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GEOLOGICAL SURVEY OF CANADA
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Canada

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EXECUTIVE SUMMARY

The accelerating Arctic cryosphere decline severely impacts the land on which northern communities live through the degradation of permafrost and the changing sea-ice cover, which further places the cultural heritage of coastal archaeological sites at risk. Sea ice decline also compromises the formation of polynyas, with unknown consequences for regional ecosystems.

From the 13th to the 19th of July 2023, a scientific cruise onboard the research vessel *William-Kennedy* allowed the collection of a suite of samples and data from the marine coastal environment of Nain, Nunatsiavut. In total, 10 surface sediment samples, 22 sediment cores, 64 conductivity-temperature-depth (CTD) profiles, 9 micro-plastic trawl and 38 water samples were collected. The cruise also allowed the recovery of 2 moorings equipped with sediment traps in Nain Bay and within deeper offshore waters. Four drop camera transects were deployed in Webb's Bay to image the seabed and study benthic habitats. Finally, acoustic sub-bottom profiling and multibeam echosounder data along the entire study area allowed a high-resolution characterization of the stratigraphy of the seafloor, helped identifying locations for sediment sampling and inferring geological information about the depositional environments.

The material and data collected during the research cruise will be key to 1) understanding the origin of subsea permafrost in Webb's Bay, 2) assessing the sea-level history of the region, 3) assessing the sediment and plankton composition across different current and sea-ice conditions which will allow us to calibrate the sedimentary signal recorded in sediment cores and 4) conducting benthic habitat characterization.

Co-led by the University of New Brunswick (UNB) and Natural Resources Canada (NRCan), this cruise was completed in collaboration with the Nunatsiavut Government, Dalhousie University and Memorial University, and was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) and NRCan.

AULLATSIJET NAILLITITAUSIMANNINGA

Tamanna pivalliajuk nunamettut Ukiuttattumi sikungit nunguvalliajuk angijualummik attuijuk nunamik tamanna taggamiut nunalimmiut inigiKattajanga nunguvalliajuk nunaup iluani Kuasimainnatuk ammalu asianguvalliajuk sikuk sautsimaKattajuk, ammalugiallak ininginnik ilukkuset taimangasuanitait satjugiami itsasuanitangit inigijangit ulugianattumelualittut. Sikunga nunguvalliamijuk attuimijut Kanuk sikuKattaniammangât, Kaujimajaulugani sakKilangajut nunakKatigengitumi avatinginnik.

Pisimajumit 13 ullunganit tikijumut 19 Joli 2023, Kaujisattilagijik umiatsuak ikimaKataulauttuk Kaujisattiup umiatsuanganut *William-Kennedy* pivitsaKattisilauttuk katitsuigiamut sunatuinnanik ottugattausonik ammalu Kaujigatsait pisimajunit imappet satjugiangata avatinganik Nain, Nunatsiavummit. Ilonnatik kitillugit senait nunait Kânganettut ottugattaulauttut, 22 nunaup iluanit, 64 ilinganiKajunut-onattonigijangit-itiningit Kanuilingatsianingit, 9 mikijut-palâsikkisajait kaliutet ammalu 38 imânit ottugattaugiamut katitsutaulauttut. Tainna umiatsuak pivitsaKattisilauttuk tigusigiamut maggonik imânottaujut kaliutet pitaKajunik nunajannik tigolalisonik iluani Nain kangitlungani ammalu iluani itijonitsait imaujunut. Sitamait atjiliugutet imânottaulaummijut iluani Webb's kangitlungani atjiliugigiamut ikkamejunut ammalu Kaujisagiamut ikkamiutanik inigijauluaKattajunut. kingullimi, nipaliujunut imânottaulaummijuk imaup KikKangani Kaujigiamut ammalu sunatuinnanik nipanik tigollaisonik Kaujigatsanik ilagitlugit ilonnanga Kaujisagiamut puttunitsamik takutsiasongugiamut Kaujigasuagiamut piusigijaujunut imaup atânettunut, ikkanganiuluak, ikulauttuk nalunaitsigiamik iniujunut nunajanik tigollaigunnagiamut ammalu sakKitigiallajumik nunaliginimmut Kaujigatsanginnik pitjutigillugit ilijauKattajunut avatimmut.

Tamakkua piKutet ammalu Kaujigatsait katitsutausimajut KaujisattuKaniammat umiatsuakut atuniKatsialangavut ukununga 1) tukisinitsaugiamut nakit pisimakkomangâmmik imâni ikkami iluani Kuasimainnatunik iluani Webb's kangitlungani, 2) Kimiggugiamut imappiup-itiningata piusigiKattasimajangit nunakKatigengitumi, 3) Kimiggugiamut nunajanganik ammalu kingukulunnik pitagijaujunut nanituinak atjigengitunik inigganiujunut ammalu sikungata piusigijanginik pivitsaKattisijumik uvattinik nalunaikkutaliugiamut nunajanganik nalunaigutinginnik allaKutiliugiamut iluani nunamut ammalu 4) Kaujigiamullu ikkamiutait inigijauKattajunut KanuilingatsiaKommangâmmik.

Ikajuttigejut-sivukkatet taikkuanguvut Ilinniavitsuak New Brunswick ammalu Piviannatunik Canadami (NRCan), tainna umiatsuak pijagelauttuk ikajuttigetlutik Nunatsiavut kavamakkunut, Dalhousie Ilinniavitsuanga ammalu Memorial Ilinniavitsuanga, ammalu kenaujattâtlutik taikkunangat Silamut Kaujisattilagijet ammalu Sanajet Kaujisattingata kaunsalliKutingit Canadami (NSERC) ammalu NRCan.

INTRODUCTION

In 2021 and 2022, joint scientific cruises funded by the National Science and Engineering Research Council of Canada (NSERC) and the Geological Survey of Canada at Natural Resources Canada led to the discovery of mounds and depressions on the seafloor of Webb's Bay, near Nain (Nunatsiavut), at a water depth of 30 m. These mounds and depressions were found to be similar to terrestrial thermokarst environments and resemble pingo-like features observed in the Beaufort Sea, although at a much smaller scale (Paull et al., 2007). A preliminary investigation of the seabed thermokarst environment in July 2022 led to the recovery of a short permafrost core (Limoges et al., 2023). The unexpected presence of subsea permafrost raises important questions regarding the past formation and preservation of subsea permafrost in such a southern area.

In addition, these previous cruises in Webb's Bay revealed subsea terraces on glacial moraines between 10 and 15 m below current sea level. These terraces may have been formed by previous relative sea level low stands, which is unknown to the Nain area but seen in areas to the north along Baffin Island (Cowan et al., 2022). Current knowledge about relative sea level changes along the central Labrador coast indicates the region was uplifting upon glacial ice retreat with a gradual sea level fall from ~10 ka to present (Clark and Fitzhugh, 1990; Vacchi et al., 2018). Discovery of these terraces poses an opportunity to produce a new relative sea level curve and challenge current knowledge about glacial processes (e.g., thinner ice, faster retreat) in the area by using cores collected from the submarine terraces. If a relative sea level lowstand is confirmed, this new knowledge could be used to reconstruct past shorelines and areas of previously unknown high geoarchaeological potential.

The objectives of this scientific expeditions were to:

1. Characterize the origin of subsea permafrost;
2. Monitor modern subsea permafrost thawing and potential release of methane;
3. Investigate submarine groundwater seepage and its likely role in the origin of permafrost;
4. Investigate benthic-pelagic cycles in the thermokarst environment;
5. Assess the influence of past sea ice and water temperature on the preservation of subsea permafrost;
6. Assess the timing of the sea-level lowstand;

7. Assess nearshore sediment transport processes in relation to recent coastal erosion in Webb's Bay;
8. Assess benthic habitat spatial variability around subsea permafrost;
9. Collect surface water for micro-plastic investigations.

PARTICIPANTS

Participants on the 2023-002 *William-Kennedy* cruise came from three universities, the Geological Survey of Canada and the Nunatsiavut Government (Figure 1, Table 1).

Figure 1. Participants of the 2023-002 *William-Kennedy* cruise. Courtesy of Kaitlyn Van De Woestyne.

Table 1. List of participants.

Family name	First name	Position	Affiliation	Role
Wyatt	Kayla	Research assistant	IRC	eDNA, water sampling, micro-plastic trawl
Eamer	Jennifer	PhD student	UNB	Logging operations, radium filter, coring
Geizer	Haley	PhD student	Dalhousie	Coring and porewater
MacMillan-Kenny	Zachary	MSc student	MUN	SBP, drop camera
Normandeau	Alexandre	Research Scientist	GSC	Chief scientist
Philibert	Genevieve	Physical Scientist	GSC	Logging operations, water filtering, coring
Pijogge	Liz	Research Scientist	NG	eDNA, water sampling, micro-plastic trawl
Regular	Kirk	Hydrographer	MI	Multibeam mapping
Van Nieuwenhove	Nicolas	Research scientist	UNB	Deck operations
Van de Woestyne	Kaitlyn	Communications	ARF	Photos, videos, stories
Manning	Desmond	Technician	GSC	Deck operations
Limoges	Audrey	Associate professor	UNB	Shore-based chief scientist

IRC: Inuit Research Coordinator
UNB: University of New Brunswick
UQAM: Université du Québec à Montréal
GSC: Geological Survey of Canada – Atlantic
IRC: Inuit Research Coordinators
SNF: Sustainable Nunatsiavut Futures
NG: Nunatsiavut Government

SUMMARY OF ACTIVITIES

The 2023-002 *William-Kennedy* cruise began on July 14 and ended July 19, 2023 (Figure 2, Table 2). The cruise allowed the collection/deployment/completion of:

1) 8 surface cores (Algar-type cores)
2) 2 box cores
3) 4 camera transects
4) 26 stand-alone CTD profiles
5) 38 CTD-Rosette profiles
    a. 15 for radium isotope analysis
    b. 5 for eDNA analysis
6) 21 gravity cores

7) 9 micro-plastic trawls
8) 1 piston core
9) 1 surface water sample for radium isotope analyses
10) 2 moorings
11) 94.5 km of sub-bottom profiles
12) ~11.5 km^2 of multibeam data

Table 2. Summary of stations completed. AC: Algar surface corer, BC: Box corer, CAM: Drop camera, CTD: Conductivity-Temperature-Depth, CTD-R: CTD-Rosette, MPN: Micro-plastic Net, GC: Gravity Corer, PC: Piston corer, SW: Surface water.

Date	AC	BC	CAM	CTD	CTD-R	GC	Mooring	MPN	PC	SW	Total
July 14				1	7	4		3		1	16
July 15	5		1		10	6					22
July 16	3		2	2	9	6					22
July 17		1	1	23	10	5			1		41
July 18		1			2		1	6			8
July 19											
Total	**8**	**2**	**4**	**26**	**38**	**21**	**2***	**9**	**1**	**1**	**112**

** Second mooring retrieved after the cruise. See text for details*

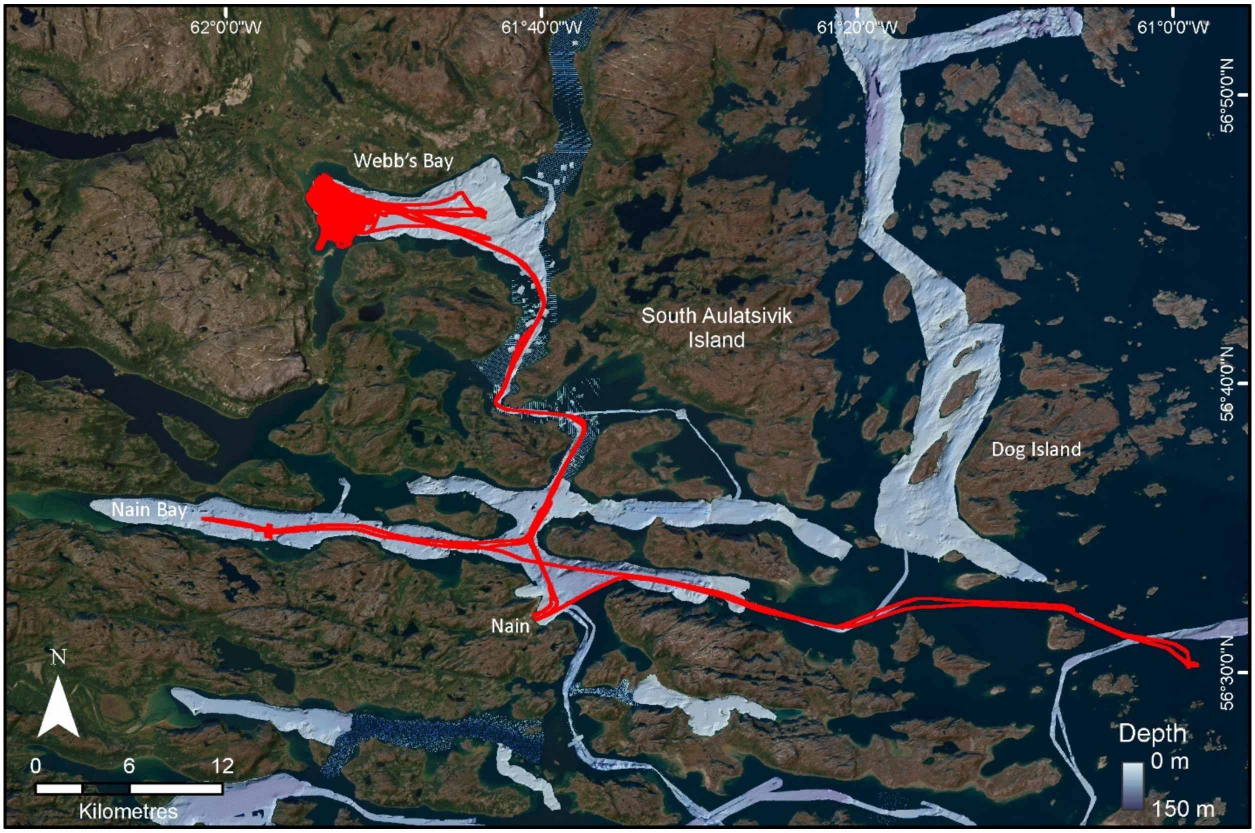

Figure 2. Cruise track of 2023-002.

EQUIPMENT AND PROCEDURES

EM-2040 dual swath multibeam echosounder

An EM-2040P MKII multibeam echosounder was used on the port-side pole of the RV *William-Kennedy*. This multibeam echosounder is a 3-sector broadband sounder and was operated at a frequency of 400 kHz, with a swath width of 100-120°. It was used in dual swath mode, with 1024 beams per ping, allowing a 20 cm grid resolution of the final dataset.

The multibeam was coupled with a Seapath 130 navigation system with an MRU 5+. Navigation issues occurred mainly on the turns (which were not logged) where the accuracy was reduced. This may be an issue with the position of the GNSS antenna being blocked by the rigid-hulled inflatable boat (RHIB). There was also a problem with the built-in self-test indicating a voltage issue with Rx. Kongsberg suggested there would be a problem with the backscatter. None were observed in preliminary data.

Sub-Bottom profiler (SBP)

A 3.5 kHz Knudsen Pinger sub-bottom profiler was pole-mounted to the starboard side of the vessel (Figure 3), and recorded data almost continuously during the first 2 days of the cruise. It was used to acquire high-resolution subsurface data (sediment stratigraphy), in order to select core locations and identify features of interest on the seabed.

The echocontrol acquisition software was consistently monitored for depth ranging. An incident occurred on July 15 where the transducer hit bottom, likely a protruding rock, and was sheared off. Therefore, no sub-bottom profiler data could be collected for the remainder of the cruise.

Figure 3. Pinger sub-bottom profiler. Courtesy of Kirk Regular.

CTD and CTD-Rosette

A stand-alone seabird 19plusV2 SeaCAT profiler CTD was used to collect water column profiles during the cruise. This year, the CTD did not have the photosynthetically active radiation (PAR) or the fluorescence sensors. Deployment steps were as follows: 1) start archiving, 2) immerse the CTD just below the surface for 2 minutes, 3) descent at 0.5 m/second and stop at about 5 meters above the bottom, 4) wait 30 seconds, 5) ascend to the surface and bring on deck, 6) turn off the instrument, 7) rinse with freshwater. The data were downloaded at the end of each day. The locations of stand-alone CTD profiles are presented in Figure B2 and Table A1. Downcast measurements are presented in Appendix D (Figs. D1-D61).

The CTD-Rosette was equipped with 12 Niskin-type bottles of 5 L with an automatic closing system that allows the sampling of seawater at specific depths. A CTD probe (SBE 19plus V2) continuously measures the conductivity, temperature, density, fluorescence, dissolved oxygen and

PAR. However, the 2023 *.xmlcon* configuration file did not match the instruments that were enabled on the CTD: with the recent update by Seabird, the *.xmlcon* file incorrectly had "6" external voltage channels enabled, but no serial RS-232 (digital) sensors, NMEA position data, or Surface PAR. Therefore, in order to collect CTD data, options 'Scan Time', 'Surface PAR' and 'NMEA positioning' had to be disabled to match the configuration file. This led to the absence of NMEA and PAR feeds during CTD-R deployment. NMEA positioning was added manually into the *.cnv* files after each CTD was collected. We also note that the oxygen sensor measurements were not calibrated onboard the ship by measuring oxygen concentration on discrete water samples through Winkler titrations.

Deployment of the CTD-R steps were as follows: 1) Turn on CTD and start archiving (recording); 2) Immerse the rosette to about 10 meters below the surface; 3) Wait 3 minutes for the plumbing system to flush (checking that the probes stabilize); 4) Bring back up to just below the surface; 5) Descend at 0.5 m/s, starting to slow down around 20 meters from the bottom by checking the altimeter to stop at 5 meters from the bottom; 6) Wait 30 seconds; 7) Ascend to the desired depths and close the bottles (waiting for wave stabilization); 8) Once at the surface and water sampling has been completed on deck, turn the CTD off; 9) Stop archiving and close deck unit. The locations of CTD-R profiles are presented in Figure B2 and Table A1. Downcast measurements are presented in Appendix D (Figs. D1-C61).

Radium isotopes

Bottom water samples were collected from the pockmarks and permafrost mound sites to determine the source of fresh water needed for subsea permafrost formation by measuring radium isotopes. Roughly 100 litres of water were collected for each sample using the Rosette's Niskin bottles and stored in 20 litre containers. Since each Rosette can collect approximately 60L of water, two Rosettes were needed at the same site to collect the 100L of water needed for these analyses (Table 3). A pump was used to filter the water through manganese-treated fibre. The pump battery drained quickly while in use and needed recharging which slowed the pumping time, limiting sample filtering capacity and subsequent sample collection each day; therefore the pump was abandoned after day one and the remaining samples were gravity filtered on the ship's deck (Figure 4A). Each sample took approximately 5 hours (1 hour per 20 litre container) to gravity-filter.

Table 3. Details of water sampling for radium isotope analyses

Station No.	Sample Type	J Day	UTC at Bottom	Lat Bottom	Long Bottom	Water Depth (m)	Rosette Depth (m)	Liters	T° collection	Salinity at bottom	Depth of sample	Time of filtering completion
0002	Surface water	195	1630	56.797150	-61.912257	1	Zodiac sampling	100	NA	NA	NA	July14 - 21:00
0005	CTDR	195	1859	56.787555	-61.905311	27	26.4	60	-0.0012	31.114	25.984	July 14 - 22:30
0006	CTDR	195	1939	56.787626	-61.905885	27.8	26.5	40	NA	NA	26.5	
0011	CTDR	195	2158	56.781982	-61.895477	26.5	25	60	NA	NA	23	July15 - 09:00
0012	CTDR	195	2229	56.781534	-61.895709	25.8	24.5	40	NA	NA	23	
0017	CTDR	196	1021	56.790479	-61.903705	27.7	26	60	-0.1803	31.219	26.136	July15 - 12:49
0018	CTDR	196	1054	56.790494	-61.902981	27.3	25	40	0.129	31.057	24.992	
0020	CTDR	196	1147	56.786538	-61.902267	28.2	25	60	0.7677	30.202	24.963	July15 - 19:10
0021	CTDR	196	1216	56.786657	-61.902899	26.8	24	40	0.2475	31.218	24.185	
0028	CTDR	196	1532	56.779186	-61.899685	16.6	14	60	4.1678	29.956	14.651	July 16 - 0430
0029	CTDR	196	1558	56.77933	-61.899216	17.2	15	40	3.9897	29.702	15.688	
0036	CTDR	196	2056	56.788025	-61.894326	31.4	30	60	-0.3265	31.285	30.726	July16 - 09:18
0037	CTDR	196	2137	56.787791	-61.894669	34	29	40	-0.3156	31.284	32.325	
0039	CTDR	197	1019	56.793663	-61.903033	19.6	14.5	60	3.3398	29.959	14.675	July16 - 14:53
0040	CTDR	197	1048	56.793714	-61.90303	20	16	40	3.2872	29.859	16.589	
0043	CTDR	197	1202	56.786022	-61.888619	33	30	60	-0.2514	31.238	29.904	July 16 - 16:50
0044	CTDR	197	1229	56.78615	-61.88829	32.9	30	40	-0.24	31.302	29.66	
0051	CTDR	197	1647	56.785972	-61.897046	27.7	25	60	2.5008	32.052	5	July 16 - 19:21
0052	CTDR	197	1715	56.786011	-61.897658	28	24	40	1.7305	30.32	5	
0056	CTDR	197	1945	56.785469	-61.908237	22	19	60	3.0016	32.645	19.332	July17 - 07:30
0057	CTDR	197	2010	56.785492	-61.908731	20.5	18	40	3.317	30.168	17.986	
0061	CTDR	198	1005	56.794486	-61.898724	20	17	60	3.7567	30.549	16.549	July 17 - 1450
0062	CTDR	198	1027	56.794724	-61.898804	19.5	16	40	3.8445	29.865	16.017	
0063	CTDR	198	1101	56.781488	-61.910546	19.4	15	60	3.6584	30.003	16.038	July17 - 17:13
0064	CTDR	198	1125	56.781818	-61.91106	20	16	40	3.8036	29.907	16.145	
0080	CTDR	198	1545	56.793472	-61.900526	21	17	60	3.844	30.125	5	July 17 - 20:27
0081	CTDR	198	1613	56.793663	-61.900351	20	16	40	3.9734	29.896	5	
0089	CTDR	198	1855	56.788522	-61.899296	28	23	60	2.5636	30.198	5	July 18 - 05:59
0090	CTDR	198	1914	56.788916	-61.900019	29	5	40	5.8259	29.543	5	
0100	CTDR	198	0029	56.791862	-61.890900	52	46	60	-0.2938	31.261	46.04	July 18 - 16:00
0101	CTDR	198	0053	56.791865	-61.889974	55	48	40	-0.321	31.297	47.973	

Radon isotopes

The Durridge RAD 7 Radon detector was used to detect and measure radon isotopes in surface seawater for the whole duration of the cruise. The RAD7 is a sniffer that can detect the 3-minute alpha decay of a radon isotope, without interference from other radiations. Continuous radon detection can be used to investigate the presence of submarine groundwater discharge in the ocean. During the cruise, the RAD 7 was connected to the saltwater pump of the vessel in a way that surface seawater was circulating continuously through the RAD 7 detector (Figure 4B). A 10-minute purge was performed to clear the system prior to logging the data. The detector printed out a complete report every hour. The complete and detailed data were extracted at the end of the cruise for analyses.

Figure 4. A) Gravity filtering for radium isotopes measurements and B) the RAD-7 setup. Courtesy of Jennifer Eamer.

Micro-plastic Net (MN)

A Low-tech Aquatic Debris Instrument (LADI) trawl was used for the micro-plastic survey. The LADI trawl was towed behind the vessel and collected micro-plastics near the sea-surface. The trawling took place at three sites: 1) Webb's Bay; 2) Nain Bay and; 3) near the offshore mooring. At these three sites, the LADI trawl was deployed three times for 30 minutes per trawl. Speed was around 2 knots during the trawl. Once the trawl was back on board, the net was rinsed, and the content was stored to be analysed back in the laboratory.

Sediment coring

Four types of coring tools were used during the 2023-002 *William-Kennedy* cruise: 1) a box corer (BC); 2) a piston corer; 3) a surface corer (Algar Lab corer); 4) and a gravity corer (Figure 5). The gravity corer was configured with two barrels, for a maximum length of 3 m.

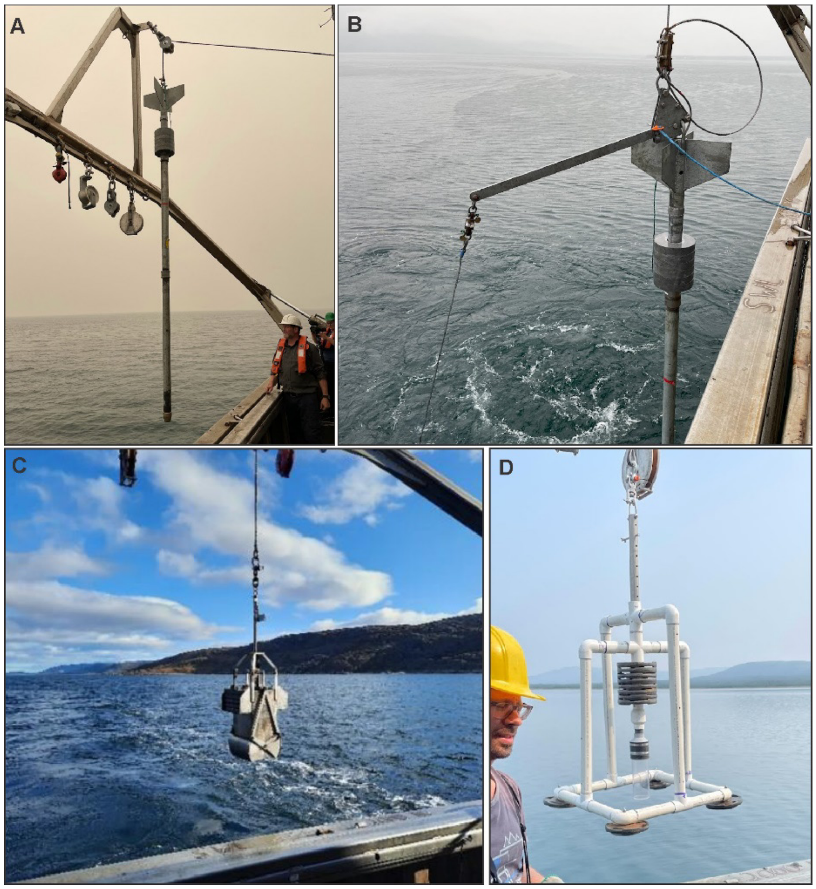

Figure 5. A) The gravity corer with 2 barrels (2.5m-long) B) The piston core with the trigger-weight; C) The box corer; and D) The surface corer (Algar-type). Courtesy of Nicolas Van Nieuwenhove.

The box corer (Fig. 5C) was used to collect surface samples (0-1 cm) only as it generally did not penetrate deep enough to recover undisturbed sedimentary sequences. Deployment speed was as fast as possible, which was approximately 100 m/min. The box corer was deployed at 2 sites (Appendix A, Table A1), and 2 surface sediment samples were bagged at each site for a series of microfossil, sedimentological, geochemical and biomarker analyses. Samples for plankton germination studies were kept in the dark at 4°C. Samples for foraminiferal analysis were tainted with Rose Bengal in order to distinguish living from dead foraminifers in the sediment at time of sampling. The Rose Bengal solution was prepared by mixing 1 g of Rose Bengal powder to 500 mL of ethanol 95% diluted to 70% (368 mL ethanol 95% + 132 mL water). This Rose Bengal solution was added to the bags containing the samples and the bags were shaken carefully to uniformly stain the living foraminifera. The third bag was kept for grain-size analyses.

The gravity corer (Figure 5A) was the most frequently used coring device during this cruise because it is a fast and easy way of collecting 1-2 m-long cores. During deployment, the gravity corer was stabilized around 15 meters above the seafloor before accelerating descent speed to maximum. Six ballast weights of 20 kg were used to facilitate penetration in the seabed. A total of 21 cores were successfully collected using the gravity corer (Table A1, Figures B1, C1-13).

A piston corer from Mooring Systems was used once to penetrate into a harder seabed (Fig. 5B). The piston corer uses a pilot weight to allow a free-fall of the corer. Once the pilot weight touches the bottom, it releases the trigger which allows a freefall of the main corer. In addition, instead of a valve, a piston is inserted in the liner. When the corer penetrates the sediment, the piston is forced upward, which eliminates water being trapped above the sample. During ascent of the corer, the piston creates a vacuum inside the liner, which helps retain the sample in the liner.

Finally, a surface corer built by Christopher Algar's laboratory at Dalhousie University, was used when surface samples were needed without any disturbances (Fig. 5D). The surface corer is contained within a plastic tubing frame that gently rests on the seabed. Once on the seabed, the weight above the corer allows the plastic liner to gently penetrate in the seabed vertically. The suction from the fine sediment is strong enough that no core catcher is needed, thereby preserving a quasi-perfect sediment-water interface. The surface corer was used 8 times at 4 different sites. At two sites near the permafrost area, triplicate cores were collected for porewater analysis, and at three sites in Webb Bay, a surface sediment sample (0-1 cm) for microfossil analysis was taken from the top of the recovered core section.

Porewater sampling

Porewater was extracted from gravity cores for chloride concentration analysis to i) help understand if the frozen layer is of marine or groundwater origin, ii) determine remineralization rates in sediments above permafrost compared to a reference site and finally, iii) later create a one-dimensional model where temperature can be manipulated to observe what chemical changes would occur with a warming climate.

Cores were obtained from the permafrost region, from locations outside of the permafrost region to serve as controls, and from areas where groundwater was hypothesized to be present. Sites were targeted based on a combination of multibeam and sub-bottom profile data. Most cores were collected using the gravity core, six cores were sampled using the Algar Lab Corer and one core was from a piston core. Over the course of four days, 20 cores were collected and processed to determine porewater chemistry (Table A1).

Once the cores were collected, a drill was used to make holes in the core liner. Holes were drilled every ~2 cm for the first 20 cm, then every 10 cm until 50 cm and finally, every 25 cm until the bottom was reached. Smaller cores were processed using the Algar Lab porewater rack and longer sections were processed horizontally (Figure 6). Cores were processed within 12 hours of collection but often after 2-6 hours. To extract porewater, rhizons were used with syringes in the lab at room temperature (Figure 6). It took ~1-2 hours for water to draw from the core. After porewater collection, samples were sub-divided for analysis. Aliquots were taken for dissolved Fe^{2+}, DIC, H_2S and the remaining volume was put in a vial for measurements of dissolved nutrients (NO_x^-, NH_4^+, PO_4^{3+}), alkalinity and chloride concentrations. Dissolved DIC, Fe^{2+} (fixed with Ferrozine reagent) and H_2S (fixed with zinc acetate reagent) subsamples were stored at ~4°C, while nutrient samples were frozen at -20°C until analysis. Nutrient samples will be analyzed post-cruise in Dr. Algar's laboratory at Dalhousie University and DIC samples will be analyzed at the University of New Hampshire in the fall 2023.

