DEHEAT

R/V Belgica

26th June – 11th July 2023

museum

Royal Belgian Institute of Natural Sciences

SCIENTIA VINCERE TENEBRAS UNIVERSITAS BRUXELLENSIS

Universiteit Antwerpen

belspo

British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Cruise scientists

Sebastiaan	van de Velde	RBINS*/Universiteit Antwerpen (PSO)
Kelle	Moreau	RBINS
Cathrin	Wittig	RBINS
Cedric	Goossens	Universiteit Antwerpen
Silvia	Hidalgo-Martinez	Universiteit Antwerpen
Astrid	Hylén	Universiteit Antwerpen
Philip	Ley	Universiteit Antwerpen
Bui	Winter	Université Libre de Bruxelles
Felipe	Sales de Freitas	Université Libre de Bruxelles
Sandra	Arndt	Université Libre de Bruxelles
Per	Hall	Gothenburg University
Mikhail	Kononets	Gothenburg University
Kate	Hendry	British Antarctic Survey
Christian	März	University of Bonn
Katrin	Wagner	University of Bonn
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Saheed	Puthan Purayil	Royal Belgian Institute of Natural Sciences
Balmonte	JP	University of Southern Denmark
Reardon	Jake	University of Southern Denmark
James	Rebecca	University of Southern Denmark
Verweirder	Lotte	Universiteit Gent
Reyniers	Piet	Universiteit Gent

* Royal Belgian Institute of Natural Sciences

Project summary

Global climate change is one of the biggest global challenges of the 21st century and urgently requires ambitious, transformative, and collective action to limit global warming. This can be achieved either by preventing emissions of carbon dioxide (CO_2) and other greenhouse gases to the atmosphere ("conventional mitigation") or by actively removing CO_2 from the atmosphere ("negative emissions"). However, to reach the Paris climate goal and limit global warming below 2°C, we will need to rely on negative emission technologies (NETs, also called Carbon Dioxide Removal technologies, CDR). A promising NET approach is Enhanced Silicate Weathering (ESW). ESW makes use of the natural weathering reaction, whereby silicate dissolution consumes atmospheric CO_2. The core idea of ESW is to distribute silicate minerals in environments that are characterized by high weathering rates, thus enhancing the uptake of atmospheric CO_2 by increasing the alkalinity of the ocean. Here, we aim at examining, for the first time, the feasibility of ESW under marine conditions, taking advantage of the coastal ocean as a large-scale, natural biogeochemical reactor. One important research question pertains to the efficiency of marine ESW in stimulating oceanic CO_2 uptake by increasing alkalinity in the coastal ocean. A second critical issue concerns the potential side-effects (both positive and negative) on marine ecosystems, including the enhanced availability of silicate and the potential release of iron and trace elements. To address these critical knowledge gaps, we will organize dedicated R/V Belgica field campaigns to quantify the sediment geochemistry and mineralogy at a site that serves as natural analogues for ESW; the Iceland continental shelf, which is rich in basalt.

DEHEAT is funded by Belspo (Research project RV/21/DEHEAT).

British Antarctic Survey participation

Kate Hendry participated as a project partner on DEHEAT and to collect samples for the Natural Environment Research Council (NERC) funded projects Silicon Cycling in Glaciated Environments (SiCLING, NE/X014819/1) and BIOPOLE (funded under the National Capability Science Multi-Centre award scheme NC-SM2). The fieldwork component was funded by Queens' College, University of Cambridge.

The polar regions are experiencing the most rapid climate change observed on Earth: temperatures are rising in some regions of the Arctic and Antarctic at more than double the global average rate, there has been a dramatic increase in extreme warming events, and there are concerns about the impact of ice melt on global systems. Marine ecosystems are already responding to - and amplifying - environmental change, with important implications for carbon burial and important natural resources such as fisheries. One important type of microalgae, which form the basis of these polar ecosystems and provide an important conduit for carbon flow from the surface to the seafloor, are diatoms. Diatoms build their microscopic shells from silica, and so dissolved silicon (DSi) is a critical nutrient for their growth. As such, we need a better understanding of how climate-sensitive processes within polar environments impact the nearshore, shelf and open ocean exchange of silicon cycling, and their consequences for regional and global systems.

The sources of this critical nutrient, DSi, to the polar oceans, especially from glacial weathering, and the physical mixing and upwelling processes that supply DSi to surface waters are likely to change into the future, with significant impacts on regional biological productivity and further afield.

SiCLING will investigate links between silicon and metal cycling within glacial sediments in Arctic and Antarctic fjords, resulting in a step-change in our understanding of silicon mobility and bioavailability in fjords, high-latitude nutrient balance, and the flow of nutrients into the polar coastal ocean and beyond. Our recent work has shown that glaciers are a substantial source of both dissolved silicon (DSi) and reactive particles of silica, termed ASi. However, the processes by which DSi and ASi escape glaciated fjords are not understood; these processes have profound implications for the supply of DSi to coastal and open ocean ecosystems in the polar regions, and ultimately how this system will respond and change in the future.
As project partners, the DEHEAT cruise will allow for additional sampling in glaciated regions of Iceland, in addition to investigating silicon cycling in basalt dominated systems.

