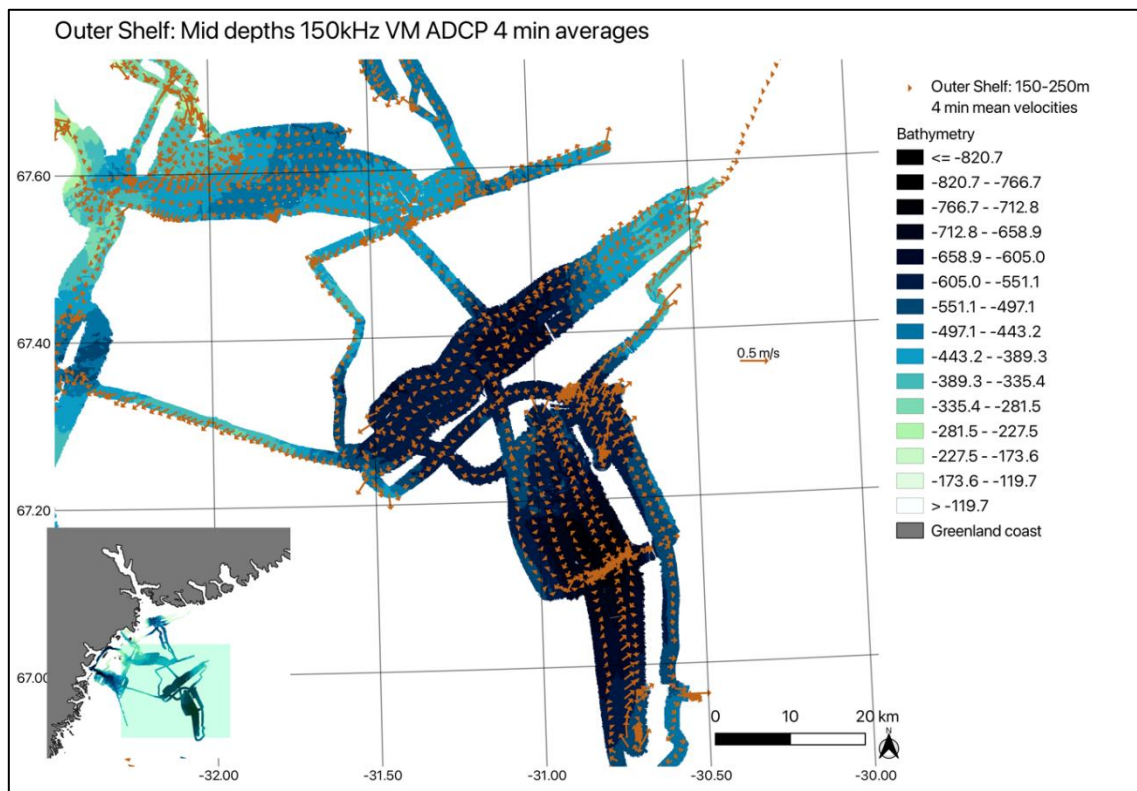


Figure 3.3-8. Outer shelf area showing 150-250 m of 150 kHz VM-ADCP (4 minute ensembles).

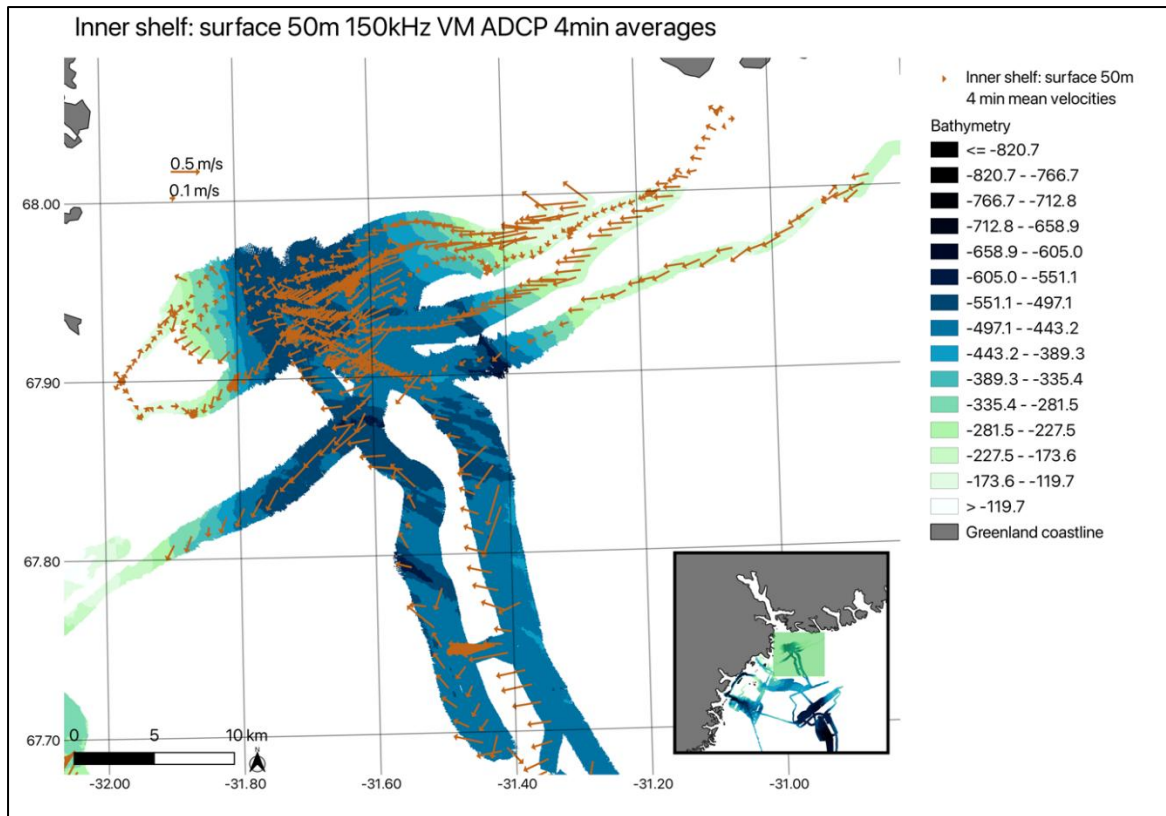


Figure 3.3-9. Inner shelf area showing the top 50 m of the 150 kHz VM-ADCP averaged in 4-minute ensembles.

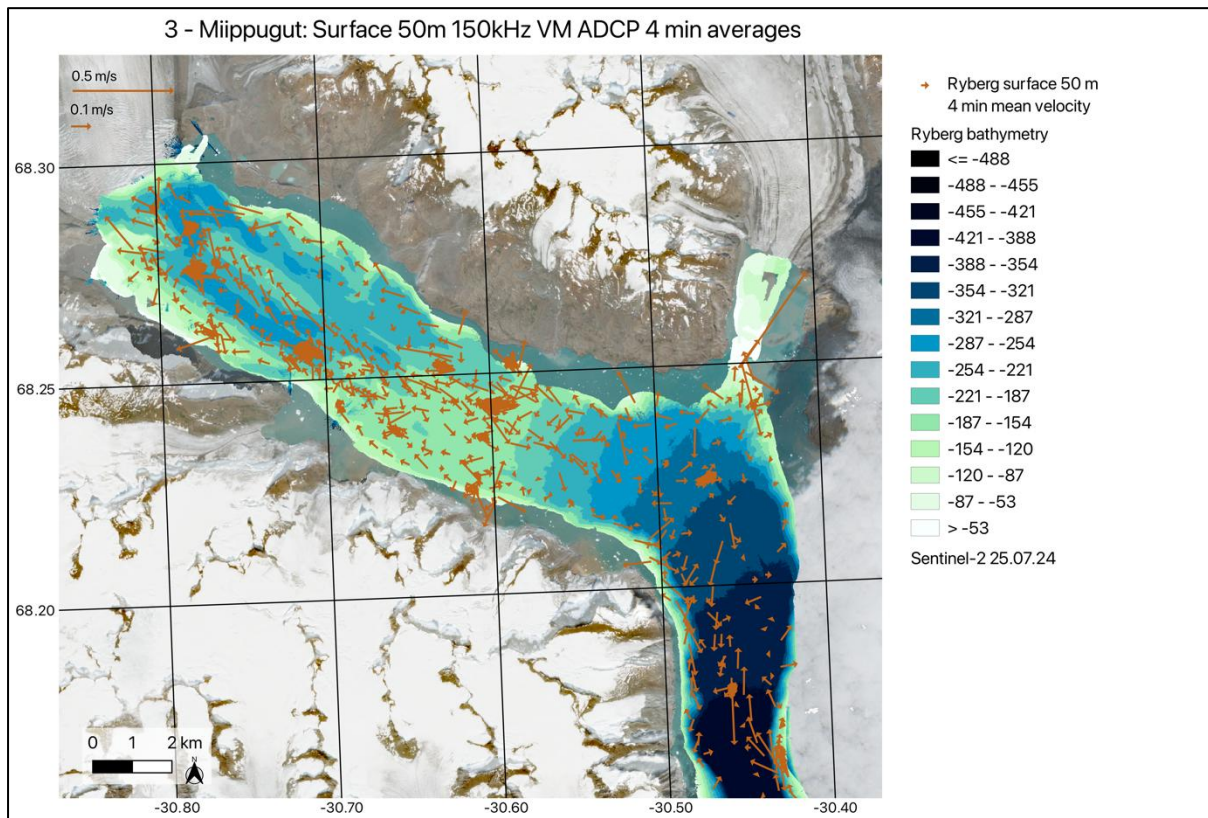


Figure 3.3-10. 3-miippugut Fjord showing the top 50 m of the 150 kHz VM-ADCP averaged in 4-minute ensembles.

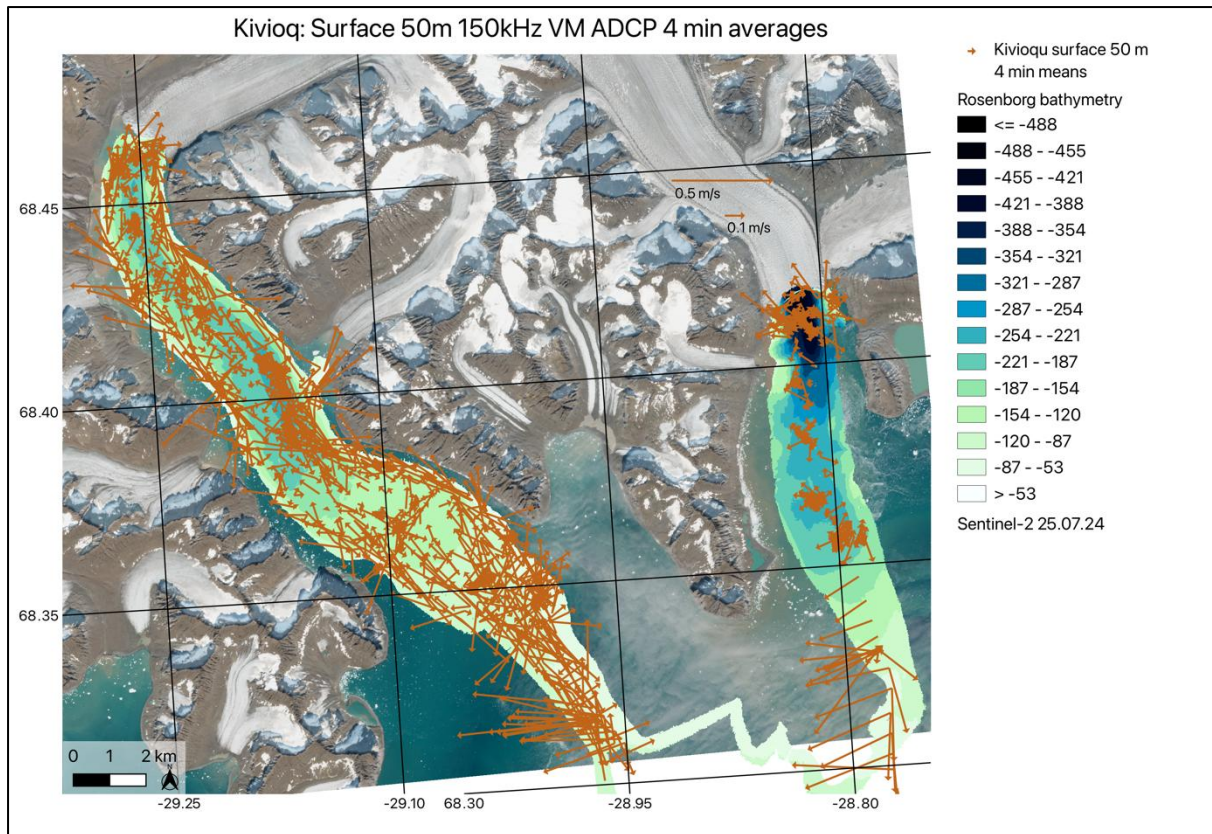


Figure 3.3-11. Kivioq Fjord showing the top 50m of the 150 kHz VM-ADCP, 4-minute ensembles.

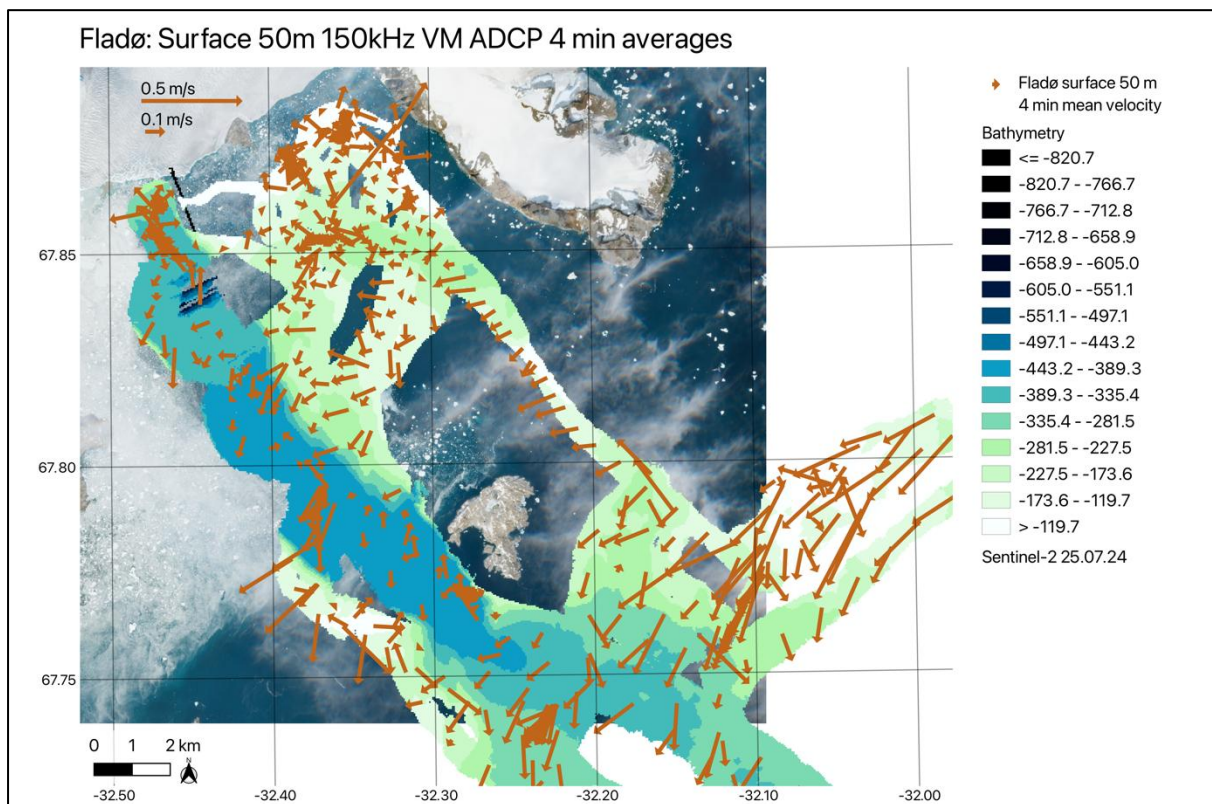


Figure 3.3-12. Fladø Trough area showing the top 50m of the 150 kHz VM-ADCP, 4-minute ensembles.

3.4 Salinometry

Author: Bryony Freer (BAS)

3.4.1 Collecting Salt Samples

On SD041, salinity samples were collected from all CTDs in Greenland waters (3 to 90) as well as from the underway uncontaminated seawater supply (UCSW) at approximately 6 hourly intervals (between 23 July and 24 August 2024). We note there are a number of gaps in the UCSW dataset as the underway system had to be turned off in sea ice to avoid the system clogging.

The process for taking the salinity samples was the same in all cases: rinse the bottle three times, fill it up to the bottom of the neck, dry the top with blue roll, seal the bottle with a stopper and then screw on the cap. For the CTDs, the number of salt samples taken was dependent on the depth of the cast and the variability of salinity throughout the water depth. Where $\delta^{18}\text{O}$ samples were collected, a salinity sample was also taken from the same Niskin bottle. Otherwise, the chosen depths for firing the Niskin bottles tried to avoid the thermocline or any other depths with significant changes in salinity. When on a joint physics-biology station, the depths chosen were also influenced by the depths that the biologists wanted to sample.

3.4.2 Salinometer Instrument and Standardisation

All salinity samples were then run through a Guildline Autosol 8400B salinometer. This salinometer measures the conductivity of a water sample with very high precision, in a water bath of a known temperature (set to 24°C). The readout is given as twice the conductivity ratio between the sample and standard seawater with salinity 35 PSU at 20°C, and 1 atmospheric pressure (known as the Vienna Standard). The instrument used (serial no. 73104) was standardised at the beginning of the cruise with the resistor set to 526 giving a standby reading of between 6038–6040. Once the instrument had been standardised it was left like this for the rest of the cruise. IAPSO standard seawater, supplied by Ocean Scientific International Ltd. (OSIL) batch number P168 was used to provide calibration readings at regular intervals: before and after each crate of 24 salt samples so that corrections could be applied to the intermediate measurements if there had been some drift within the measurements across the 24 bottles. Where possible, we ran two or three crates through the salinometer back-to-back so that we could minimise use of seawater standards; in this case, we would use the same standard reading at the end of the first crate as the reading for the start of the second crate, rather than repeating for a second time.

3.4.3 Standard Procedure for Measuring Salts

Each crate of 24 salinity samples was left in the salinometer room at least 24 hours before being analysed, to allow all samples to acclimatise to the room temperature, which was kept between 19°C and 22°C. The salinometer water bath was set to a temperature of 24°C, as it is most effective at keeping a constant temperature just above the ambient air temperature. Before starting each analysis, we recorded the air temperature in the salinometer room, and made sure to ventilate the room if it was getting too warm. We also recorded the standby and zero readings on the salinometer.

At the start and end of each crate we flushed the system with an old (previously opened) standard to remove any traces of milliQ, before taking a salinity reading from a new standard (batch P168, as described above). The standard operating procedure for measuring the salinity of each bottle (either a CTD/UCSW sample or a standard seawater bottle) was as follows: First, we gently agitate each sample (or standard) bottle a few times in order to mix the water and avoid

stratification whilst avoiding the introduction of air bubbles into the sample. Then we flush the salinometer three times with each sample (or standard) to remove any traces of the previous sample. After flushing, we take a minimum of three readings, flushing between each reading and allowing sufficient time for the readout value to stabilise on a final value. Once we have three measured values within a max range of 0.0002, we take the mean reading as the accepted value for that sample.

After completing the analysis for each crate we recorded the air temperature in the room (which had often increased by $\sim 1^{\circ}\text{C}$), and another standby and zero reading. When the salinometer was not being used it was flushed with milliQ to avoid the build-up of salt crystals in the system.

The accepted mean readout for each sample was recorded on a paper sheet and entered into the excel spreadsheet found: L:\work\scientific_work_areas\salinometer\sd041_master.xlsx. This spreadsheet converted the readout values to practical salinities. Values were also recorded by the salinometer software on the laptop in the salinometer room.

3.4.4 Issues Encountered

3.4.4.1 *Silty samples upset the salinometer*

The salinometer generally performed well, but we experienced some more significant issues when running samples from fjords with very high sediment loads. In many cases it was necessary to run 4 to 6 repeat measurements per sample to get readout values within 0.0002, which significantly increased the time taken to complete the analysis of an entire crate.

This was a particular problem when running the samples from crate 8 (analysed during night shift on 03/08/24). For this crate, it was recognised before we ran them through the salinometer that some of the samples in this crate were very silty. To address this, Povl and Ais removed the siltiest bottles from the crate to keep for later analysis. These included bottles 8-3, 8-5, 8-22 and 8-23. We went ahead and ran the rest of the crate through the salinometer. At first, the readings went smoothly. From bottle 8-12 onwards, we found it increasingly difficult to get repeat readout values within 0.0002 without taking up to 8 repeat measurements per sample. By bottle 8-17 it was not possible to get a reliable readouts within <0.0005 between repeat measurements. By bottle 8-18, the salinometer values refused to settle when taking a reading: when set to READ, it was noted that the values on the screen continually dropped at a steady rate from 7475 to <7410 within one minute and never settled. At this point it was decided to halt analysis for this crate, adding stoppers and lids back on to the bottles to prevent too much evaporation in the event that we were able to re-run these samples at a later date.

To deal with this issue with the salinometer, we took the following actions:

- The next morning we reported back to Povl and Ais and it was decided to give the salinometer cell a 24–48 h ethanol soak.
- All suspected silty samples from subsequent crates were held back for analysis at the end of the cruise to avoid causing a similar issue.
- Following the ethanol soak, we adapted the standard protocol for taking salinometer readings for all crates collected within fjord regions that were likely to be affected by siltiness. This included agitating the entire crate 15 minutes before starting analysis instead of agitating each bottle immediately before reading. We note that this may lead

to some subsequent stratification of the salinity within each bottle, but this did not seem to affect the results too much.

- We also pushed some more of the pump tube up into the pump casing so that it didn't sit so low in the sample bottle, in order to prevent the tube taking in any silt that had settled at the bottom of the bottle.
- Finally, in between bottles we added two additional steps in an attempt to negate issues caused by silty samples: (1) flush the cell with Milli-Q, and (2) flush the cell with filtered seawater.
- All subsequent crates were checked for particularly silty samples, which were then held back to run at the end of the cruise to prevent a repeat of the same issue.

These actions were successful; following the 24-48 h ethanol soak and the introduction of the updated silty sample protocol, there were no further major issues with the salinometer readings. One additional crate (13) had a number of bottles that required several repeat measurements for values to agree within <0.0002 , and so analysis was paused to re-do later for these samples. In this instance no further action to clean the salinometer was required. Once all other crates had been analysed, we repeated measurements from the bottles in crate 8 that still had enough water left (at least half full), as well as all of the siltiest samples that had been identified from other crates (including 13). These readings were successful, and caused no further problems with the salinometer. For crate 8 we found the repeat salinity measurements (analysed 23 days later) were typically between 0.004 – 0.007 higher than the original readings. For crate 13, the repeat measurements (taken 12 days later) were between 0.01–0.04 higher.

3.4.4.2 Incorrect standard batch used for single crate

The incorrect standard batch (P166 instead of P168) was used for analysis of crate 9 (10/08/24, page 9) due to a miscommunication error and mis-labelling of a box. This issue could be avoided in future by keeping boxes of different standard batch that aren't to be used on this cruise in a different cupboard or drawer.

3.5 Underway Measurements

Author: Bryony Freer (BAS)

3.5.1 Accessing Data through RVDAS

The SDA underway (navigation, meteorological + oceanographic, and bathymetry) data was saved to the RVDAS PostgreSQL database containing all current and earlier SDA cruises. To access the instruments available and the data output by the current cruise, a data view, SD041, was set up by the data manager.

The connection to the database was set up via the Matlab Database Toolbox's internal (native) PostgreSQL interface. The advantage of using the native interface over ODBC (Open Database Connectivity), which was used on SD033, is cross-platform compatibility with non-Windows operating systems, where implementation of ODBC are not readily available. Prior to SD033, the scripts called the PostgreSQL command line tools and loaded the resulting files into Matlab; on JC211 this was found to be faster than using the native interface.

3.5.1.1 Daily Workflow

For the cruise duration, a daily workflow was followed in which the underway navigation, meteorological + oceanographic, and bathymetry data for the previous day was processed. All information on the underway processing, software, prerequisites, file structure, RVDAS data streams and databases, and daily workflow can be found on the BAS GitLab page at: <https://gitlab.data.bas.ac.uk/epab/underway-data-processing>

Initially data are downloaded from the database onto the local disk and stored in a Matlab file. For most of the scripts, the day number can be provided as an argument. Examples below are provided for 12 August (day 226):

```
load_daily_nav(226);    % load daily navigation streams

append_daily_nav(226);  % append daily navigation to concatenated file

load_daily_bathy(226);  % load daily bathymetry streams

edit_daily_bathy(226);  % edit daily bathymetry streams manually

append_daily_bathy(226); % append daily bathymetry

load_daily_ocl(226);    % load daily science sensors

plot_daily_ocl(226);    % plot edited science sensors to check editing

append_daily_ocl(226);  % append science data
```

At this stage, the concatenated files of raw/edited data will be up to date. If, for any reason, a file is revised, it can be added to the concatenated file with `append_daily_[whatever]`. However, any subsequent files also need to be appended. Alternatively, all files can be concatenated using `make_total_[whatever]`.

Once all daily files have been processed, we make the averaged files of the whole cruise duration between 20 July and 30 August (at 1-s and 30-s averaged intervals) using:

```
make_ave_nav;          % calculate averaged navigation files

make_ave_bathy;        % calculate averaged bathymetry files

make_ave_ocl;          % calculate averaged science files

sd041_edit_ocl_ave;    % edit averaged OCL files to filter TSG data by flow rate, spike amplitude
                        % and value range, and remove unwanted datasets

export_underway_to_netcdf; % merge the averaged files into a single CF-compliant NetCDF file

export_track_to_gpx(4); % export the ship track to a GPX interchange file at 2-minute resolution
```

This results in the following files (Matlab tables), stored in the directory `L:\work\scientific_work_areas\underway\underway-data-processing\`:

- `sd041_nav_seapath1_1s_ave.mat`
- `sd041_nav_seapath1_30s_ave.mat`
- `sd041_nav_seapath2_1s_ave.mat`

- sd041_nav_seapath2_30s_ave.mat
- sd041_ocl_1s_ave.mat
- sd041_ocl_1s_ave_clean.mat
 - Conductivities and salinities calibrated against salinometer measurements
 - All TSG data cleaned by flow rate, spike amplitude and value range
- sd041_ocl_30s_ave.mat
- sd041_ocl_30s_ave_clean.mat
 - Conductivities and salinities calibrated against salinometer measurements
 - All TSG data cleaned by flow rate, spike amplitude and value range
- sd041_bathy_1s_ave.mat
- sd041_bathy_30s_ave.mat

3.5.2 Navigation Data

Navigational data were collected continuously throughout the cruise and loaded to RVDAS.

Table 3.5-1 Table listing the sensor location on the ship, units and RVDAS table name of the underway navigation instruments used on the SD041 cruise.

Data Stream on RVDAS	Measurement	Units	Sensor Location
attitude_ixblue_phins_surface_heading_cr p1_hehdt	Heading	degrees	
attitude_kongsberg_seapath_320_heading _port1_inhdt	Heading	degrees	port
attitude_kongsberg_seapath_320_heading _stbd1_inhdt	Heading	degrees	starboard
attitude_ixblue_phins_surface_motion_crp 1_kmatt	Motion data (heave, pitch, roll)	(degrees/100, cm)	
attitude_kongsberg_seapath_320_motion_ port1_kmatt	Motion data (heave, pitch, roll)	(degrees/100, cm)	port
attitude_kongsberg_seapath_320_motion_ stbd1_kmatt	Motion data (heave, pitch, roll)	(degrees/100, cm)	starboard
gnss_kongsberg_seapath_320_port1_ingg a	Global Positioning Data, course over ground	degrees	port
gnss_kongsberg_seapath_320_port1_invtg	Global Positioning Data, course over ground	degrees	port
gnss_kongsberg_seapath_320_stbd1_ingg a	Global Positioning Data, course over ground	degrees	starboard
gnss_kongsberg_seapath_320_stbd1_invtg	Global Positioning Data, course over ground	degrees	starboard

3.5.2.1 Processing Navigation Data

The underway navigational data was processed in Matlab (R2021a) on Windows (Windows 10 Enterprise). The scripts used were provided by Povl Abrahamsen. The Matlab scripts were modified to use the native PostgreSQL interface as detailed above, and scripts were updated to call the current set of instrumentation available. All scripts are available under L:\work\scientific_work_areas\underway\underway-data-processing.

rvdas_tables.m	Makes use of the Database Toolbox to locate all tables under the cruise view and save their names locally to the leg drive.
set_underway_params.m	Sets all the table names as listed in Table 3.5-1 to the structure <i>nav_tables</i> which is called by any scripts loading, saving, or analysing the navigation data.
load_daily_nav.m	Reads in the year day and loads the daily navigation data and saves it as a Matlab grid to the directory L:\work\scientific_work_areas\underway\nav. The data is plotted from the same script by calling <i>plot_daily_nav.m</i> . An example is shown below in Figure 3.5-1.
append_daily_nav.m	Appends the daily files within the directory L:\work\scientific_work_areas\underway\nav
make_total_nav.m	Concatenates all navigation tables within the directory L:\work\scientific_work_areas\underway\nav
make_ave_nav.m	Makes 1-s and 30-s averaged underway navigation data files. An example is shown below in Error! Reference source not found..

Example outputs of the underway navigational data processing are shown in Figure 3.5-1 and **Error! Reference source not found..**

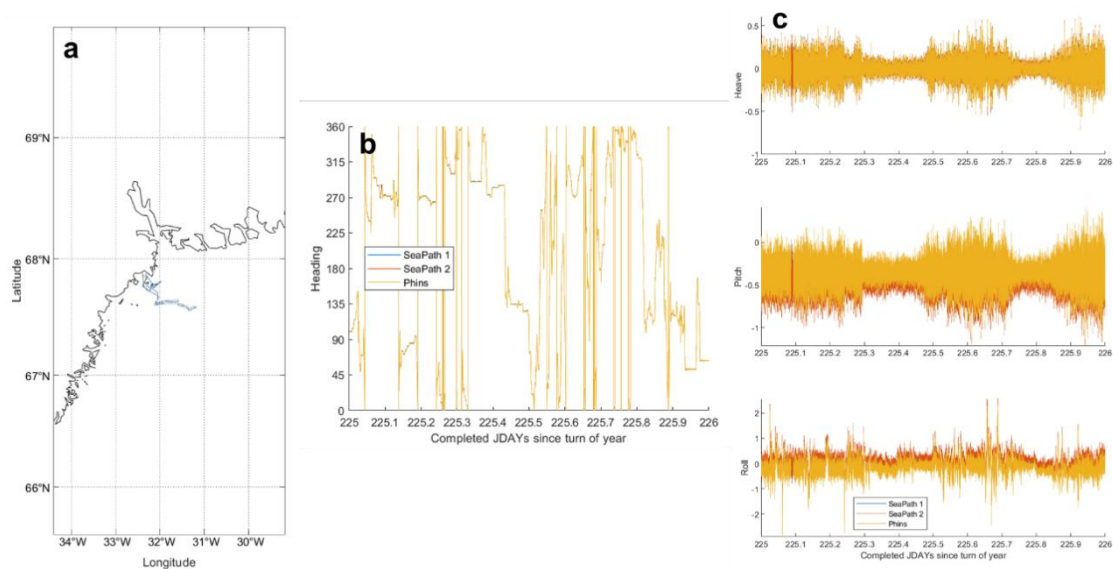


Figure 3.5-1 Example navigation outputs for a single day (12 August 2024 / Julian Day 226). (a) Ship GNSS location (dark blue) when surveying a region to the SW of Kangerlussuaq Fjord. (b) Ship heading. (c) Ship heave, pitch and roll.

3.5.3 Oceanographic and Meteorological Data

Oceanographic and meteorological data were collected continuously throughout the cruise and loaded to RVDAS.

Table 3.5-2 List of oceanographic and meteorological sensors used on SD041, their location on the ship, and the RVDAS table names, as called in the set_underway_params.m script.

Data Stream on RVDAS	Measurement	Units	Sensor	Sensor Location
anemometer_ft_tech_ft702lt_centremast1_wimwv	Wind speed and angle	degrees, m/s	anemometer	centre mast
anemometer_observator_omc116_portmast1_wimwv	Wind speed and angle	degrees, m/s	anemometer	port mast
anemometer_observator_omc116_stbdmast1_wimwv	Wind speed and angle	degrees, m/s	anemometer	starboard mast
flowmeter_litremeter_lmx24_ucsw1_plmflow1	Flow speed (TSG)	L/min	flowmeter	hull (intake at depth 7m), instrument in UCSW lab
fluorometer_wetlabs_wschr_ucsw1_pwlfluor1	Chlorophyll	counts	fluorometer	hull (intake at depth 7m), instrument in UCSW lab
met_michell_optidew2_aerosol1_pmdew1	Relative humidity	%	chilled mirror hygrometer	Port wing, deck 10
met_vaisala_hmp155e_foremast1_pvtmh2	Relative humidity, Dew point temperature, wet bulb temperature, mixing ratio	%, degrees, Celsius, g/kg	hygrometer and thermometer	foremast
met_vaisala_hmp155e_scimast1_pvtmh2	Relative humidity, Dew point temperature, wet bulb temperature, mixing ratio	%, degrees, Celsius, g/kg	hygrometer and thermometer	scimast
met_vaisala_hmp155e_scimast2_pvtmh2	Relative humidity, Dew point temperature, wet bulb temperature, mixing ratio	%, degrees, Celsius, g/kg	hygrometer and thermometer	scimast
met_vaisala_ptb330_v2_aerosol1_pvbar	Air pressure	hPa	barometer	aerosol lab
met_vaisala_ptb330_v2_aerosol2_pvbar	Air pressure	hPa	barometer	aerosol lab

radiometer_heitronics_ ct15_85_port1_phsst	Sea surface temperature	Degrees Celsius	Radiometer	port
radiometer_heitronics_ ct15_85_stbd1_phsst	Sea surface temperature	Degrees Celsius	Radiometer	starboard
radiometer_kipp_zonen_ _smp22_foremast1_pkpyran	Total incoming radiation (TIR)	W/m ²	Radiometer	foremast
radiometer_kipp_zonen_ _smp22_scimast1_pkpyran	Total incoming radiation (TIR)	W/m ²	Radiometer	scimast
radiometer_satlantic_par_ _foremast1_pspar	Photosynthetic ly available radiation (PAR)	μmol/m ² /s	Radiometer	foremast
radiometer_satlantic_par_ _scimast1_pspar	Photosynthetic ly available radiation (PAR)	μmol/m ² /s	Radiometer	scimast
soundvelocity_valeport_ minisvs_ucsw1_pvsv1	Sound velocity	m/s	sound velocity probe	hull (intake at depth 7m), instrument in aux. machine room 2
thermometer_seabird_ sbe38_ucsw1_psbst1	Water temperature	Degrees Celsius	thermometer	hull (intake at depth 7m), instrument in aux. machine room 2
thermometer_seabird_ sbe38_ucsw2_psbst1	Water temperature	Degrees Celsius	thermometer	hull (intake at depth 7m), instrument in aux. machine room 2 stb
thermosalinograph_seabird_ _sbe45_ucsw1_psbts1	Temperature, Salinity, Conductivity	Celsius, S/m, PSU	thermo- salinograph (TSG)	hull (intake at depth 7m), instrument in UCSW lab
transmissometer_wetlabs_ _cstar_ucsw1_pwltran1	beam transmission	%	transmissometer	hull (intake at depth 7m), instrument in UCSW lab

3.5.3.1 Processing OCL data

The underway oceanographic and meteorological data were processed in Matlab (R2021a) on Windows (Windows 10 Enterprise). The scripts were provided by Povl Abrahamsen. The Matlab scripts were modified to use the native PostgreSQL interface as detailed above, and scripts were updated to call the current set of instrumentation available. All scripts are available under L:\work\scientific_work_areas\underway\underway-data-processing. For more details read the documentation present in the README.md file.

rvdas_tables.m	Makes use of the Database Toolbox to locate all tables under the cruise view and save their names locally to the leg drive.
set_underway_params.m	Sets all the table names as listed in Table 3.5-2 to the structure <i>nav_tables</i> which is called by any scripts loading, saving, or analysing the oceanographic and meteorological data.
load_daily_ocl.m	Reads in the year day and loads the daily oceanographic and meteorological data and saves it as a MatLab grid to the directory L:\work\scientific_work_areas\underway\occl. The data is plotted from the same

	script by calling <i>plot_daily_ocl.m</i> . Examples of daily plots are shown in Figure 3.5-2, Figure 3.5-3 and Figure 3.5-4.
append_daily_ocl.m	Appends the daily files within the directory L:\work\scientific_work_areas\underway\ocl
make_total_ocl.m	Concatenates all oceanographic and meteorological tables within the directory L:\work\scientific_work_areas\underway\ocl
make_ave_ocl.m	Makes 1-s and 30-s averaged underway oceanographic and meteorological data files.
sd041_edit_ocl_ave.m	Edits the averaged 1-s underway oceanographic and meteorological data files, by: • Flow rate, removing all data where flow rate outside of the normal flow range (1.2 – 1.6 L/min) • Spike amplitude, removing all data for each variable where there are prominent spikes • Range, removing all data outside of a specified range for each variable Also includes code to apply offset calibration to the TSG salinity and conductivity data.
plot_ave_ocl.m	Plot averaged 30-s data of the full time series of oceanographic and meteorological data. Example plots are shown in Figure 3.5-5, Figure 3.5-6, and Figure 3.5-7.
compare_tsg_to_salinities.m	Compare underway thermosalinograph conductivity and salinity to measured salinity from salinometer samples from the UCSW tap. Shows time series of conductivity and salinity for whole cruise and offsets with the measured samples.

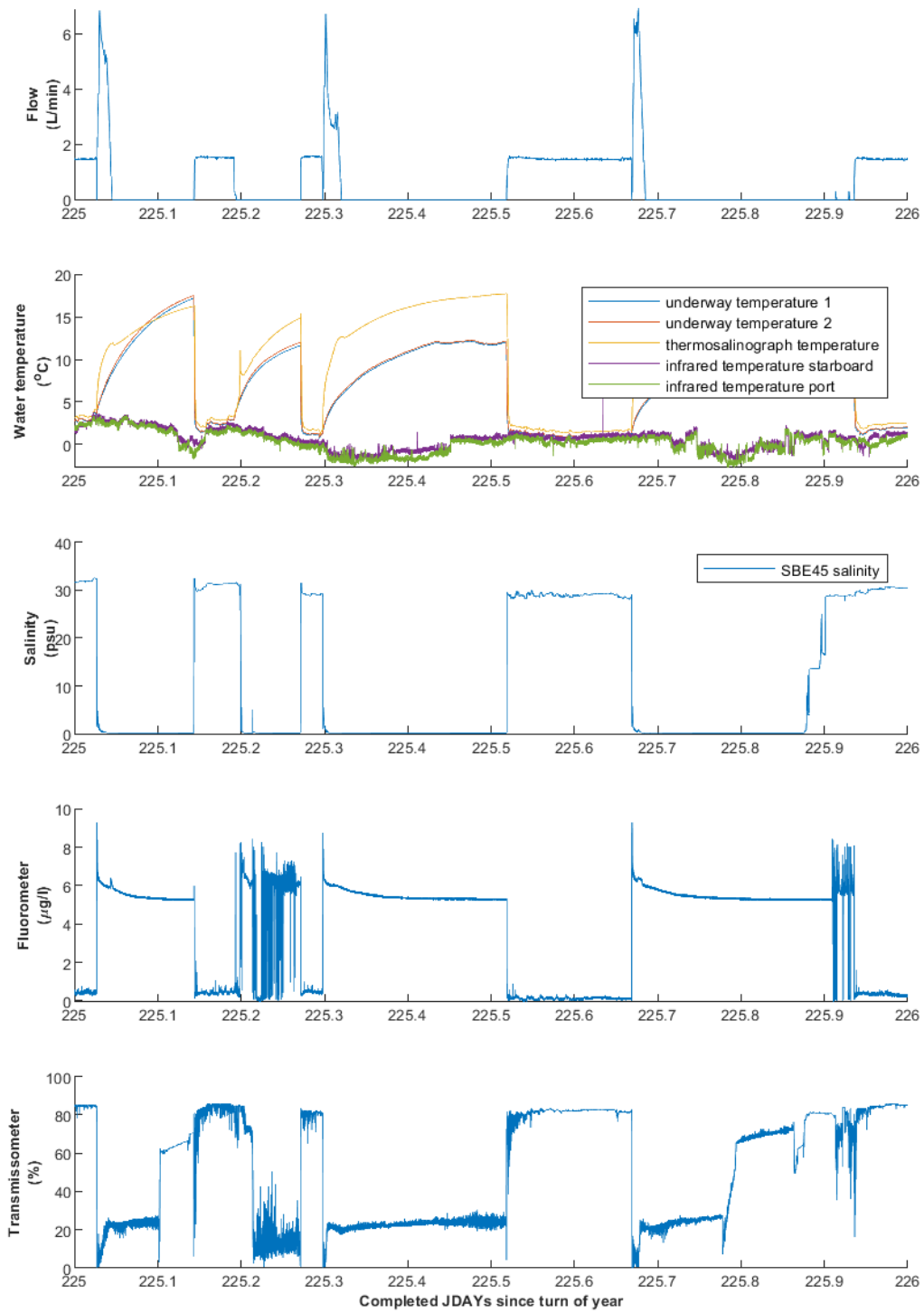


Figure 3.5-2. Example oceanographic (TSG) outputs data (flow rate, water temperature, salinity, fluorescence, transmission) for a single day (12 August 2024 / JD 226).

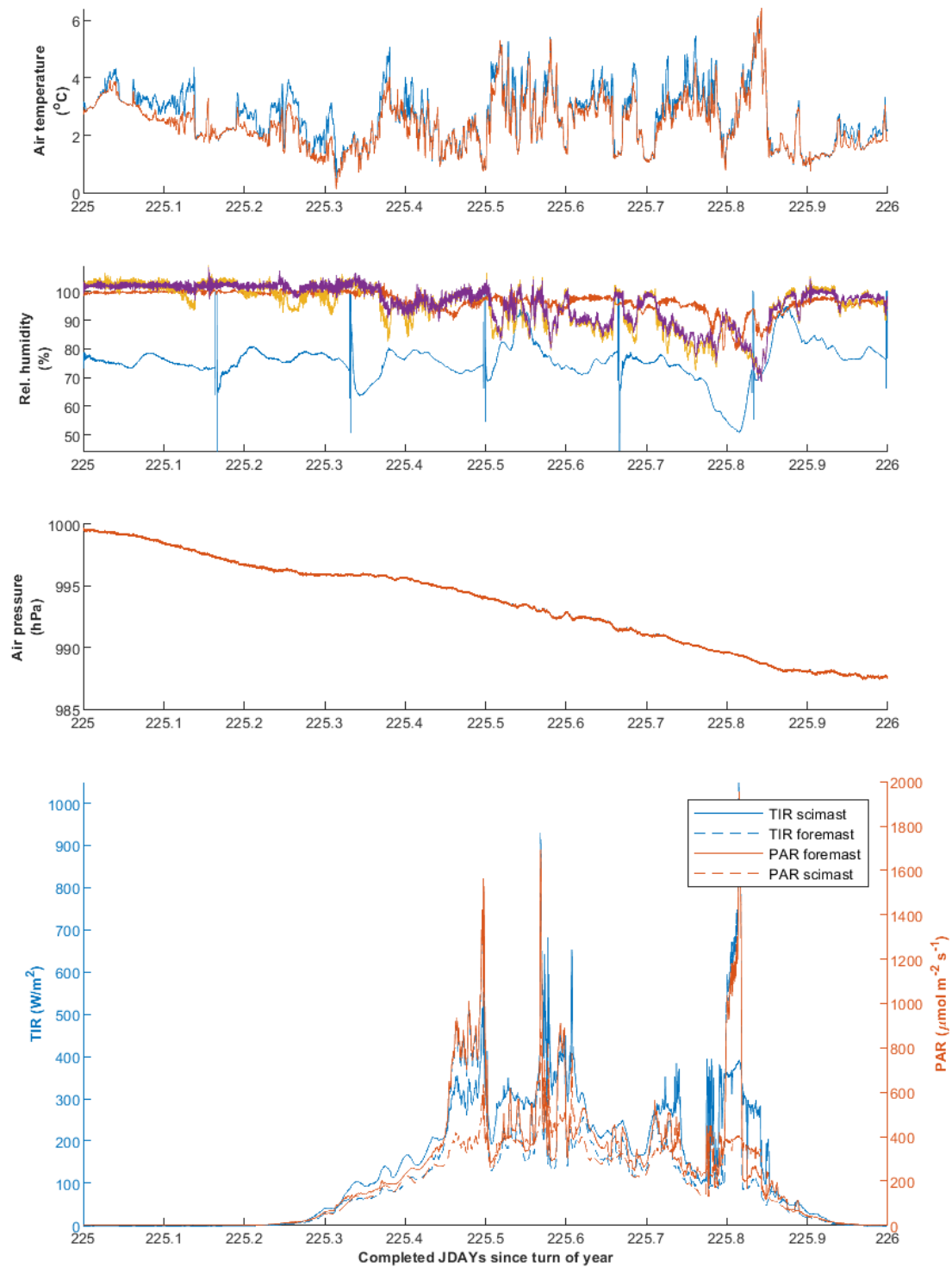


Figure 3.5-3. Example meteorological outputs (air temperature, relative humidity, air pressure and total incoming/photosynthetically available radiation) for a single day (12 August 2024 / JD 226).

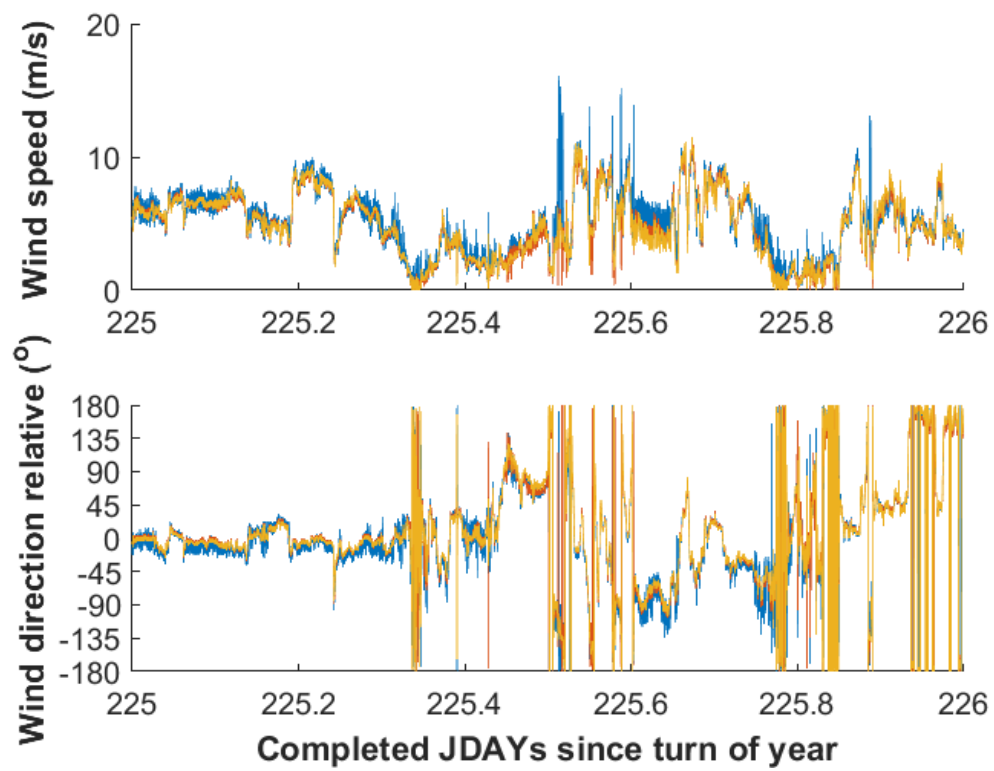


Figure 3.5-4. Example meteorological outputs (wind speed and relative direction) for a single day (12 August 2024 / JD 226)

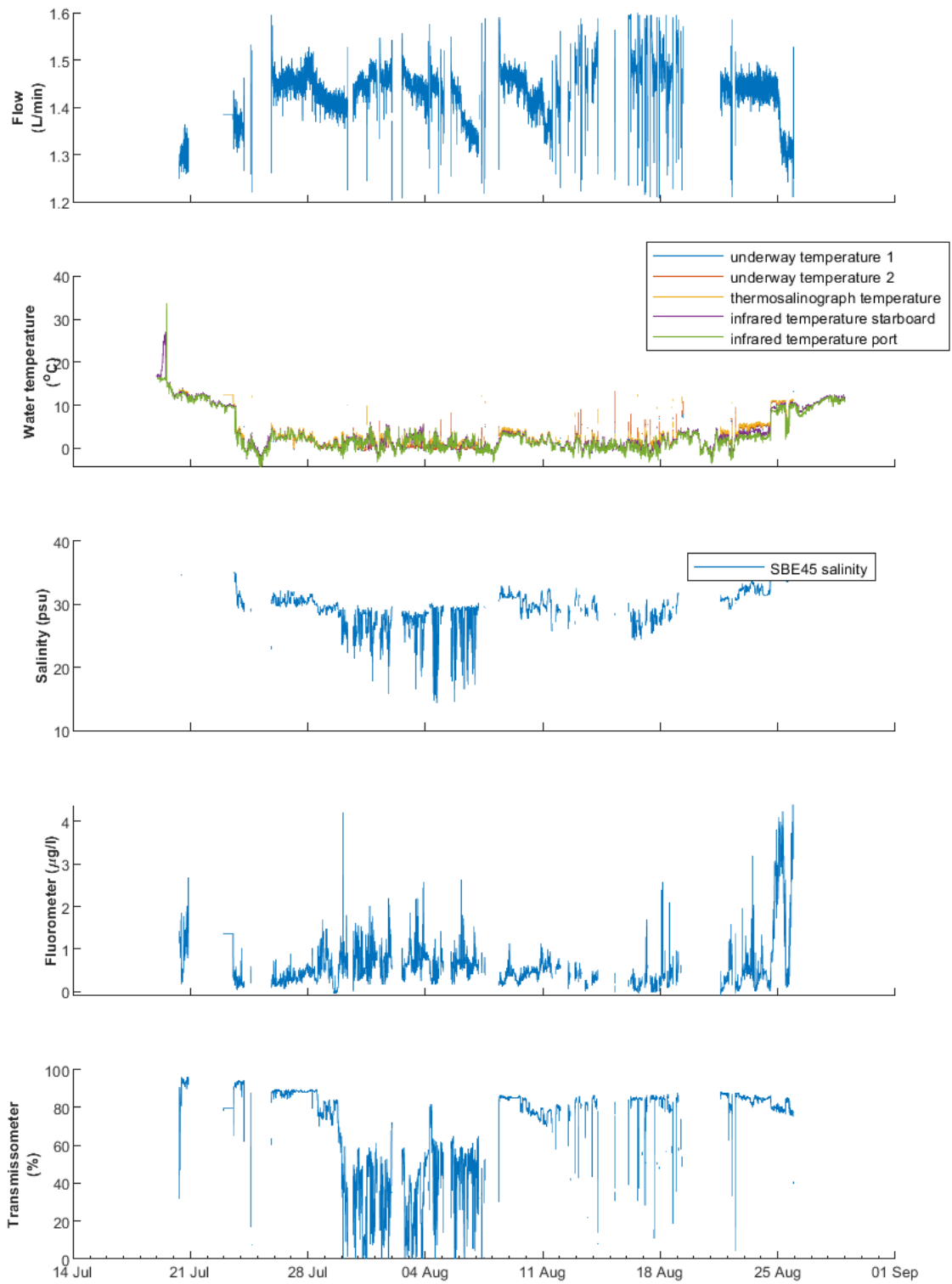


Figure 3.5-5. Time series of thermosalinograph oceanographic data (flow rate, water temperature, salinity, fluorescence, transmission) for the SD041 cruise, 19 July to 25 August 2024.

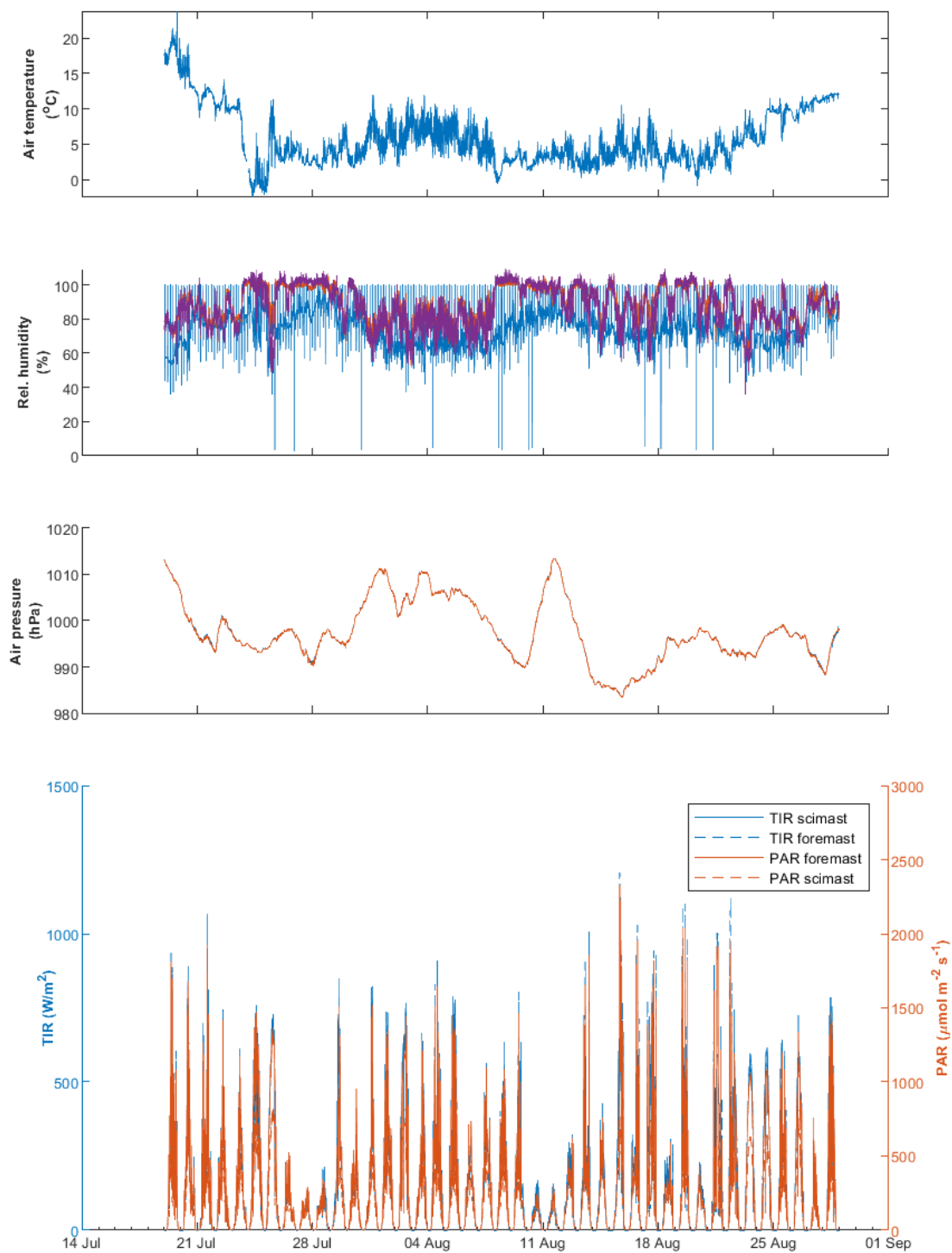


Figure 3.5-6. Time series of meteorological data outputs (air temperature, relative humidity, air pressure and radiation) for the SD041 cruise, 19 July to 29 August 2024.

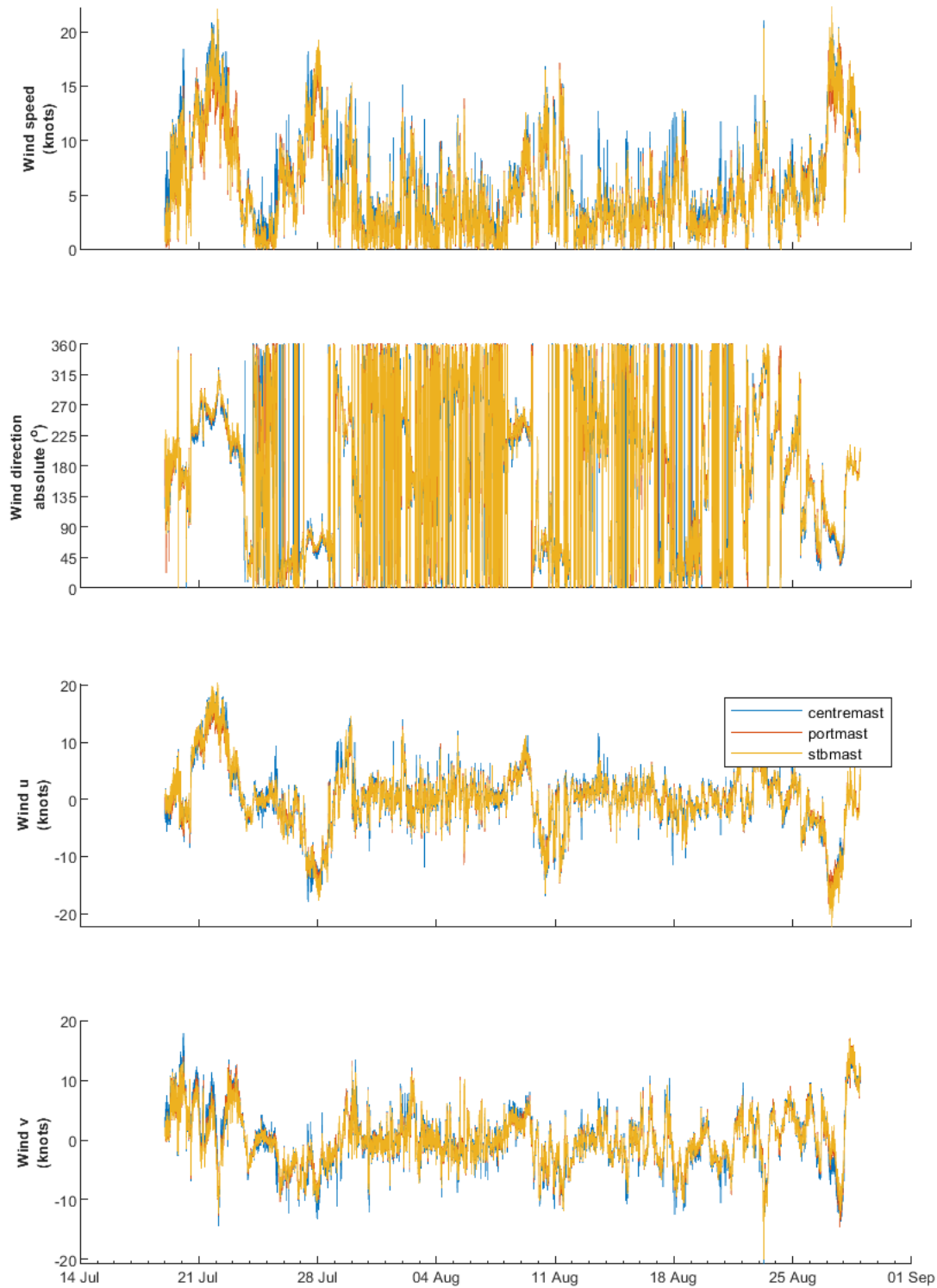


Figure 3.5-7. Time series of wind data (wind speed, absolute wind direction, wind speed u component, wind speed v component) for the SD041 cruise, 19 July to 29 August 2024.

3.5.4 Calibration of Thermosalinograph

The SBE-45 thermosalinograph (TSG) salinities were compared against salt samples collected from the uncontaminated seawater (UCSW) tap in the UCSW laboratory during the cruise. Note, we attempted to take samples every 6 hours from the UCSW tap (as close as possible to 00:00,

06:00, 12:00, 18:00 UTC) but this was not always possible when the underway inflow was switched off due to surrounding sea ice cover.

An approximate -0.001 mS/cm offset was found between the uncalibrated TSG conductivities and measured conductivity, which was calibrated by adding a 0.001 mS/cm offset to all TSG conductivity values. The TSG salinities were then re-calculated using the calibrated conductivity values. This was done within the *sd041_edit_ave_ocl.m* script.

The residual offsets between the calibrated salinities and conductivities are shown in Figure 3.5-8 and Figure 3.5-9 below (conductivity values mostly within 0.1 mS/cm; salinity values mostly within 0.1 psu).

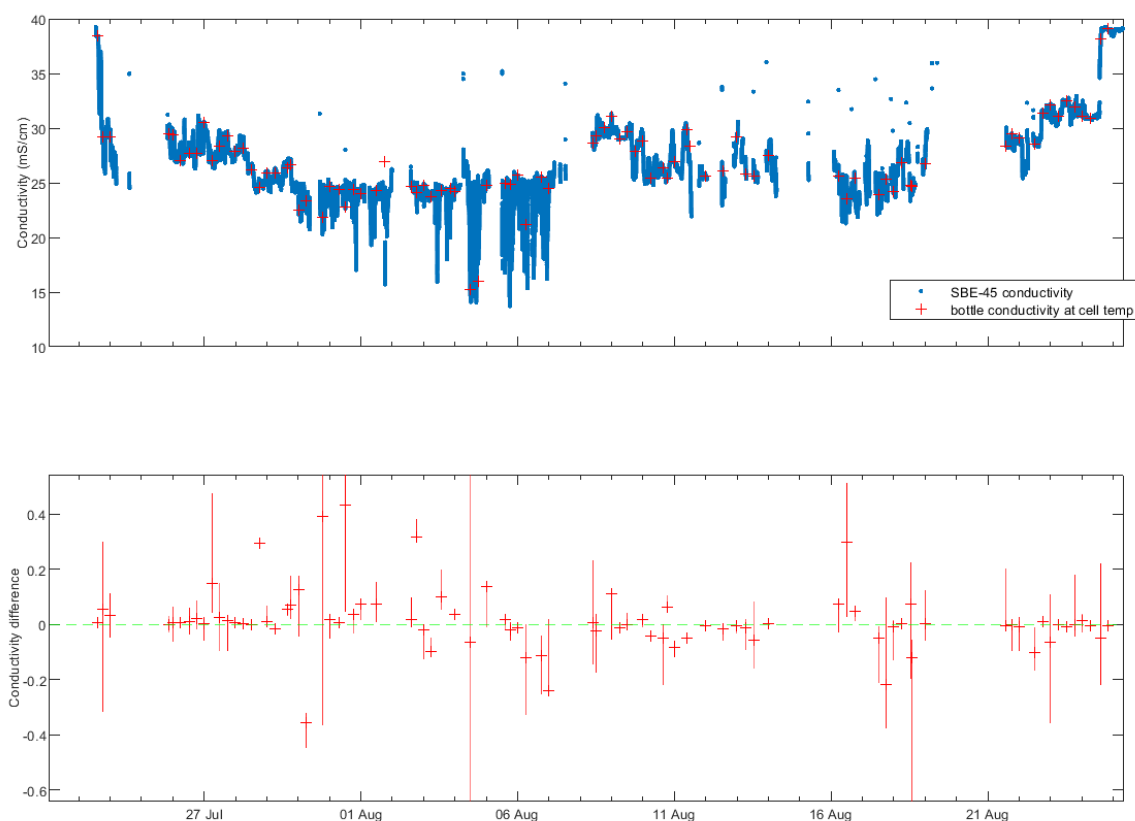


Figure 3.5-8 Calibrated TSG SBE-45 conductivity values throughout SD041 cruise (upper panel), and offsets from measured bottle conductivity values (lower panel).