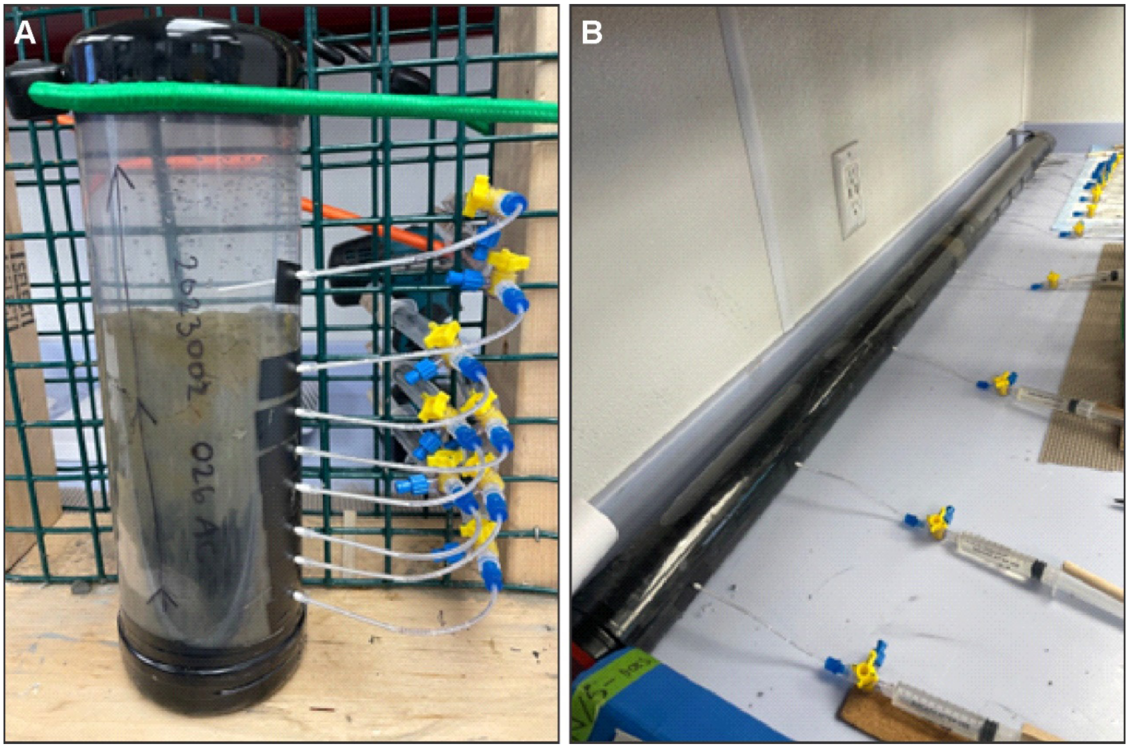

Figure 6. Extracting porewater from a small core vertically using a rack (A) and extracting porewater from a longer section of a core horizontally (B). Courtesy of Haley Geizer.

Drop Camera

The custom-built drop camera system from Natural Resources Canada (Figure 7) was deployed four times surrounding permafrost-related features in Webb's Bay, Nain. It was used to acquire images of the seabed along transects. The drop camera was lowered on the seafloor and was triggered once a weight touched bottom. The vessel gently drifted, and the camera was lowered and brought up a few meters, and then lowered again. Transects of about 20 minutes were performed. The vessel's GPS track was recorded during the image transect and the start and end coordinates and time were recorded (Table A1, Figure B3).

Figure 7. Drop camera used during the cruise. Courtesy of Zachary Macmillan.

Moorings

Mooring instruments

Two moorings equipped with sediment traps, CTDs and an Acoustic Doppler Current Profiler (ADCP) were deployed during the 2022-*William-Kennedy* cruise (Limoges et al., 2023) and their specific information is reported here again. The primary goal of the moorings was to collect sinking particles in order to assess the composition of sediment and the plankton living in the water column during different current and sea-ice conditions, and throughout the year. This information will then allow us to understand the phenology of primary production, and calibrate the sedimentary signal recorded in sediment cores.

Two HydroBios sediment traps, owned by the Université du Québec à Rimouski (UQAR) were used on the moorings. The time-programmed (see Table 4-5), multi-cupped (12 x 250 mL sample cups) sediment traps were filled with a preservative formalin solution (Hargrave et al., 2002) consisting of 9.27 L filtered seawater, 487.5ml formaldehyde 37%, 48.75g borax and 46.31g NaCl.

The inshore mooring (station 0160 of 2022-*William-Kennedy*) was equipped with an RBR duet T.D. (Temperature and Depth sensors), which was setup to record data continuously throughout the year (Table 4). A CT2X was placed at the same location on the mooring line, near the sediment trap, and was meant to measure conductivity and depth.

Table 4. Instrument configuration on mooring station 2022*William-Kennedy* 0160 (mooring_in).

	HydroBios sediment trap	**RBR Duet T.D.**	**CT2X**
Serial number (S/N)	66 07 09	206147	12202982
Depth below surface	60 m	61 m	61 m
Measured variables	Particle sedimentation	Temperature, Depth	Conductivity, Temperature
Measurement details	Sampling interval: See Table 4	Mode: Continuous	Interval: 30 min
Start date	2022-07-18 00:35	2022-07-15 00:00:00	2022-07-15 00:00:00
Working assessment	Collected 11 bottles. See text for more details	Measured continuously	Measured continuously

The sea-ice edge mooring (station 0181 of 2022-*William-Kennedy*) was equipped with a RBR Duet T.D., a CT2X, a Signature 500 ADCP and a CTD Concerto (Table 5). The RBR Duet T.D and CT2X were positioned at the sediment trap location and were setup in the same manner as the inshore mooring. The 5 beam Signature 500 ADCP was positioned about 46 m below surface, looking upwards. It was setup to measure currents, backscatter, and ice drift and ice draft. Cell size was setup to 0.5 m at sampling interval of 15 min. Just below the ADCP, a CTD Concerto equipped with a turbidity sensor, was setup to measure water column properties every 10 minutes (Table 5).

Table 5. Instrument configuration on 2022*William-Kennedy* mooring station 0181 (mooring_edge).

	HydroBios sediment trap	**RBR Duet T.D.**	**CT2X**	**Signature 500**	**CTD Concerto**
Serial number (S/N)	66 07 09	206147	12202982	101088	200331
Depth below surface	60 m	61 m	61 m	46 m	48 m
Measured variables	Particle sedimentation	Temperature, Depth	Conductivity, Temperature	Velocity, backscatter, ice drift and draft	Temperature, Conductivity, Pressure, Turbidity
Measurement details	Sampling interval: See Table 4	Mode: Continuous	Interval: 30 min	Cell size: 0.5m Range: 0.5-60m Sampling interval: 15 min Average interval: 120s	Sampling mode: average Speed: 8 Hz Duration: 5s Interval: 10 min
Start date	2022-07-18 00:35:00	2022-07-15 00:00:00	2022-07-15 00:00:00	2022-07-15 00:00:00	2022-07-15 00:00:00
Working assessment	Collected 12 bottles	Measured all year long	Flooded. No data retrieved	Measured all year long	Flooded. No data retrieved

Mooring recovery

Nain Bay

The first attempt at recovering a mooring was made for the one in Nain Bay (Mo_in) on July 18. Upon arrival, we passed over the mooring with the multibeam echosounder to make sure it was still in position and at the right location. When passing over the mooring, it was immediately evident that the top floats (B3 SUB and BUB) were no longer attached to the mooring (Figure 8). High-intensity reflections in the water column were limited to the lower BUB package and acoustic release. Despite this, we attempted to release the mooring. Several attempts to release the mooring were unsuccessful, despite the deck unit telling us the mooring had been released. In addition, additional passes over the site with the multibeam echosounder showed that the mooring was still on the bottom. A few hours of dragging the bottom with an anchor proved unsuccessful. It was determined that the acoustic release had probably worked but that something had caught on the bottom. Upon returning to Nain on July 19, locals told us the buoys had been sighted, beached in Nain Bay. On July 20, a team went by zodiac to find the lost floats and found them. Unfortunately, no scientific instruments were attached to the floats. However, the shackles were still attached to the titanium hold points of the sediment trap, which showed that it was the titanium array of the trap that corroded and failed. On Sunday July 23, 4 days after the cruise had ended, we got a report of a sighting of the mooring in Nain Bay. On Monday July 25, the Nunatsiavut Government reached out to Simon Kohlmeister to go retrieve the lost mooring. When they recovered it, it contained all the missing equipment, including the sediment traps (although the main hardware responsible for rotating the bottles was missing), the sensors and the acoustic release. An examination of the sensor data revealed that the upper floats detached from the sediment trap on July 9, during the collection of sediment into the 12th bottle (Figure 9). Therefore, the 12th bottle should be ignored for analysis since it had not completed its cycle when the trap fell over. The acoustic release and trap were then released on July 23 at 14:00 UTC, 4 days after the attempt from the *William-Kennedy*. The sediment trap was then brought to the Nunatsiavut Research Centre, where it was put in the cold room with a black plastic bag put over it to prevent light from affecting the samples. Liz Pijogge shipped the samples to UNB within the following week for pigment analysis. We note that the cups covering the spring and early summer 2023 contained very little material. This may indicate that the system may have been affected by biofouling (i.e., funnel blocked by the accumulation of living organisms), that the trap was no longer in a vertical position or that previously settled particles were flushed back into the water column. No signs of biofouling were observed upon recovery. Further analysis of the samples and sensors is needed to evaluate if such processes interfered with the collection of sediments, or if the low sediment content simply reflects the dynamics of particulate matter at the study site.

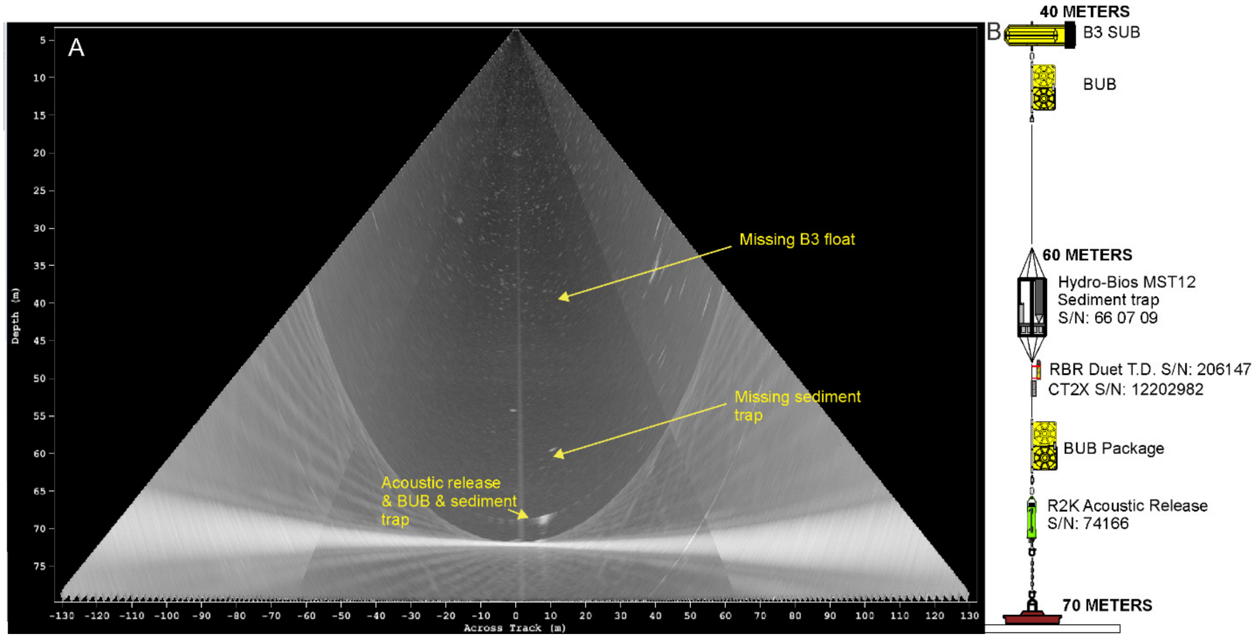

Figure 8. Water column view of the Nain Bay mooring during recovery. Note the missing float in the water column.

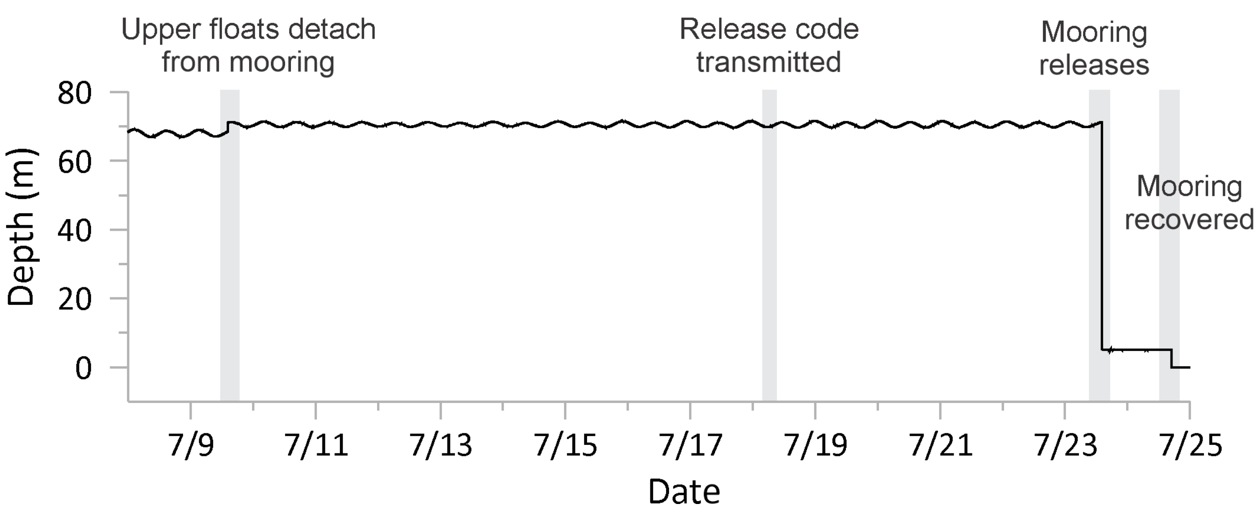

Figure 9. Sequence of events of recovering the inshore mooring. On July 9, 2023, the upper floats detached from the mooring, causing a fall of the trap and associated depth sensor. Release codes were transmitted to the release on July 18, but the mooring did not move. On July 23rd , the mooring released from the train wheel and surfaced. The depth sensor remained 5m deep. On July 24th, Simon Kohlmeister recovered the mooring and brought it back to the research centre.

Mooring Edge of sea-ice

Upon arrival to the mooring-edge site, a pass over the mooring with the multibeam revealed that the mooring was still in place with all of its components (Figure 10). Therefore, the mooring was released and floated at the surface within one minute of releasing. Recovery went relatively smoothly. However, the sediment trap had corroded considerably and one end of it broke during recovery. The other end remained attached, but only with 1 attach point instead of 3. Examination of the trap showed that the holding points had corroded and broke apart, similar to the Nain Bay mooring. This sediment trap is therefore not recommended for long deployment in the ocean. On this mooring, the ADCP and sediment trap worked as programmed. However, the CTD Concerto and the CT2X flooded, and no data could be recovered. We note that the sample cups of this sediment trap also only contained very little material.

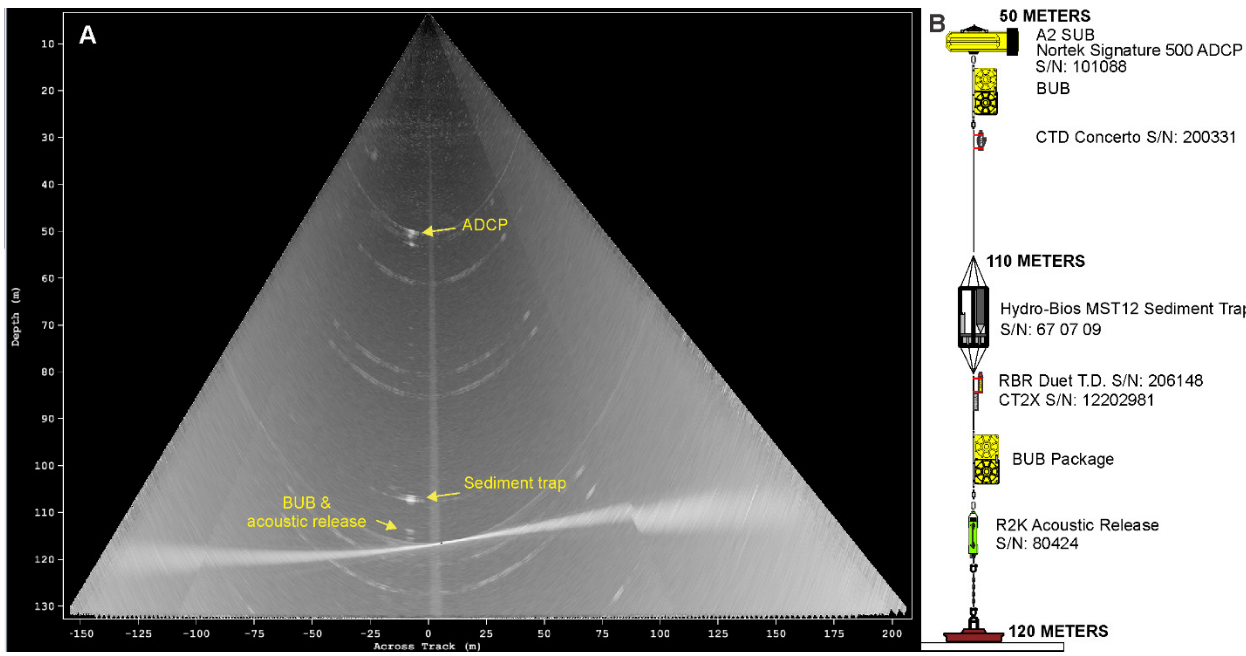

Figure 10. Water column view of the offshore mooring illustrating the position of the sediment trap and ADCP.

DAILY ACTIVITIES

This section provides a brief overview of the cruise narrative.

*All times in Atlantic Standard time

July 14, 2023

- Science staff reported to the vessel at 0700
- At 0750 the vessel departed Nain for Webb's Bay
- Chief Mate familiarized science staff with safety protocol
- 1200, Arrived at station 001
  - CTD not working on the Rosette, file was reconfigured and could be the issue
    - Depth markers on cables will be used to estimate depth and trigger Rosette bottles
  - Switched to microplastics trawl **[001]**
  - Zodiac was deployed for surface water collection in river mouth for radium testing **[002]**
- 1520 gravity core **[003]**
  - Switched to cores while trying to fix CTD issues
  - 3 attempts were made with the short corer before mud was collected
    - 140 cm recovered
  - Porewater extracted on ship
- 1535 gravity core, long **[004]**
  - 47.5 cm recovered
  - Pore water extracted on ship
- 1558 CTDR x2, **[005, 006]**
  - CTD still not functional
  - 100 litres for radium
  - Bottle at bottom for eDNA, [006]
  - pH bottle [006]
- 1654 stand alone CTD cast, **[007]**
  - Still not functional
- 1722 gravity core **[008]**
  - 151 cm recovered
  - Porewater extracted on ship
- 1730 Microplastic trawl, **[009]**
  - Completed ~1830
- 1854 CTDR **[011, 012]**
  - 100 litres for radium
  - pH bottle [012]
  - no CTD cast
  - CTD for these locations will be stations 014, 015, 016

- 1940 gravity core, **[013]**
    - 49.5 cm recovered
    - Porewater extracted on ship
- CTD resumed functionality, several casts taken **[014, 015, 016].** No NMEA feed into the GPS, so we will need to add the location of CTD manually.

July 15, 2023

Glassy day, warm

- 0545 sub bottom profiler hit bottom in ~3 m of water and is lost
- 0717 CTDR (x2) **[017, 018]**
    - 100 litres for radium
    - pH bottle [018]
- 0815 gravity core **[019]**
    - Two sections AB/CD
    - 184 cm recovered
    - Porewater extracted on ship
- 0843 CTDR (x2) **[020, 021]**
    - 100 litres for radium
    - Bottle at bottom for eDNA [020]
    - pH bottle [021]
- 0947 camera photos **[022]**
    - 15 photos taken
- 1013 gravity core, short **[023]**
    - 30 cm recovered
    - Porewater extracted on ship
    - Looking for ice in sediment, no ice
- 1048 Algar core **[024]**
    - Surface samples recovered for Dalhousie
    - 20.5 cm recovered
    - Porewater extracted on ship
- 1057 Algar core **[025]**
    - Surface samples recovered for Dalhousie
    - 20 cm recovered
    - Porewater extracted on ship
- 1105 Algar core **[026]**
    - Surface samples recovered for Dalhousie and UNB
    - 20 cm recovered
    - Porewater extracted on ship
- 1141 Algar core **[027]**
    - surface sample for UNB
- 1230 CTDR (x2) **[028, 029]**

        - 100 litres for radium
        - pH bottle [029]
- 1402 CTDR **[030]**
    - No water samples, just CTD cast
- TIME Algar core **[031]**
    - surface sample for UNB
- 1452 gravity core, long **[032]**
    - 96 cm recovered
    - ‘shallow’ terrace
- 1519 gravity core, long **[033]**
    - 183 cm recovered
        - AB/CD
    - Didn’t hit basin, will try again tomorrow
- 1601 gravity core, long **[034]**
    - 240 cm recovered
        - Core catcher (CC)
        - AB/CD
    - 14.6 water depth
- 1708 CTDR **[035]**
    - Two bottles at 15m for eDNA
    - CTD cast to bottom
    - No water samples for radium
- 1753 CTDR x2 **[036, 037]**
    - 100 litres for radium
    - pH bottle [037]
- 1850 gravity core, long **[038]**
    - 38 cm recovered
        - 1 bag CC
        - Frozen-ish at top of CC
    - Likely lost frozen section from CC at surface break

July 16, 2023

Glassy day, warm

- 0716 CTDR x2 **[039, 040]**
    - 100 litres for radium
    - pH bottle [040]
- 0758 gravity core, long **[041]**
    - 94.5 cm recovered
        - 1 bag CC
- 0822 CTDR **[042]**
    - CO_2 and methane samples, DFO

    - 25 m
    - 15 m
    - 3 m
- 0858 CTDR x2 **[043, 044]**
  - 100 litres for radium
  - Missed bottle 12 [043]
  - pH bottle [044]
  - CO2 and methane, DFO [044]
    - 30 m
    - 15 m
    - 2 m
- 0955 Algar core **[045]**
  - Surface samples recovered for Dalhousie
  - 15 cm recovered
  - Porewater extracted on ship
- 1004 Algar core **[046]**
  - Surface samples recovered for Dalhousie
  - 15.5 cm recovered
  - Porewater extracted on ship
- 1010 Algar core **[047]**
  - Surface samples recovered for Dalhousie
  - Porewater extracted on ship
- 1054 gravity core, long **[48]**
  - Middle of bay
  - Core was crooked on entry
  - 238.5 cm recovered
    - 1 bag cc
    - AB/CD
- 1120 gravity core, long **[049]**
  - Middle of bay
  - 239.5 cm recovered
    - AB/CD
- 1217 gravity core, long **[050]**
  - Small basin at 17.5 water depth
  - 260 cm recovered
    - 1 bag cc
    - AB/CD
- 1346 CTDR **[051]**
  - 100 litres for radium [051, 052]
  - Surface water samples
    - 5 m
  - Only fired 11 bottles

- 1411 CTDR **[052]**
    - CO2 and methane, DFO
        - 25 m
        - 15 m
        - 5 m
    - 10 bottles fired at 5 m
        - pH bottle at 5 m
- 1449 gravity core, long **[053]**
    - 79 cm recovered
    - Porewater extracted on ship
- 1522 camera photos **[054]**
    - 20 photos taken
- 1559 camera photos **[055]**
    - 17 photos taken

Trouble downloading photos from camera, likely a camera issue

- 1642 CTDR x2 **[056, 057]**
    - 100 litres for radium
    - Bottom water samples
    - pH bottle [057]
- 1736 gravity core, long **[058]**
    - Cored the small mounds ('pimples')
    - 182.5 cm recovered
        - AB/CD
- 1818 CTD, stand alone **[059]**
    - Test cast succesful
- 1846 CTD, stand alone **[060]**
    - Still works!

July 17, 2023

Glassy, warmish day cooling in the afternoon with a bit of rain during the piston coring

RAD7 stopped at 0231

*Bottom photos downloaded, onboard battery low and charged overnight, seemed to fix issue

- 0702 CTDR x2 **[061, 062]**
    - 100 litres for radium
    - Bottom water samples
    - pH bottle [062]
- 0758 CTDR x2 **[063, 064]**
    - 100 litres for radium

- o Bottom water samples
  - o pH bottle [064]
- 0846 gravity core, long **[065]**
  - o Maybe fell over? Questionable entry
  - o 46.5 cm recovered
    - ▪ AB, cc liner
  - o Porewater extracted on ship
- 0910 gravity core, long **[066]**
  - o over ‘pimples’
  - o 43.5 cm recovered
    - ▪ AB
    - ▪ cc liner
    - ▪ 1 bag cc
  - o Ice in cc liner
  - o Porewater extracted on ship
- 0944 gravity core, long **[067]**
  - o Supposed to be background, but contained ice
  - o 21.5 cm recovered
    - ▪ AB, cc liner
  - o Ice in cc
  - o Porewater extracted on ship
- 1012 gravity core, long **[068]**
  - o Background, other side of the hump from 067
  - o 214 cm recovered
    - ▪ AB/CD
    - ▪ cc liner
  - o Porewater extracted on ship
- 1051 CTD, standalone transect **[069 – 079]**
  - o Started on cast 8 [096], finished on cast 18 [079]
  - o Locations/times exported from Regulus
- 1243 CTDR x2 **[080, 081]**
  - o 100 litres for radium
  - o Surface water
  - o pH bottle [081]
- 1333 camera photos **[082]**
  - o 15 photos taken
  - o Locations/times exported from Regulus
- 1413 gravity core, long **[083]**
  - o Shallow depth
  - o 51 cm recovered
    - ▪ AB
  - o Porewater extracted on ship

- 1454 CTD standalone transect **[084 – 088]**
    - Started on cast 19 [084], finished on cast 23 [088]
    - Locations/times exported from Regulus
- 1554 CTDR x2 **[089, 090]**
    - 100 litres for radium
    - Surface water
    - No CTD cast taken on station 090
    - pH bottle [090]
- 1626 CTD, standalone transect **[091 – 096]**
    - Started on cast 24 [091], finished on cast 29 [096]
    - Locations/times exported from Regulus
- 1835 piston core **[097]**
    - In permafrost area
    - 130.5 recovered
        - AB/CD
            - CD has ice (we think)
                - In freezer
    - Porewater extracted on ship
- 2014 box core **[098]**
    - Entrance of Webb's Bay
    - Surface sample for UNB
- 2023 CTD standalone cast **[099]**
    - Entrance of Webb's Bay
    - Cast 30
- 2124 CTDR x2 **[100, 101]**
    - 100 litres for radium
    - Permafrost
    - Background (DEEP)
    - pH sample [101]

Ended day at 2200

July 18, 2023

Foggy, transited to Nain Bay around 0400

- 0700
    - Looked for mooring on multibeam
    - Confirmed presence
        - Only one buoy low in water column
        - Fog prevents us from releasing the mooring
- 0730 CTDR **[102]**
    - Water collected at 10 m for eDNA

        - 2 bottles
- 0820
    - Communicated with mooring responder
        - Responsive,
- 0921 microplastic trawl x2 **[104, 105]**
    - Completed 0956
- 1013
    - Mooring release triggered
        - No indication of popping
            - Release triggered ~5 times
            - Can still see small float near bottom of water column on MBES
    - Switched to trawl recovery for mooring
        - Completed 4 transects for trawl
- 1220
    - begin transit to offshore mooring, slowly with microplastic trawl
- 1221 microplastic trawl **[105]**
    - Completed at 1257
- 1300
    - En route to offshore mooring
    - Sunny, calm seas (1 m)
- 1724
    - On offshore station
- 1736 mooring trigger released **[106]**
    - 1745 buoy up
    - 1755 sediment trap up
    - Bottles removed, closed, and stored in the dark on ship – UNB
    - Both CTDs flushed, no data
    - Duet data useable, depth and temperature on trap
    - ADCP data useable

*Two of the three steel cables attached to the sediment trap cage were rusted and broken off. Two of the three eye loops on the sediment trap cage also corroded and broken off.

- 1849 CTDR **[107]**
    - 2 bottles fired at 5 m for eDNA
- 1905 Box core **[108]**
    - surface sample collection for UNB
- 1916 microplastic trawls **[109, 101, 111]**
    - Completed at 0007
- 0010
    - Transit back to Nain to borrow a bigger hook for mooring recovery attempt overnight with grapple

July 19, 2023

- Midnight
  - Arrived at Nain
    - 2 disembarked
    - Picked up bigger hook
      - Big hook and small hook connected to a chain horizontally to drag seafloor for recovery attempts
- 0050
  - Left Nain for Nain Bay
- 0300
  - On station for mooring recovery

Grappled all morning in a star pattern.

Tried releasing a few times, never worked. Continue seeing it in the water on the multibeam, so it is stuck there.

At 9h45, did a round pattern around it while surveying/ranging the transducer to locate position. Position located at 56 35' 41.96 / -61 57'51.44 at a depth of 72.6m

Mooring still in same location, per multibeam feed. Release not working, stuck on bottom
Morning calm, sunny, and warm in Nain Bay

- 0930
  - Finished mooring recovery attempt
  - Pinged for 5-7 minutes to triangulate mooring location
    - ~150-200 pings
- 1000
  - Transit back to Nain
- 1212
  - Docked in Nain

PRELIMINARY RESULTS

Subsea permafrost

A CTD transect in Webb's Bay showed that bottom waters ≤0°C occurred below 30 m water depth (Fig. 11). The 0°C isotherm is deeper than it was in July 2022 (Limoges et al., 2023), indicating an earlier warming of bottom waters than last year. To observe changes over an entire year, the temperature sensor from Nain Bay (Mo_in) can be used, even if it was positioned deeper than the depth of Webb's Bay (Fig. 12). The temperature sensor recovered from Nain Bay from a depth of 62 m indicates waters warmed above 0ºC around September/October, were at their warmest in November but started cooling by mid-November and dropped below 0 ºC in December.

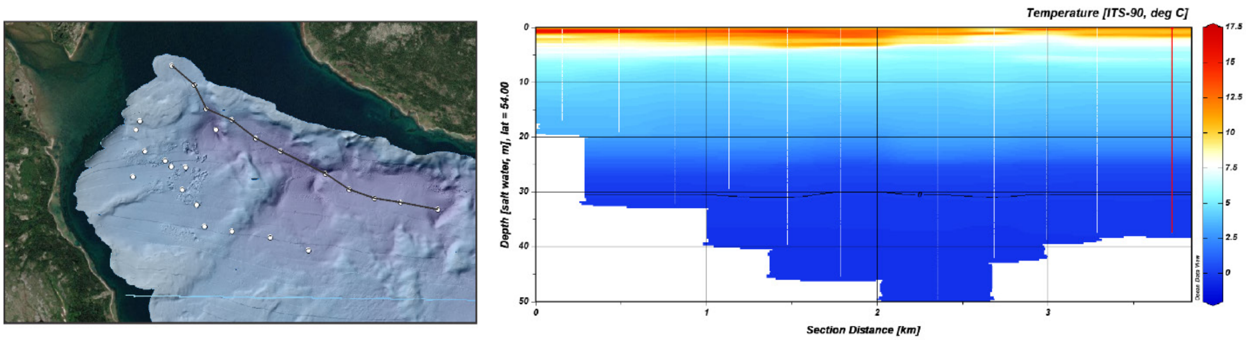

Figure 11. Water column profiles in Webb's Bay. Bottom water temperatures < 0°C appear to be a consistent feature in the bay.

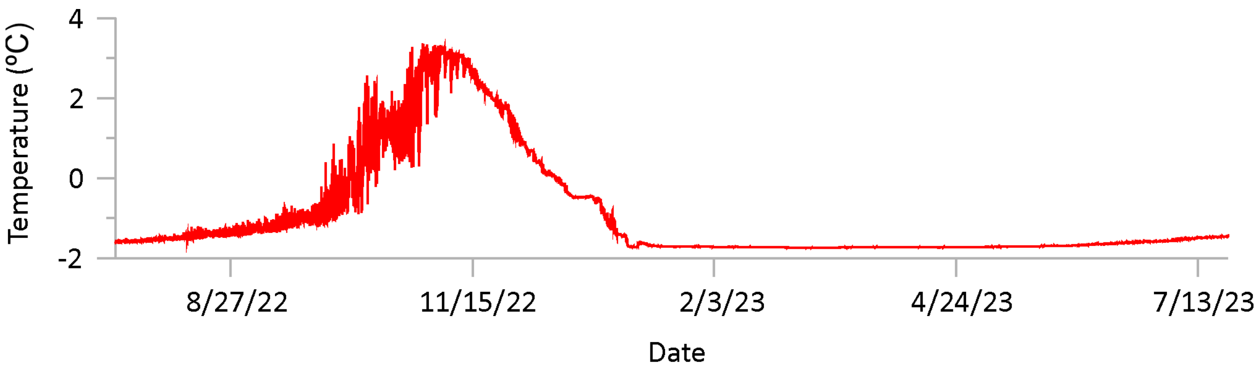

Figure 12. Water temperature in Nain Bay at Mo_in site

Repeat seabed mapping over the mounds and depressions area did not reveal major changes compared to 2021, although small changes are noticeable. Sediment cores were collected where there was suspicion of ice-rich sediment and fresh groundwater seepage (Table 6). The analysis of the porewater in the sediment cores and of radium isotopes in the bottom waters will allow us to better understand the origin of the permafrost.