BIOPOLE is an interdisciplinary NERC programme examining biogeochemical processes and ecosystem function in polar ecosystems. BIOPOLE will address a fundamental aspect of the Earth System – how nutrients in polar waters drive the global carbon cycle and primary productivity. The oceans play a vital role in absorbing atmospheric CO_2, mitigating large amounts of manmade carbon emissions. However, this part of the global carbon cycle relies on an adequate supply of nutrients to drive the carbon-absorbing marine biological processes. Much of these nutrients are exported from the polar regions. BIOPOLE will improve our ability to quantify this export and identify its sensitivity to climate change. The main questions addressed by work package one (co-led by Hendry) are: What are the key inputs that contribute to nutrient balance at the poles? How do biological processes at the poles modify these inputs? What are the global impacts? What physical, chemical and biological processes modify elemental balance en route from source to polar ocean ecosystem, and what are their sensitivities to climate change?

<u>Cruise narrative</u>

June 25th

Scientists on board at 1645 (latest). Safety briefing followed by first scientists' meeting.

June 26th

Bridge meeting at 0800 for deck operations, followed by abandon ship drill, and scientists' daily meeting.

Depart Reykjavik at 1000, to arrive on station HF3 shortly after 1200. HF3 CTD deployed, with bottles fired at 6 depths (maximum depth c. 64m). Van veen corer deployed, bringing up promising dark, muddy sediments. Box corer deployed, but over-penetrated. Further work required on the box corer before redeployment, which delayed any further box corer work for a day. Continued with GMAX corer, with a few failures due to over-long tube and other fixes required, but eventually recovered the cores required. Benthic lander deployed at H3, followed by the remaining GMAX cores.

Daily science meetings planned for 2030 every day for debriefing on the day's work and plans for following day.

Transit to HF2.

June 27th

CTD deployed at HF2, firing bottles at 4 depths. Van veen corer deployed, again recovering promising sediments. Box corer still out of action, so GMAX deployed largely with success, recovering the required cores. Returned to HF3, and gravity corer deployed with some success for 3m of sediments (although potential overpenetration possible). Box corer deployed successfully, with incubations underway. Benthic lander recovered successfully, with three chambers working fully, and one with half the syringes activated. Final HF3 GMAZ cores recovered for pigments.

Move to HF1 location for multibeam and TOPAS.

June 28th

CTD deployed at HF1. Some delays due to issues with sensor calibration, with 15m deployment nearly taking an hour. Continued with van veen and box coring – a few issues with the later as a result of overpenetration into the still muddy sediments. GMAX worked well, with efficient recovery of the required cores. Returned to HF2 to deploy benthic lander and collect some further GMAX cores. Attempted longer gravity coring, both 3m and 6m, but with limited success, although improved workflow and confidence with the crew. Transit to HF4, with multibeam and TOPAS.

June 29th

CTD deployed at HF4. Van veen and some box coring revealed very shelly sediments with lots of rocks. It was decided to move slightly to adjacent HF4 site to continue coring. The sediments were still shelly, but slightly more appropriate for coring. Box corer was used rather than GMAX to avoid damaging the core liners. The sediment surface was very uneven with lots of tube worms and soft corals, in addition to bivalve shells. We struggled to obtain good cores, but did our best!

Returned to HF2 to carry out successful 6m gravity core, yielding 3.8m of sediment with minimal loss near the surface.

It was noticed in the meantime that the TA measurements from HF2 and HF1 were lower than expected and with poor replication (DIC had worked well). Repeat casts were carried out at both stations to check results. HF1 water column structure was very different than before, whereas HF2 was similar.

June 30th

Box coring at HF2 and HF1 went smoothly and was largely successful. Lander recovery from HF2 went well, although one chamber failed due to disturbance of the stirrer by macroalgae. CTD, to collect bottom water for incubations, and box coring at HF3, before leaving the fjord for the coastal shelf sites.

Evening science presentations to crew and scientists.

Multibeam/topas to CS1-1 site.

July 1st

CTD at CS1-1 site. Pump didn't turn on initially, causing minor delay. Heave rate was 0.5m/s, which could have contributed (with the swell) to a spikey profile. Van veen and box coring revealed thick muds with tube worms and sea urchins. GMAX didn't retrieve very much sediment (mostly cores failed, or were very short) as there wasn't enough weight to penetrate the muds. Resorted to sub-sampling from box cores, for a limited set of parameters. Successful gravity coring, retrieving two good cores. Circumnavigated Heimaey to retrieve sands using van veen, successfully retrieving material from two sites (and seeing lots of puffins).

Departed for CS2.

July 2nd

CTD at CS2-2 site. Heave rate of 1m/s improved profile. Van veen and box coring revealed more grey muds. GMAX worked well, and all required cores for full sampling were retrieved efficiently. Benthic lander deployed, although challenging in the swell. Gravity coring carried out, with a successful 3m core (2.5m sediments retrieved), but an unsuccessful 6m coring attempt. Transit to CS2-1.