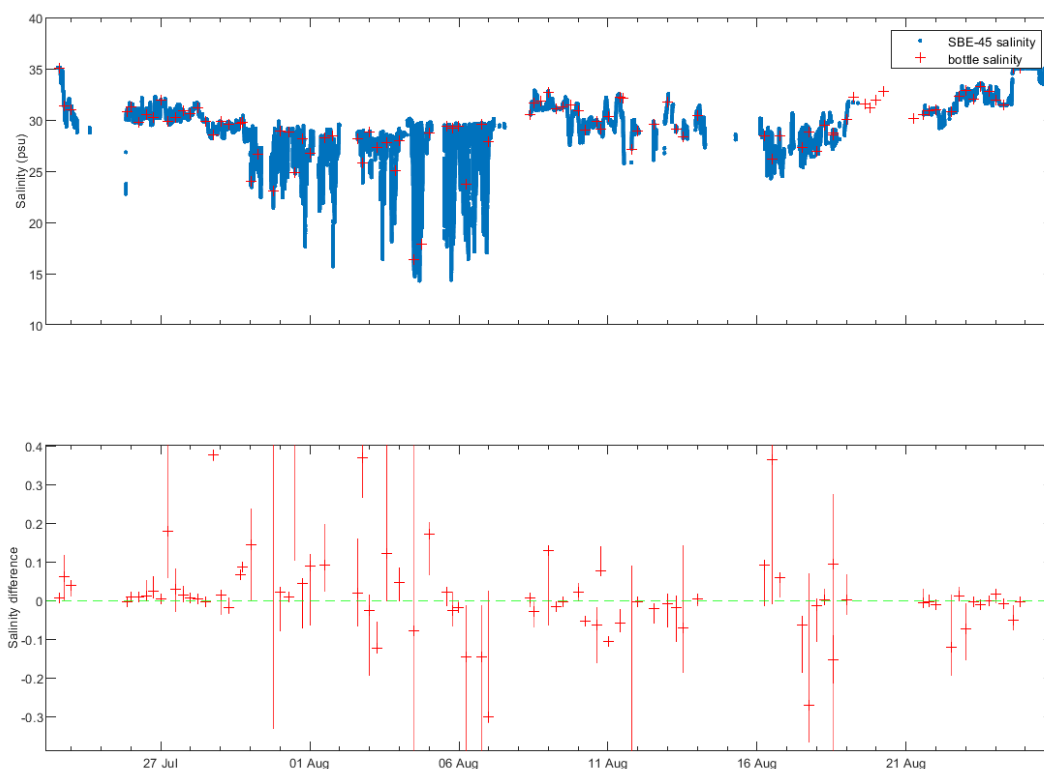


Figure 3.5-9 Calibrated TSG SBE-45 salinity values throughout SD041 cruise (upper panel), and offsets from measured bottle salinity values (lower panel).

3.5.4.1 Issues Encountered

- Intermittent UCSW supply due to sea ice conditions:** The inflow for the UCSW tap had to be switched off whenever the ship was in regions of sea ice or brash ice cover, to prevent ice clogging up the system. These periods can be identified in the flow rate measurements – for example on 12 August (Figure 3.5-2) the UCSW was switched on for 5 separate periods (where the flow rate was between $\sim 1.2 - 1.6$ L/min) and the rest of the time it was switched off (zero flow rate). During post-processing, we removed all TSG data where the flow rate was outside the 1.2-1.6 L/min range, as all recorded temperature, salinity, fluorescence and transmission values are incorrect during this time (as seen in Figure 3.5-2). This explains the gaps in the TSG time series in Figure 3.5-5.
- UCSW turned off:** For several hours between 19–21 August the flow to the TSG instruments was turned off even after the pump had been switched back on, meaning there are gaps in the TSG time series during this time (see Figure 3.5-5).
- Optidew humidity sensor:** Throughout the cruise the humidity values recorded by the *met_michell_optidew2_aerosol1_pmdew1* sensor were greatly different to those recorded by the other three humidity sensors. We investigated this with AME support (Chris Gray) and were unable to find the source of the problem. Restarting the sensor did not help. It seems that the instrument records humidity in a very different way to the other sensors, so it would be worth investigating in the future the cause of the different values and how best to use the data. We have included the data for this sensor in the daily and averaged processed datasets (e.g. can be seen by the blue line in the second panel of Figure 3.5-3 and Figure 3.5-6), but we could consider removing this in future.

- **Incorrect PAR sensor unit:** The unit of the PAR radiometer sensors was given in W/m^2 (same as the TIR sensors), but they are actually recorded in the (very helpful) unit of $\mu mol/m^2/s$. We have now changed the specified unit in the `set_underway_params.m` script and updated the axis labelling in `plot_daily_ocl()` and `plot_ave_ocl()` to reflect this.
- **Foremast folded down:** Helicopter operations meant that the foremast was folded down for a number of days when we were by the Greenland coast. We note that this may have affected the reliability of measurements such as TIR and PAR from the sensors mounted on the foremast.
- **TSG temperatures:** We note that the seawater temperatures recorded by the sensors fitted to the underway system may not be well calibrated. This is because the location of the sensors on the system means that water has to pass through some pipework and bulkhead before reaching the temperature sensor, which could affect the accuracy of the reading. There has not been sufficient time to investigate the impact of this effect on the results during this cruise, but it has been discussed in more detail in the cruise report for SD033.

3.5.5 Bathymetry Data

Bathymetric data were collected continuously throughout the cruise and loaded to RVDAS.

Table 3.5-3. Table listing the sensor location on the ship, units and RVDAS table name of the underway bathymetry instruments used on the SD041 cruise.

Data Stream on RVDAS	Measurement	Units	Sensor Location
multibeam_kongsberg_em122_hull1_kidpt	Water depth	metres	hull
multibeam_kongsberg_em712_hull1_kodpt	Water depth	metres	hull
singlebeam_kongsberg_ea640_hull1_dbdbt	Water depth	metres	hull

3.5.5.1 Processing

The underway bathymetry data was processed in Matlab (R2021a) on Windows (Windows 10 Enterprise). The scripts used were provided by Povl Abrahamsen. The Matlab scripts were modified to use an PostgreSQL interface as detailed above, and scripts were updated to call the current set of instrumentation available. All scripts are available under `L:\work\scientific_work_areas\underway\underway-data-processing`.

Table 3.5-4. Scripts used for processing underway bathymetry data (only for oceanography team plotting) during SD041.

<code>rvdas_tables.m</code>	Makes use of the Database Toolbox to locate all tables under the cruise view and save their names locally to the leg drive.
<code>set_underway_params.m</code>	Sets all the table names as listed in Table 3.5-3 to the structure <code>bathy_tables</code> which is called by any scripts loading, saving, or analysing the bathymetry data.

load_daily_bathy.m	Reads in the year day and loads the daily bathymetry data and saves it as a MatLab grid to the directory L:\work\scientific_work_areas\underway\bathy. The data is plotted from the same script by calling <i>plot_daily_bathy.m</i> .
edit_daily_bathy.m	Graphical interface to remove erroneous data points / spikes to clean the data per day.
append_daily_bathy.m	Appends the daily files within the directory L:\work\scientific_work_areas\underway\bathy
make_total_bathy.m	Concatenates all bathymetry tables within the directory L:\work\scientific_work_areas\underway\bathy
make_ave_bathy.m	Makes 1-s and 30-s averaged underway bathymetry data files. The averaged and cleaned bathymetry data for the whole cruise is plotted in Figure 3.5-10.

3.5.5.2 Issues Encountered

- Note the EM122 and EM712 instruments were only switched on in UK and Greenland waters. The EA640 was running all the time.
- The EM712 multibeam wasn't working well so was only running between 28 July – 4 August and intermittently between 7–13 August.
- The EA640 had short interruptions on 28 July, 5 & 22 August.
- Normally the EA640 is set to output the depth below the transducer, using a fixed speed of sound of 1500 m/s. From 30/08/2024 20:29 this was changed to use a sound speed profile from CTD 27, and not changed back until 8/8/2024 13:39. In the intervening dates, the corrected EA640 depths will be incorrect.

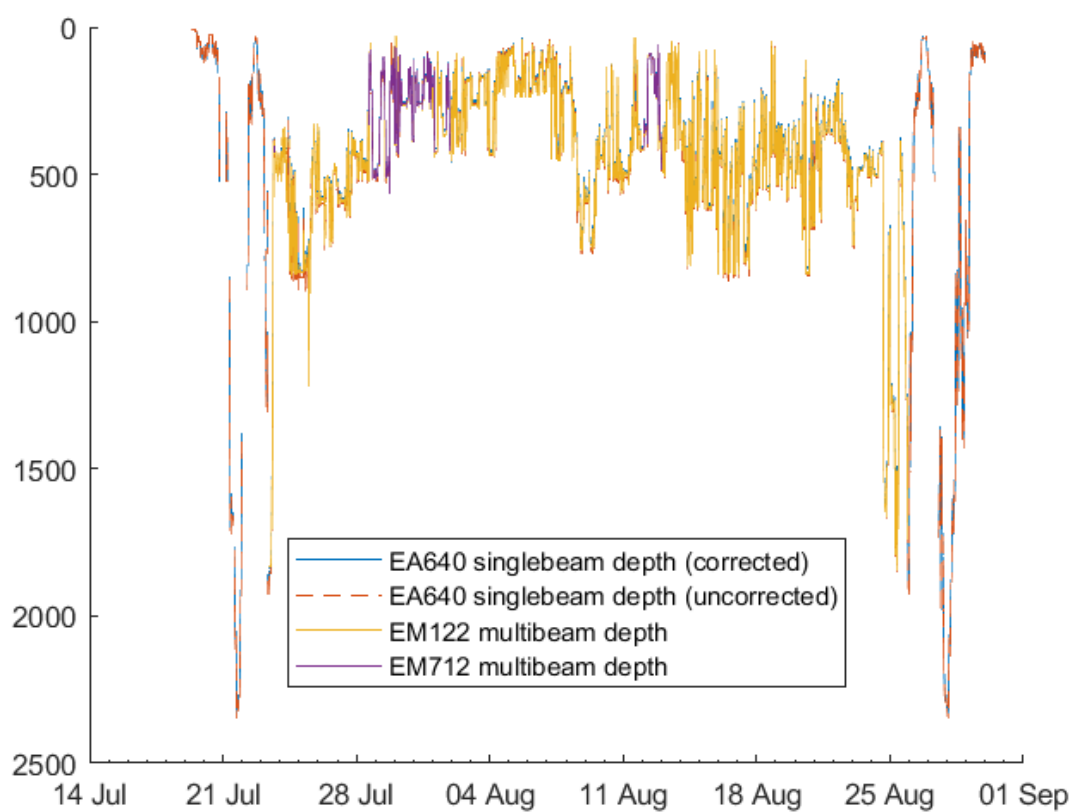


Figure 3.5-10. Time series of bathymetry measurements (water depth) for the cruise duration, 19 July to 30 August 2024. Depths were measured by the EA640 singlebeam (blue = corrected; orange dashed = uncorrected), EM122 multibeam (yellow), and EM712 multibeam (purple).

3.6 Samples for Oxygen Isotopes

Author: Povl Abrahamsen (BAS)

On SD041 a total of 307 samples were collected for stable isotopes of oxygen. These samples will be analysed with a mass spectrometer at the NERC Environmental Isotope Facility at the British Geological Survey, Keyworth, to measure the ratios of ^{18}O to ^{16}O in the water molecules; the anomaly in the ratio compared with a reference standard, VSMOW (Vienna standard mean ocean water), is designated $\delta^{18}\text{O}$. For samples in polar regions, the isotopic signature, in combination with salinity measurements, can be used to deduce the relative contributions of glacial and sea ice sources to freshwater in the samples. 303 of the samples were collected from the Niskin bottles on the CTD rosette, on 53 stations, while four were from glacial samples collected from Erebus.

Samples were collected in 50-ml glass injection vials with 20-mm necks. Each vial was labelled with a sequential number (1-307) preprinted on the label, and the station and Niskin bottle number (or glacial ice location) written on the label with marker pen. Bottles were rinsed three times before filling to the neck of the bottle. A rubber stopper was then inserted, and an aluminium cap crimped onto the top.

The sources of the four glacial samples are given in Table 3.6-1, while the distribution of CTD stations from which samples were collected is shown in figure XX. Samples were collected on the sections crossing Kangerlussuaq Trough, in 3-Miippugut and Kivioq Fjords, and near the mooring location.

Table 3.6-1. Locations of glacial samples collected on ER041.

Sample number	ER041 event	Fjord	Position	Date
204	none	3-Miippugut	68° 17.431' N 030° 49.560' W	03/08/2024
205	none	3-Miippugut	68° 17.431' N 030° 49.560' W	03/08/2024
235	91	Kivioq	68° 27.965' N 029° 15.329' W	06/08/2024
278	127	Apuliliip Apusiia	67° 52.756' N 032° 23.998' W	13/08/2024

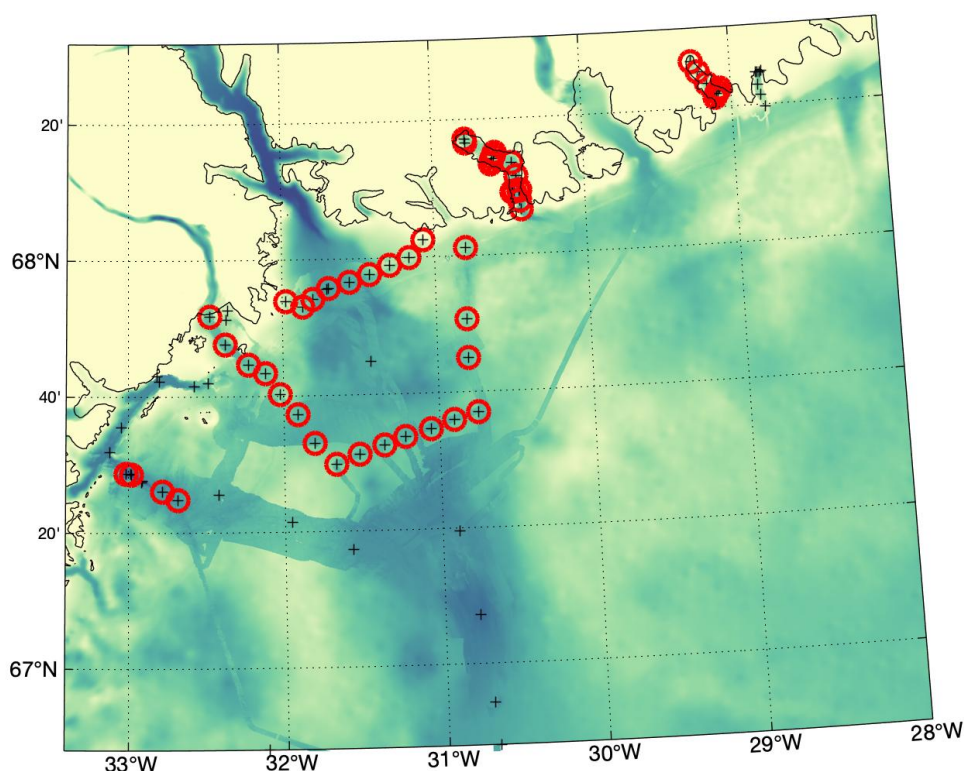


Figure 3.6-1. Distribution of $\delta^{18}\text{O}$ samples collected from the CTD on SD041. Stations where samples were collected are highlighted in red. Bathymetry is from Bedmachine 5 with multibeam bathymetry from SD041 superimposed where available.

3.7 Oceanographic Sampling from Erebus

Author: Povl Abrahamsen (BAS)

The SDA workboat Erebus was used for scientific sampling in the fjords and on the shelf during SD041. These deployments are designated ER041. In addition to deploying the Teledyne Gavia AUV (which included oceanographic instrumentation), a Sea-Bird Scientific SBE19+V2 “Seacat” CTD profiler with auxiliary sensors was deployed both for “physics only” casts, and in conjunction with biological sampling using a Niskin bottle. A Sea & Sun Technology MSS 90L microstructure profiler was also deployed simultaneously so that its near-surface ADCP to measure profiles of turbulent dissipation and currents in the upper ocean.

3.7.1 CTD profiler

To obtain multi-parameter profiles from Erebus we used a self-contained CTD system purchased by BAS to be used for the Rothera Time Series (RaTS). The instrumentation is listed in the table below. All components have a depth rating of at least 600 m.

Table 3.7-1. Instrumentation on the CTD (all manufactured by Sea-Bird Scientific).

Instrument	Serial number	Parameters	Last calibration
SBE19+V2 CTD	8321	Temperature Conductivity Pressure	20-Aug-2023 20-Aug-2023 16-Aug-2023
SBE5P pump	11790	n/a	n/a
SBE43	4460	Dissolved oxygen	12-Sep-2023
SBE18	1731	pH	01-Sep-2023

ECO-FLNTU(RT)	8490	Chlorophyll a Turbidity (NTU)	07-Sep-2023 07-Sep-2023
PAR-LOG ICSW	2320	PAR	14-Aug-2023

The CTD was deployed on three days, for a total of 46 casts, designated ER041_CTD_001 through _046. There are no data from cast 29, as the CTD was accidentally not switched on. This profile was immediately repeated as cast 30, with data collected. In addition to the casts from Erebus, the CTD was attached to the vane of the ship's main SBE911plus CTD system on stations 55, 64, and 65, to compare the readings with the ship's sensors. For processing in Matlab, these casts have been numbered 955, 964, and 965.

For operations on board, the CTD was attached to the end of the red Dyneema rope on the A-frame winch, with the line led through the metered sheave. Immediately before deployment, the CTD was switched on; the pump was set to start 30 seconds after reaching a set minimum conductivity. Once the CTD was at the sea surface, the line counter was reset and the CTD was lowered to 10 m depth. We then waited at least 30 seconds before bringing the CTD back up to the surface to start the downcast. In practice, the CTD was in the water for more than 60 seconds before the start of the downcast. Log entries were made when the CTD was deployed, when it reached the bottom, when a Niskin bottle was fired (on the biological stations), and when it was recovered. Water depths from the EM2040 multibeam are included in the log entries. The sheave appeared to work reasonably well on most casts. However, vigilance was required to ensure that the rope stayed on the sheave, and that the sheave was turning freely. On the last cast from Erebus, CTD 46, the CTD was landed on the seabed, with a discrepancy of ~20 m between the rope out and the CTD depth. No damage was sustained, but we assume that the sheave was stuck for some time without the winch operator or any of the scientists on board noticing.

After the deep casts on the biological stations, data were downloaded onto a ToughBook laptop, and preliminary processing was run to determine the chlorophyll maximum. After the end of each day where the CTD was deployed, all data were downloaded again, and full header information included in the raw files, with latitude, longitude, and depth filled in from the logsheets (with the deployment positions used). The CTD is powered by 9 alkaline D cells, which were changed after the second day as a precaution.

Data were processed with the same Matlab scripts as the SDA CTD as described in Section 3.1, with a few changes described here. As recommended by Sea-Bird Scientific, a low-pass filter was initially applied to the CTD data, with a cutoff of 0.5 s for temperature and conductivity and 1 s for pressure. Then the oxygen sensor was advanced by 6.5 s, and a cell thermal mass correction was applied with parameters $\alpha=0.04$, $\tau=8.0$. For the final data processing, data were loaded into Matlab at this stage. Here, they were processed as described in Section 3.1 except that the final bin averaging was done at a resolution of 1 dbar rather than 2. This was mainly to get higher resolution near the surface, where Erebus caused less disturbance than SDA.

For the on-board processing and plotting, further steps were done in Sea-Bird Data Processing: loop edit (with default parameters), derive (to calculate practical salinity), and bin average (to derive downcast and upcast). The downcast was then plotted in SeaPlot to identify the chlorophyll maximum for biological sampling.

The SBE18 pH sensor was calibrated on board against a seawater standard and a pH 9 buffer, resulting in the following field calibration:

Table 3.7-2. Calibration of the SBE18 pH sensor.

Buffer	pH (at measured temperature)	Voltage	Temperature
Seawater standard	8.347	2.922	17.1
pH 9 buffer	9.06	3.065	16.9

This results in the calibration parameters $pH_{slope} = 3.4905$; $pH_{offset} = 2.6512$, where $pH = 7 + (V - pH_{offset}) / (pH_{slope} * T_K * 1.98416e^{-4})$, and T_K is the temperature in degrees Kelvin. This calibration was applied to the collected profiles in Matlab. Some profiles exhibit a significant difference between upcast and downcast, with no apparent correlation with the length of time the CTD was soaking before the downcast was started.

The fluorometer gave consistently higher readings than the Chelsea AquaTracka III fluorometer on the large CTD (sometimes by a factor of 3-4). This will be investigated further once chlorophyll samples have been analysed in Cambridge. The fluorometer gave negative readings on some deep casts, indicating that the zero voltage was set too low; this was adjusted by adding an offset of 0.05 to all chlorophyll readings.

From comparisons with the ship's CTD, no offset was deemed necessary for the temperature sensor. An offset of 0.005 mS/cm was subtracted from the conductivity readings. The PAR sensor on the smaller CTD gave consistently lower readings than the large CTD on the comparison casts. However, it seems likely that the sensor was partially shadowed by the rosette. The oxygen sensor agreed well with the ship's CTD primary oxygen sensor (with calibrations from SD035 applied).

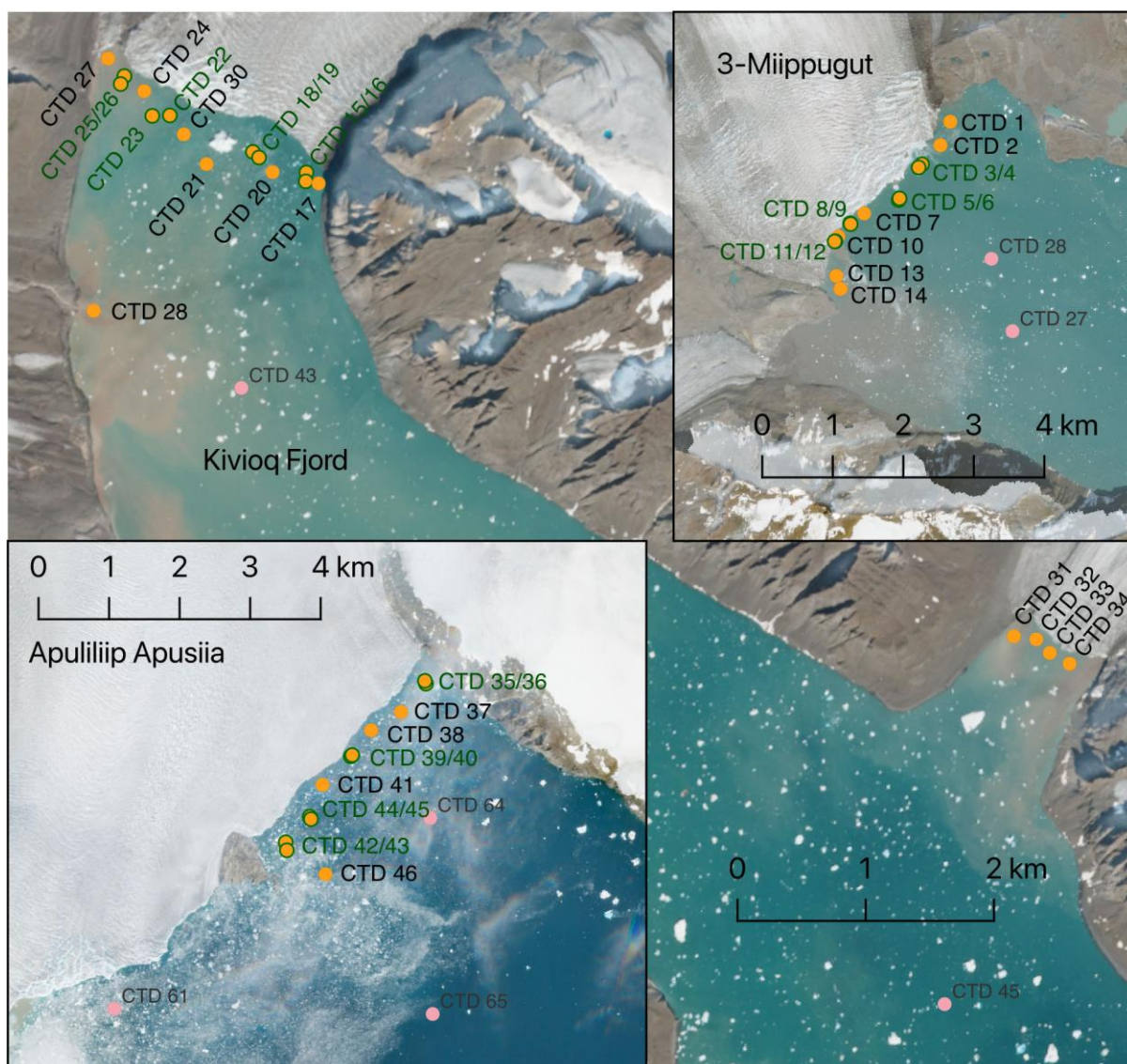


Figure 3.7-1. Locations of the ER041 CTD casts in 3-Miippugut, Kivioq Fjord, and Apuliliip Apusiia. Biological casts, where a Niskin bottle was fired, are circled and labelled in dark green. SD041 CTD casts are indicated with pink dots. Sentinel-2 high-resolution satellite images from the cloud-free day nearest to the day of sampling are shown in the background, obtained via Copernicus Data Space.

Table 3.7-3. Times and GPS positions of all CTD casts with the SBE19plusV2 CTD from Erebus on ER041. GPS positions have been obtained from the Seapath on Erebus, with times extracted from the raw CTD data. Stations where biological samples were obtained with the Niskin bottle are indicated in the first column; the bottle was fired at the deepest depth of the cast, as listed in the fourth column. Depths in the first column are the corrected water depth from the EM2040 at the time of deployment, as listed in the event log.

CTD	Date	Position	Event
3-Miippugut, 1 Aug 24			
CTD 1	01/08/24 10:11:42	68° 18.179'N 030° 46.868'W	Logging started
Event 22	01/08/24 10:15:44	68° 18.156'N 030° 46.804'W	Downcast started
Depth 63 m	01/08/24 10:17:21	68° 18.154'N 030° 46.785'W	Bottom (53 m)
	01/08/24 10:21:09	68° 18.143'N 030° 46.708'W	End of upcast

CTD	Date	Position	Event
CTD 2 Event 23 Depth 108 m	01/08/24 10:32:01 01/08/24 10:35:17 01/08/24 10:40:01 01/08/24 10:43:13	68° 18.021'N 030° 47.166'W 68° 18.002'N 030° 47.170'W 68° 17.983'N 030° 47.167'W 68° 17.969'N 030° 47.173'W	Logging started Downcast started Bottom (101 m) End of upcast
CTD 3 Event 24 Depth 135 m Bio - Niskin	01/08/24 10:52:53 01/08/24 10:55:55 01/08/24 10:59:05 01/08/24 11:04:54	68° 17.907'N 030° 47.636'W 68° 17.920'N 030° 47.597'W 68° 17.924'N 030° 47.598'W 68° 17.910'N 030° 47.601'W	Logging started Downcast started Bottom (126 m) End of upcast
CTD 4 Event 26 Depth 135 m Bio – Niskin	01/08/24 11:15:35 01/08/24 11:19:44 01/08/24 11:21:46 01/08/24 11:23:22	68° 17.898'N 030° 47.707'W 68° 17.881'N 030° 47.718'W 68° 17.876'N 030° 47.709'W 68° 17.876'N 030° 47.706'W	Logging started Downcast started Bottom (32 m) End of upcast
CTD 5 Event 31 Depth 200 m Bio – Niskin	01/08/24 12:20:39 01/08/24 12:23:18 01/08/24 12:31:54 01/08/24 12:37:01	68° 17.687'N 030° 48.276'W 68° 17.686'N 030° 48.260'W 68° 17.669'N 030° 48.224'W 68° 17.659'N 030° 48.214'W	Logging started Downcast started Bottom (191 m) End of upcast
CTD 6 Event 32 Depth 200 m Bio - Niskin	01/08/24 12:46:03 01/08/24 12:48:39 01/08/24 12:50:59 01/08/24 12:52:53	68° 17.701'N 030° 48.253'W 68° 17.691'N 030° 48.244'W 68° 17.687'N 030° 48.240'W 68° 17.684'N 030° 48.229'W	Logging started Downcast started Bottom (40 m) End of upcast
CTD 7 Event 35 Depth 130 m	01/08/24 13:56:47 01/08/24 13:58:54 01/08/24 14:01:30 01/08/24 14:04:38	68° 17.653'N 030° 49.022'W 68° 17.655'N 030° 49.033'W 68° 17.653'N 030° 49.026'W 68° 17.645'N 030° 49.019'W	Logging started Downcast started Bottom (122 m) End of upcast
CTD 8 Event 36 Depth 133 m Bio – Niskin	01/08/24 14:10:00 01/08/24 14:12:52 01/08/24 14:17:37 01/08/24 14:22:13	68° 17.611'N 030° 49.358'W 68° 17.601'N 030° 49.357'W 68° 17.604'N 030° 49.350'W 68° 17.599'N 030° 49.349'W	Logging started Downcast started Bottom (141 m) End of upcast
CTD 9 Event 37 Depth 133 m Bio - Niskin	01/08/24 14:32:17 01/08/24 14:34:41 01/08/24 14:37:01 01/08/24 14:38:20	68° 17.600'N 030° 49.348'W 68° 17.603'N 030° 49.341'W 68° 17.603'N 030° 49.337'W 68° 17.604'N 030° 49.340'W	Logging started Downcast started Bottom (53 m) End of upcast
CTD 10 Event 41 Depth 200 m	01/08/24 15:10:05 01/08/24 15:14:01 01/08/24 15:20:58 01/08/24 15:25:37	68° 17.530'N 030° 49.656'W 68° 17.530'N 030° 49.654'W 68° 17.523'N 030° 49.669'W 68° 17.526'N 030° 49.638'W	Logging started Downcast started Bottom (197 m) End of upcast
CTD 11 Event 42 Depth 206 m Bio – Niskin	01/08/24 15:38:35 01/08/24 15:41:09 01/08/24 15:48:46 01/08/24 15:52:46	68° 17.503'N 030° 49.740'W 68° 17.497'N 030° 49.724'W 68° 17.481'N 030° 49.741'W 68° 17.479'N 030° 49.732'W	Logging started Downcast started Bottom (209 m) End of upcast
CTD 12 Event 43 Depth 206 m Bio - Niskin	01/08/24 16:07:32 01/08/24 16:10:45 01/08/24 16:11:47 01/08/24 16:12:44	68° 17.505'N 030° 49.746'W 68° 17.490'N 030° 49.747'W 68° 17.485'N 030° 49.733'W 68° 17.480'N 030° 49.749'W	Logging started Downcast started Bottom (14 m) End of upcast
CTD 13 Event 46 Depth 215 m	01/08/24 16:37:16 01/08/24 16:41:44 01/08/24 16:46:46 01/08/24 16:52:52	68° 17.241'N 030° 49.917'W 68° 17.248'N 030° 49.835'W 68° 17.250'N 030° 49.775'W 68° 17.252'N 030° 49.698'W	Logging started Downcast started Bottom (206 m) End of upcast
CTD 14 Event 47 Depth 165 m	01/08/24 17:03:21 01/08/24 17:07:36 01/08/24 17:12:22 01/08/24 17:16:01	68° 17.137'N 030° 49.926'W 68° 17.132'N 030° 49.843'W 68° 17.127'N 030° 49.794'W 68° 17.120'N 030° 49.754'W	Logging started Downcast started Bottom (156 m) End of upcast
Kivioq Fjord, 6 Aug 24			
CTD 15 Event 61 Depth 94 m Bio – Niskin	06/08/24 10:04:00 06/08/24 10:06:21 06/08/24 10:08:29 06/08/24 10:12:09	68° 27.599'N 029° 14.009'W 68° 27.607'N 029° 14.000'W 68° 27.616'N 029° 14.004'W 68° 27.621'N 029° 13.993'W	Logging started Downcast started Bottom (88 m) End of upcast
CTD 16 Event 62 Depth 94 m Bio - Niskin	06/08/24 10:21:00 06/08/24 10:23:25 06/08/24 10:22:46 06/08/24 10:25:23	68° 27.569'N 029° 14.042'W 68° 27.566'N 029° 14.038'W 68° 27.566'N 029° 14.038'W 68° 27.566'N 029° 14.041'W	Logging started Downcast started Bottom (14 m) End of upcast

CTD	Date	Position	Event
CTD 17 Event 66 Depth 40 m	06/08/24 10:51:13 06/08/24 10:54:48 06/08/24 10:56:14 06/08/24 10:59:32	68° 27.548'N 029° 13.899'W 68° 27.539'N 029° 13.918'W 68° 27.537'N 029° 13.921'W 68° 27.535'N 029° 13.932'W	Logging started Downcast started Bottom (36 m) End of upcast
CTD 18 Event 67 Depth 190 m Bio – Niskin	06/08/24 11:09:55 06/08/24 11:13:29 06/08/24 11:23:20 06/08/24 11:29:23	68° 27.747'N 029° 14.522'W 68° 27.742'N 029° 14.536'W 68° 27.734'N 029° 14.611'W 68° 27.726'N 029° 14.651'W	Logging started Downcast started Bottom (185 m) End of upcast
CTD 19 Event 68 Depth 197 m Bio - Niskin	06/08/24 11:40:00 06/08/24 11:42:56 06/08/24 11:45:50 06/08/24 11:48:05	68° 27.715'N 029° 14.473'W 68° 27.715'N 029° 14.493'W 68° 27.716'N 029° 14.506'W 68° 27.717'N 029° 14.533'W	Logging started Downcast started Bottom (31 m) End of upcast
CTD 20 Event 72 Depth 183 m	06/08/24 12:15:31 06/08/24 12:17:55 06/08/24 12:22:35 06/08/24 12:28:10	68° 27.642'N 029° 14.374'W 68° 27.642'N 029° 14.388'W 68° 27.653'N 029° 14.387'W 68° 27.665'N 029° 14.395'W	Logging started Downcast started Bottom (179 m) End of upcast
CTD 21 Event 73 Depth 145 m	06/08/24 12:34:18 06/08/24 12:36:29 06/08/24 12:40:38 06/08/24 12:44:23	68° 27.749'N 029° 15.070'W 68° 27.749'N 029° 15.076'W 68° 27.756'N 029° 15.079'W 68° 27.758'N 029° 15.091'W	Logging started Downcast started Bottom (141 m) End of upcast
CTD 22 Event 74 Depth 95 m Bio – Niskin	06/08/24 13:06:26 06/08/24 13:08:32 06/08/24 13:10:58 06/08/24 13:16:25	68° 27.985'N 029° 15.317'W 68° 27.990'N 029° 15.350'W 68° 27.991'N 029° 15.373'W 68° 27.995'N 029° 15.424'W	Logging started Downcast started Bottom (92 m) End of upcast
CTD 23 Event 75 Depth 117 m Bio - Niskin	06/08/24 13:23:18 06/08/24 13:25:58 06/08/24 13:28:08 06/08/24 13:29:12	68° 28.001'N 029° 15.505'W 68° 28.009'N 029° 15.541'W 68° 28.014'N 029° 15.563'W 68° 28.017'N 029° 15.573'W	Logging started Downcast started Bottom (26 m) End of upcast
CTD 24 Event 79 Depth 105 m	06/08/24 14:03:54 06/08/24 14:07:15 06/08/24 14:10:56 06/08/24 14:13:39	68° 28.110'N 029° 15.519'W 68° 28.118'N 029° 15.529'W 68° 28.119'N 029° 15.514'W 68° 28.120'N 029° 15.505'W	Logging started Downcast started Bottom (98 m) End of upcast
CTD 25 Event 80 Depth 57 m Bio – Niskin	06/08/24 14:20:00 06/08/24 14:22:57 06/08/24 14:24:53 06/08/24 14:27:54	68° 28.195'N 029° 15.698'W 68° 28.193'N 029° 15.707'W 68° 28.192'N 029° 15.711'W 68° 28.191'N 029° 15.723'W	Logging started Downcast started Bottom (52 m) End of upcast
CTD 26 Event 81 Depth 65 m Bio - Niskin	06/08/24 14:36:13 06/08/24 14:38:09 06/08/24 14:38:56 06/08/24 14:42:05	68° 28.170'N 029° 15.761'W 68° 28.161'N 029° 15.772'W 68° 28.156'N 029° 15.778'W 68° 28.141'N 029° 15.790'W	Logging started Downcast started Bottom (28 m) End of upcast
CTD 27 Event 86 Depth 31 m	06/08/24 15:11:48 06/08/24 15:13:42 06/08/24 15:15:02 06/08/24 15:16:01	68° 28.284'N 029° 15.824'W 68° 28.277'N 029° 15.834'W 68° 28.275'N 029° 15.838'W 68° 28.271'N 029° 15.840'W	Logging started Downcast started Bottom (29 m) End of upcast
CTD 28 Event 88 Depth 50 m	06/08/24 15:42:34 06/08/24 15:44:48 06/08/24 15:46:08 06/08/24 15:47:20	68° 27.287'N 029° 16.756'W 68° 27.280'N 029° 16.731'W 68° 27.275'N 029° 16.720'W 68° 27.272'N 029° 16.711'W	Logging started Downcast started Bottom (45 m) End of upcast
CTD 30 Event 90 Depth 116 m	06/08/24 16:21:45 06/08/24 16:23:47 06/08/24 16:26:30 06/08/24 16:28:57	68° 27.887'N 029° 15.232'W 68° 27.894'N 029° 15.229'W 68° 27.905'N 029° 15.225'W 68° 27.911'N 029° 15.214'W	Logging started Downcast started Bottom (114 m) End of upcast
CTD 31 Event 92 Depth 35 m	06/08/24 17:54:59 06/08/24 17:57:22 06/08/24 17:58:14 06/08/24 17:59:05	68° 24.936'N 029° 07.718'W 68° 24.933'N 029° 07.719'W 68° 24.932'N 029° 07.721'W 68° 24.930'N 029° 07.722'W	Logging started Downcast started Bottom (30 m) End of upcast
CTD 32 Event 93 Depth 51 m	06/08/24 18:03:59 06/08/24 18:06:04 06/08/24 18:07:19 06/08/24 18:09:05	68° 24.897'N 029° 07.482'W 68° 24.899'N 029° 07.478'W 68° 24.900'N 029° 07.476'W 68° 24.902'N 029° 07.478'W	Logging started Downcast started Bottom (46 m) End of upcast

CTD	Date	Position	Event
CTD 33 Event 94 Depth 62 m	06/08/24 18:13:13 06/08/24 18:15:20 06/08/24 18:17:46 06/08/24 18:19:22	68° 24.828'N 029° 07.377'W 68° 24.824'N 029° 07.377'W 68° 24.823'N 029° 07.384'W 68° 24.823'N 029° 07.387'W	Logging started Downcast started Bottom (55 m) End of upcast
CTD 34 Event 95 Depth 41 m	06/08/24 18:27:41 06/08/24 18:29:23 06/08/24 18:30:38 06/08/24 18:33:03	68° 24.761'N 029° 07.194'W 68° 24.761'N 029° 07.195'W 68° 24.761'N 029° 07.198'W 68° 24.761'N 029° 07.203'W	Logging started Downcast started Bottom (36 m) End of upcast
13 Aug 24, Apuliliip Apusiia			
CTD 35 Event 112 Depth 63 m Bio - Niskin	13/08/24 10:17:14 13/08/24 10:20:48 13/08/24 10:23:11 13/08/24 10:24:55	67° 53.709'N 032° 20.731'W 67° 53.697'N 032° 20.736'W 67° 53.694'N 032° 20.740'W 67° 53.691'N 032° 20.744'W	Logging started Downcast started Bottom (62 m) End of upcast
CTD 36 Event 113 Depth 63 m Bio - Niskin	13/08/24 10:38:33 13/08/24 10:41:37 13/08/24 10:43:14 13/08/24 10:44:08	67° 53.722'N 032° 20.740'W 67° 53.721'N 032° 20.743'W 67° 53.720'N 032° 20.745'W 67° 53.720'N 032° 20.746'W	Logging started Downcast started Bottom (19 m) End of upcast
CTD 37 Event 119 Depth 103 m	13/08/24 11:40:03 13/08/24 11:43:17 13/08/24 11:46:20 13/08/24 11:49:07	67° 53.533'N 032° 21.344'W 67° 53.531'N 032° 21.343'W 67° 53.531'N 032° 21.326'W 67° 53.531'N 032° 21.308'W	Logging started Downcast started Bottom (98 m) End of upcast
CTD 38 Event 120 Depth 100 m	13/08/24 12:33:14 13/08/24 12:35:53 13/08/24 12:38:36 13/08/24 12:41:49	67° 53.449'N 032° 22.016'W 67° 53.440'N 032° 22.035'W 67° 53.434'N 032° 22.065'W 67° 53.430'N 032° 22.091'W	Logging started Downcast started Bottom (96 m) End of upcast
CTD 39 Event 121 Depth 68 m Bio - Niskin	13/08/24 12:33:14 13/08/24 12:35:53 13/08/24 12:38:36 13/08/24 12:41:49	67° 53.449'N 032° 22.016'W 67° 53.440'N 032° 22.035'W 67° 53.434'N 032° 22.065'W 67° 53.430'N 032° 22.091'W	Logging started Downcast started Bottom (96 m) End of upcast
CTD 40 Event 123 Depth 68 m Bio - Niskin	13/08/24 13:48:51 13/08/24 13:51:00 13/08/24 13:52:14 13/08/24 13:53:10	67° 53.290'N 032° 22.502'W 67° 53.292'N 032° 22.500'W 67° 53.292'N 032° 22.501'W 67° 53.292'N 032° 22.502'W	Logging started Downcast started Bottom (20 m) End of upcast
CTD 41 Event 126 Depth 90 m	13/08/24 14:40:10 13/08/24 14:41:39 13/08/24 14:43:23 13/08/24 14:45:03	67° 53.126'N 032° 23.200'W 67° 53.122'N 032° 23.224'W 67° 53.121'N 032° 23.232'W 67° 53.117'N 032° 23.244'W	Logging started Downcast started Bottom (74 m) End of upcast
CTD 42 Event 128 Depth 57 m Bio - Niskin	13/08/24 15:28:20 13/08/24 15:30:29 13/08/24 15:31:59 13/08/24 15:34:08	67° 52.759'N 032° 24.166'W 67° 52.761'N 032° 24.187'W 67° 52.762'N 032° 24.197'W 67° 52.764'N 032° 24.202'W	Logging started Downcast started Bottom (53 m) End of upcast
CTD 43 Event 129 Depth 57 m Bio - Niskin	13/08/24 15:45:06 13/08/24 15:47:44 13/08/24 15:50:02 13/08/24 15:50:58	67° 52.695'N 032° 24.186'W 67° 52.700'N 032° 24.219'W 67° 52.702'N 032° 24.233'W 67° 52.702'N 032° 24.239'W	Logging started Downcast started Bottom (34 m) End of upcast
CTD 44 Event 133 Depth 79 m Bio - Niskin	13/08/24 16:54:06 13/08/24 16:56:20 13/08/24 16:58:28 13/08/24 17:01:29	67° 52.911'N 032° 23.589'W 67° 52.906'N 032° 23.599'W 67° 52.900'N 032° 23.610'W 67° 52.891'N 032° 23.624'W	Logging started Downcast started Bottom (74 m) End of upcast
CTD 45 Event 134 Depth 79 m Bio - Niskin	13/08/24 17:48:33 13/08/24 17:50:38 13/08/24 17:51:23 13/08/24 17:52:36	67° 52.890'N 032° 23.596'W 67° 52.888'N 032° 23.606'W 67° 52.888'N 032° 23.606'W 67° 52.886'N 032° 23.615'W	Logging started Downcast started Bottom (27 m) End of upcast
CTD 46 Event 139 Depth 81 m	13/08/24 18:41:00 13/08/24 18:43:14 13/08/24 18:44:47 13/08/24 18:47:11	67° 52.473'N 032° 23.541'W 67° 52.461'N 032° 23.538'W 67° 52.448'N 032° 23.529'W 67° 52.437'N 032° 23.527'W	Logging started Downcast started Bottom (81 m) End of upcast

3.8 Erebus MSS, ADCP and Idronaut CTD

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We are grateful to all the crew and science team who helped with the manual deployment and recovery of the MSS Profiler and ADCP on Erebus.

3.8.1 Science Summary and Objective:

Sampling was carried out at the terminus of three marine-terminating glaciers in the Arctic Circle along south-eastern Greenland (Figure 3.8-1). The purpose of the sampling was to elucidate the interactions between marine-terminating glaciers and the ocean by measuring hydrography and turbulence at the glacier front. Glaciers were selected based on accessibility and stage of melting. The terminus of three glacier fronts was accessible. The gradient of glacier thinning increased from south to north (pink in Figure 3.8-1). All deployments were conducted from the small boat Erebus.

3.8.1.1 Instruments Description and Specifications

Table 3.8-1 Technical details and data paths for three instruments used at the terminus of the three glaciers during and in conjunction with turbulence profiling.

Drifting ADCP	Teledyne RDI Sentinel V100 (300 kHz) ADCP http://vocab.nerc.ac.uk/collection/L22/current/TOOL1719/ Raw files: /leg/work/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-3miippugut/raw/ /leg/work/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-Fladø/raw/ /leg/work/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-kivioq/raw/ Processes files: /leg/work/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-3miippugut/ /leg/work/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-Fladø/ /leg/work/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-kivioq/
MSS90	Microstructure Probe MSS 90 https://www.sea-sun-tech.com/product/microstructure-probe-mss-90/ Dara: /legwork/scientific_work_areas/erebus/MSS90-basil/Kivioq/ Raw files: /leg/work/scientific_work_areas/erebus/MSS90-basil/3Miippugut/MSS/ /leg/work/scientific_work_areas/erebus/MSS90-basil/Kivioq/MSS/ /legwork/scientific_work_areas/erebus/MSS90-basil/Fladø/MSS Processed files: /leg/work/scientific_work_areas/erebus/MSS90-basil/3Miippugut/Processed/ /leg/work/scientific_work_areas/erebus/MSS90-basil/Kivioq/Processed/ /leg/work/scientific_work_areas/erebus/MSS90-basil/Fladø/Processed/
CTD idronaut	Idronaut Ocean Seven 308 CTD Logger https://www.idronaut.it/multiparameter-ctds/oceanographic-ctds/os308-oceanographic-ctd/ /legwork/scientific_work_areas/erebus/MSS90-basil/CalibrationTS_Idronautprofiles/

3.8.2 Turbulence Measurements: MSS90 Profiler

The MSS90 is a multi-parameter profiler for measuring microstructure and turbulence in marine waters. The SAMS owned MSS90 is equipped with high resolution microstructure and turbulence sensors (temperature and current shear), CTD sensors (temperature, conductivity, pressure),

oxygen and fluorescence sensors. Disturbing vibrations of the profiler itself are measured by an accelerometer which measures the horizontal acceleration of the profiler housing.

The shear sensor measures the turbulent velocity fluctuations and the vibration of the MSS profiler. The acceleration sensor is therefore required to measure the contribution of the profiler vibration and remove it from the turbulent kinetic energy dissipation rate calculations.

Table 3.8-2. MSS sensor characteristics. mS/cm is millisiemens per centimetre and is a measure of electrical conductivity.

Sensor	Range	Accuracy	Resolution	Time constant
Microstructure turbulence	0 to 6 s ⁻¹ (dissipation rate 10 ⁻² to 10 ⁻¹¹ W/kg)	n/a	~10 ⁻³ s ⁻¹ (10 ⁻¹¹ W/kg)	4 ms
Microstructure Temperature	-2 to +38 °C	+/- 0.02 °C	0.002 °C	10 ms
Pressure	10; 20; 50; Bar	+/- 0.1 %fs	0.002%fs	30 ms
Precision temperature	-2 to +38 °C	+/- 0.01 °C	0.001 °C	150 ms at 1m/s
Precision conductivity	0 to 6 mS/cm 0 to 60 mS/cm	+/- 0.005 mS/cm +/- 0.02 mS/cm	+/- 0.0001 mS/cm +/- 0.001 mS/cm	50 ms at 1m/s

The MSS profiler was balanced with negative buoyancy to operate in free sink mode (Figure 3.8-2a). The target sink speed was 0.75 - 0.85 m/s. Three free sink speed checks were made at the start of each section and then randomly during profiling. The average sink speed measured was 0.83 m/s (n = 12 measurements).

The deployments were carried out from Erebus using a Kevlar cable, which transmits data back to a deck unit. This cable is very flexible, robust and reliable. It minimises the transfer of vibration from the vessel to the microstructure profiler during the free sink method. The cable was coiled on a portable electric winch, but the electrical capacity was not used. Instead, the MSS profiler was deployed and recovered by hand (Figure 3.8-2b).

3.8.2.1 Data Pre-processing

MSSpro (Version 1.05) was used for the pre-processing of the raw data. The MSSpro software is designed for use with the MSS Profiler (Prandke, 2011).

- Step 1. The Cutgraf software utility was used to manually define the base of each profile. This converted *.MRD raw files into *.tob files (raw data path shown in Table 3.8-1).
- Step 2. The standard Fasteps processing was used to calculate the turbulent kinetic energy rate and other hydrographic parameters in a single step using set calibration coefficients. This step uses the cut data *.tob files (raw data path given in Table 3.8-1).
- Step 3. The processed output was then read using phyton, saved as netCDF files and placed on the shared drive (processed data path given in Table 3.8-1).
- Step 4. The data from the netCDF files were used to produce the preliminary figures (Figure 3.8-4b, Figure 3.8-5b, Figure 3.8-6b). The station values in each figure represent the average of all casts at that station.

Following the recommendations in Prandke 2011, future processing will use the batch operations (an advanced processing tool of MSSpro) to recalculate all variables. Later work should include the calculation of turbulent kinetic energy dissipation rate, thermal dissipation rate, eddy diffusivity, Cox number, turbulence, Thorpe scale.

*****Note***:** MSS profile still needs to be calibrated using T and S from the Idronaut CTD data.

3.8.3 Drifting ADCP

Teledyne Sentinel V Acoustic Doppler Current Profiler (ADCP) with Transducer Recovery Model S100. This ADCP measures currents throughout the water column. It has profiling ranges between 1m and 150m and a depth rating of 200m. Data were downloaded at the end of each day and processed on board.

Table 3.8-3. Pre-deployment set up.

Parameters	3-Miippugut	Kivioq	Near Fladø
Range (m)	150	150	150
Cell size (m)	2	2	2
Blank (m)	0	0	0
Number of cells	75	75	75
First cell (m)	2.18	2.62	2.62
Number of Pings	1	1	1
Ping Intervals	1	1	1
Time between ensembles (s)		1	1
Band width (%)	25	25	25
Ambiguity velocity (m/s)	2.75	1	1
Standard deviation (cm/s)	6.99	4.75	4.75
ADCP depth	1	1	1
Salinity	30	30	30
Heading Adjustment	0	0	0
Magnetic variation	0	0	0

3.8.3.1 Data Processing

The processing scripts are saved on the shared drive. The steps are as follow:

- STEP1. The raw data was extracted using the MATLAB function `rdradcp.m`, which reads the raw binary ADCP file NAME and places the relevant configuration and measurement data into an ADCP data structure.
- STEP2. Two MATLAB scripts were then written to clean up the output from `rdradcp` function. The cleaning included removing the times when the ADCP was out of the water and the echo data below the bottom. These two scripts also plot the raw data, the cleaned data and the station data.

The sequence of work was:

Table 3.8-4. Data processing sequence.

drifting_adcp_preprocessing1.m	STEP 1. Uses <code>rdradcp.m</code> <code>ADCP= RDRADCP(NAME)</code> to build the MATLAB file of the raw data Plots the raw data if <code>testfig=1</code> STEP 2. Resamples the data for times in the water, importing information from the field log. STEP 3. Rotate the velocities according to the magnetic variation at that LAT Plots the clean and rotated relative velocities if <code>testfig=1</code> STEP4. Computes the absolute velocities by removing Erebus drifting speed. Calculate the Erebus speed from the Erebus track log and then subtract these values from the relative velocities. Plots the clean and rotated absolute velocities, <code>xdirr=1</code> will flip the direction of the x axis, - time decreases instead of increasing. STEP 5. Saves the figure if <code>issavefig=1</code> and saves the data if <code>issave=1</code>
Drifting_adcp_preprocessing2_avg_stn.m	STEP1. Opens the MATLAB file. Removes the bottom, and averaged time to get one profile per station.

	Plots a figure to view if testfig=1 STEP2. Average the data per station using time from the field log ➤ In the case of 3miippugut STN4, the user can choose to average before, after or all time at this station. 'Before' and 'after' is in reference to the calving event that causes a wave. The flow direction appears to have change before and after the calving event. Saves the figure ifsave=1
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3.8.4 Idronaut CTD Ocean Seven 308

The Idronaut CTD casts were used to calibrate the MSS temperature and conductivity sensors. The instrument is compact and designed to facilitate integration with third party instruments. Here the Idronaut CTD was mounted on the MSS90 (Figure 3.8-2c) and lowered manually.

This data was not processed on board.

3.8.4.1 *Narrative of the days at the glacier front*

August 03, 24. We entered 3-Miippugut fjord (pronounced: Pingasut-Miippugut) in the early hours of Tuesday 30 July. The marine terminus of the glacier is Sorgenfri Gletsjer, which has retreated only slightly (~2 km) since 2002, based on mapping of the glacier front from satellite Sentinel-2 imagery. By August 03, Erebus had already spent three full days at the glacier front, so we knew that we would be facing a semi-dense ice mélange and strong currents. Our observations suggested that the inflow is on the right (northern) side of the glacier, while the outflow is on the left (southern) side looking towards the glacier. The water is very turbid, especially on the south side where the outflow was identified. On August 03 the MSS turbulence profiler, the Idronaut CTD and the drifting ADCP was loaded onto the Erebus for a day of sampling. The plan was to complete a full transect of current and turbulence measurements across the front of Sorgenfri Gletsjer, with a target spacing of 200 m and 250 m between stations. Meltwater plumes have been observed and ocean current velocities are estimated to be high, exceeding 1.4 kt in places. The ADCP was set for this speed and a salinity of 30.

Deployments went well and the section was completed, despite some challenges, thanks to the hard work and dedication of everyone on board Erebus (crew and science teams). The environment was extreme, very dynamic, fast-moving ice and water, several small and calving events interrupted our work several times. A large calving event at Station 7 (Figure 3.8-4a) caused some delay as we waited for conditions to be safe to approach the station again. This calving event produced some interesting data from the ADCP: a change in vertical velocities and an apparent strengthening of the ocean currents after the event. Three MSS profiles were taken at almost every station except Station 5, where strong currents carried ice and trapped us, pushing us towards the glacier front. Due to the unsafe conditions, we abandoned this station and moved on to Station 8 (Figure 3.8-4a). The third cast of Station 5 was aborted before it reached 100m, as the MSS cable became entangled in the ice, and conditions became unsafe for another deployment.

A total of 12 stations (Figure 3.8-4a), with 7 stations along the glacier front, 3 stations at the southern land outflow, 1 calibration station (only one cast) and 1 sink speed check station (4 casts). The sink speed check station (Station 0 in Figure 3.8-4b) can also be used as a background measurement of shear due to its greater distance from the glacier front (e.g., this station is 2.3 km from the glacier front and 1.8 km from 7 which is only 430m from the Glacier front). The depth of the profiles was 100 m (or bottom if shallower).

August 05, 24. On the August 05 we sampled in Kivioq Fjord. The glacier is called Rosenberg, and according to satellite images it is retreating faster than Sorgenfri glacier. We have been in Kivioq since 04 August. MSS, ADCP and Idronaut CTD are prepared and loaded onto Erebus to measure turbulence on the Rosenberg glacier front. There is a grounded iceberg near the centre of the front. The SDA went between the iceberg and the glacier, so we have a good idea of the depth and sea conditions. Bottom depths range from 50m on the left flank to ~200 m near the grounded iceberg and right flank. The outflow appears to be small and concentrated to the left of the grounded iceberg, while the inflow appears to be to the right. The water is clear, and conditions appear MCh calmer than at 3-miippugut. We plan to do the sink rate test on the first MSS cast to save time. We plan to profile to the bottom, so 6 stations for 4 hours seemed reasonable. Gavia will be working right after us to cover some of the bottom oceanography.

The 6 stations were completed with three casts in each station (Figure 3.42).

August 13, 2024. On August 13 we sampled the glacier front of Apuliliip Apusiia in Paattuulaajik Kertivaat. Gavia had a very successful day yesterday and we are very lucky to have this day to focus on turbulence. Oceanography and biology will be sampling at the same time, small CTD, MSS, Idronaut, ADCP, Bongo and Niskin were loaded onto Erebus in the early morning. The plan was to sample 7 stations across the glacier front, spaced ~400 m apart. Three stations were to be combined oceanography and biology stations, each taking ~1 h each.

Conditions were calm, so we overachieved and were able to complete 8 oceanographic and 4 oceanography + biological stations (station 1, 2, 4 and 7; Figure 3.8-6a). Extra station 8 was taken opportunistically as we waited for the helicopter to take off to get close to the SDA for pick up. This station can be used to look at the background shear. Station 8 is located 830 m from the glacier terminus and 400 m from Station 1, making it a good location for comparison.

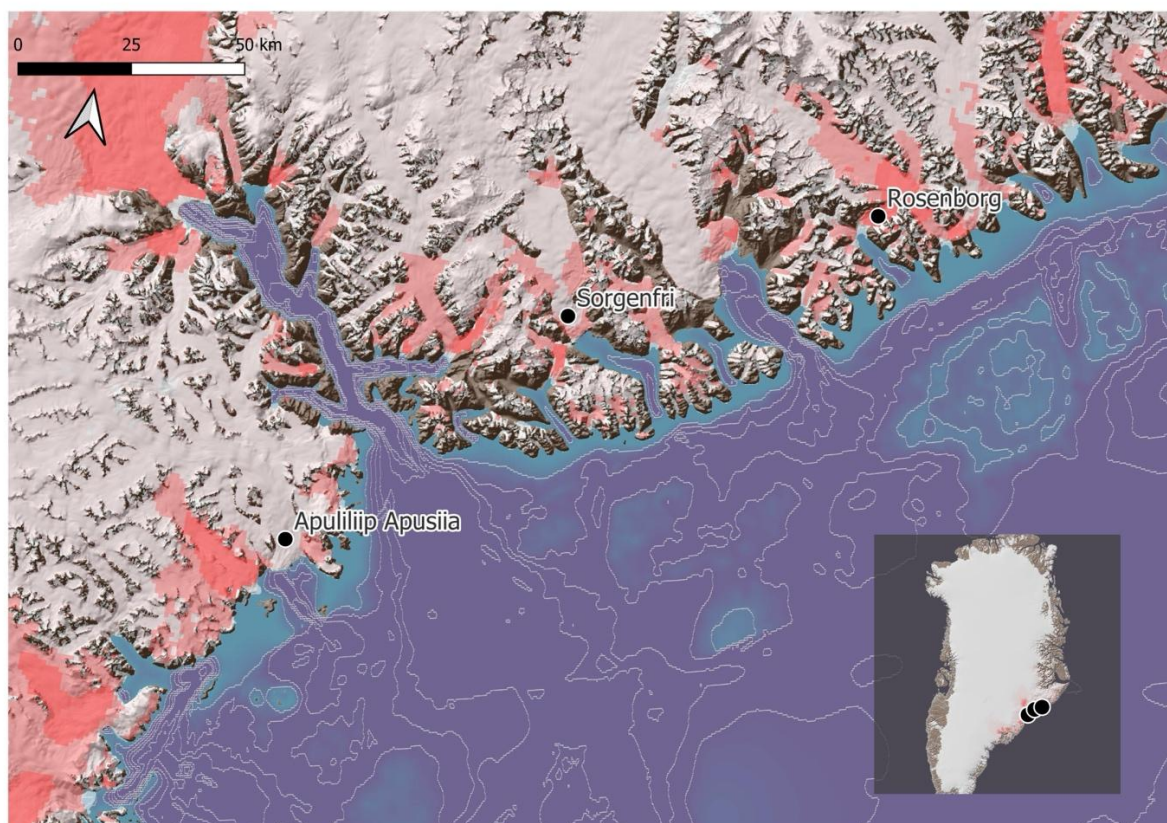


Figure 3.8-1. Location of the places visited and name of the marine terminating glaciers in front of which MSS profiler and drifting ADCP survey was conducted. Ocean bathymetry is from BedMachine deeper than 500 m in purple to shallow areas in green, contour line is 500m isobath. Rock and Snow layers are from QGreenland. White colours delimit glacial ice. Overlaid transparent red highlights melting rates (higher = darker red).



(c)



Figure 3.8-2. MSS deployment using free sinking-method and hand recovery. (a) Lea demonstrates the free sink method. (b) Lea demonstrates manual recovery. (c) Calibration set up using Idronaut CTD.

(a)

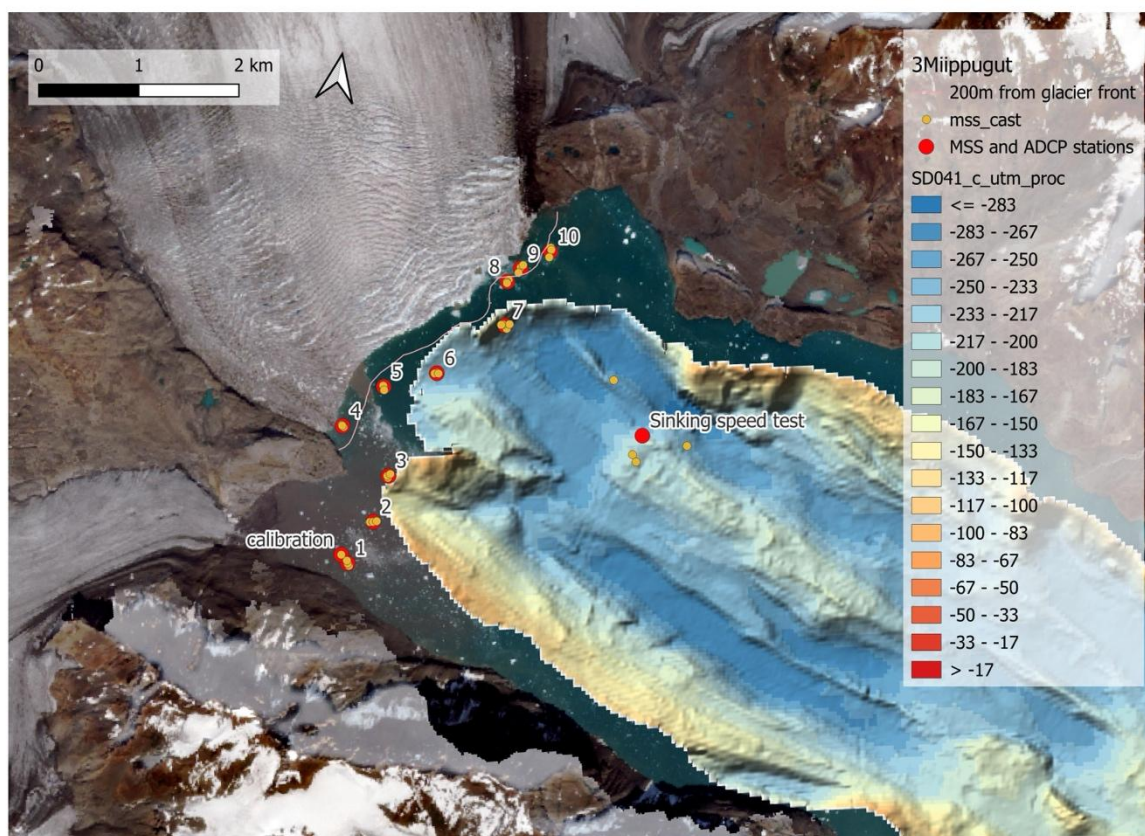


(b)



Figure 3.8-3. Drifting ADCP set up on (a) before deployment, (b) during deployment.