Table 6. Purpose of sediment cores collected during the cruise. See text for details.

Station No.	Sample Type	Lat Bottom	Long Bottom	Location	Purpose
0003	GC	56.790041	61.906422	Webb's Bay	Porewater - SGD
0004	GC	56.786702	61.903225	Webb's Bay	Porewater - SGD
0008	GC	56.788148	61.906083	Webb's Bay	Porewater - background

0013	GC	56.782331	61.899091	Webb's Bay	Porewater - SGD
0019	GC	56.790132	61.900552	Webb's Bay	Porewater - SGD
0023	GC	56.790487	61.904763	Webb's Bay	Porewater - SGD
0024	AC	56.787517	61.894428	Webb's Bay	Porewater - Permafrost
0025	AC	56.78756	61.894638	Webb's Bay	Porewater - Permafrost
0026	AC	56.78739	61.894845	Webb's Bay	Porewater - Permafrost
0027	AC	56.776796	61.839926	Webb's Bay	Surface sediment
0031	AC	56.787327	61.757207	Webb's Bay	Surface sediment
0032	GC	56.775736	61.734026	Webb's Bay	Sea-level
0033	GC	56.774298	61.734683	Webb's Bay	Sea-level
0034	GC	56.777621	61.735824	Webb's Bay	Sea-level
0038	GC	56.787285	61.894561	Webb's Bay	Porewater - Permafrost
0041	GC	56.793062	61.904142	Webb's Bay	Porewater - SGD
0045	AC	56.785024	61.884553	Webb's Bay	Porewater - Background
0046	AC	56.785195	61.88536	Webb's Bay	Porewater - Background
0047	AC	56.785477	61.88541	Webb's Bay	Porewater - Background
0048	GC	56.776926	61.796935	Webb's Bay	Holocene record
0049	GC	56.777093	61.796179	Webb's Bay	Holocene record
0050	GC	56.77454	61.735398	Webb's Bay	Sea-level
0053	GC	56.786197	61.896503	Webb's Bay	Porewater - Permafrost
0058	GC	56.78608	61.894397	Webb's Bay	Pimples - permafrost
0065	GC	56.793619	61.905158	Webb's Bay	Porewater - SGD
0066	GC	56.787277	61.892296	Webb's Bay	Porewater - Permafrost
0067	GC	56.785165	61.887378	Webb's Bay	Porewater - Permafrost
0068	GC	56.782108	61.881617	Webb's Bay	Background
0083	GC	56.779988	61.898997	Webb's Bay	Porewater - SGD
0097	PC	56.788307	61.893736	Webb's Bay	Porewater - permafrost
0098	BC	56.760817	61.725579	Webb's Bay	Surface sediment
0108	BC	56.510728	61.005339	Offshore	Surface sediment

Benthic habitats

Webb's Bay had previously been surveyed in 2022, revealing limited biological diversity and abundance. The habitat itself appeared homogeneous and was composed entirely of fine sediments with some patches of benthic diatoms (microalgal mats). To confirm these initial findings, a more thorough exploration of the region was conducted, leading to the identification of similar patterns in both biological life and substrate composition. The scarcity of benthic epifauna in Webb's Bay is a distinct characteristic of the Nain region, potentially influenced by the impact of subsea permafrost. Nevertheless, additional investigations are necessary to establish this connection with certainty.

Throughout all four photographic transects, the dominant substrate were fine sediments (i.e., mud and/or sand) (Fig. 13). Typically, these substrates in the Nain region would host abundant invertebrate taxa, including brittle stars (Ophiuroidea spp.) and tube-dwelling anemones (Ceriantharia spp.). Many sites also displayed an extensive coverage of benthic diatom mats atop the fine sediments, indicative of heightened productivity (Fig. 13A). These mats formed a discernible brown layer over the sediment.

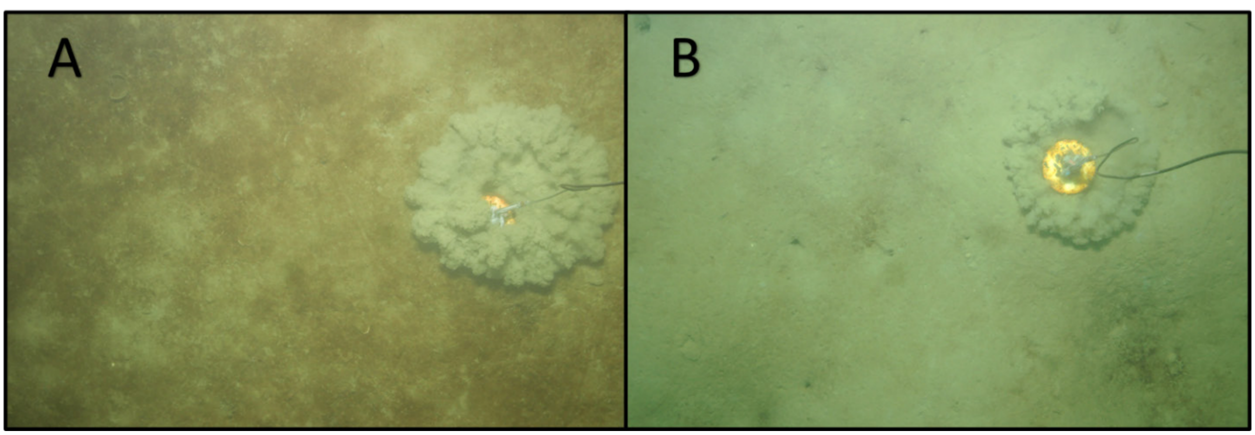

Figure 13. Dominant substrates identified in Webb's Bay, Nain. A) Fine sediments overlain with benthic diatom mats (brown coverage); B) Fine sediments.

Few taxa were observed in the photographic transects. Initial visual analysis of the images showed the presence of invertebrate taxa such as ascidians (Tunicata spp.), which formed minor clusters along the fine sediment (refer to Fig. 14A). In addition, infauna was evident in the photos, with bivalve siphons exposed above the sediment, along with signs of bioturbation (see Fig. 14B & 14C). One ctenophore (Bolinopsis infundibulum) was observed swimming above the seafloor (Fig. 14D). Occasional sightings of small bryozoans (Bryozoa spp.) and aggregations of sponges, likely Haliclona spp., were recorded at a low density (see Fig. 14E and 14F). Additionally, the tentacles of a sea cucumber (Psolus spp.) were observed (Fig. 14G). These had been noted in high abundance during the 2022 photographic survey within cobble-rich areas of Webb's Bay

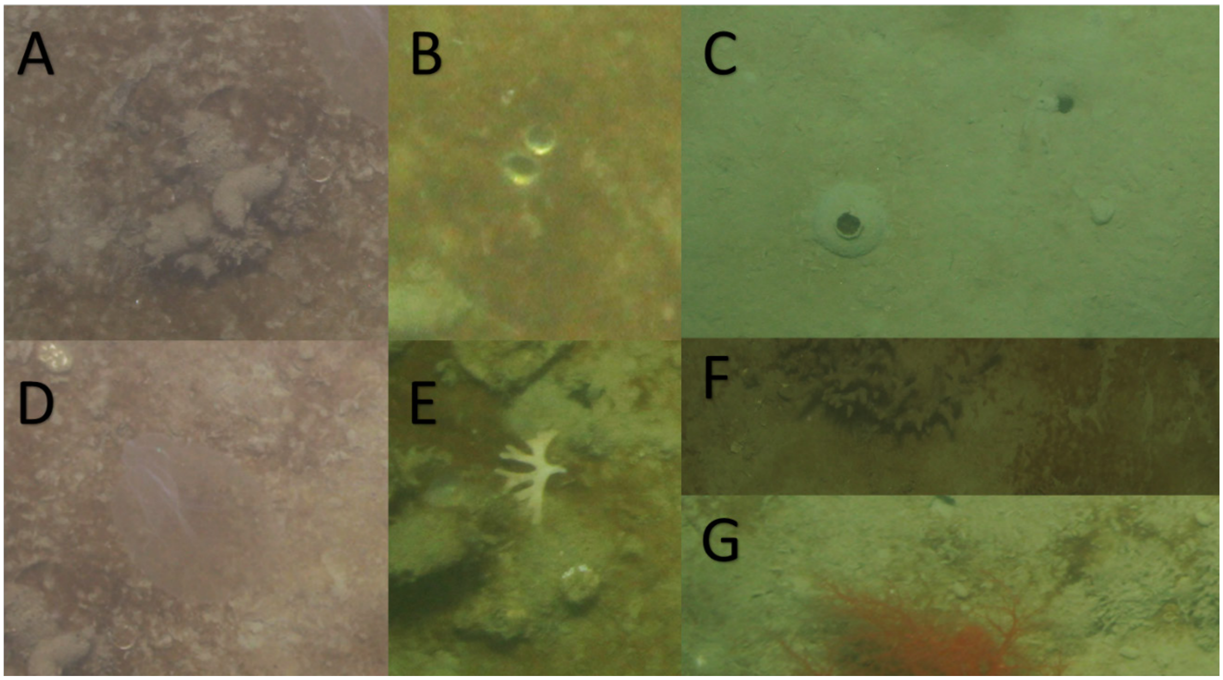

Figure 14. Benthic invertebrate taxa identified in Webb's Bay, Nain. A) Ascidians; B) Bivalve; C) Infauna bioturbation; D) Ctenophore; E) Bryozoan; F) Sponge; G) Sea cucumber.

REFERENCES

Clark, P.U., Fitzhugh, W.W., 1990. Late deglaciation of the central Labrador coast and its implications for the age of glacial lakes Naskaupi and McLean and for prehistory. Quaternary Research 34, 296–305. https://doi.org/10.1016/0033-5894(90)90042-J

Cowan, B., Carter, J., Forbes, D.L., Bell, T., 2022. Postglacial sea-level lowstand on Cumberland Peninsula, Baffin Island, Nunavut. Can. J. Earth Sci. 59, 772–784. https://doi.org/10.1139/cjes-2021-0026

Hargrave, B.T., Walsh, I.D., Murray, D.W., 2002. Seasonal and spatial patterns in mass and organic matter sedimentation in the North Water. Deep Sea Research Part II: Topical Studies in Oceanography 49, 5227–5244.

King, E.L., Normandeau, A., Carson, T., Fraser, P., Staniforth, C., Limoges, A., MacDonald, B., Murrillo-Perez, F.J., Van Nieuwenhove, N., 2022. Pockmarks, a paleo fluid efflux event, glacial meltwater channels, sponge colonies, and trawling impacts in Emerald Basin, Scotian Shelf: autonomous underwater vehicle surveys, William Kennedy 2022-001 cruise report (No. 8933). https://doi.org/10.4095/331174

Limoges, A., Normandeau, A., Eamer, J.B.R., Van Nieuwenhove, N., Atkinson, M., Sharpe, H., Audet, T., Carson, T., Nochasak, C., Pijogge, L., Winters, J., 2023. 2022William-Kennedy expedition: Nunatsiavut Coastal Interaction Project (NCIP) (No. 8994). https://doi.org/10.4095/332085

Paull, C.K., Ussler, W., Dallimore, S.R., Blasco, S.M., Lorenson, T.D., Melling, H., Medioli, B.E., Nixon, F.M., McLaughlin, F.A., 2007. Origin of pingo-like features on the Beaufort Sea shelf and their possible relationship to decomposing methane gas hydrates. Geophysical Research Letters 34, 1–5. https://doi.org/10.1029/2006GL027977

Vacchi, M., Engelhart, S.E., Nikitina, D., Ashe, E.L., Peltier, W.R., Roy, K., Kopp, R.E., Horton, B.P., 2018. Postglacial relative sea-level histories along the eastern Canadian coastline. Quaternary Science Reviews 201, 124–146. https://doi.org/10.1016/j.quascirev.2018.09.043

APPENDIX A: STATION SUMMARY

Table A 1: List of all stations

Station No.	Sample Type	J Day	UTC	Lat.	Long.	Location	Water Depth (m)	Rosette Depth (m)	Net Depth (m)	Corer length (cm)	App. Penetration (cm)	Core length (cm)	No. of Sections	Bagged	No. of Samples	Comments
0001	MPN	195	1621	56.792037	61.89741	Webb's Bay	41	--	Surface	--	--	--	--	--	--	Net hauled at surface of water for 30 min for microplastic analyses. Azimut 116. Speed 2 kn.
0002	SW	195	1630	56.797150	61.912257	Webb's Bay, River Mouth	approx. 1m	--	--	--	--	--	--	--	--	5 cubitainers (20L) filled by hand from zodiac boat at river mouth for Radium analyses of cartridge 002 on Geopump. Low tide at river mouth.
0003	GC	195	1820	56.790041	61.906422	Webb's Bay	25	--	--	140	60	29.5	1	0		Pore water extracted for Dal.
0004	GC	195	1835	56.786702	61.903225	Webb's Bay	26	--	--	370	85	47.5	1	1		1 bag for core catcher. Pore water extracted for Dal.
0005	CTDR	195	1859	56.787555	61.905311	Webb's Bay	27	26.4	--	--	--	--	--	--	--	3 cubitainers (20L) filled for Radium analyses of cartridge 005-006 by gravity. For background conditions. Touched bottom with CTD
0006	CTDR	195	1939	56.787626	61.905885	Webb's Bay	27.8	26.5	--	--	--	--	--	--	--	2 cubitainers (20L) filled for Radium analyses of cartridge 005-006 by gravity. For background conditions. 11 bottles fired at 26.5 m. 1 bottle at 3m for eDNA (see coordinate at surface). 1 water sample for pH analyses.
0007	CTD	195	1959	56.788025	61.906722	Webb's Bay	28	--	--	--	--	--	--	--	--	
0008	GC	195	2022	56.788148	61.906083	Webb's Bay	28	--	--	370	191	151	1	1		1 bag for core catcher. Pore water extracted for Dal.
0009	MPN	195	2047	56.786646	61.899659	Webb's Bay	30	--	Surface	--	--	--	--	--	--	Net hauled at surface of water for 30 min for microplastic

																analyses. Azimut 105. Speed 2 kn.
0010	MPN	195	2117	56.781792	61.885145	Webb's Bay	37	--	Surface	--	--	--	--	--	--	Net hauled at surface of water for 30 min for microplastic analyses. Azimut 278. Speed 2.5 kn.
0011	CTDR	195	2158	56.781982	61.895477	Webb's Bay	26.5	25	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 011-012 by gravity.
0012	CTDR	195	2229	56.781534	61.895709	Webb's Bay	25.8	24.5	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 011-012 by gravity. 1 water sample for pH analyses.
0013	GC	195	2248	56.782331	61.899091	Webb's Bay	26	--	--	370	86	49.5	1	0	--	Pore water extracted for Dal.
0014	CTDR	195	0018	56.781496	61.897225	Webb's Bay	24.6	--	--	--	--	--	--	--	--	Just the CTD on the Rosette. No water sampling. Configuration file 2022.
0015	CTDR	195	0031	56.782037	61.892965	Webb's Bay	30	--	--	--	--	--	--	--	--	Just the CTD on the Rosette. No water sampling. Configuration file 2022.
0016	CTDR	195	0058	56.782365	61.893663	Webb's Bay	30	--	--	--	--	--	--	--	--	Just the CTD on the Rosette. No water sampling. Configuration file 2023.
0017	CTDR	196	1021	56.790479	61.903705	Webb's Bay	27.7	26	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 017-018 by gravity.
0018	CTDR	196	1054	56.790494	61.902981	Webb's Bay	27.3	25	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 017-018 by gravity. 1 water sample for pH analyses.
0019	GC	196	1115	56.790132	61.900552	Webb's Bay	29	--	--	370	225	178	2	0	--	AB = 150.5 cm CD = 27.5 cm
0020	CTDR	196	1147	56.786538	61.902267	Webb's Bay	28.2	25	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 020-021. 1 bottle at bottom for eDNA.
0021	CTDR	196	1216	56.786657	61.902899	Webb's Bay	26.8	24	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 020-021 by gravity. 1 water sample for pH analyses.
0022	CAM	196	1248	56.790087	-61.90426	Webb's Bay	26.8	--	--	--	--	--	--	--	--	
0023	GC	196	1312	56.790487	61.904763	Webb's Bay	25.6			140	56	30	1	0	--	
0024	AC	196	1348	56.787517	61.894428	Webb's Bay	30	--	--	--	--	20.5	1	0	--	Pore water extracted for Dal.

0025	AC	196	1357	56.78756	61.894638	Webb’s Bay	29.7	--	--	--	--	20	1	0	--	Pore water extracted for Dal.
0026	AC	196	1405	56.78739	61.894845	Webb’s Bay	30	--	--	--	--	20	1	1	--	Pore water extracted for Dal. 1 sample of surface sediment for UNB.
0027	AC	196	1441	56.776796	61.839926	Webb’s Bay	36.8	--	--	--	--	0	0	1	--	Algar Corer used to collect surface sample. No cores were kept. Only scraped the surface of sediment. UNB: 1 sample.
0028	CTDR	196	1532	56.779186	61.899685	Webb’s Bay	16.6	14	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 028-029.
0029	CTDR	196	1558	56.77933	61.899216	Webb’s Bay	17.2	15	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 028-029. 1 water sample for pH analyses.
0030	CTDR	196	1704	56.786474	61.760354	Webb’s Bay	45	43	--	--	--	--	--	--	--	Just the CTD on the Rosette. No water sampling.
0031	AC	196	1720	56.787327	61.757207	Webb’s Bay	46.5	--	--	--	--	--	--	1	--	Algar Corer used to collect surface sample. No cores were kept. Only scraped the surface of sediment. UNB: 1 sample.
0032	GC	196	1752	56.775736	61.734026	Webb’s Bay	16	--	--	370	118	96	1	2	--	1 bag for core catcher. 1 bag for core cutter.
0033	GC	196	1819	56.774298	61.734683	Webb’s Bay	17.3	--	--	370	236	183	2	1	--	2 sections AB = 150cm CD = 33 cm, 1 bag core catcher
0034	GC	196	1901	56.777621	61.735824	Webb’s Bay	14.6	--	--	370	236	240	2	1	--	2 sections AB = 150cm CD = 89 cm, 1 liner for core catcher = 14 cm
0035	CTDR	196	2010	56.776211	61.837826	Webb’s Bay	39	37	--	--	--	--	--	--	--	Water sample taken at 15 m deep for eDNA analyses : 56,775939 ; -61,836638 UTC 2014
0036	CTDR	196	2056	56.788025	61.894326	Webb’s Bay	31.4	30	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 036-037 by gravity.
0037	CTDR	196	2137	56.787791	61.894669	Webb’s Bay	34	29	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 036-037 by gravity. 1 water sample for pH analyses.
0038	GC	196	2150	56.787285	61.894561	Webb’s Bay	31	--	--	370	80	38	1	2	--	1 section AB 38 cm; 1 liner for core catcher 10 cm; 1 bag for core catcher, partly frozen sediment in core catcher. Coring target is permafrost.

0039	CTDR	197	1019	56.793663	61.903033	Webb's Bay	19.6	14.5	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 039-040 by gravity.
0040	CTDR	197	1048	56.793714	61.90303	Webb's Bay	20	16	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 039-040 by gravity. 1 water sample for pH analyses.
0041	GC	197	1058	56.793062	61.904142	Webb's Bay	23.9	--	--	370	150	94.5	1	1	--	1 bag for core catcher. Pore water extracted for Dal.
0042	CTDR	197	1125	56.787613	61.894875	Webb's Bay	30	26	--	--	--	--	--	--	3	3 sample taken at different depth for DFO. 1 sample at 26 m (see bottom for coord.) 1 sample at 15 m (56.787649, -61.894956, UTC 1128) and 1 sample at 2 m (see surface up for coord.)
0043	CTDR	197	1202	56.786022	61.888619	Webb's Bay	33	30	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 043-044 by gravity.
0044	CTDR	197	1229	56.78615	61.88829	Webb's Bay	32.9	30	--	--	--	--	--	--	3	Cubitainers (20L) filled for Radium analyses of cartridge 043-044 by gravity. 1 water sample for pH analyses. 3 sample taken at different depth for DFO. 1 sample at 30 m (see bottom for coord.) 1 sample at 15 m (56.786264, -61.888131, UTC 1233) and 1 sample at 2 m (see surface up for coord.)
0045	AC	197	1255	56.785024	61.884553	Webb's Bay	30	--	--	--	--	15	1	--	--	Algar corer. Pore water extracted for Dal.
0046	AC	197	1304	56.785195	61.88536	Webb's Bay	29.3	--	--	--	--	15.5	1	--	--	Algar corer. Pore water extracted for Dal.
0047	AC	197	1310	56.785477	61.88541	Webb's Bay	28.9	--	--	--	--	14	1	--	--	Algar corer. Pore water extracted for Dal.
0048	GC	197	1354	56.776926	61.796935	Webb's Bay	47	--	--	370	317	225	2	2	--	2 sections AB = 150 cm CD = 69 cm 1 bag for core cutter, 1 liner for core catcher = 13.5 cm liner entered sideways in sediments
0049	GC	197	1420	56.777093	61.796179	Webb's Bay	47	--	--	370	317	223	2	1	--	2 sections AB = 150 cm CD = 71.5 cm, 1 liner for core catcher = 14.5 cm, liner entered straight in sediments

0050	GC	197	1517	56.77454	61.735398	Webb's Bay	17.7	--	--	370	312	252	2	2	--	2 sections AB = 150 cm CD = 99 cm, 1 bag + 1 liner for core catcher = 8 cm,
0051	CTDR	197	1647	56.785972	61.897046	Webb's Bay	27.7	25	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 051-052 by gravity with sample taken at 5m deep. 56.786105; -61.897407; UTC 1651; 5m deep
0052	CTDR	197	1715	56.786011	61.897658	Webb's Bay	28	24	--	--	--	--	--	--	3	Cubitainers (20L) filled for Radium analyses of cartridge 051-052 by gravity with sample taken at 5m deep. (56.786210; -61.897699; UTC 1721) 1 water sample for pH analyses at 5m deep. 3 sample taken at different depth for DFO: 1 sample at 24 m (see bottom for coord.) 1 sample at 15 m (56.786145, -61.897624, UTC 1233) and 1 sample at 5 m (56.786210; -61.897699; UTC 1721)
0053	GC	197	1749	56.786197	61.896503	Webb's Bay	27.7	--	--	370	110	79	1	0	--	Pore water extracted for Dal.
0054	CAM	197	1825	56.780961	-61.891137	Webb's Bay	26	--	--	--	--	--	--	--	--	20 photos of seabed were taken.
0055	CAM	197	1903	56.779965	-61.897775	Webb's Bay	22	--	--	--	--	--	--	--	--	17 photos of seabed were taken.
0056	CTDR	197	1945	56.785469	61.908237	Webb's Bay	22	19	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 056-057 by gravity.
0057	CTDR	197	2010	56.785492	61.908731	Webb's Bay	20.5	18	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 056-057 by gravity. 1 water sample for pH analyses.
0058	GC	197	2036	56.78608	61.894397	Webb's Bay	29	--	--	370	270	165	2	1		2 sections AB = 141 cm, CD = 17.5 cm and 1 liner 17.5 cm for core catcher sediment.
0059	CTD	197	2120	56.788902	61.896824	Webb's Bay	30	26.8	--	--	--	--	--	--	--	CTD stand alone
0060	CTD	197	2149	56.7927	61.891041	Webb's Bay	57	53								CTD stand alone. CTD hit bottom.
0061	CTDR	198	1005	56.794486	61.898724	Webb's Bay	20	17	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 061-062 by gravity.

0062	CTDR	198	1027	56.794724	61.898804	Webb's Bay	19.5	16	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 061-062 by gravity. 1 water sample for pH analyses.
0063	CTDR	198	1101	56.781488	61.910546	Webb's Bay	19.4	15	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 063-064 by gravity.
0064	CTDR	198	1125	56.781818	61.91106	Webb's Bay	20	16	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 063-064 by gravity. 1 water sample for pH analyses.
0065	GC	198	1146	56.793619	61.905158	Webb's Bay	18.8	--	--	370	N/A	33.5	1	1	--	1 section AB 33.5 cm + 1 liner for core catcher sediment = 13 cm ; Corer potentially fell on the side when entering the seabed. Pore water extracted for Dal.
0066	GC	198	1210	56.787277	61.892296	Webb's Bay	30	--	--	370	71	35	1	2	--	1 section AB 35 cm + 1 liner for core catcher sediment = 8.5 cm and 1 bag for core catcher sediments. Ice in sediment of core catcher. Liner with cc sediment has been put in freezer. Pore water extracted by Dal.
0067	GC	198	1244	56.785165	61.887378	Webb's Bay	31.5	--	--	370	44	13	1	1	--	1 section AB 13 cm + 1 liner for core catcher sediment = 8.5 cm. Ice in sediment of core catcher. Liner with cc sediment has been put in freezer. Pore water extracted by Dal. Aimed to be background conditions, but still permafrost conditions.
0068	GC	198	1312	56.782108	61.881617	Webb's Bay	38	--	--	370	315	198	2	1	--	2 sections AB = 144.5 cm, CD =57 cm and 1 liner 16 cm for core catcher sediment. No ice. Background conditions. Pore water extracted.
0069	CTD	198	13:53	56.784161	-61.849825	Webb's Bay	45		--	--	--	--	--	--	--	Failed. Same record as station 0070
0070	CTD	198	14:04	56.784927	-61.856888	Webb's Bay	45		--	--	--	--	--	--	--	
0071	CTD	198	14:12	56.785438	-61.861597	Webb's Bay	44	40	--	--	--	--	--	--	--	
0072	CTD	198	14:20	56.786354	-61.866399	Webb's Bay	47	43	--	--	--	--	--	--	--	

0073	CTD	198	14:29	56.78802	-61.870812	Webb’s Bay	53	50	--	--	--	--	--	--	--	
0074	CTD	198	14:40	56.790374	-61.879123	Webb’s Bay	49	45	--	--	--	--	--	--	--	
0075	CTD	198	14:49	56.791767	-61.883576	Webb’s Bay	45	40	--	--	--	--	--	--	--	
0076	CTD	198	14:57	56.793655	-61.888061	Webb’s Bay	34	30	--	--	--	--	--	--	--	
0077	CTD	198	15:05	56.794884	-61.892786	Webb’s Bay	38	33	--	--	--	--	--	--	--	
0078	CTD	198	15:14	56.797291	-61.894971	Webb’s Bay	22	19	--	--	--	--	--	--	--	
0079	CTD	198	15:25	56.799296	-61.899067	Webb’s Bay	19	15	--	--	--	--	--	--	--	
0080	CTDR	198	1545	56.793472	61.900526	Webb’s Bay	21	17	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 080-081 by gravity with sample taken at 5m deep. (56.793518; -61.900581; UTC 1548)
0081	CTDR	198	1613	56.793663	61.900351	Webb’s Bay	20	16	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 080-081 by gravity with sample taken at 5m deep. (56.793732; -61.900486; UTC 1618) + 1 sample for pH analyses at 5m deep.
0082	CAM	198	16:33	56.793532	-61.90322	Webb’s Bay	19	--	--	--	--	--	--	--	--	15 photos taken at bottom with 4k camera.
0083	GC	198	1712	56.779988	61.898997	Webb’s Bay	21	--	--	370	62	51	1	--	--	8
0084	CTD	198	17:55	56.793769	-61.905162	Webb’s Bay	17	12	--	--	--	--	--	--	--	
0085	CTD	198	18:06	56.792875	-61.90596	Webb’s Bay	20	15	--	--	--	--	--	--	--	
0086	CTD	198	18:17	56.790606	-61.904404	Webb’s Bay	24	20	--	--	--	--	--	--	--	
0087	CTD	198	18:28	56.789572	-61.90063	Webb’s Bay	28	23	--	--	--	--	--	--	--	
0088	CTD	198	18:43	56.789001	-61.899468	Webb’s Bay	29	25	--	--	--	--	--	--	--	
0089	CTDR	198	1855	56.788522	61.899296	Webb’s Bay	28	23	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 089-090 by gravity with sample taken at 5m deep. (56.788673; -61.899266; UTC 1852)

0090	CTDR	198	1914	56.788916	61.900019	Webb's Bay	29	5	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 089-090 by gravity with sample taken at 5m deep. (56.788916; -61.900019; UTC 1914) + 1 sample for pH analyses at 5m deep. No CTD profile, just water sampling at 5m.
0091	CTD	198	19:27	56.786667	-61.897488	Webb's Bay	29	24	--	--	--	--	--	--	--	
0092	CTD	198	19:39	56.785048	-61.894851	Webb's Bay	29	24	--	--	--	--	--	--	--	
0093	CTD	198	19:49	56.782853	-61.893432	Webb's Bay	30	25	--	--	--	--	--	--	--	
0094	CTD	198	20:08	56.780182	-61.874118	Webb's Bay	39	34	--	--	--	--	--	--	--	
0095	CTD	198	20:22	56.781565	-61.881252	Webb's Bay	37	32	--	--	--	--	--	--	--	
0096	CTD	198	20:35	56.782297	-61.888426	Webb's Bay	31	26	--	--	--	--	--	--	--	
0097	PC	198	2135	56.788307	61.893736	Webb's Bay	32	--	--	370?	185	130.5	2	0	--	Piston core over permafrost area. 2 sections AB = 85 cm, CD = 45.5. Potential presence of ice in section CD. CD was put in freezer. Pore water extracted in AB.
0098	BC	198	2314	56.760817	61.725579	Webb's Bay	38	--	--	--	--	--	--	2	--	1 sample for UNB. 1 sample for GSC for grainsize.
0099	CTD	198	2321	56.760792	61.726026	Webb's Bay	37	33	--	--	--	--	--	--	--	
0100	CTDR	198	0029	56.791862	61.890900	Webb's Bay	52	46	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 100-101 by gravity.
0101	CTDR	198	0053	56.791865	61.889974	Webb's Bay	55	48	--	--	--	--	--	--	--	Cubitainers (20L) filled for Radium analyses of cartridge 100-101 by gravity + 1 sample for pH analyses.
0102	CTDR	199	1034	56.597593	61.962876	Webb's Bay	75	70	--	--	--	--	--	--	--	Water samples collected at 10 m deep for eDNA analyses 56, 597487, -61.962427, UTC 1040.
0103	MPN	199	1142	56.595655	61.969555	Webb's Bay	72	--	Surface	--	--	--	--	--	--	Microplastics collected by Research Center. Net hauled at surface at 2kn for 30 minutes.
0104	MPN	199	1220	56.60214	62.030045	Webb's Bay	64	--	Surface	--	--	--	--	--	--	Microplastics collected by Research Center. Net hauled at surface at 2kn for 30 minutes.

