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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 presence of coastal and marine geohazards and coastal erosion, which further places the cultural heritage of coastal archaeological sites at risks. Sea ice decline also compromises the formation of polynyas, with unknown consequences for the regional ecosystems.

From the 10th to the 18th of July 2022, 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, 42 surface sediment samples, 29 sediment cores, 41 conductivity-temperature-depth (CTD) profiles, 13 water samples, 24 phytoplankton nets and 13 zooplankton nets were collected. The cruise allowed the deployment of 2 moorings equipped with sediment traps in Nain Bay and within deeper offshore waters. Triangulation showed that the 2 moorings were correctly placed near their target locations. Drop camera transects were deployed in Webb Bay and at the easternmost tip of Paul's Island to image the seabed and study benthic habitats. Finally, acoustic sub-bottom profiling 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) evaluating the productivity and dynamics of small recurring polynyas (i.e., rattles) on diverse timescales, 2) assessing marine and coastal geohazards (e.g., landslides) in relation to the deglacial history of Nain, 3) investigate the seabed geomorphology in Webb Bay and linkages with permafrost and sea-level changes and 4) conducting benthic habitat characterization.

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

AULLATSIJET NAILLITITAUSIMANNINGA

Tânna angillivalliajuk Ukiuttattumi nillatâttoKattajut nunguvalliajut pimmagittumik attuitluni nunamik tamakkuninga taggami nunalet inopvigiKattajangit tamânejunut satjugiami ammalu imappimi nunami ulugianattumettisijuk ammalu satjugianga situvallialittuk, tamanna ininganottisijuk ilukkusinganik taimangasuanit satjugiami itsasuanittait inigijangit ulugianattumettisimmijuk. Sikunga nunguvallialittuk attuimijuk inigganigijanginnik, Kaujimajaulugani sakKilâttunut ilinganiKajumut nunakKatigengitumi avatigijanginnik.

Pisimajumit tânna 10th tikijumut tânna 18th Joli 2022, Kaujisattilagijik umiatsuak ikimajuk Kaujisattet umiangagut William-Kennedy pivitsaKattisilauttuk katitsuigiamut ottugattausonik ammalu Kaujigatsanik imappimit satjugiami avatinganit Nain, Nunatsiavummit. Ilonnangit kitillugit, 42 Kânganejunit imânit ottugattaugajattunut, 29 imânit atânganit, 41 nakituinnak-nigumittojunut-itiniKajunut KanuilingakKomangâmmik, 13 imânit ottugattausot, 24 kingugalakulunnut nuluat ammalu 13 mikinitsanik omajunut nuluat katitsutaulauttut. Tainna umiatsuak pivitsaKattisilauttuk ilisigiamut kalittaujunut tigusigunnagiamut imânejunik Nain kangitlunganit ammalu itijunneluattunik kitâni imammit. Pingasolingajut takutitsilauttuk taikkua maggok kalittaujut ilijautsialauttut inigijanginnut. katailaummijut atjiliugutimmik Webb's kangitlungani ammalu kitâniuluak Paul's Island-imi atjiliugigiamut ikkanganik ammalu Kaujisagiamut omajunik itijummiutanik inigijauKattajumut. kingullimi, nipaliuKattajumut ikkaneKataujunut KanuilngatsiaKommangât Kaujisattaujumut pivitsaKattisilauttuk takutsausiajumik piusigijangita pitagijangit ikkanganik, kajulauttuk nalunaitsigiamut inigijauKatajunut imâneKattajunut ottugagunnagiamut ammalu Kaujimajaungitunut nunangata Kaujigatsanginnik pitjutigillugit ilisipviuKattajunut avatinganik.

Tânna piKutik ammalu Kaujigatsait katitsutaujut Kaujisaniammat tainna umiatsuak atuniKatsialangavuk ukununga 1) Kimiggugiamut piguvalliajut ammalu takuminattunut mikijunut sakKinginnatunik sikugunnaKatangitunut (sollu ingganet) atjigengitunut Kangaulimmat, 2) Kimiggulugit imappinga ammalu satjugiami nunangita ulugianaKattajunik (sollu nunak situjut) ilinganiKajunut aujuittoKattasimajut piusigijaulautsimajunut Nainimi, 3) Kaujisallugit ikkangata nunanga ammalu Kânganejunut iluani Webb's kangitlungani ammalu atajunut KuasimanginnaKattajunut nunaup iluani ammalu imanga-imattâvalliajut asiangujunut ammalu Kaujisallutillu ikkamiutanik inigijauKattajunut piusigijanginnik.