(a)



(c)

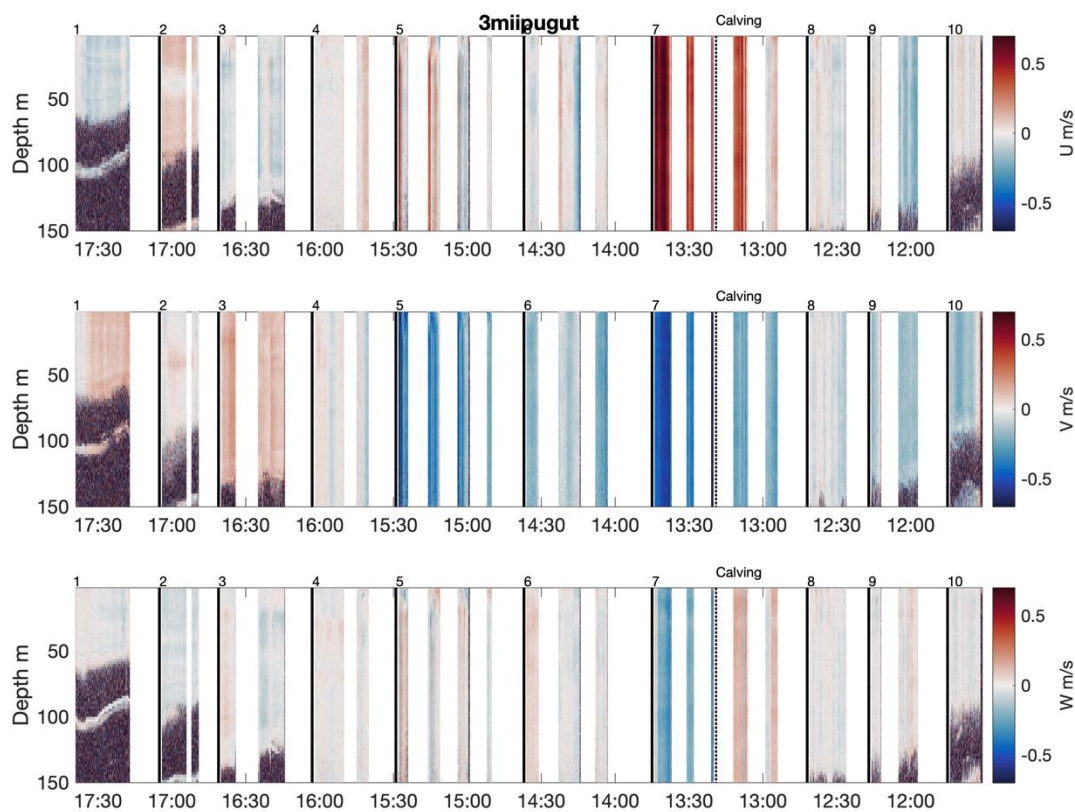
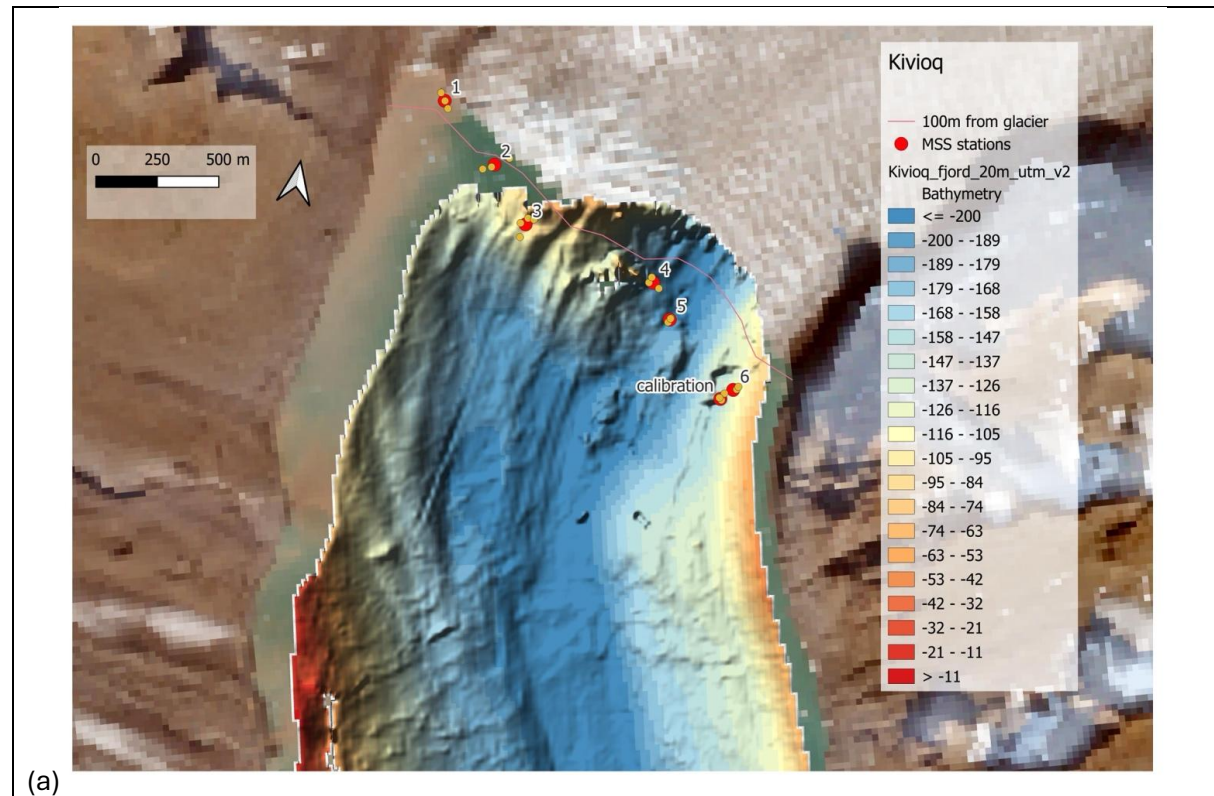


Figure 3.8-4. Glacier terminus section at 3– Miippugut 03 August 2024. (a) Map of station (red circle) and casts (yellow dots), maintaining a distance of approximately 200 m from the glacier front when safe to do so. (b) Pre-processed MSS profiler output averaging all casts per station. "The 'Sink Speed Test' station in (a) is the same as station 0 in (b). (c) Processed data from the drifting ADCP. Note that the station numbering used in this figure has been reversed in relation to the station numbers found in the field log.



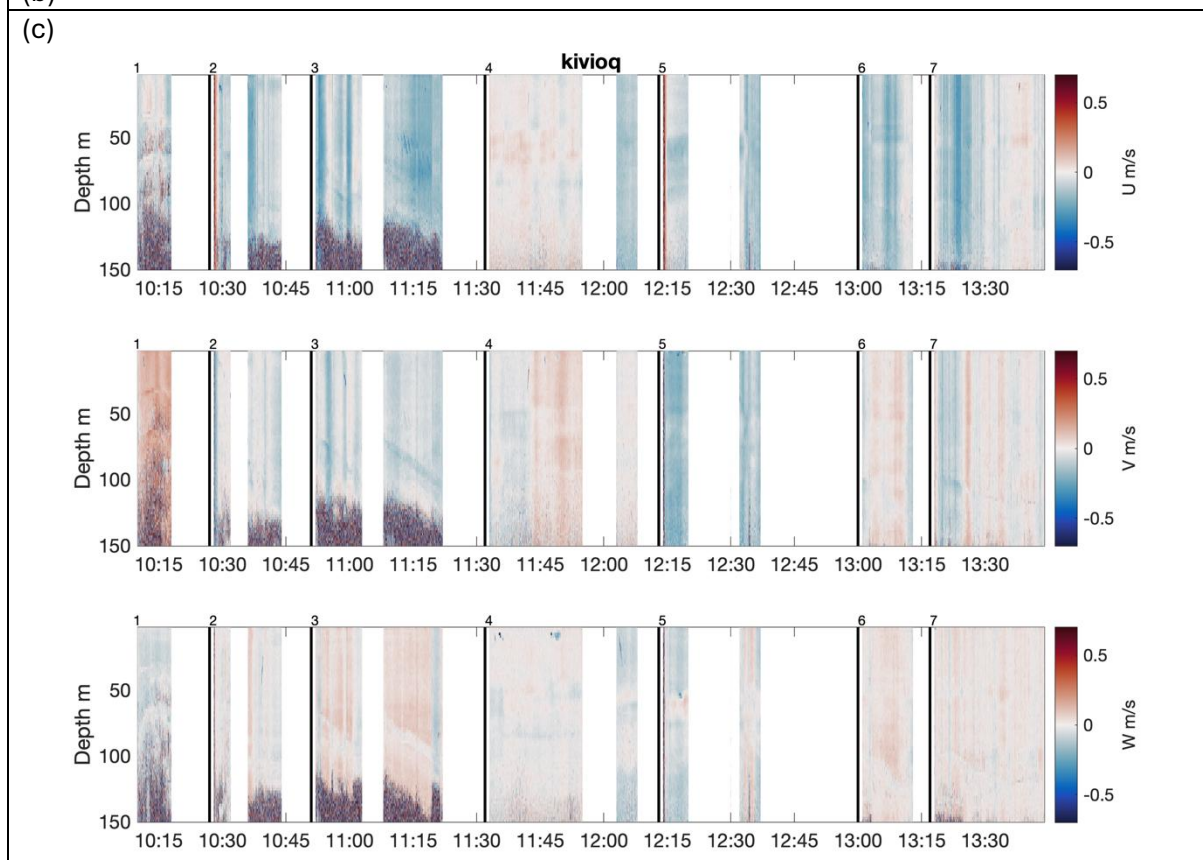
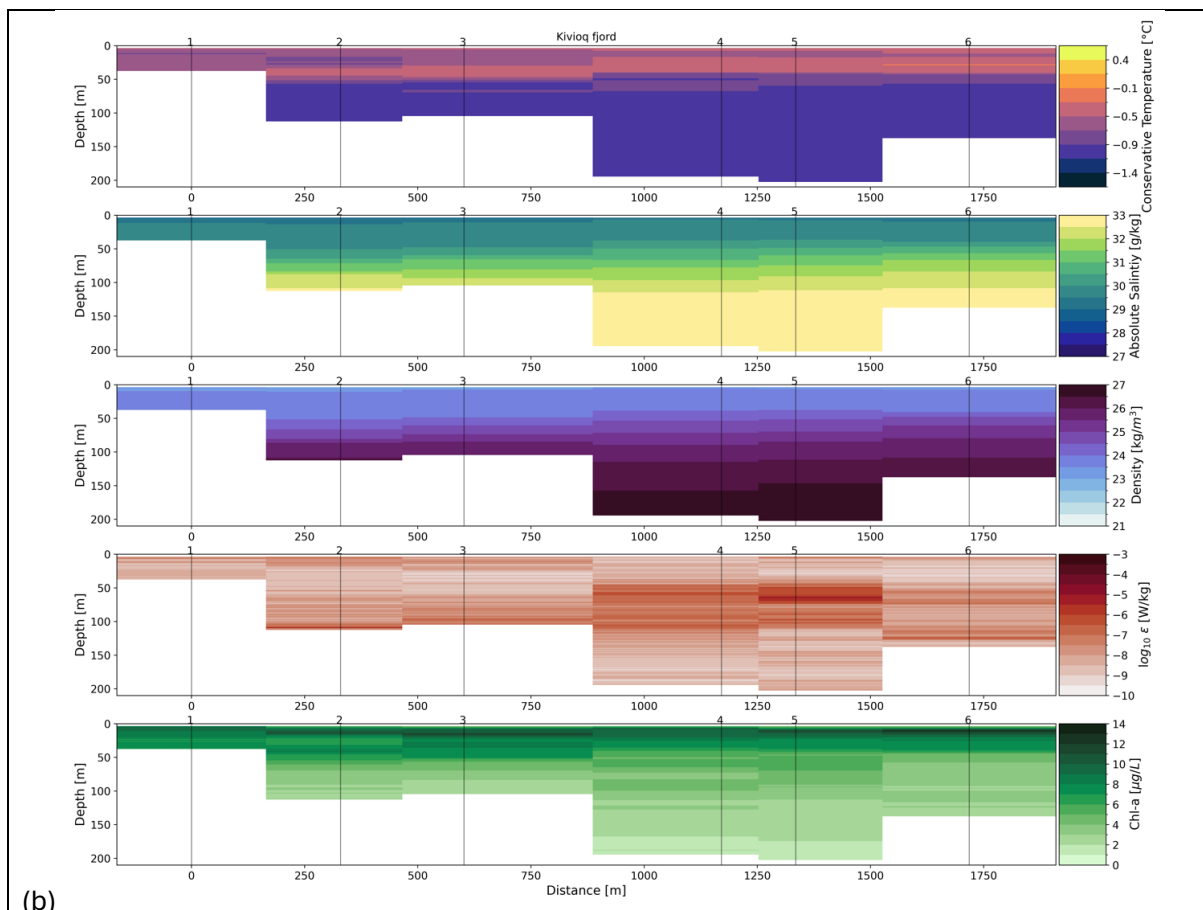
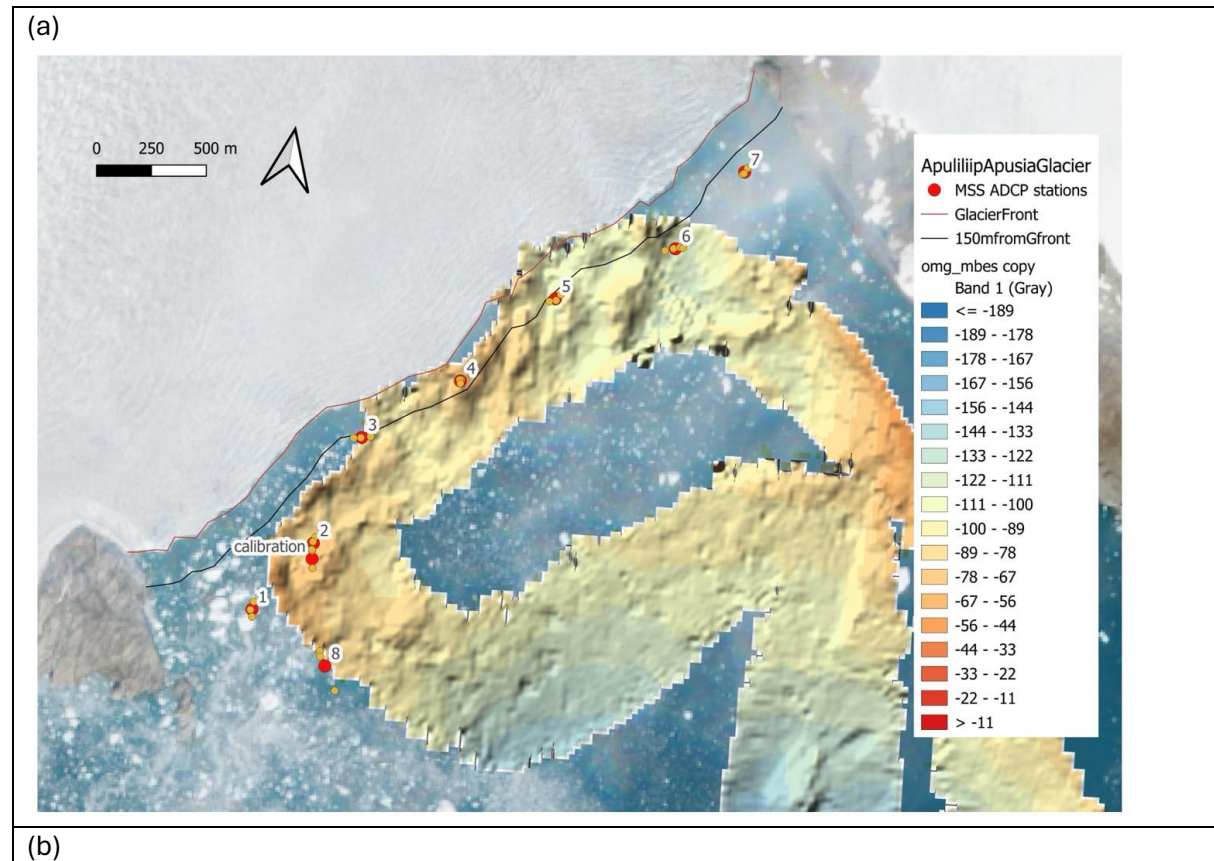


Figure 3.8-5. Rosenberg Glacier terminus section Kivioq 05 August 2024. (a) Map of stations (red circles) and casts (yellow dots), maintaining a distance of ~100 m from the glacier front when safe to do so. (b) Pre-processed MSS profiler output averaging all casts per station. (c) Processed data from the drifting ADCP. Note that the station numbering used in this figure has been reversed in relation to the station numbers found in the field log.



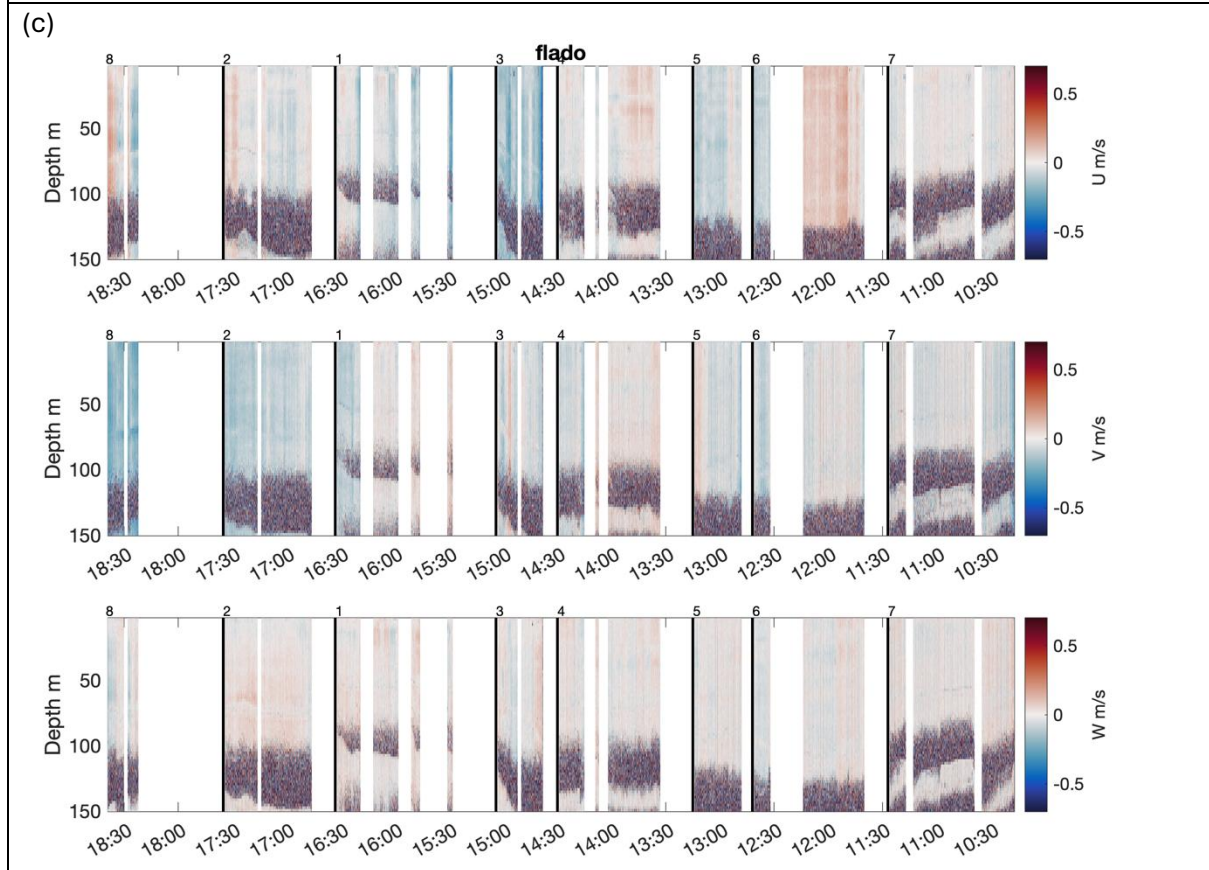
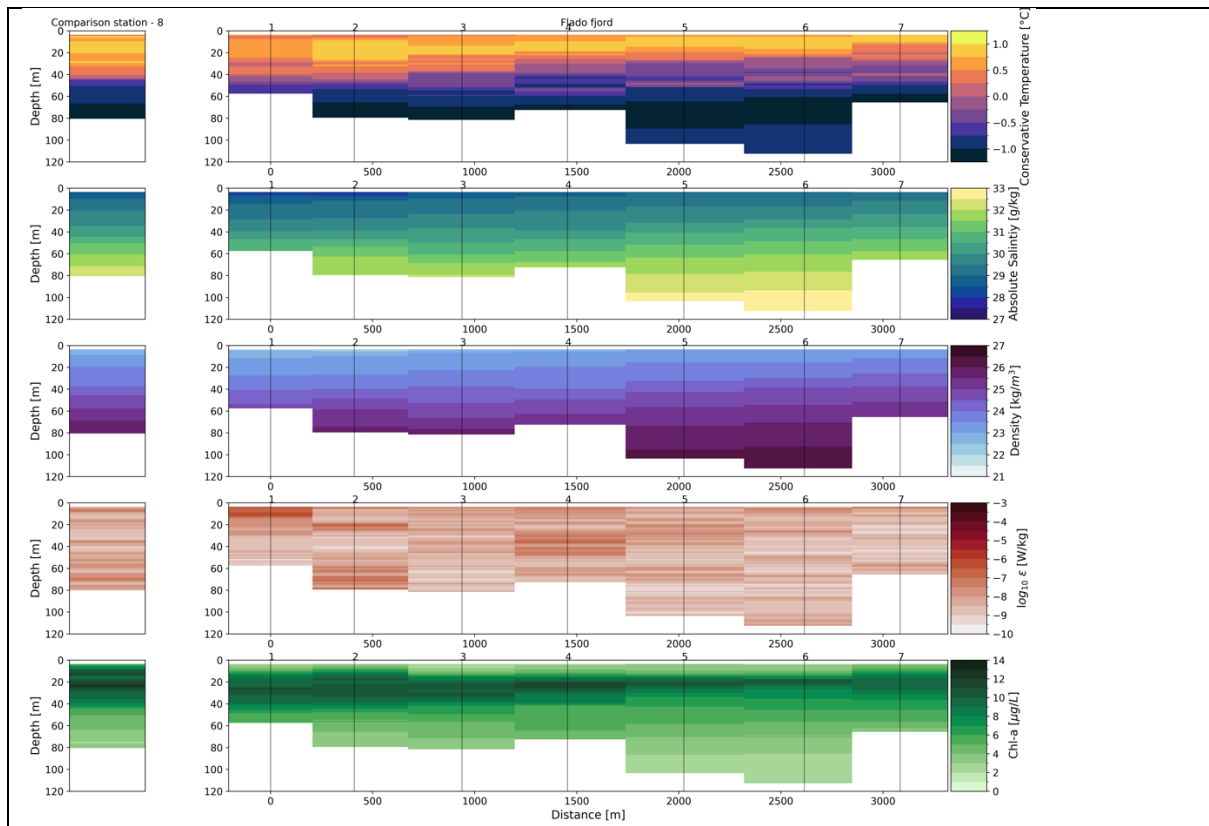


Figure 3.8-6. Apuliliip Apusiia Glacier terminus section near Fladø, 13 August 2024. (a) Map of stations (red circles) and casts (yellow dots), maintaining a distance of ~150 m from the glacier front when safe to do so. Biological stations were 1, 2 4 and 7. (b) Pre-processed MSS profiler output averaging all casts per station.

(c) Processed data from the drifting ADCP. Note that the station numbering used in this figure has been reversed in relation to the station numbers found in the field log.

3.9 Mooring and LoTUS buoys

Authors: Povl Abrahamsen (BAS), Clara Manno (BAS), and Flo Atherden (BAS)

A sub-surface oceanographic mooring was deployed in the deep trough off Annassip Kangersiva during the cruise (25 Jul – 17 Aug) and redeployed on 20 Aug with the intention of recovering the following year. In addition, three bottom-tethered Long Term Underwater Sensing (LoTUS) buoys were deployed in the entrance of Kangerlussuaq Fjord, on the sill leading to Kangerlussuaq Fjord, and on the sill in 3-Miippugut Fjord. Mechanical aspects of the mooring deployments are described in the AME report, while this section will describe the instrumentation and overall deployments.

Positions and dates of deployment and recovery are given in the table below, with further detail in the subsequent sections. We intend to recover and redeploy the mooring in summer 2025 and finally recover it in summer 2026. The LoTUS buoys are programmed to release on 1 July 2026. They will transmit their data back via Iridium when they reach the surface and have a satellite connection.

Table 3.9-1. Locations and deployment dates of the moorings deployed on SD041.

Mooring	Deployment	Recovery	Latitude	Longitude	Depth
KANG-GLAC A	25/07/24 11:45	17/08/24 12:57	67° 28.740' N	033° 01.362' W	740
KANG-GLAC B	20/08/24 15:58		67° 28.684' N	032° 59.199' W	834
LoTUS 75	29/07/24 14:05		67° 55.319' N	031° 41.162' W	497
LoTUS 76	03/08/24 12:14		68° 14.545' N	030° 35.128' W	175
LoTUS 77	22/08/24 20:57		67° 33.608' N	031° 13.471' W	442

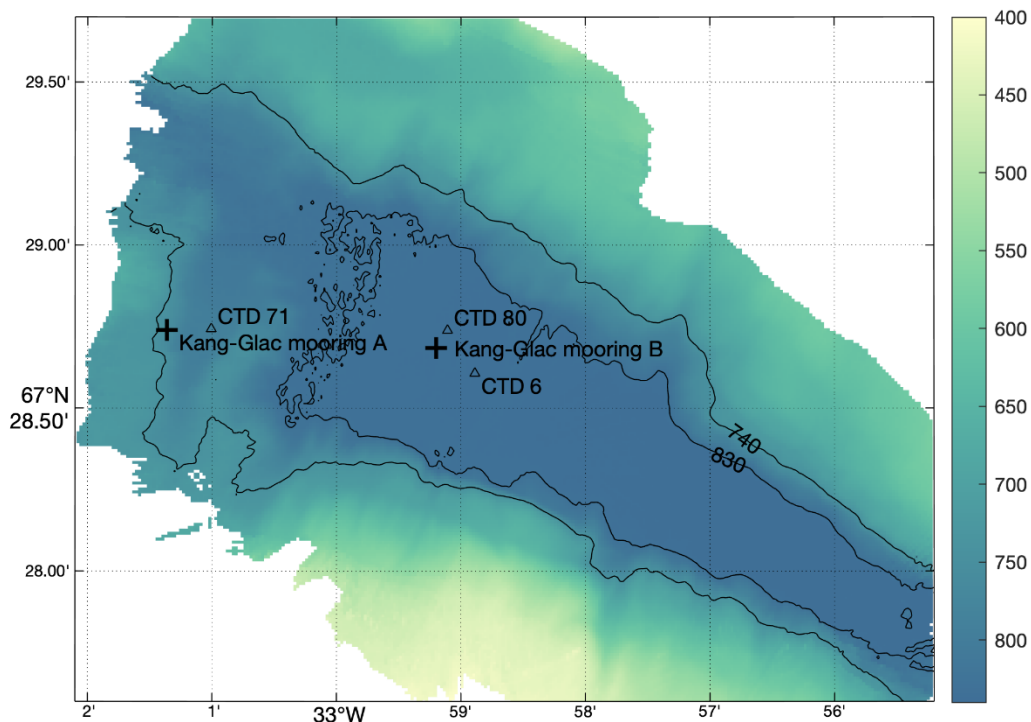


Figure 3.9-1. Map of the KANG-GLAC mooring trough, with EM122 multibeam bathymetry (gridded from SD041_b lines 387-390). Depth contours at 740 and 830 m depth are shown, along with the locations of nearby CTD casts.

3.10 KANG-GLAC Mooring

Authors: Povl Abrahamsen (BAS), Clara Manno (BAS), and Flo Atherden (BAS)

3.10.1 Design Considerations

The KANG-GLAC mooring is intended to measure physical conditions in the upper water column, ideally up to the level of warm inflow toward the coast, and to collect sediments falling through the water at high temporal resolution during the cruise, and at lower resolution over an annual cycle. In addition, a pH sensor is mounted near the top of the mooring. While the original plan was to deploy a profiling float with CTD, a dissolved oxygen optode, chlorophyll fluorometer, and turbidity sensor near the mooring, to provide profiles of these parameters from the seabed to the surface, this was delayed and was not delivered in time for the cruise. While we hope to deploy this next season, additional temperature sensors were subsequently added to the mooring to at least provide some temperature profiles. The mooring has an upward-looking 75-kHz ADCP to measure currents in the upper water column, with a conductivity-temperature-pressure-oxygen recorder nearby, a deep sediment trap with a single-level current meter beneath, a pH sensor near the top, and temperature recorders distributed across depths (clamped onto the mooring rope). To measure currents at a range of depths, the buoy holding the ADCP had to be at least 400-500 m deep, while the pH sensor had to be at 200-300 m depth – but not shallow enough to be at risk of iceberg strikes. On the second mooring deployment, over the winter, a weak link was added immediately below the uppermost buoyancy (and above the uppermost instrumentation), in the hope that if the buoyancy were to get snagged on an iceberg, the link would break and the instrumentation would sink down along the mooring, but still be recovered. The main mooring line is made of 10-mm Dyneema rope (with polyester outer braid). Most instruments have been installed in-line, except the SBE-39s, which have been attached with hose clamps, directly onto

the rope (with a short length of plastic tubing to protect the rope), and the SAMI-pH, which is also clamped onto the rope with a custom plastic clamp, further secured with a large hose clamp.

3.10.2 First Deployment Attempt

The first attempt to deploy the KANG-GLAC mooring was made on the morning of 25 July. The ship was in relatively high concentrations of sea ice, and while there was open water in the wake of the ship, ice floes still crossed over the open water, tangling with the mooring rope. After deploying the top 280 m length of rope, the rope had become so tangled with ice floes, with some parts of the rope above the ice and some below, that the decision was made to stop the deployment and recover the top of the mooring. One SBE-39 temperature logger (s/n 0088) was caught on a piece of ice and not recovered; the remaining instrumentation on the top rope was recovered.

3.10.3 First Successful Deployment

After the ship had been repositioned, the bridge was confident that the lead behind the ship was remaining more open, and another attempt was made to deploy the mooring, but without the uppermost rope (with temperature recorders and SAMI-pH) above the ADCP. A 10-m length of thick polypropylene floating rope was shackled directly onto the top of the ADCP buoy, with two 9-inch plastic trawl floats installed above to aid in recovery. This deployment was successful, though the mooring was deployed slightly shallower than intended, in approx. 740 m water depth.

After dropping the anchor weight, the vessel located the mooring using the EM122 multibeam (in water column view) and EK80 fisheries echo sounders. The vessel relocated to within 10 m of the mooring location, with all mooring elements clearly visible on both echo sounders.

3.10.4 First Recovery

After returning to the mooring location on 17 August, the location was assessed. There was much less sea ice in the area with scattered bergy bits, but a large iceberg was almost directly above the mooring (~10 m from the edge), so the vessel moved away to do CTD cast 71, and by the time the CTD was recovered, the iceberg had moved a safe distance. The location of the mooring was confirmed again with the multibeam, and the vessel then moved to port on thrusters. The mooring was released on the starboard side of the vessel at 12:57; six minutes later the ADCP buoy popped up to the surface, and the ship moved back to starboard to recover. The recovery was uneventful, with all instrumentation recovered successfully. Data were downloaded from all instruments in the afternoon.

The pressure record from SBE-39 0668, which was the only instrument with temperature and pressure sensors, started to get increasingly noisy and drifted to lower values on 05 August, before dropping almost 200 dbar on 09 August. At the end of the time series the noise exceeds the tidal signal that is visible at the start of the deployment. The instrument was not redeployed.

3.10.5 Second Deployment

On return to the mooring site on 20 August there were only very scattered ice floes and bergy bits, with a few larger icebergs a safe distance away. The vessel had a clear 1.5-nm run toward the target deployment site, and the mooring was deployed uneventfully, with the additional rope above the ADCP buoy, and with the weak link beneath the uppermost buoyancy. The mooring was deployed slightly east of the original target position, but almost exactly at the target depth of 834 m.

Again, the position of the mooring was verified with EK80 and EM122. Somewhat surprisingly, the reflections from buoyancy and instrumentation appeared almost 20 m shallower than would be expected, though there are no indications that the seabed has any features of this magnitude near the deployment site. This discrepancy remains somewhat of a mystery, hopefully to be clarified when the mooring is recovered next year.

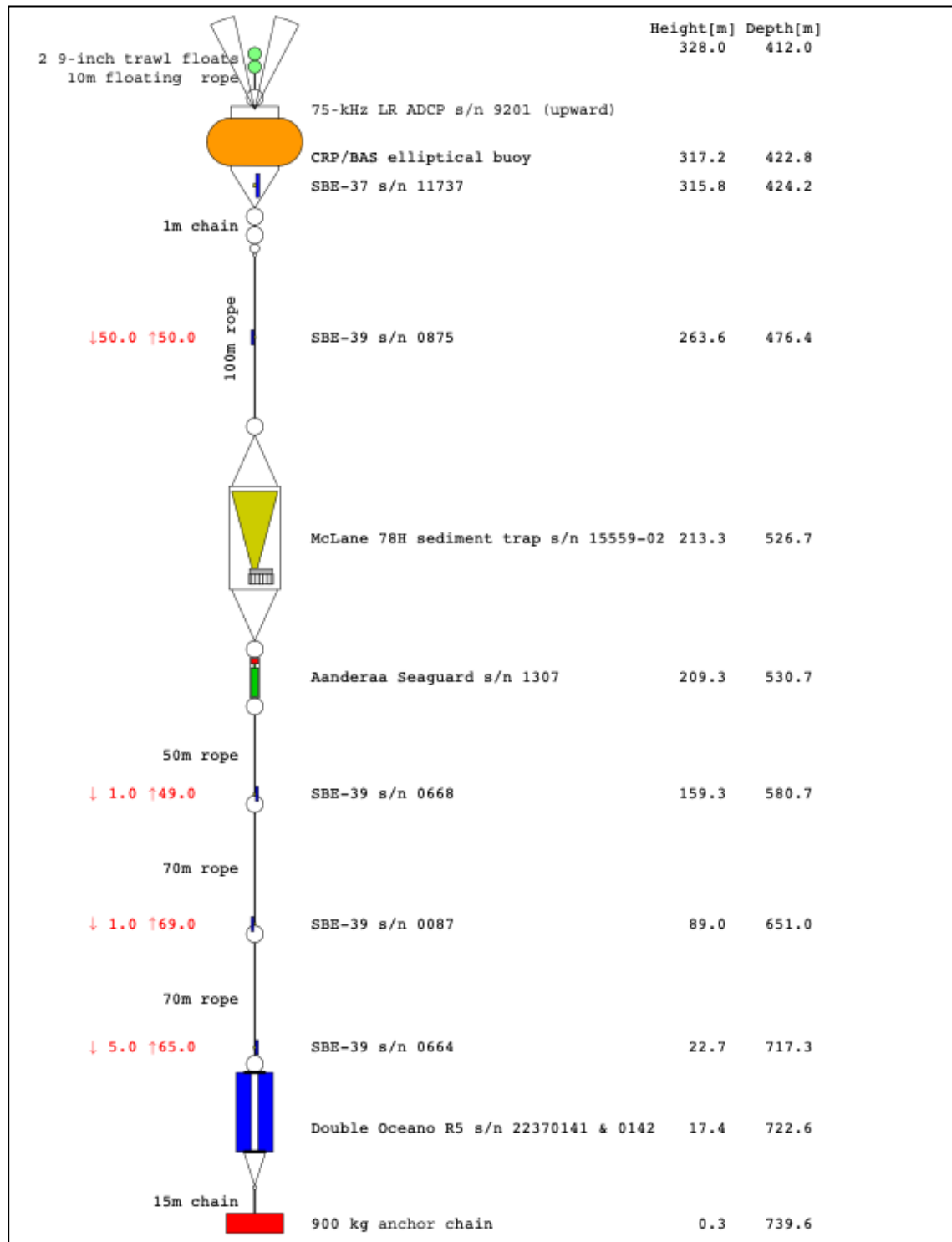


Figure 3.10-1. KANG-GLAC mooring A, deployed 25 July - 17 August 2024.

In addition to verifying the location of the mooring with sonar, communications were tested with both acoustic releases. Both were communicating clearly, indicating that they were vertical, with 6.1-6.2 V battery.

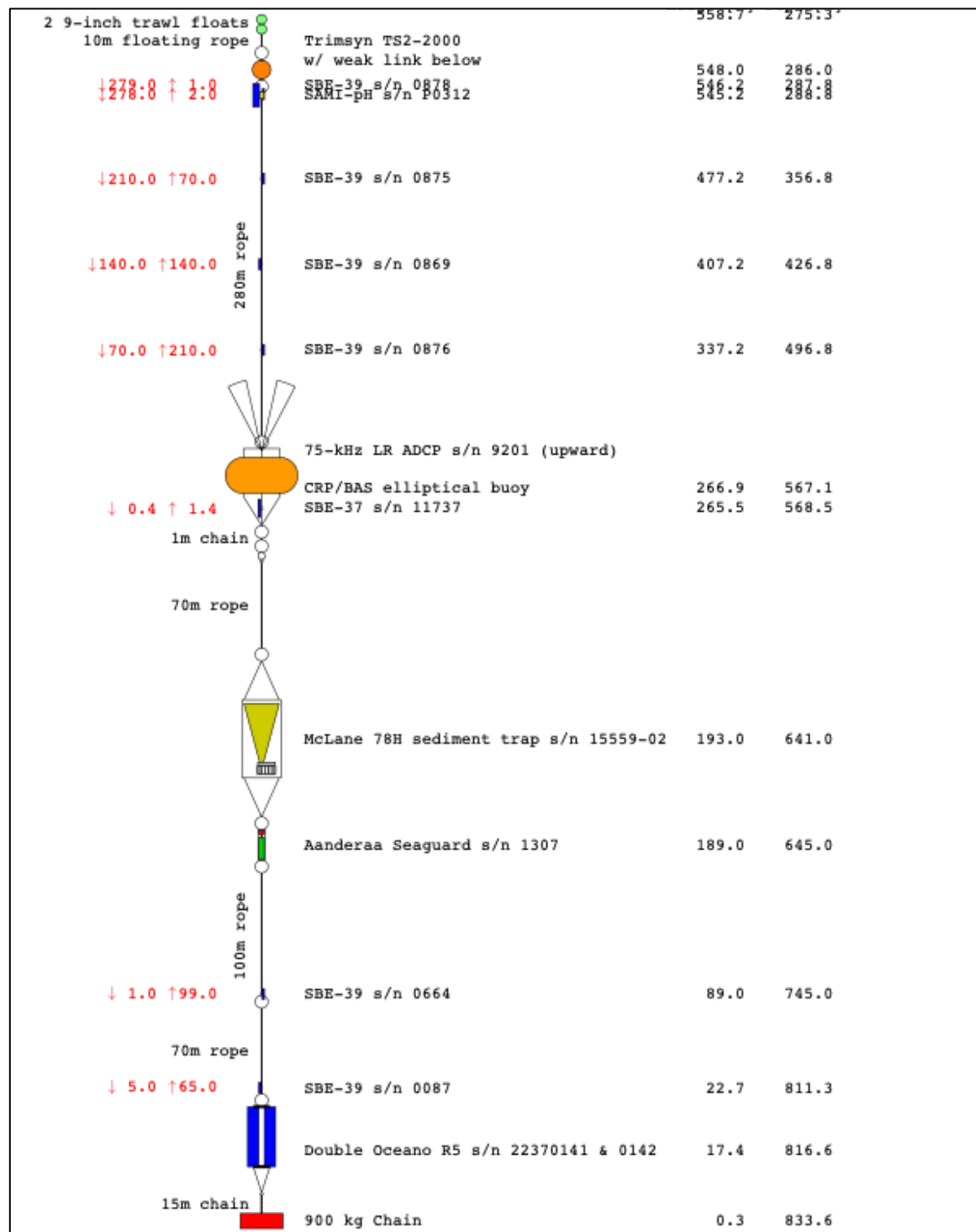


Figure 3.10-2. KANG-GLAC mooring B, deployed 20 August 2024, with recovery expected in 2025.

Table 3.10-1. Mooring A instrumentation details.

Height above bottom (m)	Nominal Depth (m)	Instrument/sn	Parameters measured	Sample interval (min)	Start/stop time, UTC (dd/mm/yyyy hh:mm:ss)	Clock drift (hh:mm:ss)	First good/Last good record/comments (times are instrument times – uncorrected for drift)
317	423	Long-Ranger ADCP 9201	U, V, W, T, P 31 bins 16-m bin size Low power Narrow BW	20 – 40 pings per ensemble	24/07/24 09:00:00 17/08/24 14:39:30	-00:00:15	25/07/24 12:00:00 17/08/24 12:20:00
316	424	SBE-37SMP-ODO 11737	T, C, P, O	30	24/07/24 09:00:00 17/08/24 14:56:10	+00:00:01	25/07/24 12:00:52 17/08/24 12:30:50
264	476	SBE-39 0875	T	20	24/07/24 09:00:00 17/08/24 15:41:00	-00:00:01	25/07/24 12:00:00 17/08/24 12:39:59
213	527	McLane Parflux 78H 15559-02	Carbon Flux	2 days	25/07/24 14:00:00 17/08/24 13:44:00	NA	Trap bottles 6 and 10 did not rotate as programmed and collected for 4 days each.
209	531	Seaguard 1307	U, V, T, O	30	24/07/24 09:00:00 17/08/24 15:50:00	-00:00:19	25/07/24 12:00:00 17/08/24 12:30:00
159	581	SBE-39 0668	T, P	20	24/07/24 09:00:00 17/08/24 15:36:55	-00:00:04	25/07/24 12:00:00 17/08/24 12:40:00
89	651	SBE-39 0087	T	20	24/07/24 09:00:00 17/08/24 15:26:50	-00:00:04	25/07/24 12:00:00 17/08/24 12:40:00
23	717	SBE-39 0664	T	20	24/07/24 09:00:00 17/08/24 15:33:25	-00:00:01	25/07/24 12:00:00 17/08/24 12:40:00
17	723	Releases: Exail Oceano R5 2237-0141 & 2237-0142					

Table 3.10-2. Mooring B instrumentation details

Height above bottom (m)	Nominal Depth (m)	Instrument/sn	Parameters measured	Sample interval (min)	Start time, UTC (dd/mm/yyyy hh:mm:ss)	Comments
546	286	SBE-39 0878	T	15	20/08/24 09:00:00	
545	289	SAMI-pH P0312	pH	6 hours	21/08/24 06:00:00	
477	357	SBE-39 0875	T	15	20/08/24 09:00:00	
407	427	SBE-39 0869	T	15	20/08/24 09:00:00	
337	497	SBE-39 0876	T	15	20/08/24 09:00:00	
267	567	Long Ranger ADCP 9201	U, V, W, T, P 36 bins 16-m bin size High power Narrow BW	30 – 11 pings per ensemble	20/08/24 09:00:00	With Long Ranger External Battery Pack s/n 581441, containing four alkaline batteries. Mounted in CRP elliptical buoy, along with Xeos Apollo X7 Iridium beacon s/n 1091 and Xeos XMB-11K VHF beacon s/n 1169 (154.585 MHz).
266	568	SBE-37SMP 11737	T, C, P, O	30	20/08/24 09:00:00	
193	641	McLane Parflux 78H 15559-02	Carbon flux	Variable, see Table 3.10-1	21/08/24 00:05:00	Sampling schedule designed to capture variability during the productive season.
189	645	Seaguard 1307	U, V, T, O	30	20/08/24 09:00:00	
89	745	SBE-39 0664	T	20	20/08/24 09:00:00	
23	811	SBE-39 0087	T	20	20/08/24 09:00:00	
17	817	Releases: Exail Oceano R5 2237-0141 & 2237-0142				

Table 3.10-3. Sampling schedule of Sediment trap for Mooring B, each event number represents one bottle rotation. Event 1 indicates the start of sampling (i.e. a bottle rotating under the collection funnel). Event 22 indicates the end of sampling, with the funnel rotating to port 0, where there is no collection bottle.

Event number	Date and Time, UTC
1	21/08/24 00:05:00
2	01/09/24 00:05:00
3	16/09/24 00:05:00
4	01/10/24 00:05:00
5	01/11/24 00:05:00
6	01/12/24 00:05:00
7	01/01/2025 00:05:00
8	01/02/2025 00:05:00
9	01/03/2025 00:05:00
10	01/04/2025 00:05:00
11	16/04/2025 00:05:00
12	01/05/2025 00:05:00
13	17/05/2025 00:05:00
14	01/06/2025 00:05:00
15	16/06/2025 00:05:00
16	01/07/2025 00:05:00
17	11/07/2025 00:05:00
18	21/07/2025 00:05:00
19	01/08/2025 00:05:00
20	11/08/2025 00:05:00
21	21/08/2025 00:05:00
22	01/08/2025 00:05:00

3.10.6 Sediment Trap Preparation

To preserve the sinking particulate material collected in the sediment trap a solution of < 4% buffered formalin solution.

3.10.7 SAMI pH Preparation

SAMI pH was flushed using milli-Q prior to deployment. The stability and accuracy of the pH SAMI was validated using a synthetic sea water pH standard (8.01 pH at 25 °C), prepared following (Paulsen and Dickson, 2020).

3.10.8 LoTUS Buoys

Three LoTUS buoys were deployed on SD041. The LoTUS buoy is a self-contained pop-up buoy that measures temperature near the seabed. The electronics are contained in an Atlantic Floats (formerly Pantherplast) 10-1800-LG 10-inch plastic trawl float, including alkaline batteries, temperature logger, burn-wire release, and Iridium short burst data (SBD) satellite transceiver. A 5-m long tether is attached to the release, inside one of the lugs of the trawl float. The anchors consisted of three links of large ship's anchor chain (with a total weight of 10-11 kg), bundled together with a short length of 10-mm galvanised steel chain, attached to the tether using a 5/16" galvanised bow shackle. During deployment, the buoy measures temperature at a pre-programmed interval. At the (pre-programmed) release date, the buoy will activate the burn-wire release and float to the surface. Once there is a satellite connection (which could take some time, if it were to pop up under ice), the buoy will transmit its data back by Iridium SBD. The LoTUS buoys were developed by Prof. Jakob Kutteneuler at Kungliga Tekniska Högskolan (KTH; Royal Institute of Technology) in Stockholm, and commercialised by spin-out company Sailport AB. Further documentation can be found at <http://www.lotussensing.com/>.

The three LoTUS buoys, s/n 75, 76, and 77, were provided pre-programmed to start sampling on 1 Aug 24 and release on 1 Jul 2026, with a sampling interval of one hour. Iridium subscriptions and data conversion will be handled by Sailport.

The LoTUS buoys were deployed from the starboard quarter of the ship. With the ship slowed down to ~1 knot, the anchor was lowered to just above the water on a bight of rope. When the ship was almost in position, the buoy was dropped into the water, and once it had streamed away from the anchor, the anchor was released.



Figure 3.10-3. LoTUS buoy 75 on deck prior to deployment, with the tether still taped to the buoy.

4 ACTIVITY REPORT: BIOLOGY ACOUSTIC, SAMPLING AND EXPERIMENTS

4.1 Bio-acoustic: EK80 Echo-Sounder

Acquisition and author: Vincent Doñate Felipe (Stokholm University)

The EK80 system is a split-beam echo sounder commonly used for imaging the water column. SDA has six hull-mounted transducers operating at different frequencies: ES18, ES38-7, ES70-7C, ES120-7C, ES200-7C, and ES333-7C.

During cruise SD041, EK80 data was collected continuously to compare the scattering layers identified in the echograms with the biological captures from the bongo nets and MOCNESS, and to potentially identify gas plumes and meltwater plumes around the Kangerlussuaq Trough. The Simrad EK80 Echosounder v. 21.15.187 software was used for operating the system and acquiring the data. To prevent cross-talking with the other acoustic systems operated during SD041, EK80 ping triggering was managed by Kongsberg's synchronization unit K-Sync.

4.1.1 Acquisition

The EK80 system was also operated on transit in the UK EEZ at 16:50 (UTC) on the July 19 together with TOPAS and EM712 systems. Data was logged from 18:58 to 20:25 when the system was stopped just before crossing to the Faroese EEZ. Data logging on the EK80 system was started again at 12:53 on July 25 and continued throughout most of the time SDA was in the Greenlandic EEZ. The system parameters used for the six transducers during most of the SD041 cruise are summarised in Table 4.1-1.

The only occasions when these settings were changed were during a test of the wideband mode on the July 27 from 12:00 to 13:07, during part of the survey around the Fladø Trough on the August 13 from 17:49 to 22:28, during a CTD and bongo nets deployments on the August 14 from 16:37 to 18:54, and finally during the survey at the continental slope off the Kangerlussuaq Trough on August 25 from 09:27 to the end of the scientific survey of the cruise at 21:43. During the test, the Fladø Trough survey, and the deployments, the pulse mode was changed to frequency-modulated (FM), meaning that the acoustic pulses created range within an interval of frequencies (Table 4.1-2). The transducer ES18 was always operated using CW mode. During the test, pulse lengths of 2.048 and 4.096 ms were tried. A pulse length of 2.048 ms was used for the Fladø Trough survey, and 4.096 ms was used for the deployments. For the survey at the continental slope, a CW mode was kept, but the pulse length of the ES18, ES38-7, and ES70-7C transducers was increased to 2.048 ms due to greater depths.

Table 4.1-1. EK80 default settings.

Transducer type	ES18	ES38-7	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Temperature	0	0	0	0	0	0
Salinity	33.5	33.5	33.5	33.5	33.5	33.5
Mode	Active	Active	Active	Active	Active	Active
Pulse type	CW	CW	CW	CW	CW	CW
Frequency (kHz)	18	38	70	120	200	333
Transducer Serial no.	2172	190-narrow	437	1588	666	210
WBT Serial no.	720835	721576	721579	721585	721591	721746
Transducer depth (m)	0	0	0	0	0	0

Pulse length (ms)	1.024	1.024	1.024	1.024	1.024	1.024
Max Power (W)	1600	2000	750	225	150	50
Ramping	Slow	Fast	Fast	Fast	Fast	Fast

Table 4.1-2. Modified settings for wideband surveying.

Transducer type	ES18	ES38-7	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Pulse type	CW	LFM Up	LFM Up	LFM Up	LFM Up	LFM Up
Start Frequency (kHz)	18	34	45	90	160	280
End Frequency (kHz)	18	45	90	170	260	450
Pulse length (ms)	2.048/4.096	2.048/4.096	2.048/4.096	2.048/4.096	2.048/4.096	2.048/4.096

The ping rate during the cruise was set to maximum in the EK80 acquisition software and controlled from the K-Sync synchronization unit. EK80 was in the second group of K-Sync together with the 75 and 150 kHz ADCPs. The multibeam systems (EM122 and 712) and the EA640 were in the first group, whereas the TOPAS PS18 was in the third. In the beginning, the active period of the EK80 in the K-Sync period was set to 2 s, which was decreased to 1.3 s when we got to waters shallower than 1000 m. Toward the end of the cruise, after realizing a strong continuous noise parallel to the sea surface, the active period was set to external triggering, which modifies the time of the EK80 active period according to the current depth.

4.1.2 Processing

EK80 data were processed in MATLAB 2024a using a series of internal scripts provided by Kongsberg Maritime (L. Anderson, personal communication). The frequency-modulated (FM) data was match-filtered by using an idealized replica signal. The resulting .mat files are loaded in MATLAB 2024a for range correction and plotting using a script provided by Christian Stranne (Stockholm University). Range from the transducer face was corrected using the mean harmonic sound speed based on the nearest in time and space CTD profile and then converted to depth by accounting for a 7 m transducer draft.

4.1.3 Examples

Features that can be identified with EK80 data include thermohaline stratification (Figure 4.1-1a, b), zooplankton (Figure 4.1-1.a1 and a2), fish (Figure 4.1-1a.4), fish schools, internal waves (Figure 4.1-1f), Kelvin-Helmholtz instabilities (Figure 4.1-1e), and potentially gas seeps (Figure 4.1-1d) and meltwater plumes (Figure 4.1-1.c).

4.1.4 Performance

In general, EK80 has performed well during the cruise SD041. The only issues encountered in EK80 data are a limited range recorded and noise from the ship and other acoustic systems. Limited range recorded means that the data was only logged from the surface to a specified range. This was done to avoid deep sub-bottom data acquisition. On a few occasions, the seafloor itself went deeper than the range recorded, and this prevented the logging of the entire water column until the range recorded was changed.

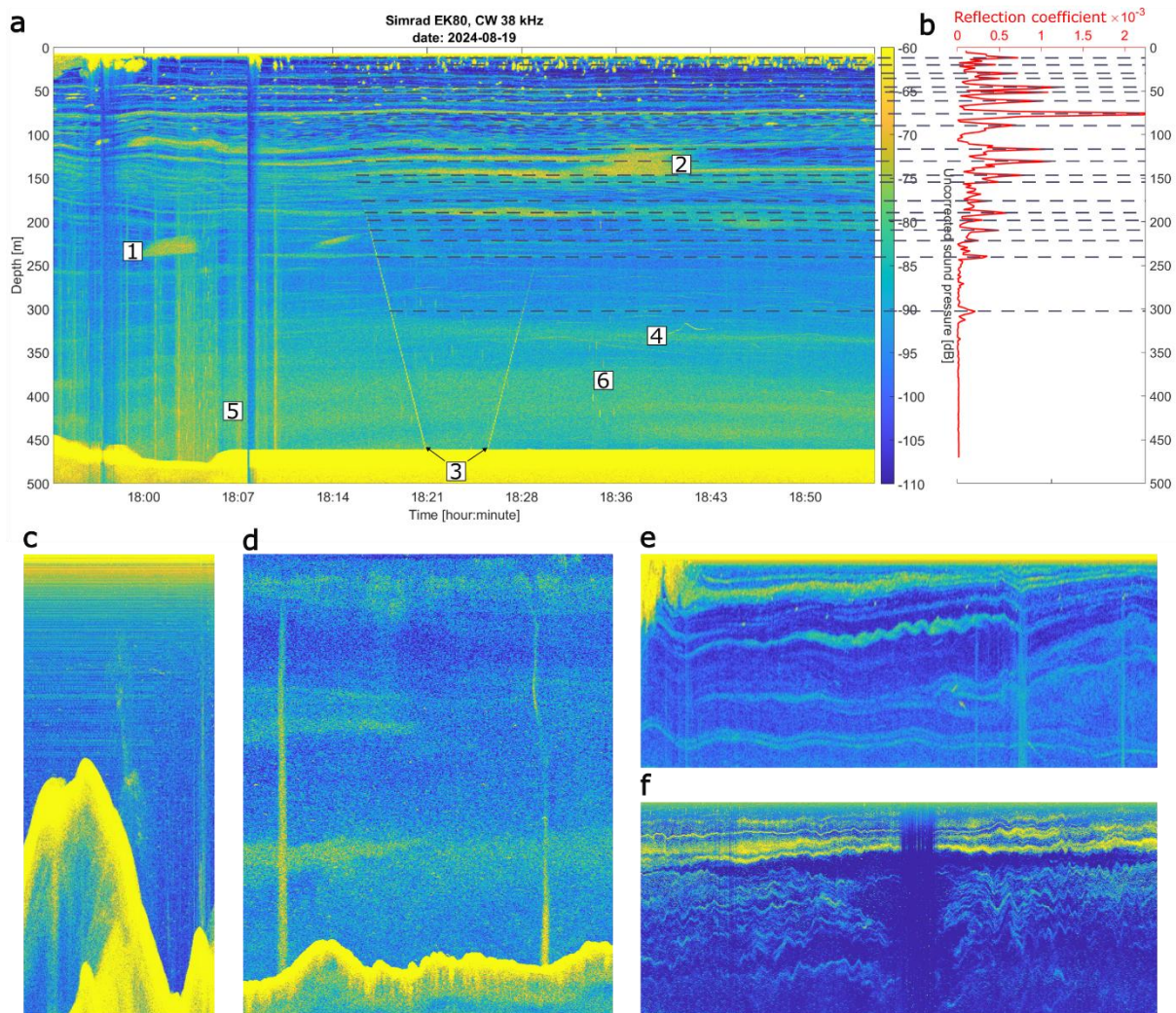


Figure 4.1-1. Examples of the features identified with the EK80 system during the cruise SD041. (a) Echogram from the 38 kHz showing: 1 biological aggregation, 2 biological aggregations aligned with thermohaline stratification, 3 CTD cast, 4 a single fish swimming under the static vessel, 5 noise from the thrusters, and 6 noise from the USBL of the CTD. The dashed lines indicate where there is supposed to be reflection of the acoustic beam according to the data from the CTD profile, aligned with the peaks of the reflection coefficient in Figure 4.1-1b. (b) Reflection coefficient calculated from the data of the CTD shown in Figure 4.1-1a. The dashed lines represent the peaks on the reflection coefficient, and are extended to Figure 4.1-1a where the CTD data was acquired. (c), (d), (e), (f) examples of perhaps meltwater plume, gas seeps, Kelvin-Helmholtz instabilities, and internal waves respectively.

The most obtrusive interference happened on August 24 from 15:28 to 18:33. This was caused by a cross-talk with TOPAS PS18 (Figure 4.1-2c). Since the active periods of TOPAS and EK80 were set to fixed period in K-Sync, when getting to deeper waters, the acoustic beam of TOPAS was received when the EK80 period in K-Sync was active. This was solved by setting the active period of TOPAS and EK80 to external triggering, meaning that the active period was automatically adjusted based on the water depth information that K-Sync was receiving.

In terms of relatively common interferences, we find those caused by the ship's thrusters, which affect the entire water column in the EK80 data mainly when reverse thrust is applied (Figure 4.1-1a.5). Also, interferences that are a few pings wide and a few tens of ms long. The 200 kHz system seems to be more sensitive to this noise. These interferences are caused by the USBL beacons installed in the CTD during CTD casts (Figure 4.1-1a.6), and by other acoustic systems

from the ship that are not synchronized with the scientific systems (Figure 4.1-2b). The latter started appearing from July 28 at 16:40 to August 08 at 08:18 in an almost continuous way and continued to August 18 at 23:25 in a discontinuous way. We unsuccessfully tried to solve the issue by modifying parameters from the EK80 and turning off TOPAS PS18 and the ADCPs, so the best guess for explaining this noise is the ship's navigational echo sounders, which are not synchronized with the scientific echo sounders and they run intermittently depending on the ship's safety needs. This noise seems to be accentuated on the ES70-7C and ES120-7C when using the wideband mode, perhaps because cross-talking with the 75 and 150 kHz ADCPs is added. Another issue identified during most of the cruise is a signal in the ES18 present at the first 100-150 m of the water column, which is restricted to the first 50 m or less on some occasions (Figure 4.1-2a).

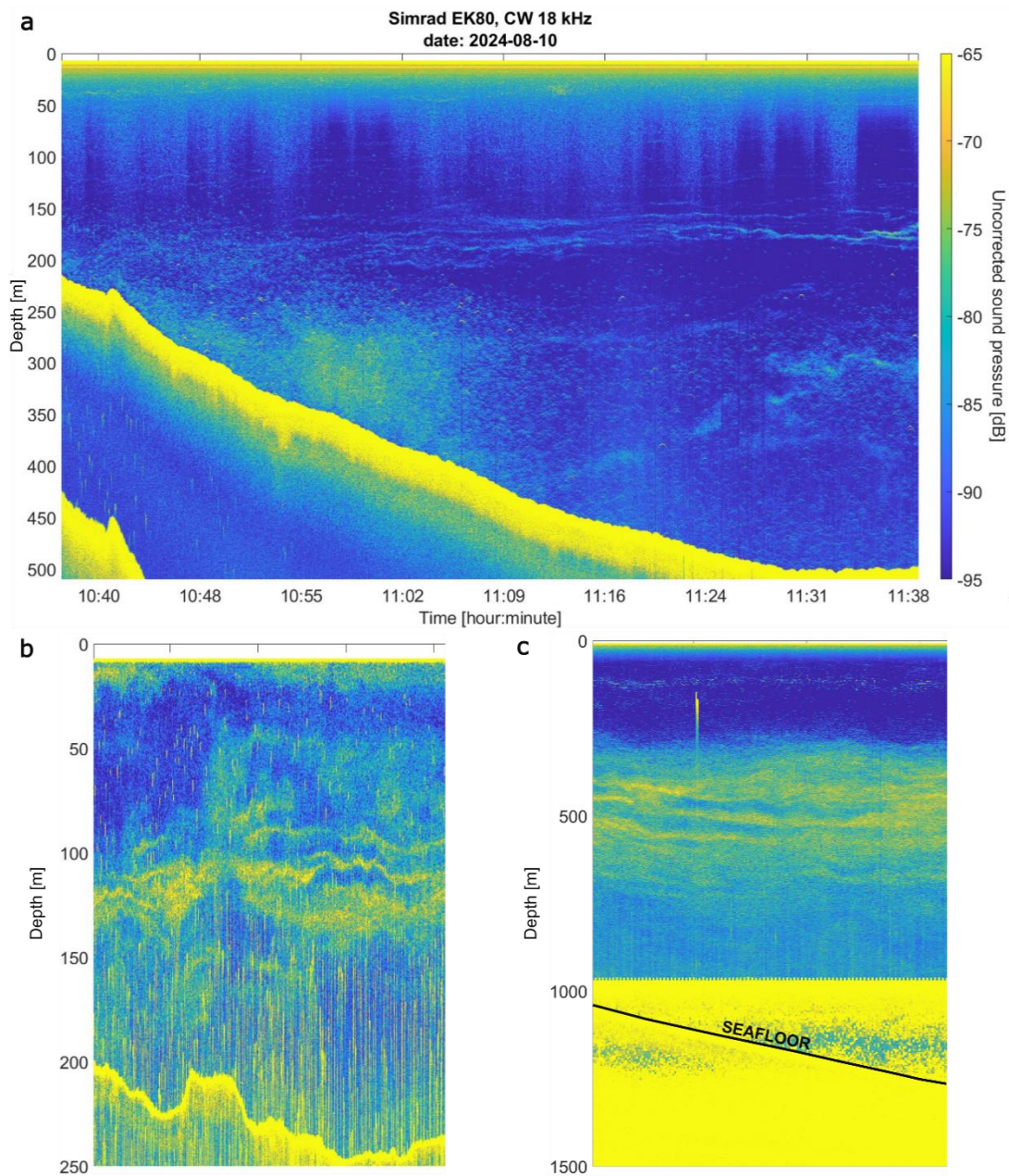


Figure 4.1-2. Examples of typical interferences identified during the cruise SD041. (a) Signal in the 18 kHz at the first 50-150 m. (b) Interference from an unsynchronized acoustic system which is accentuated in the

200 kHz. (c) Interference parallel to the sea surface and extending at around 950 m deep, caused by the TOPAS PS18.

4.2 Bongo Nets

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A Bongo net containing a spring-tensioned motion compensation unit was deployed regularly throughout cruise SD041. The net contains 2 x 61 cm diameter rings, both with 200 μ m mesh (Figure 4.2-1).

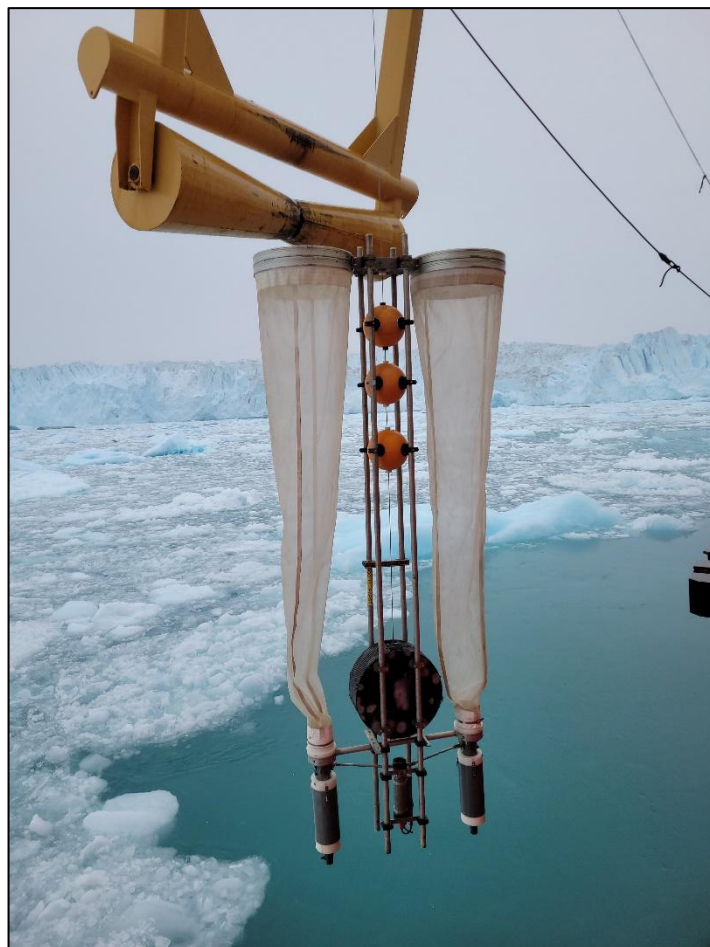


Figure 4.2-1. Bongo net deployed during SD041.

The cod-ends contained taps through which samples were collected at the end of the deployment. Above the cod-ends was a customised open-closing mechanism which could be programmed to open and close the entrance to the cod-ends at preset depths. When closed, water flowing through the nets was channelled through a vent just above the cod-ends. Water entered the cod-ends only when the mechanism was open (Figure 4.2-1).

Deployments were carried out off the starboard side using the hydrographic winch with a 6 mm non-conducting wire (the Hydro wire). The wire went through a block which was suspended from the starboard gantry A-frame. The Bongo rested on a specialised ~4 m high customised stand

(Figure 4.2-3). The stand was bolted down to the deck matrix either in the hanger (when not in use) or on the starboard deck (when ready to be deployed).