July 3rd

CTD at CS2-1. Van veen revealed some sands, but moved to alternative site slightly closer to land and found more sand, so adjusted CS2-1 accordingly. Box coring went well, GMAX struggled somewhat, so instead subsampled the remaining required cores (for a reduced sampling plan) from the box core. Longer gravity coring was not successful. Van veen search for new CS2-0 site.

More TOPAS in the evening before moving to CS2-4.

July 4th

CTD at CS2-4 (697m water depth). Box core yielded very little poorly structured sediment; GMAX failed. So moved to old CS2-3 (Renamed CS2-4-shallow at ~290m water depth), in contrast to CS2-4-deep from the morning). New CTD cast. Box coring was successful, so for efficiency took multiple subcores from a few box core casts.

Move to new CS2-0 site, from yesterday's coring search.

July 5th

CTD at CD2-0. Sediments were sandy, so challenging to core. Subsampled from boxcorer (note that rhizon sampling for Mg isotopes was carried out instead using centrifugation with filter holders, which worked well). Moved back to CS2-2 to retrieve the lander, which was successful after a short delay.

Start transit to Reyderfjordur.

Health and safety and MSDS meeting with those with medical responsibilities.

July 6th

New location in Reyderfjordur. CTD at deepest station at RF1, followed by successful box coring and GMAX coring for required sampling.
Successful long coring (over 5m) and good deployment of lander. Multibeaming outside of the fjord in the evening fog.

July 7th

Logistics call on FRB to pick up supplies. CTD at shallowest station on southern limb at RF3, followed by successful box coring and GMAX coring for required sampling. Successful long coring (over 5m).

Multibeam, with an additional CTD in northern limb of fjord, at RF-K (42m water depth).

July 8th

Lander recovery had been planned first for the day, but was delayed due to fog. CTD at RF2 first instead, then box coring. One box core brought up sulphidic muds with ikaite. GMAX successful, but could not find the sulphidic mud again. Lander recovery successful in the afternoon, followed by multibeaming of the fjords.

Group celebration in the evening with crew and scientists on the Bridge deck.

July 9th

Some multibeam efforts to try and find depression where the sulphidic muds near RH2 could be, but no candidate areas found. CTD at site RF4. Box coring revealed shelly sands that were not appropriate for coring, so moved into the fjord to find a better site, which was found after a couple of attempts. Box cored muddy sands and subsampled for required cores. Multibeam in fjord, before and of science at 1600.

Transit back to Reykjavik.

BAS sampling

Sampling was carried out in the water column, porewaters and sediments for dissolved silicon (DSi) and silicon isotopes for the SiCLING project. In addition, samples were collected from the water column for salinity and oxygen isotope analysis, for use as freshwater tracers an as part of the BIOPOLE project.

Dissolved silicon/silicon isotopes in the water column

Water was collected from Niskin bottles from 3-6 depths per station. The water was filtered into pre-cleaned plastic bottles through a 0.4 mm polycarbonate membrane. The samples were stored at 4°C.

Dissolved silicon/silicon isotopes in porewaters

Sediments were sliced at 0.5-2cm intervals, depending on depth, and placed in plastic containers. Cleaned Rhizon filters were used to extract the porewaters, which were stored in pre-cleaned plastic vials (for isotopes) and Eppendorf tubes (for DSi concentration analysis only). The samples were collected in duplicate.

DSi analysis will be carried out within a month at the British Antarctic Survey using colorimetric methods. Silicon isotopes will be measured as part of the SiCLING project, using pre-concentration, column chemistry purification methods, and analysis using a multi-collector inductively coupled plasma mass spectrometer (Ng et al., 2020).