SivukkiutiuKataujok Ilinniavitsuak New Brunswick-imit ammalu Piviannatunut Canadami, tamanna umiatsuakut suliagijaulauttuk ikajuttigetlutik kavamakkunut Nunatsiavummit, Université du Québec à Montréal, Université Laval, Dalhousie Ilinniavitsuanga ammalu Memorial Ilinniavitsuanga, ammalu kenaujattâsimatlutik taikkununga KaujisattilagijiuKattajut ammalu Kaujisattet kaunsalliKutingit Canadami ammalu NRCan.

INTRODUCTION

In the coastal zone of Nain (Nunatsiavut), a substantial body of archaeological data documents cultural and subsistence activities by Dorset and Thule-Inuit cultures for more than two millennia (Hood, 2008). Several archaeological sites are located near small recurring polynyas, which are open-water areas that develop within sea ice-covered regions and that are key components of the Arctic productivity budget. Polynyas and associated ice-edge habitats have provided subsistence resources for hunting cultures (Dorset, Thule, Inuit) living along the (sub)arctic coasts for millennia (Ribeiro et al., 2021; Woollett et al., 2000) and still are crucial to local communities today for fishing, hunting and gathering. However, the coastal environment and the polynyas are at risk due to the accelerating Arctic warming and knock-on effect on sea ice and coastlines submersion and erosion. Recent studies have shown that the changing cryosphere is affecting coastal erosion (Fritz et al., 2017) and can even have consequences for coastal and marine geohazards such as nearshore landslides (Normandeau et al., 2021; Syvitski and Normandeau, 2023), which in turn has consequences for public safety and coastal infrastructure. The accelerating warming can thus compromise the existence of polynyas and can affect the land on which Inuit live through coastal erosion and the presence of coastal and marine geohazards.

Despite the recognized cultural and ecological values of the coastal zone and polynyas in Labrador, the oceanographic and/or geologic processes involved in their formation and evolution are unknown and no study has documented their present and past dynamics in relation to cryospheric changes. This limits our ability to understand the influence of coastal evolution and the presence of polynyas on the regional ecosystem and determine the role they played in the establishment of early settlements along the Nunatsiavut coast. Additionally, there is urgency to study these sensitive oceanographic features, gain knowledge on their present-day functioning, and better define how polynya activity translates into the sediment signal before potentially significant changes occur.

The objectives of this project are to:

1) Determine the spatial and long-term variability in phytoplankton production in the Nain archipelago;
2) Assess the role of environmental factors, including recurring polynyas, on phytoplankton variability;
3) Reconstruct changes in sea ice and primary production for the past two millennia;
4) Study the phenology of primary producers in Nain Bay and at the land-fast sea-ice edge;
5) Perform environmental DNA (eDNA), DNA, water quality and plankton surveys;
6) Assess marine and coastal geohazards in relation to the deglacial history of Nain;
7) Investigate the mounds and depressions in Webb Bay and their potential linkages with permafrost;
8) Investigate the origin of terraces observed at 10-15 m water depth and their potential formation during a sea-level lowstand.

PARTICIPANTS

Participants on the 2022William-Kennedy cruise came from three universities, the Geological Survey of Canada and the Government of Nunatsiavut (Table 1). Additional collaborators to the project (Table 2) provided input on the research objectives of this cruise.

Table 1. List of participants.

Name (Family, First)	Position	Affiliation	Role
Atkinson, Margaret	MSc student	UNB	Sediment sampling
Audet, Tiffany	MSc student	UQAM	Sediment sampling
Carson, Thomas	Technician	GSC	Deployment moorings
Eamer, Jordan	Researcher	GSC	Sediment sampling; Deployment moorings; SBP
Limoges, Audrey	Associate Professor	UNB	Chief scientist; CTD, CTD-R; PN, ZN; Sediment sampling; Sediment traps
Nochasak, Caroline	IRC	SNF	CTD-R, PN, ZN
Pijogge, Liz	Researcher	NG	CTD-R, PN, ZN
Sharpe, Hannah	MSc student	UNB	Sediment sampling
Van Nieuwenhove, Nicolas	Researcher	UNB	Deck operations CTD, CTD-R; PN, ZN; Sediment sampling
Winters, John	IRC	SNF	CTD-R, PN, ZN
Normandeau, Alexandre	Researcher	GSC	Shore-based scientist – on call; Moorings, sediment sampling; SBP

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

Table 2. List of collaborators.