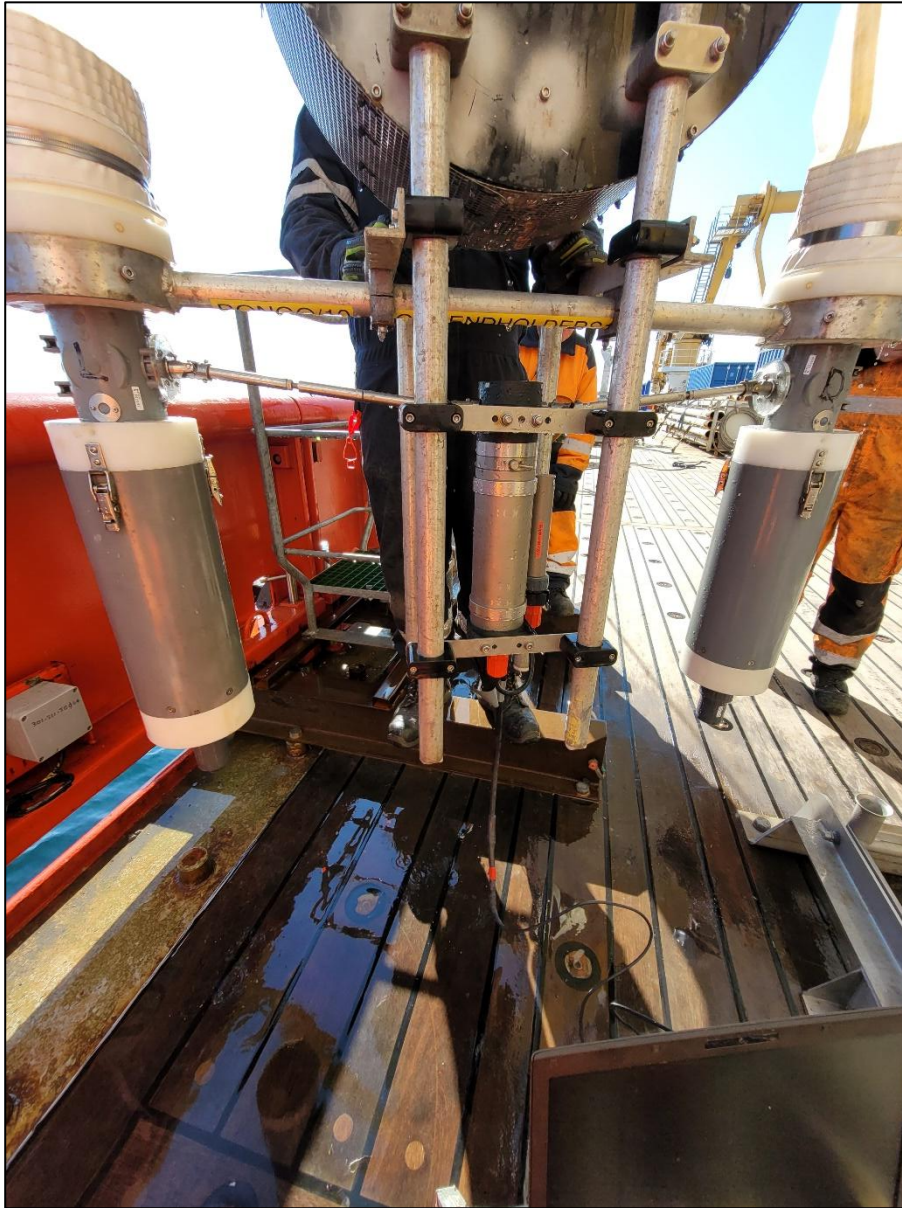


Figure 4.2-2. Open closing mechanism used on SD041.

To connect the Bongo net to the deployment wire, the Bongo net was lowered down to an angle of around 30 degrees above deck through a spool and winch mechanism integrated within Bongo stand (Figure 4.2-3). The net was winched back up to vertical once the wire was attached and the net ready to deploy.

Descent of the net was carried out at a speed of ~ 0.5 m/s, which was measured by a gauge integrated within the winch system. It was hauled in at a speed of ~ 0.3 m/s.

The usual protocol was for the first deployment to be made to 50 m with the cod-end mechanism in the open position throughout the deployment. A second deployment sampled the water depth interval 200 to 50 m, through programming the cod-end mechanism to open and close at the respective lower and upper depths while hauling in. Where there was less than 200 m of water

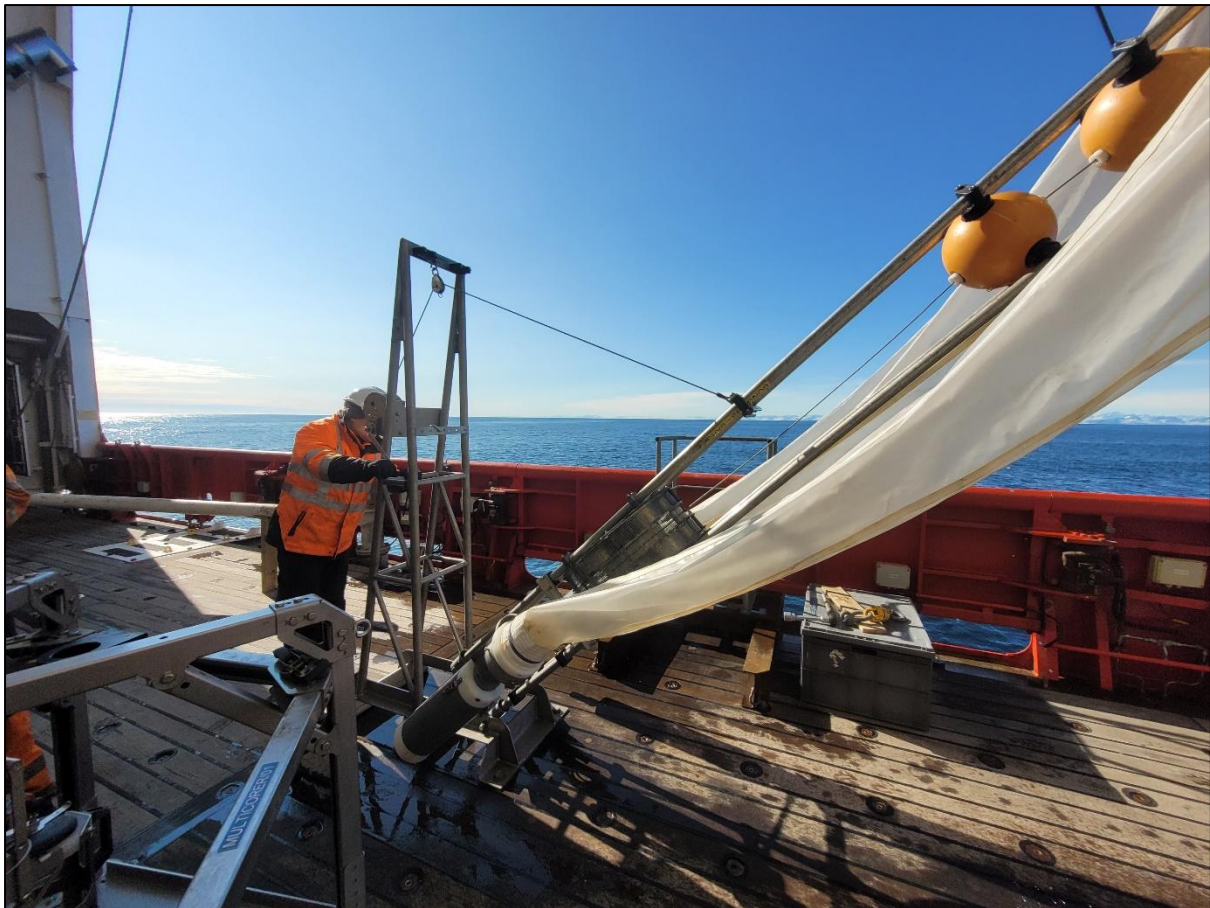


Figure 4.2-3. Bongo and frame showing the lowering bridle to allow access to connect/disconnect the Hydrowire.

depth, the net was deployed to within 15 m of the seabed before being hauled in. Occasionally, a 400 to 200 m depth interval was sampled through the same principal of depth-programming the cod-end mechanism. The net was thoroughly rinsed between deployments to minimise cross contamination.

Programming depths was carried out in the Oceanlab 3.0 software operated on a Windows-based PC and connected to the Bongo mechanism using a specialised connection cable (subsea to FTDI serial to USB; Figure 4.2-4). The programme requires the mechanism first to pass through a trigger depth, which was most frequently set to 5 m below the opening depth. The net was sent to 10 to 15 m below this trigger depth to ensure that it was passed during the descent phase.

The Bongo mechanism stored a memory of its operations which was downloaded and examined to ensure that the opening/closing device operated as instructed. It was found that effective opening and closing depth were around 2 to 3 m shallower than programmed.

Given that the bongo contained two nets with the same mesh size, each deployment provided two samples that were nominally identical. In the vast majority of deployments, one of these two samples was preserved completely intact in buffered 4% formaldehyde. Where any individual specimens were extracted from the catch, this was noted on the back of the sample label. The other net-catch was used as a source of specimens for bioassays, biochemical and molecular analyses with the remnants discarded.

Invariably, each Bongo net deployment was made immediately after a CTD deployment.

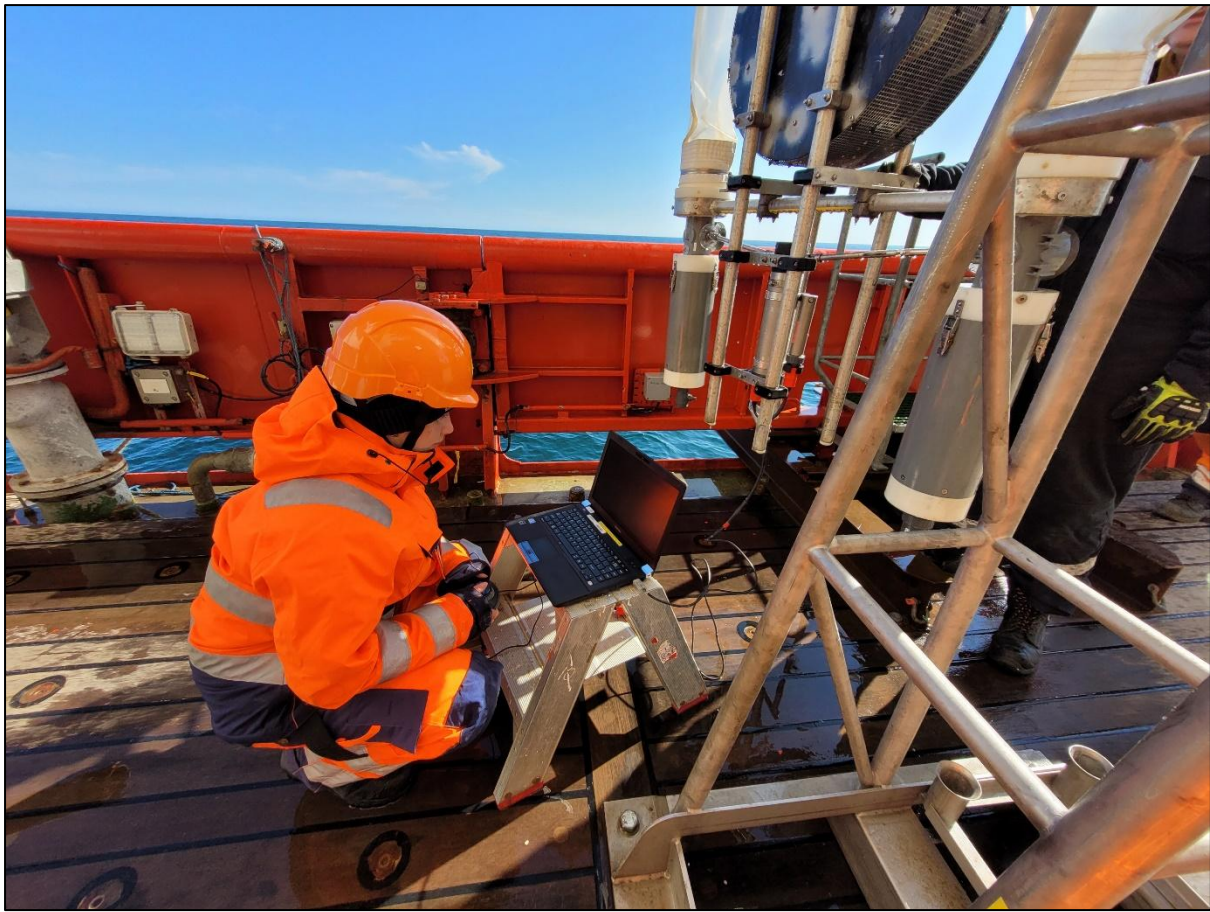


Figure 4.2-4. Reprogramming the cod-end mechanism prior to deployment.

Test deployments were carried out (Events 143 to 148 on 7th August) to examine the impact on catches of any trapped air within the cod-ends being released when opening at depth. Deployments between 0 and 50 m were made: (1) with nets continuously open versus opening at 50 m and closing at 5 m or (2) with the cod-ends prefilled versus not prefilled with water. Results were inconclusive on whether trapped air made any difference to catches. Nevertheless, there were further concerns that this trapped air may cause an implosion of the cod-ends when at depths greater than 200 m, so small holes were drilled in the collars just above the cod-ends, covered with 100 μm mesh, to allow any air within them to be released and pressure to be equalised. Prior tests (Event 180) were carried out with one collar drilled and the other not drilled (and the cod-end containing air) to ensure this modification did not affect catchability of zooplankton. There was no evident difference between the drilled and non-drilled samples which was reassuring with regards the previous concern over trapped air and catchability, of most relevance to the 200 to 50 m samples.

For certain deployments, a mini-Bongo (Hydro-bios Apstein) with a mouth opening diameter of 8.5 cm and a 67 μm mesh net was also attached to the Bongo frame. The net was open for the duration of each haul. It was thoroughly rinsed before the sample was collected when the net was outboard at just above the height of the gunwale. None of these samples were retained given they did not contain the target organism, Foraminifera.

In total, 60 deployments were made during SD041 (Table 4.2-1).

Table 4.2-1. Bongo net deployments during SD041.

Time	Lat	Long	Event	Net depth interval (m)	Action
24/08/24 12:06	65.75046	-30.653	285		deployment/outWater
24/08/24 11:53	65.75046	-30.653	285	200-50	deployment/atDepth
24/08/24 11:47	65.75046	-30.653	285		deployment/inWater
24/08/24 11:46	65.75046	-30.653	285		deployment/inWater
24/08/24 11:40	65.75046	-30.653	284		deployment/outWater
24/08/24 11:37	65.75046	-30.653	284	50-0	deployment/atDepth
24/08/24 11:33	65.75046	-30.653	284		deployment/inWater
23/08/24 13:39	66.64243	-30.6608	277		deployment/outWater
23/08/24 13:29	66.64244	-30.6608	277	200-50	deployment/atDepth
23/08/24 13:21	66.64243	-30.6608	277		deployment/inWater
23/08/24 13:12	66.64243	-30.6608	276		deployment/outWater
23/08/24 13:10	66.64243	-30.6608	276	50-0	deployment/atDepth
23/08/24 13:07	66.64244	-30.6608	276		deployment/inWater
22/08/24 15:20	67.73355	-31.0122	269		deployment/outWater
22/08/24 15:09	67.73421	-31.0105	269	200-50	deployment/atDepth
22/08/24 15:01	67.73805	-31.0036	269		deployment/inWater
22/08/24 14:54	67.73698	-31.0057	268		deployment/outWater
22/08/24 14:50	67.73801	-31.0048	268	50-0	deployment/atDepth
22/08/24 14:46	67.73805	-31.0036	268		deployment/inWater
19/08/24 20:06	67.41702	-32.4334	244		deployment/outWater
19/08/24 19:56	67.41927	-32.4315	244	200-50	deployment/atDepth
19/08/24 19:46	67.42167	-32.4276	244		deployment/inWater
19/08/24 19:41	67.42422	-32.4242	243		deployment/outWater
19/08/24 19:37	67.42565	-32.4228	243	50-0	deployment/atDepth
19/08/24 19:34	67.42569	-32.4228	243		deployment/inWater
19/08/24 12:21	67.35676	-31.956	240		deployment/outWater
19/08/24 12:10	67.35676	-31.956	240	200-50	deployment/atDepth
19/08/24 12:02	67.35676	-31.956	240		deployment/inWater
19/08/24 11:53	67.35676	-31.956	239		deployment/outWater
19/08/24 11:50	67.35676	-31.956	239	50-0	deployment/atDepth
19/08/24 11:46	67.35676	-31.956	239		deployment/inWater
18/08/24 22:04	67.69997	-32.4858	236		deployment/outWater
18/08/24 22:01	67.69997	-32.4858	236	50-0	deployment/atDepth
18/08/24 21:59	67.69997	-32.4858	236		deployment/inWater
18/08/24 21:53	67.69997	-32.4858	235		deployment/outWater
18/08/24 21:39	67.69997	-32.4858	235	200-50	deployment/atDepth
18/08/24 21:21	67.69997	-32.4858	235		deployment/inWater
18/08/24 16:20	67.69269	-32.5767	233		deployment/outWater
18/08/24 16:10	67.69269	-32.5767	233	200-50	deployment/atDepth
18/08/24 15:59	67.69269	-32.5767	233		deployment/inWater
18/08/24 15:09	67.6927	-32.5763	232		deployment/outWater
18/08/24 15:06	67.69264	-32.5754	232	50-0	deployment/atDepth

18/08/24 15:02	67.69261	-32.575	232		deployment/inWater
17/08/24 17:10	67.41136	-32.683	223		deployment/outWater
17/08/24 16:58	67.4135	-32.683	223	200-50	deployment/atDepth
17/08/24 16:50	67.41412	-32.6833	223		deployment/inWater
17/08/24 16:38	67.41412	-32.6833	222		deployment/outWater
17/08/24 16:36	67.41427	-32.6834	222	50-0	deployment/atDepth
17/08/24 16:33	67.41437	-32.6833	222		deployment/inWater
15/08/24 14:54	67.70579	-32.8017	209		deployment/outWater
15/08/24 14:30	67.70569	-32.8016	209	400-200	deployment/inWater
15/08/24 13:42	67.70522	-32.8011	209		deployment/inWater
15/08/24 12:50	67.70502	-32.8005	208		deployment/outWater
15/08/24 12:41	67.70501	-32.8005	208	200-50	deployment/atDepth
15/08/24 12:34	67.70503	-32.8005	208		deployment/inWater
15/08/24 12:25	67.70462	-32.8003	207		deployment/outWater
15/08/24 12:23	67.70462	-32.8003	207	50-0	deployment/atDepth
15/08/24 12:19	67.70454	-32.8003	207		deployment/inWater
14/08/24 18:42	67.59529	-33.0465	203		deployment/outWater
14/08/24 18:29	67.59489	-33.046	203	200-50	deployment/atDepth
14/08/24 18:24	67.5948	-33.0457	203		deployment/inWater
14/08/24 18:14	67.59445	-33.0441	202		deployment/outWater
14/08/24 18:11	67.59446	-33.0441	202	50-0	deployment/atDepth
14/08/24 18:09	67.59446	-33.0441	202		deployment/inWater
12/08/24 17:19	67.85389	-32.3584	192		deployment/outWater
12/08/24 17:10	67.85414	-32.359	192	190-50	deployment/atDepth
12/08/24 17:04	67.85428	-32.3601	192		deployment/inWater
12/08/24 14:25	67.87763	-32.3528	189		deployment/outWater
12/08/24 14:19	67.8782	-32.3535	189	0-90	deployment/atDepth
12/08/24 14:10	67.87833	-32.354	189		deployment/inWater
11/08/24 20:52	67.74353	-32.2259	180		deployment/outWater
11/08/24 20:42	67.74305	-32.2253	180	200-50	deployment/atDepth
11/08/24 20:35	67.74297	-32.2248	180		deployment/inWater
11/08/24 20:27	67.74293	-32.2247	179		deployment/outWater
11/08/24 20:25	67.74312	-32.2239	179	0-50	deployment/atDepth
11/08/24 20:22	67.74328	-32.2237	179		deployment/inWater
11/08/24 16:40	67.86073	-32.4669	176		deployment/outWater
11/08/24 16:35	67.86155	-32.4684	176	0-50	deployment/atDepth
11/08/24 16:25	67.86186	-32.4708	176		deployment/inWater
09/08/24 20:49	67.54798	-31.8019	164		deployment/outWater
09/08/24 20:41	67.54973	-31.8019	164	0-50	deployment/atDepth
09/08/24 20:38	67.54974	-31.8019	164		deployment/inWater
07/08/24 22:43	68.35391	-28.8012	151		deployment/outWater
07/08/24 22:30	68.35402	-28.8017	151	0-170	deployment/atDepth
07/08/24 22:18	68.35476	-28.8013	151		deployment/inWater
07/08/24 20:25	68.41227	-28.818	149		deployment/outWater
07/08/24 20:18	68.41227	-28.818	149	200-50	deployment/atDepth
07/08/24 20:11	68.41235	-28.8176	149		deployment/inWater

07/08/24 20:06	68.41235	-28.8176	148		deployment/outWater
07/08/24 19:56	68.41235	-28.8176	148	200-50	deployment/atDepth
07/08/24 19:48	68.41235	-28.8176	148		deployment/inWater
07/08/24 15:45	68.41223	-28.816	146		deployment/outWater
07/08/24 15:41	68.41223	-28.816	146	50-0	deployment/atDepth
07/08/24 15:37	68.41223	-28.8159	146		deployment/inWater
07/08/24 15:22	68.41223	-28.8159	145		deployment/outWater
07/08/24 15:20	68.41223	-28.8159	145	50-0	deployment/atDepth
07/08/24 15:17	68.41223	-28.816	145		deployment/inWater
07/08/24 15:01	68.41223	-28.816	144		deployment/outWater
07/08/24 14:57	68.41223	-28.816	144	0-50	deployment/atDepth
07/08/24 14:51	68.41223	-28.816	144		deployment/inWater
07/08/24 14:42	68.41223	-28.816	143		deployment/outWater
07/08/24 14:40	68.41223	-28.8159	143	0-50	deployment/atDepth
07/08/24 14:35	68.41223	-28.816	143		deployment/inWater
07/08/24 14:31	68.41223	-28.816	142		deployment/outWater
07/08/24 14:26	68.41223	-28.8159	142	0-50	deployment/atDepth
07/08/24 14:23	68.41223	-28.8159	142		deployment/inWater
06/08/24 16:08	68.36707	-29.0928	133		deployment/outWater
06/08/24 15:56	68.36707	-29.0925	133	100-50	deployment/atDepth
06/08/24 15:46	68.36707	-29.0925	133		deployment/inWater
06/08/24 15:38	68.36708	-29.0925	132		deployment/outWater
06/08/24 15:35	68.36708	-29.0925	132	0-50	deployment/atDepth
06/08/24 15:31	68.36708	-29.0926	132		deployment/inWater
05/08/24 16:10	68.39232	-29.1602	122		deployment/outWater
05/08/24 16:03	68.39233	-29.1602	122	200-50	deployment/atDepth
05/08/24 15:54	68.39232	-29.1602	122		deployment/inWater
05/08/24 15:49	68.39233	-29.1602	121		deployment/outWater
05/08/24 15:43	68.39233	-29.1602	121	0-50	deployment/atDepth
05/08/24 15:39	68.39233	-29.1602	121		deployment/inWater
05/08/24 14:06	68.42325	-29.2182	119		deployment/outWater
05/08/24 14:02	68.42325	-29.2182	119	150-50	deployment/atDepth
05/08/24 13:56	68.42325	-29.2182	119		deployment/inWater
05/08/24 13:43	68.42325	-29.2182	118		deployment/outWater
05/08/24 13:40	68.42325	-29.2182	118	0-50	deployment/atDepth
05/08/24 13:34	68.42326	-29.2181	118		deployment/inWater
05/08/24 11:54	68.44633	-29.2565	115		deployment/outWater
05/08/24 11:44	68.44633	-29.2565	115	200-50	deployment/atDepth
05/08/24 11:36	68.44633	-29.2565	115		deployment/inWater
05/08/24 11:22	68.44633	-29.2565	114		deployment/outWater
05/08/24 11:20	68.44633	-29.2565	114	0-50	deployment/atDepth
05/08/24 11:13	68.44641	-29.2565	114		deployment/inWater
04/08/24 03:04	68.10732	-30.4232	106		deployment/outWater
04/08/24 02:56	68.10732	-30.4232	106	0-100	deployment/atDepth
04/08/24 02:48	68.10732	-30.4232	106		deployment/inWater
04/08/24 02:21	68.10732	-30.4232	105		deployment/outWater

04/08/24 02:00	68.10732	-30.4232	105	300-200	deployment/atDepth
04/08/24 01:24	68.10737	-30.4228	105		deployment/inWater
04/08/24 01:16	68.10737	-30.4227	104		deployment/outWater
04/08/24 01:03	68.10737	-30.4227	104	200-0	deployment/atDepth
04/08/24 00:47	68.10737	-30.4228	104		deployment/inWater
03/08/24 18:44	68.2566	-30.7112	101		deployment/outWater
03/08/24 18:35	68.2566	-30.7112	101	200-50	deployment/atDepth
03/08/24 18:27	68.2566	-30.7112	101		deployment/inWater
03/08/24 18:19	68.2566	-30.7112	100		deployment/outWater
03/08/24 18:16	68.2566	-30.7112	100	0-50	deployment/atDepth
03/08/24 18:13	68.2566	-30.7112	100		deployment/inWater
01/08/24 16:31	68.19059	-30.4487	87		deployment/outWater
01/08/24 16:20	68.19065	-30.4501	87	200-50	deployment/atDepth
01/08/24 16:10	68.19066	-30.4504	87		deployment/inWater
01/08/24 15:54	68.19052	-30.4505	86		deployment/outWater
01/08/24 15:51	68.19051	-30.4503	86	0-50	deployment/atDepth
01/08/24 15:48	68.19051	-30.4503	86		deployment/inWater
01/08/24 12:47	68.22332	-30.4768	83		deployment/outWater
01/08/24 12:40	68.22332	-30.4768	83	200-50	deployment/atDepth
01/08/24 12:30	68.22332	-30.4768	83		deployment/inWater
01/08/24 12:19	68.22332	-30.4768	82		deployment/outWater
01/08/24 12:16	68.22332	-30.4768	82	0-50	deployment/atDepth
01/08/24 12:13	68.22332	-30.4768	82		deployment/inWater
31/07/24 15:57	68.23486	-30.6022	69		deployment/outWater
31/07/24 15:50	68.23486	-30.6022	69	0-100	deployment/atDepth
31/07/24 15:43	68.23486	-30.6022	69		deployment/inWater
31/07/24 11:28	68.27515	-30.7774	65		deployment/outWater
31/07/24 11:17	68.27506	-30.7773	65	200-50	deployment/atDepth
31/07/24 11:06	68.27506	-30.7773	65		deployment/inWater
31/07/24 10:56	68.27506	-30.7773	64		deployment/outWater
31/07/24 10:53	68.27507	-30.7773	64	0-50	deployment/atDepth
31/07/24 10:50	68.27506	-30.7773	64		deployment/inWater
28/07/24 11:51	67.74455	-31.4609	35		deployment/outWater
28/07/24 11:32	67.7457	-31.4546	35	400-200	deployment/atDepth
28/07/24 11:13	67.747	-31.4451	35		deployment/inWater
28/07/24 11:05	67.74716	-31.4433	34		deployment/outWater
28/07/24 10:55	67.74748	-31.4375	34	0-200	deployment/atDepth
28/07/24 10:44	67.74782	-31.4313	34		deployment/inWater
26/07/24 13:17	66.90962	-30.7174	20		deployment/outWater
26/07/24 12:59	66.90815	-30.7161	20	400-200	deployment/atDepth
26/07/24 12:43	66.90649	-30.7155	20		deployment/inWater
26/07/24 12:21	66.9061	-30.7147	19		deployment/outWater
26/07/24 12:09	66.90491	-30.7124	19	0-200	deployment/atDepth
26/07/24 12:00	66.90406	-30.7104	19		deployment/inWater
25/07/24 14:35	67.4917	-33.0032	13		deployment/outWater
25/07/24 14:24	67.49159	-33.0038	13	0-200	deployment/atDepth

25/07/24 14:15	67.49158	-33.0042	13		deployment/inWater
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4.3 MOCNESS Deployments

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The MOCNESS net system is designed to capture meso- and micro-zooplankton and is particularly effective at capturing fast moving taxa such as euphausiids, amphipods and chaetognaths. It also collects copepods down to the minimum mesh size of 300 μm . The net system was deployed at most locations visited by the KANG-GLAC expedition in south-east Greenland to examine zooplankton community distribution. At two of these locations (the mouth of Kangerlussuaq Fjord and close to the mooring site), it was deployed every 6 hours over a 24 h period to determine diel cycles in the vertical distribution of the zooplankton community.

The MOCNESS has a mouth opening area of 1 m^2 and contains 9 x 330 μm meshed nets. It was nominally trawled at between 2 and 3 knots. The angle of the net in the water, which affects effective mouth opening area, was logged on certain deployments. The device did not contain a flow meter but did have sensors for temperature and salinity. Volume filtered was otherwise estimated through reference to the second-by-second log of ship speed through the water and wire hauling speed and assuming a 45° net angle (approximate average from logged deployments). The system was operated through the BAS Down Wire Net Monitor (DWNM) system and driven by customised software developed by AME in Labview 2020 SP1. It was deployed from the aft deck using the ship's biological wire with fibre optic communications.

During all deployments, net 1 was open during the descent to the maximum sampling depth. The remaining 8 nets (nets 2 to 9) were opened and closed during the reascent to the surface. Nets 2 to 9 hence provided a depth-discrete profile of vertical plankton community distribution.

All but one of the deployments of the MOCNESS were carried out in shelf environments where the depth of the seabed varied between 200 m and 800 m. Sampling depth intervals were therefore varied to accommodate these differing bottom depths. In each instance, the depth intervals always divided the upper layers so that they were subdivisions of the top 200 m. This allowed comparison with Bongo catches which invariably also sampled from 200 m upwards. The deepest bottom depth was no greater than 15 m above the seabed. One MOCNESS deployment was carried out at the shelf edge where the seabed was greater than 1000 m. Maximum sampling depth in this instance was 1000 m.

The MOCNESS was paid out between 0.3 and 0.5 m/s and hauled in at 0.1 to 0.3 m/s.

With the exception of net 1, for which the catch was discarded, all net catches were split with a Folsom splitter into two subdivisions. One subdivision was immediately preserved in buffered 4% formaldehyde (note that for particularly large catches, a further subdivision to one quarter of the catch was made before preservation). The other half of the catch was first weighed (wet weight) then sorted into the lowest possible taxonomic level to determine taxonomic diversity, abundance and biomass. All wet weights were measured either with a Pols S-182 scales (resolution to 1 g) for the whole ½ sample or Marel M series 2200 scales (resolution to 0.05 g) for individual taxa.

Post-sorting, the ½ sample was reconstituted and kept at low temperature (~3°C) to allow further extraction and/or analysis of specimens for other purposes. For instance, where there was a high

abundance of euphausiids, these were measured for total body length to determine a species-specific body-size frequency distribution. Copepods were sometimes extracted for lipid sac size, CHN and metabolomic analyses. The remainder of the ½ sample was discarded.

Two deployments were unsuccessful to a certain degree 1) the first due mistaking net position due to a faulty camera and triggering the net prematurely 2) due to nets snagging on the side bars because they were not horizontal on deployment. In these instances, it was possible to determine which depth strata were missed and to ascertain the depth strata actually sampled during the deployment. Sample labels and records were adjusted to reflect these realised depth-strata.

Bucket 7 (150 to 100 m) was lost on Event 167 (10/8/24 07:08 UTC). There were no other losses of cod-ends or samples.

The MOCNESS was deployed 18 times during SD041.



Figure 4.3-1. MOCNESS being deployed during SD041.



Figure 4.3-2. MOCNESS deployment showing deployment method on SD041.



Figure 4.3-3. MOCNESS recovery during detachment of cod-ends (cod-ends resting in grey buckets here).

Table 4.3-1. MOCNESS deployments on SD041.

Time (UTC)	Latitude (decimal degrees)	Longitude (decimal degrees)	Speed over ground (knots)	Speed through water (knots)	Bridge event number	net depth	Event action type (volume filtered m ³)		Comment
24/08/24 18:38	65.11289	-30.6499	1.7	3.8	286	5	Net 9 closed		
24/08/24 18:32	65.11455	-30.6572	2.5	3.7	286	100	Net 9 open	569	
24/08/24 18:21	65.1172	-30.6699	2.8	4.8	286	200	Net 8 open	863	
24/08/24 18:17	65.11862	-30.677	2.7	4.6	286	300	Net 7 open	445	
24/08/24 18:12	65.11988	-30.6836	1.9	3.3	286	400	Net 6 open	452	
24/08/24 18:03	65.12188	-30.6921	2.4	4.3	286	500	Net 5 open	729	
24/08/24 17:57	65.12373	-30.699	2	3.8	286	600	Net 4 open	562	
24/08/24 17:45	65.12696	-30.7121	1.9	3.9	286	800	Net 3 open	110 0	
24/08/24 17:37	65.12959	-30.721	2	3.6	286	1000	Net 2 open	830	
24/08/24 16:35	65.15318	-30.7789	2.1	4	286		deployment/inWater		
21/08/24 18:27	67.77555	-30.7226	1.8	4.3	261	5	Net 9 closed		
21/08/24 18:23	67.77472	-30.726	1.8	4.4	261	25	Net 9 open	374	
21/08/24 18:17	67.7731	-30.7326	1.8	3.9	261	50	Net 8 open	707	
21/08/24 18:10	67.7709	-30.741	1.9	4.7	261	100	Net 7 open	925	
21/08/24 18:01	67.76803	-30.7516	2	4.6	261	150	Net 6 open	115 0	
21/08/24 17:51	67.76458	-30.7631	2.2	5.2	261	200	Net 5 open	127 2	
21/08/24 17:45	67.76195	-30.7709	2	4.8	261	250	Net 4 open	840	
21/08/24 17:39	67.75988	-30.7766	2	4.3	261	300	Net 3 open	669	
21/08/24 17:36	67.75878	-30.7795	2.1	5.1	261	320	Net 2 open	339	
21/08/24 17:14	67.75118	-30.8004	1	2.9	261		deployment/inWater		
17/08/24 01:38	67.48078	-32.9647	1.7	2.3	218	5	Net 9 closed		
17/08/24 01:35	67.47946	-32.9633	1.7	2.1	218	50	Net 9 open	174	
17/08/24 01:32	67.47816	-32.9618	1.5	2	218	100	Net 8 open	185	
17/08/24 01:24	67.47517	-32.9584	1.6	2.2	218	200	Net 7 open	437	
17/08/24 01:16	67.47202	-32.9547	1.5	2.3	218	300	Net 6 open	469	

17/08/24 01:06	67.46899	-32.9482	1.6	2.3	218	400	Net 5 open	545	
17/08/24 00:58	67.46745	-32.939	1.7	2.6	218	500	Net 4 open	515	
17/08/24 00:50	67.46662	-32.9299	1.7	2.6	218	600	Net 3 open	464	
17/08/24 00:41	67.46565	-32.9187	1.7	2.6	218	700	Net 2 open	592	
17/08/24 00:08	67.45374	-32.8865	2.1	3.4	218		deployment/inWater		
16/08/24 20:06	67.49432	-33.0158	2.5	3.5	217	5	Net 9 closed		
16/08/24 20:01	67.49216	-33.01	2.4	3.5	217	50	Net 9 open	364	
16/08/24 19:56	67.4897	-33.0031	2.4	3.6	217	100	Net 8 open	435	
16/08/24 19:46	67.48524	-32.9908	2.3	3.5	217	200	Net 7 open	815	
16/08/24 19:36	67.48038	-32.9814	2.2	3.5	217	300	Net 6 open	795	
16/08/24 19:26	67.47553	-32.9715	2.3	3.6	217	400	Net 5 open	849	
16/08/24 19:19	67.47348	-32.9619	2.2	3.4	217	500	Net 4 open	584	
16/08/24 19:14	67.47232	-32.9541	2.1	3.3	217	600	Net 3 open	476	
16/08/24 19:08	67.47176	-32.9459	1.8	2.8	217	700	Net 2 open	495	
16/08/24 18:20	67.45609	-32.8999	1.9	2.9	217		deployment/inWater		
16/08/24 13:47	67.49287	-33.0176	1.9	2.8	216		Net 9 closed		
16/08/24 13:43	67.49137	-33.0137	1.9	2.6	216	50	Net 9 open	164	
16/08/24 13:34	67.48806	-33.0046	1.9	2.8	216	100	Net 8 open	290	
16/08/24 13:26	67.48495	-32.9961	2.3	3.6	216	200	Net 7 open	882	
16/08/24 13:17	67.48141	-32.9854	2	3	216	300	Net 6 open	708	
16/08/24 13:07	67.47779	-32.9732	2.4	3.5	216	400	Net 5 open	769	
16/08/24 13:02	67.47561	-32.967	2.3	3.4	216	500	Net 4 open	429	
16/08/24 12:57	67.47366	-32.9612	2.1	3.1	216	600	Net 3 open	425	
16/08/24 12:50	67.47174	-32.9543	1.4	2.1	216	700	Net 2 open	498	
16/08/24 12:15	67.46033	-32.917	2.1	3.2	216		deployment/inWater		
16/08/24 07:50	67.49706	-33.0223	2.3	2.7	214	5	Net 9 closed		
16/08/24 07:45	67.49494	-33.0162	2.3	2.3	214	50	Net 9 open	332	
16/08/24 07:39	67.49224	-33.0085	2.4	2.5	214	100	Net 8 open	420	

16/08/24 07:29	67.48751	-32.9953	2.5	3.3	214	200	Net 7 open	753	
16/08/24 07:18	67.48296	-32.9825	2.3	2.7	214	300	Net 6 open	776	
16/08/24 07:09	67.47895	-32.9706	2.3	3.1	214	400	Net 5 open	661	
16/08/24 07:00	67.47551	-32.9598	2.2	3.1	214	500	Net 4 open	607	
16/08/24 06:52	67.47248	-32.95	2.2	2.6	214	600	Net 3 open	548	
16/08/24 06:46	67.47024	-32.9423	2	2.7	214	700	Net 2 open	462	
16/08/24 06:08	67.4554	-32.8998	2.1	3.5	214		deployment/inWater		
11/08/24 02:03	67.93707	-31.626	1.4	3	171	5	Net 9 closed		
11/08/24 01:57	67.93724	-31.6326	1.5	3.1	171	50	Net 9 open	381	
11/08/24 01:52	67.93726	-31.6382	1.5	3.1	171	100	Net 8 open	342	
11/08/24 01:47	67.93725	-31.6438	1.5	3	171	150	Net 7 open	306	
11/08/24 01:42	67.93742	-31.6493	1.5	3.1	171	200	Net 6 open	278	
11/08/24 01:36	67.93775	-31.6553	1.4	2.9	171	250	Net 5 open	319	
11/08/24 01:30	67.93818	-31.6613	1.3	2.8	171	300	Net 4 open	368	
11/08/24 01:19	67.9388	-31.6731	1.6	2.7	171	400	Net 3 open	693	
11/08/24 01:14	67.93899	-31.6787	1.6	2.9	171	450	Net 2 open	322	
11/08/24 00:42	67.9396	-31.7161	1.7	3.4	171		deployment/inWater		
10/08/24 19:52	67.96926	-31.567	2.1	4.7	170	5	Net 9 closed		
10/08/24 19:44	67.96649	-31.5777	2.2	5.1	170	50	Net 9 open	853	
10/08/24 19:35	67.96338	-31.5895	2.2	5	170	100	Net 8 open	950	
10/08/24 19:27	67.96064	-31.5997	2.2	4.8	170	150	Net 7 open	760	
10/08/24 19:20	67.95838	-31.6088	2.3	4.8	170	200	Net 6 open	680	
10/08/24 19:12	67.9559	-31.6192	1.9	4.9	170	250	Net 5 open	850	
10/08/24 19:06	67.95406	-31.6271	2.3	5	170	300	Net 4 open	650	
10/08/24 18:54	67.95071	-31.6424	2	4.6	170	400	Net 3 open	140 0	
10/08/24 18:47	67.9489	-31.6511	2	4.8	170	450	Net 2 open	930	
10/08/24 18:08	67.95044	-31.7074	2.5	4.7	170		deployment/inWater		
10/08/24 13:32	67.96633	-31.6069	1.7	3.8	168	5	Net 9 closed		

10/08/24 13:26	67.9651	-31.6143	1.7	3.9	168	50	Net 9 open	464	
10/08/24 13:19	67.96365	-31.6232	2.1	3.7	168	100	Net 8 open	588	
10/08/24 13:12	67.9624	-31.6324	1.9	3.8	168	150	Net 7 open	503	
10/08/24 13:05	67.96123	-31.6414	2	4	168	205	Net 6 open	584	
10/08/24 13:01	67.96054	-31.6468	1.9	3.6	168	250	Net 5 open	313	
10/08/24 12:57	67.95989	-31.652	1.9	3.5	168	300	Net 4 open	322	
10/08/24 12:47	67.95887	-31.6639	1.9	3.2	168	400	Net 3 open	690	
10/08/24 12:39	67.95813	-31.6727	1.3	3.1	168	450	Net 2 open	495	
10/08/24 12:03	67.9518	-31.7164	1.3	2.5	168		deployment/inWater		
10/08/24 07:29	67.95815	-31.6041	2.1	4.5	167	5	Net 9 closed		
10/08/24 07:21	67.95665	-31.6153	2.2	5.1	167	50	Net 9 open	600	
10/08/24 07:14	67.95554	-31.6255	2.2	5	167	100	Net 8 open	624	
10/08/24 07:08	67.95466	-31.6348	2.1	4.7	167	150	Net 7 open	620	cod end bucket lost
10/08/24 07:02	67.95392	-31.6437	2	4.5	167	200	Net 6 open	620	
10/08/24 06:56	67.95335	-31.6522	2	4.4	167	250	Net 5 open	620	
10/08/24 06:51	67.95303	-31.6597	1.8	4.2	167	300	Net 4 open	570	
10/08/24 06:41	67.95265	-31.6736	1.9	4.2	167	400	Net 3 open	110 0	
10/08/24 06:32	67.95218	-31.6849	1.9	4	167	450	Net 2 open	780	
10/08/24 06:08	67.12974	-30.705	9.5	12.5	167	0	deployment/inWater		
09/08/24 11:23	67.11069	-30.8493	1.9	3.3	162	5	Net 9 closed		
09/08/24 11:15	67.11135	-30.8375	2	4	162	100	Net 9 open	781	
09/08/24 11:10	67.11178	-30.8308	1.5	2.6	162	200	Net 8 open	545	
09/08/24 10:57	67.11221	-30.8191	1.6	3	162	300	Net 7 open	111 8	
09/08/24 10:48	67.11335	-30.811	1.3	2.6	162	400	Net 6 open	790	4 and 5 misfired
09/08/24 10:33	67.11589	-30.7978	1.9	3.5	162	500	Net 3 open	130 0	
09/08/24 10:12	67.12232	-30.7745	2	3.4	162	700	Net 2 open	219 0	1/4 catch preserved (formalin), Note that intention was to go to 600 m

									but Net 3 misfired so integrated to 500 m
09/08/24 09:36	67.13314	-30.7316	1.7	3	162		deployment/inWater		
08/08/24 21:35	67.10335	-30.8464	1.9	3.5	158	5	Net 9 closed		
08/08/24 21:32	67.1041	-30.8429	1.9	3.4	158	50	Net 9 open	337	
08/08/24 21:28	67.10511	-30.8383	1.9	3.2	158	100	Net 8 open	385	
08/08/24 21:19	67.10751	-30.8281	1.9	3.5	158	200	Net 7 open	928	
08/08/24 21:10	67.10992	-30.8178	1.9	3.5	158	300	Net 6 open	860	
08/08/24 20:58	67.11302	-30.8044	1.9	2.9	158	400	Net 5 open	111 2	
08/08/24 20:48	67.11592	-30.793	1.9	3.4	158	500	Net 4 open	926	
08/08/24 20:38	67.11911	-30.7815	2.1	3.6	158	600	Net 3 open	824	
08/08/24 20:31	67.12142	-30.7727	2	3.2	158	700	Net 2 open	768	
08/08/24 19:55	67.13146	-30.7244	2	2.4	158		deployment/inWater		
06/08/24 14:30	68.36754	-29.1192	2.2	2.6	130		deployment/outWater		
06/08/24 14:27	68.36866	-29.1216	2.2	2.7	130	5	Net 9 closed		
06/08/24 14:25	68.36987	-29.1242	2.2	2.7	130	24.4	Net 9 open	180	
06/08/24 14:22	68.37129	-29.1272	2.3	2.8	130	48.3	Net 8 open	220	
06/08/24 14:17	68.37344	-29.1319	2.5	3.2	130	74.1	Net 7 open	367	
06/08/24 14:12	68.37579	-29.1383	2.8	4.2	130	100	Net 6 open	478	
06/08/24 14:06	68.38001	-29.1416	2.8	3.9	130	124.1	Net 5 open	581	
06/08/24 14:04	68.38159	-29.1423	2.6	3.2	130	147.8	Net 4 open	217	
06/08/24 14:00	68.38374	-29.1431	2.1	2.9	130	175.5	Net 3 open	321	
06/08/24 13:55	68.38655	-29.1461	2.8	3.9	130	184.3	Net 2 open	444	
06/08/24 13:24	68.40646	-29.1654	1.7	2.1	130		deployment/inWater		
03/08/24 11:41	68.24277	-30.6542	1.4	1.9	98		MOCNESS on deck		
03/08/24 11:36	68.24446	-30.6629	2.5	3.2	98		deployment/outWater		
03/08/24 11:34	68.24493	-30.6655	2	2.6	98	4.5	Net 9 closed		
03/08/24 11:32	68.24525	-30.6674	1.6	1.8	98	14.7	Net 9 open	90	

03/08/24 11:30	68.24562	-30.6698	1.2	1.5	98	29.8	Net 8 open	109	
03/08/24 11:26	68.2461	-30.6733	1.3	1.5	98	49.8	Net 7 open	175	
03/08/24 11:20	68.24675	-30.6787	1.5	2	98	70.2	Net 6 open	270	
03/08/24 11:12	68.24809	-30.6885	2.1	2.9	98	89.3	Net 5 open	489	
03/08/24 11:10	68.24847	-30.691	2.2	2.9	98	109.2	Net 4 open	118	
03/08/24 11:07	68.24903	-30.6947	1.5	2.1	98	129.6	Net 3 open	172	
03/08/24 11:05	68.24933	-30.6967	1.4	1.8	98	142.7	Net 2 open	106	
03/08/24 10:53	68.25193	-30.7135	1.6	2	98		deployment/inWater		
03/08/24 10:53	68.25193	-30.7135	1.6	2	98	0	In water		
02/08/24 13:17	68.13709	-30.4281	1.6	1.7	89	0	On deck		
02/08/24 13:09	68.14057	-30.429	1.6	1.6	89	0	Commence recovery		
02/08/24 13:06	68.14173	-30.4292	1.7	1.6	89	5.04	Net 9 closed		
02/08/24 13:02	68.1438	-30.4298	1.9	1.7	89	25.2	Net 9 open	204	
02/08/24 12:57	68.14607	-30.4309	2	2.3	89	51.1	Net 8 open	251	
02/08/24 12:50	68.14945	-30.434	1.6	1.4	89	101.3	Net 7 open	376	
02/08/24 12:40	68.1547	-30.4399	2.4	2.3	89	150.4	Net 6 open	622	
02/08/24 12:33	68.15864	-30.4444	2.2	2.2	89	200.2	Net 5 open	476	
02/08/24 12:24	68.16359	-30.4475	2.2	2.2	89	250.4	Net 4 open	559	
02/08/24 12:18	68.16725	-30.4496	2.2	2.3	89	300	Net 3 open	419	
02/08/24 12:07	68.17308	-30.453	2	2.4	89	352	Net 2 open	623	
02/08/24 11:33	68.19356	-30.4538	1.9	2.2	89		deployment/inWater		
29/07/24 17:21	67.90794	-31.5957	1.8	2	49		deployment/outWater		
29/07/24 17:16	67.90716	-31.5901	1.8	2.1	49	5	Net 2 closed	Test deployment. Note that nets 3 to 9 were closed in quick succession at 5m. Catches of 3 to 9 were discarded	
29/07/24 17:10	67.90621	-31.5825	1.8	2.1	49	50	Net 2 open	365	
29/07/24 17:01	67.9047	-31.569	2.3	2.8	49		deployment/inWater		
29/07/24 16:24	67.90077	-31.5459	2.1	3.6	48		deployment/outWater		

29/07/24 15:58	67.90678	-31.5805	2.1	3.3	48	100	Net 9 closed	Closure of net 9 at 100 m (was not aware both nets 2 and 3 had misfired during present deployment and that of E49, where it was assumed that only top 50 m had been missed - means that combined E48 and E49 sampled whole water column apart from 100 to 50 m)	
29/07/24 15:51	67.90866	-31.5906	2.1	3.3	48	150	Net 9 open	670	
29/07/24 15:42	67.9109	-31.6038	2.2	3.5	48	200	Net 8 open	871	
29/07/24 15:35	67.91249	-31.6137	2.2	3.6	48	250	Net 7 open	620	
29/07/24 15:29	67.91404	-31.6232	2.2	3.5	48	300	Net 6 open	593	
29/07/24 15:17	67.91644	-31.6397	2.1	3.1	48	400	Net 5 open	102 9	
29/07/24 15:09	67.91778	-31.6509	2	3.2	48	450	Net 4 open	646	
29/07/24 15:08	67.91795	-31.6525	2	3.2	48	450	Net 3 open	Net 3 - mistakenly misfired	
29/07/24 15:08	67.91806	-31.6535	2	3.2	48	450	Net 2 open	Net 2 Mistakenly misfired - catch discarded - note that entire haul was hauled in at 0.2 m/s	
29/07/24 15:08	67.91809	-31.6537	2	3.2	48		deployment/atDepth		
29/07/24 14:28	67.92367	-31.713	1.9	2.6	48		deployment/inWater		
26/07/24 20:11	66.86505	-30.6642	1.8	3	21		deployment/outWater	End of net trial. Catch preserved (1/2 subsamples). All systems functioned as intended. Note that there is no flow meter on net	
26/07/24 20:09	66.86419	-30.6667	1.7	2.9	21	7.9	Net 9 closed		
26/07/24 20:08	66.86387	-30.6676	1.8	3	21	19	Net 9 open	77	

26/07/24 20:06	66.86353	-30.6686	1.7	3.1	21	29.2	Net 8 open	85	
26/07/24 20:05	66.86309	-30.67	1.7	2.9	21	39.6	Net 7 open	114	
26/07/24 20:04	66.86263	-30.6714	1.7	2.8	21	49.2	Net 6 open	113	
26/07/24 20:01	66.86206	-30.6736	1.7	3.2	21	60.2	Net 5 open	167	
26/07/24 20:00	66.86171	-30.6755	1.8	3.1	21	69.9	Net 4 open	131	
26/07/24 19:58	66.86142	-30.6776	1.9	3.4	21	79.4	Net 3 open	145	
26/07/24 19:55	66.86089	-30.6817	2	3.4	21	95.8	Net 2 open	285	
26/07/24 19:54	66.86077	-30.6826	2	3.2	21	100	deployment/ at Depth		
26/07/24 19:43	66.85937	-30.6969	2	3.2	21		deployment/ in Water		Net trial

4.4 Floating Sediment Trap

Authors: Flo Atherden (BAS), Alena Sakovich (BAS), Luisa Patrolecco (ISPRA)

4.4.1 Background

The floating trap consists of three stainless-steel carousels in succession on a line, deployed at 50, 100 and 150 metres with 50 metres of wire between each carousel. At the top of the trap array, a single small surface buoy is attached and at the bottom a 10 kg steel weight. An Iridium beacon was mounted on the buoy so the floating trap could be tracked and located. Each carousel contains 4 metal bottles (6L) to collect sinking particulate material, in order to measure the vertical movement of particles over selected short-term timescales and determine particle fluxes. Each bottle has a lid with the lids to each carousel being closed via a release messenger mechanism prior to recovery to prevent contamination during the recovering phase and ensure it is truly the specified deployment depths bring sampled. The trap was deployed off the aft deck using the mooring winch set-up. The ship was stationary during deployment and recovery to minimise tension on the wire. The floating sediment trap was deployed six times, with the deployment time ranging from 10-18 hours (see Table 4.4-1). In Kivioq the bathymetry of the Fjord prevented deployment of every carousel, consequently only two carousels were deployed (at 50 m and 100 m).

4.4.2 Sample Processing

Bottles were allocated as follows from each carousel at each depth:

- i. 1 bottle for biogeochemical analyses (POC/PIC/Silicate and nutrient analyses)
- ii. 1 bottle for compositional/qualitative analyses in Cambridge
- iii. bottles for microplastic analyses

For all bottles, samples were decanted into 10 L carbuoys before any analyses took place, with bottles rinsed with milli-Q.

4.4.3 Biogeochemical Analyses

Nutrient analyses were taken using the same methods as sampling from the CTD (section 4.7). POC, PIC and silicate was sampled using the same method as the CTD with the exception that two technical replicates for each parameter were taken for each depth.

4.4.4 Microplastic Analyses

Each sample was filtered using the 47 mm vacuum pump filtration system (flushed with milli-q three times before use). Samples were filtered on to 10-micron metal meshes that were rinsed with milli-q and 50% filtered ethanol solution beforehand. During filtering, to minimise contamination, aluminium foil was used to cover the filtration beakers when not transferring liquid. Two blank filters were exposed to the air each time liquid is poured to monitor the airborne contamination. One blank was placed to the left of the rig and one blank to the right of the rig.

All filters were preserved at -20°C for analysis in Cambridge using Focal Plane Array Fourier Transform Infrared (FPA FTIR) analyses. Metal meshes were used as this enables sample oxidation and digestion without transferring samples onto new filters.

4.4.5 Qualitative Compositional Analyses

The carboy of each depth was left to settle in the 4°C Science refrigerator for 24 hours. After which 5-5.5 L was siphoned off and the remaining settled material was preserved by spiking to a concentration of < 4% formalin. Samples will be analysed back in Cambridge.

Table 4.4-1. Floating trap deployments.

Event number	Deployment/Recovery	Latitude (dd)	Longitude (dd)	Date and Time (UTC)	Floating trap number	Hours deployed
17	Deployment	66.96713	-30.71225	26/07/2024 10:16:00	FST 1	12 hours, 22 minutes
17	Recovery	66.96269	-30.56130	26/07/2024 22:41:00		
84	Deployment	68.18697	-30.45451	01/08/2024 14:48:17	FST 2	17 hours, 38 minutes
84	Recovery	68.15753	-30.46858	02/08/2024 08:26:00		
129	Deployment	68.44548	-29.25501	06/08/2024 11:59:00	FST 3	10 hours, 4 minutes
129	Recovery	68.44653	-29.25508	06/08/2024 22:03:00		
200	Deployment	67.45781	-32.90578	14/08/2024 11:10:48	FST 4	17 hours
200	Recovery	67.45597	-32.80184	15/08/2024 04:10:48		
237	Deployment	67.35741	-31.95955	19/08/2024 10:25:00	FST 5	12 hours, 35 minutes
237	Recovery	67.31398	-32.06097	19/08/2024 23:00:00		
263	Deployment	67.74945	-30.80246	21/08/2024 23:24:00	FST 6	13 hours, 52 minutes
263	Recovery	67.76364	-31.02541	22/08/2024 13:16:00		

4.5 Zooplankton Preservation Experiments

Author: Flo Atherden (BAS)

4.5.1 Rationale

This experiment aims to determine the effect of formalin preservation in sediment traps on the lipid chemistry of zooplankton which actively swim into the trap (swimmers). Swimmers are not part of the carbon flux but can give an indication of the community present around the trap. Traps are also able to sample animals which may be underrepresented in nets (e.g. pteropods, gelatinous zooplankton). Understanding the effect of prolonged formalin preservation may facilitate further analysis of swimmers (lipid analysis), beyond identification and size measurements.

4.5.2 Method

Zooplankton were picked from two MOCNESS nets (event #261 and #286). Copepods of various stages and species were picked after the sample had been split (see Table 4.5-1 for details). Multiple treatments were used. The first treatment involved freezing zooplankton at -80°C. The second treatment involved preserving in with 4 % formalin used for the moored sediment trap (see section 4.4) for 24 hours, after which animals were ‘washed’ in milli-Q and frozen at -80°C. The remaining 3 treatments samples were just preserved with the moored sediment trap formalin. The formalin samples will be transported back to BAS in the same way as sediment trap samples. Lipid analysis will be conducted back at British Antarctic Survey, Cambridge. The multiple formalin preserved treatments will be analysed at different time points (e.g. 6 months, 1 year) to determine the long-term effects of formalin preservation on lipid zooplankton lipids.

Table 4.5-1. Species collected for zooplankton preservation experiment.

Event	Net number(s)	Net depth range (m)	Species	Stage	Treatment	No. individuals per replicate	No. replicates
261	3 & 2	320-250	<i>Calanus hyperboreus</i>	C5	Frozen	3	5
					Formalin (24 hours) then frozen	3	5
					Formalin	3	5
					Formalin	3	5
					Formalin	3	5
261	3 & 2	320-250	<i>Calanus hyperboreus</i>	Female	Frozen	3	5
					Formalin (24 hours) then frozen	3	5
					Formalin	3	5
					Formalin	3	5
					Formalin	3	5
283	2	1000-800	<i>Calanus finmarchicus</i>	C5	Frozen	3	5
					Formalin (24 hours) then frozen	3	5
					Formalin	3	5
					Formalin	3	5

					Formalin	3	5
283	9	100-5	<i>Calanus finmarchicus</i>	C5	Frozen	3	5
					Formalin (24 hours) then frozen	3, one replicate with 2	5
					Formalin	3	5
					Formalin	3	5
					Formalin	3	5

4.6 Microplastics Incubation Experiments with Copepod *Calanus hyperboreus*

Authors: Alena Sakovich (BAS), Clara Manno (BAS), Flo Atherden (BAS), Geraint Tarling (BAS), Gabi Stowasser (BAS)

Laboratory feeding experiments on microplastics (MPs) and zooplankton are crucial for assessing how MPs ingestion affects species' health, behaviour, and physiology. These studies also evaluate broader impacts, such as disruptions to marine food webs and biogeochemical processes. One key area of focus is how MPs ingestion affects lipid metabolism in copepods, which are vital to the Arctic lipid pump and hence overall carbon sequestration.

These experiments compare the effects of ingesting pristine versus biofouled MPs on the Arctic copepod *Calanus hyperboreus* in its juvenile stage (Copepodite CV). Given this species' critical role in the lipid pump during overwintering, when lipid metabolism is vital for survival, the hypothesis is that MPs ingestion may hinder lipid accumulation. The study also explores whether biofouled MPs might worsen or mitigate these effects due to their nutritional coatings, and how MPs ingestion alters zooplankton's carbon and nitrogen content, indicating potential nutritional stress.

4.6.1 Methodology

4.6.1.1 Experimental Design

Three experiments were conducted during the KANG-GLAC cruise:

- **Experiment I:** Exposure of copepods to pristine nylon-6 granules (5-25 µm size) with algae food.
- **Experiment II:** Conditions as per Experiment I, but without algae food to simulate Arctic winter conditions when algae prey is scarce.
- **Experiment III:** Exposure to biofouled nylon-6 granules (pre-conditioned in Arctic seawater for 27 days) in the presence of algae food.

C. hyperboreus individuals were collected using a Bongo net with a spring tensioned motion compensation unit at various locations along the southeastern coast of Greenland. Specimens were transferred to 1 L beakers with filtered seawater (1.2 µm) and acclimatized for 12-24 hours in the cold room (7°C).

After acclimatization, healthy, intact, and active copepods were placed in 50 mL Falcon tubes filled with filtered seawater and spiked with nylon MPs. Treatments included:

- 20 μg MPs L⁻¹ (~10 MPs mL⁻¹)
- 200 μg MPs L⁻¹ (~100 MPs mL⁻¹)
- Control (absence of MPs / with and without food)



Figure 4.6-1. The example of the copepod *C.hyperboreus* chosen for the experiments (juvenile stage CV).

Each treatment consisted of three replicates – three Falcon tubes per treatment, and each tube contained two copepods. In Experiment III, the number of copepods was reduced to one per tube due to the late-season conditions in the Arctic, which led to a shortage of copepods of this species and developmental stage in the Bongo samples.

Tubes with copepods were placed on a vertical rotator set to rotate at 1 rpm with a 90° tilt angle. Consistent rotation ensured that the MPs solution and algae food remained suspended in the water and available for ingestion by the copepods. An additional rotator was used to duplicate the experimental setup, allowing for extra replicates per experiment. Thus, each experiment consisted of two simultaneous incubations and six Falcon tubes per treatment. The rotators were placed in a refrigerated incubator set at 4°C.



Figure 4.6-2. The experimental setup with the rotators and the Falcon tubes inside the refrigerated incubator.

Copepods were fed once per 2-day period with mixed algae culture (*Nannochloropsis* sp, *Tetraselmis* sp, *Pavlova* sp, *Tetraselmis* sp, *Isochrysis* sp, *Thalassiosira weissflogii*) at a concentration of 4600 cells mL⁻¹. All tubes were aerated in the same day when the food was given. In Experiment III, biofouled MPs were used. The stimulation of biofouling was conducted onboard, when pristine nylon-6 granules were incubated in seawater (collected from uncontaminated seawater system on 23.07.24 15:10 UTC) for 27 days in the cold room; ambient temperature of 7°C.

Table 4.6-1. The overview of the conducted experiments.

Experiment	Bongo event number	Seawater origin	Number of specimens per treatment	Experiment duration
I	Event 13	Collected from uncontaminated seawater system on 25.07.24 19:30 UTC	12	26.07.24 - 02.08.24
II	Event 104, 105, 106	CTD cast 42 – Event 103 (mixed collection depth)	12	04.08.24 - 10.08.24
III	Event 222, 223, 233	CTD cast 71 – Event 220 (mixed collection depth)	6	19.08.24 - 25.08.24

After the experiments were completed, the copepods were collected and photographed under a stereomicroscope for subsequent measurement of the lipid sac using the image analysis software ImageJ. The copepods were then frozen at -80°C until further processing for analysis. Post-experiment analyses will include:

1. Lipid Profile and Fatty Acids Analysis: to assess potential changes in the lipid reserves of juvenile copepods due to MPs ingestion (to be conducted at the University of Durham).
2. Carbon and Nitrogen Isotope Analysis, and C/N Ratio analysis: to provide insights into potential alterations of carbon and nitrogen content due to MPs exposure for the evaluation of shifts in nutritional status and possible changes in metabolic processes due to MPs exposure (to be conducted at BAS).

4.7 Biological CTD Sampling Overview

The table below summarises the different biological parameters taken. Additional information can be found in the following sections.

Table 4.7-1. CTD Table of biological parameters taken.

Time	Event	Latitude	Longitude	DOC	DIC/TA	Phytoplankton	Nutrients	POC, PIC, Silicate	POM	Chlorophyll-a
25/07/2024 02:53	10	67.47664	-32.9823		X	X	X	X	X	
26/07/2024 06:17	16	67.32537	-30.8961		X	X	X	X	X	
27/07/2024 22:07	27	67.54226	-31.3543		X	X	X	X	X	
28/07/2024 09:55	33	67.74785	-31.4312		X	X	X	X	X	
28/07/2024 17:03	36	67.89808	-31.9748		X	X	X	X	X	
28/07/2024 21:51	39	67.92852	-31.6997		X	X	X	X	X	
29/07/2024 10:06	46	68.04263	-31.0746		X	X	X	X	X	
30/07/2024 14:09	52	68.27517	-30.7777		X	X	X	X	X	
31/07/2024 15:07	68	68.23482	-30.6023		X	X	X	X	X	
01/08/2024 11:32	81	68.22333	-30.4769		X	X	X	X	X	
01/08 /2024 15:07	85	68.19054	-30.4502		X	X	X	X	X	
03/08/2024 23:45	103	68.10942	-30.4235		X	X	X	X	X	
05/08/2024 10:38	113	68.4468	-29.2564		X	X	X	X	X	
05/08/2024 15:05	120	68.3923	-29.1602		X	X	X	X	X	
06/08/2024 15:05	131	68.3664	-29.0928		X	X	X	X	X	
07/08/2024 13:38	141	68.41218	-28.8169		X	X	X	X	X	
07/08/2024 21:35	150	68.35665	-28.8047		X	X	X	X	X	
08/08/2024 18:24	157	67.11925	-30.7814		X	X	X	X	X	
09/08/2024 19:42	163	67.54976	-31.8018							X
10/08/2024 14:41	169	67.92678	-31.7079							X
11/08/2024 15:30	175	67.86326	-32.4713		X	X	X	X	X	
11/08/2024 18:05	177	67.79407	-32.3718							X
11/08/2024 19:41	178	67.74312	-32.2239		X	X	X	X	X	
12/08/2024 13:36	188	67.87831	-32.3541		X	X	X	X	X	
15/08/2024 11:26	206	67.70455	-32.8003		X	X	X	X	X	
17/08/2024 18:16	224	67.43512	-32.7831		X	X	X	X	X	

18/08/2024 20:41	234	67.69995	-32.4859		X	X	X	X	X	
19/08/2024 10:51	238	67.35675	-31.9559		X	X	X	X	X	
19/08/2024 18:09	242	67.42565	-32.4228		X	X	X	X	X	
20/08/2024 12:22	253	67.53248	-33.1203		X	X	X	X	X	
21/08/2024 21:21	262	67.7498	-30.8004				X	X	X	
23/08/2024 11:17	275	66.64247	-30.6608				X	X	X	
24/08/2024 10:33	283	65.75049	-30.653				X	X	X	
24/08/2024 19:37	287	65.16355	-30.5662				X	X	X	

4.8 CTD sampling for Nutrient Analyses

Authors: Nicoletta Calace (ISPRA) and Luisa Patrolecco (ISPRA)

4.8.1 Introduction and Aims

The polar ice sheets are deteriorating at an accelerated rate in response to climate change. Warm ocean waters increase ice melting, which, in turn, introduces fresh water to adjacent seas and this freshwater and nutrient flux alters ocean circulation and coastal ecosystems. It has become imperative to understand how the deterioration of the ice sheets will progress as our climate warms, as well as the cascading effects on ocean circulation and marine productivity.