0105	MPN	199	1522	56.594845	61.951821	Webb’s Bay	79	--	Surface	--	--	--	--	--	--	Microplastics collected by Research Center. Net hauled at surface at 2kn for 30 minutes.
0106	Mooring	199	2036	56.506461	61.004948	Off shore	122	--	--	--	--	--	--	--	--	Buoy and ADCP onboard 56.508821; 61.008195, UTC 2045. Sediment trap on board 56.508041, 61.005762, UTC 2055.
0107	CTDR	199	2151	56.509910	61.006901	Off shore	123	115	--	--	--	--	--	--	--	Water samples for eDNA taken at 5 m deep (see coord. for surface down).
0108	BC	199	2202	56.510728	61.005339	Off shore	125	--	--	--	--	--	--	--	--	1 sample for UNB. 1 sample for GSC for grain size.
0109	MPN	199	2216	56.514870	61.002620	Off shore	124	--	--	--	--	--	--	--	--	Microplastics collected by Research Center. Net hauled at surface at 2kn for 30 minutes. Azimut 300.
0110	MPN	199	2302	56.524690	61.057678	Off shore	62	--	--	--	--	--	--	--	--	Microplastics collected by Research Center. Net hauled at surface at 2kn for 30 minutes. Azimut 280.
0111	MPN	199	2336	56.532498	61.097659	Off shore	65	--	--	--	--	--	--	--	--	Microplastics collected by Research Center. Net hauled at surface at 2kn for 30 minutes. Azimut 294.
0112	Mooring	204	--	56.594989	-61.964289	Nain Bay	72	--	--	--	--	--	--	--	--	Recovered in 2 sections. Upper floats recovered on July 20. Lower float and instruments recovered on July 24, 4 days after the mooring was released. See cruise report for details

APPENDIX B: LOCATION OF SAMPLING STATIONS

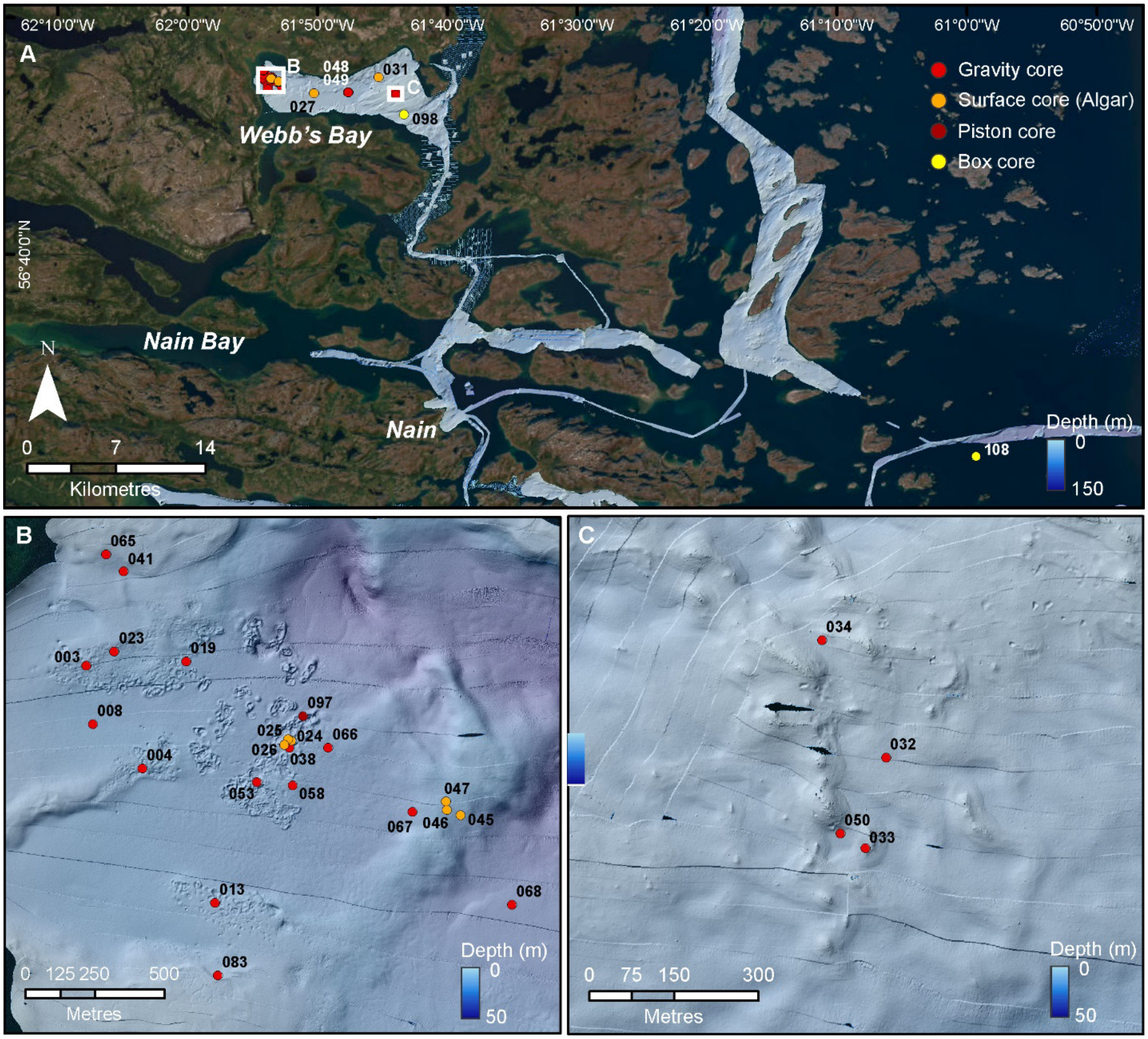

Figure B 1. Location of gravity cores, surface cores, piston cores and box cores.

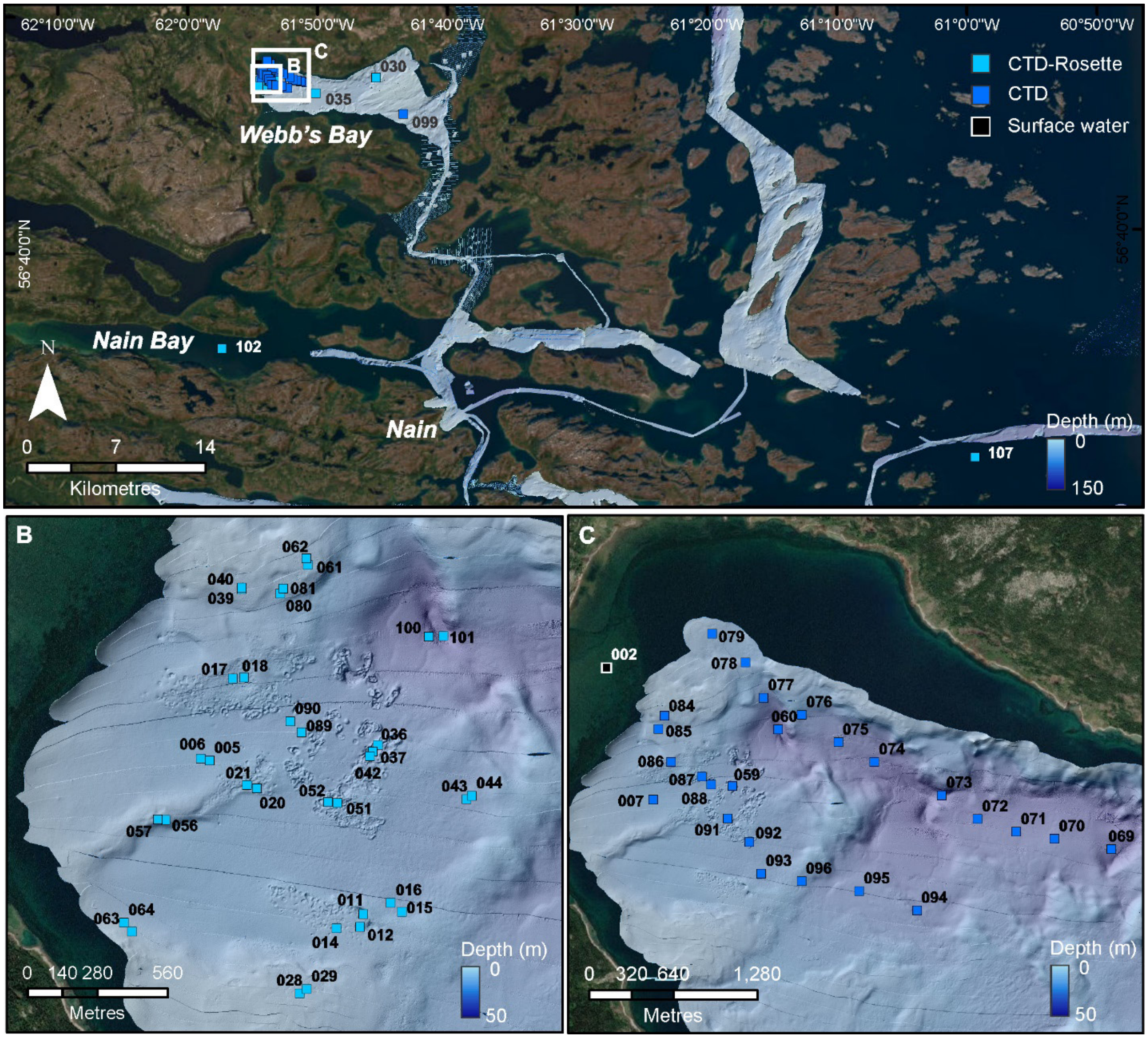

Figure B 2. Location of surface water sample, CTD and CTD-Rosettes

Figure B 3. Location of micro-plastic nets trawls and camera stations.

APPENDIX C: CORE STRATIGRAPHY

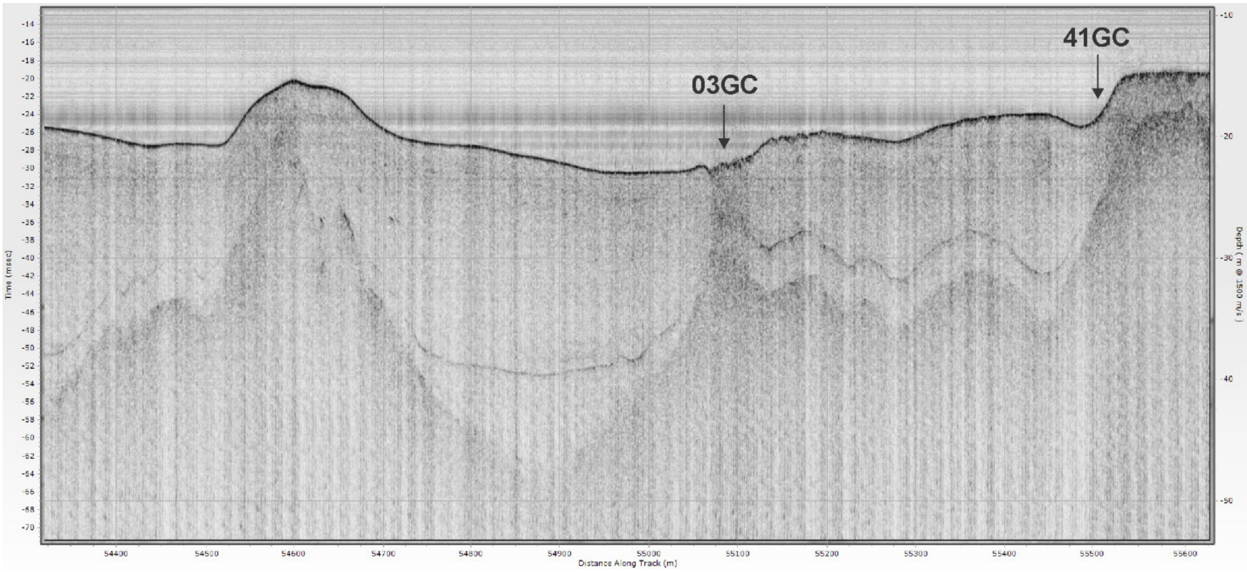

Figure C 1. Stratigraphy of cores 03 and 41.

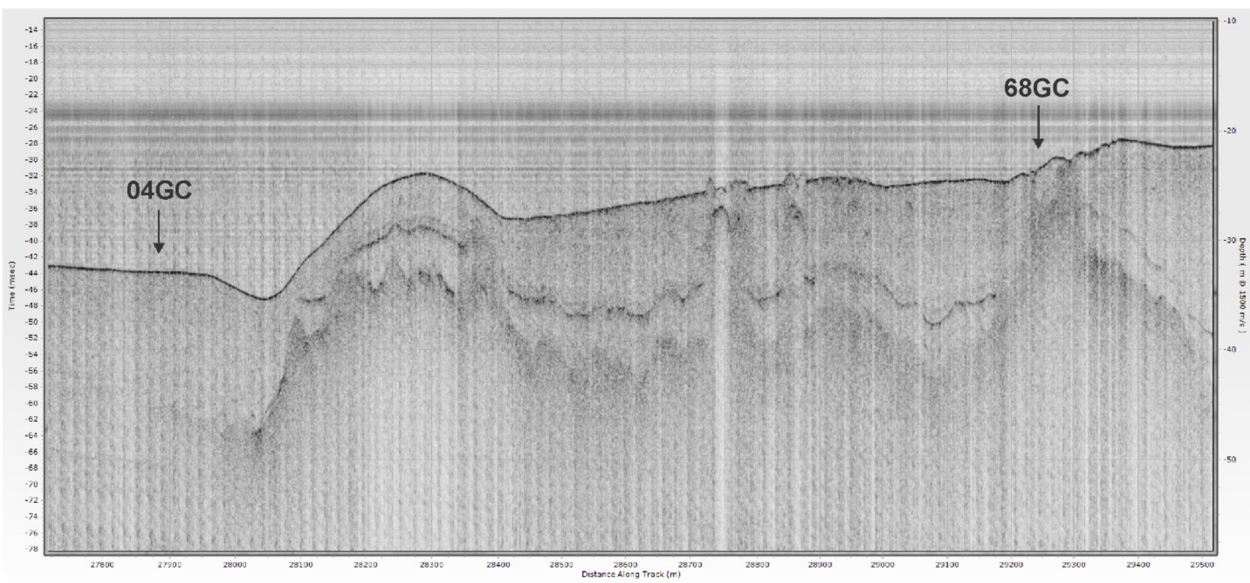

Figure C 2. Stratigraphy of cores 04 and 68.

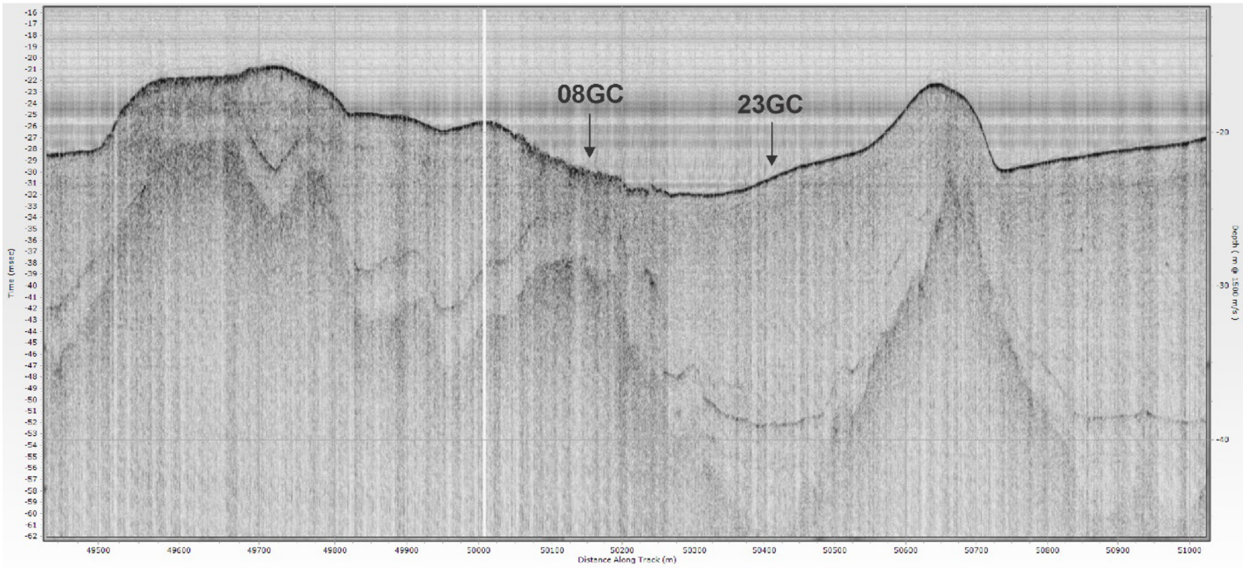

Figure C 3. Stratigraphy of cores 08 and 23.

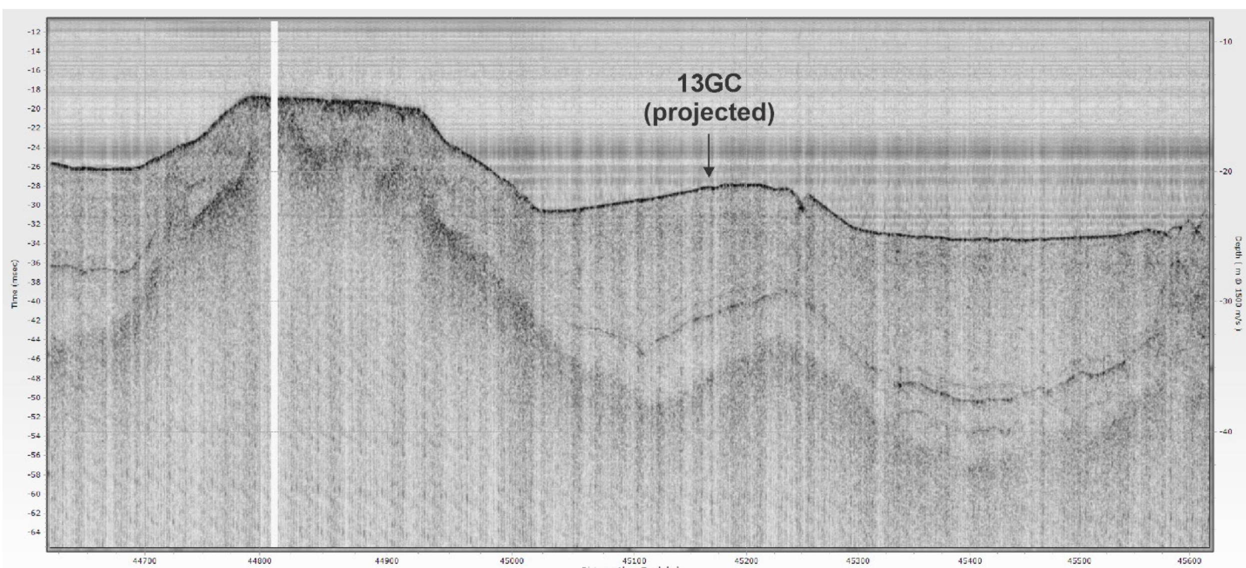

Figure C 4. Stratigraphy of core 13.

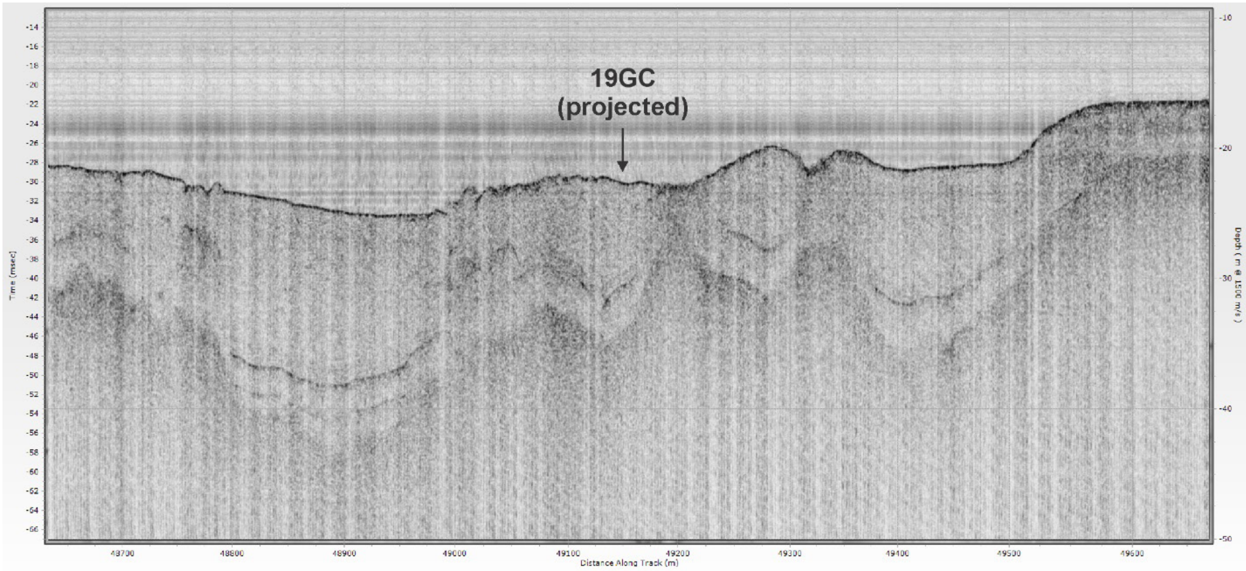

Figure C 5. Stratigraphy of core 19.

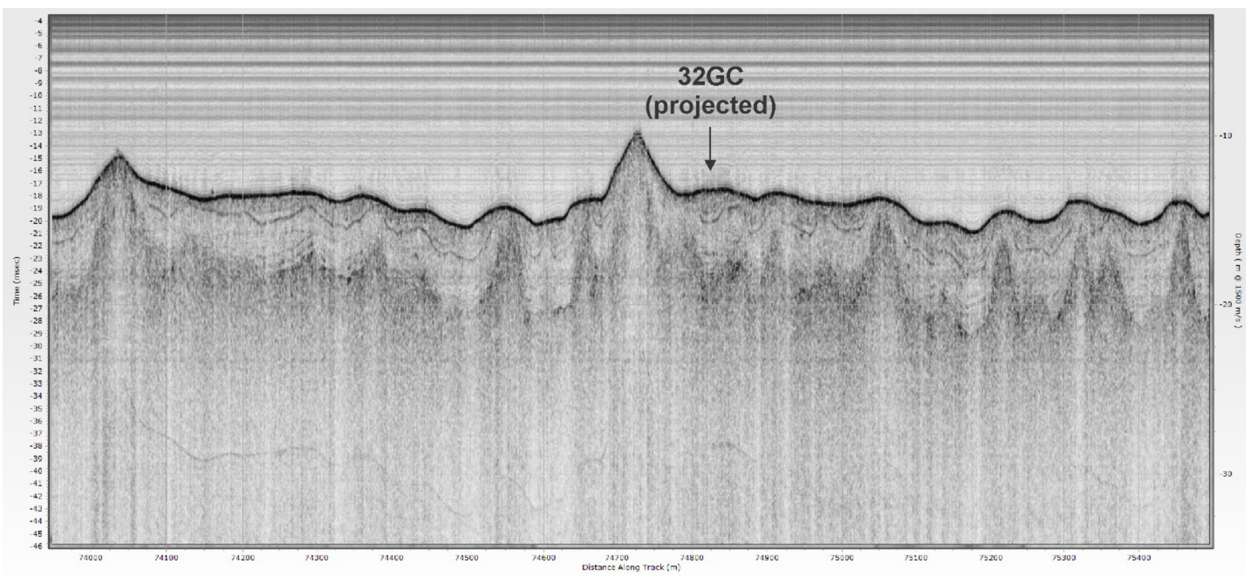

Figure C 6. Stratigraphy of core 32.

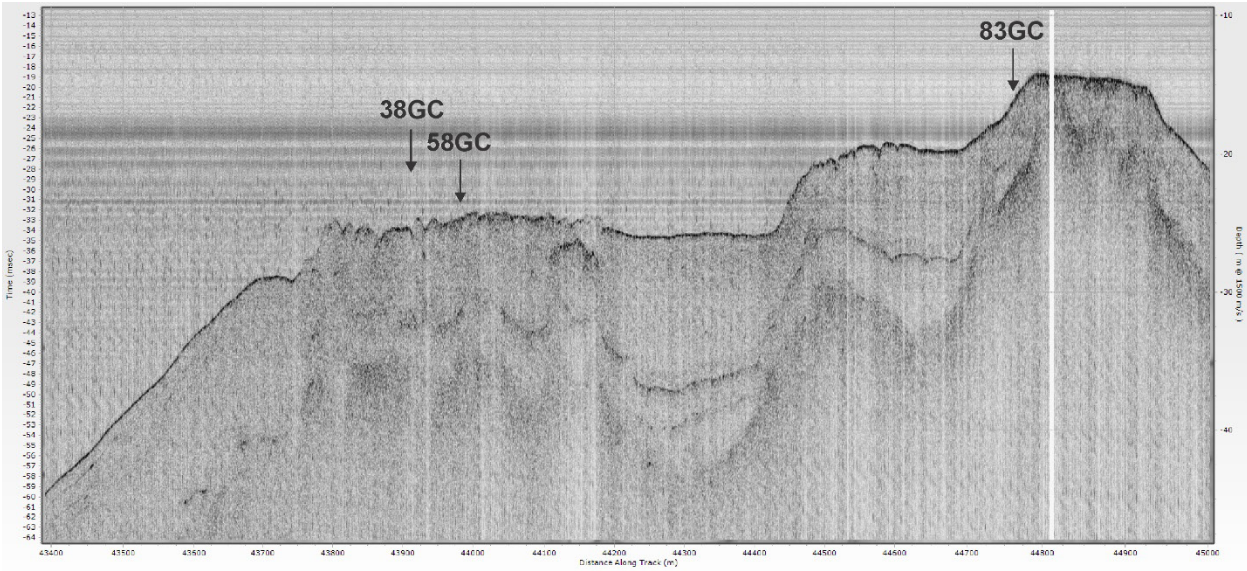

Figure C 7. Stratigraphy of cores 38, 58 and 83.

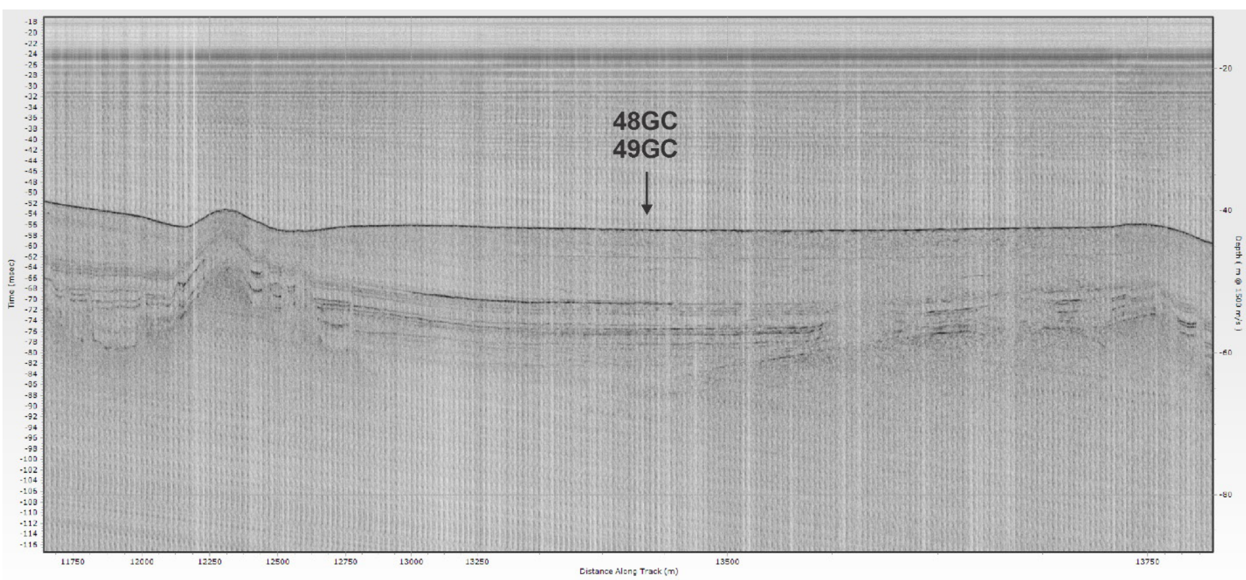

Figure C 8. Stratigraphy of cores 48 and 49.

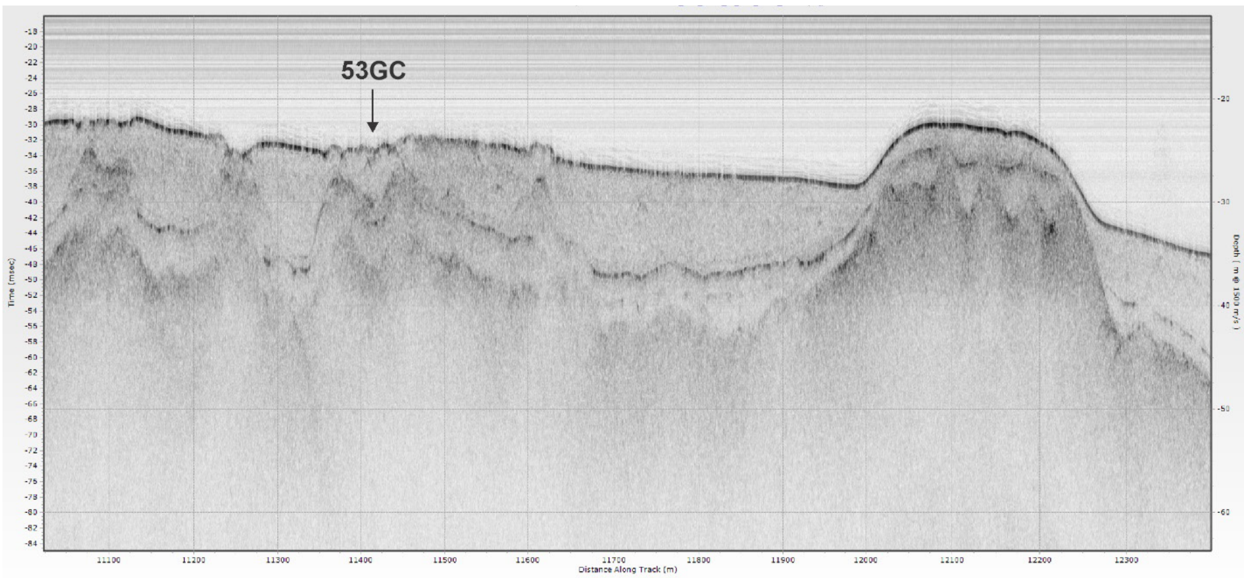

Figure C 9. Stratigraphy of core 53.

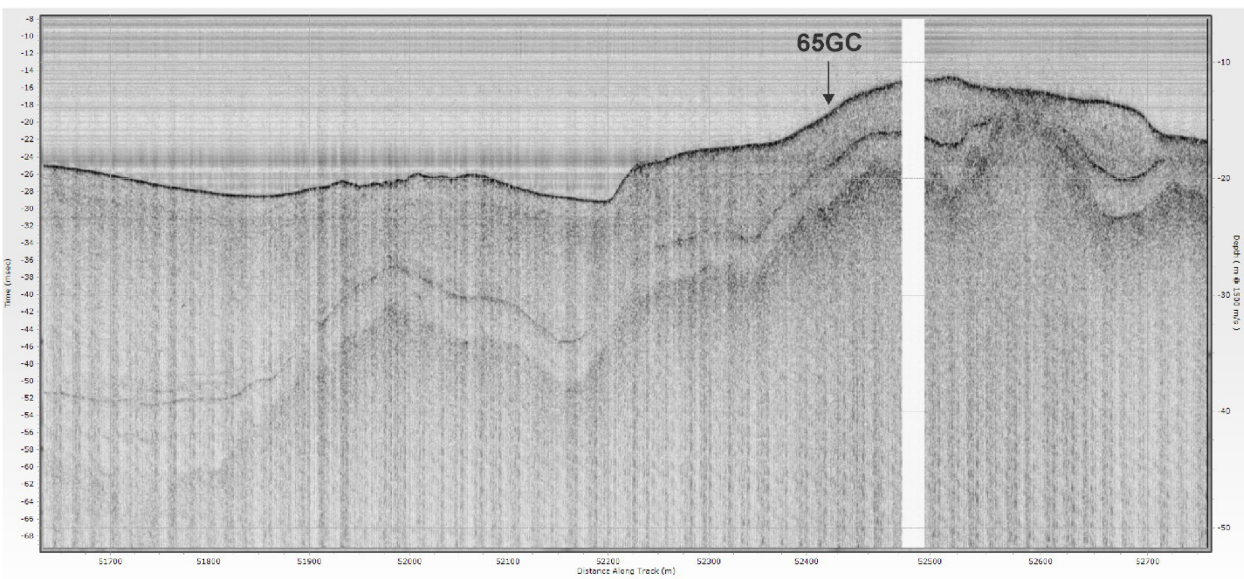

Figure C 10. Stratigraphy of core 65.