Solid phase reactive silicon pools and silicon isotopes

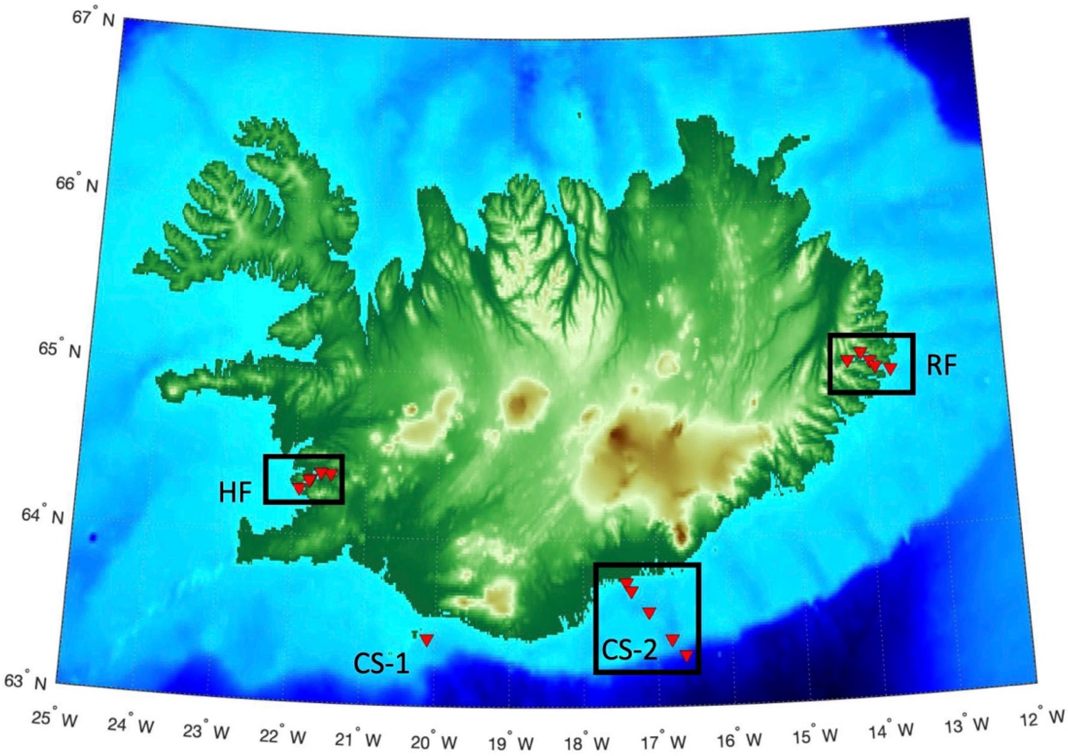
Small subsamples of the sediments were stored in plastic bags at 4°C. The reactive silicon content of the sediments will be extracted using sequential leaching methods (Pickering et al., 2020). This will allow us to assess the amount and nature of the silicon that is adsorbed or loosely bound to reactive species, biogenic and other amorphous silica, and lithogenic unreactive silica.

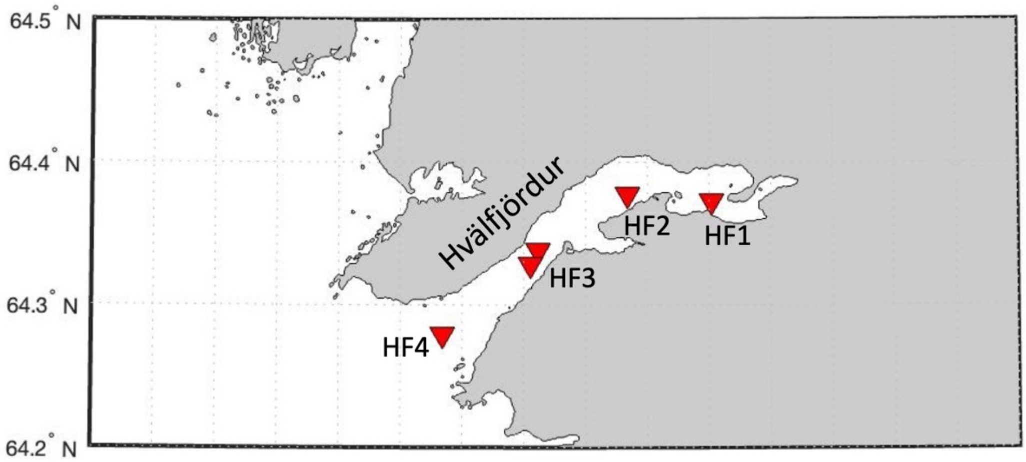
Silicon content will be analysed by colorimetric methods. Silicon isotopes will be measured as part of the SiCLING project, using pre-concentration, column chemistry purification methods, and analysis using a multi-collector inductively coupled plasma mass spectrometer (Ng et al., 2020). The extracts will also be analysed for metal content to assess the relationship with iron, manganese and 'lithogenic' elements such as aluminium (Ward et al., 2022).