In the framework of KANG-GLAC project, studying nutrient cycling in SE Greenland is crucial for understanding whether changes occur because of interactions between warm water inflows and glacier meltwater outflows. Moreover, we aim to quantify dissolved nutrient concentrations in fjord/shelf waters to derive benthic fluxes of nutrients from organic matter remineralisation. Thus, these analyses will provide new knowledge on the cycling of organic matter in Greenland's coastal waters as the freshwater and nutrient supply increases.

4.8.2 Sampling and Analyses

Sampling and storage_steps were:

- i. Attach clean rubber tubing and plastic syringes equipped with a certified cellulose acetate filter with a nominal pore size of 0.45 μm to the Niskin bottle spigot.
- ii. Fill each vial individually and gather a total of 10 vials.
- iii. Place 10 vials into a plastic bag and ensure they are labelled.
- iv. Storage the bag to the -20 °C freezer.

Analyses for nutrients (N-NH₄, N-NO₂, N-NO₃, P-PO₄, Si-SiO₂, TDN) in the laboratory at ISPRA will be performed using the following methods:

- Ammonium (N-NH₄): method is based on a series of photochemically catalyzed reactions that lead to the formation of indophenol blue. The concentration of the compound is then measured using a colorimetric method (absorbance at 630 nm).
- Nitrites (N-NO₂): method is based on a series of reactions that lead to the formation of an coloured diazo dye, which is then measured using a colorimetric method (absorbance at 550 nm).
- Nitrates (N-NO₃): method is based on their reduction, in a heterogeneous phase, to nitrites, followed by the quantification of total nitrites using the colorimetric method (absorbance at 550 nm).
- Orthophosphates (P-PO₄): method is based on the formation of a blue phosphomolybdate complex (belonging to the molybdenum blues group), whose concentration is measured using a colorimetric method (absorbance at 880 nm).
- Silicates (Si-SiO₂): method is based on the formation of a silicomolybdic polyacid, which is subsequently reduced to molybdenum blue, and determined using a colorimetric method (absorbance at 810/820 nm).
- TDN: method is based on the preliminary oxidation of all nitrogen forms, including organic nitrogen, to nitrate, followed by the quantification of total nitrate using a colorimetric method (absorbance at 550 nm).

The limits of quantification for analyses of nutrients are reported in Table 4.8-1.

Table 4.8-1. Limits of quantification for nutrients analyses. They are calculated as 10 times the standard deviation of seven replicates of method blank.

Parameter	Chemical symbol	Quantification limits (LOQ)	Unit of Measurement	Reference
Ammonium	N-NH ₄	10	µg N/L	Guideline ISPRA 56/2010 (Flow Injection Analysis; FIA)
Nitrites	N-NO ₂	3	µg N/L	Guideline ISPRA 56/2010 (FIA)
Nitrates	N-NO ₃	5	µg N/L	Guideline ISPRA 56/2010 (FIA)
Orthophosphates	P-PO ₄	0.5	µg P/L	Guideline ISPRA 56/2010 (FIA)
Silicates	Si-SiO ₂	10	µg Si/L	Guideline ISPRA 56/2010 (FIA)
Total dissolved nitrogen	TDN	20	µg N/L	Guideline ISPRA 56/2010 (FIA)

In Table 4.8-2 are reported details of samples collected by Niskin-CTD and in Table 4.8-3 are reported details of samples collected from the floating sediment traps for nutrient analysis.

Table 4.8-2. Sampling sites and characteristics for nutrients analysis (with Niskin-CTD).

Sampling date	Time	Event	Label	Depth (m)	Vials (10 mL)	Label Colour	Note
25/07/24	h3.00	10	ST1	SURF	10	BRASIL	FROZEN -20°C
				15	10	BLACK	FROZEN -20°C
				50	10	ORANGE	FROZEN -20°C
				100	10	YELLOW	FROZEN -20°C
				200	10	WHITE	FROZEN -20°C
				300	10	RED	FROZEN -20°C
				500	10	BLUE	FROZEN -20°C
				824	10	GRENN	FROZEN -20°C
26/07/24	h 6.00	16	ST2	SURF	10	White	FROZEN -20°C
				24	10	Green	FROZEN -20°C
				50	10	Blue	FROZEN -20°C
				100	10	Orange	FROZEN -20°C
				300	10	Red	FROZEN -20°C
				500	10	Yellow	FROZEN -20°C
27/07/24	h 21.30	21	ST3	SURF	10	Orange	FROZEN -20°C
				18	10	Red	FROZEN -20°C
				50	10	White	FROZEN -20°C
				130	10	Green	FROZEN -20°C
				300	10	Blue	FROZEN -20°C
				BOTTOM	10	Yellow	FROZEN -20°C
28/07/24	h 9.40	33	ST4	SURF	10	Orange	FROZEN -20°C

				30	10	Green	FROZEN -20°C
				50	10	Red	FROZEN -20°C
				150	10	Blue	FROZEN -20°C
				200	10	White	FROZEN -20°C
				400	10	Yellow	FROZEN -20°C
28/07/24	h 16.30	36	ST5	SURF	10	Yellow	FROZEN -20°C
				15 Chlor max	10	Orange	FROZEN -20°C
				75 BOTTOM	10	Red	FROZEN -20°C
28/07/24	21.00	39	ST6	SURF	10	blu	FROZEN -20°C
				25 Chlor max	10	orange	FROZEN -20°C
				50	10	white	FROZEN -20°C
				110	10	green	FROZEN -20°C
				200	10	red	FROZEN -20°C
				500 bottom	10	yellow	FROZEN -20°C
29/07/24	9.00	46	ST7	SURF	10	blu	FROZEN -20°C
				15 chlor max	10	white	FROZEN -20°C
				50	10	orange	FROZEN -20°C
				Bottom	10	black	FROZEN -20°C
30/07/24	13.30	50	ST8	SURF	10	orange	FROZEN -20°C
				28 chlor max	10	blue	FROZEN -20°C
				50	10	red	FROZEN -20°C
				100	10	yellow	FROZEN -20°C
				Bottom		green	FROZEN -20°C
31/07/24	13.45	68	ST9	SURF	10	GREEN	FROZEN -20°C
				50	10	YELLOW	FROZEN -20°C
				100	10	ORANGE	FROZEN -20°C
				BOTTOM	10	RED	FROZEN -20°C
01/08/24	10.30	81	ST10	SURF	10	GREEN	FROZEN -20°C
				18 Chlor max	10	RED	FROZEN -20°C
				50	10	BLUE	FROZEN -20°C
				130	10	YELLOW	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
				50	10	YELLOW	FROZEN -20°C
				110	10	RED	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
01/08/24	close to glacier with Erebus		BIO1	SURF	10	RED	FROZEN -20°C
				BOTTOM	10	BRASIL	FROZEN -20°C
				37	10	GREEN	FROZEN -20°C
01/08/24	close to glacier with Erebus		BIO3	SURF	10	WHITE	FROZEN -20°C
				50	10	GREEN	FROZEN -20°C

				14	10	WHITE	FROZEN -20°C
				BOTTOM	10	YELLOW	FROZEN -20°C
03/08/24	23.00	103	ST12	SURF	10	green	FROZEN -20°C
				50	10	blue	FROZEN -20°C
				100	10	red	FROZEN -20°C
				200	10	black	FROZEN -20°C
05/08/24	10.00	113	ST13	SURF MAX	10	ORANGE	FROZEN -20°C
				50	10	BLUE	FROZEN -20°C
				100	10	BLACK	FROZEN -20°C
				BOTTOM	10	YELLOW	FROZEN -20°C
05/08/24	14.00	120	ST14	SURF	10	BLACK	FROZEN -20°C
				18 MAX	10	GREEN	FROZEN -20°C
				60	10	ORANGE	FROZEN -20°C
				100	10	RED	FROZEN -20°C
				BOTTOM		YELLOW	FROZEN -20°C
06/08/24	14.30	131	ST15	SURF	10	GREEN	FROZEN -20°C
				10 MAX	10	WHITE	FROZEN -20°C
				50	10	YELLOW	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
06/08/24	close to glacier with Erebus, Il° Fjord		BIO1	SURF	10	RED	FROZEN -20°C
				10m	10	RED	FROZEN -20°C
				BOTTOM	10	RED	FROZEN -20°C
06/08/24	close to glacier with Erebus, Il° Fjord		BIO2	SURF	10	BLUE	FROZEN -20°C
				50m	10	BLUE	FROZEN -20°C
				BOTTOM	10	BLUE	FROZEN -20°C
06/08/24	close to glacier with Erebus, Il° Fjord		BIO3	SURF	10	ORANGE	FROZEN -20°C
				24m	10	ORANGE	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
06/08/24	close to glacier with Erebus, Il° Fjord		BIO4	SURF	10	GREEN	FROZEN -20°C
				25m	10	GREEN	FROZEN -20°C
				BOTTOM	10	GREEN	FROZEN -20°C
06/08/24	River from glacier Il° fjord		FIUME	SURFACE	10	NEUTRA	FROZEN -20°C

07/08/24	h 13.00 bay, north II° fjord	141	ST 16	35 MAX CHLOROPH	10	BLUE	FROZEN -20°C
				70 MAX TURBIDITY	10	ORANGE	FROZEN -20°C
				100 m	10	YELLOW	FROZEN -20°C
				BOTTOM (412m)	10	GREEN	FROZEN -20°C
07/08/24	h 21.00 outside bay	150	ST 17	SURF	10	GREEN	FROZEN -20°C
				20m	10	YELLOW	FROZEN -20°C
				100m	10	BLUE	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
08/08/24	h 18.00	152	ST 18	SURF	10	BLACK	FROZEN -20°C
				36m	10	RED	FROZEN -20°C
				100m	10	BLUE	FROZEN -20°C
				200m	10	YELLOW	FROZEN -20°C
				500m	10	GREEN	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
11/08/24	h 15.00	175	ST 19	SURF	10	YELLOW	FROZEN -20°C
				15m	10	GREEN	FROZEN -20°C
				75m	10	ORANGE	FROZEN -20°C
				150m	10	RED	FROZEN -20°C
				BOTTOM	10	BLACK	FROZEN -20°C
11/08/24	h 19.15	178	ST 20	SURF	10	BLUE	FROZEN -20°C
				20m	10	BLACK	FROZEN -20°C
				50m	10	GREEN	FROZEN -20°C
				150m	10	RED	FROZEN -20°C
				BOTTOM	10	YELLOW	FROZEN -20°C
12/08/24	h 13.00	188	ST 21	SURF	10	BLUE	FROZEN -20°C
				15m	10	GREEN	FROZEN -20°C
				50.5m	10	RED	FROZEN -20°C
				BOTTOM	10	WHITE	FROZEN -20°C
13/08/24	close to glacier with Erebus, Fladø Trough		BIO1	SURF	10	ORANGE	FROZEN -20°C
				17m	10		FROZEN -20°C
				BOTTOM	10		FROZEN -20°C
13/08/24	close to glacier with Erebus, Fladø Trough		BIO2	SURF	10	YELLOW	FROZEN -20°C
				20m	10		FROZEN -20°C
				BOTTOM	10		FROZEN -20°C

13/08/24	close to glacier with Erebus, Fladø Trough		BIO3	SURF	10	GREEN	FROZEN -20°C
				27m	10		FROZEN -20°C
				BOTTOM	10		FROZEN -20°C
13/08/24	close to glacier with Erebus, Fladø Trough		BIO4	SURF	10	RED	FROZEN -20°C
				24m	10		FROZEN -20°C
				BOTTOM	10		FROZEN -20°C
15/08/24	h10.45	206	ST 22	SURF	10	GREEN	FROZEN -20°C
				15m	10	RED	FROZEN -20°C
				50m	10	BLUE	FROZEN -20°C
				100m	10	WHITE	FROZEN -20°C
				200m	10	YELLOW	FROZEN -20°C
				400m	10	BLACK	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
17/08/24	h17.30	224	ST 23	SURF	10	GREEN	FROZEN -20°C
				16m	10	BRASIL	FROZEN -20°C
				60m	10	YELLOW	FROZEN -20°C
				150m	10	BLUE	FROZEN -20°C
				225m	10	WHITE	FROZEN -20°C
				BOTTOM	10	ORANGE	FROZEN -20°C
18/08/24	h20.00	234	ST 24	SURF	10	WHITE	FROZEN -20°C
				25m	10	ORANGE	FROZEN -20°C
				60m	10	YELLOW	FROZEN -20°C
				155m	10	BLACK	FROZEN -20°C
				BOTTOM	10	RED	FROZEN -20°C
19/08/24	h10.30	238	ST 25	YELLOW	10	YELLOW	FROZEN -20°C
				BRASIL	10	BRASIL	FROZEN -20°C
				RED	10	RED	FROZEN -20°C
				BLUE	10	BLUE	FROZEN -20°C
				GREEN	10	GREEN	FROZEN -20°C
				ORANGE	10	ORANGE	FROZEN -20°C

Table 4.8-3. Sampling sites and characteristics for nutrients analysis (from floating sediment trap).

Sampling date	Sampling time (h)	Sample name	Water depth (m)	VIALS (10 mL)	Notes
26/07/24	H 21.30	FT1	50	10	FROZEN -20°C
		FT2	100	10	FROZEN -20°C
		FT3	150	10	FROZEN -20°C
01/08/24		FT4	50	10	FROZEN -20°C
		FT5	100	10	FROZEN -20°C

		FT6	150	10	FROZEN -20°C
06/08/24		FT7	50	10	FROZEN -20°C
		FT8	100	10	FROZEN -20°C
14/08/24		FT9	50	10	FROZEN -20°C
		FT10	100	10	FROZEN -20°C
		FT11	150	10	FROZEN -20°C

4.9 Biogeochemistry: POC, PIC, and Silicates

Authors: Flo Atherden (BAS), Alena Sakovich (BAS), Clara Manno (BAS)

4.9.1 Rationale

Water samples for particulate organic carbon (POC), particulate inorganic carbon (PIC) and silica (biogenic and lithogenic) analysis were taken from the CTD to determine their concentrations across different water masses, within fjords, on shelf and off shelf. This provides the stock of these different parameters throughout the water column. The ratio of POC:PIC can indicate whether calcifying organisms (e.g. pteropods) are dominating the particulate flux. Biogenic and Lithogenic analyses allow for determining whether silica is of biological origin (e.g. diatoms) or from other sources (e.g. glacial vs. terrigenous input). A high biogenic silica content can indicate diatoms are major contributors to the POC flux.

4.9.2 Methods

In the main, six depths per CTD cast were chosen when sampling for biology (Table 3.1-1). Depths chosen consistently covered the surface, chlorophyll max and bottom, with other depths chosen to fill in the water profile, sample different water masses/interesting features within the water column (e.g. temperature maximum or minimum). 6L of water per depth was sampled from the CTD using rubber tubing and 10L carbuoys. Carbuoys were rinsed three times with water from the required depth before sampling. Additional samples were taken from the Erebus work in 3-miippugut, Kivioq and Fladø. Please see the Erebus biological station report for details.

4.9.3 Filtration

Samples for POC were filtered under ~ 20 psi, with PIC and Silicate filtered under 20-30 psi. To minimise the potential airbourne contamination, filtration cups were covered with polyethylene sampling bags or foil during filtration. Metal tweezers for handling filtered were cleaned with isopropanol or ethanol. For POC and PIC analyses, water was filtered onto a pre-ashed, pre-weighed 25 mm GF/F filter or 47 mm GF/F. POC and PIC samples were run on both the plastic and glass filtration rig. Samples were folded and returned to tin foil, and loosely wrapped up to allow the filters to dry for 24 hours, after which samples were sealed and stored at -20 °C. Two different blanks for POC analyses were performed. A blank where 300-1500 ml of Milli-Q was filtered onto a GF/F.

Silicate samples were filtered onto 25 mm polycarbonate filters (pore size 0.45 um, Millipore and Sartorius). These samples were always run on the plastic rig to prevent contamination with the glass filtration rig. Samples were stored in petri dishes and left to dry out for 24 hours. Samples were sealed with parafilm and stored at -20 °C. Filters will be analysed back in the BAS laboratories in Cambridge.

Analyses of Isotopes

Authors: Nicoletta Calace (ISPRA), Luisa Patrolecco (ISPRA), Gabriele Stowasser (BAS)

4.9.4 Introduction and Aims

Polar marine ecosystems are particularly vulnerable to the effects of climate change. Warming temperatures, freshening seawater, and disruption to sea-ice formation potentially all have cascading effects on food webs. The spatial distribution of the stable isotopes of carbon and nitrogen have proven useful in identifying the spatial patterns of a range of biogeochemical processes, such as nutrient utilization by phytoplankton. We aim to produce isotopic composition of carbon and nitrogen of particulate organic matter (POM) along the SDA's route and within Greenland fjords visited during KANG-GLAC using surface seawater samples to produce a baseline for interpreting stable isotope compositions of POM at Latitudes > 58°N. This is a useful tool to understand the movement, migration, and diet of higher trophic level animals from stable isotope compositions. We plan to apply a Bayesian mixing model by means of the Simmr package in R software to estimate the origin of the POM. This analysis is important to assign contributions to POM to both terrestrial and marine sources, and to understand global fluxes of organic matter.

4.9.5 Sampling and Analytical Determination

The sampling and storage steps were:

1. Collect 10L of surface sea waters from uncontaminated seawater system of ship or from CDT casts, when the underway seawater system pump is not active.
2. Before beginning filtration, rinse all filtration cups and filter holders with Milli-Q water.
3. Use forceps to place a Whatman GF/F filter (Ø 47 mm), pre-combusted at 450°C for 4 hours, onto the filter holder and attach the filter cup with the metal holder.
4. Pour water from 10 L tank into a smaller 1 L cylinder measuring jug which will be used to fill the filtration cups.
5. When filtering, watch the 3L waste water bottle to ensure the water level does not exceed the maximum line. When the maximum line is reached, turn off the filter valves and the pump, empty the waste bottle, and pour filtered water into a suitable sink. When the level of water in the filtration cup gets low, add more water from the measuring jug, repeating this until all the water has been filtered.
6. Once all water has been filtered, rinse the inside of the cup with a small amount of filtered seawater to wash particles off the cup walls and on to the filter. Allow the vacuum to continue for a few seconds once the cup is empty to dry the filter.
7. Remove the filter using clean forceps and place in a labelled aluminium foil packet.
8. Store samples in the freezer at -20 °C.



Figure 4.9-1. Filtration system for isotope analyses.

4.10 Analyses of Isotopes

Filters were treated by acidification with 100 μL of 1N HCl to completely remove carbonates and then re-placed in the oven for 2 h and finally POC determined by a CHN Elemental Analyzer Flash 2000 (Thermo Scientific; Bremen, Germany). TPN was directly determined by CHN Elemental Analyzer Flash 2000 (Thermo Scientific, Bremen, Germany) on filters that were not acidified. Reference material BCSS (NRC, Canada) was used to assess the accuracy of analytical data. Simultaneously $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ ratios in the samples were determined using an Isotope Ratio Mass Spectrometer (Delta Plus, Thermo Scientific, Bremen, Germany) coupled with an CHN Elemental Analyzer Flash 2000 (Thermo Scientific, Bremen, Germany).

Isotope ratios were expressed as parts per thousands (‰) differences from a standard reference material:

$$\delta X = R_{\text{sample}}/R_{\text{reference}} - 1 \times 10^3$$

where X is ^{13}C or ^{15}N , and R is the corresponding ratio $^{13}\text{C}/^{12}\text{C}$ or $^{15}\text{N}/^{14}\text{N}$. The standard reference materials were Vienna Pee Dee Belemnite for carbon and atmospheric N_2 for nitrogen.

International standards IAEA-600 ($\delta^{13}\text{C} = -27.77\text{‰}$ and $\delta^{15}\text{N} = 1.00\text{‰}$), USGS40 ($\delta^{13}\text{C} = -26.39\text{‰}$ and $\delta^{15}\text{N} = -4.52\text{‰}$), IAEA-C-8 ($\delta^{13}\text{C} = -18.31\text{‰}$), IAEA-CH6 ($\delta^{13}\text{C} = -10.45\text{‰}$), IAEA-

N-1 ($\delta^{15}\text{N} = + 0.43\text{‰}$), and IAEA-N-2 ($\delta^{15}\text{N} = 20.41$) (International Atomic Energy Agency, Austria) were analysed as certified references materials to calibrate the results, to check the instrument functioning and detect possible drift deviations.

Table 4.10-1. Limits of quantification for POC and TPN analyses. They are calculated as 10 times the standard deviation of at least three replicates of a method blank.

Parameter	Abbreviation	Quantification limits (LOQ, $\mu\text{mol/L}$)	Reference
Particulate organic carbon	POC	0.2	Guideline ISPRA 56/2010
Total particulate nitrogen	TPN	0.5	Guideline ISPRA 56/2010



Figure 4.10-1. Map of sampling sites for isotope analyses.

Table 4.10-2. Sampling sites for isotope analyses.

Date / Time	Latitude (dd)	Long. (dd)	Sea Surface Temp. (°C)	Sea Surface Salinity (psu)	Chloro-phyll (cts)	Label	Comment
24/08/2024 20:00	65.16352	-30.5662	10.71518	34.9982	260	GRO43	7L FROM CTD
24/08/2024 11:00	65.75046	-30.653	5.263855	31.6607	93	GRO42	7L FROM CTD
23/08/2024 11:00	66.64243	-30.6608	5.264404	33.2723	108	GRO41	4L FROM CTD
22/08/2024 11:00	67.86491	-30.7663	3.597137	30.5991	84	BLANK 3	5L MILLIQ
21/08/2024 15:10	67.75086	-30.798	2.684967	30.7594	85	GRO40	10L FROM PUMP
20/08/2024 13:30	67.52663	-33.097	20.87354	31.5388	399	GRO39	8L FROM CTD
19/08/2024 18:30	67.42569	-32.4228	2.60202	30.8718	90	GRO38	8L FROM CTD
19/08/2024 11:30	67.35676	-31.956	3.762085	32.4477	100	GRO37	8L FROM CTD
18/08/2024 21:00	67.69997	-32.4858	13.40009	0.1577	400	GRO36	7L FROM CTD
18/08/2024 10:30	67.60535	-32.296	3.176575	30.2528	96	GRO35	10L FROM PUMP
17/08/2024 18:30	67.43524	-32.7839	0.720612	27.8945	91	GRO34	10L FROM CTD
16/08/2024 10:55	67.45707	-33.0455	-0.25369	24.9768	86	GRO32	9.7L FROM PUMP
15/08/2024 11:45	67.70454	-32.8002	17.23749	0.1433	386	GR031	8L FROM CTD SOUTH COAST
14/08/2024 18:00	67.59417	-33.0436	14.5986	0.1305	392	GRO30	8L FROM CTD
13/08/2024 15:40	67.77524	-32.1559	1.006439	28.4339	93	GRO29	8L FROM PUMP
12/08/2024 14:00	67.87833	-32.354	0.46756	28.8417	108	GRO28	7L FROM CTD
11/08/2024 20:15	67.74327	-32.2237	1.089844	29.79	118	GRO27	8L FROM CTD
11/08/2024 16:00	67.86286	-32.4724	12.0748	0.2849	387	GRO26	3L FROM CTD
11/08/2024 12:40	67.80138	-32.3869	1.222473	26.9594	109	GRO25	7L FROM PUMP
10/08/2024 10:00	67.98191	-31.3563	2.129669	30.2257	112	GRO24	8L FROM PUMP FRONT MAIN FJORD
09/08/2024 11:40	67.10686	-30.8845	4.077209	31.5476	95	GRO23	10L FROM PUMP
08/08/2024 18:00	67.11261	-30.8453	3.701477	31.0619	97	GRO22	8L FROM CTD
08/08/2024 10:00	67.91563	-29.8986	2.771637	30.7297	97	BLANK 2	5L MILLIQ
07/08/2024 21:00	68.38549	-28.8104	21.13629	13.7195	379	GRO21	2L FROM CTD OUTSIDE BAY
07/08/2024 14:00	68.41221	-28.8156	11.33331	0.2253	393	GRO20	2L FROM CTD (NORTHERN BAY FROM II° FJORD)
06/08/2024 15:30	68.36708	-29.0926	0.745178	26.1803	104	GRO19	3L FROM CTD
05/08/2024 15:00	68.39229	-29.1602	-0.09314	29.2477	120	GRO18	3.6 L FROM CTD second fjord

05/08/202 4 11:00	68.44676	-29.2564	17.05057	28.7345	99	GRO17	2 L FROM CTD SECOND FJORD
03/08/202 4 10:00	68.27657	-30.7644	-0.06696	28.2813	117	GRO15	1.5 L FROM PUMP
03/08/202 4 00:00	68.24022	-30.44	-0.01657	28.7923	121	GRO16	5 L FROM CTD
01/08/202 4 16:20	68.19051	-30.4503	0.833466	27.7371	122	GRO14	2.5 L FROM CTD
01/08/202 4 11:30	68.22332	-30.4768	0.54425	27.0909	99	GRO13	2 L LOT OF PARTICULATE
31/07/202 4 14:45	68.23892	-30.5945	2.697174	25.6508	105	GRO12	2 L FROM PUMP (LOT OF PARTICULATE MATTER)
30/07/202 4 14:30	68.27519	-30.7779	13.79251	0.1212	401	GRO11	2,5 L FROM CTD, HIGH SUSPENDED PARTICULATE
29/07/202 4 10:00	68.04224	-31.0753	-0.18811	28.9555	108	GRO10	7.7 L from CTD
28/07/202 4 17:30	67.89698	-31.9721	-0.19916	28.5011	118	GRO9	5 L FROM PUMP
28/07/202 4 11:10	67.74701	-31.4449	1.061615	29.8593	101	GRO8	9 L FROM PUMP
27/07/202 4 22:00	67.54224	-31.3544	1.693237	30.0064	116	GRO7	8 L FROM UNDERWATER PUMP
27/07/202 4 07:40	67.32428	-30.8985	1.317047	29.6281	96	GRO6	9 L FROM UNDERWATER PUMP
26/07/202 4 16:45	67.26394	-30.9853	1.859253	29.5691	99	GRO5	9 L (FROM UNDERWATER PUMP)
26/07/202 4 07:00	67.32529	-30.906	2.474426	29.7384	98	GRO4	10 L (FROM NISKIN SURFACE)
25/07/202 4 21:40	67.33038	-31.1908	4.074341	30.8571	101	GRO3	10 L FROM UNDERWATER PUMP
25/07/202 4 04:00	67.47591	-32.9724	19.36826	28.6951	399	GRO2	9 L FROM NISKIN SURFACE
24/07/202 4 14:37	67.45712	-32.9122	3.817596	28.6326	92	GRO1	2,5 L FROM PUMP (Clogged filter, orange particulate, possible origin from internal pipes)
23/07/202 4 21:15	66.20737	-30.622	4.29657	31.3449	101	ISL2	6 L from pump
23/07/202 4 13:50	65.12563	-30.3134	9.964142	35.063	111	ISL1	6 L from pump
20/07/202 4 17:40	59.2961	-5.90547	12.90744	34.9506	152	EDI2	5 L from pump
20/07/202 4 14:00	58.90338	-4.38676	12.91885	34.3008	124	BLANK 1	5 L MILLI-Q
20/07/202 4 10:05	58.88368	-3.04636	13.2915	34.5853	142	EDI1	5 L from pump

To establish an isotopic baseline for particulate organic matter (POM) across the water column POM was obtained through filtering waters collected by Niskin bottles deployed via a CTD rosette. From the CTD water was taken from various depths at each station. All water samples collected were processed on-board. Depending on the density of particles varying volumes of seawater per depth were filtered onto pre-ashed 47mm GF/F filters and the filters stored frozen at -80°C.

Table 4.10-3. Sampling details for POM on SD041.

Event	CTD event	Sample depths (m, in the water column)							
16	7	5	25	50	100	200	300	500	574
27	11	5	18	50	130	300	415		
33	16	5	30	50	150	200	400	457	
36	17	5	15	45	75				
39	20	5	27	50	110	200	487		
46	25	5	15	50	93				
52	26	5	28	50	100	250			
68	31	5	50	100	153				
81	35	5	18	50	130	295			
85	36	5	50	110	250	354			
Erebus1	Bio1 Bio2 Bio3 Bio4	Each station comprising of surface, Chlmax and bottom sample							
103	42	5	15	50	100	200	419		
Glacier ice, 3- miipuggut Fjord									
113	43	5	50	100	209				
120	45	5	18	60	100	205			
131	46	5	50	121					
Erebus2	Bio1 Bio2 Bio3 Bio4	Each station comprising of surface, Chlmax and bottom sample							
141	53	35	70	100	418				
150	55	5	20	100	200				
157	57	5	36	100	200	500	748		
175	61	5	15	75	150	299			
178	63	5	20	50	150	347			
188	64	5	15	50	95				
Erebus3	Bio1 Bio4	Each station comprising of surface, Chlmax and bottom sample							
206	70	5	15	50	100	200	400	599	
224	73	5	16	60	150	225	570		
234	75	5	25	60	155	413			
238	76	5	30	60	150	250	387		
242	78	5	20	70	100	180	470		
253	79	5	22	60	200	400	657		
262	81	5	18	45	100	180	351		
275	85	5	15	40	125	250	473		
283	88	5	30	80	125	250	407		
287	89	5	25	65	150	300	600	1000	1490

4.11 Emerging organic micropollutants analyses

Author: Luisa Patrolecco (ISPRA)

4.11.1 Introduction and Aims

As part of the KANG-GLAC cruise SD041, and within the framework of the project Work Package 3 Biological and Biogeochemical Processes, we investigated the presence of persistent organic micropollutants in surface coastal marine waters. Our focus was on emerging bioactive compounds that can affect the marine ecosystem at various levels of the trophic chain. These organic micropollutants can reach polar regions from lower latitudes through long-range atmospheric transport, oceanic currents, or local secondary emissions resulting from glacier and sea-ice melting, which previously trapped these substances. The targeted contaminants include nonylphenols, bisphenol A (commonly associated with plastic production and environmental dispersion), pharmaceutical residues (such as steroid hormones, anti-inflammatories, and antibiotics), as well as personal care products like triclosan, a disinfectant ingredient found in toothpaste and soaps. The spread of these compounds into marine ecosystems is alarming due to their "pseudo-persistence" and the inherent biological activity of many of these substances, even at low environmental concentrations.

4.11.2 Sampling Protocol and Sample Pre-treatment

Surface seawater was sampled at 24 selected sites along the southeast coast of Greenland (Figure 4.11-1), using the ship's underway system, specifically from the uncontaminated water supply in the seawater laboratory, when the pump was active, and no sea-ice was present. In areas with sea-ice, surface seawater samples were collected using Niskin bottles from CTD casts. Detailed information on sampling sites and procedures is provided in Table 4.11-1 below.

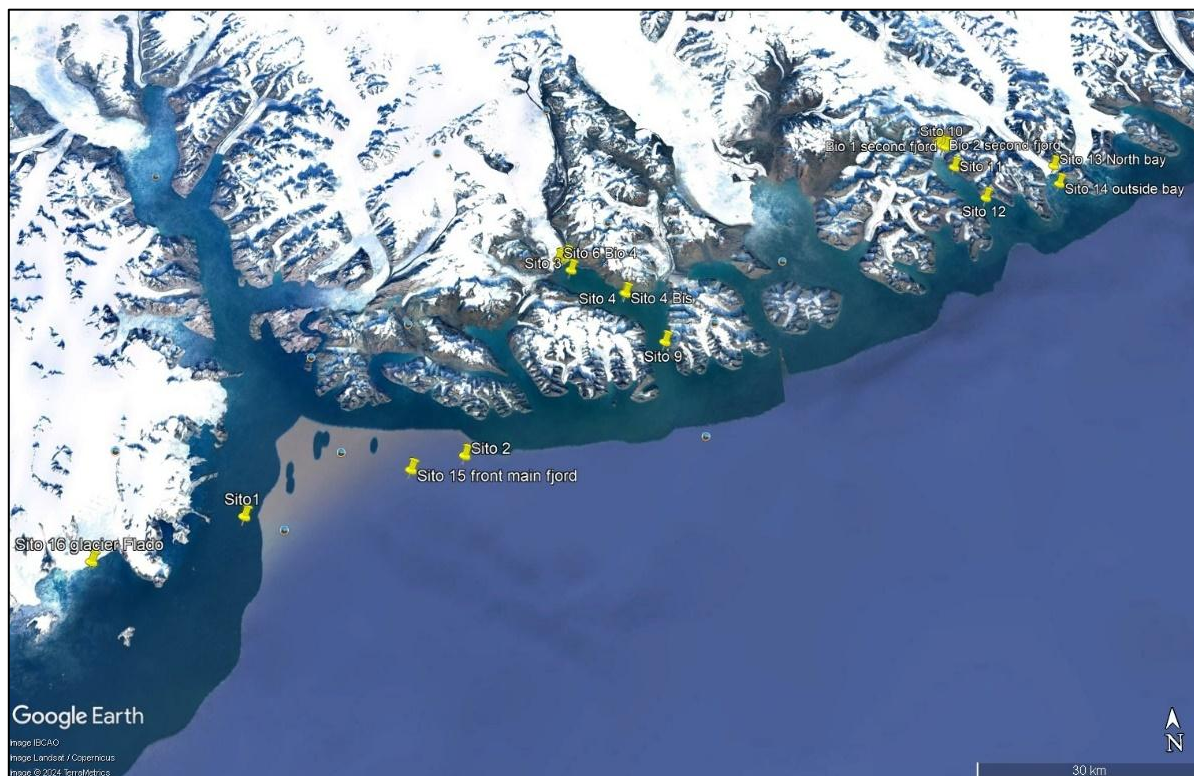


Figure 4.11-1. Map of sampling sites for organic micropollutant analyses.

Table 4.11-1. Sampling sites and sample information for organic micropollutant analyses. KF is Kangerlussuaq Fjord.

Sample name	Event	Day	Time	Latitude (degrees N; DD)	Longitude (degrees W; DD)	Sea-water T (°C)	Salinity (ups)	Depth	Storage
SITO 1		28 July	h 16.30	67.92323	-31.92446	-0.16		SURF from pump	
NPs									1L SPE
Pharma									1L SPE
SITO 2		29 July	h 9.00	67.99975	-31.16856	0.22		SURF from pump	
NPs									1.5 L SPE
Pharma									1.5 L SPE
SITO 3	50	30 July	h 13.30	68.27453	-30.77890	1.23		SURF from CTD	
NPs									1L SPE
Pharma									1L SPE
SITO 4		30 July	17.20	68.23444	-30.57255	2.84	25.0492	SURF from pump	
NPs									1L SPE
Pharma									1L SPE
SITO 5 BIO1		01 Aug.	h11.18	68.29812	-30.79524			SURF from Niskin with Erebus	
NPs									1L SPE
Pharma									1L SPE
SITO 6 BIO4		01 Aug.	h16.08	68.29174	-30.82910			SURF from Niskin with Erebus	
NPs									200mL SPE
Pharma									750 mL SPE
SITO 7 BIO2		01 Aug.	h12.47	68.29496	-30.804151			SURF from Niskin with Erebus	
NPs									1L SPE
Pharma									1L SPE
SITO 8 BIO3		01 Aug.	h14.33	68.29334	-30.822480			SURF from Niskin with Erebus	
NPs									1L SPE
Pharma									1L SPE
SITO 4 BIS		03 Aug.	h 20.40	68.23504	-30.57588	4.033	23.7885	SURF from pump	
PHARMA									1L -20°C only for PHARMA
SITO 9	103	03 Aug.	h 23.00	68.15671	-30.43490	0.5123 29	28.4647	SURF from CTD	
NPs									1L SPE
PHARMA									1L SPE

SITO 10	113	05 Aug.	h 10.00	68.46144	-29.24415	1.8	28.8159	SURF from CTD	
NPs									1L SPE
PHARMA									1L SPE
SITO 11	120	05 Aug.	h 14.00	68.42325	-29.21815	- 0.3062 13	29.0450	SURF from CTD	
NPs									1L SPE
PHARMA									1L SPE
SITO 12	131	06 Aug.	h 14.30	68.36754	-29.11916	0.7204 59	25.8634	SURF from CTD	
NPs									1L SPE
PHARMA									1L SPE
BIO1 Second Fjord		06 Aug.	h10.22	68.45944	-29.23398			SURF from Niskin with Erebus	
NPs									1L SPE
Pharma									1L SPE
BIO2 Second fjord		06 Aug.	h11.41	68.46193	-29.24131			SURF from Niskin with Erebus	
NPs									1L -20°C
Pharma									1L -20°C
BIO3 Second fjord		06 Aug.	h13.25	68.46679	-29.25882			SURF from Niskin with Erebus	
NPs									1L -20°C
Pharma									1L -20°C
BIO4 Second fjord		06 Aug.	h14.37	68.46942	-29.26275			SURF from Niskin with Erebus	
NPs									1L -20°C
Pharma									1L -20°C
SITO 13 NORTHERN BAY- Chololate Bay	141	07 Aug.	h 13.00	68.41697	-28.81346	0.9741 21	5.4434	SURF from CTD	
NPs									1L -20°C
Pharma									1L -20°C
SITO 14 outside bay	150	07 Aug.	h 21.00	68.38549	-28.81044		13.7195	SURF from CTD	
NPs									1L -20°C
Pharma									1L -20°C
SITO 15 front KF		10 Aug.	h 10.00	67.98191	-31.35630	2.1296 69	30.2257	surf from pump	
NPs									1L -20°C
Pharma									1L -20°C
SITO 16 front	175	11 Aug.	h 15.00	67.86607	-32.42726			surf from CTD	

glacier Fladø									
NPs									1L -20°C
Pharma									1L -20°C
BIO1 FLADØ TROUGH		13 Aug.		67.89536	-32.34566			SURF from Niskin with Erebus	
NPs									1L -20°C
Pharma									1L -20°C
BIO4 FLADØ TROUGH		13 Aug.		67.88147	-32.39335			SURF from Niskin with Erebus	
NPs									1L -20°C
Pharma									1L -20°C
SITO 17 South Coast	206	14 Aug.	h 17.00	67.59153	-33.04229			surf from CTD	
NPs									1L -20°C
Pharma									1L -20°C

In both cases (sampling from pump or from Niskin bottles), water was collected into pre-cleaned HDPE plastic bottles (2 L), which had been washed with solvent and ultrapure water. The samples were kept at in-situ temperature during handling, following the methods below.

The extraction of target analytes was carried out in the ship's main laboratory using Solid-Phase Extraction (SPE) with a manifold vacuum system (as shown in Figure 4.11-2). Supelclean LC-18 SPE cartridges, packed with a specific adsorbent solid phase (6 mL tubes, 1 g solid phase), were utilized. The cartridges were pre-activated by sequentially passing the following solvents through them: acetone (5 mL), methanol (10 mL), and ultrapure water (20 mL). One liter of unfiltered water sample was then passed through each cartridge, allowing the contaminants to be adsorbed onto the solid phase, while the filtered water was discarded. The cartridges were then sealed with parafilm and stored at 4°C in plastic bags until they were shipped to Italy. Once in the Italian laboratories, the organic contaminants adsorbed on each cartridge will be eluted using appropriate solvents (20 mL of either acetone or methanol, depending on the specific class of contaminants). Following gentle evaporation using a nitrogen stream, the extracts will be reconstituted in 0.5 mL of a methanol:water mixture (60:40, v/v). The final reconstituted extract will then be analyzed for target organic micropollutants using high-performance liquid chromatography (HPLC) coupled with high-resolution mass spectrometry (HRMS) on an Orbitrap Exploris 120 spectrometer (Thermo Fisher Scientific, Massachusetts, USA).



Figure 4.11-2. Solid Phase Extraction (SPE) vacuum manifold system used during SD041.

4.12 Biogeochemistry: Chlorophyll Calibration

Samples for chlorophyll were taken from the CTD to help calibrate the fluorometers on both the main CTD and the CTD deployed on Erebus. Six depths were chosen in the top 200 m, with particular care taken to capture a range of values from the fluorometer. Samples were collected from the CTD into carboys wrapped in black bin liners to maintain a dark environment. ~ 500 ml of water was filtered onto 25 mm GF/Fs in the dark with the filter rig wrapped in foil to minimise light exposure. Filters were then stored at -80 °C for analysis in Cambridge.

4.13 Biological Sampling on Erebus

Authors: Flo Atherden (BAS), Alena Sakovich (BAS), Rhiannon Jones (BAS), Luisa Patrolecco (ISPRA), Gabi Stowasser (BAS), Geraint Tarling (BAS), Clara Manno (BAS).

4.13.1 Rationale

Glacial fronts can be highly localised hot spots of biological activity, as evidenced by a high abundance of megafauna such as birds and seals. However exactly how sediment plumes and freshwater inputs from glacial fronts impact primary and secondary productivity is as-yet unclear. High sediment loads and sudden freshening events may result in mass zooplankton deaths, creating easy foraging for predators (e.g. birds). However, the high nutrient load from terrigenous sources may also provide a sustained area of high phytoplankton productivity. Glacier meltwater can be highly enriched in Fe, Mn, Si, and other bioactive elements, due to the erosion, transportation, and weathering of terrestrial bedrock material. Zooplankton may also become trapped at glacial fronts due to complex and changeable circulation patterns. By

sampling from a small boat, we were able to get very close to the glacier as well as choose sampling locations both inside and outside of localised plumes.

We sampled for biological parameters from the following sample sites; 3-miippugut, Kivioq, and Fladø. The following parameters were taken from water samples; POC, PIC, SI, nutrients, and POM, and additional 4 L samples for particulate metal and iron-silica interactions were taken from surface water samples where trace-metal clean sampling was possible. These were filtered under trace-metal clean conditions for total particulate metals, particulate metal speciation, total silicate and particulate silicate speciation, and Si/Fe scanning x-ray microscopy. In addition, we sampled using the ‘baby bongo’ a small plankton net (Apstein 50 cm, with opening and closing mechanism) which was fitted with a 65 µm mesh, allowing us to capture phytoplankton, zooplankton and faecal pellets. Samples were processed on arrival back to the SDA, with net samples preserved in < 4% formalin water samples processed for POC, PIC, SI, nutrients, and POM using the same methods discussed in CTD Section 4.8 above.

4.13.2 3-miippugut (Ryberg) Fjord

Sampling date: 1/08/24

Crew: Joseph Laurence, Elizabeth Coase, Jack Wilmschurst

Science team: Flo Atherden, Povl Abrahamsen, Vincent Doñate Felipe

4.13.2.1 Methods

Four biology stations covered [Bio 1-4], with an aim to cover stations with river-like outflows from the glacier front with a high sediment load (e.g. plume) and stations ‘outside of the plume’ where the current from the glacier and sediment load is reduced. Previous Erebus deployments had identified two major river like plumes from glacial front though exact positions had not been established. Therefore, identifying being ‘within plume’ and ‘outside plume’ was done on Erebus by observing the current moving and surface sediment load.

Each station was sampled as follows though there are station specific differences to nets due to failures, challenging conditions and different capture methods attempted. In general net depth were set to capture the deep chlorophyll max but were sometimes limited by conditions.

1. CTD was sent down with 5L Niskin to collect bottom water, (the Niskin was closed using a messenger system). The niskin was emptied into a carboy, with one rinse taking place to preserve as much water volume as possible. As an extra precaution for the observed high sediment load in the fjords, the Niskin was then flushed by soaking in surface water in an “open position”.

2. CTD profile of first cast was downloaded to identify the deep chlorophyll max (i.e., non-surface peak). The deep chlorophyll maximum was often weak; however, it seemed better to get a sample deeper into the water column and more distinct than a surface sample which was taken by hand in any case.

3. A second CTD cast with the niskin collected water from the chl max, which was again decanted into a carboy with one rinse.

4. Once the second CTD took place surface water sample were taken by hand by submerging 5L carboy and a 4L acid cleaned Nalgene into the surface waters. For consistency one rinse took place with 5L carboy, no rinse was done with the acid cleaned Nalgene. The samples were taken somewhere between 5-15 cm from the very surface of the water.

5. Netting took place with the baby bongo fitted with a 65 µm net, depths and types of deployment varied. Vertically hauled nets were deployed off the A-frame, with the wire pre weighted with messengers. The net was hauled in the open position throughout. One horizontal net sampling was attempted. The cod end and opening of the net were secured using rope and held in the surface water alongside Erebus for 5 minutes.

Stations were given a descriptor; the physics team has previously identified 4 sampling stations across the glacier front named ice station 1-4.

Table 4.13-1. 3-miippugut fjord biological sampling summary.

Station	Sample	Depth deployed	Comment
Bio 1	CTD3, Deep niskin	125m	Labelled also as Ice station 2 to match some oceanography sample names
	CTD4, Chl max niskin	30m	
	Surface water sample	0m	
	BabyBongo1	Failed	Failed, weight on wired activated closing mechanism, deployment tweaked to prevent this again.
	BabyBongo2	50-0m	
Bio2	BabyBongo3	50-0m	Deployed first as was still on the wire, station also labelled as 'river plume 1'. Ice calving took place between Bio 1 and 2, roughly 1200 UTC
	CTD5, Deep niskin	190m	
	CTD6, Chl max niskin	37m	
	Surface water sample	0m	
	BabyBongo4	0m	Horizontally 'trawled', trying to get into to flow from glacier but didn't appear to be massively successful
Bio3	CTD8, Deep niskin	141m	'river plume 2' however the flow became less clear as we sampled it. Flow rate and apparent sediment load was weaker than station bio 2
	CTD9, Chl max niskin	50m	
	Surface water sample		
	Babybongo5	60-0m	Depth increased to capture the chl max, 'drop1'
	Babybongo6	60-0m	'drop2', repositioned for this deployment as we had drifted relatively far from the original site.
Bio4	CTD11, Deep niskin	200m	Current really very strong, max wire out likely to be unrelated to depth. This

			station was tricky to manoeuvre in as there is very strong current and ice behind, so Joe was driving Erebus from the back and kicking the engine to remain 'largely' in position. Joe estimated if not moving the Erebus was drifting at 1.2 knots.
	CTD 12, Chl max niskin	14 m	
	Surface water sample	0m	
	Baby bongo 7	30-0m	Only one drop possible due to highly difficult conditions. There was a massive amount of sediment in the net after recovery, split into 3 sample nalgenes. 'Part1-3'

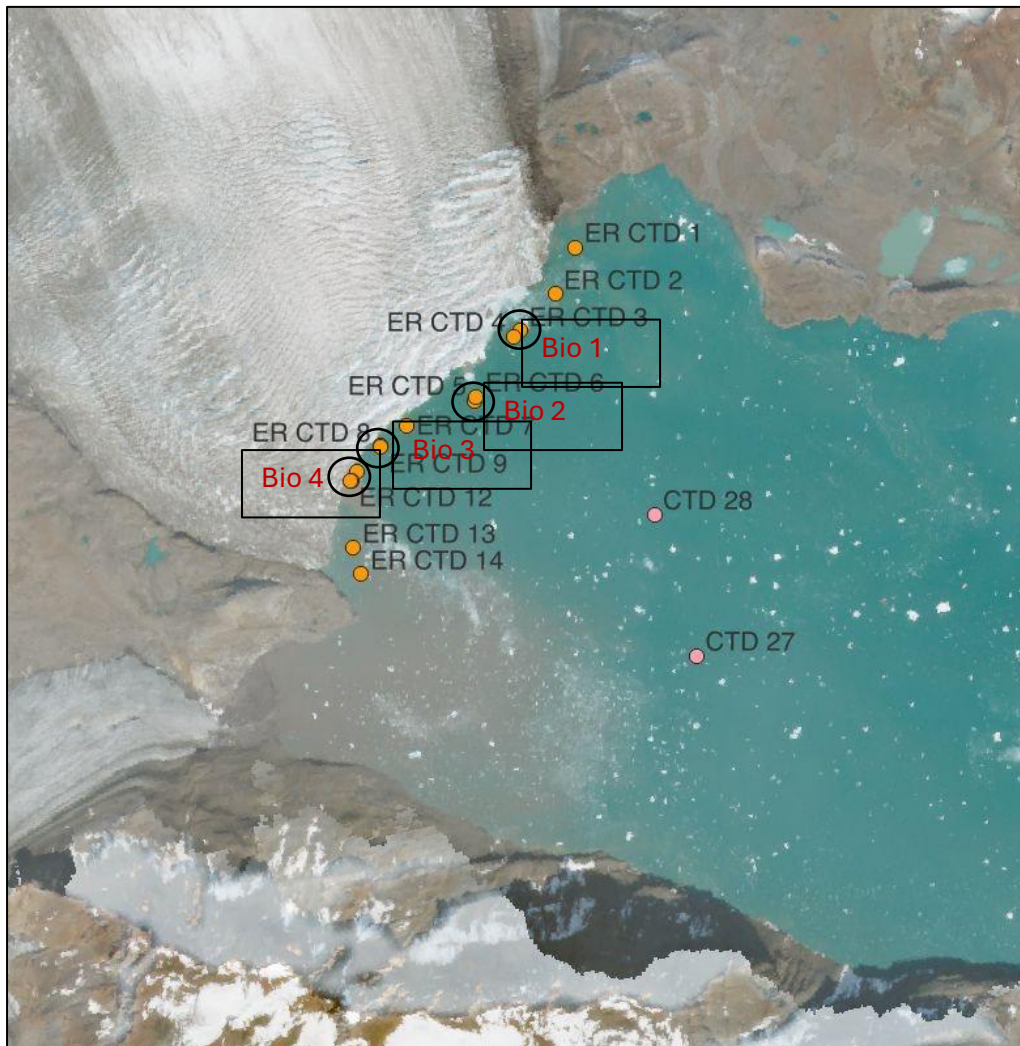


Figure 4.13-1. Satellite image of 3-miippugut showing Erebus bio-CTD sampling sites.

4.13.3 Kivioq Fjord

Sample date: 6/8/24 (2nd day of Erebus sampling in Kivioq)

One glacier front was sampled for the biology (four stations). There was an additional river surface water sampling site and the physical oceanography team sampled from a second glacier front in the side of the Fjord.

Crew: Joseph Laurence, Elizabeth Coase, Alan Simmons

Science team: Flo Atherden, Alena Sakovich, Povl Abrahamsen

4.13.3.1 Methods

Methods followed previous sampling in 3-miippugut (was Ryberg), with the following exceptions.

1. For the mid-water column water sample, the temperature max was chosen at sites Bio 2-4 as there was an interesting pocket of warmer water, and the deep chlorophyll max was either weak or close to the surface. Please see each station summary for details
2. No horizontal net was towed, and each station had two vertically towed drops. The net depth was adjusted where bathymetry was limiting.
3. On two occasions zooplankton were caught at the surface or on the rim of the net. These animals were preserved separately as they are not part of the 'quantitative catch'. See station summary and further sampling for details.
4. An additional river water surface sample was taken.

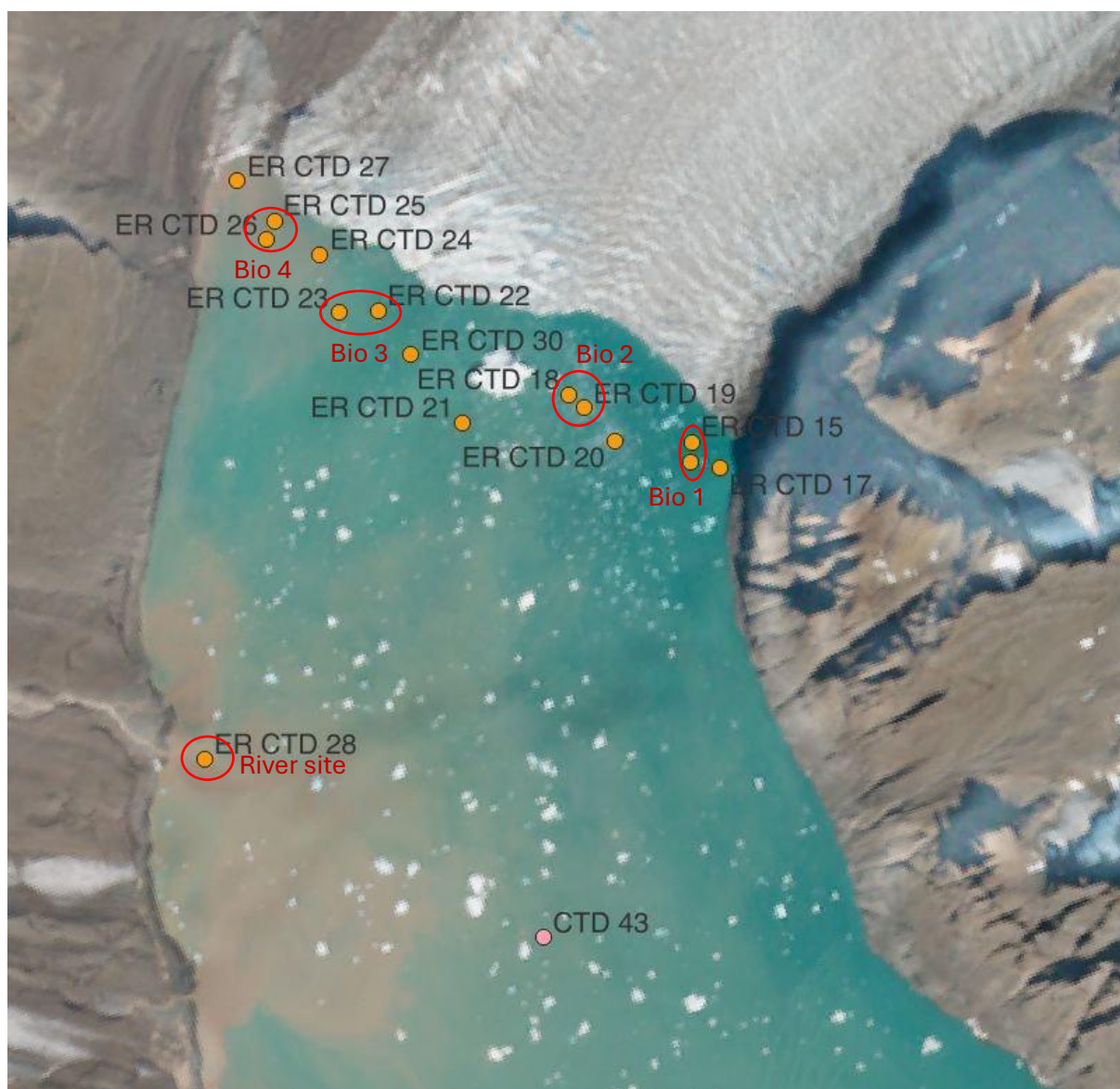
Table 4.13-2. Kivioq biological sampling summary .

Station	Sample	Depth deployed	Comment
Bio 1	CTD15, Deep niskin	85m	
	CTD16, Mid niskin	10m	Chl max taken
	Surface water sample	0m	
	BabyBongo8	50-0m	'drop1'
	BabyBongo9	50-0m	'drop2'
Bio2	CTD18, Deep niskin	183m	
	CTD19, Mid niskin	30m	Temperature max and deep chlorophyll max
	Surface water sample	0m	
	BabyBongo10	50-0m	'drop1'
	BabyBongo11	50-0m	'drop2'
Bio3	CTD22, Deep Niskin	90m	
	CTD23, Mid niskin	24m	Temperature max
	Surface water sample	0m	
	Babybongo12	50-0m	'drop1' Jelly present on outside of net & preserved separately

	Babybongo13	50-0m	'drop2'
Bio4	CTD25, Deep niskin	48m	Bio 4 the station most in the plume.
	CTD26, Mid niskin	25m	Temperature max
	Surface water sample	0m	
	Babybongo14	35-0m	'drop1'. Water depth 45 m
	Babybongo15	35-0m	'drop2'
River sample	Surface water sample	0m	Took at the largest mouth of the river, as close as possible on Erebus, very strong current present.
	CTD28	No water taken	Depth 40m, this was taken close to but not the exact same site as the surface water sample due to the strong current.

Additional sampling: Ice sampling, we took two ice samples, one a very small sample and another very large block. This large block was taken on the SDA, broken up using a crowbar and a sledge hammer and stored in the -20. Samples will be taken back to BAS to be analysed in a clean environment. O18 samples from the oceanography team were taken on board.

Surface Themisto samples were taken from the second glacier front. They were floating in a 'current' across the surface. These were preserved separately.





4.13.4 Fladø

Sample date: 13/8/24 (2nd day of Erebus sampling in Fladø)

Crew: Joseph Laurence, Elizabeth Coase, Alan Simmons

Science team: Florence Atherden (BAS), Alena Sakovich (BAS), Lea Riehn (SAMS), Laura Castro de la Guardia (SAMS)

The glacier front was sampled for the biology (four stations). The sampling was combined with MSS profiling as such, due to additional time pressure, 3 bio sampling sites were initially planned (with 7 MSS stations). However, as time went on, we were able to add an additional sampling site: Bio 4. Bio 4 is positioned between Bio 3 and Bio 2 and was chosen due to interesting biological activity at this end of the Fjord. A high number of pteropods were caught at Bio 3, in addition there were birds and seals feeding, as well as large icebergs in this area.

In general, this site had a lot less sediment than the other two locations, with high visibility (estimated at 5-10 m). The ice present was MCh cleaner, with very little sediment laden/dirty ice. It was difficult to determine the location of any 'plumes' or glacial outflow for selecting stations from Erebus. The previous day Lev had photographed the site (see image below) and from above there is a slight increase in sediment in Bio station 1.







Figure 4.13-3. Photos from Fladø Area, Apuliliip Apusiia glacier (credit Lev Tarasov). Note, these photos were taken the day before we sampled from Erebus and there was more ice (brash ice and icebergs) in the water when biological sampling.

4.13.4.1 Methods

Methods followed previous sampling in 3-miipuput, with the following exceptions:

1. No horizontal net was towed, and each station had two vertically towed drops. The net depth was 50-0m at every station.
2. A red jellyfish was sampled using a bucket
3. Some ice was sampled & recovered for O18 samples (no biological analyses were sampled as the ice was too small.

Table 4.13-3. Fladø area sampling summary.

Station	Sample	Depth deployed	Comment
Bio 1	CTD35, Deep niskin	60m	Bottom – 63m, ‘MSS station 1’
	CTD36, Mid niskin	17m	Chl max taken
	Surface water sample	0m	
	BabyBongo17	50-0m	‘drop1’, first bongo (Babybongo16) failed as the wire out was not zeroed

	BabyBongo18	50-0m	'drop2'.
Bio2	CTD39, Deep niskin	62m	Bottom – 68m, 'MSS station 4'
	CTD40, Mid niskin	20m	Chl max taken
	Surface water sample	0m	
	BabyBongo19	50-0m	'drop1', water depth 70 m
	BabyBongo20	50-0m	'drop2'
Bio3	CTD42, Deep Niskin	50m	Bottom – 57m
	CTD43, Mid niskin	27m	Chl max
	Surface water sample	0m	
	Babybongo21	50-0m	'drop1'
	Babybongo22	50-0m	'drop2'
Bio4	CTD44, Deep niskin	70m	Bottom – 79 m. This station took place after a significant iceberg broke in two. There may be some interesting physical aspects of this station which reflect the iceberg breaking. There was a gap between CTD44 and CTD45 in order to do the MSS sampling at the site.
	CTD45, Mid niskin	24m	Temperature max and Chl max
	Surface water sample	0m	
	Babybongo23	35-0m	'drop1'
	Babybongo24	35-0m	'drop2'
	Bucket	Red jelly sampled	Red Jelly seen while doing the bongo. Sampled using a bucket & Flo took photographs for identification.

5 Gavia AUV operations

Authors: Lewis Drysdale (SAMS), John Howe (SAMS)

5.1 Introduction and Summary

A Teledyne Gavia Offshore Surveyor autonomous underwater vehicle (AUV) nicknamed ‘Freya’ was used to collect in-situ observations of bathymetry and oceanography (Table 5.1-1) on the inner shelf and adjacent to marine terminating glaciers. 122 km of mission lines were run across 7.5 days and 29 hours of sub-marine mission time.

The vehicle is the 55th to be built in Iceland at the Gavia facility and was delivered to NERC in 2015 for users of the National Marine Equipment Pool. The Gavia is a modular AUV with users able to switch modules and thereby operate different sensors from the vehicle in different configurations. During SD041 the vehicle was operated with the module combination seen in Figure 5.1-1 and sensors described in Table 5.1-1. The AUV is configured to be positively buoyant at the surface and hence descends and completes each mission using its propulsion and guidance systems. Missions are series of commanded behaviours uploaded to the vehicle via WiFi. Once the AUV has completed all its behaviours, it floats to the surface and sends its position via Iridium messaging service. The AUV is typically used for seafloor mapping, being able to track its height relative to the seabed, but it can also track depth using observations of pressure. If the AUV encounters obstacles it can avoid them by increasing pitch, reducing speed, or ‘braking’. If AUV encounters the seabed or loses the ability to navigate, it will abort its mission and return to the surface.

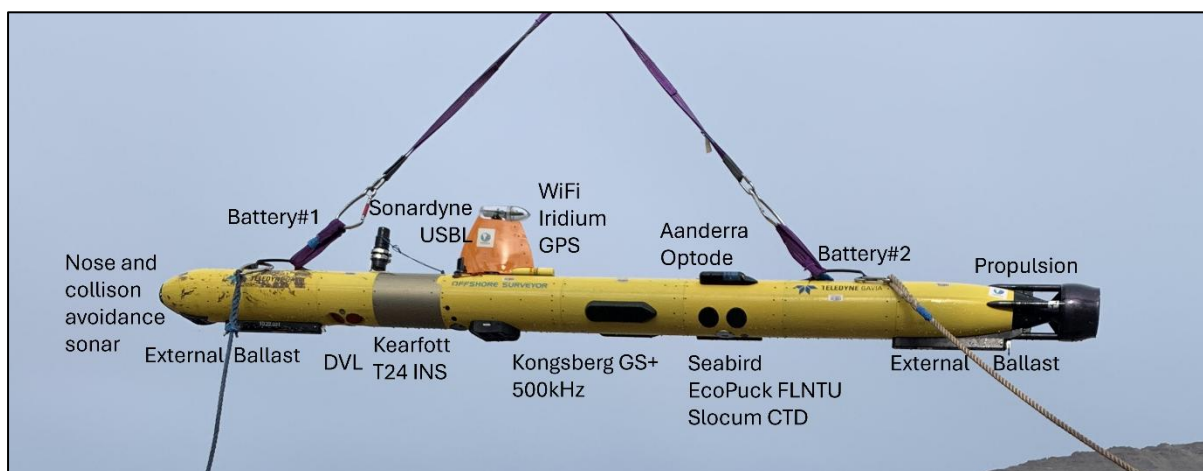


Figure 5.1-1. Gavia AUV ‘Freya’ configuration for SD041. The AUV is 3.5 m long and weighs 106 kg.

All Gavia missions were run from the workboat Erebus, which had a removable A-Frame powered by a removable Hydraulic Power Unit (HPU). Erebus has an acoustic pod fitted to the hull with a suite of hydro-acoustic sensors including a Kongsberg EM2040, Simrad EK80, and Sonardyne Micro-Ranger 2. The A-Frame, HPU, and acoustic pod were fixed to the vessel during all Gavia operations. The Sonardyne MR2 and Kongsberg EM2040 were used during every survey day, but the EK80 remained turned off. At the beginning of each survey day, the Erebus was launched and brought to the ship's starboard side where kit and personnel were loaded, the acoustics sensors turned on, and the AUV was lowered to the starboard side of Erebus using the starboard crane. The AUV was secured alongside, Erebus moved away from the ship, then the AUV was transferred

to the Erebus aft and lifted outbound of the A-frame and secured ready for transit to the survey site (Figure 5.1-2). Once at the survey site, the AUV was lowered into the water, the ballasting was assessed using a light floating line, and the AUV was sent on a mission. The reverse was done on recovery.