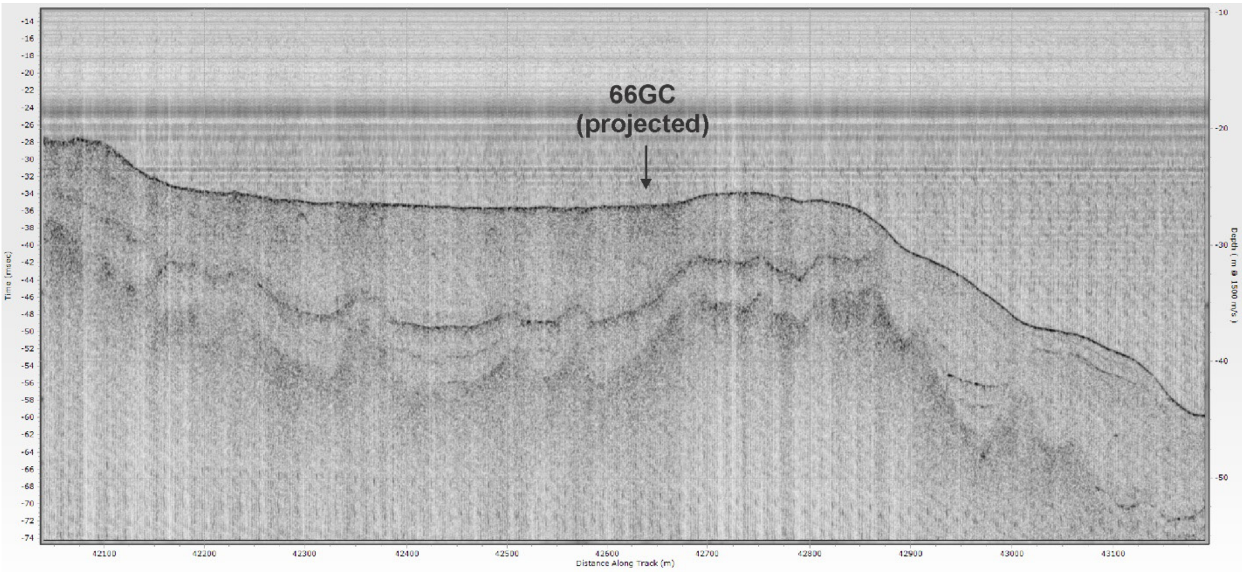

Figure C 11. Stratigraphy of core 66.

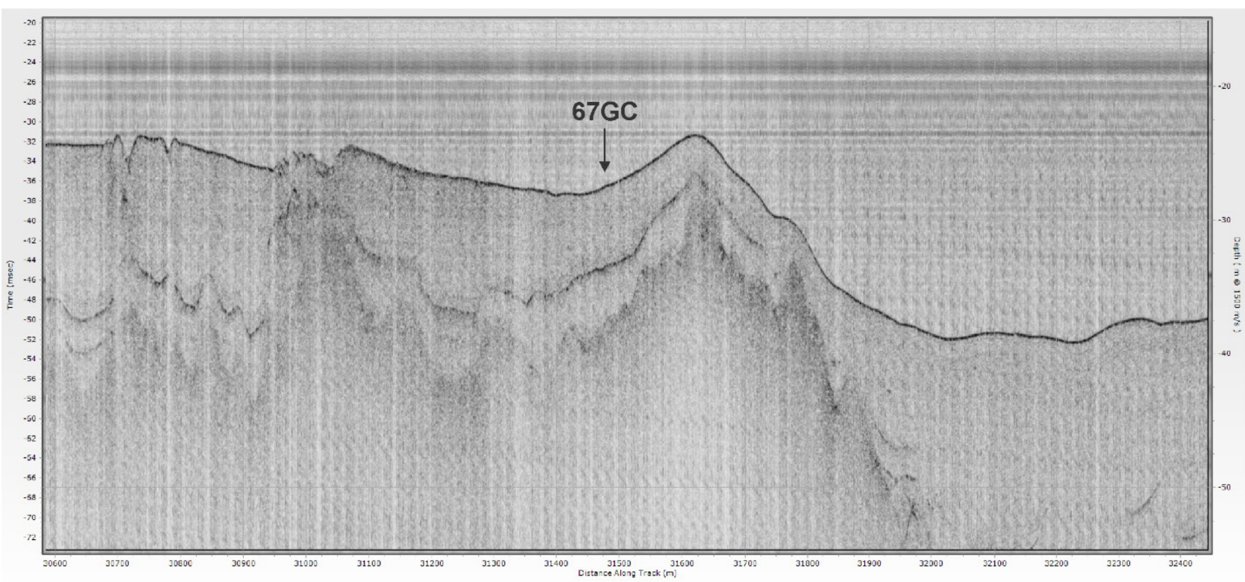

Figure C 12. Stratigraphy of core 67.

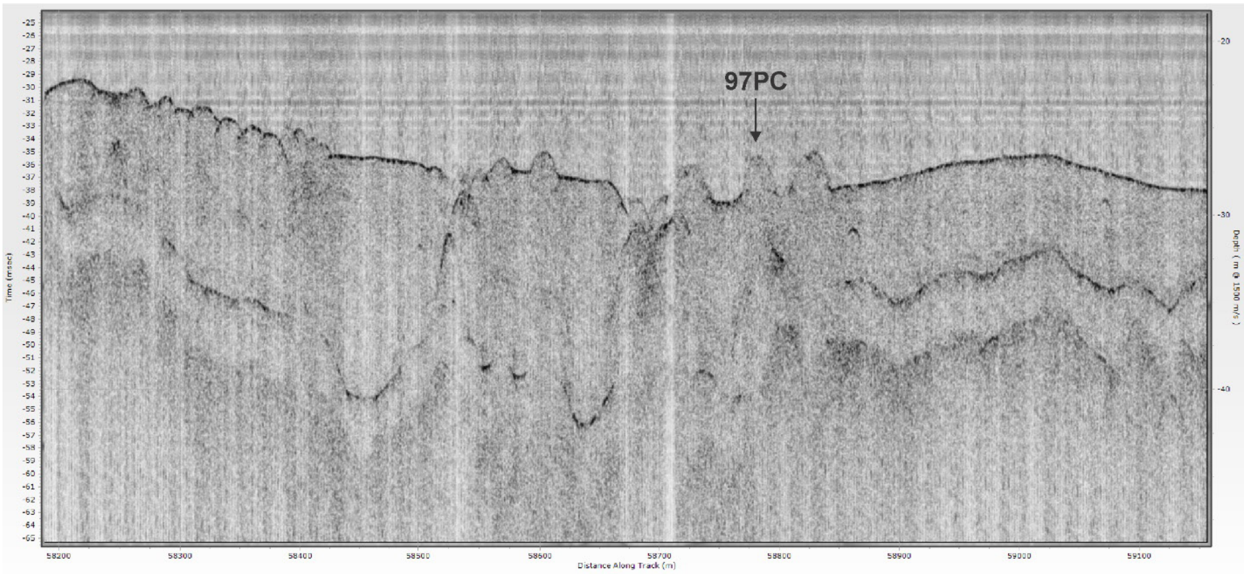

Figure C 13. Stratigraphy of core 97.