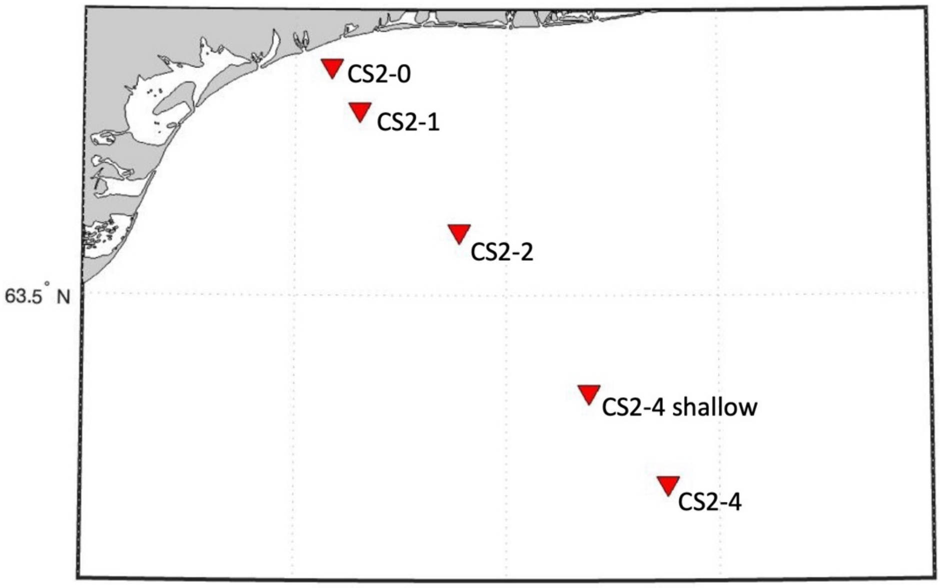
Salinity and oxygen isotopes

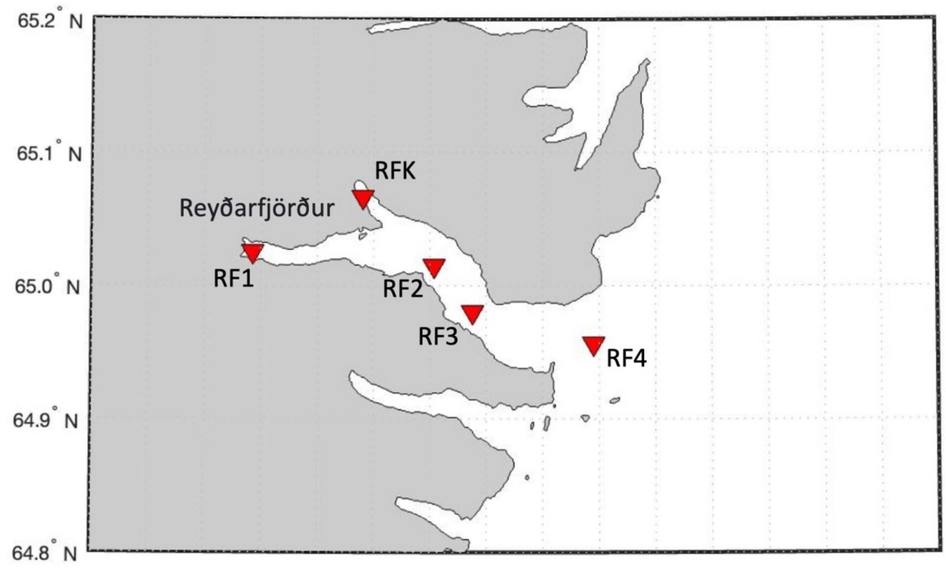
Water was collected from Niskin bottles from 3-6 depths per station. Glass bottles were rinsed three times then filled with water. A minimal headspace was left, and the bottles and bottle necks dried thoroughly before sealing with a rubber bung and clamped shut with a metal seal. The bottles were stored at ambient temperature on the ship, and 4°C for transportation.

Station locations






CS2-0
CS2-1
CS2-2
63.5° N
CS2-4 shallow
CS2-4


65.2° N
65.1° N
RFK
Reyðarfjörður
RF1
65.0° N
RF2
RF3
RF4
64.9° N
64.8° N

Station and sample list

Silica samples

Station	Date	Lat (N)	Lon (W)	Water depth (m)	Sample depth (m)	Notes	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	62	CTD - depth 1, niskin bottle 1 (250ml)	*All DSi samples filtered at 0.4um through PC membranes
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	40	CTD - depth 2, niskin bottle 12 (250ml)	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	20	CTD - depth 3, niskin bottle 17 (250ml)	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	5	CTD - depth 4, niskin bottle 23 (500ml)	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	63.8	C1 - Porewaters collected for DSi and Si isotopes in bottles	*All porewaters filtered through rhizons
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	63.8	C2 - Porewaters collected for DSi only in Eppendorf tubes	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	63.8	Sediments (C2)	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	24	CTD - depth 1, niskin bottle 8 (250ml)	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	16	CTD - depth 2, niskin bottle 13 (250ml)	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	9	CTD - depth 3, niskin bottle 18 (250ml)	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	5	CTD - depth 4, niskin bottle 23 (500ml)	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	27.5	C1 - Porewaters collected in centrifuge tubes for DSi (and perhaps isotopes)	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	27.5	C2 - Porewaters collected for DSi only in Eppendorf tubes	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	27.5	Sediments (C2)	
HF3	27/06/2023	64° 20.28976'	21° 46.6130'	63.8	63.8	Lander waters (9 samples from x3 chambers)	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	15	CTD - depth 1, niskin bottle 7 (250ml)	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	10	CTD - depth 2, niskin bottle 15 (250ml)	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	5	CTD - depth 3, niskin bottle 22 (500ml)	
HF1	28/06/2023	64° 22.6848'	21° 37.9583'	18.0	18.0	C1 - Porewaters collected for DSi and Si isotopes in bottles	
HF1	28/06/2023	64° 22.6848'	21° 37.9583'	18.0	18.0	C2 - Porewaters collected for DSi only in Eppendorf tubes	