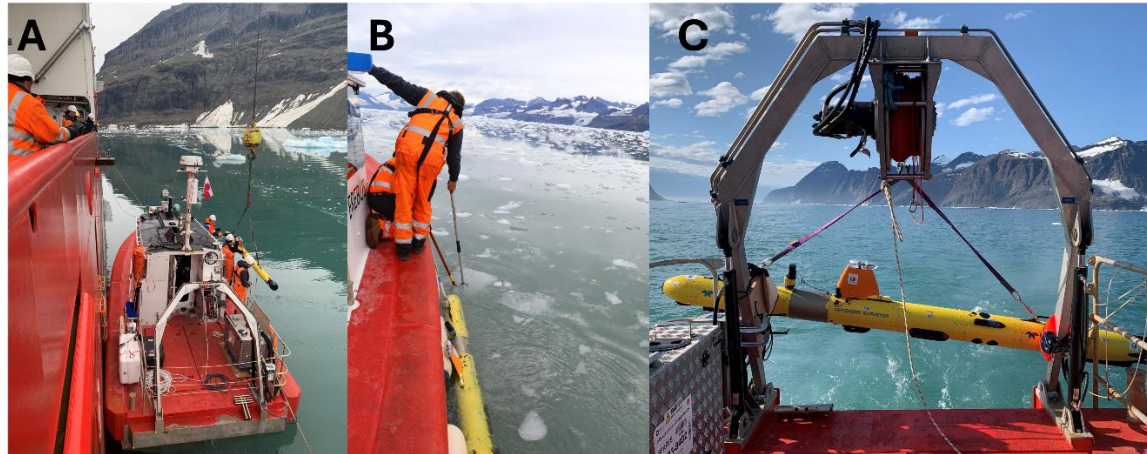


Figure 5.1-2. A) “Freya” being lowered to the starboard side of Erebus from the SDA main deck. B) The AUV secured alongside Erebus by lines fore and aft and protected with fenders. Small icy bits were a continual threat to the AUV on the surface and were pushed away using boat hooks and poles. C) the AUV secured to the A-Frame for transit. A 3-1 pully attached to the block was used with two lifting strops connected to lifting points on the AUV.

AUV missions were created using Teledyne Control Centre software. Seabed mapping missions were run in a “lawnmower” pattern at 650 rpm with 50% alternation and 30 m beam width. Altitude (or bottom track) above the seabed varied throughout the campaign, 10 m was settled on for most surveys as it was the best fit for avoiding seabed while maintaining best data quality. Oceanography missions were straight lines at bottom track of 15 or 10 m or constant depth. Every mission started with a dive at 850 rpm to constant depth of 10-20 m followed by a short dive lawnmower pattern with duration greater than $\text{max-descent-rate (m/s)} / \text{target depth (m)}$, typically run at 750 rpm. This mission execution ensured that the AUV was able to dive below any strong surface density gradients and surface ice, but then had enough time to reach the seabed (within range of DVL bottom track). On mission end, the AUV was commanded to ascend to constant depth of 10 m and float to surface from there. Mission start and finish locations were as close to each other as possible to ensure the Gavia returned to ice-free areas or known surface density.

Table 5.1-1. Gavia AUV module sensors.

Sensor	Observation
Geoswath+ 500 kHz side scan sonar	Sea floor bathymetry Sea floor side scan sonar
Seabird FLNTU EcoPuck sn. FLNTUSLC-8576	Fluorescence and Turbidity
Aanderra optode 4831F sn. 806	O ₂ concentration and temperature
Seabird Slocum Glider Payload CTD	Conductivity, Temperature and Pressure (CTD)
Kerfott t24 seanav	Pitch, roll, heading
Teledyne 1200kHz WorkHorse Navigator DVL	Velocity, altitude

Valeport Mini-SVS	sound velocity, pressure (and co-located temperature sensor, used to derive salinity)
Other non AUV sensors	Observation
YSI CastAway CTD SN CC1138011	Conductivity, Temperature, Pressure. Used to compute a sound velocity profile and determine AUV ballast
Sonardyne Nano USBL Address 2207	Position tracking up to 1000 m using Ultra-Short BaseLine

5.2 AUV survey narrative

Tuesday 30th July 24: 3-Miippugut

Depart for the Sorgenfri glacier front at 0930 hrs. The glacier front was in deep water of between 200-150m. A series of dives were executed near the glacier but we returned to SDA for a reconfiguration of the AUV ballast. The AUV was then deployed at the glacial front at 1558 - 1620 hrs for a 20-minute survey to 180m, **RF_M2**. The 500kHz Geoswath+ data was problematic with faint side-scan data, possibly due to the high volume of suspended sediment in the water column scattering the signal. AUV missions were stopped at 1730 hrs and Erebus continue to collect MBES data along the south margin of the fjord 1730-1830 hrs.

Wednesday 31st July 24: 3-Miippugut

Mission **RF_M4** was planned for a small region of ice-free water 1 km in front of the Sorgenfri glacial front. The AUV surfaced at 1125 hrs and was recovered to Erebus at 1135. **RF_M5** was planned with ascent/descent dive plan of a direct dive to a target depth of 200m. At 1218 hrs the AUV dived to 199m, however once at her deepest point the vehicle returned to 90m. At 1240 hrs the AUV surfaced after failing to stay at the seabed depth of approximately 200m. Mission **RF-M5** 1312 hrs managed to find depths of 220m successfully, but surfaced after an emergency brake at 1330 hrs. The AUV was recovered, and Erebus used the MBES to survey to the east of the Sorgenfri glacial front and into a small bay with water depths of ~20-70m. **RF_M6** mission was planned to survey seabed of the bay, avoiding the loose ice. AUV was launched at 1425 hrs and surfaced at 1430 hrs. **RF_M7** launched again at 1514 hrs and surfaced at 1518 hrs. For mission attempt **RF-M8** the ice moved into the bay and the AUV survey area was slowly being covered (Figure 5.2-3). Erebus could also potentially become blocked in by ice and the AUV might also be difficult to recover or could be lost under ice bergs – so the mission was abandoned. Erebus pushed out of the ice and motored slowly west 100m from the glacier front, collecting MBES data. A short oceanographic section was prepared, **RF_M9** using the AUV at a target depth of 10m in water depths of ~150m along 1km of the Sorgenfri glacier front. At 1638 hrs the AUV was deployed and successfully carried out the mission to 600m distanced but surfaced at 1645 hrs after navigation accuracy exceeded the mission parameters. AUV surfaced for the required GPS fix, but ice conditions and the proximity of a very active meltwater plumes meant the mission was aborted from the vessel laptop, and the AUV recovered safely back to Erebus. AUV surveys were concluded for the day and Erebus continued very slowly through extensive pack ice to the rendezvous point collecting water samples and MBES data on route to the SDA for 1810 hrs.



Figure 5.2-1. Freya surfaces after a failed mission near a meltwater plume and southward moving ice raft. Surface (glacial) ice coverage was hard to predict due to meltwater plume induced current close to the glacier. Photo: Lewis Drysdale.

Friday 2nd August 24: 3-miippugut ('Neil's moraine')

Using Erebus, the AUV team surveyed the bay and marine-terminating glacier at the NE of the main 3-Miippugut Fjord. The approaching fjord slope rises steeply from ~350m – 4m and the priority initially was to survey using the onboard EM2040 MBES. After finding a safe passage over the moraine ("Neill Moraine"), Erebus moved inside the bay and surveyed depths to ~120m adjacent to the glacier front. The first AUV mission, **RF-M10** used a short lawnmower plan to test the behavior of the vehicle. The 3.4km mission was successful. **RF-M11** continued with a lawnmower N-S across the bay, on surfacing the AUV was immediately sent back on survey, **RF_M12**, . **RF_M13** was another N-S lawnmower to within 100m of the grounded glacial front. On surfacing at 1758 hrs the AUV was sent on a short line (**RF_M14**) to obtain some GoPro footage of the vehicle diving and surfacing. There was almost zero visibility and no light at 5 m water depth. After a short survey using the Erebus MBES of the moraine ridge, the team returned to the SDA at 1915 hrs.

Monday 5th August 24: Kivioq Fjord

Departure at 0900 from SDA proceeded to the glacial front and began MSS profiles east to west. In the afternoon the team switched to AUV deployments (Figure 5.4). A grounded iceberg sat directly in front of the glacier making mission planning difficult. A series of short lines of ~1km length at 7.5m above the seabed were run out from the glacier **KF_M1** & **KF_M2**.



Figure 5.2-2. Freya in front of main glacier of Kivioq Fjord. Photo: Lewis Drysdale.

Wednesday 7th August 24: Rosenborg Gletsjer

Erebus was launched at 0900. The western corner of the grounded ice had a large volume of meltwater and sediment was flowing south from the ice. Flowing strongly down the western margin of the fjord. **ROF_M1** was run within the meltwater flow in water depths 18-98m. The next mission ran NE-SW in front of the glacier, **ROF_M2**/suffered an emergency brake. **ROF_M3** also had an emergency brake. Three large ice calving events also produced significant amounts of drifting ice enough for the survey area to be moved south **ROF_M4** aimed survey the deep water adjacent to the eastern glacier front. The AUV performed emergency brakes and surfaced early. Missions **ROF_M5** and **ROF_M6** moved away from the glacier front, as drifting ice now covered the previous area and ended early with the AUV surfacing having encountered obstacles on the seafloor. Following **ROF_M6**, the vehicle surfaced covered in red mud (Figure 5.2-3)

Monday 12th August 24 Paattuulaajit Ikertivaat

The first survey was in front of the Apulitiip Apusiia glacier, around the ice-free NE embayment. **CB_M1** began at 1018-1212. On retrieval the AUV had many emergency brakes. Following missions were at higher altitudes. Geoswath+ was reconfigured to open the swath angle out to 75 degrees (from usual 60). The following surveys, **CB_M2** (10.6km, 1 hr. 48min), **CB_M3** (11.7km, 1 hr. 59 mins) and the final shorter mission, **CB_M4** (4.1km 41 mins) were successful. The missions ended at 1815 hrs. and recovery onto SDA at 1915 hrs.

Sunday 18th August 24

Erebus launched at 1330 to survey the southeastern extent of the inner trough perpendicular to the coast, behind 'Deception' island. A moderate sea state meant that the AUV was colliding with the hull of Erebus as it was being transported and lifting the AUV on the A-frame was risky for personnel. A decision was made to launch the AUV on a transit mission to reach the survey site

under its own power, The AUV surfaced at the waypoint but conditions onboard Erebus had by then made the proposed mission of ~1.5hrs untenable. The AUV was recovered, and both it and Erebus returned safely to SDA.



Figure 5.2-3. Freya after ROF-M6 showing signs of collision with the seabed. Photo: Lewis Drysdale.

Tuesday 20th August 24: East of Uunartaajiit

Uunartaajiit island. The AUV was launched at 1100 for mission **MR-M1** across the northern extent of a trough east of Uunartaajiit island. Upon recovery from the pack ice the slight offshore breeze had pushed the ice across the proposed survey area (Figure 5.2-4). Erebus surveyed south and east to find looser, more open pack ice. The second mission **MR_M2** was launched at 1530-1810 and saw the AUV complete her deepest dive of 435m. The AUV was recovered to Erebus and was brought back onboard SDA at 1900hrs.



Figure 5.2-4. Gavia AUV “on surface” after mission MR-M1. Photo: Lewis Drysdale.

Wednesday 21st August 24: Inner Shelf Ne of Kangerlussuaq Trough

The first AUV mission, **NGK_M1**, from 1230-1446hrs aimed to survey the unknown region of possibly glacier troughs oriented perpendicular to the coast. The survey was successful although on recovery a large iceberg had moved across the survey area and was positioned close to the

recovery position. a new survey site chosen slightly northeast of the iceberg’s southwestern trajectory. The final mission **NGK_M2**, 1552-1830hrs expanded the previous survey aiming to build on the suggestion from the Erebus MBES of shelf depressions. The Erebus used the time waiting on the AUV to survey the region with the 2040 system. AUV surfaced at 1830 and secured on the A-frame and moved to the southeast to join SDA.

5.3 Equipment Performance

AUV surveys conducted between 30 July and 31 July (around northwest 3-miippugut) were beset by depth tracking errors and every mission ended in an abort (Table 5.5-1). Oceanographic data were collected but none of the missions executed during this time had reasonable bathymetric survey data. Tracking errors occur when the AUV was not able to follow its planned (or forecasted) depth or pitch trajectory. The result is a mission abort to surface before the AUV reaches its desired altitude. The autopilot crewmember, which is a virtual component of the AUV, controls the vehicle and takes in control commands like heading, depth and velocity. The autopilot allows the AUV a maximum of seven attempts to correct its descent behaviour and at each attempt the commanded depth value, set by the autopilot, is reset to the measured AUV depth. If the mission behaviour is not completed before seven attempts are made, the mission is aborted and the AUV ascends to the surface. All missions (excluding those where the vehicle could not dive to initial constant depth) failed due to tracking errors resulting from reaching the seven-attempt limit. When plotted, the depth tracking failure can be seen as a “sawtooth” pattern of commanded depth against the linear vehicle depth (Figure 5.3-1).

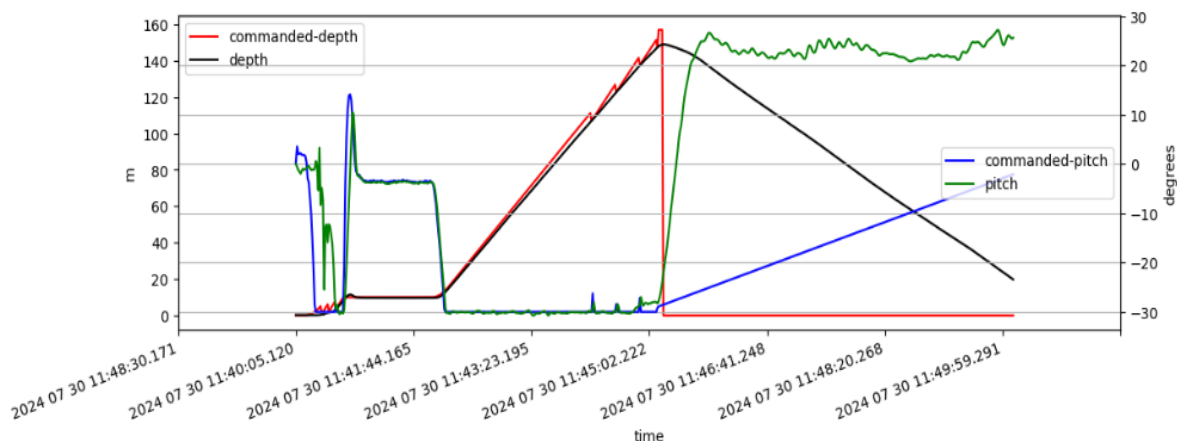


Figure 5.3-1. Dive sequence from mission start to mission abort of RF-M1(11:40). Observed depth (black line) is tracking away from commanded depth (red line) reaching the threshold seven timeouts. Pitch, meanwhile, is tracking well on the commanded value.

A density difference of $\sim 10 \sigma$ between surface and AUV target depth was observed in 3-miippugut and was clearly contributing to the AUV’s failure to follow its predicted depth trajectory since the AUV became more buoyant as density increased with depth. Other factors that are likely to have contributed to failure during these initial missions were high sediment load, which likely caused attenuation of acoustic beams from the Doppler Velocity Logger (DVL), and strong non-tidal currents (suspected meltwater plumes) proximal to the glacier terminus that caused reduction in forward (and downward) trajectory. Soft sediments on the seabed are likely to have led to poor acoustic return from the DVL beams back to the transducer (also affecting the GeoSwath), reducing the DVL range to ~ 20 m, compared to 30 m normal operating range (data not shown). Accurate DVL readings are required to keep AUV on track relative to the seabed.

After some discussion over email with engineers at Teledyne, significant changes were made to the ballast and trim. The Gavia AUV is balanced/ballasted using internal plates and external cubes. The internal plates require a breakdown of the vehicle under dry covered conditions. The cubes can be adjusted anywhere with access to the vehicle underside but are limited to 12 cubes fore and across two ballast rails. Internal ballast increases the weight and determines the pitch of the vehicle, while the external ballast fine tunes trim and helps roll-stability. To address depth tracking issues, the new ballast configuration was enough to submerge up to 50% of the control tower, with AUV trim such that the bow is angled slightly up to achieve best collision avoidance and with as MCh external ballast as possible to enhance stability and allow for changes to ballast in the field (see Figure 5.3-2).

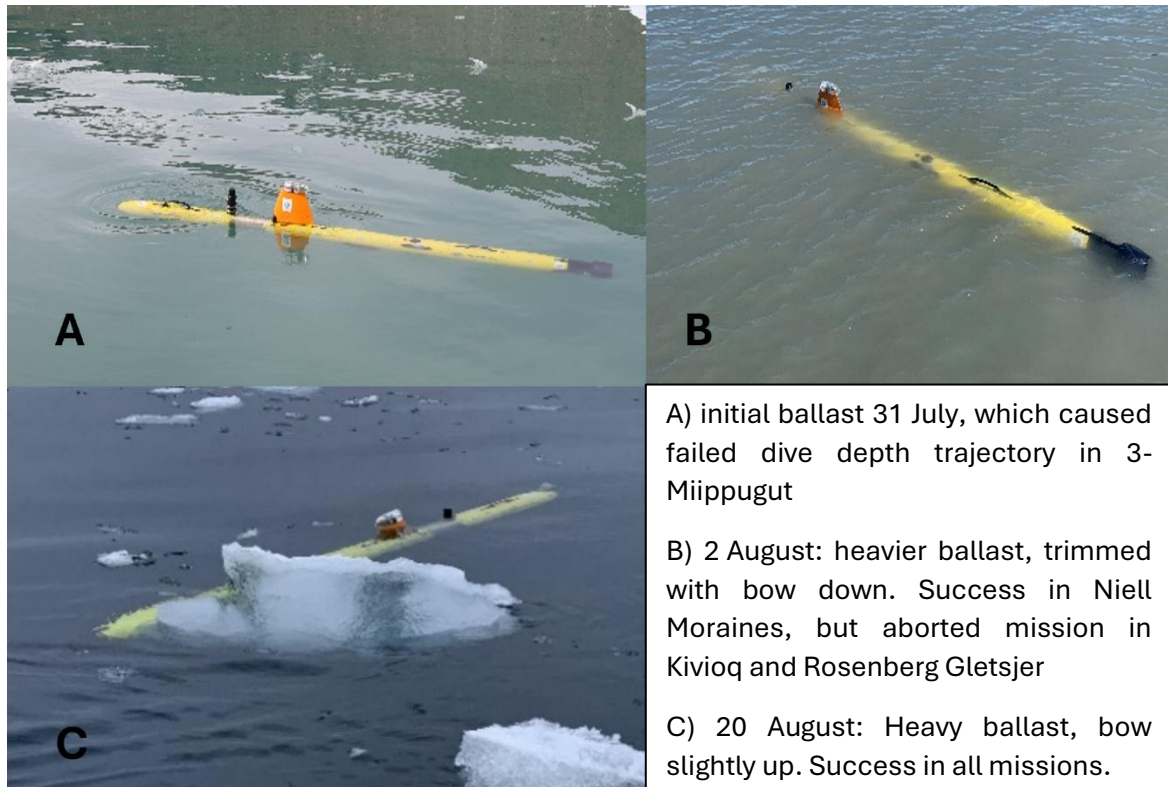


Figure 5.3-2. Three ballast configurations used during SD041. C was the most suitable but also least resilient to changes in surface density.

AUV missions executed on the 2nd August around the moraines in 3-miippugut using a heavier ballast configuration were all completed successfully. Dives RF-M10,11,12,13 were in water depths < 100 m and density gradients between surface and deep of < 6 σ . DVL bottom lock was around 15 m depth, however, which suggest that the high sediment load (in-water and seabed) was affecting beam attenuation.

In Kivioq the AUV again experienced failure to fulfil its mission despite improving trim and ballast. Three across-fjord, along-glacier lines were achieved, although each ended in an abort. The main reason for the AUV aborting was thought to be related to the steep and varied bathymetry. Across-fjord surface density differences observed as well. The AUV ballast, which was “heavy” was not well suited for changes in surface density. During KF-M1(15:31), for example, the AUV maintained a commanded altitude of ~10 m for 15 minutes of mission, despite an early emergency brake due to overshooting its target depth, but the DVL lost bottom track and the AUV aborted due to maximum deviations away from its depth trajectory. The GPS coordinates sent by

the AUVs Iridium antenna were reporting unusual positions. After several attempts to locate the AUV, it was found with just a few centimetres of the control tower above the surface, hence poor GPS signal quality.

Missions executed in Rosenborg Gletsjer, on the other hand, were beset by multiple emergency brakes and the AUV connecting with the seabed on several occasions as a result. Steep slopes and highly complex bathymetry were observed by the ships swath systems and are likely to have contributed to the AUV failure (Figure 5.3-3).

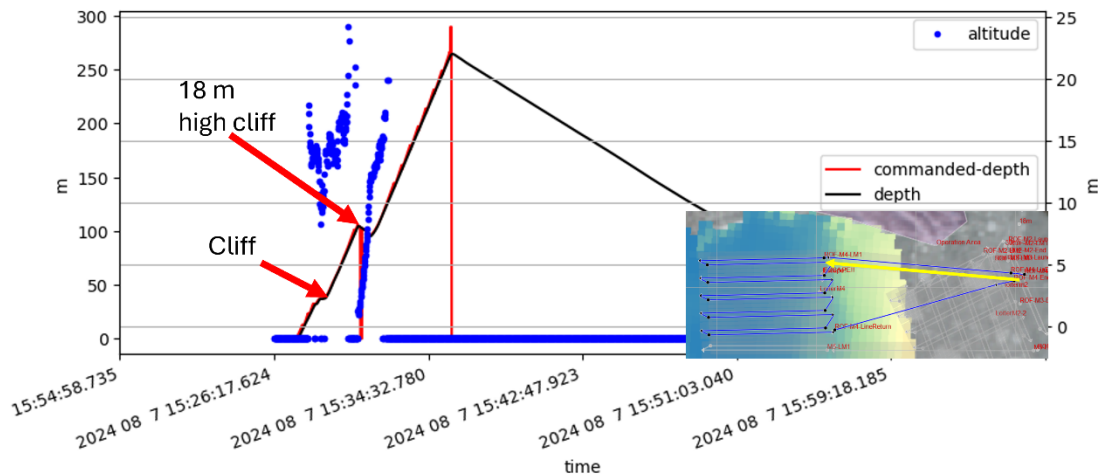


Figure 5.3-3. Failed swath mission from Rosenborg Gletsjer.

There were no more changes that could be made to the AUV ballast but dive and depth tracking parameters are user changeable so we looked to these. The depth and auto pilot configuration files set the depth and dive tracking parameters. Min-altitude was increased from 1 to 6 m, min-target-altitude was increased from 1.5 to 6.5 m. These parameters have rarely been changed as they allow the Gavia to descend to suitable depths for seabed photography. Also changed were depth-track-error from 5-10m and max-descent-rate from 0.8 to 0.7 m/s. These changes allowed the AUV to descend slower and with greater margin of error. The changes also accounted for any sharp changes in seabed by allowing the AUV to use its brakes earlier (further from the seabed). Following these changes, AUV missions had 100% success across steep, deep, and complex bathymetry, and for the rest of the campaign.

5.4 Data retrieval, processing and initial results

On completion of a mission, non-bathy data were exported from Control Center the Gavia via WiFi or Ethernet cable.

.xml (zipped) files are exported to:

```
/PROJECT_NAME/files/log
```

and .RAW data files to:

```
/PROJECT_NAME/files/SENSOR
```

Where PROJECT_NAME is the the Control Sensor campaign (listed in Table 5.4-1) and SENSOR is 'ecopcuk-flntu' or 'ctd-slocum' for example.

Bathy data (i.e. GS+ .RDF files) are copied direct from the GeoSwath module via Ethernet cable (further details in subsection 8.4)

The .RAW files are approximately 6 minute chunks of data that contain the observations made by each respective oceanographic sensor, but have no time, date, GPS index.

Log data (.xml) were processed using a Python based toolbox <https://github.com/LewisDrysdale/GaviaSciTools>. Two scripts are required to convert zipped log data:

```
gst.gst_unzip_log_data("log data path")
```

inputs: absolute path to folder containing .xml log files

```
gst.gst_read_log_data(logdir, savedir, types)
```

inputs: absolute path to folder containing .xml log files, absolute path to folder where processed data is to be saved, list of sensor data to be processed

The resulting files are merged .csv files and are saved in

```
/PROJECT_NAME/files/processed-log-data
```

Table 5.4-1. Naming convention of Gavia AUV campaigns during SD041.

30 th ,31 st July and 2 nd Aug	SD041-KANGGLAC-3-MIIPPUGUT
5 th Aug	SD041-KANG-GLAC-KVIOQ
7 th August	SD041-KANG-GLAC-ROSENBERG-GLETSJER
12 th August	SD041-KANGGLAC-PAATTUULAAJIT IKERTIVAAT
20 th August	SD041-KANGGLAC-EAST OF UUNARTAAJIT
21 st August	SD041-KANGGLAC-INNER SHELF NE OF KANGERUSSUAQ TROUGH

CTD, FLNTU, and Optode sensors were activated whenever the Gavia AUV was on mission. The data correspond to vertical profiles (during dive and surface phases) and across-fjord sections, as missions were typically run along the glacier front.

Temperature and salinity data from the Slocum CTD (Figure 5.4-1) show that of the six regions surveyed, each were characteristically different from each other. In particular, the ‘true’ fjords surveyed north of KG mouth were characterised by low salinity <25, low temperature water. Shelf and glacier regions south and east of KG mouth had, however, typically higher salinities >25 and had the highest recorded temperatures >2°C.

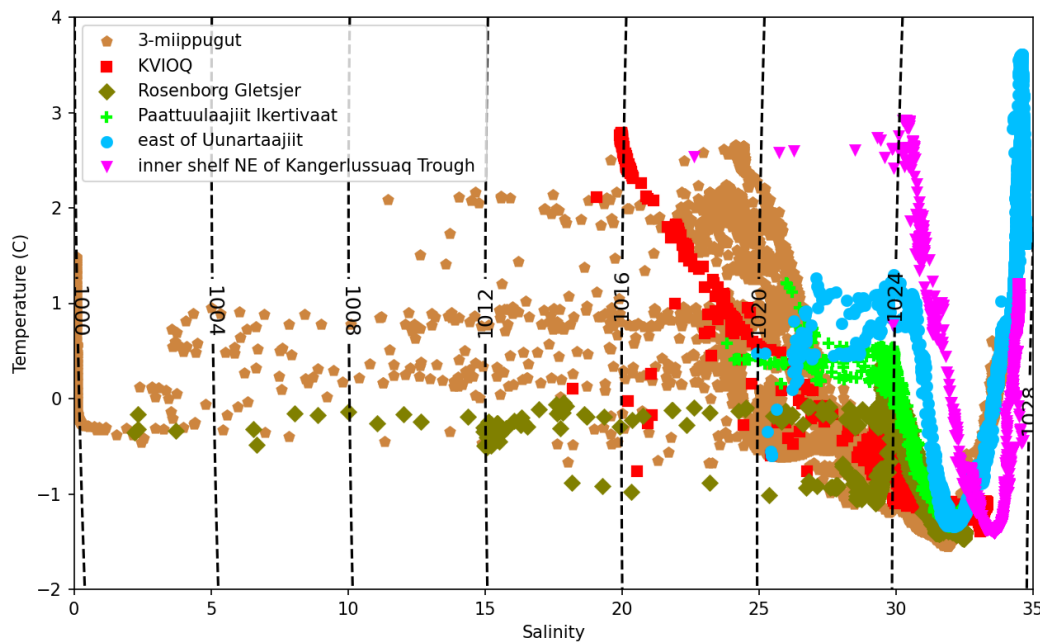


Figure 5.4-1 T-S diagram of all Salinity and Temperature data from the Slocum CTD sensor during all Gavia AUV missions.

Other sensors on the AUV performed well. Data from the turbidity sensor (figure 8.11), for example, show differing sediment regimes across the fjords surveyed.

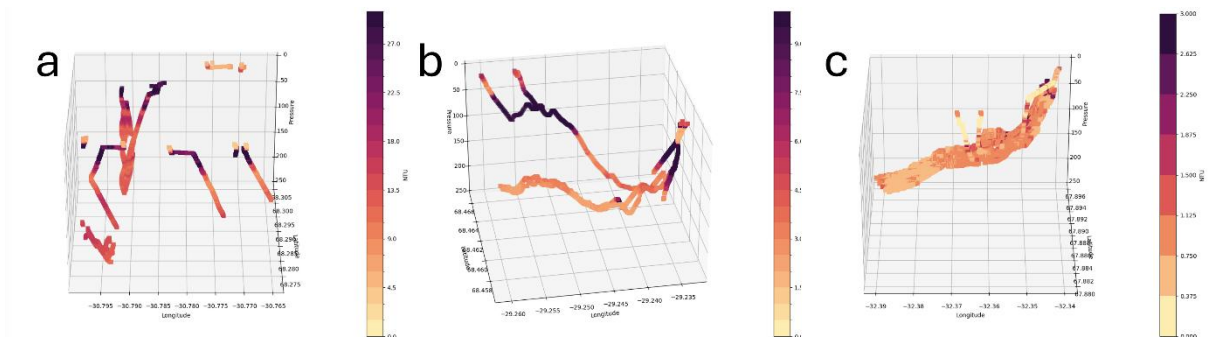


Figure 5.4-2 Turbidity plotted as a function of depth and latitude and longitude for a) 3-miippugut, scale 0-30; b) Kivioq, scale 0-10, c) Paattuulaajit Ikertivaat, scale 0-3

5.5 AUV bathymetry and side-scan sonar data processing methods plus initial results

AUV bathymetry and side-scan sonar data is produced by the 500 kHz Kongsberg Geoacoustics interferometric bathymetry system. Unlike multibeam echo sounders, the Geoswath+ system is a bathymetric side scan sonar utilizing two staves of sound at an angle of 60° below the transducer with maximum ranges beneath the vehicle of 30m and an absolute horizontal range of 75m. For the surveys in SE Greenland the altitude of the vehicle varied from a minimum of 7.5m to a maximum of 12m. 7.5m was found to be too low for vehicle safety in terms of too close to

avoid collisions with the seabed in the irregular glaciomarine environment. 12m was found to be too high for data density mostly due to the high volume of suspended sediment from the glaciers. Most surveys unless indicated were conducted at 10m altitude (bottom track altitude). This compromise produced acceptable data density and vehicle safety. All surveys were conducted with an AUV propulsion work rate of 650rpm producing a speed through water of approximately 1.4-1.7m/s (~3 knots). The bathymetric and side scan sonar data was cleaned in GS4 Geoacoustics software and imported into Caris HIPS and SIPS v11 corrected for sound velocity and rendered as Caris geo-spatial files. Final cleaning was completed before exporting as GeoTiff into QGIS. The brief workflow is as follows:

GS4 (Kongsberg Geoacoustics)

1. Setup project with UTM Zone 25N (SE Greenland) and define the processed file export to 'flagged .RDF'
2. Define filters such as limits (most effective), across track, along track and amplitude
3. Import raw .RDF from the Geoswath AUV module data directly or from the AUV or saved RAW data folder (e.g. L:\work\scientific_work_areas\Gavia_AUV\RAW Geoswath).
4. Replay the individual files with the filters to filter nadir and above seabed noise (for KANG-GLAC data only the 'limits' filter was applied) for each file.
5. Remove files with no data or poor data from the project
6. Export processed (flagged .RDF) files to Caris HIPS and SIPS folder structure

Caris HIPS and SIPS v11

1. Setup new project, define UTM zone 25N (SE Greenland).
2. Import flagged RDF from GS4 (e.g., C:\Users\Public\Documents\GS4\Paattuulaajit Ikertivaatp_Fjord), applying limit filter and AUV vessel file.
3. Generate survey lines in the project and check in correct location.
4. Check and smooth navigation and attitude using editors.
5. Process lines for Total Propagated Uncertainty (TPU) applying sound velocity correction using the CastAway CTD profiles and converted to Caris format (.svp).
6. Grid the survey lines either as a single map sheet (single surface) or as individual grids. Gridding at 0.5m CUBE (Combined Uncertainty Bathymetric Estimator) produced data holes in the surfaces, a grid of 1-2m CUBE produced reasonable results from 10 m altitude AUV height above seabed.
7. Apply Subset editor to filter surface noise in small areas.
8. Export CSAR raster with depth as GeoTiff for QGIS.
9. Select lines for side scan mosaic. Use SIPS side scan engine.
10. Open side scan editor and apply TVG, Gain, Despeckle, Nadir Offset, Altitude and Time offset settings appropriate to obtain best quality of the line. Save file as a beam pattern file (.bp).
11. Using SIPS side scan mosaic, apply beam pattern file and smooth gyro and smooth attitude.
12. Grid to 0.1m – creates large file sizes (~200-500Mb) but gets good resolution and intensity quality.
13. Export CSAR as raster with intensity as GeoTiff for QGIS.

5.5.1 Initial Results from AUV Seabed Mapping

3-Miippugut fjord aka 'Ryberg fjord & Neill Moraine', tributary glacier: The survey extended for 0.7 km² comprising three AUV seabed surveys. The shallowest point is 33 m in the south, and the deepest sounding is 125 m, adjacent to the glacier front in the north. The bathymetry revealed a seafloor constrained to the south of the bay by the obvious arcuate moraines which to the east are exposed at low tide. Beyond these terminal moraines, vessel-based bathymetry revealed a steep slope bisected by channels extending to beyond 300 m water depth. North of the moraines the seafloor of the bay is complex, from transverse ridges, moraines, to the south to a deeper water ~100 m basin in the north. The seafloor is dominated by complex ridges, interpreted to be crevasse-squeeze ridges. These ridges are most pronounced in the shallower water, <70 m of the bay in the southwest. Mass wasting channels dominate the flanks of the ridges, perhaps a testament to their fine-grained sediment composition. The survey closest to the glacier recorded poorer quality data, the result of the high volume of suspended sediment in the water column scattering the AUV sonar.

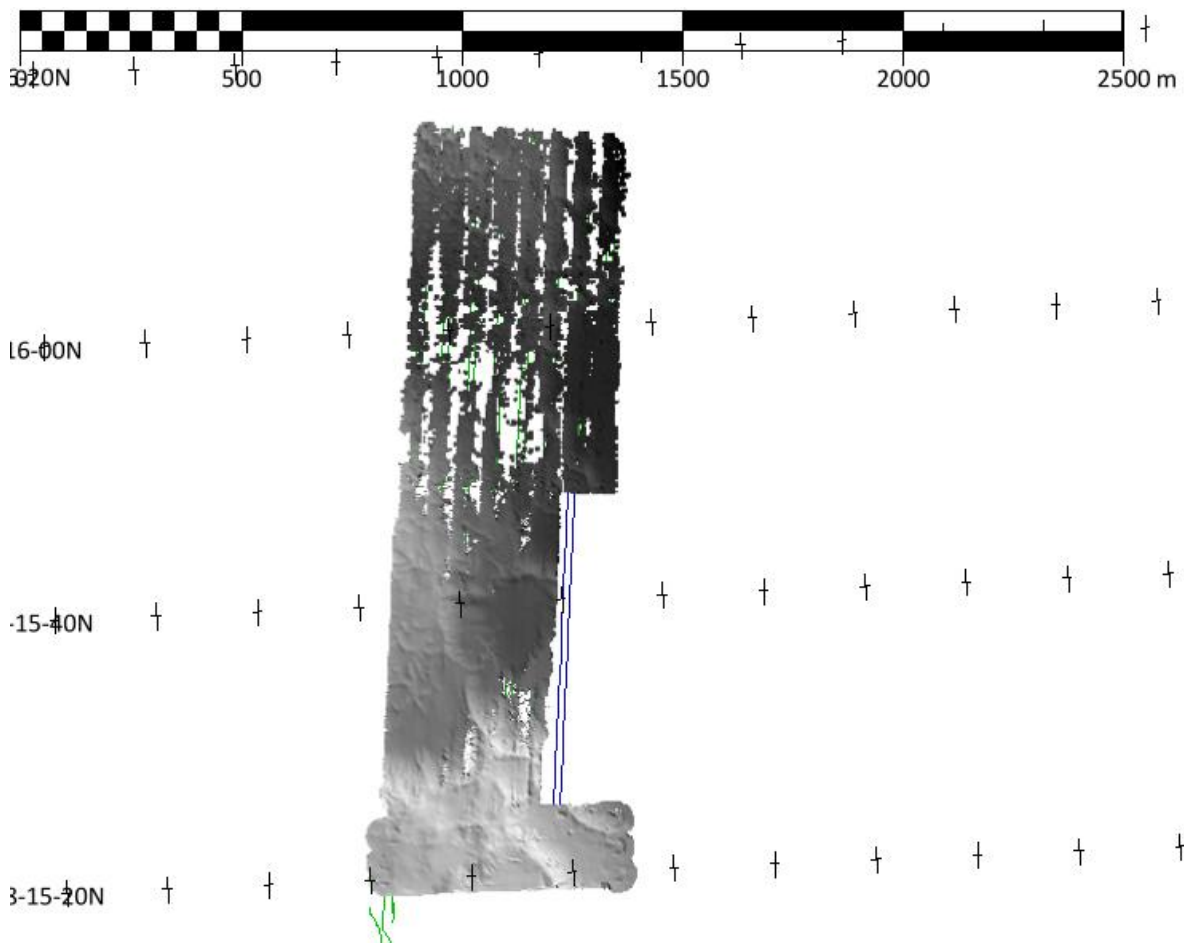


Figure 5.5-1. AUV-derived bathymetry of the small tributary glacial bay northeast of 3-Miippugut fjord. Water depths are between 33-125 m. Greyscale shading, combined 5-m and 2-m bathymetric grids. Data gaps due to suspended sediment in the bay scattering the sonar.

Kivioq Fjord: The survey in front of the grounded Rosenberg glacier, comprised two short AUV missions, each one 0.04km² and 0.06km². The two surveys were designed to survey a strip along the glacier front (60m wide and ~1km long). And either side of a grounded iceberg in 150m. Both

the front of the glacier and the margins of the grounded iceberg were imaged with the AUV sonar. Bathymetrically the shallowest soundings of 72m occurred at the western extent of the northern glacial survey. The deepest soundings of 209m were found in the central region of the glacial front survey. Both regions of seafloor were dominated by linear, northeast to southwest oriented subglacial streamlines and, for the northern glacier front survey, a complex bathymetric high of poorly sorted sediments, interpreted as a grounding zone wedge.

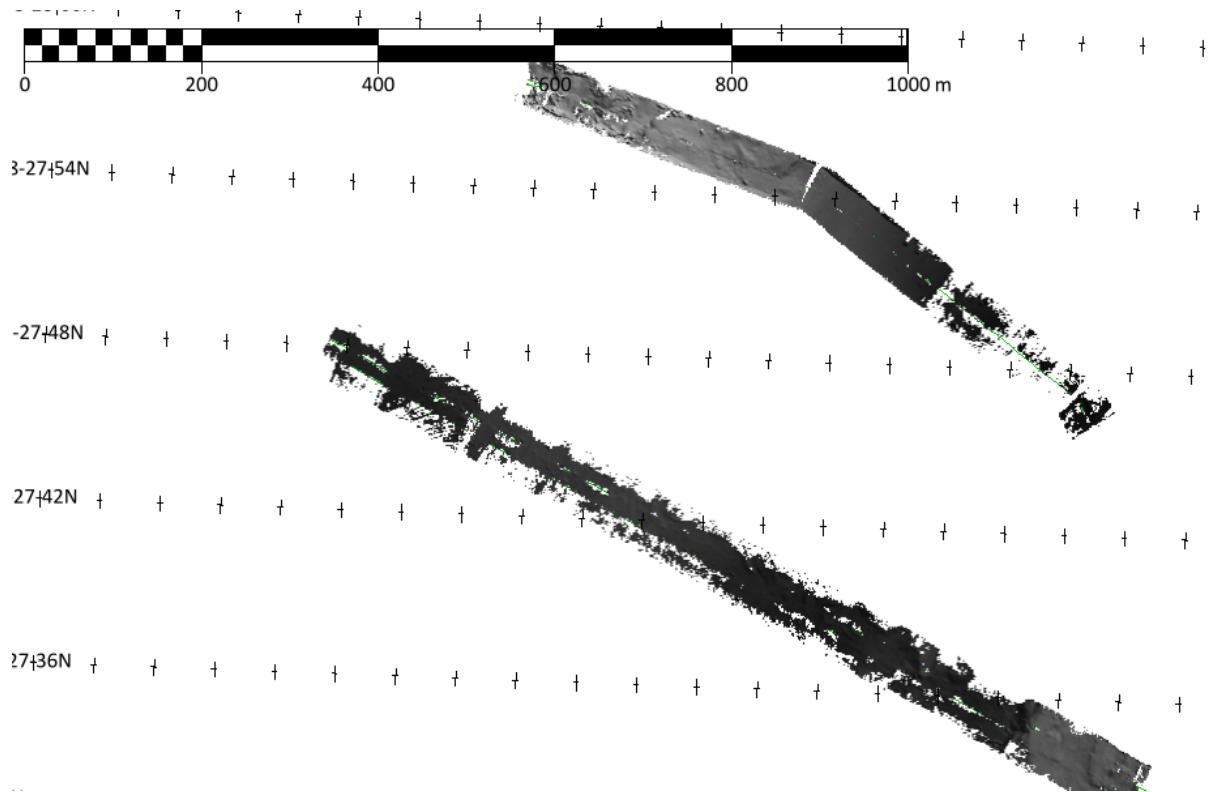


Figure 5.5-2. AUV-derived bathymetry of Kivioq Fjord. Water depths are between 90-180 m. Greyscale shading, 2-m bathymetric grid. Data gaps due to sonar scattering by suspended sediment in the water column.

Unnamed fjord, Rosenborg Glacier (known as Chocolate Bay): Two surveys were conducted near to the grounding line of the Rosenborg glacier in this unnamed fjord. The first short survey of 0.04km² aimed to examine the seafloor beneath the highly active meltwater plume emerging from the western corner of the glacier. The plume was recognized by the orange, brown colour from the suspended sediment plume that extended across the fjord. This survey recorded the shallowest sounding of 18m at the southern extent and the deepest point of 98m in the central part of the survey. The seafloor across the region was dominated by exposed bedrock and fine-grained sediments, cut through with east-west oriented channels adjacent to the terminus of a small land-based glacier. The other survey, located at the eastern Rosenborg glacier terminus was 0.15km² and recorded the shallowest point of 27m in the northern small glacial embayment and a deepest point of 220m directly in front of the grounded ice margin. This survey revealed a predominantly rock slope with numerous submarine cliffs, one with ~20m in vertical height between 84m-104m water depth. Rocky boulder covered slopes dominate with very fine-grained sediments only found below 140m depth adjacent to the glacier.

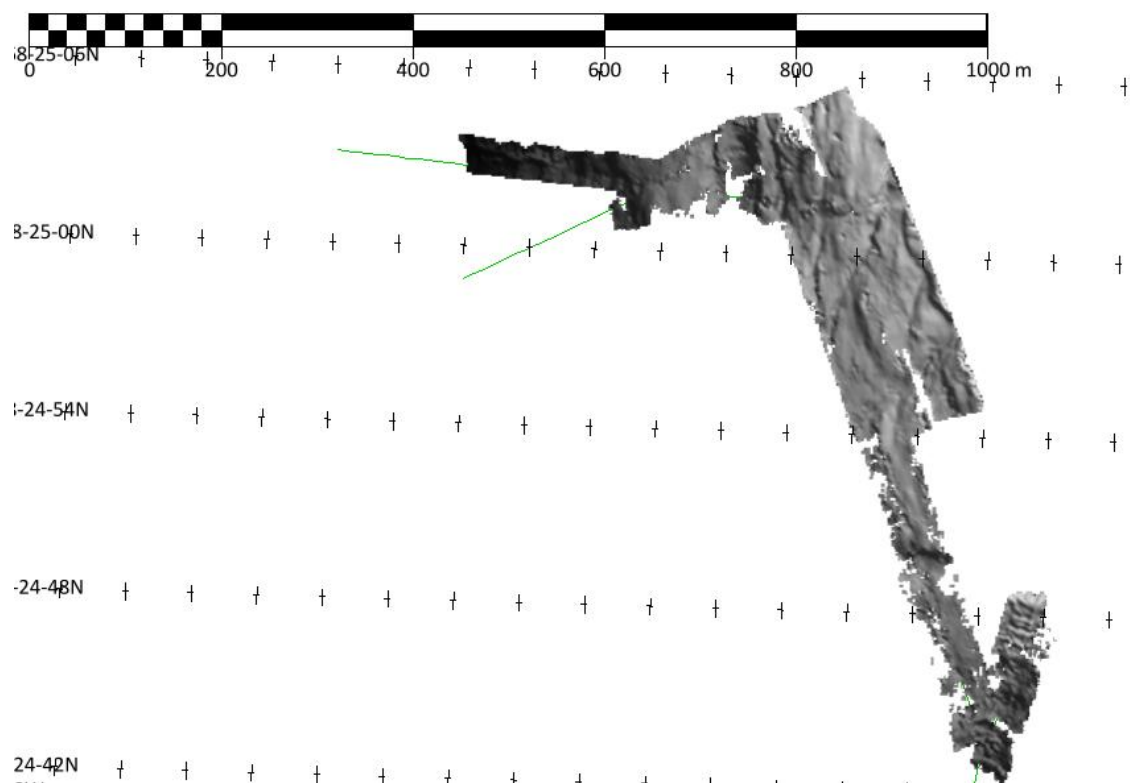


Figure 5.5-3. AUV-derived bathymetry of Unnamed fjord, east part of Rosenborg glacier. Water depths are between 30-220 m. Greyscale shading, 2-m bathymetric grid. Data gaps due to AUV collision with seabed.

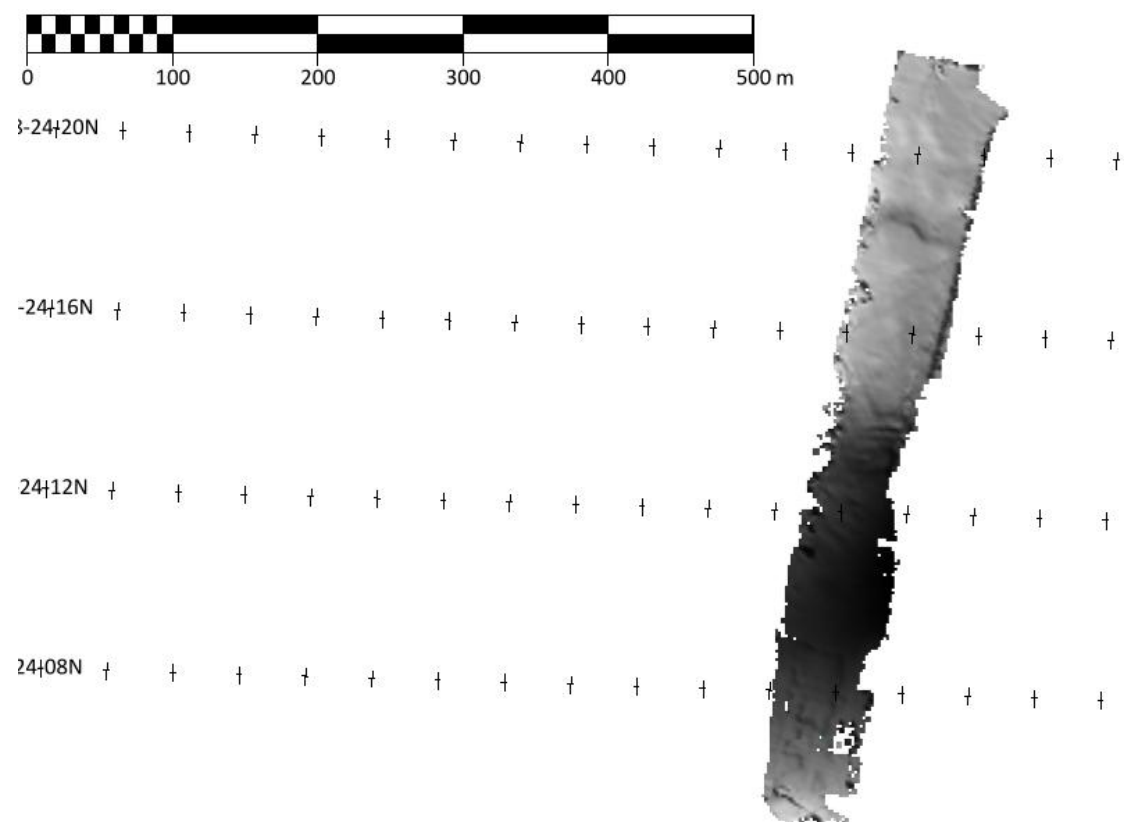


Figure 5.5-4. AUV-derived bathymetry of Unnamed fjord, west part of Rosenborg glacier, in location of meltwater plume. Water depths are between 18-98 m. Greyscale shading, 2-m bathymetric grid.

Paattuulaajit Ikertivaat: The survey was conducted in front of the Apulitiitp Apusiia glacier, concentrated at its northeastern extent which was relatively ice free at the time of the survey. The survey comprised four AUV missions, oriented northeast to southwest, approximately 100m from the grounded ice margin. The 1km² survey recorded a shallowest sounding of 34m in the northeast, close to the shore and 112m in the central region of the glacier front. The deeper regions are dominated by linear ridges, perpendicular to the glacier front, interpreted as subglacial streamlines and arcuate, linear ridges interpreted as crevasse-squeeze ridges. The shallower region, to the southwest of the glacier front is dominated by two 80-100m wide, 3-10m high ridges, with mass-wasting channels on either side. Radiating from the southeast slopes are numerous sediment lobes, presumably debris flow in origin. The entire region is covered in crevasse-squeeze ridges.

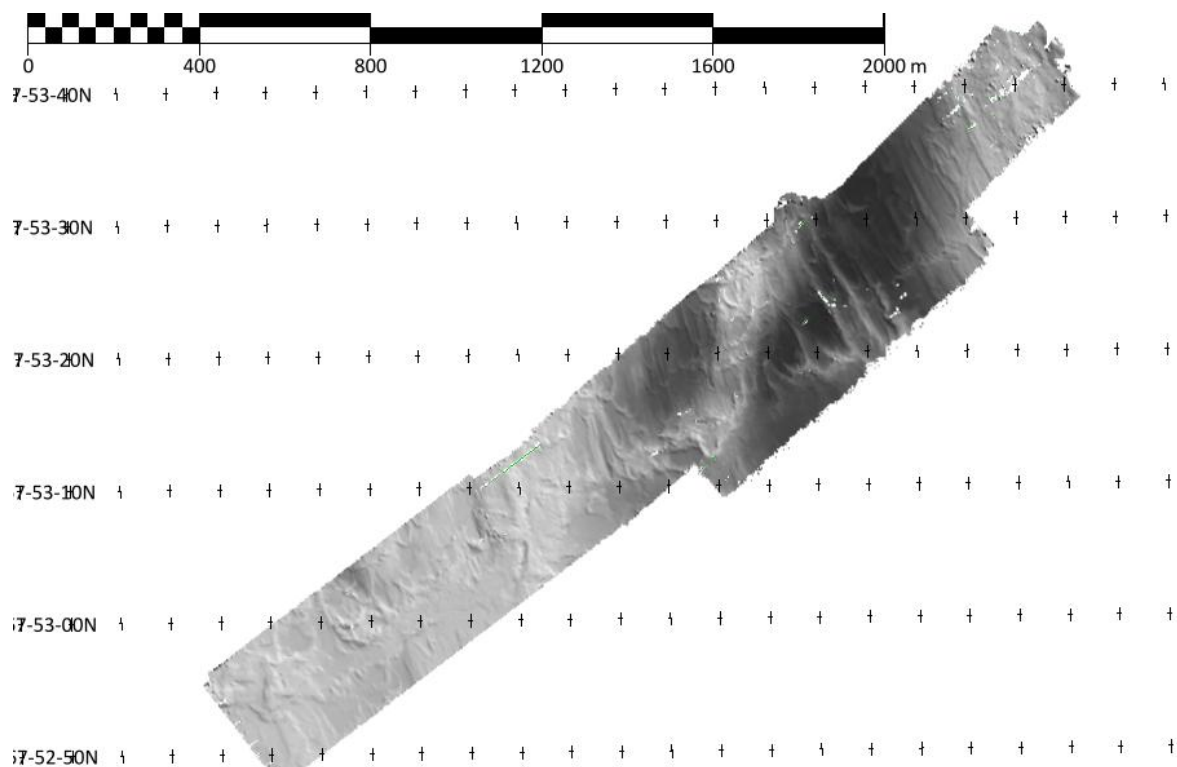


Figure 5.5-5. AUV-derived bathymetry of Paattuulaajit Ikertivaat. Water depths are between 70-120 m. Greyscale shading, 1-m bathymetric grid.

East of Uunartaajit: Two surveys were intended to bridge the deeper water (~400m) between the two highs (~250m) of a trough east of Uunartaajit island and close to where the mooring was placed. The 1.5km² survey covered the trough with highs to the south and north. The shallowest depth was 212m and the deepest at 445m (the deepest survey for our AUV). The survey is dominated by rock outcrops to the north, deeply eroded by rocky channels. The bedrock high is oriented to the southwest with the deepest point, 445m current-scoured sediment. The current direction can be determined by the comet-tails of the ice rafted debris and appears flowing from the northwest to the southeast, i.e. out from Uunartaajit island and seaward of the main Deception Trough. In addition, the southern region is deeply scoured by iceberg plough marks and keel marks. A very interesting region combining bottom-current and glacial history.

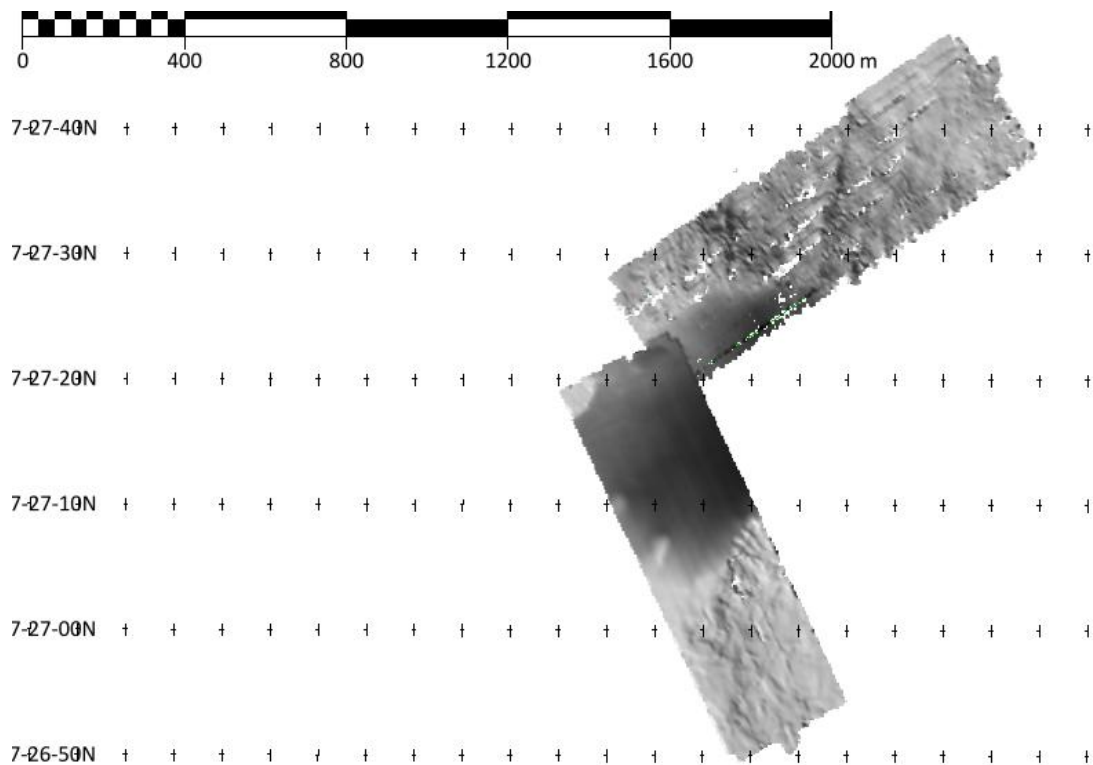


Figure 5.5-6. AUV-derived bathymetry of east of Uunartaajiit island. Water depths are between 210-445 m. Greyscale shading, combined 5-m and 1-m bathymetric grids.

2- miippugut fjord, Northern Kangerlussuaq shelf: Two AUV surveys were conducted across a small region of the continental shelf north of the main Kangerlussuaq fjord and offshore from 2-Miippugut fjord. The survey covered a 0.5km² region of the shelf at a mid-point southeast of 2-Miippugut fjord. The survey revealed a complex region of subdued bathymetry with the shallowest sounding of 266m and the deepest sounding of 319m. The survey is dominated by a northwest to southeast trending depression, 150m to 190m wide with a steep side of up to 50m relief. The side scan sonar suggests boulder filled margins possibly of exposed glacial till. Gridded surfaces to 0.5m show only a few iceberg ploughmarks, suggesting either a high sedimentation rate or that this region of the shelf experiences few deep-keeled ice bergs.

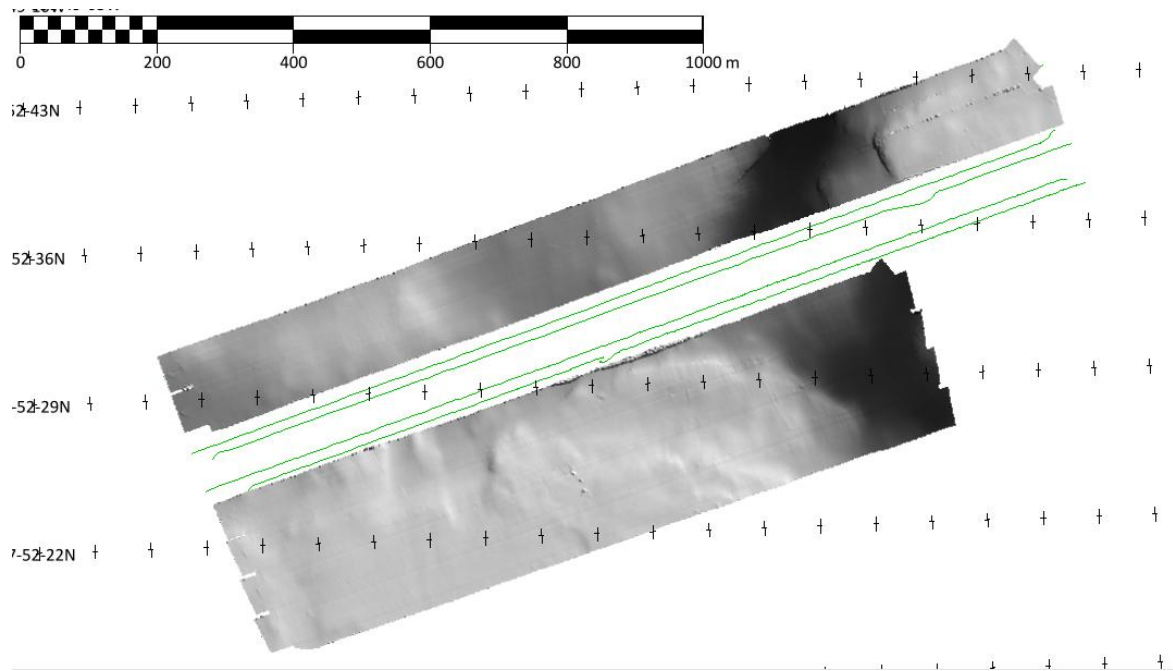


Figure 5.5-7. AUV-derived bathymetry of the continental shelf southeast of 2-Miippugut fjord. Water depths are between 267-319 m. Greyscale shading, 0.5-m bathymetric grid. Gap is due to poor quality data being removed.

Table 5.5-1. Gavia AUV mission/event log.