APPENDIX D: CTD AND CTD-R PLOTS

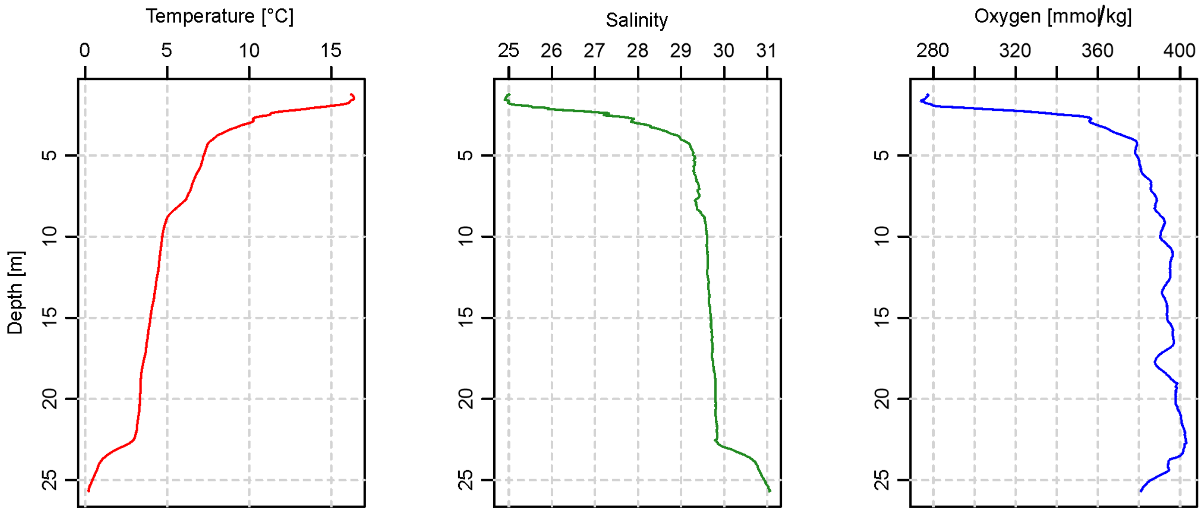

Figure D 1. CTD plot of station 05

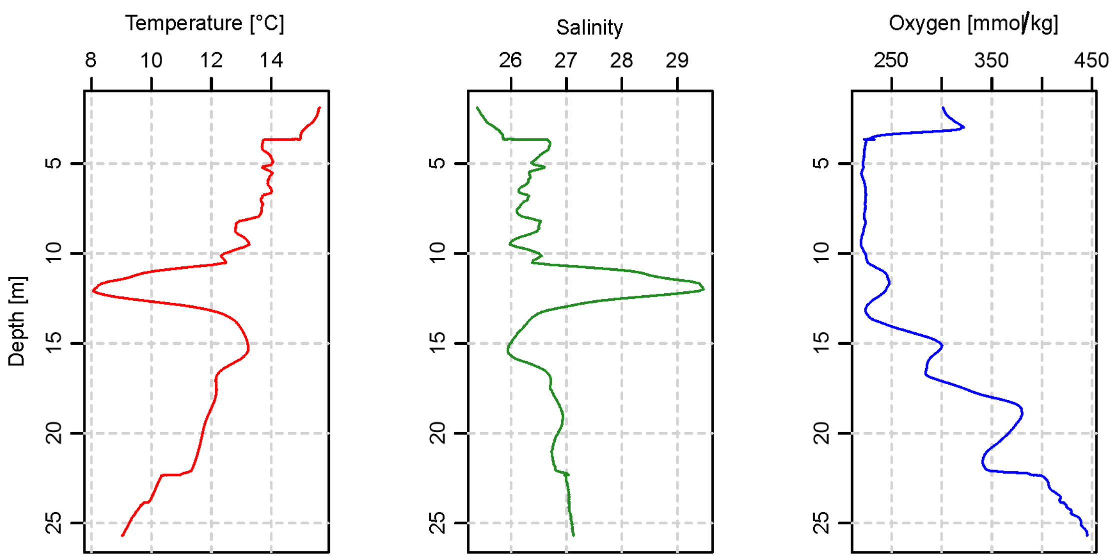

Figure D 2. CTD plot of station 07

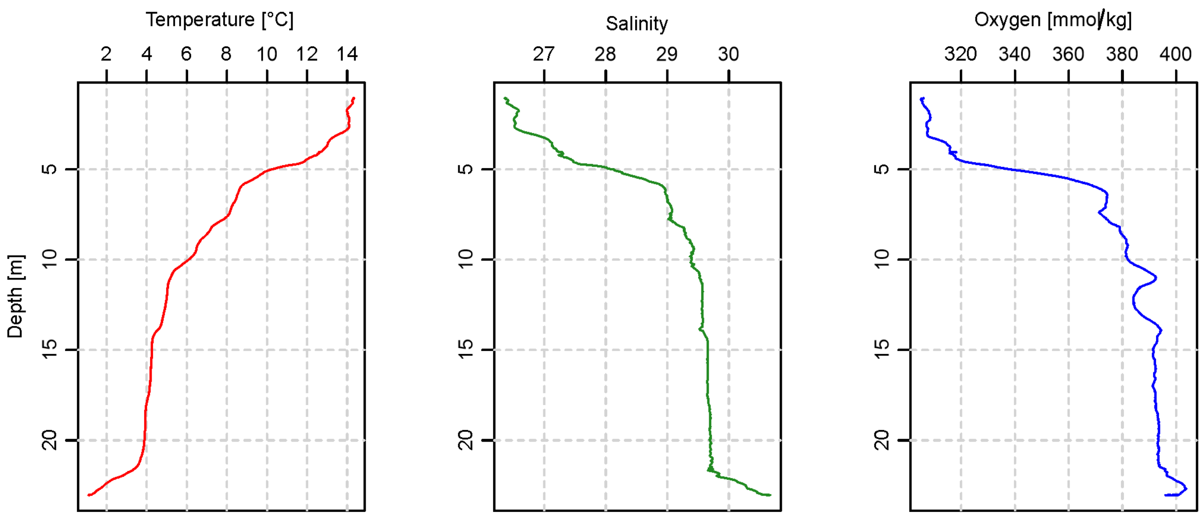

Figure D 3. CTD plot of station 14

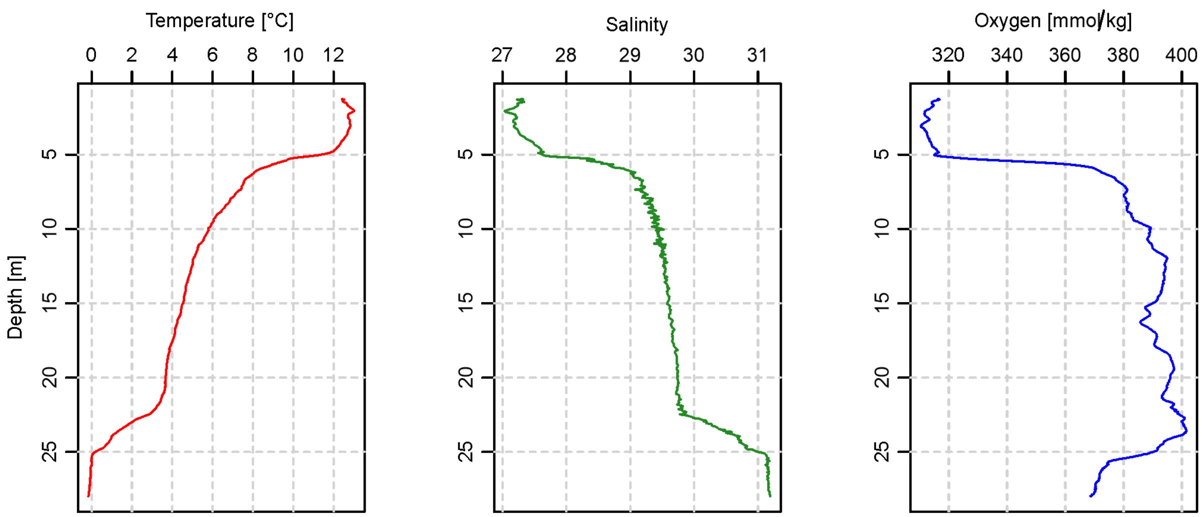

Figure D 4. CTD plot of station 15

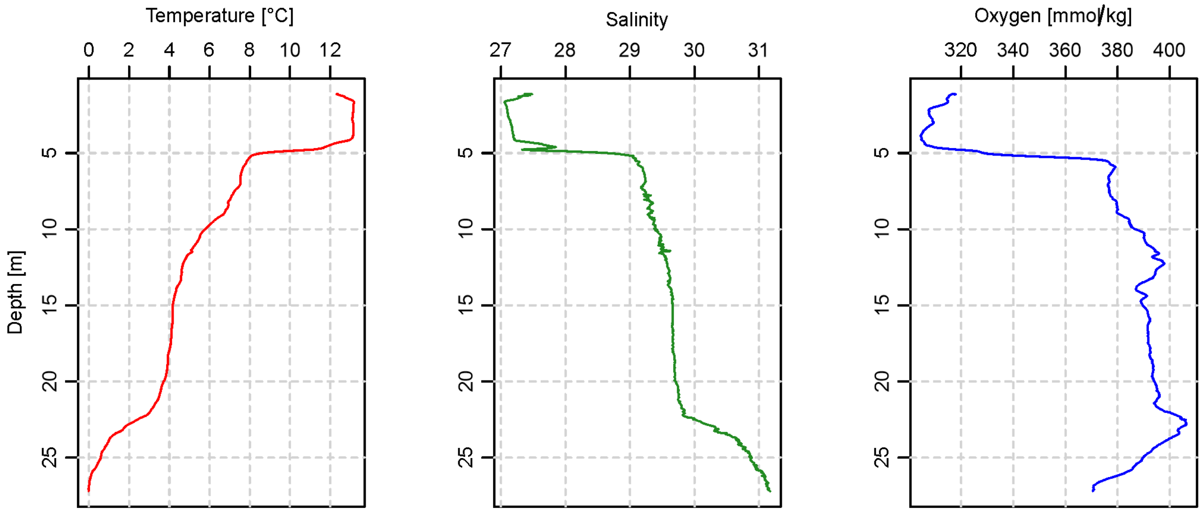

Figure D 5. CTD plot of station 16

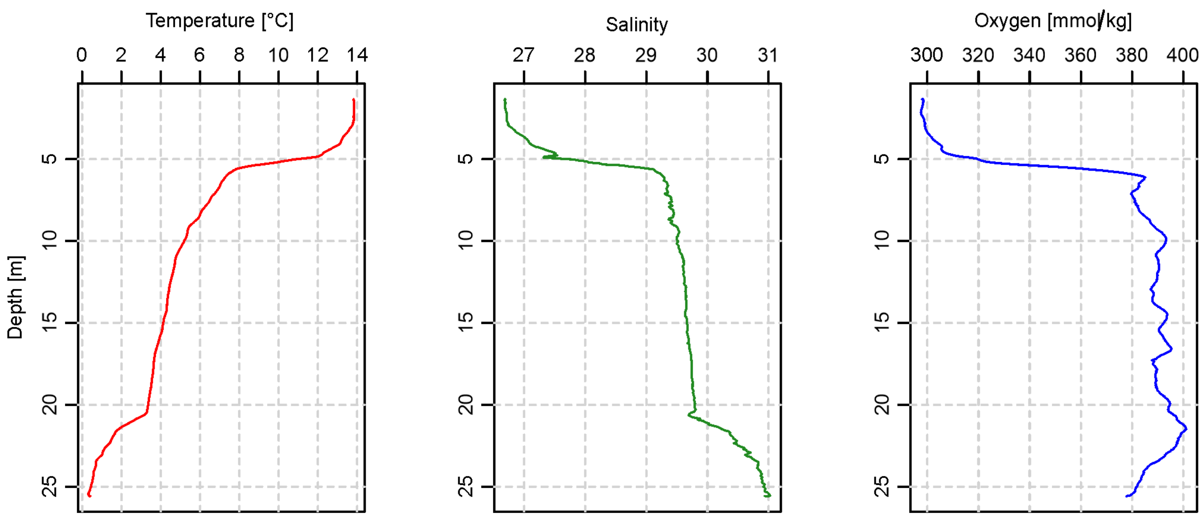

Figure D 6. CTD plot of station 17

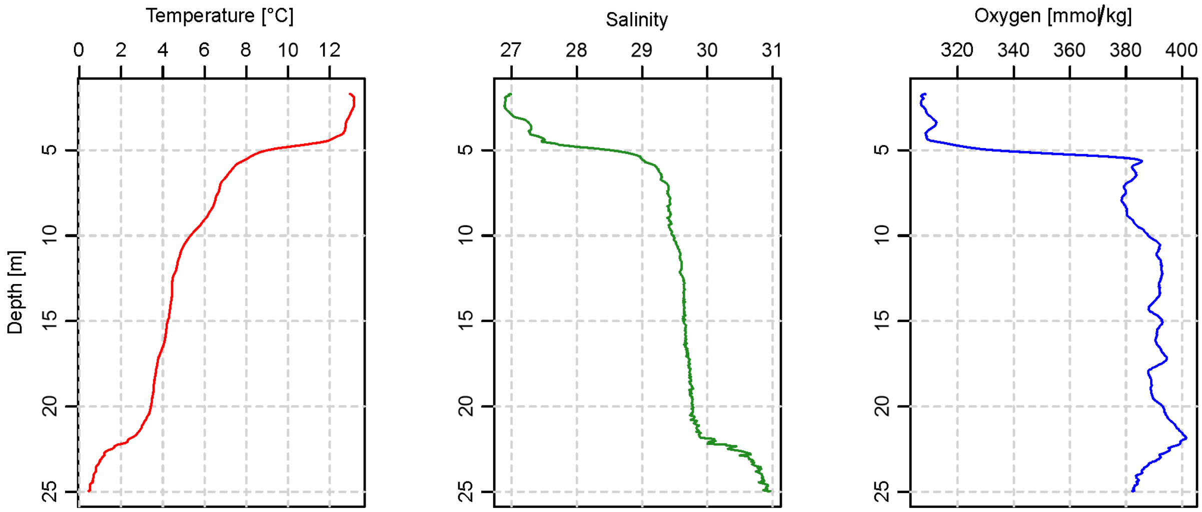

Figure D 7. CTD plot of station 18

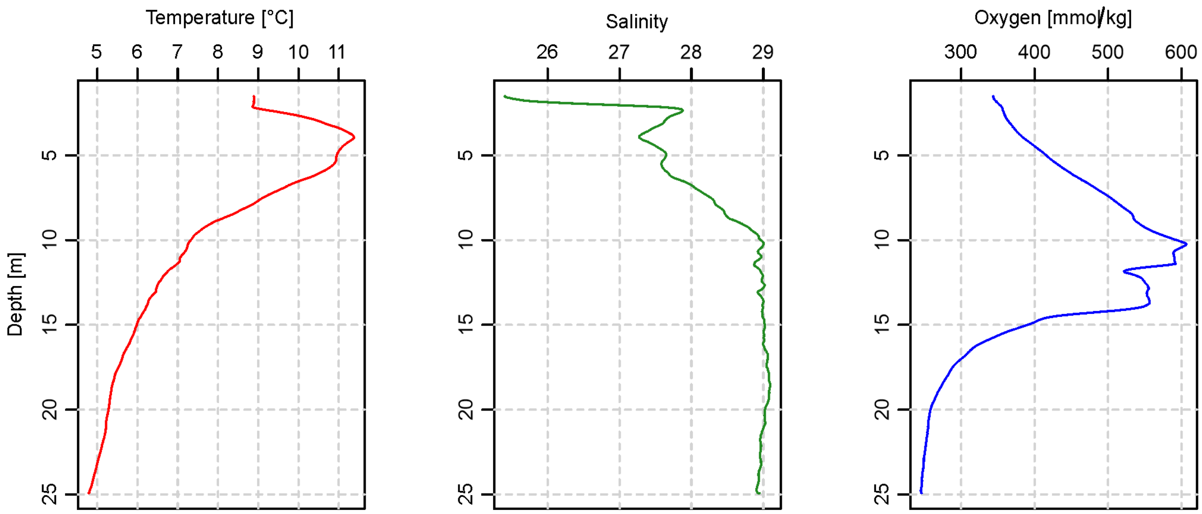

Figure D 8. CTD plot of station 20

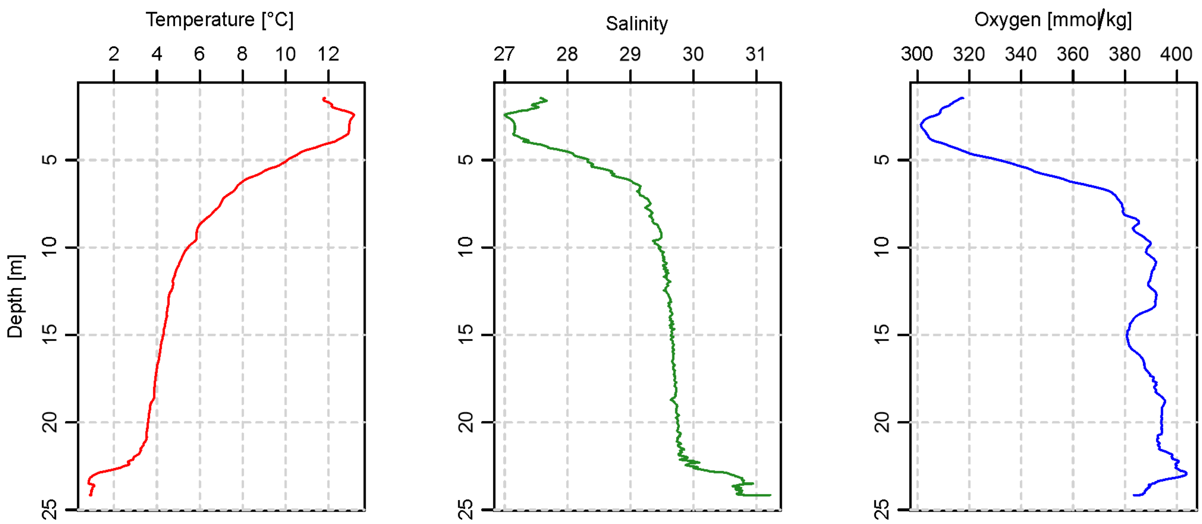

Figure D 9. CTD plot of station 21

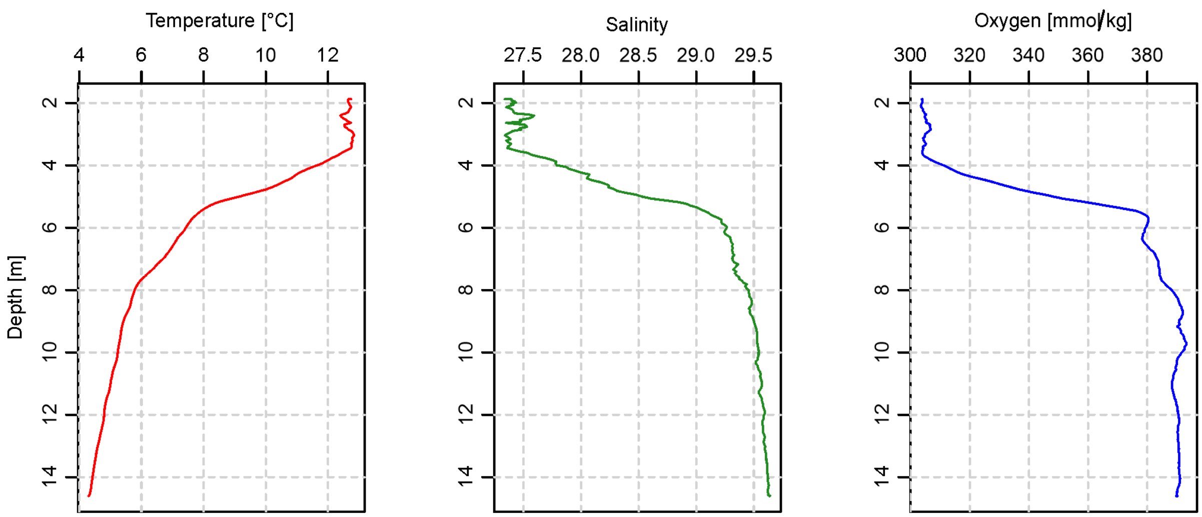

Figure D 10. CTD plot of station 28

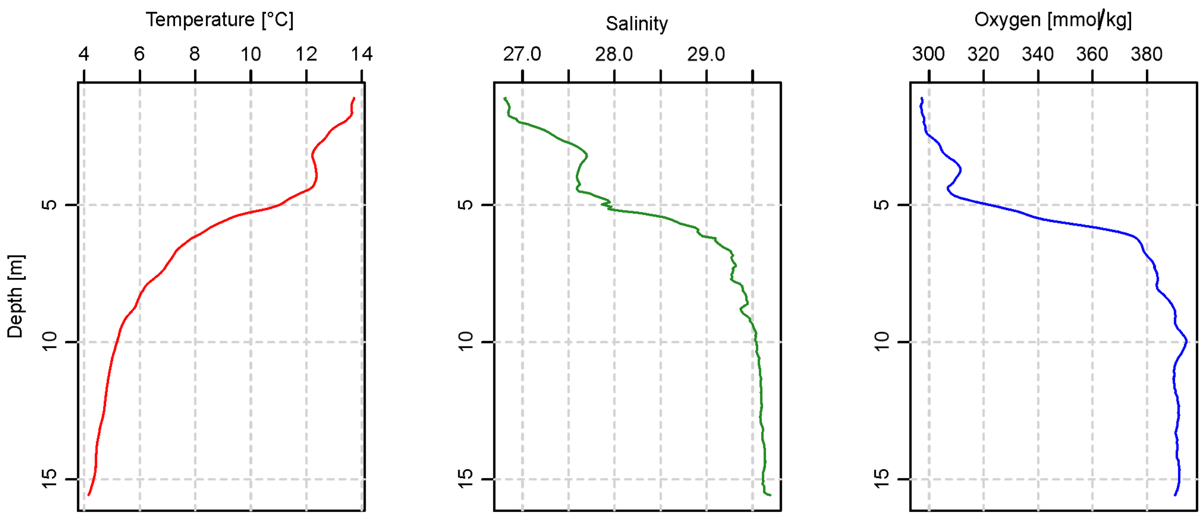

Figure D 11. CTD plot of station 29

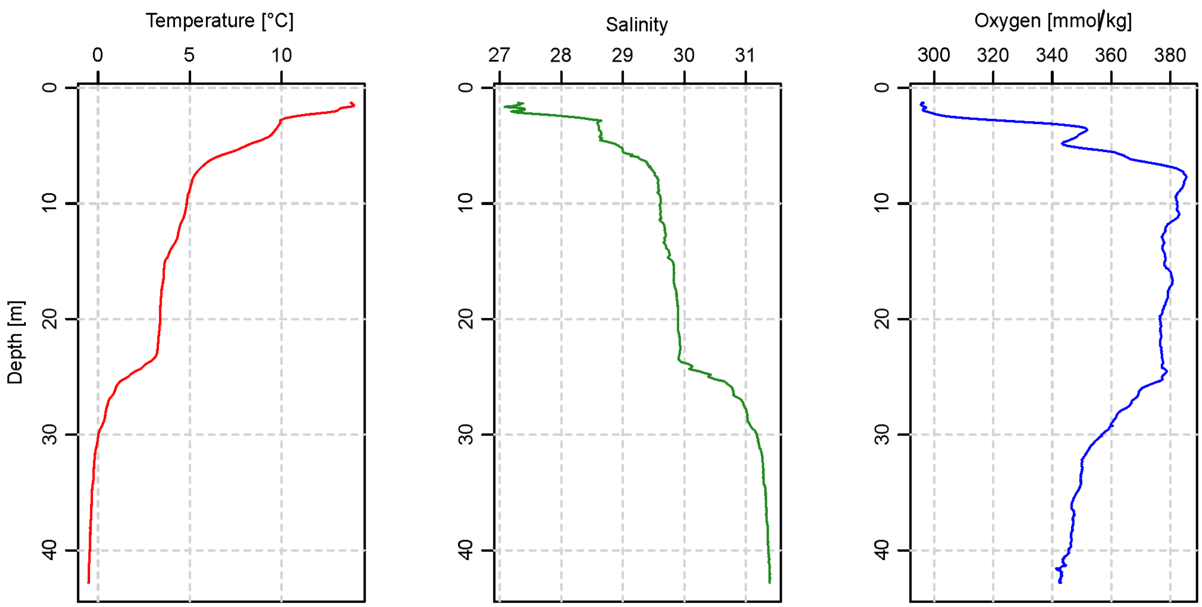

Figure D 12. CTD plot of station 30

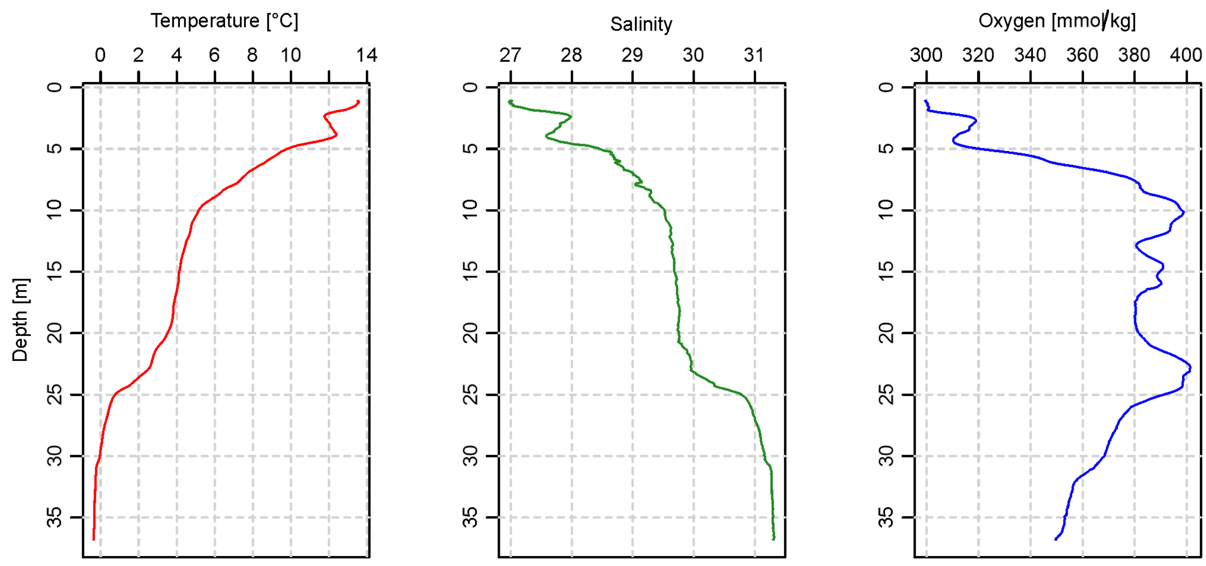

Figure D 13. CTD plot of station 35

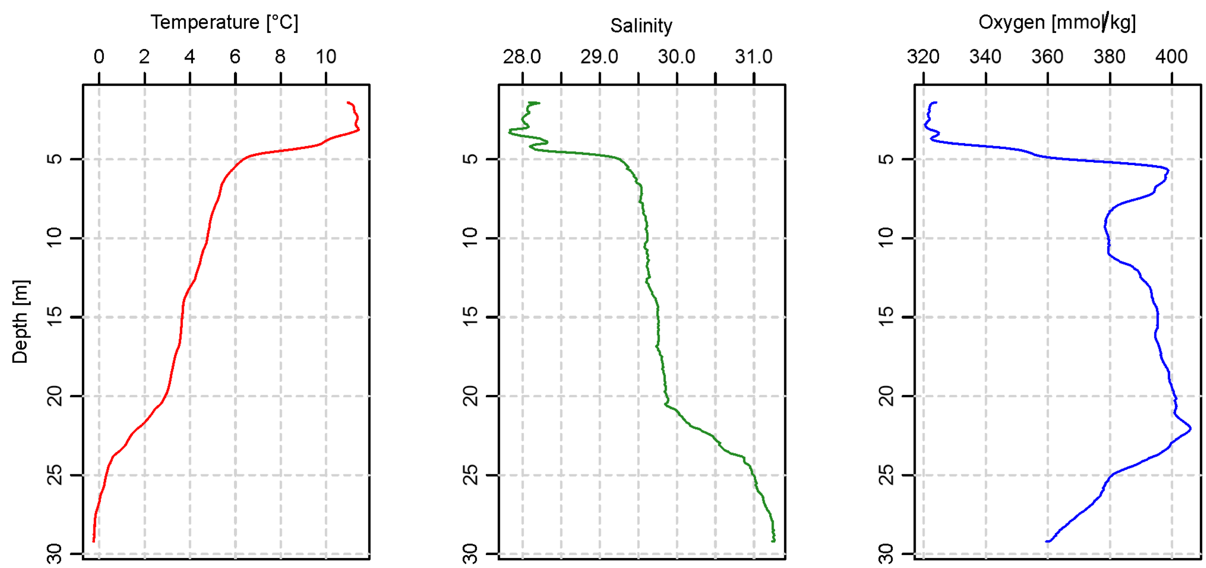

Figure D 14. CTD plot of station 36

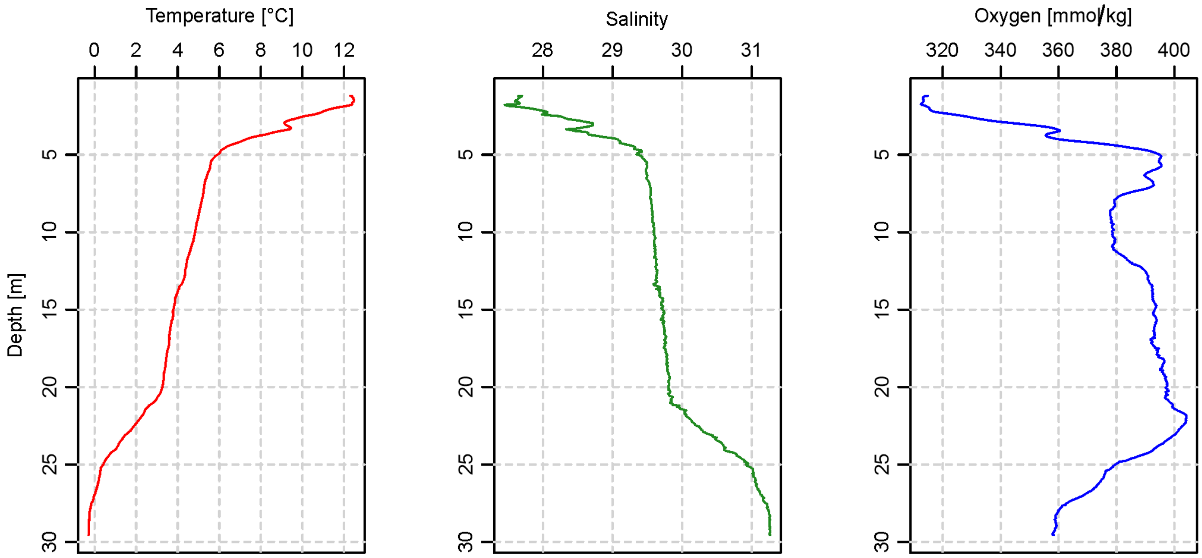

Figure D 15. CTD plot of station 37

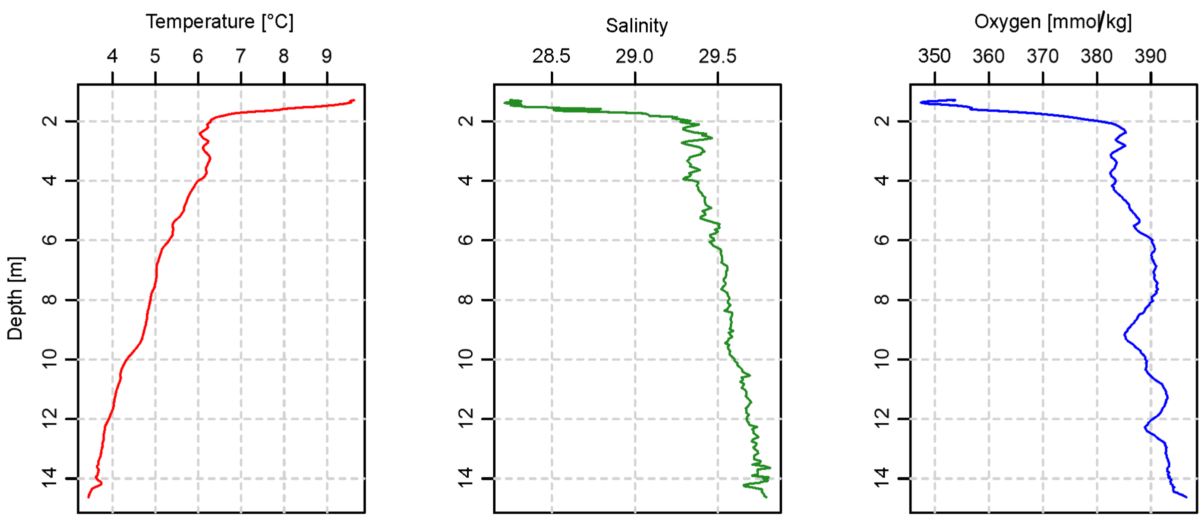

Figure D 16. CTD plot of station 39

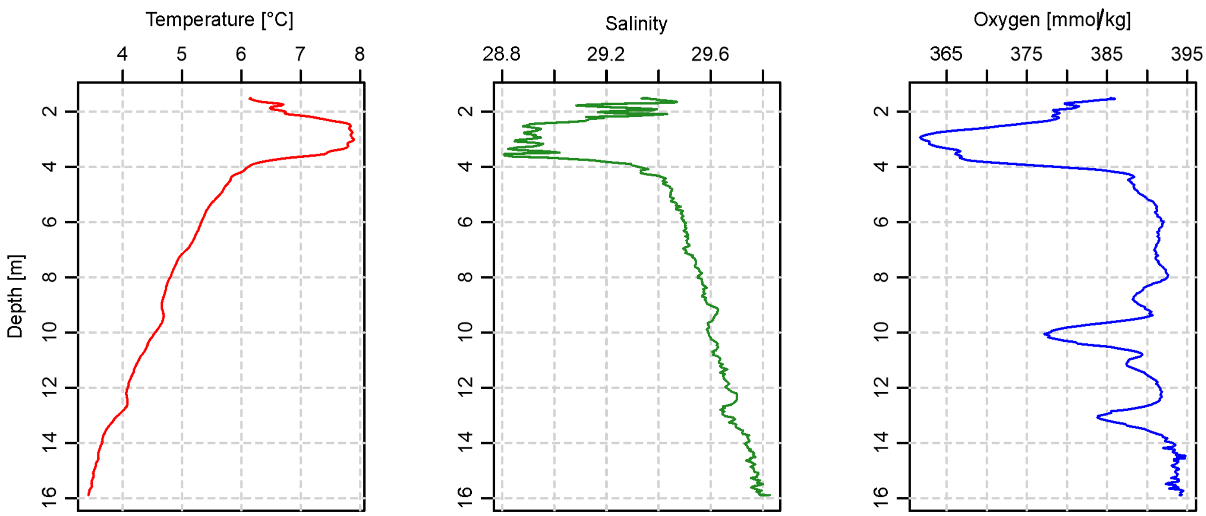

Figure D 17. CTD plot of station 40

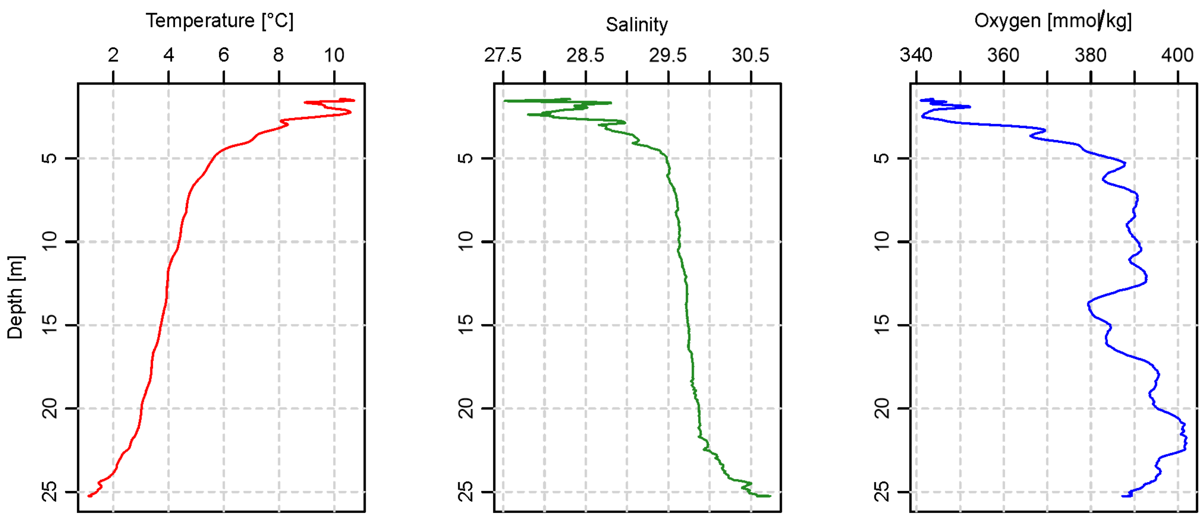

Figure D 18. CTD plot of station 42

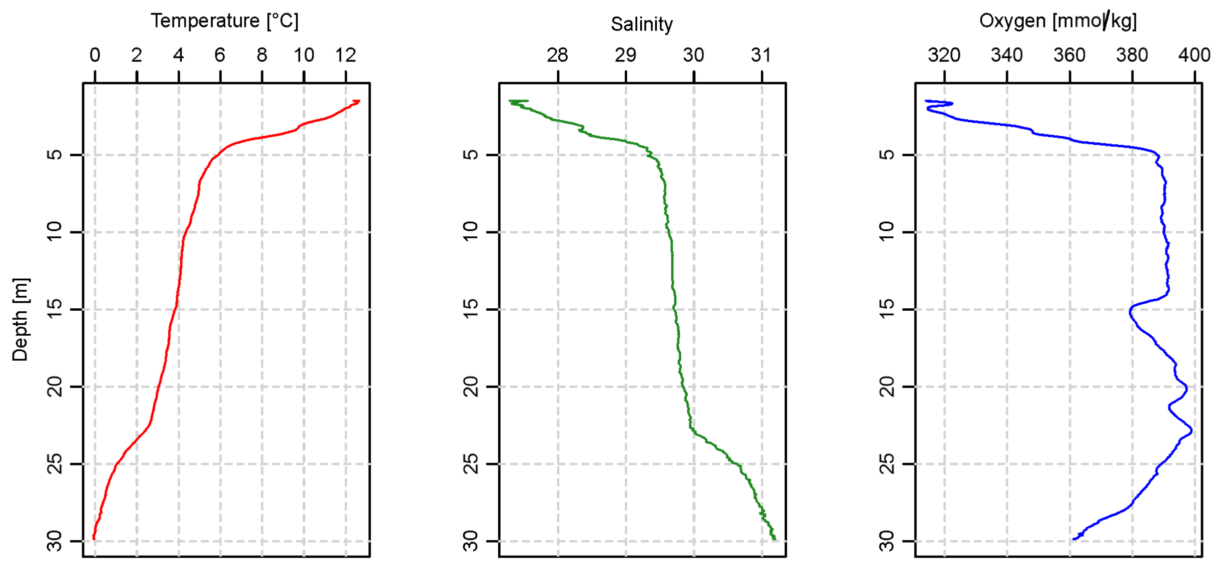

Figure D 19. CTD plot of station 43

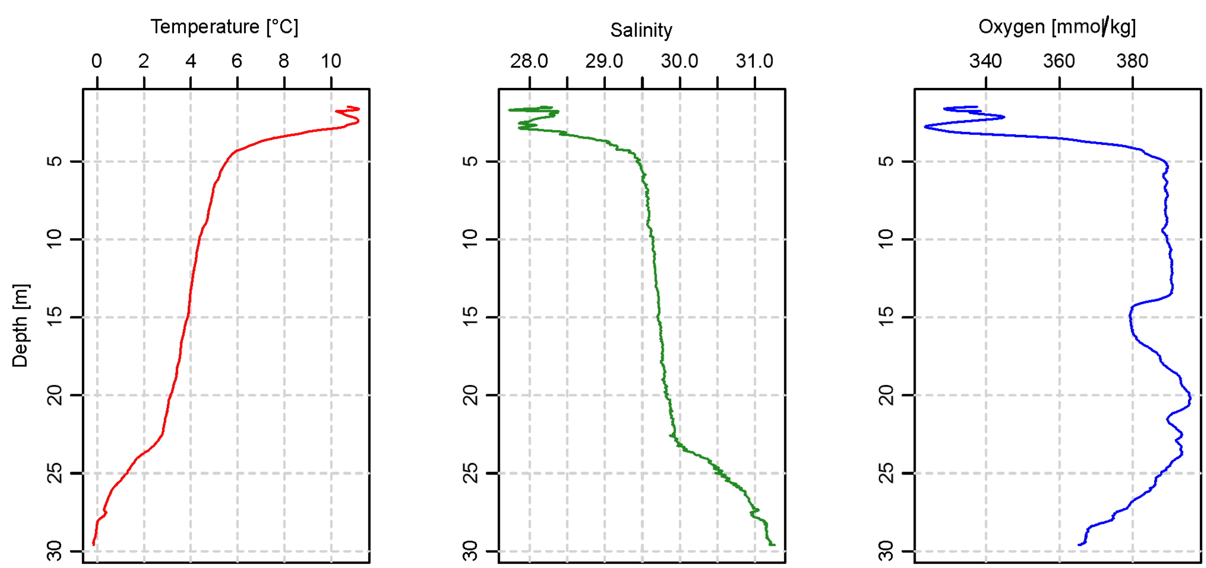

Figure D 20. CTD plot of station 44