HF1	28/06/2023	64° 22.6848'	21° 37.9583'	18.0	18.0	Sediments (C2)	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	30	CTD - depth 1, niskin bottle 7 (250ml)	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	18	CTD - depth 2, niskin bottle 12 (250ml)	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	14	CTD - depth 3, niskin bottle 15 (250ml)	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	5	CTD - depth 4, niskin bottle 22 (500ml)	
HF4	29/06/2023	64° 16.949'	21° 54.871'	32.8	32.8	C1 - Porewaters collected in centrifuge tubes for DSi (and perhaps isotopes)	
HF4	29/06/2023	64° 16.949'	21° 54.871'	32.8	32.8	C2 - Porewaters collected for DSi only in Eppendorf tubes	
HF4	29/06/2023	64° 16.949'	21° 54.871'	32.8	32.8	Sediments (C2)	
HF2	30/06/2023	64° 22.699'	21° 37.94'	27.5	27.5	Lander waters (9 samples from x4 chambers)	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	130	CTD - depth 1, niskin bottle 5 (250ml)	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	70	CTD - depth 2, niskin bottle 8 (250ml)	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	30	CTD - depth 3, niskin bottle 12 (250ml)	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	17	CTD - depth 4, niskin bottle 17 (250ml)	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	5	CTD - depth 5, niskin bottle 22 (500ml)	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	133.6	H2S core - Porewaters collected for DSi only in Eppendorf tubes	
CS1-1	01/07/2023	63° 25.6625'	20° 20.6907'	61	61	Marine sands endmember	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	189	CTD - depth 1, niskin bottle 2 (250ml)	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	120	CTD - depth 2, niskin bottle 8 (250ml)	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	60	CTD - depth 3, niskin bottle 11 (250ml)	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	25	CTD - depth 4, niskin bottle 15 (250ml)	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	10	CTD - depth 5, niskin bottle 19 (250ml)	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	5	CTD - depth 6, niskin bottle 23 (500ml)	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	192.2	C1 - Porewaters collected for DSi and Si isotopes in bottles	

CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	192.2	C2 - Porewaters collected for DSi only in Eppendorf tubes	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	192.2	Sediments (C2)	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	120.0	CTD - depth 1, niskin bottle 2 (250ml)	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	70.0	CTD - depth 2, niskin bottle 7 (250ml)	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	20.0	CTD - depth 3, niskin bottle 12 (250ml)	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	10.0	CTD - depth 4, niskin bottle 15 (250ml)	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	5.0	CTD - depth 5, niskin bottle 22 (500ml)	
CS2-1	03/07/2023	63° 43.7865'	17° 24.6430'	79.0	79.0	C1 - Porewaters collected for DSi and Si isotopes in bottles	*Sediments from alternate site
CS2-1	03/07/2023	63° 43.7865'	17° 24.6430'	79.0	89.0	C2 - Porewaters collected for DSi only in Eppendorf tubes	*Sediments from alternate site
CS2-1	03/07/2023	63° 43.7865'	17° 24.6430'	79.0	89.0	Sediments (C2)	*Sediments from alternate site
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	690.0	CTD - depth 1, niskin bottle 2 (250ml)	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	460.0	CTD - depth 2, niskin bottle 8 (250ml)	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	120.0	CTD - depth 3, niskin bottle 14 (250ml)	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	25.0	CTD - depth 4, niskin bottle 16 (250ml)	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	10.0	CTD - depth 5, niskin bottle 19 (250ml)	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	5.0	CTD - depth 6, niskin bottle 22 (500ml)	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	697.0	C1 - core surface scrape porewaters	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	697.0	C1 - core surface scrape sediments	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	697.0	C2 - core surface scrape porewaters	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	697.0	C2 - core surface scrape sediments	*Also known as CS2-4-DEEP
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	290	CTD - depth 1, niskin bottle 7 (250ml)	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	60	CTD - depth 2, niskin bottle 12 (250ml)	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	15	CTD - depth 3, niskin bottle 15 (250ml)	*Other data may refer to CS2-3

CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	5	CTD - depth 4, niskin bottle 22 (500ml)	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	299.0	C1 - Porewaters collected in centrifuge tubes for DSi (and perhaps isotopes)	*Sediments/porewaters labelled as CS2-4/also known as CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	299.0	C2 - Porewaters collected for DSi only in Eppendorf tubes	*Sediments/porewaters labelled as CS2-4/also known as CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	299.0	Sediments (C2)	*Sediments/porewaters labelled as CS2-4/also known as CS2-3
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	40	CTD - depth 1, niskin bottle 3 (250ml)	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	15.0	CTD - depth 2, niskin bottle 12 (250ml)	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	5.0	CTD - depth 3, niskin bottle 22 (500ml)	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	43.0	C1 - Porewaters collected for DSi and Si isotopes in bottles	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	43.0	C2 - Porewaters collected for DSi only in Eppendorf tubes	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	43.0	Sediments (C1)	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	43.0	Additional sediments from Mg isotope extraction (in centrifuge tubes)	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	43.0	One additional porewater sample from Mg isotope extraction	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	192.2	Lander waters (9 samples from x4 chambers)	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	162.0	CTD - depth 1, niskin bottle 3 (250ml)	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	130.0	CTD - depth 2, niskin bottle 9 (250ml)	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	85.0	CTD - depth 3, niskin bottle 11 (250ml)	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	30.0	CTD - depth 4, niskin bottle 15 (250ml)	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	10.0	CTD - depth 5, niskin bottle 20 (250ml)	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	5.0	CTD - depth 6, niskin bottle 23 (250ml x 2)	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	50.0	CTD - depth 1, niskin bottle 3 (250ml)	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	25.0	CTD - depth 2, niskin bottle 12 (250ml)	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	5.0	CTD - depth 3, niskin bottle 21 (250ml x 2)	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	55.0	C1 - Porewaters collected for DSi and Si isotopes in bottles	

RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	55.0	C2 - Porewaters collected for DSi only in Eppendorf tubes	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	55.0	Sediments (C1)	
RFK	07/07/2023	65° 3.987'	14° 1.110'	42.0	40.0	CTD - depth 1, niskin bottle 3 (250ml)	
RFK	07/07/2023	65° 3.987'	14° 1.110'	42.0	13.0	CTD - depth 2, niskin bottle 12 (250ml)	
RFK	07/07/2023	65° 3.987'	14° 1.110'	42.0	5.0	CTD - depth 3, niskin bottle 22 (250ml x 2)	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	145.0	CTD - depth 1, niskin bottle 3 (250ml)	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	25.0	CTD - depth 2, niskin bottle 10 (250ml)	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	15.0	CTD - depth 3, niskin bottle 13 (250ml)	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	10.0	CTD - depth 4, niskin bottle 16 (250ml)	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	5.0	CTD - depth 5, niskin bottle 20 (250ml x 2)	
RF1	08/07/2023	64° 58.7976'	13° 49.4151'	167.0	167.0	Lander waters (9 samples from x4 chambers)	
RF4	09/07/2023	64° 57.3991'	13° 36.5422'	169.0	166.0	CTD - depth 1, niskin bottle 5 (250ml)	
RF4	09/07/2023	64° 57.3991'	13° 36.5422'	169.0	135.0	CTD - depth 2, niskin bottle 10 (250ml)	
RF4	09/07/2023	64° 57.3991'	13° 36.5422'	169.0	65.0	CTD - depth 3, niskin bottle 16 (250ml)	
RF4	09/07/2023	64° 57.3991'	13° 36.5422'	169.0	5.0	CTD - depth 4, niskin bottle 22 (250ml x 2)	
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	136.0	136.0	C1 - Porewaters collected for Si isotopes in bottles	*0.5ml aliquot taken for DSi analysis
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	136.0	136.0	Sediments (C1)	

Oxygen isotope samples

Station	**Date**	**Lat (N)**	**Lon (W)**	**Water depth (m)**	**Sample depth (m)**	**Notes**	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	62	CTD - depth 1A, niskin bottle 1	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	62	CTD - depth 1B, niskin bottle 1	

HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	40	CTD - depth 2, niskin bottle 13	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	20	CTD - depth 3, niskin bottle 18	
HF3	26/06/2023	64° 20.28976'	21° 46.6130'	63.8	5	CTD - depth 4, niskin bottle 24	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	24	CTD - depth 1, niskin bottle 9	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	16	CTD - depth 2A, niskin bottle 14	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	16	CTD - depth 2B, niskin bottle 14	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	9	CTD - depth 3, niskin bottle 19	
HF2	27/06/2023	64° 22.699'	21° 37.94'	27.5	5	CTD - depth 4, niskin bottle 24	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	15	CTD - depth 1A, niskin bottle 1	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	15	CTD - depth 1B, niskin bottle 1	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	10	CTD - depth 2A, niskin bottle 17	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	10	CTD - depth 2B, niskin bottle 17	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	5	CTD - depth 3A, niskin bottle 24	
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	5	CTD - depth 3B, niskin bottle 24	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	30	CTD - depth 1, niskin bottle 9	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	18	CTD - depth 2, niskin bottle 14	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	14	CTD - depth 3, niskin bottle 19	
HF4	29/06/2023	64° 16.7576'	21° 55.9612'	33.0	5	CTD - depth 4, niskin bottle 24	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	130	CTD - depth 1, niskin bottle 1	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	70	CTD - depth 2A, niskin bottle 7	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	70	CTD - depth 2B, niskin bottle 7	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	30	CTD - depth 3, niskin bottle 11	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	17	CTD - depth 4, niskin bottle 15	
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	5	CTD - depth 5, niskin bottle 19	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	189	CTD - depth 1, niskin bottle 1	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	120	CTD - depth 2, niskin bottle 7	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	60	CTD - depth 3, niskin bottle 12	

CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	25	CTD - depth 4, niskin bottle 14	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	10	CTD - depth 5, niskin bottle 17	
CS2-2	02/07/2023	63° 34.0400'	17° 6.6464'	192.2	5	CTD - depth 6, niskin bottle 21	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	120.0	CTD - depth 1, niskin bottle 1	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	70.0	CTD - depth 2, niskin bottle 8	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	20.0	CTD - depth 3, niskin bottle 14	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	10.0	CTD - depth 4A, niskin bottle 17	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	10.0	CTD - depth 4B, niskin bottle 17	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	5.0	CTD - depth 5A, niskin bottle 19	
CS2-1	03/07/2023	63° 41.6909'	17° 20.8773'	126.6	5.0	CTD - depth 5B, niskin bottle 19	
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	690.0	CTD - depth 1, niskin bottle 1	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	460.0	CTD - depth 2, niskin bottle 7	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	120.0	CTD - depth 3, niskin bottle 14	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	25.0	CTD - depth 4, niskin bottle 15	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	10.0	CTD - depth 5, niskin bottle 20	*Also known as CS2-4-DEEP
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	5.0	CTD - depth 6, niskin bottle 21	*Also known as CS2-4-DEEP
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	290	CTD - depth 1, niskin bottle 1	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	60	CTD - depth 2, niskin bottle 9	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	15	CTD - depth 3, niskin bottle 14	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	5	CTD - depth 4A, niskin bottle 19	*Other data may refer to CS2-3
CS2-4-SHALLOW	04/07/2023	63° 18.097'	16° 37.289'	299.0	5	CTD - depth 4B, niskin bottle 19	*Other data may refer to CS2-3
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	40	CTD - depth 1, niskin bottle 1	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	15	CTD - depth 2, niskin bottle 9	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	5	CTD - depth 3A, niskin bottle 17	
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	5	CTD - depth 3B, niskin bottle 17	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	162.0	CTD - depth 1, niskin bottle 1	

RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	130.0	CTD - depth 2, niskin bottle 7	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	85.0	CTD - depth 3, niskin bottle 11	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	30.0	CTD - depth 4, niskin bottle 15	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	10.0	CTD - depth 5, niskin bottle 20	
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	5.0	CTD - depth 6, niskin bottle 22	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	50.0	CTD - depth 1, niskin bottle 1	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	25.0	CTD - depth 2, niskin bottle 9	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	5.0	CTD - depth 3A, niskin bottle 17	
RF3	07/07/2023	65° 1.5261'	14° 12.8512'	55.0	5.0	CTD - depth 3A, niskin bottle 17	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	145.0	CTD - depth 1, niskin bottle 1	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	25.0	CTD - depth 2, niskin bottle 7	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	15.0	CTD - depth 3, niskin bottle 11	
RF2	08/07/2023	65° 0.9021'	13° 53.5279'	150.2	5.0	CTD - depth 5, niskin bottle 19	
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	169.0	166.0	CTD - depth 1, niskin bottle 1	
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	169.0	135.0	CTD - depth 2, niskin bottle 7	
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	169.0	65.0	CTD - depth 3, niskin bottle 13	
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	169.0	5.0	CTD - depth 4, niskin bottle 19	

Salts

Station	**Date**	**Lat (N)**	**Lon (W)**	**Water depth (m)**	**Sample depth (m)**	**Notes**
HF1	28/06/2023	64° 22.3615'	21° 29.7312'	18.0	15	CTD - depth 1, niskin bottle 1 (4 x 60ml)
HF1	29/06/2023	64° 22.6005'	21° 29.4969'	20.0	15	CTD - depth 1, niskin bottle 7 (4 x 60ml)
HF1	29/06/2023	64° 22.6005'	21° 29.4969'	20.0	10	CTD - depth 1, niskin bottle 17 (4 x 60ml)
HF1bis	29/06/2023	64° 22.6005'	21° 29.4969'	20.0	5	CTD - depth 1, niskin bottle 24 (4 x 60ml)
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	130	CTD - depth 1, niskin bottle 1 (4 x 60ml)

CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	70	CTD - depth 2, niskin bottle 7 (4 x 60ml)
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	30	CTD - depth 3, niskin bottle 11 (4 x 60ml)
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	17	CTD - depth 4, niskin bottle 15 (4 x 60ml)
CS1-1	01/07/2023	63° 24.2003'	20° 6.5980'	133.6	5	CTD - depth 5, niskin bottle 19 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	690.0	CTD - depth 1, niskin bottle 1 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	460.0	CTD - depth 2, niskin bottle 7 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	120.0	CTD - depth 3, niskin bottle 14 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	25.0	CTD - depth 4, niskin bottle 15 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	10.0	CTD - depth 5, niskin bottle 20 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	5.0	CTD - depth 6, niskin bottle 21 (4 x 60ml)
CS2-4	04/07/2023	63° 18.0969'	16° 37.2871'	697.0	300.0	CTD - 300m, niskin bottle 10 (4 x 60ml)
CS2-0	05/07/2023	63° 23.926'	16° 48.280'	43.0	5	CTD - depth 3, niskin bottle 17 (4 x 60ml)
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	162.0	CTD - depth 1, niskin bottle 1 (4 x 60ml)
RF1	06/07/2023	64° 58.7976'	13° 49.4151'	167.0	85.0	CTD - depth 3, niskin bottle 11 (4 x 60ml)
RF4	09/07/2023	64° 57.7407'	13° 39.3891'	169.0	166.0	CTD - depth 1, niskin bottle 1 (4 x 60ml)

References

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