	Name	Mission plan	Date	Start Time (UTC)	Time on mission	Start Lat (DDM)	Start Lon (DDM)	End Lat (DDM)	End Lon (DDM)	Distance travelled (km)	Max. Depth (m)	Ultimate reason for end	Comments
1	RF-M1	Lawnmower 15 m bottom track	Tues, 30 Jul 24	11:30:28	00:00:43	68 16.358	30 46.941	68 16.335	30 46.762	0.00	0	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
2	RF-M1	Lawnmower 15 m bottom track	Tues, 30 Jul 24	11:35:00	00:00:01	68 16.358	30 46.941	68 16.354	30 46.976	0.00	0	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
3	RF-M1	Lawnmower 15 m bottom track	Tues, 30 Jul 24	11:39:00	00:00:01	68 16.358	30 46.941	68 16.365	30 47.013	0.00	0	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
4	RF-M1	Lawnmower 15 m bottom track	Tues, 30 Jul 24	11:40:04	00:05:04	68 16.367	30 47.018	68 16.391	30 46.542	0.70	145	Abort: Failed to track depth	Using ship's wake to force vehicle to dive. AUV reached 140 m and the end of the first line before aborting. A density of 1028 kg/m3 was measured just before aborting.
5	RF-M2	Lawnmower 15 m bottom track	Tues, 30 Jul 24	15:42:50	00:00:45	68 16.499	30 47.834	68 16.533	30 47.828	0.00	0	Abort: Failed to track depth	Struggling to dive. Unable to match depth trajectory
6	RF-M2	Lawnmower 15 m bottom track	Tues, 30 Jul 24	15:44:00	00:00:00	68 16.499	30 47.834	68 16.533	30 47.868	0.00	0	Abort: Failed to track depth	Struggling to dive. Unable to match depth trajectory
7	RF-M2	Lawnmower 15 m bottom track	Tues, 30 Jul 24	15:57:46	00:15:37	68 16.453	30 47.504	68 16.546	30 47.868	0.87	230	Emergency brake from Depth Pilot. Emergency brake. Abort: Failed to track depth	Overshot target depth/altitude. Unable to match depth trajectory after brake
8	RF-M3	Lawnmower 15 m bottom track	Tues, 30 Jul 24	17:00:52	00:01:07	68 16.430	30 46.387	68 16.436	30 47.300	0.00	24	Failed to track depth	Struggling to dive. Unable to match depth trajectory
9	RF-M3	Lawnmower 15 m bottom track	Tues, 30 Jul 24	17:08:50	00:03:51	68 16.426	30 46.262	68 16.435	30 45.984	0.00	125	Abort: Failed to track depth	Struggling to dive. Unable to match depth trajectory
10	RF-M4	Lawnmower 15 m bottom track	Wed, 31 Jul 24	11:09:34	00:00:22	68 17.652	30 48.150	68 17.640	30 48.142	0.00	0	Mission aborted by user due to vehicle not diving	Conditions too calm to enable dive
11	RF-M4	Lawnmower 15 m bottom track	Wed, 31 Jul 24	11:12:19	00:00:22	68 17.628	30 48.100	69 17.627	31 48.063	0.00	1	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive

12	RF-M4	Lawnmower 15 m bottom track	Wed, 31 Jul 24	11:14:57	00:04:36	68 17.624	30 48.018			0.00	112	Abort: Failed to track depth	Struggling to dive. Unable to match depth trajectory
13	RF-M5	Lawnmower 15 m bottom track	Wed, 31 Jul 24	12:14:40	00:00:19	68 17.701	30 47.185	68 17.697	30 47.137	0.00	1.5	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
14	RF-M5	Use ascent/sdescent action to deep dive and follow lawnmower pattern	Wed, 31 Jul 24	12:18:08	00:24:35	68 17.705	30 47.108			0.09	200	Failed to track depth	Timeout due to inability to follow dept trajectory. Positional standard deviation high ~25 m
15	RF-M5		Wed, 31 Jul 24	13:05:57	00:00:21	68 17.774	30 47.030			0.00	2	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
16	RF-M5		Wed, 31 Jul 24	13:09:39	00:00:09	68 17.770	30 47.059			0.00	2	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
17	RF-M5	Use ascent/sdescent action to deep dive and follow lawnmower pattern	Wed, 31 Jul 24	13:12:06	00:12:09	68 17.753	30 47.076			0.00	203	Failed to track depth	Timeout due to inability to follow dept trajectory. Positional standard deviation high ~25 m
18	RF-M6	Dive to 10 m then follow lawnmower dive pattern	Wed, 31 Jul 24	14:24:25	00:01:38	68 18.226	30 46.171			0.00	15.5	Failed to track depth	
19	RF-M7		Wed, 31 Jul 24	15:11:32	00:00:15	68 18.258	30 46.510			0.00	2	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
20	RF-M7		Wed, 31 Jul 24	15:13:00	00:02:29	68 18.241	30 46.572			0.00	13	Failed to track depth	Struggling to dive. Unable to match depth trajectory
21	RF-M9		Wed, 31 Jul 24	16:36:01	00:00:25	68 17.509	30 49.376			0.00	1.6	Mission aborted by user due to vehicle not diving	Conditions too calm/ballast not sufficient to enable dive
22	RF-M9		Wed, 31 Jul 24	16:38:27	00:08:26	68 17.510	30 49.397			0.00	9	Failed to track depth	Navigation unsafe: Position accuracy exceeded maximum allowed variance.
23	Ballast configuration changed to much heavier vehicle, keeping most ballast on the external rails												
24	RF-M10		Fri, 02 Aug 2019	11:58:08	00:42:25	68 15.282	30 26.267			3.40	81	Mission complete	

25	RF-M11		Fri, 02 Aug 2020	12:48:21	00:00:56	68 15.294	30 26.342				1	Abort by user	Conditions too calm/ballast not sufficient to enable dive
26	RF-M11		Fri, 02 Aug 2021	12:50:10	02:10:09	68 15.258	30 26.308	68 15.382	30 26.300	12.20		Mission complete	
27	RF-M12		Fri, 02 Aug 2022	15:05:41	00:02:28	68 15.355	30 26.158	68 1.485	30 26.123	0.12	46	Mission complete	test mission to see if geoswath module stats pinging autonomously
28	RF-M13		Fri, 02 Aug 2023	15:31:32	02:25:32	68 15.744	30 26.191	68 15.793	30 25.931	13.80		Mission complete	
29	RF-M14		Fri, 02 Aug 24	18:10:19	00:02:05	68 15.655	30 26.053	68 15.650	30 26.054			Mission complete	GoPro Mission
30	KF-M1		Mon, 05 Aug 24	14:55:44	05:26:00	68 27.965	29 15.316	68 27.768	29 14.277	0.10	80	Abort failure to track depth	Reached 80 m depth and acquired bottom lock but failed to track depth due to light ballasting
31	KF-M1		Mon, 05 Aug 24	15:31:10	00:14:54	68 27.951	29 15.634	68 27.944	29 15.629	0.93		Abort: Failed to track dept	15:33:47: Info: Emergency brake from Depth Pilot.
32	KF-M2		Mon, 05 Aug 24	17:02:06	00:00:00	68 27.518	29 14.013	68 27.763	29 14.332			Aborted by user due to inability to dive	
33	KF-M2		Mon, 05 Aug 24	17:03:37	00:00:26	68 27.519	29 14.046	68 27.521	29 14.041	0.10		Failure to track depth	Second attempt at diving. AUV dived to 4 m but was not able to follow its depth trajectory so aborted to surface
34	KF-M2		Mon, 05 Aug 24	17:14:43	00:02:49	68 27.510	29 14.036	68 27.527	29 14.369			Failure to track depth	Reached 100 m but failed to track depth, possibly due the AUV attempt to track steep down slope
35	KF-M2		Mon, 05 Aug 24	17:41:18	00:35:28	68 27.507	29 13.990	68 27.610	29 14.268	2.80		emergency brake from depth pilot	Set AUV on short slope paralell dive in order to force to bottom and obtain bottom track before attempting the steep slope into the basin.
36	ROF-M1	Lawnmower pattern running approximately north south towards eastern end of main glacier	Wed, 07 Aug 24	11:50:26	00:16:53	68 24.088	28 50.535	68 24.059	28 50.486	1.10	90	Failure to track depth	Was unable to recover after two incidences of Emergency brake from Depth Pilot

37	ROF-M2		Wed, 07 Aug 24	13:30:42	00:26:42	68 25.091	28 47.492	68 24.882	28 48.085	1.90	204	Failure to track depth	Was unable to recover after two incidences of Emergency brake from Depth Pilot
38	ROF-M3		Wed, 07 Aug 24	14:41:25	00:10:48	68 25.058	28 47.509	68 24.765	28 47.265	0.61		Failure to track depth	Emergency brake from Depth Pilot.
39	ROF-M4		Wed, 07 Aug 24	15:27:12	00:08:30	68 25.032	28 47.470	68 24.949	28 48.505	0.33	260	Failure to track depth	Emergency brake from Depth Pilot.
40	ROF-M5		Wed, 07 Aug 24	17:13:17	00:04:18	68 24.864	28 47.187	68 24.697	28 47.492	0.06	120	Failure to track depth	
41	ROF-M6	Atttempt dive to 200 m usiNg lawnmower and deep dive tables	Wed, 07 Aug 24	17:37:19	00:08:53	68 24.643	28 47.359	68 24.669	28 47.261	0.09	231	Failure to track depth	Emergency brake from Depth Pilot.
42	Depth Pilot: max-descet-rate 0.8 -> 0.7; min-altitude 1 -> 6 Autopilot: depth-track-error 5 -> 10 Depth-Pilot2: min-target-altitude -> 6.5 Ballast and trim adjusted												
43	CB-M1	12 m bottom track lawnmower (60 m GS sonar range) + 7.5 m bottom track lawnmower (30 m GS sonar range)	Mon, 12 Aug 24	10:17:47	01:47:52	67 53.677	32 20.390	67 53.681	32 20.421	8.80	105	Mission complete	Seven instances of emergency brake from Depth Pilot during 7.5 m bottom track phase of mission, all occuring on upslope legs of mission
44	CB-M2	10 m bottom track lawnmower	Mon, 12 Aug 24	12:15:00	02:00:54	67 53.683	32 20.418	67 53.181	32 22.094	10.60	102	Mission complete	Three instances of emergency brake from Depth Pilot , all occuring on upslope legs of mission
45	CB-M3	10 m bottom track lawnmower	Mon, 12 Aug 24	14:52:06	02:03:48	67 53.187	32 22.111	67 53.185	32 22.112	11.00	85	Mission complete	one emergency brake
46	CB-M4	10 m bottom track lawnmower	Mon, 12 Aug 24	17:22:05	00:46:48	67 53.189	32 21.748	67 53.126	32 21.747	3.80	100	Mission complete	one emergency brake

47	transit	transit line to mission location	Sun, 18 Aug 24					67 41.859	32 31.897			Mission complete	Surfaced due to exceeding position accuracy but completed mission
48	MR-M1	Lawnmower GS constant altitude of 10m	Tues, 20 Aug 24	10:59:57	03:18:29	67 27.807	33 06.053			14.50	434	Mission complete	Emergency brake at 11:31:14, 11:34:34, 11:37:41, 11:58:26, 12:01:57, 12:05:52, 12:09:00, 12:14:24, 12:31:41, 12:34:56, 12:38:37, 12:53:20, 13:03:02, 13:06:16, 13:10:53, 13:33:52, 13:36:58, 13:40:08, 14:03:43, 14:07:21, 14:10:59
49	MR-M2	Lawnmower GS constant altitude of 10m	Tues, 20 Aug 24	15:29:58	02:29:41	67 26.679	33 06.981	67 27.534	33 04.641	11.60	435.2	Mission complete	Emergency brake at 16:00:48, 16:09:59, 16:15:06, 16:35:07, 16:39:42, 16:59:19, 17:24:04, 17:50:53
	Vehicle restart due to GPS position error of ~115 m												
50	MKG-M1	Lawnmower GS constant altitude of 12m	Wed, 21 Au 24	12:29:33	01:54:21	67 52.271	30 48.510	67 52.279	30 48.510	9.70	302	Mission complete	Emergency brake at 13:26:45
51	NKG-M2	Lawnmower GS constant altitude of 10m	Wed, 21 Au 24	15:52:11	02:28:48	67 52.390	30 49.056	68 52.389	31 49.056	12.70	310	Mission complete	Emergency brake at 16:16:57, 17:59:02
					28:44:24					121.90			

6 Data Management

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6.1 Underway Data Logging Systems

Underway data usually refers to the outputs of systems that make continuous measurements of the environment when they are operational. Underway data loggers receive (or request) these outputs, timestamp them, and store them securely for onward reuse.

Some systems can provide their entire digital data output to underway data loggers in real-time (e.g., air temperature sensors) while other systems produce data that are too complex to be recorded by underway loggers (e.g., underwater video) – these systems typically record to local acquisition machines and these data are synchronised to central storage onboard (see synchronisation section below). In the middle are systems that create complex datagrams but also output simplified summary information that can be integrated into underway loggers (e.g., wave radar summary statistics).

The SDA operates a primary underway data logging system (RVDAS) and a secondary system (SCS) to provide an element of redundancy. The pathway from underway sensor output to data access and visualisation is given in Figure 6.1-1 below:

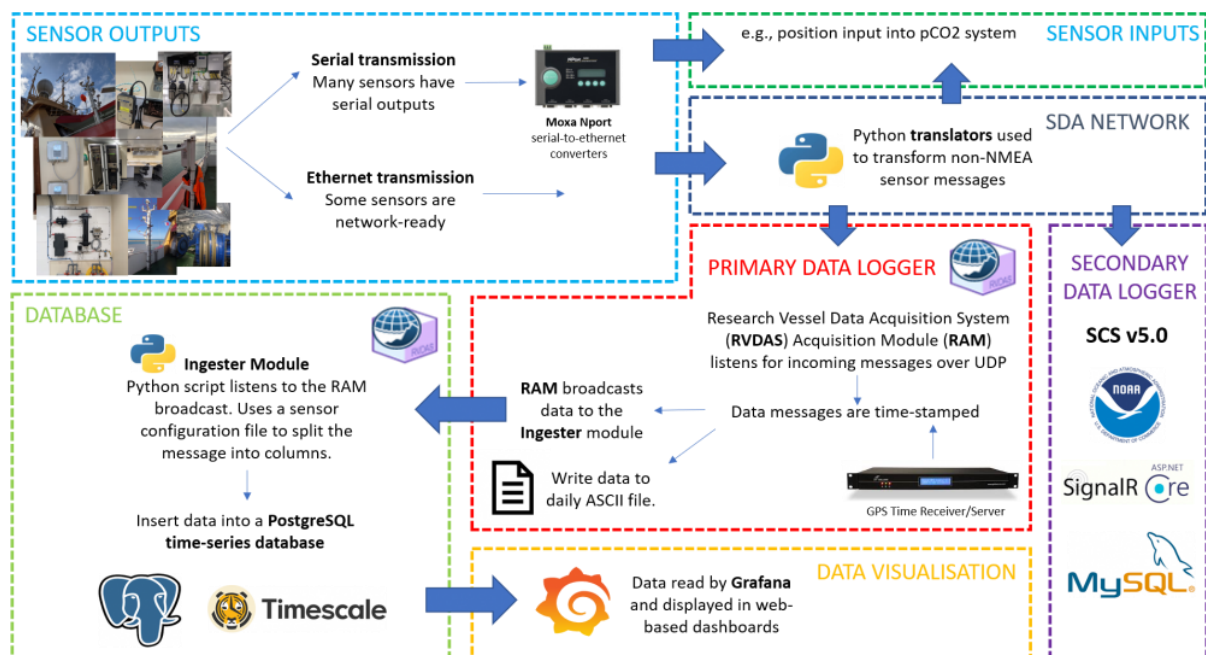


Figure 6.1-1 Data workflow of the underway logging system

6.1.1 Research Vessel Data Acquisition System (RVDAS)

RVDAS is a co-development between the National Marine Facilities team at the National Oceanography Centre, and members of various marine science support teams at BAS. It is the primary logging system used on the SDA and has been operational since March 2021 when the first GPS sensors were integrated. During SD041, RVDAS logged 60 separate data streams – details of which can be seen in the tables below:

Table 6.1-1. Colour index of system groups used in Table 6.1-2.

Position and Attitude	Bathymetry
Sea Surface Oceanography	Potential Field
Atmosphere and Meteorology	Monitoring systems

Table 6.1-2. A list of all the underway data streams logged by RVDAS during SD041.

	system Name	Installed Location	RVDAS name
	Fugro Oceanstar v3 GNSS	Centre Main Mast	sd_gnss_fugro_oceanstar_centremast1
	SAAB R5 Supreme GNSS	Centre Main Mast	sd_gnss_saab_r5_supreme_centremast1
	Seatex GNSS (Part of Kongsberg Seapath 320)	Port Main Mast	sd_gnss_kongsberg_seapath_320_port1
	Seatex GNSS (Part of Kongsberg Seapath 320)	Starboard Main Mast	sd_gnss_kongsbegr_seapath_320_stbd1
	Seatex MRU5+ (part of Kongsberg Seapath 320)	Deck 2, near CRP	sd_attitude_kongsberg_seapath_320_motion_port1
	Seatex MRU5+ (part of Kongsberg Seapath 320)	Deck 2, near CRP	sd_attitude_kongsberg_seapath_320_motion_stbd1
	Kongsberg Seapath 320 Heading	Various	sd_attitude_kongsberg_seapath_320_heading_port1
	Kongsberg Seapath 320 Heading	Various	sd_attitude_kongsberg_seapath_320_heading_stbd1
	iXblue Phins Surface PAA00011-C inertial navigation system (Heading)	Deck 2, near CRP	sd_attitude_ixblue_phins_surface_heading_crp1
	iXblue Phins Surface PAA00011-C inertial navigation system (Attitude)	Deck 2, near CRP	sd_attitude_ixblue_phins_surface_attitude_crp1
	SMC (Ship Motion Company) IMU-108 motion reference units	Mooring space	sd_attitude_smc_imu108_heli1
	Raytheon Standard 30 MF Gyro	Instrument Room Port, Deck 8	sd_attitude_raytheon_standard_30mf_port1
	Raytheon Standard 30 MF Gyro	Instrument Room Starboard, Deck 8	sd_attitude_raytheon_standard_30mf_stbd1
	Safran (Sagen) BlueNaute Gyro	Instrument Room Centre, Deck 8	sd_attitude_safran_bluenta_centrelin e1
	Northern Solutions EMES60 Electromagnetic Speed Logger	Hull	sd_speedlog_northern_solutions_emes60_hull1
	Skipper DL850 Doppler Speed Logger	Hull	sd_speedlog_skipper_dl850_hull1
	Sea-Bird Electronics SBE45 MicroTSG Thermosalinograph	UCSW Lab, Deck 3	sd_thermosalinograph_seabird_sbe45_ucsw1
	Sea-Bird WET Labs C-Star Transmissometer (CST)	UCSW Lab, Deck 3	sd_transmissometer_wetlabs_cstar_ucsw1
	Sea-Bird WETStar Flow-through Fluorometer (WSCHL)	UCSW Lab, Deck 3	sd_fluorometer_wetlabs_wschl_ucsw1
	Heitronics CT15.85 Infrared Radiation Thermometer	Port wing, Deck 10	sd_radiometer_heitronics_ct15_85_port1
	Heitronics CT15.85 Infrared Radiation Thermometer	Starboard wing, Deck 10	sd_radiometer_heitronics_ct15_85_stbd1
	Rutter sigma S6 WaMoS II wave radar	Various	sd_wave_rutter_sigma_s6_wamos_ii_bridge1
	Valeport miniSVS Sound Velocity Probe	Starboard Aux Machinery 2, Deck 1	sd_soundvelocity_valeport_minisvs_ucsw1
	Sea-Bird Electronics SBE38 Thermometer	Starboard Aux Machinery 2, Deck 1	sd_thermometer_seabird_sbe38_ucsw1
	Sea-Bird Electronics SBE38 Thermometer	Starboard Aux Machinery 2, Deck 1	sd_thermometer_seabird_sbe38_ucsw2
	Observator OMC-116M Windsensor	Port Main Mast	sd_anemometer_observator_omc116_portmast1

Observer OMC-116M Windsensor	Starboard Main Mast	sd_anemometer_observator_omc116_stbdmast1
FT Technologies FT702LT V22 Windsensor	Centre Main Mast	sd_anemometer_ft_tech_ft702lt_centremast1
Biral SWS-200 Visibility & Present Weather Sensor	Starboard wing, Deck 10	sd_met_biral_sws200_stbd1
Eliasson CBME80 Ceilometer	Starboard wing, Deck 10	sd_cloud_eliasson_cbme80_stbd1
Sea-Bird Satlantic Photosynthetically Active Radiation (PAR) Sensor	Science Mast, Deck 11	sd_radiometer_satlantic_par_scimast1
Sea-Bird Satlantic Photosynthetically Active Radiation (PAR) Sensor	Foremast	sd_radiometer_satlantic_par_foremast1
Vaisala HMP155E Air Temperature & Humidity	Science Mast, Deck 11	sd_met_vaisala_hmp155e_scimast1
Vaisala HMP155E Air Temperature & Humidity	Science Mast, Deck 11	sd_met_vaisala_hmp155e_scimast2
Vaisala HMP155E Air Temperature & Humidity	Foremast	sd_met_vaisala_hmp155e_foremast1
Kipp & Zonen SGR4-A Pyrgeometer (IR radiation)	Science Mast, Deck 11	sd_radiometer_kipp_zonen_sgr4_scimast1
Kipp & Zonen SGR4-A Pyrgeometer (IR radiation)	Foremast	sd_radiometer_kipp_zonen_sgr4_foremast1
Kipp & Zonen SMP22-A Pyranometer (Solar irradiance)	Science Mast, Deck 11	sd_radiometer_kipp_zonen_smp22_scimast1
Kipp & Zonen SMP22-A Pyranometer (Solar irradiance)	Foremast	sd_radiometer_kipp_zonen_smp22_foremast1
METEK Usonic-3 Class-A H Anemometer	Port Main Mast	sd_anemometer_metek_usonic3_portmast1
METEK Usonic-3 Class-A H Anemometer	Starboard Main Mast	sd_anemometer_metek_usonic3_stbdmast1
METEK Usonic-3 Class-A H Anemometer	Foremast	sd_anemometer_metek_usonic3_foremast1
Vaisala PTB330 Barometer	Aerosol Lab, Deck 10	sd_met_vaisala_ptb330_v2_aerosol1
Vaisala PTB330 Barometer	Aerosol Lab, Deck 10	sd_met_vaisala_ptb330_v2_aerosol2
Vaisala CL31 Lidar Ceilometer	Starboard wing, Deck 10	sd_cloud_vaisala_cl31_stbd1
Thies Clima Laser Precipitation Monitor (Disdrometer)	Science Mast, Deck 11	sd_met_thiesclima_5_4110_scimast1
Campbell Scientific (Goodrich) 0871LH1 Freezing-Rain sensor	Science Mast, Deck 11	sd_met_campbell_0871lh1_scimast1
Kongsberg EM122 multibeam	Hull	sd_multibeam_kongsberg_em122_hull1
Kongsberg EM712 multibeam	Hull	sd_multibeam_kongsberg_em712_hull1
Kongsberg EA640 singlebeam	Hull	sd_singlebeam_kongsberg_ea640_hull1
Skipper GDS102 singlebeam navigation echosounder	Hull	sd_singlebeam_skipper_gds102_hull1
Dynamic Gravity Systems (DgS) AT1M Gravity Sensor	Gravity Meter Room, Deck 2	sd_gravimeter_dgs_at1m_grav1
ODIM Winch logging and monitoring system ¹	Winch Control Room, Deck 5	sd_winch_odim_v3_wcr1
Litremeter LMX.24 PeltonWheel Flowmeter with a Fluidwell F112-P control/display unit	UCSW Lab, Deck 3	sd_flowmeter_litremeter_lmx24_ucsw1
Kongsberg Vessel Insight data logging system ¹	Deck2	sd_datalogger_kongsberg_vessel_insight_omni0
Schneider APC Temperature Data Logger ¹	Various	sd_platform_schneider_ap8953_omni0
Comet T3510 Air Temperature and Humidity ¹	Server Room	sd_platform_comet_t3510_omni0
Yotta A1819 Air Temperature ¹	Various	sd_platform_yotta_a1819_omni0
C4R hoist monitoring ¹	Various	sd_platform_c4r_hoist_hull1_

¹These systems comprise multiple sensors logging together to a single data stream. A metadata element such as serial id or variable name is recorded to differentiate individual sensors.

6.1.2 Scientific Computing System (SCS v5.x.x)

The SCS is developed by the National Oceanic and Atmospheric Administration (NOAA) and is freely available at <https://scsshore.noaa.gov/> . The SCS is used as a secondary data logger on the SDA and while the software provides a wide range of functions, the only module in use is the ACQ logging service. This works in a very similar way to RVDAS by listening to incoming data streams, timestamping them, and then writing the output to daily ascii files and a MySQL database table. Most (but not all) of the data streams in Table 6.1-2 are replicated in the SCS and these data could be used to backfill RVDAS should it suffer an outage. It should be noted that an upstream failure (e.g., in a Moxa unit or in one of the Python translators) would affect SCS just the same as RVDAS. The system worked as expected without any issues.

6.2 Cruise Directory Dstructure and Data Volume

A new cruise folder was setup at the start of the leg (2024-07-17) to hold all data generated during SD041. The full SAN pathname was `/data/cruise/sda/current/` ('current' being a symbolic link to `/20240717`) although most cruise participants accessed this path through a Samba connection called, 'leg'. Within the cruise folder were the following sub-directories:

/system – contains read-only instrument sub-directories containing data synchronised from local acquisition machines (e.g., `/system/ctd_seabird_sbe911` plus for all CTD data).

Table 6.2-1. Data with file sizes for datasets generated during SD041.

Name	Size as of 31/08/2024
adcp_teledyne_ocean_surveyor	8.3 GB
aerosol_handix_pops	1.1GB
bioacoustic_simrad_ms70	324 GB
camera_axis_m1045	2.8GB
datalogger_bas_eventlog	285MB
datalogger_basnoc_rvdas	154 GB
datalogger_noaa_scs	30GB
dgs_gravity_logger	2.4GB
multibeam_kongsberg_em122	45 GB
multibeam_kongsberg_em712	15 GB
platform_bas_dwnm	219 MB
platform_light_structures_ilms	224GB
sbp_kongsberg_topas_ps018	41 GB
wave_rutter_sigma_s6_wamos_ii	1.9TB
TOTAL	2.8 TB

/work - is a writable area for cruise participants and contains the following sub-directories

`/cruise_information` – Folder to store official cruise documentation such as standard operating procedures etc.

`/cruise_report` – Folder to store the final cruise report.

`/cruise_summary_form` – Folder to store the CSR to be sent to BODC. The CSR forms the basis of the cruise entry in their online cruise inventory.

/data_management – An area for the onboard data managers to store summary data (e.g., scanned paper event logs) and provide access to useful data and information products such as sensor metadata and cruise tracks.

/scientific_work_areas – A folder for cruise participants to store their onboard work related to the cruise. Sub-folders should normally be named with the type of equipment or science discipline rather than an individual's name and filenames should be relevant and meaningful.

/X_other_work_areas – A folder to store work files that need to be backed up but are not directly related to the cruise science objectives. Folders should be named using an individual's name in this area.

Note that the total data volume under the SD041 cruise leg folder was 4.1 TB, with the /work sub-directory containing 1.3 TB.

6.3 Observations, Performance and Recommendations

The data logging system worked well for the duration of the cruise. However, the following observations have been reported for the following instruments:

- Gravimeter: The synchronisation of the data to RVDAS was interrupted at the beginning of the cruise after some development to monitor the UPS. This has been resolved on 04/08/2024. Additional information is available in the gravimeter equipment report.
- Seapath 1 and 2: The GNSS Kongsberg Seapath 320+ were rebooted on 10th August at 09:36 UTC due to an issue with the DP system. Although it was rapidly turned back on (at 09:49 UTC), several instruments were affected by this abrupt interruption. This includes in particular the acoustic instruments (EM122, TOPAS, EK80) but also with the Motion Reference Unit.
- Uncontaminated Sea Water System (UCSW): Due to ice, the pump was often turned off and on while the hoist deployed or flushed depending on environmental conditions.
- Due to the helicopter operations, the foremast had to be lowered/raised several times during the cruise. As a consequence, the sensor located on the foremast might have been impacted by this move. The specific dates and times are given below:
 - 2024-07-28 14:00 UTC – Foremast lowered
 - 2024-07-29 14:00 UTC– Foremast raised
 - 2024-08-09 14:30 UTC– Foremast lowered
 - 2024-08-22 14:14 UTC– Foremast raised
- The webcam images were not collected during the cruise (only from 22/08/2024).

6.3.1 Access to Ship's Drives

Access to the internal drives of the ship is crucial for the success of a cruise. Indeed, without access to the leg drive, creating maps, accessing, and processing data is no longer possible. However, access to the internal drives of the ship is currently only possible when internet is available. Although we only encountered short period of interruptions, this could be a critical risk for upcoming cruises. We recommend to have a direct access to the internal access of the SAN that is independent of the internet access.

6.4 Event Logging

Keeping a record of when events occur during a cruise is vital in providing context to scientific data collected. The SDA event logging system has been developed by Jeremy Robst (BAS IT) and is a modified version of an event logger extensively used on the JCR since 2003. Any type of event can be logged in the system, but the primary focus is over-the-side instrument deployments (e.g., CTD, gravity corer, etc.) and other scientific events (e.g., acoustic survey or general science activity logs).

While the bridge event log is managed by the bridge officers, the science event logs are created and managed by the scientist recording specific scientific equipment deployment events. The scientist uses the event number assigned by the bridge for each deployment. Science logs can be configured to include variables from various data streams pulled from the RVDAS Postgres database or include user-defined variables using Boolean, Integer or String field types. The science logs offer recording of specific instrument deployments and can be tailored to a sampling regime. Logs can be downloaded into csv files for reporting purposes.

The following event logs were created during SD041. They are stored in the work/data_management/eventlogs/digital_logs folder:

Table 6.4-1. List of event logs from SD041 cruise.

Name of event log	Description
Marine Mammal Observations	Record of the effort for marine mammal observations
Mini-Bongo	Record of mini-Bongo deployments
LoTUS buoy	Record of LoTUS buoy deployments
Floating sediment trap	Record of floating sediment trap deployments
Mooring	Record of mooring deployments
Coring	Record of Coring deployments (include multicorer, gravity core and piston core deploymenets)
Rapid cast CTD	Record of rapid cast CTD deployments
Bongo net	Record of Bongo net deployments
MOCNESS	Record of MOCNESS deployments
Underway salinity sample	Record of underway salinity sampling
ADCP	Record of ADCP events and parameter changes
Micro Structure Shear Probe	Record of the MSS deployments from Erebus
CTD	Record of the CTD deployments
Isotope POM	Record of the isotope for particulate organic matter sampling
Multibeam EM122/EM712	Record of EM712 and EM122 events and parameter changes
Sub-bottom Profiler TOPAS	Record of the sub-bottom profiler TOPAS parameter changes
EK80	Record of the EK80 parameter changes
Gravimeter	Record of the gravimeter events
EA640	Record of the EA640 events
SDA Underway System	Record of the SDA underway system events. This includes changes from the UCSW pump and hoist, seapath and the foremast position.
Erebus	Record of all the deployments on Erebus.

6.4.1 Erebus Event Numbering

Erebus was considered as its own platform. Before each sortie, the Seapath 320+ GNSS system was turned on to record the position and attitude of the boat. The GNSS NMEA messages were

recorded and converted to a CSV file after each day of deployment. Each time Erebus was leaving SDA for science, an event number was assigned as for any other over-the-side deployments. Besides, Erebus worked also independently with its own event number rolling system for deployment from Erebus. The time and location for each deployment was manually taken and later entered to the global SDA event logging system.

6.4.2 Helicopter Event Numbering

Like Erebus, each time the helicopter left SDA, an event number was assigned to the sortie. A sortie was defined as the science party going out and back from the field meaning that a same event number was given to the helicopter leaving for depositing the scientists on the field and leaving for picking them up. Any activity on the field was then recorded independently from the ship's activities.

Table 6.4-2. Number of Deployments

Deployment name	Number of deployments
Bongo net	61
MOCNESS	18
CTD	90
Multicorer	24 sampled (2 failed)
Gravity corer	32 sampled (2 failed)
Piston corer	10 sampled (2 failed)
LoTUS buoy	3
Rapid cast CTD	1
Floating sediment trap	6
Erebus	13 days or 14 sorties (+1 in Scapa Flow)
Helicopter	9

6.5 Datasets and Usage

The following tables provide a summary of all the datasets collected on SD041 and they are intended as a single place for future users (and data managers) to discover the breadth of data acquired and to show where the data resided at the end of the cruise and who is likely to work on them afterwards. Note that what constitutes an individual dataset is somewhat subjective and that some of the datasets below are an amalgamation of multiple instruments (e.g., there is a single table describing all the underway data outputs). Pathnames given are relative to the cruise 'leg' folder (/data/cruise/sda/20240717)

6.5.1 RRS Sir David Attenborough Scientific Equipment

Dataset	Ship's permanently fitted underway sensors	
Instruments	Multiple (see RVDAS section above)	
Description	Timestamped outputs from 61 separate data streams as recorded by the RVDAS data logging system. Includes permanently fitted sensors associated with position and attitude, sea surface oceanography, atmosphere and meteorology, bathymetry, and platform monitoring. Available as daily ascii files and replicated within a PostgreSQL database.	
Metadata	Digital logs	Work/data_management/eventlogs/digital_logs/SDA_Underway_Systems.csv
	Individual message metadata	work/data_management/Underway_data_description_message.pdf
Digital data	Raw daily files	system/datalogger_basnoc_rvdas/acquisition/

Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Contacts	Alice Fremand (BAS)

Dataset	Uncontaminated sea water sampling	
Instruments	Non-toxic sea water supply (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0413/)	
Description	Sea water sampled from the ship's uncontaminated sea water supply. Water is sourced from an inlet that can be deployed 30 cm below the hull, the depth of which is ~7.1 m. Due to a mixture of environmental conditions and hoist issues, sampling also occurred with the inlet in either the flush or retracted position. Water was sampled from a number of labs around the vessel. See Sampling section for the onward processing of underway water samples.	
Metadata	Digital Logs	Work/data_management/eventlogs/digital_logs/SDA_Underway_Systems.csv
Digital data	Raw	See related water analysis datasets for data links
Contacts	See related water analysis datasets for contacts	

Dataset	Gravity meter	
Instruments	Dynamic Gravity systems AT1M gravity meter (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1728/)	
Description	A high resolution 1Hz marine gravity meter with integrated GPS position and time recording. The instrument has an accuracy at sea of 0.7 mGals, a platform range of 30 degrees roll and pitch. The data and GPS recording rate is 1Hz. See section 2.3 for additional information	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/gravimeter.csv
Digital data	Raw	system/dgs_gravity_logger/acquisition/GravityData
	Pre-Processed	work/scientific_work_areas/gravimeter
Long-term preservation	Raw and pre-processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Alice Fremand (BAS)	

Dataset	MSCL Multi-sensor coring logger	
Instruments	GEOTEK Multi-Sensor Core Logger (MSCL-S) analyser	
Description	An automated, high-resolution, multi-sensor system used for non-destructive, geophysical measurements of sediment and rock cores. Whole core analysis of p-wave velocity, Gamma density and Magnetic Susceptibility. See section 2.5 for additional information.	
Metadata	work/scientific_work_areas/mscl	
Digital data	Raw	work/scientific_work_areas/mscl/*Outputfiles
	Processed	work/scientific_work_areas/mscl
Long-term preservation	Raw and processed data will be stored on the SAN at BAS.	
Contacts	Eloise Littlely (BAS)	

Dataset	SEM BSE images (.tif)	
Instruments	Scanning Electron Microscope Hitachi TM4000Plus	
Description	Tabletop Scanning Electron Microscope (SEM) capable of capturing Backscatter Electron (BSE) and Secondary Electron (SE) images of geological, biological and other physical samples. See section 2.7 for additional information.	
Metadata	Txt. files (time, instrument parameters etc.)	work/ scientific_work_areas /SEM/SD041_KangGlac/
Digital data	Images (Sample map & BSE images – .jpg, .tif)	work/ scientific_work_areas /SEM/SD041_KangGlac/
Long-term preservation	All original data will be stored on the SAN at BAS.	

Contacts	Joe Metcalfe (BAS)
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Dataset	Wave radar				
Instruments	Rutter	Sigma	s6	WaMoS	II wave radar (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0999/)
Description	The wave radar gives information about the wave height, length, and other parameters of the waves The system was turned on from 23/07/2024 to 09/08/2024.				
Digital data	Digital logs				
Digital data	Raw	system/wave_rutter_sigma_s6_wamos_ii/acquisition			
Contacts	Alice Fremand (BAS)				

6.5.2 Hull-mounted Instruments

Dataset	EA640 singlebeam bathymetry		
Instruments	Kongsberg EA640 singlebeam bathymetric echosounder (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0965/)		
Description	The EA640 singlebeam echosounder is used to measure the depth below the transducer. It is used to estimate water depth.		
Metadata	Digital logs	work/data_management/event_logs/digital_logs/EA640.csv	
Digital data	Raw	No data were recorded locally although depths were logged by the RVDAS data logging system.	
Long-term preservation	See RVDAS data logging system information		
Contacts	Alice Fremand (BAS)		

Dataset	EK80			
Instruments	Simrad	EK80	bioacoustic	echosounder
	(http://vocab.nerc.ac.uk/collection/L22/current/TOOL1205/)			
Description	A high precision scientific echo sounder, designed to simultaneously operate frequencies ranging from 10 to 500 kHz. See section 4.1 for additional information.			
Metadata	Digital logs	work/data_management/event_logs/digital_logs/ EK80.csv		
Digital data	Raw	system/bioacoustic_simrad_ek80/acquisition/EK80_Data		
	processed	Work/scientific_work_areas/ek80_processing/		
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.			
Contacts	Vicent Donate (Stockholm University)			

Dataset	EM122				
Instruments	Kongsberg	EM122	multibeam	bathymetric	echosounder (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0492/)
Description	Full ocean depth multibeam echosounder used during most of the cruise to map water depths. For more details see section 2.1.1				
Metadata	Digital logs	work/data_management/event_logs/digital_logs/ Multibeam_EM122_EM712.csv			
Digital data	Raw	system/multibeam_kongsberg_em122/acquisition/raw			
	Processed	work/scientific_work_areas/multibeam_em122/			
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.				
Contacts	Rob Larter (BAS), Kelly Hogan (BAS) and Alice Fremand (BAS) Data acquisition and processing: Rob Larter (BAS), Kelly Hogan (BAS), Alice Fremand (BAS), Joe Metcalfe (BAS), Vicent Donate (Stockholm University), Freja Strandlod (GEUS), Matthew Hunt (Durham University), Holly Jenkins (Durham University).				

Dataset	EM712			
Instruments	Kongsberg EM712 multibeam bathymetric echosounder (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1601/)			
Description	Continental shelf depth multibeam echosounder used in the Larsen C area to map water depths. For more details see section 2.1.1			
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Multibeam_EM122_EM712.csv		
Digital data	Raw	system/multibeam_kongsberg_em712/acquisition/raw		
	Processed	work/scientific_work_areas/multibeam/em712		
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.			
Contacts	Rob Larter (BAS), Kelly Hogan (BAS) and Alice Fremand (BAS) Data acquisition and processing: Rob Larter (BAS), Kelly Hogan (BAS), Alice Fremand (BAS), Joe Metcalfe (BAS), Vicent Donate (Stockholm University), Freja Strandlod (GEUS), Matthew Hunt (Durham University), Holly Jenkins (Durham University).			

Dataset	TOPAS data				
Instruments	Kongsberg (Simrad) TOPAS PS018 sub-bottom profiler (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0859/)				
Description	TOPAS parametric sub bottom profiler is a high spatial resolution system designed for use in depths from 10 metres to full ocean depth operation. See the sub-bottom profiler section 2.2 for additional information.				
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Sub-bottom_Profiler_TOPAS.csv			
Digital data	Raw	system/sbp_kongsberg_topas_ps018/acquisition			
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.				
Contacts	Rob Larter (BAS), Kelly Hogan (BAS) and Alice Fremand (BAS) <u>Data acquisition and processing:</u> Rob Larter (BAS), Kelly Hogan (BAS), Alice Fremand (BAS), Joe Metcalfe (BAS), Vicent Donate (Stockholm University), Freja Strandlod (GEUS), Matthew Hunt (Durham University), Holly Jenkins (Durham University).				

Dataset	Vessel-mounted acoustic doppler current profiler (VM-ADCP) data						
Instruments	Teledyne RDI Ocean Surveyor 75kHz vessel-mounted ADCP (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0351/) Teledyne RDI Ocean Surveyor 150kHz vessel-mounted ADCP (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0062/)						
Description	The vessel mounted Acoustic Doppler Current Profiler (VM-ADCP) data were collected continuously during the cruise. See section 3.3 for additional information.						
Metadata	Digital logs			work/data_management/event_logs/digital_logs			
Digital data	Raw			system/adcp_teledyne_ocean_surveyor/acquisition			
	Processed			work/scientific_work_areas/VM-ADCP			
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.						
Contacts	Povl Abrahamsen (BAS) Processing: Lea Riehn (SAMS)						

Dataset	Marine Mammal Observations (MMO)				
Instruments	Binoculars				
Description	MMO watches were undertaken ahead of turning on the multibeam bathymetric echosounders. In addition, opportunistic sightings were recorded and linked to photos taken by cruise participants.				

Metadata	Digital logs	work/data_management/event_logs/digital_logs
Digital data	Identification photos	Work/scientific_areas/marine_mammal_observation/
Contacts	Matt Hunt (Durham University)	

6.5.3 Over-the-side Deployments

Dataset	CTD	
Instruments	Sea-Bird SBE 911plus CTD systems installed on a Stainless Steel (SS) frame. (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0058/) List of sensors : 1 x Pressure Sensor: Paroscientific Digiquartz (part of http://vocab.nerc.ac.uk/collection/L22/current/TOOL1508/) 2 x Temperature Sensor: Sea-Bird SBE 3plus (part of http://vocab.nerc.ac.uk/collection/L22/current/TOOL1508/) 2 x Conductivity Sensor: Sea-Bird SBE 4C (part of http://vocab.nerc.ac.uk/collection/L22/current/TOOL1508/) 2 x Submersible Pump: Sea-Bird SBE 5T (part of http://vocab.nerc.ac.uk/collection/L22/current/TOOL1508/) 2 x Oxygen Sensor: Sea-Bird SBE 43 (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0036/) 1 x Transmissometer : WETLabs C-Star (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0160/) 1 x Fluorometer: Chelsea Aquatracka III (Chlorophyll A) (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0424/) 1 x Standard thermometer: Seabird SBE35 (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0318/) 1 x Altimeter : Tritech PA-200 (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0059/) 1 x Fluorometer: WETLabs CDOM 1 x Backscatter Sensor: WETLabs ECO BB(RT)D (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0060/) 1 x PAR Sensor: Biospherical Instruments Inc. QCP-2350 (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1186/) Niskin Bottles: https://vocab.nerc.ac.uk/collection/L22/current/TOOL0412/	
Description	Conductivity, temperature and pressure measurements of the water column along with additional sensors measuring Oxygen, Chlorophyll-a, PAR, backscatter and water clarity. More information about the CTD processing on the CTD chapter: section 3.1 of the report.	
Metadata	Paper Logs	Scans of the paper logs are in the following directory: work/data_management/eventlogs/paper_logs/
	Digital logs	work/data_management/event_logs/digital_logs/CTD.csv
Digital data	Raw	system/ctd_seabird_sbe911plus/acquisition/data/SD041/CTD
	Pre-processed	work/scientific_work_areas/ctd/SBEproc (data conversion, correction f conductivity cell)
	Processed	work/scientific_work_areas/ctd/BASproc
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Physical samples	See section 7.6.5 for water sample information and contacts.	
Contacts	Oceanography: Main contact: Povl Abrahamsen (BAS) Processing team: Martim Mas e Braga (St Andrews), Povl Abrahamsen (BAS) Physical samples: see section 7.6.5.	

Dataset	Lowered Acoustic Doppler Current Profiler (L-ADCP) data
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Instruments	2 x Teledyne RDI WHM300 ADCP	
Description	L-ADCP data were collected at every CTD deployment to look at the current in the water column. See for more information the L-ADCP chapter: section 3.2	
Metadata	Digital logs	work/data_management/event_logs/paper_logs/ CTD Logsheets.csv system/ctd_seabird_sbe911plus/acquisition/data/SD041/L-ADCP/
Digital data	Raw	system/ctd_seabird_sbe911plus/acquisition/data/SD041/L-ADCP/Data
	Processed	work/scientific_work_areas/L-ADCP/LDEO_output
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Contact: Povl Abrahamsen Processing team: Laura Castro de la Guardia (SAMS), Povl Abrahamsen (BAS)	

Dataset	RapidCAST CTD	
Instruments	Valeport RapidPro CTD	
Description	The RapidCAST CTD was deployed at the beginning of the cruise to get a sound velocity profile for the multibeam.	
Matadata	Digital logs	work/data_management/event_logs/digital_logs/Rapid_cast_CTD.csv
Digital data	Raw and pre-processed data	work/scientific_work_areas/rapid_cast_ctd
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Chris Gray (BAS)	

Dataset	Bongo net	
Instruments	British Antarctic Survey Motion Compensated Bongo Net (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0993/)	
Description	A motion-compensated upwards and downwards looking Bongo net - one facing upwards, one downwards. The instrument is designed for capturing zooplankton moving up and down the water column. It uses a spring mechanism to compensate for the platform's movements, maintaining the net's upward and downward velocity close to steady-state. The system uses sealed cod ends and a time-controlled open/close mechanism. The cod ends need to be pre-filled with water before deployment to avoid implosion. For additional information, see section 4.2.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Bongo_net.csv
Physical sample	Collect the sample and preserve them in Nalgene bottles with buffered formalin and will be processed at BAS. Zooplankton specimens collected and preserved at -80°C.	
Long-term preservation	Refer to lab report. -80°C with buffered formalin.	
Contacts	Geraint Tarling (BAS), Clara Manno (BAS)	

Dataset	MOCNESS net	
Instruments	British Antarctic Survey multiple plankton net system based on MOCNESS (https://vocab.nerc.ac.uk/collection/L22/current/NETT0185/)	
Description	A British Antarctic Survey-built version of the Multiple Opening and Closing Net with an Environmental Sensing System (MOCNESS) originally designed by Wiebe et al. (1976) for capturing zooplankton. This version consists of nine nets, which can be towed to a maximum depth of 1000 m. A live data stream allows an operator on the ship to close a net, thus triggering the opening of the next one. The first net is open when the system goes in the water; when the maximum depth is reached, the operator triggers it to close, thus automatically prompting the next one to open. This mode of operation is repeated until all nets have collected samples. This system allows for accurate control over timing and location of samples, which are collected sequentially through the nine nets. For additional information, see section 4.3.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/MOCNESS.csv

Physical data	Collect the sample and preserve them in Nalgene bottles with buffered formalin and will be processed at BAS. Collect Zooplankton specimen for formalin experiment stored at +4°C and -80°C.
Long-term preservation	Refer to lab report. +4°C with buffered formalin. Zooplankton specimen at -80°C.
Contacts	Geraint Tarling (BAS), Gabi Stowasser (BAS)

Dataset	Floating sediment trap	
Instruments	British Antarctic Survey floating sediment trap	
Description	A British Antarctic Survey-built version of a floating trap (AME). It collects sediments flux sinking materials at 3 different depths (50, 100 and 150m depth). Each depth has 4 different cylinder collectors with an open/close mechanism triggered with a messenger. See section 4.4 for additional details.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Floating_sediment_trap.csv
Physical data	See tables for physical samples below in the 7.6.6 floating sediment trap section.	
Long-term preservation	Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Clara Manno (BAS), Flo Atherden (BAS)	

Dataset	Down-wire Net monitor	
Instruments	CTD, camera, lights, altimeter, light sensor, current meter	
Description	The system was fixed to the MOCNESS net. The platform can be of different composition. During SD041, the system consisted of different instruments (CTD, altimeter and current meter), a camera, lights and light sensors. The system allowed users to take stills images from the camera system.	
Digital data	Raw	System/platform_bas_dwnm/acquisition/DWNM_Data
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Gareth Flint (BAS) and Geraint Tarling (BAS)	

Dataset	Multicorer	
Instruments	Oktopus MC12 multicorer (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1191/)	
Description	Collects multiple cores of undisturbed samples of the upper boundary layers between sea floor and the water column. The samples have been collected for future analysis for organic carbon, inorganic carbon, Pb210 dating, particle size and foraminifera. In addition, pore water and sediment samples have been collected for future nutrients and trace metal analysis. See additional information in section 2.6.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs
	List of samples	work/scientific_work_areas/multicorer/logsheets
Physical data	Physical samples will be analysed in different laboratories. More information on the protocols, methodologies and sample preservation available in the lab report.	
Long-term preservation	- Trace metal and isotope pore water are acidified and kept at room temperature. - Nutrient pore waters and solid sediment samples are preserved at -20°C. - Sediments for organic carbon, inorganic carbon, Pb210 dating, particle size and foraminifera analysis kept at +4°C.	
Contacts	Nutrients and trace metal analysis: Rhiannon Jones (BAS), Katrin Wagner (Bonn University), Christian Maerz (Bonn University)	

	organic carbon, inorganic carbon, Pb210 dating, particle size and foraminifera analysis: Jerry Lloyd (Durham University)
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Dataset	Piston and trigger corer	
Instruments	NIOZ gravity corer and unspecified trigger corer	
Description	Long Piston Corer (LPC) developed by BAS in collaboration with Marine Project Developments of Hull, originally trialled in 1992. Piston corers use heavy tubes which are plunged into the seafloor to extract samples of mud sediment. A piston inside the tube allows scientists to capture the longest possible samples. The corer can collect undisturbed marine sediment cores with barrel lengths of up to 30m. See additional information in section 2.4.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Coring.csv work/data_management/sample/coring/
Physical data	Physical samples will be stored at Durham University.	
Long term preservation	Samples kept at fridge temperature (4°C).	
Contacts	Jerry Lloyd (Durham University)	

Dataset	Gravity corer	
Instruments	NIOZ gravity corer	
Description	Gravity corer built in 2010 by P.Smit, Netherland. It was primarily used in the Paleo - Ice Sheets and Quaternary Sediments Work packages at BAS. The corer uses the pull of gravity to penetrate the seabed with a core barrel to collect samples. Corer can configure 3 m, 6 m, 9 m, and 12 m barrels. See additional information in Section 2.4.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Coring.csv work/data_management/sample/coring/
Physical data	Physical samples will be stored at Durham University	
Long term preservation	Samples kept at fridge temperature (4°C).	
Contacts	Jerry Lloyd (Durham University)	

6.5.4 Mooring and Buoys

Dataset	KANG-GLAC mooring	
Instruments	2 x Exail Oceano R5 acoustic releases 7 x Sea-Bird Scientific SBE39 temperature recorders (3 on mooring A, 7 on mooring B - https://vocab.nerc.ac.uk/collection/L22/current/TOOL0266/) 1 x Sea-Bird Scientific SBE39 temperature/pressure recorder (mooring A only -) 1 x Sea-Bird Scientific SBE37-SMP-ODO temperature/conductivity/pressure/oxygen recorder 1 x Teledyne RDI Long Ranger ADCP with external battery case 1 x McLane Parflux 78H sediment trap 1 x Xylem Aanderaa Seaguard current meter with oxygen optode 1 x SAMI-pH moored pH sensor (mooring B only)	
Description	Sub-surface oceanographic mooring deployed and recovered during the cruise (mooring A) and re-deployed for recovery in 2025 (mooring B). See additional information in section 3.10.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs work/scientific_work_areas/mooring/logsheets
Digital data	Work/scientific_work_areas/mooring/recovery	
Physical samples	From sediment trap: Collect sediment trap bottles with buffered formalin and will be processed at BAS. +4°C with buffered formalin.	
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	

Contacts	Povl Abrahamsen (BAS), Clara Manno (BAS)
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Dataset	LoTUS buoy	
Instruments	LoTUS buoy (http://www.lotussensing.com/)	
Description	The LoTUS system is a novel small, lightweight, expendable, bottom landing, moored, multiyear climate buoy tailored for collection of time series of bottom temperature in remote regions. It collects temperature at 5m above the seabed. See additional information in section 3.10.8.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/LoTUS_buoy.csv
Long-term preservation	Metadata will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre. The data will be sent to BAS by the supplier when the buoy surfaces after 1 st July 2026.	
Contacts	Povl Abrahamsen (BAS)	

6.5.5 Water Sampling and Underway Seawater Experiments

	Water samples for Nutrients, POM and isotope analysis			
Data source	CTD	UCSW	Erebus	Ice sampling
	Yes	Yes	Yes	No
Instruments	N/A (samples frozen for future analysis)			
Description	Seawater collected using Niskin bottles and the uncontaminated sea water system will be analysed in Italy for nutrients (Phosphate, Nitrate, Nitrite, Silicate, Total dissolved Nitrogen, Amonia) and POM (Particulate Organic Matter) and isotopes (Carbon, Nitrogen, Sulfure). See additional information in sections 4.7 and 0.			
Metadata	Paper Logs	Scans of the paper logs are in the following directory: work/data_management/event_logs/paper_logs		
	Digital logs	work/scientific_work_areas/ctd work/ data_management/event_logs/Isotope_POM.csv		
Physical samples	Frozen samples to be analysed in the future.			
Contact	Luisa Patrolecco (ISPRA) and Nicoletta Calace (ISPRA)			

Dataset	CTD bottle samples - Salinity analysis			
Data sources	CTD	UCSW	Erebus	Ice samples
	Yes	Yes	No	No
Instruments	Guildline Autosol 8400B Salinometer (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0454/)			
Description	Seawater was sampled for salinity analysis. For details see the report chapter on CTD or salinity sampling. See additional information in section 3.4.			
Metadata	Paper Logs	Scans of the paper logs are in the following directory: work/data_management/event_logs/paper_logs/Salinometer logsheets/		
Digital data	raw	work/scientific_work_areas/salinometer/		
	Processed	work/scientific_work_areas/salinometer/sd041_master.xlsx		
Physical samples	None			
Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.			
Contacts	Povl Abrahamsen (BAS) Analysis: Povl Abrahamsen (BAS), Bryony Freer (BAS), Laura Castro de la Guardia (SAMS), Lea Riehn (SAMS), Martim Mas e Braga (St Andrews)			

Dataset	CTD bottle and ice samples - Oxygen isotope analysis (O18)			
Data sources	CTD	UCSW	Erebus	Ice samples from Erebus
	Yes (303 samples)	No	No	Yes (4 samples)
Instruments	NA			

Description	Seawater has been sampled in 50mL glass vials and will be sent to the NERC environmental isotope facility at BGS Keyworth. See additional information in Section 3.6.		
Metadata	Paper Logs	Scans of the paper logs are in the following directory: work/data_management/event_logs/paper_logs/CTD water samples	
	Digital logs	Work/scientific_work_areas/ctd/O-18	sampling/SD041 O-18 samples.xlsx
Physical samples	50mL glass vials. Refer to lab report for additional information.		
Long-term preservation	Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.		
Contacts	Povl Abrahamsen (BAS) Analysis: Melanie Leng (BGS), Carol Arrowsmith (BGS)		

Dataset	CTD bottle samples – TA/DIC			
Data Source	CTD	UCSW	Erebus	Ice samples from Erebus
	Yes	No	No	No
Description	Seawater collected using Niskin bottles and stored in glass bottles for future analysis for Total Alkalinity (TA) and Dissolved Inorganic Carbon (DIC). For details see the report chapter on TA/DIC by Clara Manno.			
Metadata	Digital logs		work/scientific_work_areas/ctd/	
Physical samples	Samples stored in +4°C and preserved in mercury chloride.			
Long-term preservation	Samples stored in +4°C and preserved in mercury chloride. Refer to lab report for additional information			
Contacts	Clara Manno (BAS)			

Dataset	CTD bottle samples – DOC			
Data Source	CTD	UCSW	Erebus	Ice samples from Erebus
	Yes	No	No	No
Description	Seawater collected using Niskin bottles, water filtered in a Nalgene bottle for future analysis for Dissolved Organic Carbon (DOC). For details see the report chapter on DOC by Clara Manno.			
Metadata	Digital logs		work/scientific_work_areas/ctd/	
Physical samples	Samples stored in -20°C.			
Long-term preservation	Samples stored in -20°C. Refer to lab report for additional information			
Contacts	Clara Manno (BAS)			

Dataset	CTD bottle and ice samples – POC/PIC/Si			
Data Source	CTD	UCSW	Erebus	Ice samples from Erebus
	Yes	No	Yes	Yes
Description	Seawater collected using Niskin bottles and Erebus using carbuoy will be processed at BAS for Particulate Organic Carbon (POC), Particulate Inorganic Carbon (PIC) and particulate Silicate (Si). Ice collected from Erebus for future analysys kept in block. For details see the report chapter on POC/PIC/Si by Clara Manno and Flo Atherden: section 4.9.			
Metadata	Digital logs		work/scientific_work_areas/ctd/	
Physical samples	Filters stored in -20°C. Ice block stored at -20°C			
Long-term preservation	Filters stored in -20°C. Refer to lab report for additional information			
Contacts	Clara Manno (BAS), Flo Atherden (BAS)			

Dataset	Experiment - Microplastics
Instruments	Plankton wheel inside incubator

Description	Copepods from Bongo were incubated at different microplastic concentrations. Organisms were collected after 7 days and stored for further analysis in terms of lipides analysis and isotope analysis. See section 4.6 for additional information.
Physical data	Copepod specimens and incubation seawater preserved at -80°C.
Long-term preservation	Refer to lab report. -80°C with buffered formalin.
Contacts	Alena Sakovich (BAS) and Clara Manno (BAS)

Dataset	CTD bottle samples – phytoplankton composition			
Data sources	CTD	UCSW	Erebus	Ice samples from Erebus
	Yes	No	No	Yes
Instruments	Niskin bottles (http://vocab.nerc.ac.uk/collection/L22/current/TOOL0412/)			
Description	Seawater collected using Niskin bottles were sampled for future analysis of phytoplankton composition.			
	Digital logs		work/scientific_work_areas/ctd	
Physical samples	+4°C stained in Lugols and preserved in small amber plastic bottles			
Long-term preservation	+4°C stained in Lugols and preserved in small amber plastic bottles			
Contacts	Clara Manno (BAS)			

6.5.6 Sediment Trap Sampling

Floating sediment trap – POC/PIC/Si and microplastic		
Dataset		
Description	Sinking materials collected from floating sediment trap will be processed at BAS for Particulate Organic Carbon (POC), Particulate Inorganic Carbon (PIC), particulate Silicate (Si) and microplastics. For details see the report chapter on POC/PIC/Si by Clara Manno and Flo Atherden and microplastic section by Alena Sakovich (Section 4.9).	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Floating_sediment_trap.csv
Physical samples	Sinking materials stored in -20°C. Ice block stored at -20°C	
Long-term preservation	Sinking materials stored in -20°C. Refer to lab report for additional information	
Contacts	Clara Manno (BAS), Flo Atherden (BAS), Alena Sakovich	

Dataset	Floating sediment trap - sediment flux sinking materials	
Description	Sediments flux sinking materials at 3 different depths (50, 100 and 150m depth).	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Floating_sediment_trap.csv
Physical data	Collect the sample and preserve them in Nalgene bottles with buffered formalin and will be processed at BAS. See floating sediment trap section for additional information.	
Long-term preservation	Refer to lab report. +4°C with buffered formalin.	
Contacts	Clara Manno (BAS), Flo Atherden (BAS)	

6.5.7 Erebus Scientific Instruments

Dataset	CastAway CTD		
Instruments	SonTek CastAway CTD (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1926/)		
Description	The CastAway CTD was deployed from Erebus to calibrate the AUV GAVIA.		
Matadata	Digital logs	work/data_management/event_logs/digital_logs/Erebus.csv	
Digital data	Raw	work/scientific_work_areas/erebus/ctd_CastAway/	

Long-term preservation	Raw data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.
Contacts	John Howe (SAMS) and Lewis Drysdale (SAMS)

Dataset	SeaCat CTD	
Instruments	Sea-Bird Scientific 19plusV2 CTD Sea-Bird Scientific 5P pump Sea-Bird Scientific 43 dissolved oxygen sensor Sea-Bird Scientific 18 pH sensor Sea-Bird Scientific ECO-FLNTU(RT) chlorophyll a fluorometer and turbidity sensor Sea-Bird Scientific PAR-LOG PAR sensor.	
Description	CTD used from Erebus lowered from the A-frame winch. Additional information is available in section 3.7.	
Calibration	Work/scientific_work_areas/erebus/ctd_SBE19plusV2/Calibration	
Matadata	Digital logs	work/data_management/event_logs/digital_logs/erebus
Digital data	Raw	work/scientific_work_areas/erebus/ ctd_SBE19plusV2/raw
	Processed	work/scientific_work_areas/erebus/ ctd_SBE19plusV2/SBEproc (conversion and preliminary processing) work/scientific_work_areas/erebus/ ctd_SBE19plusV2/BASproc
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Povl Abrahamsen (BAS) Operator: Povl Abrahamsen (BAS), Laura Castro de la Guardia (SAMS) Analysis: Povl Abrahamsen (BAS)	

Dataset	Mini Bongo	
Instruments	British Antarctic Survey Mini-Bongo net (https://vocab.nerc.ac.uk/collection/L22/current/TOOL0994/)	
Description	A British Antarctic Survey-built small and light version of a Bongo net, the Mini-Bongo can be deployed from smaller boats with small winches. It is mainly used to catch small Zooplankton in good condition in depth up to about 100m. Additional information can be found in Section 4.13.	
Matadata	Digital logs	work/data_management/event_logs/digital_logs/erebus
Digital data	Raw	work/scientific_work_areas/
Physical samples	Collect the sample and preserve them in Nalgene bottles with buffered formalin and will be processed at BAS. Zooplankton specimens collected and preserved at -80°C.	
Contacts	Clara Manno (BAS), Flo Atherden (BAS)	

Dataset	Erebus ADCP	
Instruments	Teledyne RDI Sentinel V100 (300 kHz) ADCP (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1719/)	
Description	An Acoustic Doppler Current Profiler (ADCP) used to measure currents throughout the water column. The Sentinel V ADCP can be used for a wide variety of coastal and upper ocean applications and can be deployed on buoys or mounted on the seafloor. Real-time data can be transmitted to shore via a cable link or acoustic modem, or data can be stored internally for short or long-term deployments. It can also be upgraded to include bottom track for vessel-mounted applications. It has profiling ranges from <1m to >150 m and a 200m depth rating. Additional information can be found in Section 3.8.	
Metadata	Digital logs	/legwork/scientific_work_areas/erebus/MSS90-basil/*.pdf Or /legwork/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-kivioq/*.xlsx /legwork/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-3miippugut/*.xlsx /legwork/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-Fladø/*.xlsx
Digital data	Raw	/legwork/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-kivioq/raw /legwork/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-3miippugut/raw/ /legwork/scientific_work_areas/erebus/ADCP_glacierfront/ADCP-faldo/raw/
Contacts	Laura Castro de la Guardia (SAMS) and Lea Riehn (SAMS)	

Dataset	Erebus MSS	
Instruments	Microstructure Probe MSS 90	
Description	https://www.sea-sun-tech.com/product/microstructure-probe-mss-90/ The MSS 90 is a multiparameter probe for measuring micro-scale water stratification as well as the intensity of small scale turbulence in water down to approx. 500 m (optional for 1000 m). The MSS 90 profiler was equipped with 9 different sensors mounted at the bottom cap. Standard sensor equipment: • Pressure transducer • Temperature (PT100)* • Conductivity • 2 x Shear • Fast temperature sensor (NTC) • Acceleration (vibrations) – intern Additional sensors (max.3): • Oxygen • Fluorometer Additional information can be found in Section 3.8.	
Metadata	Digital logs	/legwork/scientific_work_areas/erebus/MSS90-basil/*.pdf /legwork/scientific_work_areas/erebus/MSS90-basil/Kivioq/*.xlsx /legwork/scientific_work_areas/erebus/MSS90-basil/Fladø/*.xlsx /legwork/scientific_work_areas/erebus/MSS90-basil/3Miippugut/*.xlsx
Digital data	Raw	/legwork/scientific_work_areas/erebus/MSS90-basil/Kivioq/MSS/ /legwork/scientific_work_areas/erebus/MSS90-basil/Fladø/MSS/ /legwork/scientific_work_areas/erebus/MSS90-basil/3Miippugut/MSS/
Contacts	Laura Castro de la Guardia (SAMS) and Lea Riehn (SAMS)	

Dataset	Erebus CTD Idronaut	
Instruments	Idronaut Ocean Seven 308 CTD Logger	
Description	https://www.idronaut.it/multiparameter-ctds/oceanographic-ctds/os308-oceanographic-ctd/ The OCEAN SEVEN 308 CTD combines very high-quality electronics with exceptional sensors accuracy fulfilling the demand for a self-recording high performance CTD probe with very compact dimension and very low power consumption. This CTD can be easily integrated/adapted to third-party systems such as floating profilers and/or oceanographic moorings, ROVs and AUVs. IDRONAUT prides itself on the design of its full ocean depth, pump-free, low-maintenance sensor, central to which is the high accuracy seven-platinum-ring quartz conductivity cell. The self-flushing sensors makes this CTD ideal for fast profiling in a wide range of water types. Additional information can be found in Section 3.8.	
Metadata	Digital logs	calibration profiles /legwork/scientific_work_areas/erebus/MSS90-basil/*.pdf /legwork/scientific_work_areas/erebus/MSS90-basil/Kivioq/*.xlsx /legwork/scientific_work_areas/erebus/MSS90-basil/Fladø/*.xlsx /legwork/scientific_work_areas/erebus/MSS90-basil/3Miippugut/*.xlsx
Digital data	Raw	/legwork/scientific_work_areas/erebus/MSS90-basil/CalibrationTS_Idronautprofiles/
Contacts	Laura Castro de la Guardia (SAMS) and Lea Riehn (SAMS)	

Dataset	EM2040
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Instruments	Kongsberg EM 2040 multibeam echosounder (http://vocab.nerc.ac.uk/collection/L22/current/TOOL1528/)		
Description	The EM2040 multibeam echosounder is primarily used to map the seafloor. Data were collected opportunistically as part of the completion of the HAT and SAT of the instrument. Additional information can be found in Section 2.1.2.		
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Erebus.csv	
Digital data	Raw	Work/scientific_work_areas/erebus/multibeam_em2040/raw	
	Processed	Work/scientific_work_areas/erebus/multibeam_em2040/mb	
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.		
Contacts	Rob Larter (BAS), Kelly Hogan (BAS) and Alice Fremand (BAS) <u>Data acquisition and processing:</u> John Howe (SAMS), Rob Larter (BAS), Kelly Hogan (BAS), Alice Fremand (BAS), Joe Metcalfe (BAS), Vicent Donate (Stockholm University).		