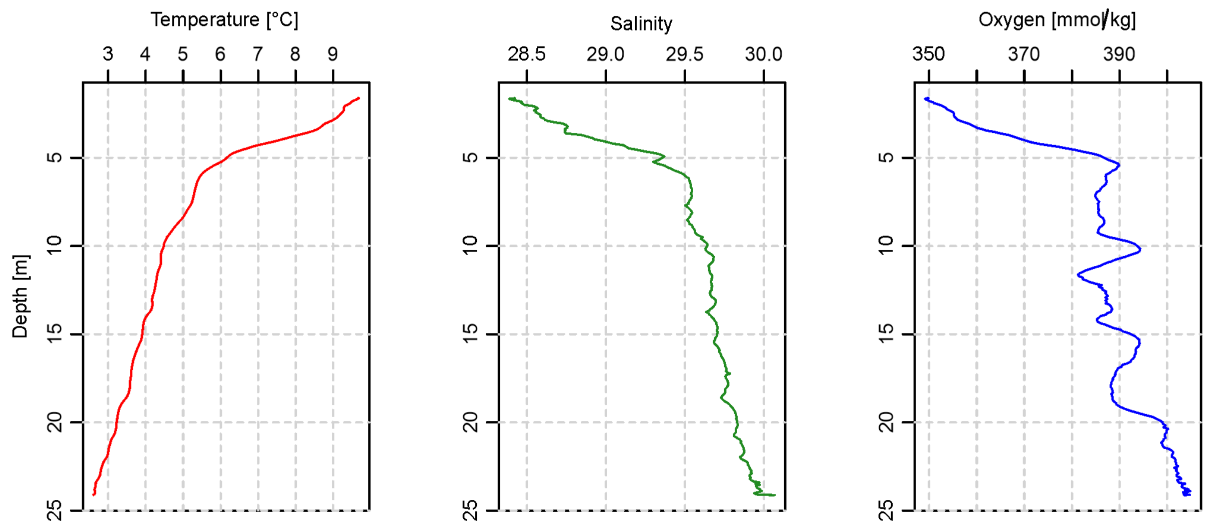

Figure D 21. CTD plot of station 51

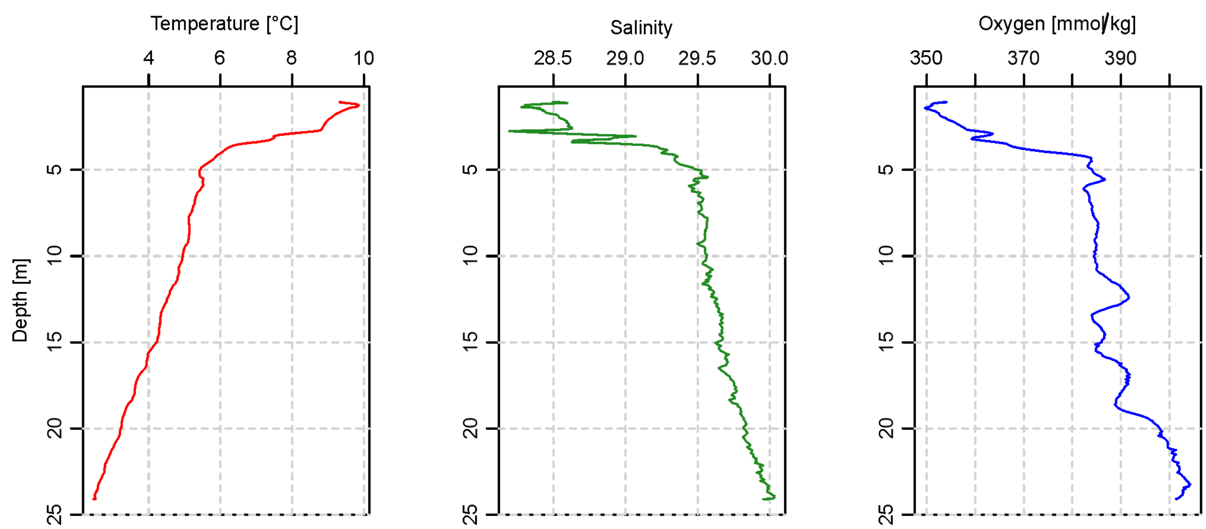

Figure D 22. CTD plot of station 52

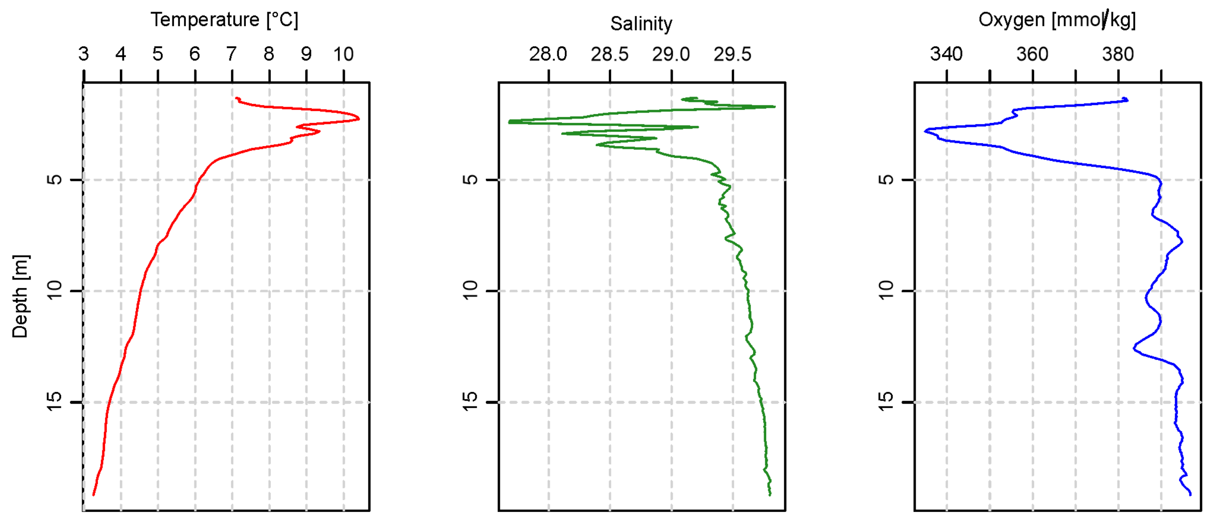

Figure D 23. CTD plot of station 56

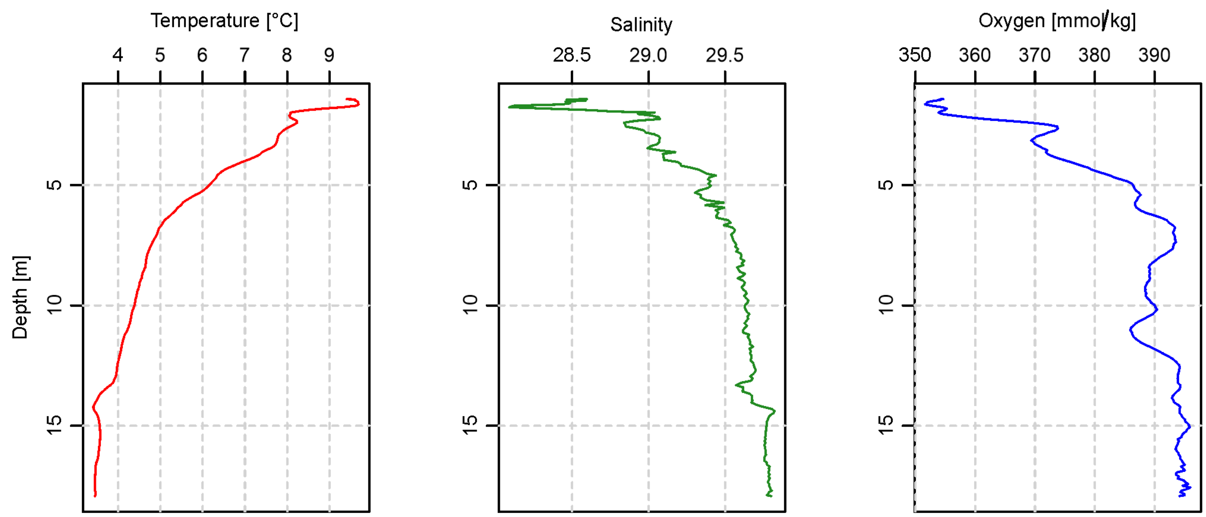

Figure D 24. CTD plot of station 57

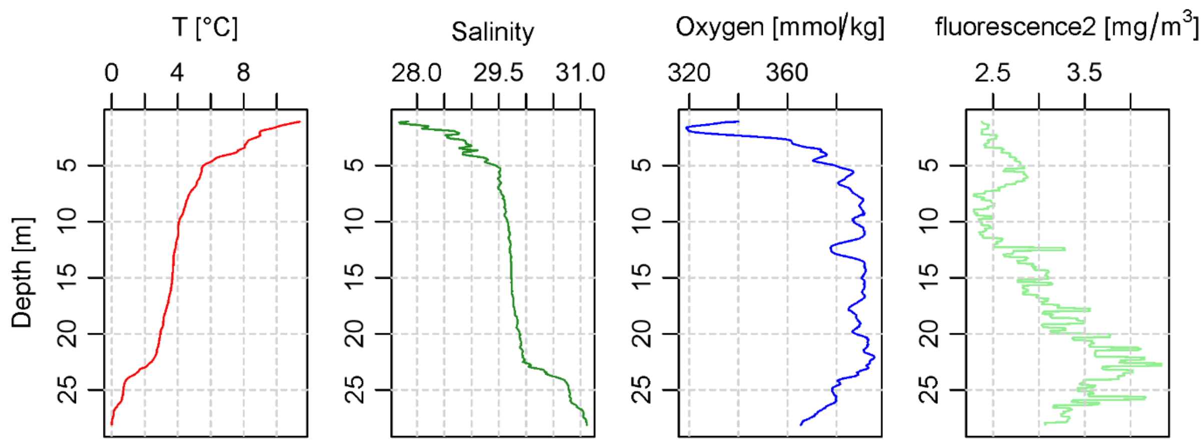

Figure D 25. CTD plot of station 59

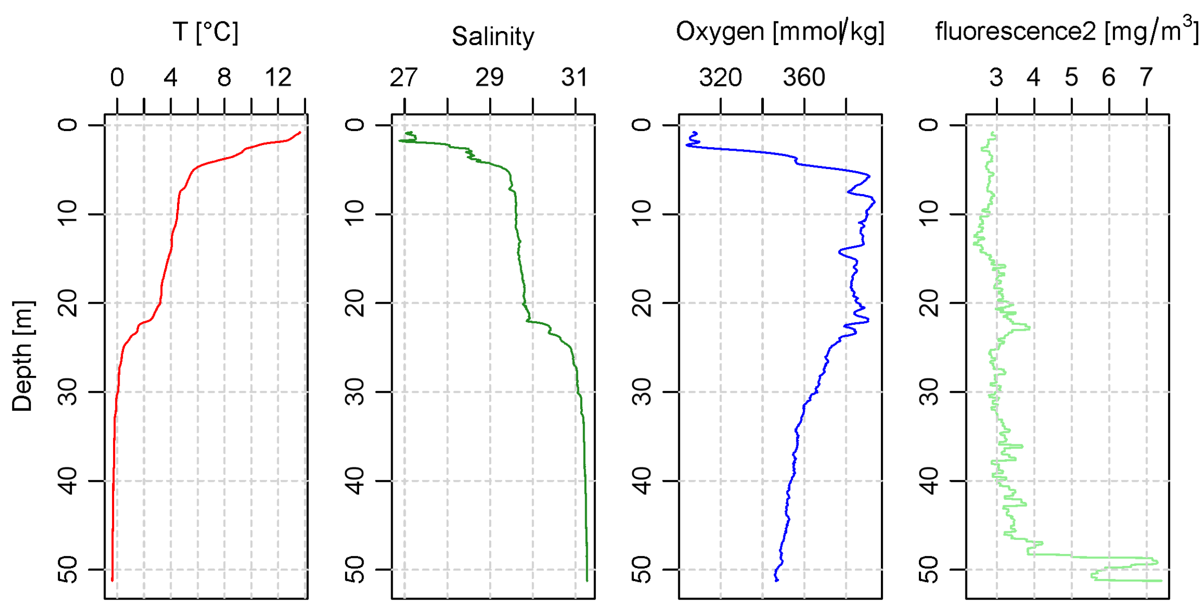

Figure D 26. CTD plot of station 60

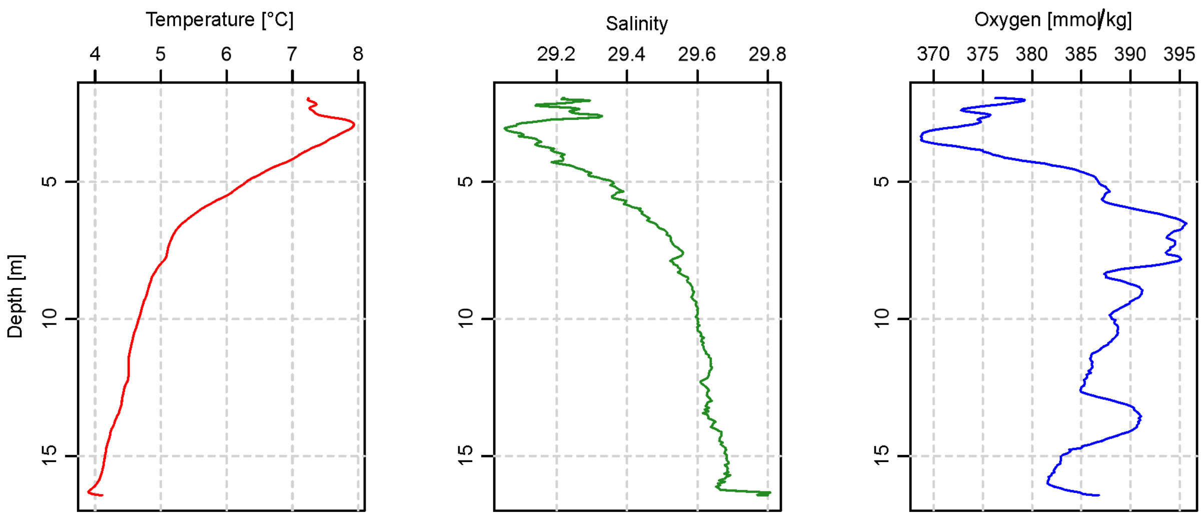

Figure D 27. CTD plot of station 61

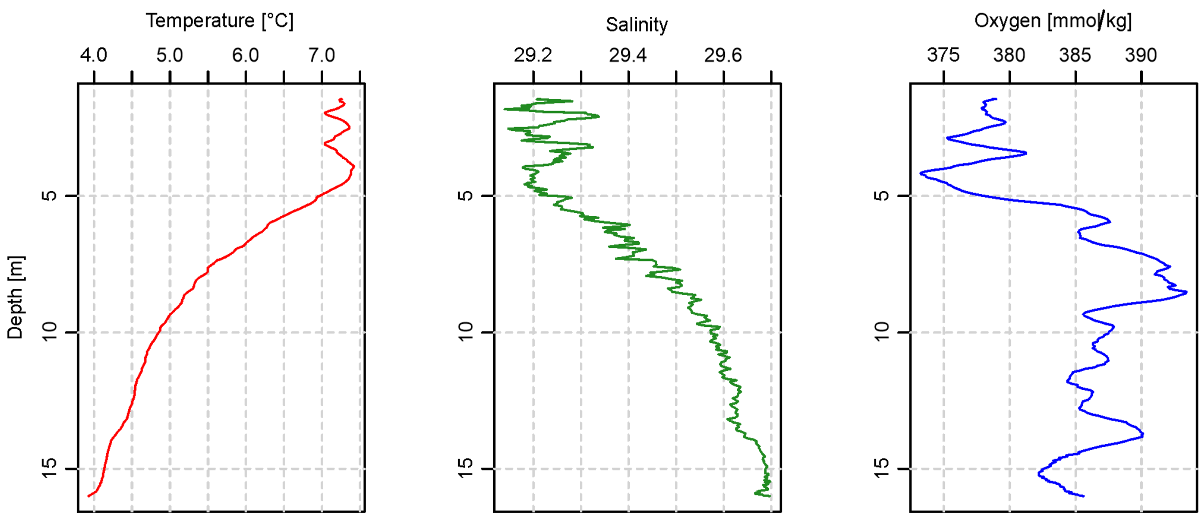

Figure D 28. CTD plot of station 62

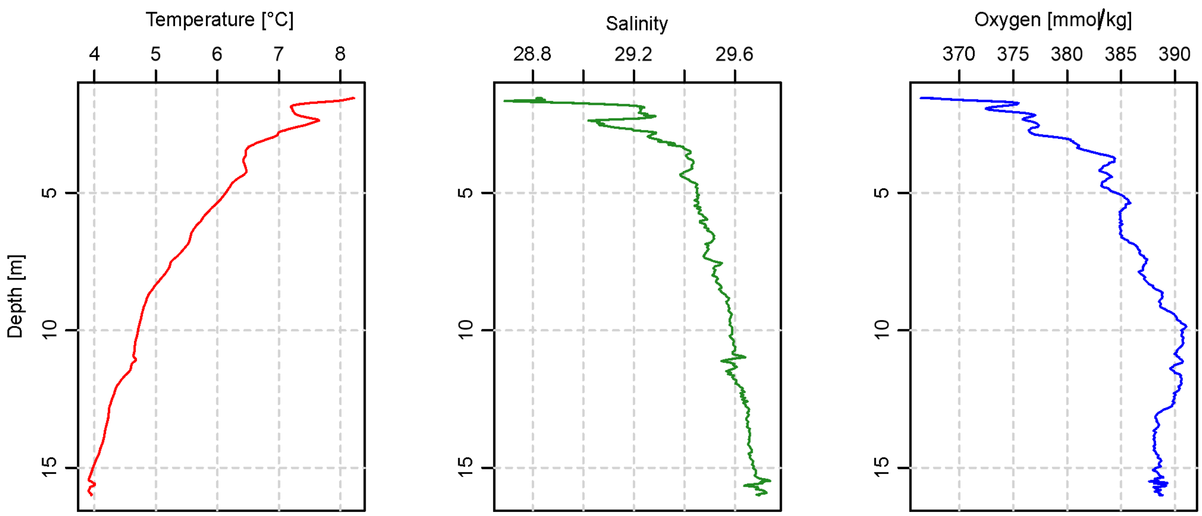

Figure D 29. CTD plot of station 63

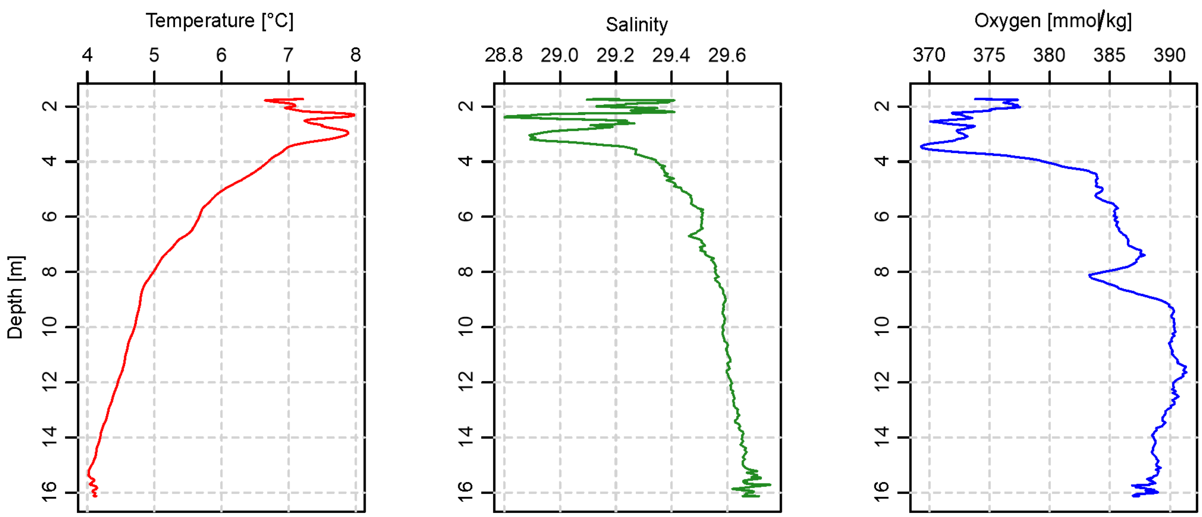

Figure D 30. CTD plot of station 64

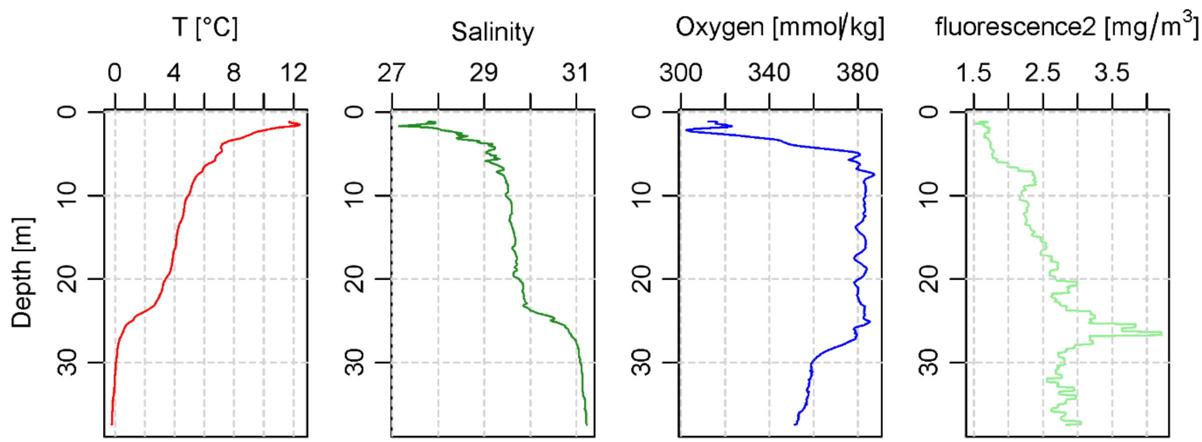

Figure D 31. CTD plot of station 70

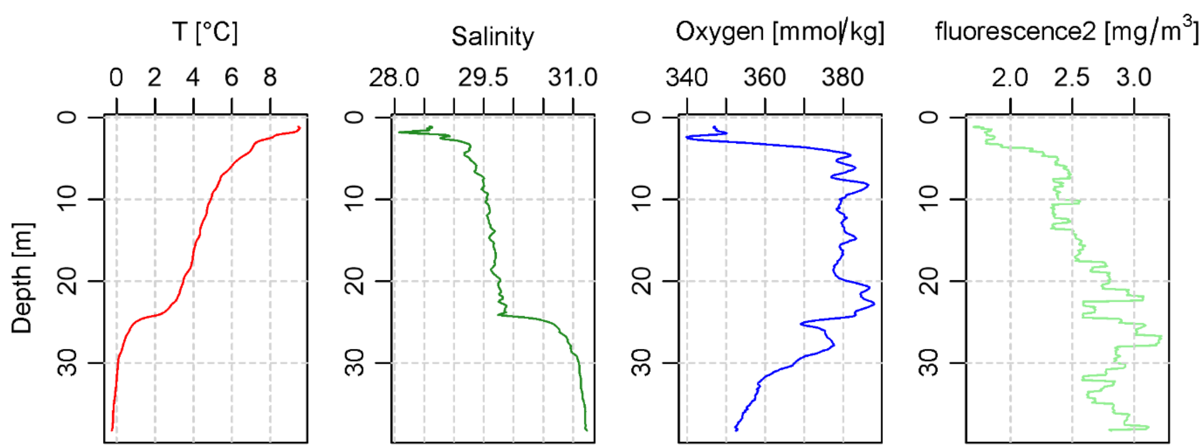

Figure D 32. CTD plot of station 71

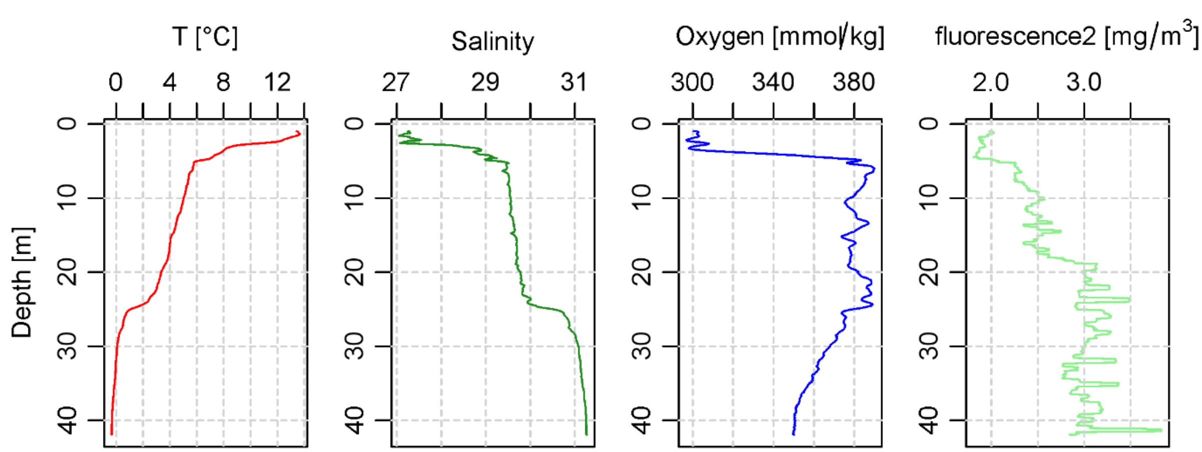

Figure D 33. CTD plot of station 72

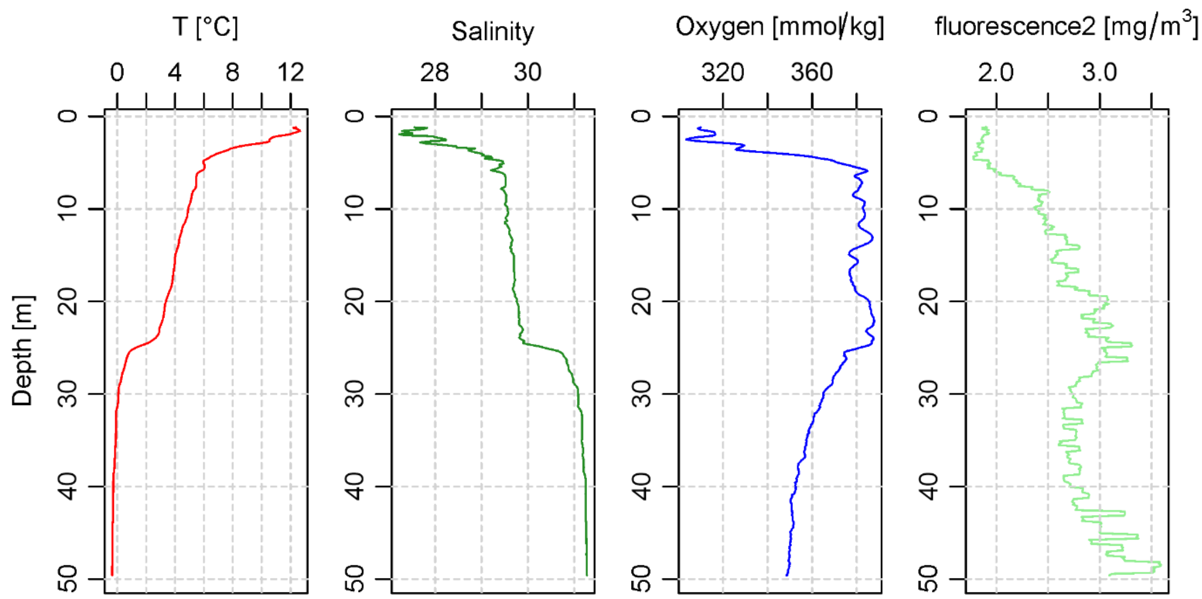

Figure D 34. CTD plot of station 73

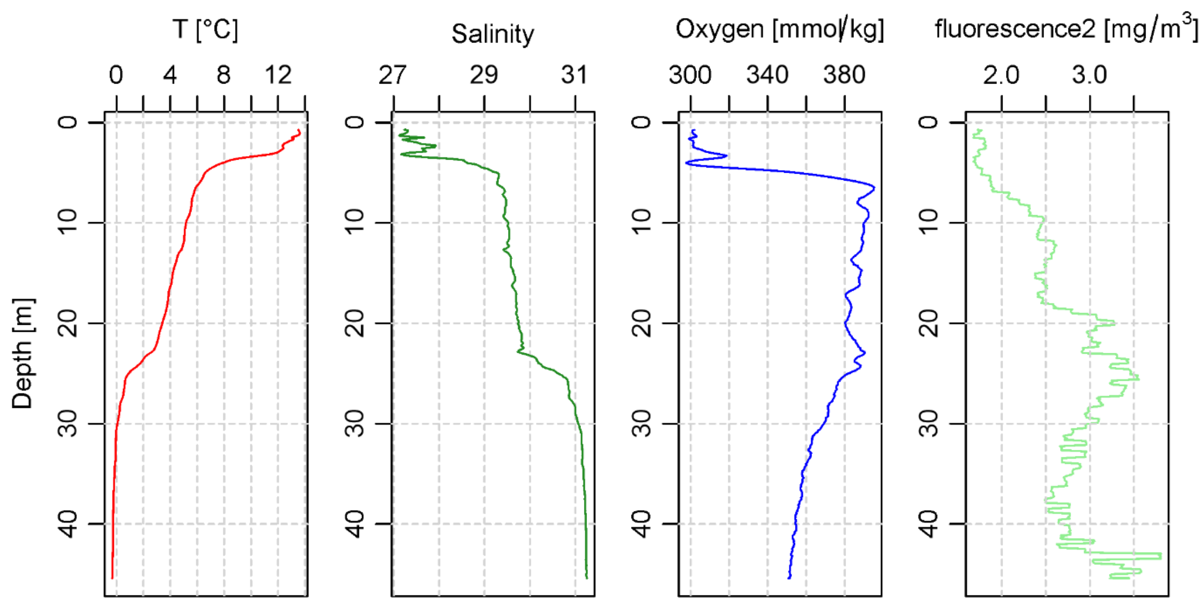

Figure D 35. CTD plot of station 74

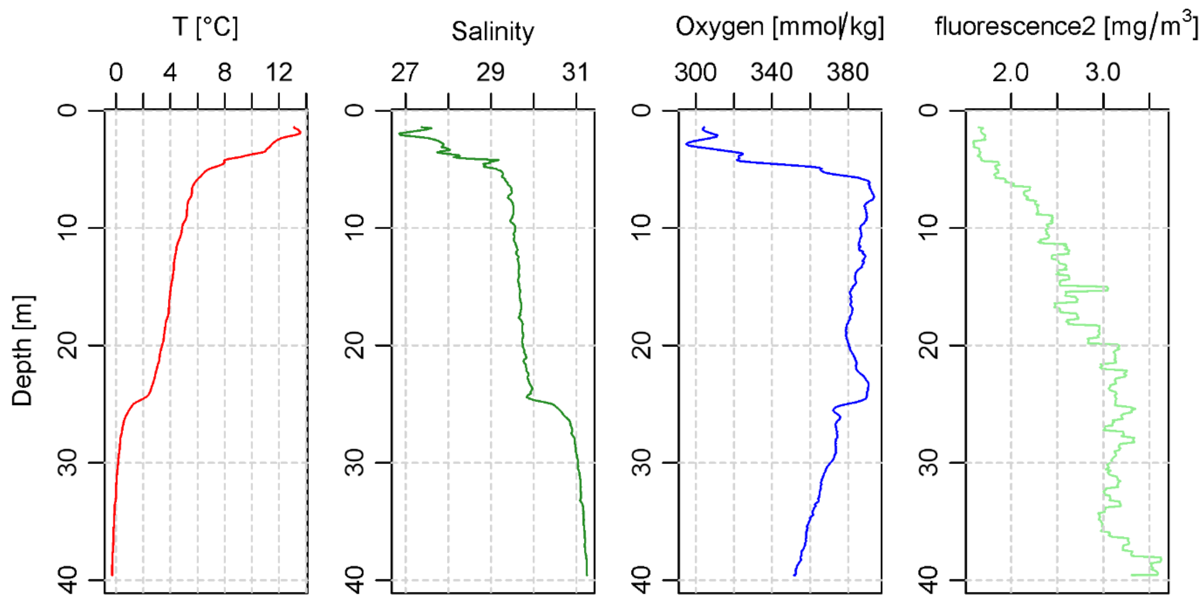

Figure D 36. CTD plot of station 75

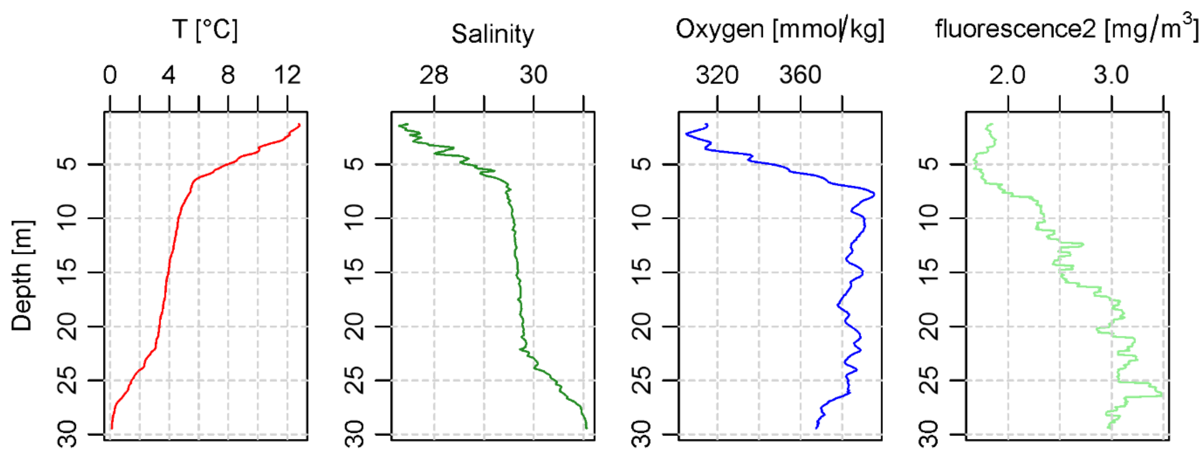

Figure D 37. CTD plot of station 76

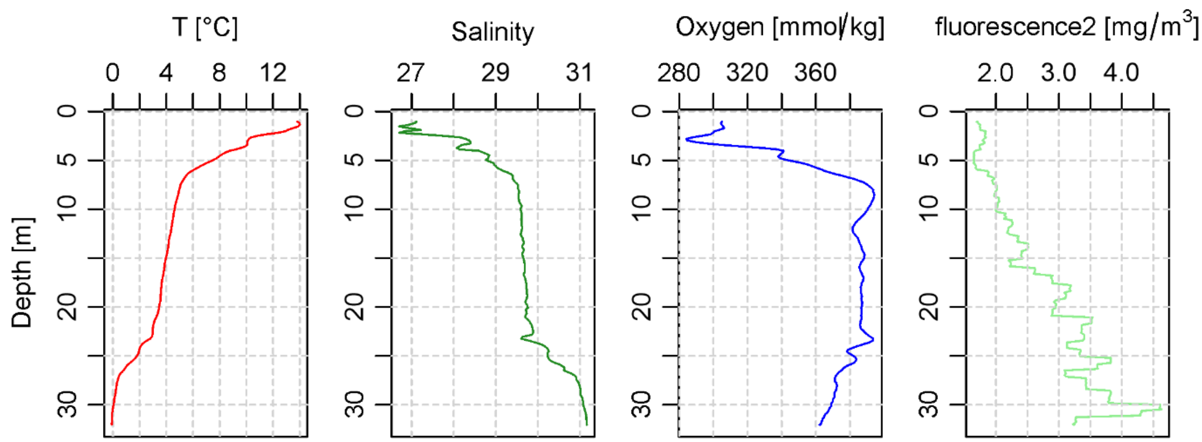

Figure D 38. CTD plot of station 77

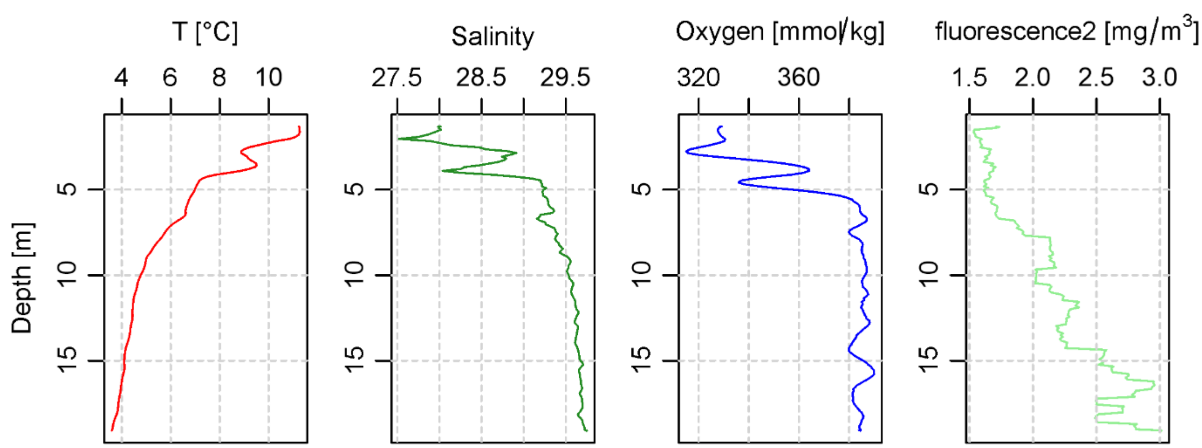

Figure D 39. CTD plot of station 78

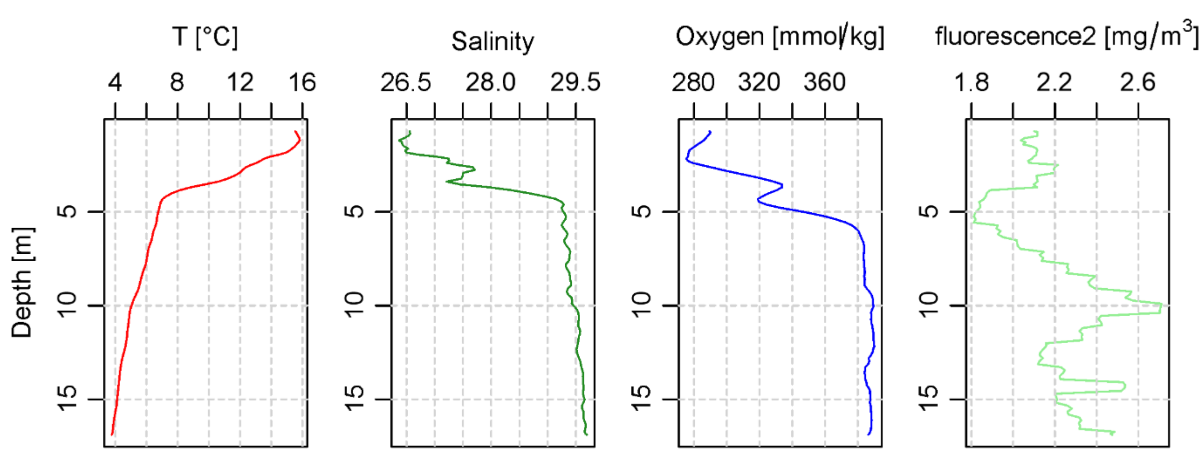

Figure D 40. CTD plot of station 79