Dataset	GNSS Seapath 320+	
Instruments	Kongsberg Seatex Seapath 320+ precise heading, attitude and positioning sensor (https://vocab.nerc.ac.uk/collection/L22/current/TOOL0491/)	
Description	A navigational system including two Global Navigation Satellite System (GNSS) receivers and a MRU 5+ inertial sensor. The data were recorded each time Erebus was used for science purposes. The NMEA telegram output were then exported and processed to CSV.	
Metadata	Digital logs	work/data_management/event_logs/digital_logs/Erebus.csv
Digital data	Raw	Work/scientific_work_areas/erebus/gnss/raw
	Processed	Work/scientific_work_areas/erebus/gnss/processed
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	Alice Fremand (BAS)	

6.5.8 Gavia Autonomous Underwater Vehicle

Dataset	Teledyne GAVIA Autonomous Underwater Vehicle (AUV)	
Instruments	Teledyne GAVIA AUV	
Description	An autonomous underwater vehicle used to take different scientific measurements including but not limited to ADCP, CTD, side scan sonar and bathymetry. Additional information can be found in Section 0.	
Metadata	Digital log	work/data_management/event_logs/digital_logs/Erebus.csv
Digital data	Raw and processed data	<u>Non bathymetry data:</u> work/scientific_work_areas/Gavia_AUV/data/*/files/data and work/scientific_work_areas/Gavia_AUV/data/*/files/log where * is the name of the location contains the raw data. work/scientific_work_areas/Gavia_AUV/data/*/files/processed-log-data where * is the name of the location contains the pre-processed merged data <u>Bathymetry data:</u> work/scientific_work_areas/Gavia_AUV/RAW Geoswath: raw data. work/scientific_work_areas/Gavia_AUV/Processed Geoswath: converted and filtered data (RDF format) work/scientific_work_areas/Gavia_AUV/Caris Project: Caris project per geographical areas. work/scientific_work_areas/Gavia_AUV/Data Export XYZ: ASCII XYZ export in UTM25N.
Long-term preservation	Raw and processed data will be stored on the SAN at BAS. Metadata will be stored in the Marine Metadata Portal developed by the UK Polar Data Centre.	
Contacts	John Howe (SAMS) and Lewis Drysdale (SAMS)	

7 Equipment Report (Electronics)

Authors: Chris Gray (BAS) and Nikita Petrov (BAS)

7.1 Systems used on SD041

Instrument	#SN if Used	Make and Model	Comments
Acoustic			
Bio Multi-beam(ME70)	No		
Bio Multi-beam(MS70)	No		
Bio Multi-freq (EK80)	Yes		
Omnidirectional SU94	No		
Omnidirectional SC94	No		
Scanmar net system	No		
Echo sounder (EA640)	Yes		
Bottom profile (Topas)	Yes		
Swath (EM122)	Yes		
Swath (EM712)	Yes		
ADCP 75kHz	Yes		
ADCP 120kHz	Yes		
USBL	Yes	2010 WMT	
Underway Mini SVS	No		
K-Sync	Yes		
Meteorological			
Air Temperature and Humidity 1 foremast	U0221024	Vaisala HMP-155	
Air Temperature and Humidity 2 science mast 1 inboard	S0850275 2020	Vaisala HMP-155	
Air Temperature and Humidity 3 science mast 1 outboard	S0850273 2020	Vaisala HMP-155	
3D Winds foremast	0115018894	Metek uSonic-3 Cl.AH	
3D Winds science mast 2 port	0111016979	Metek uSonic-3 Cl.AH	
3D Winds science mast 2 stbd	0111016986	Metek uSonic-3 Cl.AH	
Dew Point PT100	174768	Mitchell Inst. Opti-Dew 2	
Dew Point Chilled Mirror	174220	Mitchell Inst. Opti-Dew 2	
PAR Sensor foremast	PARSERICSA-2212	Seabird PAR-SER ICESA	
PAR Sensor science mast	PARSERICSA-2040	Seabird PAR-SER ICESA	
Precipitation	07200150	TheisClima Drisdrometer	
Freezing Rain	0490	Rosemount 0871LH1	
Radiometric SST 1 port	13316	Heitronics CT15.85	
Radiometric SST 2 stbd	13317	Heitronics CT15.85	
Solar Radiation SW foremast	190029	Kipp & Zonen SMP22-A	
Solar Radiation LW foremast	190056	Kipp & Zonen SGR4-A	
Solar Radiation SW science mast	190028	Kipp & Zonen SMP22-A	
Solar Radiation LW science mast	190057	Kipp & Zonen SGR4-A	
Visibility Sensor	Not fiited		
Barometer 1 upper	N2410065	Vaisala PTB 330	
Barometer 2 lower	N2410066	Vaisala PTB 330	

Celiometer	U0250643	Vaisala CL31	
Underway Sea Water			
Fluorometer	WSCHL-1664	Wet Labs	
Transmissometer	CST 1505DR	C-Star	
Thermosalinograph	SBE45 0724	SBE45	
Temperature 1	SBE38 0765	SBE38	
Temperature 2	SB38 1143	SBE38	
Flow Meter	2201079	Litre-miter	
Towed Systems			
Magnetometer	Not used		
XBT	No used		
Rapid cast (CTD)	69836	Rapid Pro CTD	
Rapid cast (SVP)	#SN/No	Rapid Pro SVP	
Other Ship Science Systems			
Gravity Meter	#SN/No	Dynamic Gravity Systems AT1M	
Piccaro	#SN/No		
Black Carbon	#SN/No		
TE49i	#SN/No		
Goniometer	#SN/No		
Ship wave recorder	#SN/No		
Ti CTD			
Deck unit 1	No	SBE11plus	
Underwater ACD/ Depth	No	SBE9plus	
Temp1	No	SBE3plus	
Temp2	No	SBE3plus	
Cond1	No	SBE 4C	
Cond2	No	SBE 4C	
Pump1	No	SBE5T	
Pump2	No	SBE5T	
Standards Thermometer	No	SBE35	
Transmissometer	No	C-Star	
Oxygen sensor	No	SBE43	
PAR sensor	No	QCP2350	
Fluorometer	No	CTG Aqua Tracker MkIII	
Altimeter	No	Tritech S10127 232	
CTD swivel linkage	No	Focal Technologies Group	
L-ADCP Master Down	No	TeleDyne WHM300	
L-ADCP Slave Up	No	TeleDyne WHM300	
Pylon	No	SBE32	
SS CTD			
Deck unit 1	11-1113	SBE11plus	
Underwater ACD/ Depth	09P20391-0541	SBE9plus	
Temp1	035766	SBE3plus	
Temp2	032705	SBE3plus	
Cond1	042222	SBE 4C	
Cond2	044471	SBE 4C	
Pump1	4488	SBE5T	
Pump2	4709	SBE5T	
Standards Thermometer	3535231-0047 then 0024	SBE35	17/08/2024 – during cast 071 0047 ‘failed to initialise water sampler’ replace.
Transmissometer	1831DR	C-Star	
Oxygen sensor1	430245	SBE43	
Oxygen sensor2	432290 then 3634	SBE43	26/07/2024 – 2290 had been noisy during casts, replaced
PAR sensor	70636	Biospherical Instruments Inc. QCP-2350	
Fluorometer	09-7324-001	CTG Aqua Tracker MkIII	

Altimeter	10127.244740	PA200	
CTD swivel linkage	196115	Focal Technologies Group	
L-ADCP Master Down	14443 then 15060	TeleDyne WHM300	24/07/2024 – 14443 lost comms after cast 005
L-ADCP Slave Up	14897	TeleDyne WHM300	
Back Scatter Fluorometer	1635	Wetlabs EcoBB	
Eco Fluorometer	4837	Wetlabs Eco CDOM	
Pylon	3270740-0922 then 1106	SBE32	24/07/2024 – SBE32 didn't fire during cast 005

7.2 Notes on instruments used

7.2.1 ADCP

Before science began on the cruise, the ADCP's were turned ON.

The L-ADCP's had an issue at the beginning where they were losing the NEMA string, a restarted on 04/08/2024 sorted this issue out for the rest of the cruise.

On 10/08/2024 the EO restarted the SDA Seapath but didn't tell the scientists. All acoustic instruments went down. The L-ADCP's came back by itself after some time.

All acoustic systems were turned OFF on 29/08/2024.

7.2.2 Biological Echo Sounder (EK80)

Before science began on the cruise, the EK80 was turned ON.

On 10/08/2024 the EO restarted the SDA Seapath but didn't tell the scientists. All acoustic instruments went down. The EK80 came back by itself after some time.

All acoustic systems were turned OFF on 29/08/2024.

7.2.3 Single Beam Echosounder (EA640)

Before science began on the cruise, the EA640 was turned ON.

On 10/08/2024 the EO restarted the SDA Seapath but didn't tell the scientists. All acoustic instruments went down. The EA640 came back by itself after some time.

All acoustic systems were turned OFF on 29/08/2024.

7.2.4 Sub-bottom Profiler (TOPAS)

Before science began on the cruise, the TOPAS was turned ON.

The TOPAS kept crashing during the cruise requiring a restart of the PC and software. Kongsberg has been emailed and made aware of the issue though they could not provide a fix for the issue.

On 10/08/2024, the EO restarted the SDA seapath but didn't tell the scientists. All acoustic instruments went down. All came back by themselves except for TOPAS. Config file loaded, external trigger set, the K-Sync is triggering but the TOPAS is not transmitting. Neither the internal nor external triggers are getting it to transmit. Restarted twice, then turned off for an hour, Kelly and Alice read manually and tried to debug. PC stopped being able to connect to the transceiver unit. Inspected all fuses, plug laptop directly into the transceiver unit with ethernet, changed PC IP to 192.168.70.1 and could communicate with transceiver unit. In server room pulled out all the cables and hard power cycled everything. Unit started to transmit but no image in software.

Backed up config files, reinstalled software and power cycled system again, the TOPAS started working again.

All acoustic systems were turned OFF on 29/08/2024.

7.2.5 Multibeam Echo Sounder (EM122)

Before science began on the cruise, the EM122 was turned ON.

The EM122 required a few restarts during the cruise. On one occasion the ethernet cables on the front of the deck unit had to be reseated.

On 10/08/2024 the EO restarted the SDA Seapath but didn't tell the scientists. All acoustic instruments went down. The EM122 came back by itself after some time but had to be restarted the next day as the system date was a day behind.

All acoustic systems were turned OFF on 29/08/2024.

7.2.6 Multibeam Echo Sounder (EM712)

Before science began on the cruise, the EM712 was turned ON.

On 10/08/2024 the EO restarted the SDA Seapath but didn't tell the scientists. All acoustic instruments went down. The EM712 came back by itself after some time.

The EM712 was restarted several times throughout the cruise, it also experienced an issue during the cruise where it failed to detect the transducer. This caused the EM712 to be run periodically throughout the cruise. After communications with Kongsberg and sending them the results of the telnet test, they think it had something to do with the K Sync but would require one of their technicians to fix.

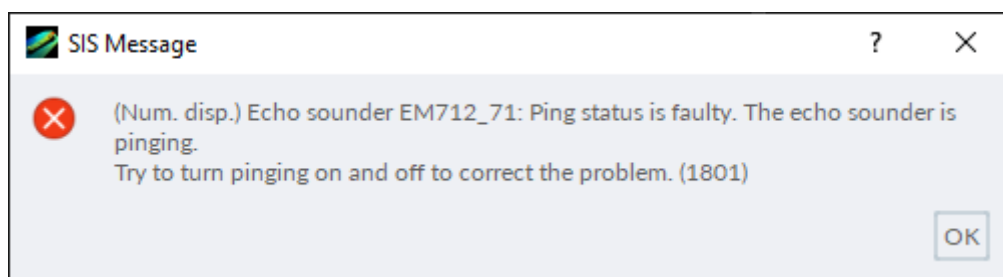


Figure 7.2-1. EM712 error.

All acoustic systems were turned OFF on 29/08/2024.

7.2.7 USBL

The USBL beacon was attached to the CTD SS frame and was used during the cruise.

All batteries were disconnected on 26/07/2024 and the USBLs were packed away.

All acoustic systems were turned OFF on 29/08/2024.

7.2.8 Notes about Meteorological Systems

During the cruise, a scientist made mention that the Opti-Dew 2 data was not matching the data of the other instruments. The tube on the inside of the instrument box was replaced.

The Opti-Dew 2 was turned OFF on 30/08/2024.

7.2.9 Notes about Underway Water Systems

On 20/07/2024, the uncontaminated seawater system was turned ON, and a leakage from the transmissometer was found. Four junction O-rings were lubricated with 111 grease. All optics were cleaned and calibrated twice. The maximum flow rate with the fully open inlet valve and closed overflow valve is 1.3 L/min. The Deck Engineers decreased it as the previous flow rate was too high and giving issues.

The UCSW was flushed and drained on 22/07/2024. The tapes have been swopped around and are now correct, so cold is cold and hot is hot.

At the beginning of the cruise the micro switch the on the deployed pole only showed 'UP' or 'FLUSH' but never deployed. The firmware on the switch was updated and the pole then showed all three states; 'UP', 'FLUSH' and 'DEPLOYED'.

The system was turned ON and OFF due to ice conditions throughout the cruise.

On 28/08/2024, the system was flushed with fresh water for 15 minutes and then turned OFF.

7.2.10 Black Carbon

The Black Carbon system was left running throughout the cruise.

7.2.11 Notes about CTD

Basic Stats			
No#Of Casts SS	90	No#of Successful Casts (SS)	85
Max Depth of SS	1491,1m	Min Depth of SS	85.8m
Cable Removed Standard (m)	2	No# of Re-terminations (elect.)	1
No#Of Casts Titanium	0	No Successful Casts (Titanium)	-
Max Depth of Titanium	-	Min Depth of Titanium	-
Cable Removed Titanium (m)	-	No# of Re-terminations (elect.)	-

Table 7.2-1. Information about CTD configuration(s).

SS CTD			
Deck unit 1	11-1113	SBE11plus	
Underwater ACD/ Depth	09P20391- 0541	SBE9plus	
Temp1	035766	SBE3plus	
Temp2	032705	SBE3plus	
Cond1	042222	SBE 4C	
Cond2	044471	SBE 4C	

Pump1	4488	SBE5T	
Pump2	4709	SBE5T	
Standards Thermometer	3535231-0047 then 0024	SBE35	17/08/2024 – during cast 071 0047 ‘failed to initialise water sampler’ replace.
Transmissometer	1831DR	C-Star	
Oxygen sensor1	430245	SBE43	
Oxygen sensor2	432290 then 3634	SBE43	26/07/2024 – 2290 had been noisy during casts, replaced
PAR sensor	70636	Biospherical Instruments Inc. QCP-2350	
Fluorometer	09-7324-001	CTG Aqua Tracker MkIII	
Altimeter	10127.244740	PA200	
CTD swivel linkage	196115	Focal Technologies Group	
L-ADCP Master Down	14443 then 15060	TeleDyne WHM300	24/07/2024 – 14443 lost comms after cast 005
L-ADCP Slave Up	14897	TeleDyne WHM300	
Back Scatter Fluorometer	1635	Wetlabs EcoBB	
Eco Fluorometer	4837	Wetlabs Eco CDOM	
Pylon	3270740-0922 then 1106	SBE32	24/07/2024 – SBE32 didn’t fire during cast 005

The mechanical (18/07/2024) and electrical (19/07/2024) termination was made at the start of the cruise. The new oil filled junction box was used during the cruise and performed well, we did not have to do an electrical termination due to failure. The R-type CTD swivel pin was replaced to the usual one (bolt and nuts). The termination was successfully tested with the megohmmeter:

- 250V > 220M
- 500V > 550M
- 1000V = short

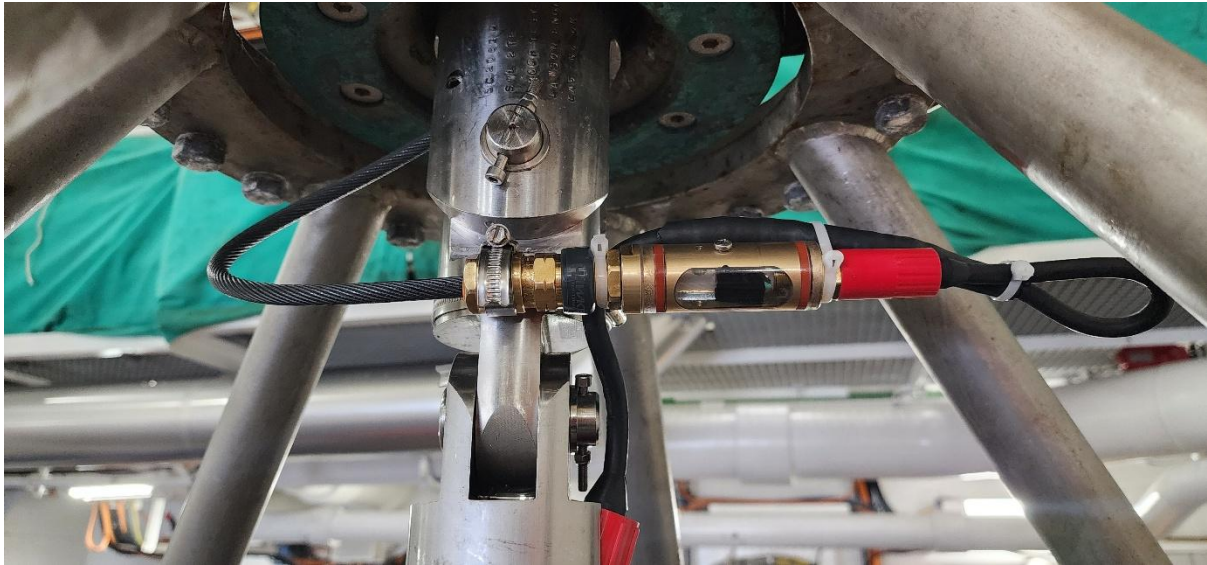


Figure 7.2-2. New oil filled junction box termination.

The short caused at 100V of the mega test was investigated.

- Mega tested the blue bulging going to the winch, fine.
- Mega tested the black bulging to the winch control room, also shorting. This is where issue lies.



Figure 7.2-3. Wires mega tested inside the junction box on the CTD drum.

The CTD niskin setup consisted of 19 normal and 5 double spigot niskins fitted to SS frame before the first cast. Double spigot niskins fitted to the SS frame at locations 20, 21, 22, 23, 24. All niskins numbers were corrected, and strap added.

Before the first cast on 21/07/2024, the boom hit it's 4 tonne limit when going in sequence. When CTD was locked in, it had 1.7tonne tension on wire, compared to the 0.7tonne for metal free. The Sequence was reset and the cast commenced.

Science bosun suggested that the CTD pin be replaced.



Figure 7.2-4. CTD pins.

The pigtail for L-ADCP charger cable was changed for the new one on 27/07/2024.

During cast 004, communications were lost to the deck unit at about 310m, the CTD was brought back on deck to inspect the issue. The connectors on the SBE32 were cleaned and a new cast was done. During cast 005 none of the bottles fired even though they showed on the Seasave software. While on deck communications were lost to everything, deck unit, MOXA and PC. The cable was mega tested cable, then the cable and swivel were mega tests, both configurations were correct. A new SBE35 was tested, a new cable directly from the 9+ to the SBE35 was tested both were working correctly. A new SBE32 was tested and it was found that the original SBE32 had failed and was replaced. The SBE32 which failed was opened and salt deposits were found to be shorting one of the connectors on the PCB. It was cleaned afterwards and retested at the end of the cruise and fired bottles on command again, however, it is still suggested to be sent back to the manufacturer.



Figure 7.2-5. Salt deposits on SBE32.

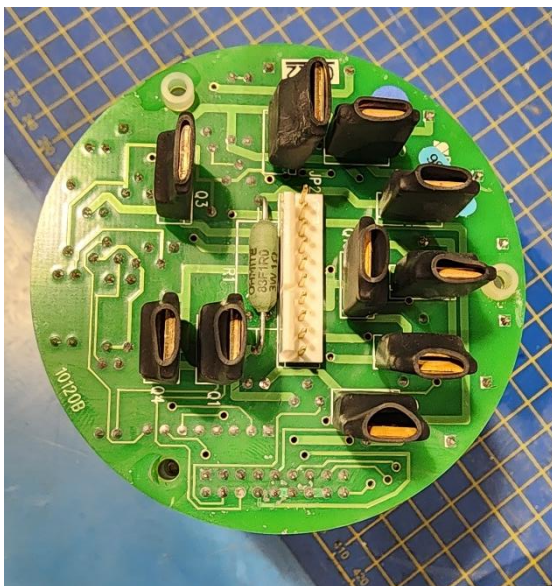


Figure 7.2-6. SBE32 after being cleaned.



Figure 7.2-7. When the original SBE32 was removed, one of the bolts broke off. it was drilled out and re-threaded, however some damage on the solenoid can be seen.

After resolving the SBE32 issue we could not connect to the master L-ADCP. The cable and connectors were cleaned and retested. We tested directly from the L-ADCP to the silver junction box but neither of these resolved the issue. A new L-ADCP was used and found that the original had failed. The L-ADCP which was replaced after the cast 005 was opened and inspected. There was evidence of a leakage at some point (there was no water inside, but there were white deposits), and at least one tantalum capacitor is blown.

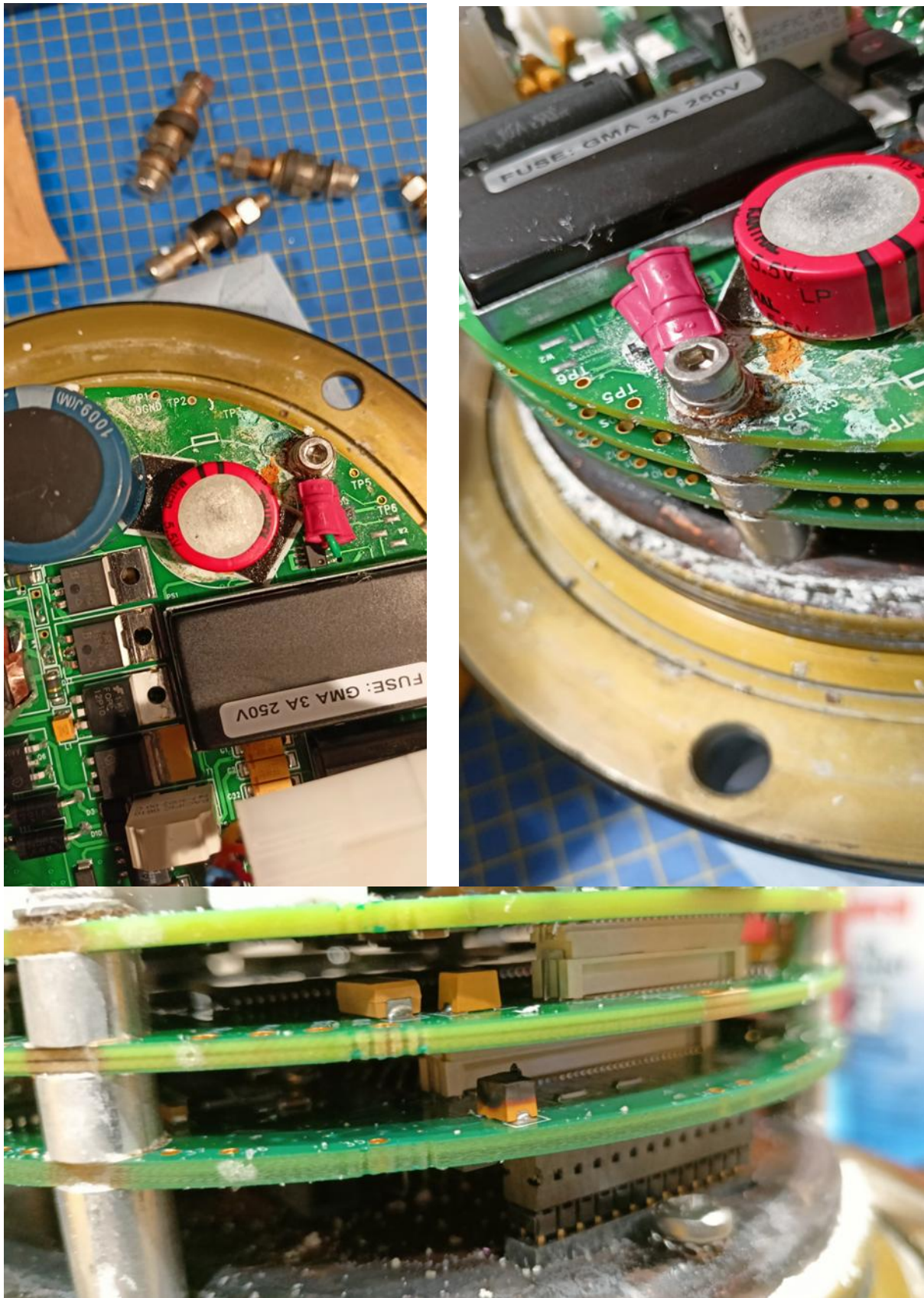


Figure 7.2-8. L-ADCP water ingress and blown capacitor.

During the cast 12 recovery the CTD hit the ship, breaking a piece of the fin off where the PAR is located, denting the frame, and breaking a piece of the top collar off.



Figure 7.2-9. Piece of fin broken off during recovery.



Figure 7.2-10. Dent in CTD during recovery.



Figure 7.2-11. Collar spike which broke off during recovery.

The SB19 was attached to CTD for a few casts and on cast 065 the SB19 and Idronaut were attached.



Figure 7.2-12. SB19 attached to the CTD (left), SB19 and Idronaut attached to the CTD (right).

On 16/08/2024, the winch operator put 6 tonnes on the CTD wire for about 5 minutes. Mega tested, everything fine. Visual inspection of potted termination and cracks were found, shining a light on the cracks showed the light refracting further into the potting. It was decided to re-terminate the wire. After the deck engineer inspected the first 50m of wire, about 2m were found to be damaged. They were cut off and the wire was re-terminated, and the potted oil filled

junction box was used. The next day the termination was load tested and passed. When the electrical termination was redone, the plastic sleeve was found to be broken. The potted oil filled junction box was used this time which also worked well throughout the cruise. It should be noted however, depending on the ambient temperature the electrical potting compound can take up to a day to set. See the graph on the potting instructions. The deck workshop was around 17°C, which meant the electrical potting compound took about 1.5hours to set.



Figure 7.2-13. Bullet after overload.



Figure 7.2-14. Cracks in mechanical potting after overload.



Figure 7.2-15. Broken sleeve in OFJB found after overloading.



Figure 7.2-16. New OFJB after re-termination.

On 29/8/2024, Carlos (AB), welded the pin back onto the CTD collar.



Figure 7.2-17. Pin welded back on collar.

7.2.12 Notes About Gravity Meter

The Gravity meter was turned on once the ship left Rosyth. During the trip the data was not being transfer to Grafana. After some debugging, the APCUPSD software installed during refit was the issue. The software was uninstalled and the data began to appear on Grafana again. No data was lost during the cruise as it was still on the Gravity Meter tablet.

The gravity meter tablet went down twice, the first on 18/08/2024, due to an error when windows tried to update. The second on 29/08/2024 due to a 36871 windows error code.

For the second outage, the TLS services were turned off following Microsoft's guide for Windows:

- Press Win+R and type inetctl.cpl and press Enter.
- Open Internet Properties settings, click Advanced options.
- Select all the options as on the screenshot below, and then try again.

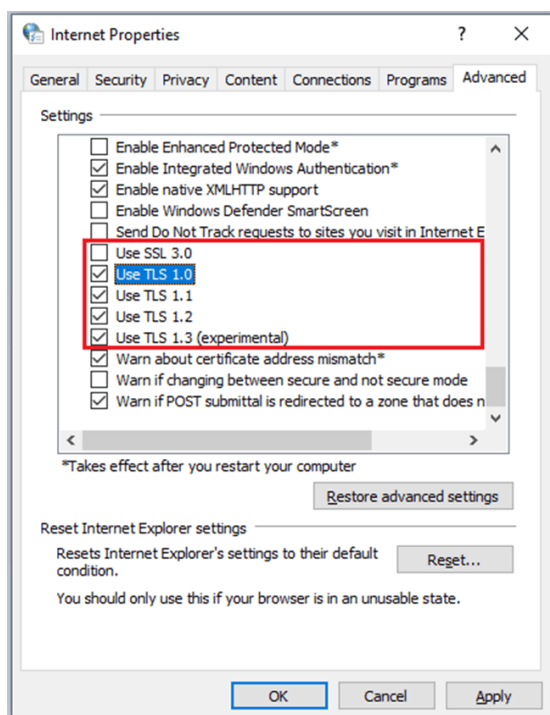


Figure 7.2-18. Imaging showing where to turn TLS services ON/OFF.

The Gravity meter was turned OFF on 30/08/2024.

7.3 Erebus Instrumentation

Table 7.3-1. List of Erebus instruments.

Instrument	#SN if Used	Make and Model	Comments
Bio Multi-freq (EK80)	Yes	Simrad EK80	HWS 1046 TDCR ES38-7: 213 ES70-7C: 484 ES120-7C: 1664 ES200-7C 721 TCVR 38kHz: 738168 70kHz: 738173 120kHz: 738171 200kHz: 738182
Swath (EM2040)	Yes	Kongsberg EM2040	HWS 1048 PU 232 TX 128 RX 150
USBL	No	Sonardyne Micro-Ranger2	ESH 329580-003 MRT 329693-001
Mini SVS	Yes	Valeport miniSVS	SVS 37458
SeaPath 320	Yes	Seatex Seapath 320+	HMI HMI-A924NS1034 PU SP320-B907NS2034 ANT1NHE12060016

			ANT2NHE11500033 MRU 8749
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7.4 Erebus Instrumentation Notes

7.4.1 Biological Echo Sounder (EK80)

System not used during Erebus science.

7.4.2 Multibeam Echo Sounder (EM2040)

Before official science was done with Erebus, we were able to take it out in Scapa Flow on 20/07/2024 and do a patch test. Everything went well, Alice and Rob Larter were able to complete the test and calibrate the system.

7.4.3 Mini SVS

The system was used and no issues were reported.

7.4.4 USBL

During the patch test in Scapa Flow we were also able to test the new USBL system on board Erebus. Everything worked as it should. The PC was 4 minutes ahead, the time was adjusted to the correct value.



Figure 7.4-1. USBL setup for test the system on Erebus.



Figure 7.4-2. USBL screen showing it picked up the beacon.

During the first week of Erebus science, 27/07/2024 – 04/08/2024, the heading offset was $\pm 140^\circ$, the scientist onboards managed to fix the issue while they were out. The USBL depth was out by about 20m compared to Gavia, this is something to look at to improve the SVP. The speed of sound in water was changed for the USBL system.

In the first fjord, the USBL range was quite lower, however after that the ranged improve and was able to pick up the Gavia USBL at the maximum range.

7.4.5 Seapath GPS

During the patch test in Scapa Flow the Seapath was also used and everything worked correctly.

During the first week of Erebus science, 27/07/2024 – 04/08/2024, the Seapath system was never all green. The top right 'pos value' was always yellow, however, after the first week all indicators were all green.

7.5 Additional Notes on Erebus

Before science began on Erebus, IT installed a screen at the front of Erebus to make it easier for the driver to flow survey lines. The scientist who were going to use the acoustic systems on Erebus were shown the correct procedure to turn the system ON and OFF.



Figure 7.5-1. Screen installed by IT at the front of Erebus.

During the first week of Erebus science, 27/07/2024 – 04/08/2024, Rob Larter found the z for the RX and TX were negative and positive and had different values. This was said to be corrected by him but when the Data Manager went to check Erebus after the science was done, the values had not been changed

7.5.1 Information Learnt by the Launchman during Science

On top of the winch, attached a mount so that when Erebus mast was lowered, Gavia could rest on this orange pad instead of levering Erebus rooftop like it usually would (which is fine it's just an improvement whilst the A-Frame is available). Picture below.



Figure 7.5-2. Orange pad on A-Frame.

Carlos also made a metal sleeve with a central point for a shackle, this allowed us to lift Gavia and use the metering sheave without the lifting equipment sliding around. Picture below.



Figure 7.5-3. Metal sleeve on A-Frame.

The A-Frame controls were raised to improve body posture for the user. Picture below.



Figure 7.5-4. Raised A-Frame controls.

The STBD side of the A-Frame is a wooden bed for Gavia's bow, there are 3 components here the wooden bed and 2 clamps. Picture below.

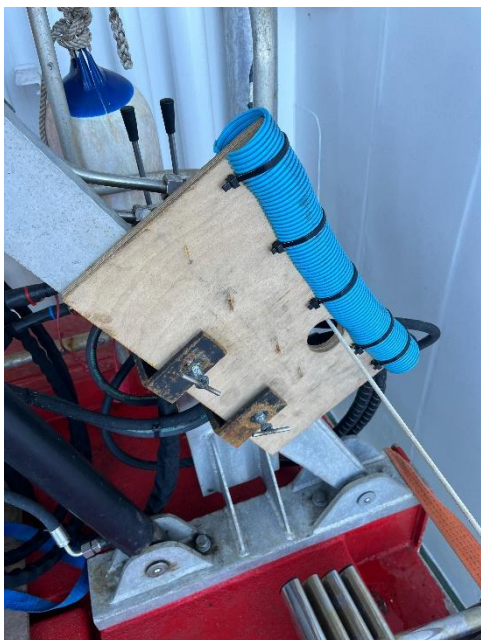


Figure 7.5-5. STBD side wooden bed.

The port side of the A-Frame is a section of rubber cable tied to it, the bed for Gavia's stern. Picture below.



Figure 7.5-6. Port side rubber.

When the A-Frame is all the way in so that rams are fully closed, if the engine hatches are opened, they rest on the rams themselves. This explains the scuffs, in future some rubber should be stuck to the rams. It is also worth noting that with the HPU onboard only the port side engine hatch can be opened. To move the HPU and open the STBD hatch is quite awkward without a crane and not suitable for a daily occurrence which was the regularity of lauchman engine checks during KANG-GLAC. Picture below.

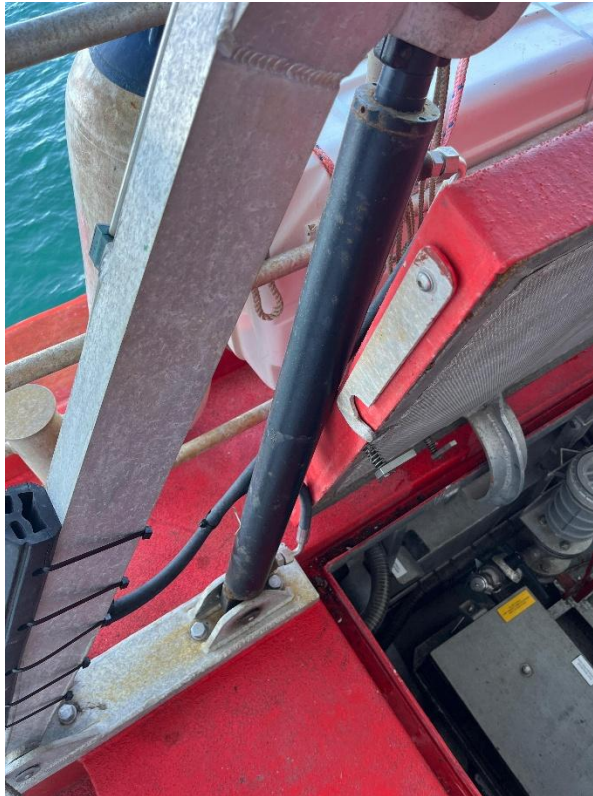


Figure 7.5-7. A-Frame rams hitting the engine hatch when opened.

The 2 cable pipes going from the pod to the FWB bilge area, if Erebus is moving into a wave height of $\pm 1\text{m}$ then water will start to pour in on semi regular basis. Mostly this cruise this was not an issue as we were in perfect conditions. It was highlighted one afternoon in slightly wavier conditions. It has been raised as a safety issue as this ingress of water has the potential to fill Erebus forward bilge space, it's also exposing everything in that space to saltwater. Rocktex cable glands have been mentioned in discussions onboard, ultimately this will need an adequate cap to stop water coming in. Picture below.



Figure 7.5-8. Cable pipes located inside Erebus haul.

Additionally, I remember us discussing the HPU and thinking about alternatives. Another safety issue had to be raised onboard after a handful of days of significant time spent using the HPU in zero wind conditions - essentially this led to some people having lasting headaches and we also noted the prolonged exposure to elevated noise levels which became uncomfortable for all.

7.6 Additional Work Completed on SD041

Made a plate to hold two battery test points for floating sediment trap top release.



Figure 7.6-1. Plate for floating sediment trap top release.

Made cable for moored sediment trap to test the power draw of the camera motor. The correct parts were sourced which can be used to build a proper cable.

On 22/07/2024, there was an issue with ships USBL system, PC was not ON and something was wrong with the KVM. Yellow LED status light, after trying the reset button, unplugged the power and everything worked. Had to do this twice but it worked in the end. This issue occurred again on 23/07/2024. USBL pole also had an issue where it would lose comms with beacon and then come back throughout cast.

The drone was flown a number of times throughout the cruise, either to take pictures for PR or to help the ship navigate the water as they were uncharted. This was done on the request of the bridge as on 29/07/2024, the ship hit the seabed and bent the sounder pole.

8 Equipment Report (Mechanical)

Authors: Gareth Flint (BAS), Alex Murphy (BAS), Katy Cartlidge (BAS)

8.1 Science Equipment

8.1.1 Bio Wire

Set-up: 11 dB from PC to fish initially.

Cruise: Fibre damaged after hauling termination through block. Re-terminated 25th-26th July with OFJB on black fibre. Load test and subsequent MOCNESS deployment successful. Fibre optic losses measured at 8 dB after re-termination – a significant improvement on the original method and a large amount of headroom in the loss budget.

The splicer keeps putting bubbles in the splice and needs servicing. Cleaver is also not working properly. Used IT's instead.

Minor oil leak (weeping) from hosetail for compensation tube. PTFE tape added & oil topped up. Lost approximately 15 ml.

Some time later, water was observed in the JB tube. The oil was drained down and refilled with clean oil. The water content was fairly low overall, but still significant (maybe 5%). Again, the hosetail seems to be at fault and it was resealed with Loctite 577. No further leaks were apparent after this.

8.1.1.1 Post-cruise Tasks

1. Pump for OFJB
2. Manual for OFJB termination
3. Service splicer and cleaver
4. Mk2 OFJB is better than Mk3, just needs a fibre guide, possibly an alignment pin & the draw bar modifying for thread length and flat
5. Bench & vice for re-terminating in winch room

8.1.2 Down-wire Net Monitor

Set-up: Problem with camera (no signal/unsupported signal screen flashing interspersed with camera footage). Fish inspected & SMB connector replaced, camera marginally better but still mostly not working. 914-HDE motherboard replaced with the one from the spare deck box and fitted with a receiving (1310 nm) optical module. Camera fully operational.

Cruise: Some minor changes were made to the software to add additional data feeds from the ship. These were followed by a swathe of changes implemented by Metis to add features requested by the scientists (Geraint & Sophie), and to remove some of the bugs from the previous iteration. The software worked without fault throughout and there remains little left to do.

The altimeter's performance is dependent on the trawl angle, which is different for different nets. It should have a range of 100 m, but is only appearing at 50 m. It may be possible to mount it on a gimbal to keep it vertical (we will lose the actual trawl angle of the nets in this case), or brackets need to be adjustable and a 'zero' function added to the DWNM software.

The CTD was reoriented to vertical to drain on recovery due to pump occasionally operating on deck.

8.1.2.1 Post-cruise Tasks

1. Spare SMB connectors (75 Ohm) and crimp tools
2. One deck box still has Brainboxes serial converter in – replace with Moxa
3. Remove SDI splitters from deck boxes
4. Assign serial numbers to PCs & deck boxes
5. Spare set of multiplexers/single multiplexer & 2x optical modules (Tx/Rx)
6. More ‘swivel’ (double-ended optilink) connectors for OFJB
7. Termination kit for OFJB – O-rings, bootlaces, bootlace crimper, spare bulkheads, Wago, cable glands, tube.
8. RMA for multiplexer, S/N 914-0026013
9. Test removed VDX in 2500 m fish with serial dropouts.

8.1.3 Rayfin Camera

Cruise: The camera struggled to connect via the ship’s network and assigning it a static IP address killed it. OEM tech support used remote desktop to reset/reconfigure it over a period of several hours. On completion, the camera was initially connected via a switch and DHCP router to check the connection and the camera’s settings. It was then connected back to the ship’s network where it finally worked correctly.

There was also an issue with the camera outputting the video at too high resolution for the fibre-HDMI converter and/or monitors. The streaming resolution was curtailed via API to 1920x1080.

A user guide for the SDA has now been written.

8.1.3.1 Post-cruise Tasks

1. It should be possible to convert the fibre input to SDI so it can be viewed/recorded on the DWNM PCs via the existing video cards. We have a converter, but may need a 3G module for it as the video card can only accept a 3G-SDI feed. Or a HDMI-SDI converter.
2. Multicorer camera bracket needs remaking, hard to mount camera and angle not great. GF- Mk2 design underway.
3. [Plug in mains timer](#) so no-one melts the camera.
4. Box with everything in e.g., lights, EBS lasers, cables, etc.

8.1.4 MOCNESS System

Setup: Deployed on BIO wire. Failed on deck test, output shaft binding on housing; very sensitive to misalignment.

8.1.4.1 Stations

18 deployments, 16 successful, 2 partial

1: Success

2: Partial. Camera issues meant it was difficult to see if the nets had fired. It appeared one net hadn’t fired, so we fired it again. Turns out it probably had and we were a net out of sync. Had to do a second dip to get the surface 50 m. Camera subsequently rectified and net bars labelled so we can read them during deployment and ensure the physical net status corresponds to the DWNM status.

3: Success. Caught a small cod.

4: Success. Water too cloudy to see camera.

5: Success. Altimeter proving unreliable, probably due to variability of mounting angle.

6: Partial. One net got hung up on bars and didn't drop. Suspect due to nets being out of parallel on setup. Shallow deployment carried out to confirm net operation. No faults observed.

All following deployments were successful, except for losing a bucket on one cast.

8.1.4.2 Post-cruise Tasks

1. Wire tethers for cod ends & spare pins
2. Spare stepper motor for release unit (on order)
3. Spare bulkheads
4. Fix release unit #2 – make it oil filled
5. Add hydraulic coupler for topping up oil (Staubli, as used on OFJB).
6. Dedicated instrument mounts esp. for camera and lamp

8.1.5 Bongo Net System

Setup: Deployed on GP wire.

O/C ball valves initially very stiff and needed loosening up before they were operational. They are quite scored/worn and need replacing.

The swage on the bongo was done incorrectly last time (insufficient tail on the dead end). As Gareth forgot the size 5 dies he bought for the ship, we were unable to re-terminate it. It was monitored early on in the cruise and was holding fast. **Everyone needs to be made aware of the need to follow the splicing instructions** (hardcopy inside the swaging box, copy on the shared drive).

8.1.5.1 Stations

60 deployments, 60 successful.

Scientists didn't close one of the valves properly so one cod end was empty. This is primarily a result of the valves and handles being in a poor state.

Some poor samples were being collected with the Bongo in O/C mode. It was suspected that the cod ends were not filling with water at shallow depths. When the valves were operated, a large bubble of air was released, affecting sampling. Mesh-covered holes were made in the valve housings (as high as possible). The cod ends need mesh adding too, although we did not have sheet material on board.

15th August: the multi-purpose wire jumped off winch room inboard sheave at 400 m deployed depth. The wire was badly damaged, but the inner core appeared unaffected and the bongo was recovered. The cause was incorrect alignment of snatch blocks set up in the winch room, see inset picture for the arrangement of the offending block setup. The outboard block was set up in a similar fashion, but in the absence of a suitable lashing point, was secured to the coring warp drum.

The snatch block setup was used as there is not enough vertical height available on the gantry to deploy the bongo using the main block, compounded by being unable to open the bulwark doors due to the coring equipment obstructing it. The blocks allow the MP to be ran higher through the forward window.

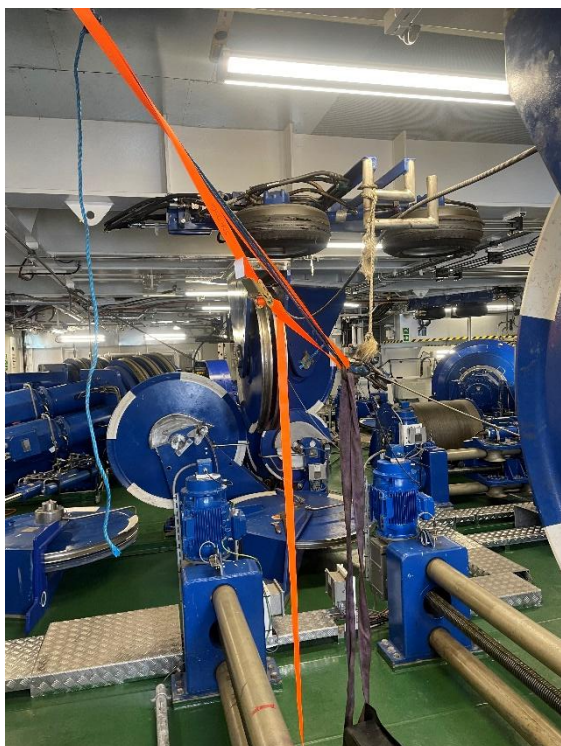


Figure 8.1-1. Photo of misaligned snatch blocks on multi-purpose wire.

Additional observations following this event were that the main block is too narrow to allow correct running of the MP wire through the outboard sheave, and that the cheek plate clearance on the block is potentially large enough to allow the MP wire through.

The event resulted in a safety case being raised, and the proposal at the safety meeting will be the replacement of the block. If/when this is done, AME will have to ensure the Bongo can be lifted clear of the deck with the headroom available on the gantry, either by pre-tensioning the MCU wire, or shortening the bongo itself.

8.1.5.2 Post-cruise Tasks

1. Most of the cod end valves are now damaged, a new set + spares are required
2. Stainless trial valve on order – should be less fragile than the plastic ones
3. Spare cod ends
4. Replace O/C ball valves
5. Add mesh holes to cod ends

8.1.6 Plastic-free Floating Sediment Traps

Set-up: During setup, a problem was encountered with the Xeos Rover iridium beacon: once all the (new) batteries had been installed, the beacon beeped and flashed a red LED. Connecting to the beacon via Bluetooth on the Xeos Beacon app revealed that this was caused by a low tap voltage in one of the strings. Putting washers between batteries to increase contact (initially) resolved this issue.

8.1.6.1 Stations

6 deployments, 6 successful.

1: Successful, but both the iridium and VHF beacons stopped working during deployment – the Iridium beacon due to low tap voltage as in setup. The ship stayed nearby so as not to lose the traps and both beacons mysteriously worked fine once recovered. Putting a radar reflector on the toy buoy would allow the ship to leave the traps if this issue arose again, although in calm

seas the bridge can already detect the top buoy on radar from three miles away. Noted that removing traps is quite fiddly.



Figure 8.1-2. Photo of unclosed bottle on sediment trap.

2: Success, no return of the beacon issue. Xeos sending two emails per SBD message, contacted support. Resolved. Quick links and larger shackles attached below each trap so thicker rope can be used to stopper off, and easier to remove traps. One of the bottles on the lowest traps did not fully close due to the wire getting caught (see Figure 8.1-2).

3: Wire rope pulled off sheave and is damaged. Replaced with new one. Successful recovery. Reports of the crush washer leaking, aluminium washers ordered for the future, but they will need to be replaced after each deployment.

4: Wire rope pulled off sheave again, not damaged. Successful recovery.

8.1.6.2 Post-cruise Tasks

1. The wires have now been used on two cruises – replace before the next one.
2. Spare 6 mm Wichard shackles & swivels needed.
3. Still some issues when recovering the traps with the existing hardware. Stoppering off and disconnecting the traps are both a little challenging.
4. Implement the single-point bottle release modification.

8.1.7 Mooring

Set-up: The MIL-SPEC connector for the transducer cable was replaced.

The deck set electrocution issue was found to be caused by corroded contacts inside the domestic 3-pin plug. The plug was re-wired & the bonding lead removed from the case.

The sediment trap did not rotate at all and the screws holding the rotor on were loosened, at which point the rotor appeared to turn freely. There were only two isolation bushings for the sediment trap and no spare ball bearings or Variseals. The 1T shackles purchased for the trap were too small to fit through the lifting points and 2T ones were used instead.

The scientific mooring winch failed, the ship's stbd quarter mooring winch was used – via snatch blocks – to deploy the mooring.

8.1.7.1 First Deployment

Deployment was initially attempted early on the 25th of July but was aborted due to ice closing in behind the ship. At this point, all that had been deployed was 280 m of rope above the main buoy, with one SAMI-pH and seven SBE-39 temperature loggers clamped directly onto the rope. One SBE-39 was lost upon recovery (which had been jubilee clipped directly onto rope).

Deployment was reattempted successfully later on the 25th of July, at 67.47903° N, 33.02253° W. The 280 m of rope above the buoy was left out, including the SAMI-pH and seven SBE-39 loggers.

Mooring instruments (see Figure 3.10-1 for mooring diagram):

VHF: 154.585 MHz

IRIDIUM (Apollo X7): 301434060108850

ARs (Oceano R5): 22370141 & 22370142

8.1.7.2 Second Deployment

The mooring was recovered on 17/08/24.

The sediment trap had not operated correctly and some investigation was carried out to determine the cause. The motor unit was removed and driven independently of the rotor, generating no faults. The oil was also topped up in the motor unit. When reattached to the rotor, the software was still generating port location faults, and the rotor was seen to momentarily stall on occasion. The screws securing the rotor were loosened to hand tight and the trap operated through two full rotations without fault. The screws were removed, Loctite added, and refitted to hand tight before a final full test was carried out with the sampling bottle fitted.

McLane were contacted and suggested a firmware update, however it was the day of the planned deployment and we were reluctant to carry it out with the trap set up and ready to go. It should be carried out at a suitable opportunity in the future.

The sediment trap shackles were severely corroded where they had been in contact with the stainless frame, despite efforts to tape them up. A new set of PTFE bushings were made up for the redeployment.

There was some corrosion apparent on the acoustic release top tandem link washers, probably galvanic from the 316 washers to super-duplex releases. PTFE spacers were made to separate the two.

At the request of Mark Inall, a weak link was made to enable separation of the floats at the top of the mooring in the event of it being dragged by ice. The pin in a 2T shackle was replaced with a PTFE pin of 11.8 mm OD and with a 6.5 mm hole drilled through it. Two iterations of the weak link were destructively tested to approximately 230 kg prior to the third one being made.

The mooring was redeployed on 20/08/24 at 67 28.673'N, 032 59.179'W in approximately 830 m water depth. See Figure 3.10-2 for second mooring diagram.



Figure 8.1-3. PTFE pin in the 2T shackle.

8.1.8 Gravity Corer

Set-up: Set up on trestle on STB side of ship then lowered and craned across to GP wire.

8.1.8.1 Stations

34 deployments, 34 successful.

1st core: 8 m

2nd core: 3 m (hit 10 cm diameter rock)

3rd core: 7 m

Modified during the cruise to add a tab to the bomb with three holes in it. This allows a 6 m gravity core to be deployed mid-ship, eliminating the need for the crane/trellis, and speeding up deployment significantly.

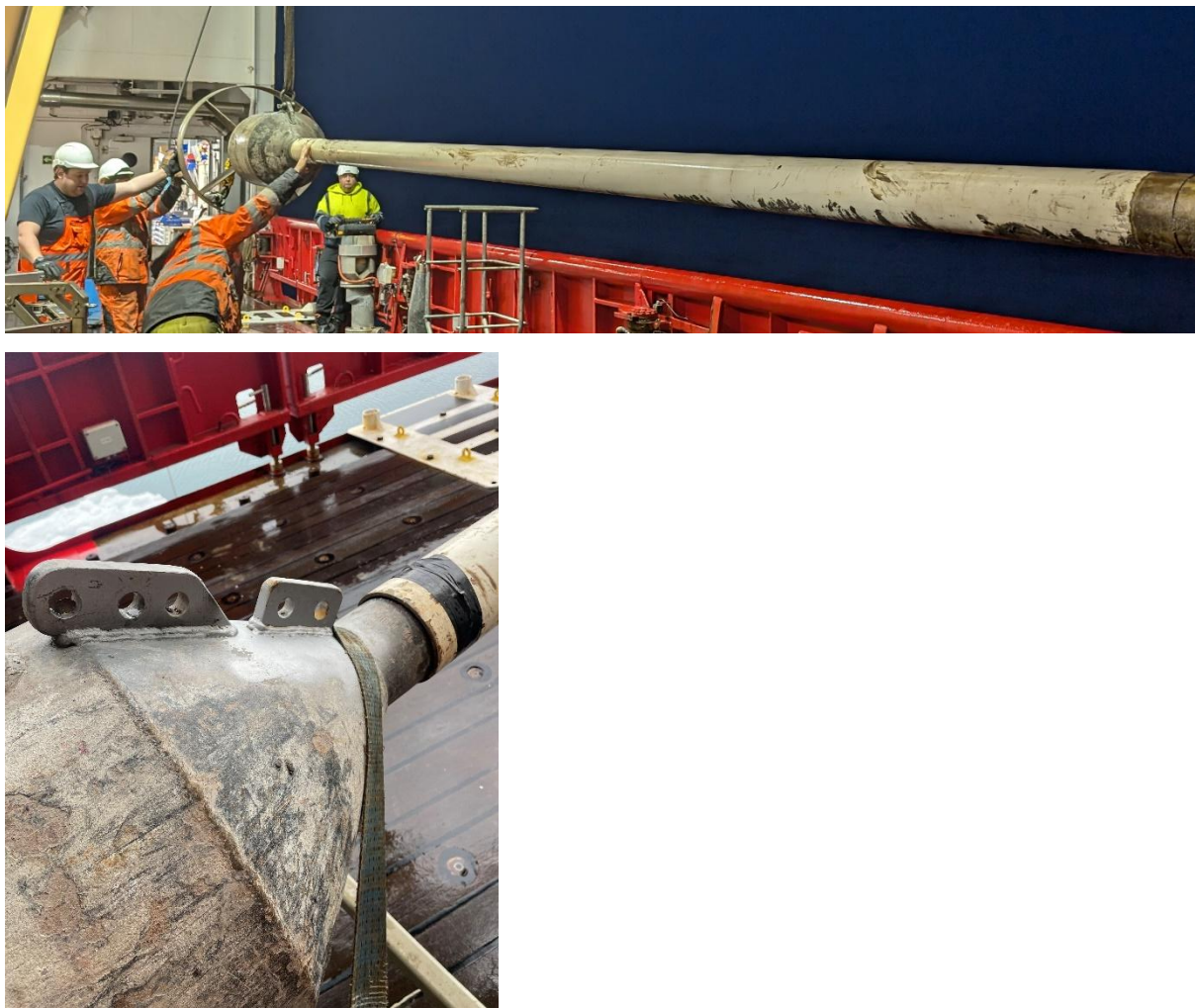


Figure 8.1-4. Photographs of gravity coring on SD041.

8.1.9 Piston Corer

Set-up: The bomb was set up in the cup at the top of the trellis on the starboard side of the ship and remained there between deployments. The barrels were lined on the trestles just inboard and craned onto the trellis, and onto the bomb. The trellis was then lowered, and the corer craned across to the cup in front of the mid-ship A-frame, where it could be connected to the GP wire.

Deployment of the piston corer requires transferring the load multiple times between the GP wire and the auxiliary wire. The rigging layout required for this took some trial and error, but the eventual successful solution was the one shown below.

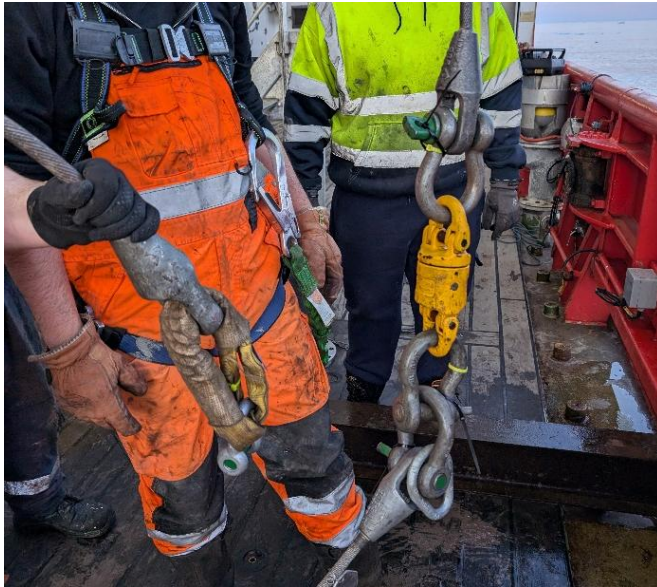


Figure 8.1-5. Successful rigging set-up for piston coring on SD041.

8.1.9.1 Stations

12 deployments, 10 successful.

The first deployment (27/07, event no 8) was unsuccessful due to the trigger releasing before the hydrostatic safety pin had retracted. This was evidenced by severe bending to the pin. Two explanations were suggested:

- The trigger weight was not heavy enough, causing the trigger to release almost immediately.
- The O-ring in the hydrostatic pin was undersized, which then allowed water in, so the pin did not work. When the trigger was released at the seabed, it hit the pin.

The pin was machined back to straight by the deck engineers, the trigger weight replaced with a heavier alternative, and the O-ring replaced. Surprisingly, 2.4 m of sediment was still recovered.

The second deployment (03/08, event no 96) was successful and recovered 8.5 m of sediment. The trigger weight was covered in mud, suggesting that it had sank, which could have affected the quality of the core recovery.

On the third deployment (05/08, event no 124), there was a shock of 7.1 t on the GP wire after the corer hit the seabed. This was suspected to be closer to 10 t in reality, due to the sampling rate of the tension measurements. As the SWL had been exceeded for some components, the rigging was inspected upon recovery and found to be undamaged. The core cutter and the O-ring in the pressure release valve were also damaged (see Figure 8.1-1). The tension spike was attributed to incorrect measurements in the piston corer wire length spreadsheet (now fixed).

The first deployment on the 12/08 (event number 182) led to another spike of 7.3 t on the GP. Upon inspection of the accelerometer data from the bomb, this was attributed to a reasonably high freefall of 7 m combined with particularly low-viscosity mud – the bomb decelerated through the mud at the same rate as through the water. 7 m of freefall had been used previously without issue, but it was limited to 5 m in subsequent deployments to prevent recurrence of this problem.

The second deployment on the 12/08 (event number 184) was unsuccessful. The core liner imploded, possibly due to the glue not setting in cold and humid conditions, and no sediment was recovered. The liners were subsequently glued in Park Avenue instead.



Figure 8.1-1. Photographs of damaged core cutter and O-ring in the pressure release valve.

8.1.9.2 Safety Considerations for Piston Coring on SDA

Following the first deployment, there was considerable discussion about the safety of the piston corer going forward, involving the science bosun (Dave Peck), chief officer (Fergus Walker), and ship safety officer (Joe Hooper). Numerous problems were identified:

1. When accounting for the weight of the wire, data from coring trials and the JCR show a maximum tension of 3.6 t at the bottom of the GP wire, however the shackle attaching the piston to the pennant wire has a SWL of 3.25 t.
2. Some components of the rigging (the piston, joining bar and piston lifting block) are unrated for lifting.
3. Should the trigger accidentally release on deck or whilst the corer is being lowered, the resulting drop would exert a weight-equivalent force in the region of 30 t on the rigging. Many components would likely not survive this.
4. During deployment, the pennant wire is wound up onto the auxiliary drum to attach the lower end to the trigger, then the whole corer is lowered until the top of the pennant wire is at head height, at which point it is transferred from the auxiliary winch to the GP wire. With the pennant wire at its current length (44 m), the shackles attaching the pennant wire to the auxiliary wire are wound onto the drum, with more wire being wound on top of them. This risks the wire jumping off or becoming damaged as it is unspooled.
5. The eye at the top of the pennant wire is not small enough for two shackles to fit through simultaneously. This means that it cannot be pulled through the block on a 4.75 t shackle, then transferred to an 8t shackle when it is attached to the corer, so a large 8 t shackle must pass through the block and risk getting caught.

Proposed solutions included:

1. Using soft shackles and Dyneema instead of traditional shackles and the pennant wire. This would allow them to be safely wrapped onto the auxiliary drum.

2. Using the coring warp instead of the GP. This would allow for a shorter pennant wire (where the shackles would not reach the drum) since the elongation is much less than that of the GP.
3. Using extra sheaves to increase the distance to the auxiliary drum. This suggestion was scrapped due to the 'triangle of death' it would create.
4. Load testing all parts and replacing unsuitable ones where possible.
5. Replacing the 3.25 t shackle with a 4.75 t shackle.

From the 01/08-03/08, the spare pennant wire was shortened to 16 m and terminated at each end with a spelter socket. It was then load tested to 10 t using a water bag. With this wire, it ought to be possible to do two-barrel cores in 200 m water depth on the GP wire, and 1500 m water depth on the CW.

On the 06/08, a remaining section of the spare pennant wire was shortened to 13 m and terminated at one end with a spelter socket, and at the other with a swaged hard eye. It was again tested to 10 t. With this 'daisy chain' of pennant wires, it is now possible to do two-barrel cores in up to 2000 m of water. The 13 m section should be attached at the top, with the swaged end connected to the GP and the speltered end connected to the other pennant wire.

The 3.25 t shackle that attaches the piston to the pennant wire was replaced with a 4.75 t shackle.

It was not possible to use the coring warp and there were no soft shackles on board, but these would be an ideal solution for next time.

8.1.9.3 *Post-cruise Tasks*

1. Make piston coring safe;
2. New trigger or new corer or new entire system depending on budget;
3. New trigger will have attachment points at top and bottom (instead of wire clamp), top will go directly onto GP wire and bottom will go onto Dyneema made-up lengths for various barrel lengths/depths. This will avoid the shackles spooling on drum problem because the Dyneema splice/soft shackle can be easily wound onto the drum without issue;
4. New entire system would involve some sort of davit to move corer into place without the need for a crane;
5. All components going forward need to be load tested and upgraded to stronger versions where possible.
6. Buy glue specifically for PVC tubes, rather than the ABS glue that is currently used.

8.1.10 **Multicorer**

Setup: With new feet installed, with the aim of reducing sinkage-related failure in soft sediment.

8.1.10.1 *Stations*

26 deployments, 25 successful.

The new feet appear to be working well in soft sediment. No deployments were unsuccessful due to sediment being too soft, although on a few occasions the multicorer did appear to still have sunk beyond the feet.

On the first deployment (24/07, event no 8), the camera didn't work, due to a battery issue. By the second deployment, the biowire was in the process of re-termination so the multicorer was moved to mid-ship and connected to the GP wire (with no fibre and thus no camera).

On the third deployment, one tube was lost due to being set up incorrectly.

On the 11/08 (event no 173), no tubes fired on the first deployment. It was successfully reattempted with 6 tubes and noted that the sediment was quite gravelly.

On the 16/08 (event no 210), no tubes fired on the first deployment. It was successfully reattempted twice, with four tubes each time.

For the final deployment (24/08, event no 282), the multicorer was moved aft for a test of the camera, the issues at the start having now been resolved. The corer triggered prematurely at depth due to excessive heave. The wire tension was oscillating by up to 800 kg and camera footage shows the significant motion of the sliding mechanism during deployment, which eventually became of sufficient magnitude to trigger the corer. This is largely attributable to the extra heave generated on aft deployments (the sea state was moderate with a long swell), the winch speed was also at the equipment maximum (1 m/s). An SOP amendment was made to reflect the additional operational risks of aft deployments on the GP & biowire, which don't have active heave compensation.

The scientists requested a number of specialist multicorer tubes, with small holes drilled every 10 mm to enable them to extract the core waters. The tubes that had been made prior to the cruise were unsuitable due to incorrect dimensioning. Holes were instead drilled into existing tubes; this worked well.

8.2 Equipment Success Rate

In summary for SD041, total deployments was 151, with 3 failed attempts, and 2 partially successful attempts.

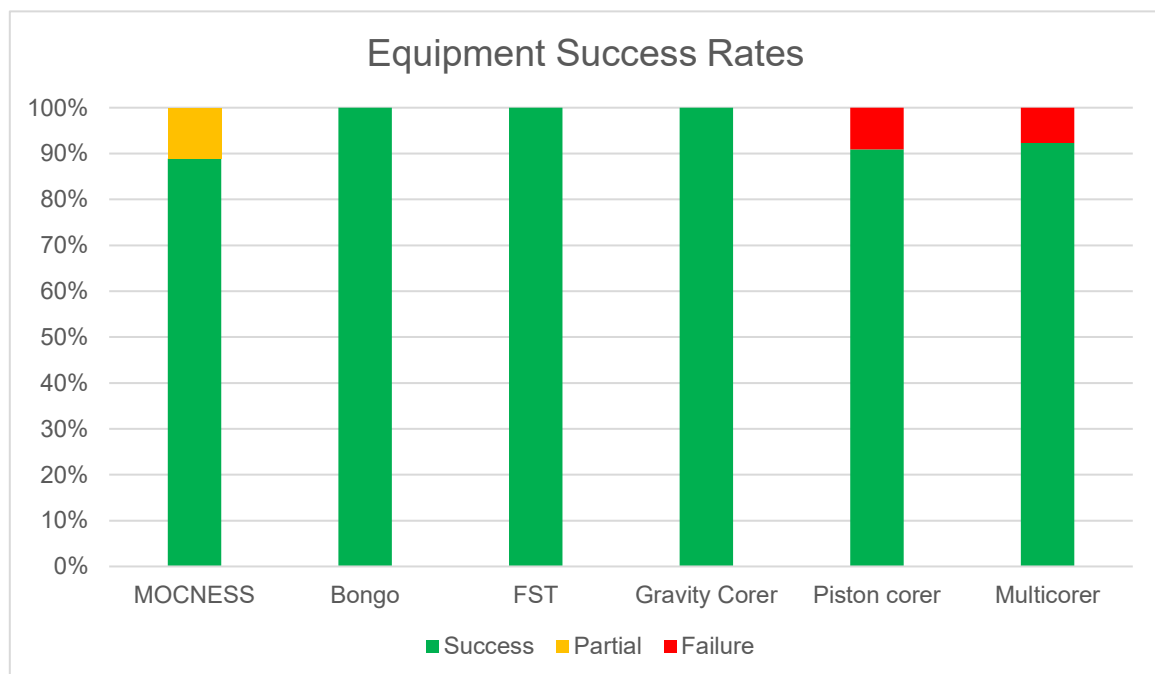


Figure 8.2-1. Graph showing equipment success rate on SD041.

8.3 Additional Notes

Workshop:

- Talurit size 5 swaging ferrules for bongo
- Die grinder
- Small-medium jubilee clips (70-120 mm)

Consumables:

- Araldite
- Fibre optic strongbacks
- Kevlar tape – RS 885-5271
- Polyprop rope (6 & 10 mm)

Other: Following the piston corer challenges, it was highlighted that none of our lifting equipment has certificates or an inspection regime in place. It is quite pressing that we implement something satisfactory in accordance with MCA regulations. It has been requested that IMES carry out thorough inspections on equipment left on the ship at the end of the cruise, including the shackle cupboard and bridles for the Mammoth and MOCNESS nets. Equipment that is heading south this season also needs registering. The best options for an inspection and database provider are Glomac (used by Vehicles), Concord (who supply most of our lifting equipment), or IMES.

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