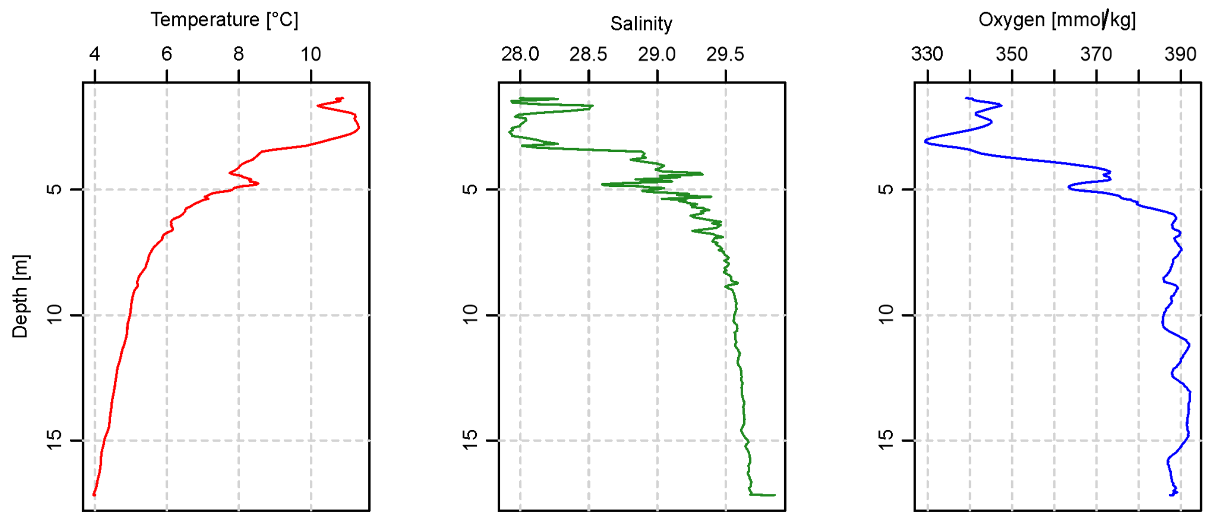

Figure D 41. CTD plot of station 81

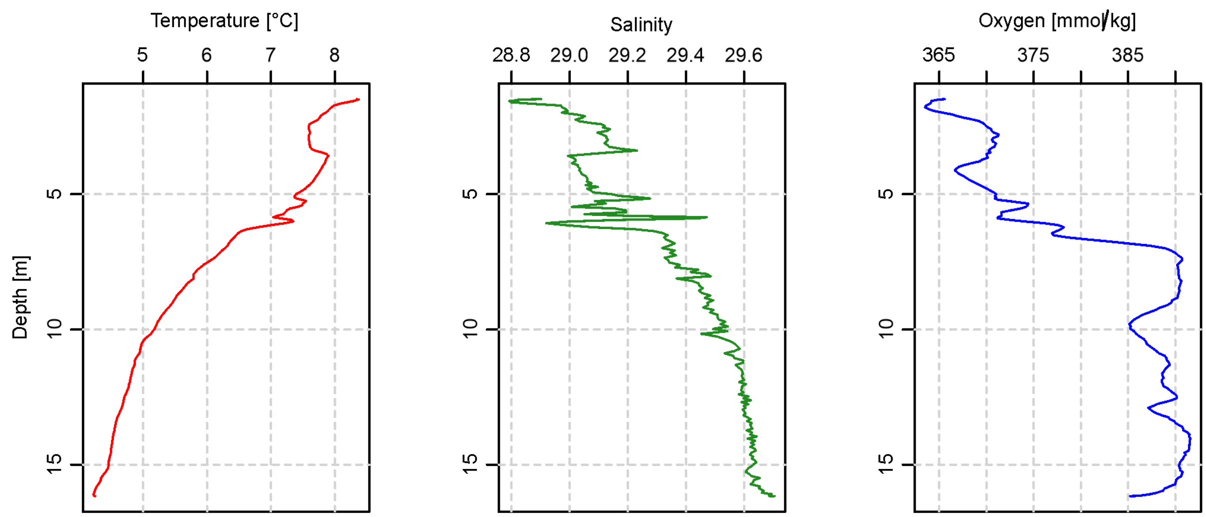

Figure D 42. CTD plot of station 82

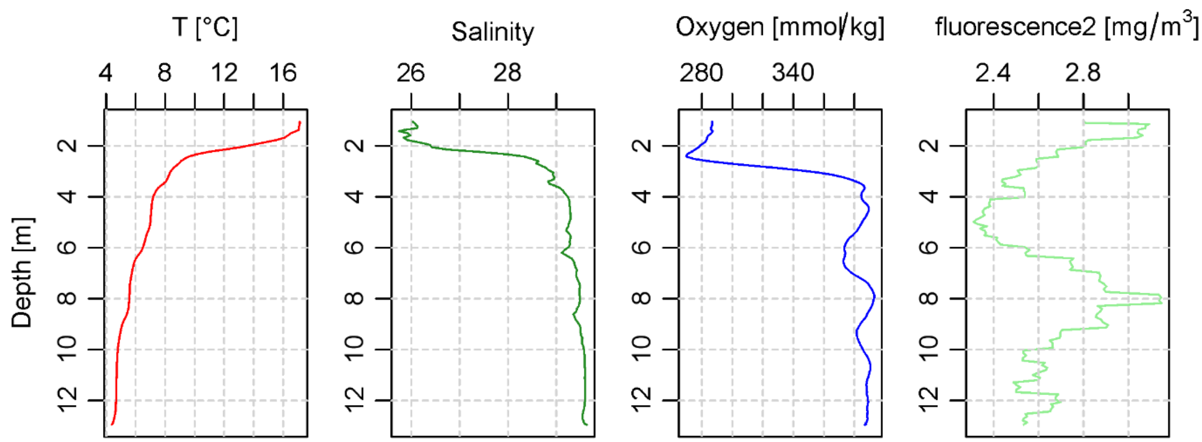

Figure D 43. CTD plot of station 84

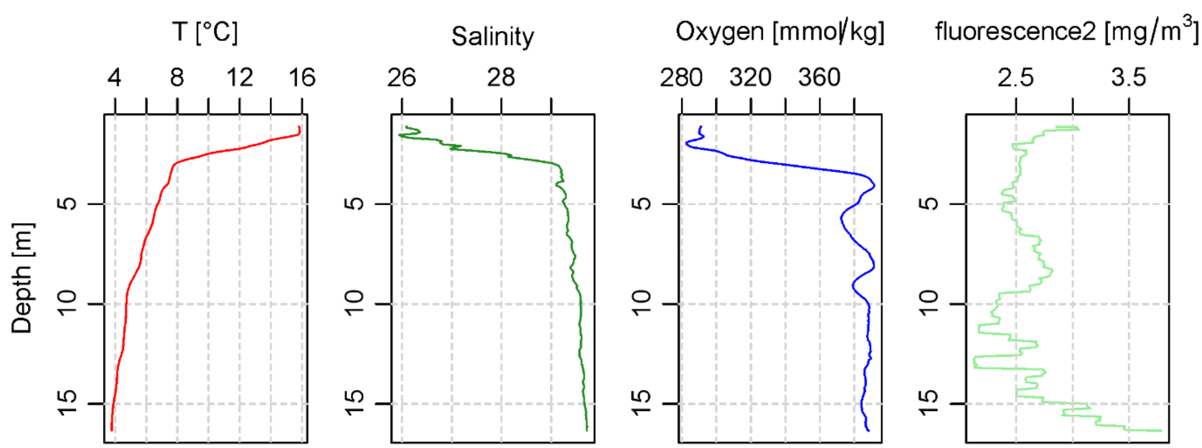

Figure D 44. CTD plot of station 85

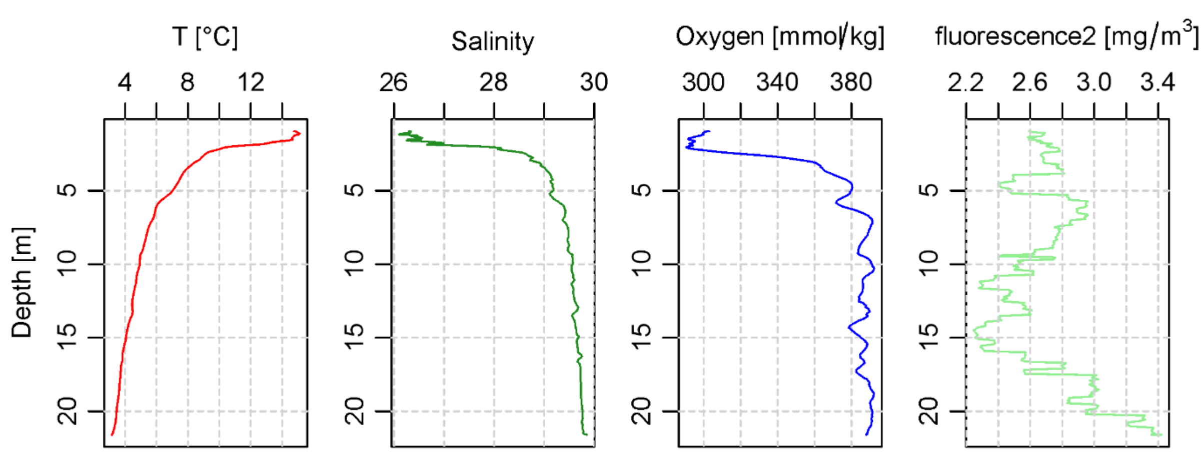

Figure D 45. CTD plot of station 86

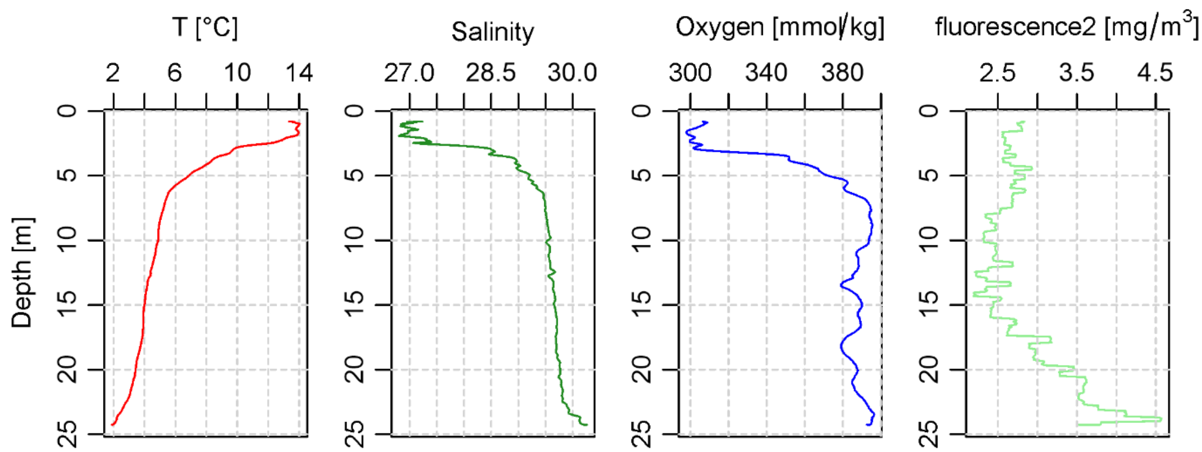

Figure D 46. CTD plot of station 87

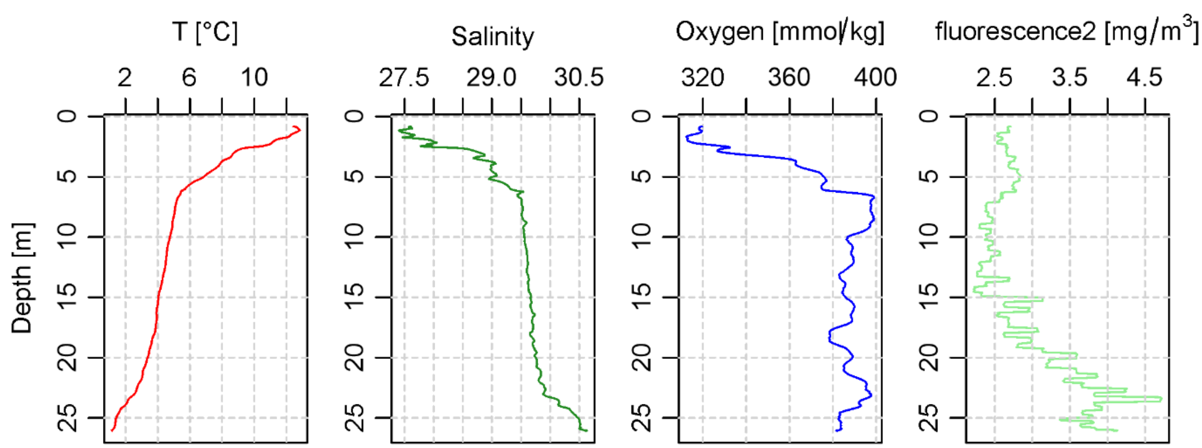

Figure D 47. CTD plot of station 88

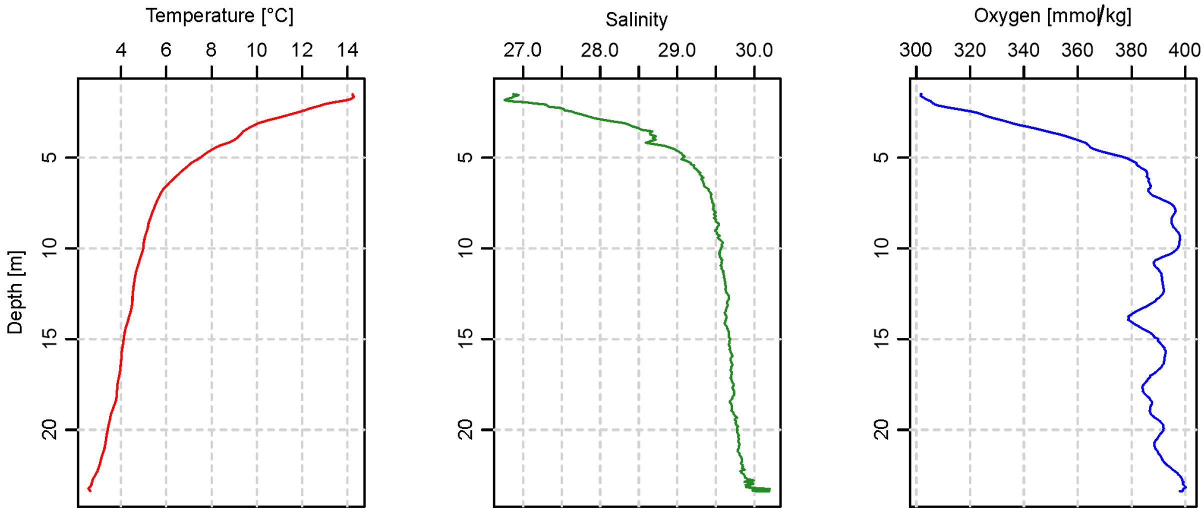

Figure D 48. CTD plot of station 89

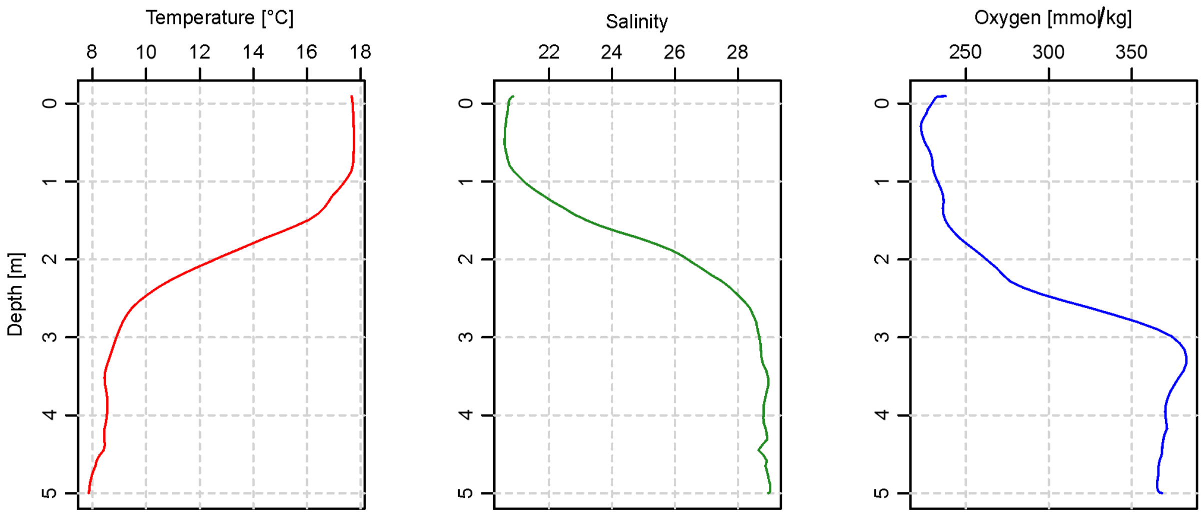

Figure D 49. CTD plot of station 90

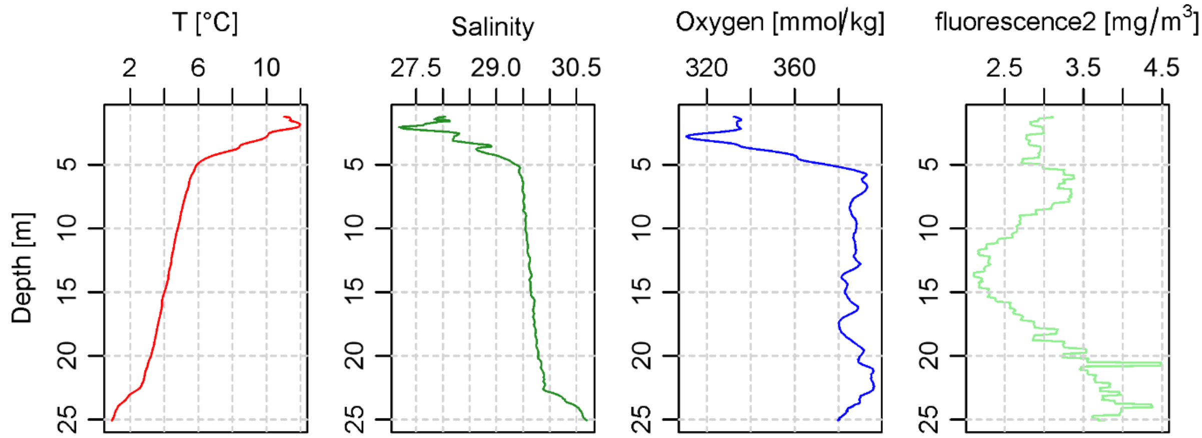

Figure D 50. CTD plot of station 91

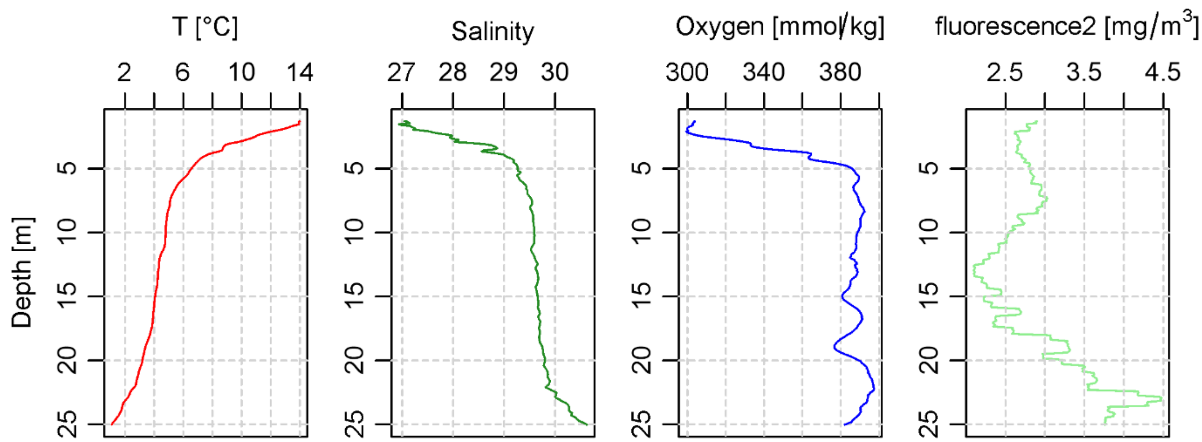

Figure D 51. CTD plot of station 92

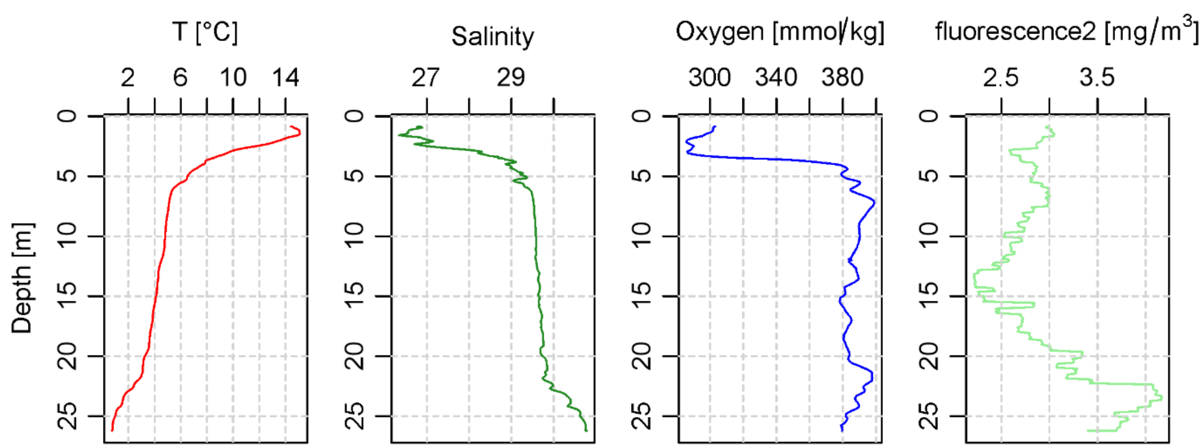

Figure D 52. CTD plot of station 93

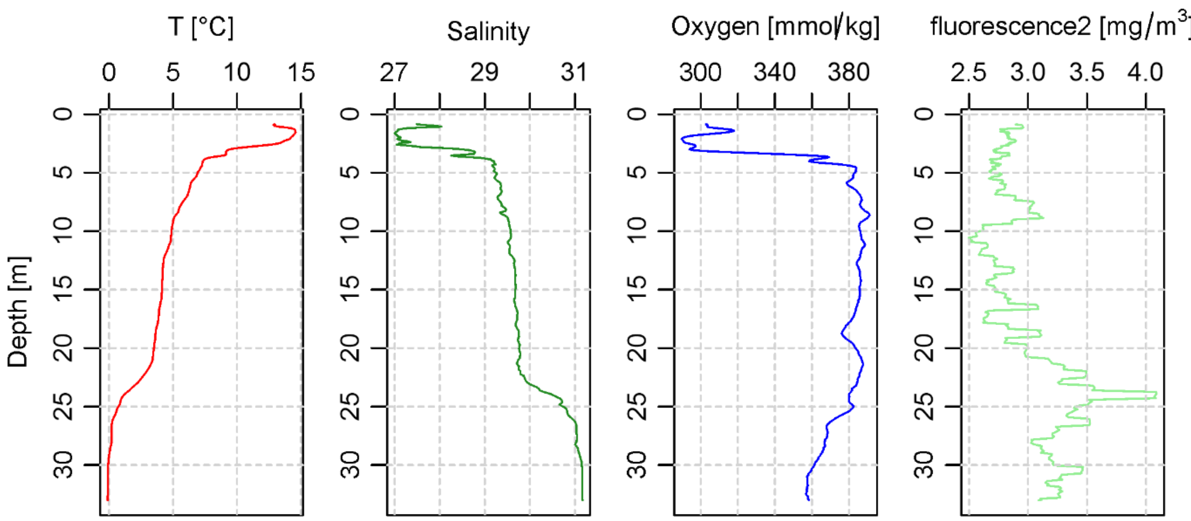

Figure D 53. CTD plot of station 94

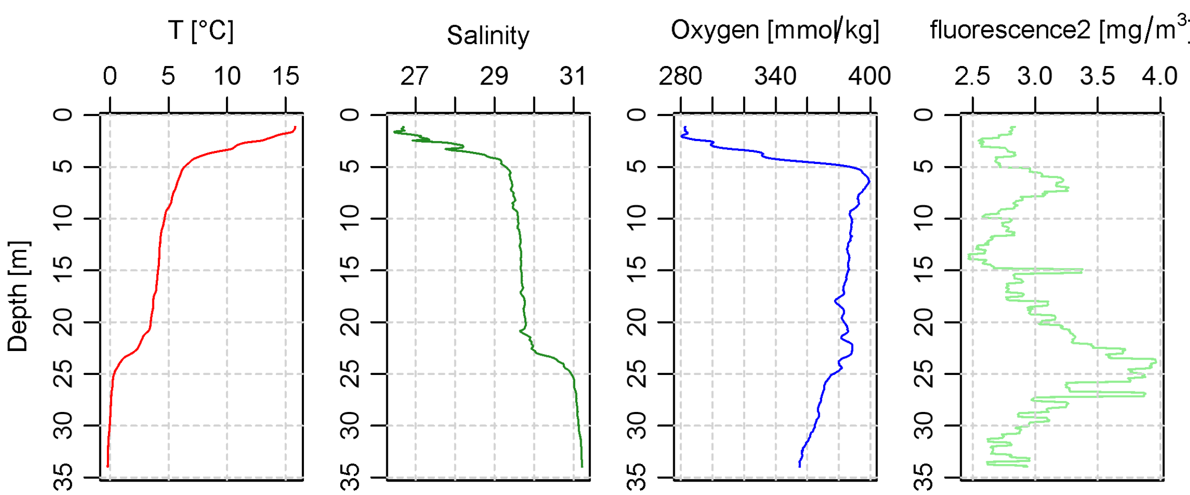

Figure D 54. CTD plot of station 95

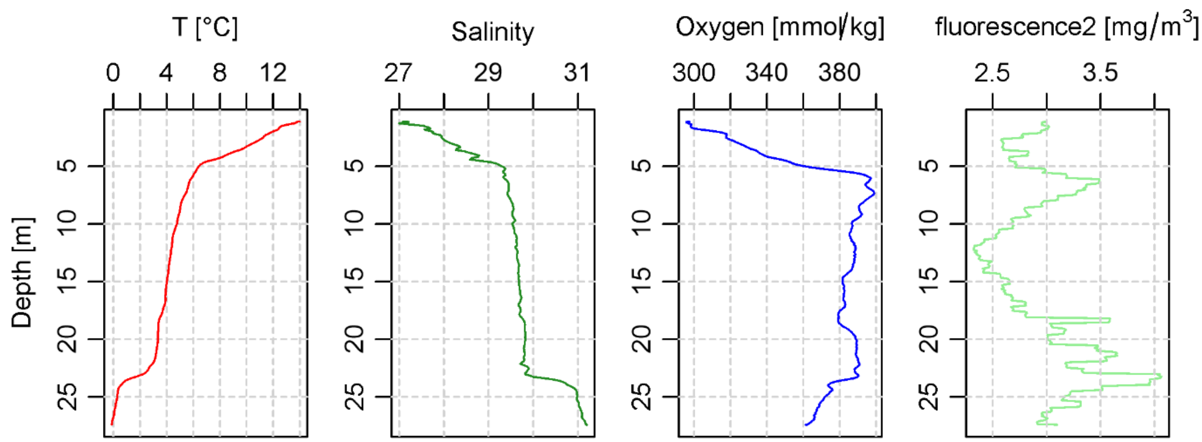

Figure D 55. CTD plot of station 96

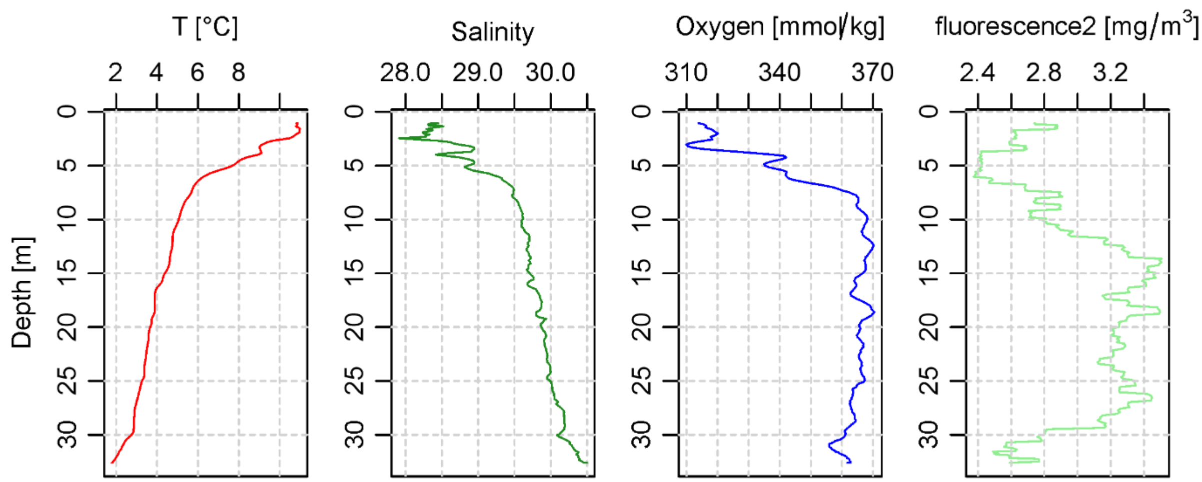

Figure D 56. CTD plot of station 99

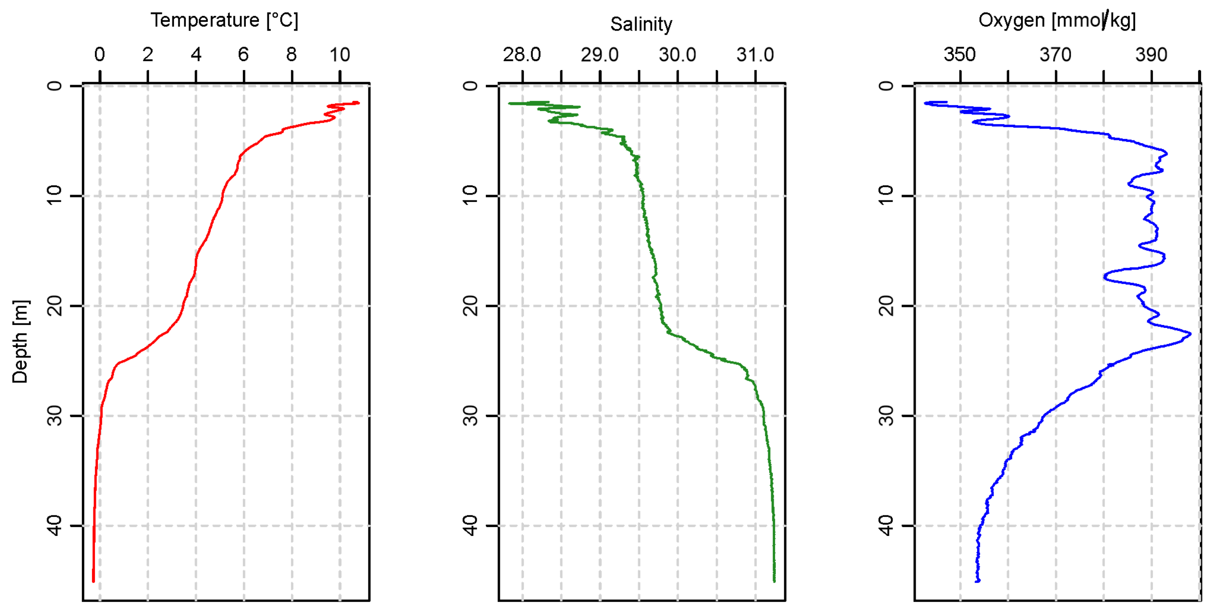

Figure D 57. CTD plot of station 100

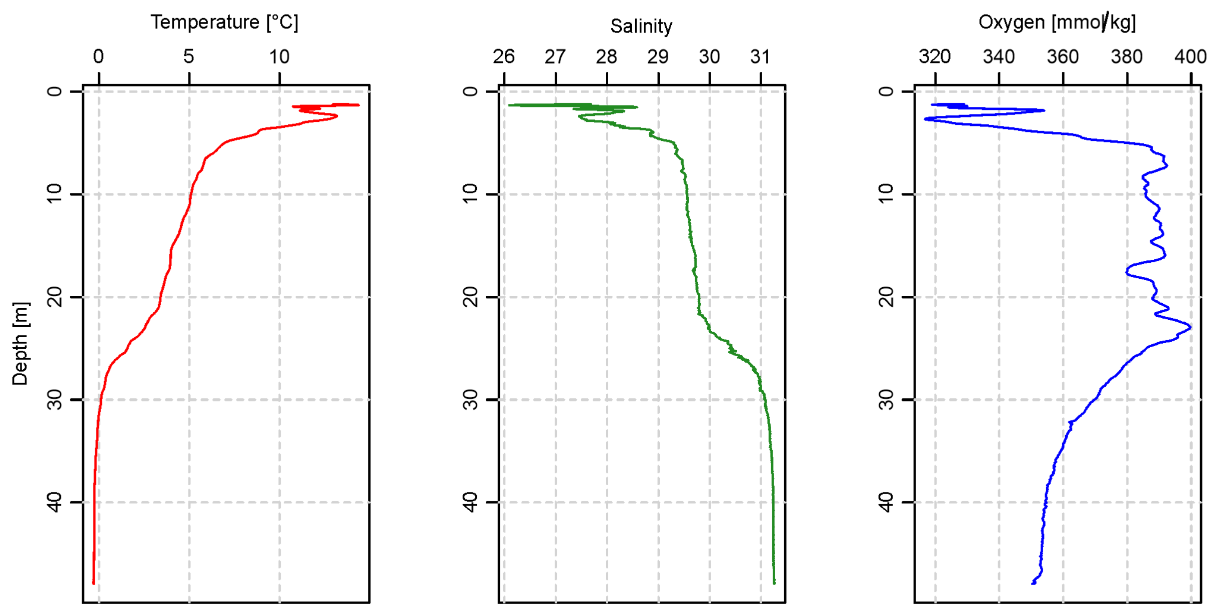

Figure D 58. CTD plot of station 101

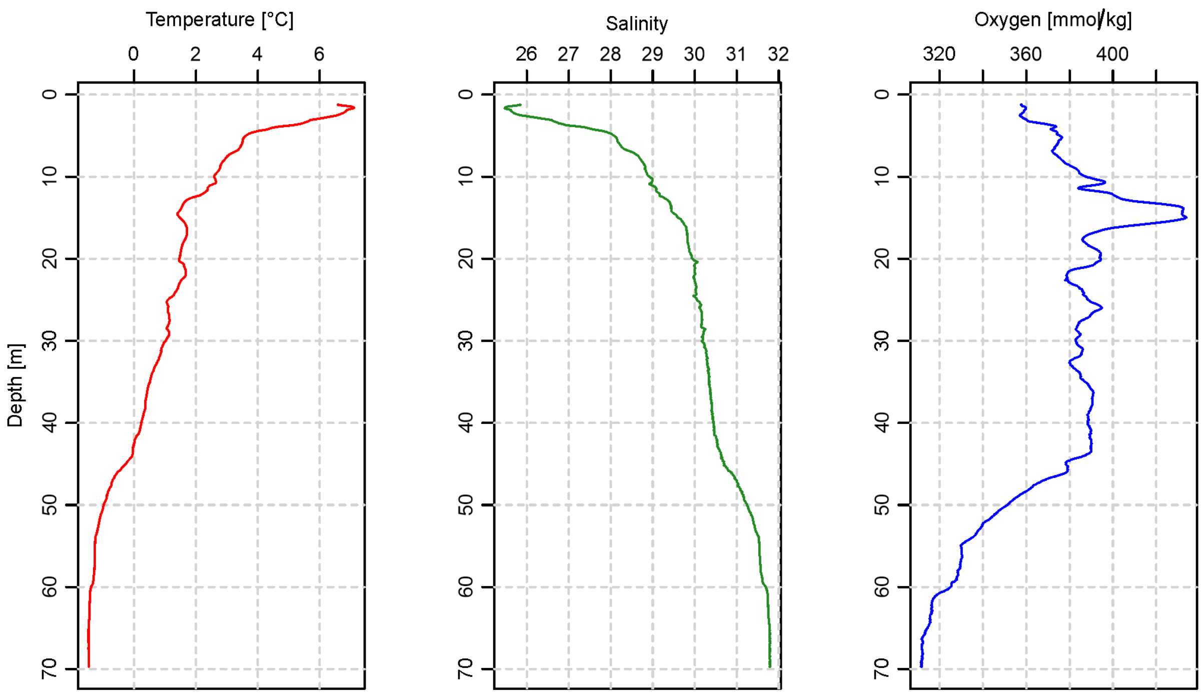

Figure D 59. CTD plot of station 102

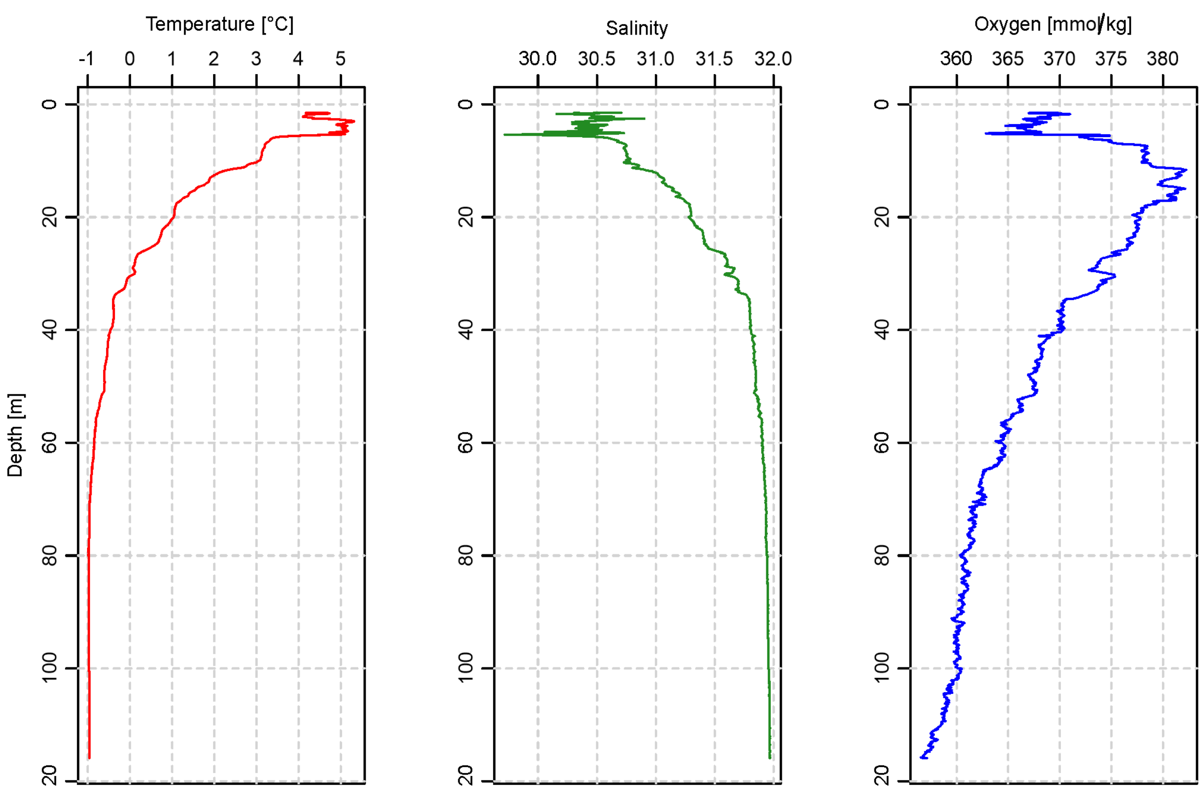

Figure D 60. CTD plot of station 107