Name (Family, First)	Affiliation
Bhiry, Najat	Université Laval
de Vernal, Anne	Université du Québec à Montréal
Edinger, Evan	Memorial University
Gigault, Julien	Université Laval
Harrison, Emma	Dalhousie University
Laing, Rodd	Nunatsiavut Government
Oliver, Eric	Dalhousie University
Robert, Katleen	Memorial University
Saunders, Michelle	Nunatsiavut Government
Sherwood, Owen	Dalhousie University
Sipler, Rachel	Bigelow Laboratory for Ocean Sciences

SUMMARY OF THE ACTIVITIES

The 2022William-Kennedy cruise began the night of July 10 and ended July 18, 2022. A summary of the cruise track and operations is available in figure 1. The cruise allowed the:

1) collection of 29 gravity cores
2) collection of 42 box cores
3) acquisition of 41 CTD profiles
4) collection of 12 water samples
5) collection of 24 phytoplankton nets
6) collection of 13 zooplankton nets
7) deployment of 2 moorings
8) recovering of 1 mooring for the Nunasiavut government
9) 8 drop camera transects
10) ~925 km of sub-bottom profiles

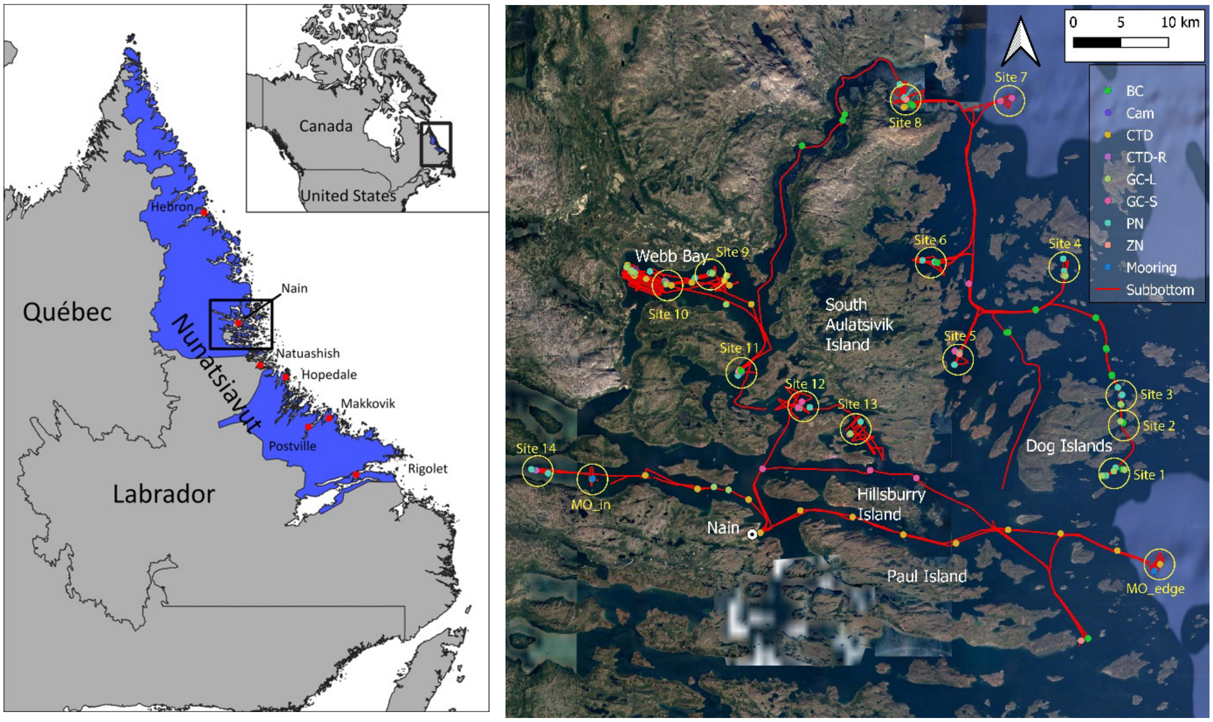

Figure 1. Sampling sites and sub-bottom profiler lines of the 2022William-Kennedy cruise. Yellow circles represent site numbers (not to be confused with station numbers) in the following tables.

Table 3. Summary of stations completed. CTD: Conductivity-Temperature-Depth, CTD-R: CTD-Rosette, PN: Phytoplankton Net, ZN: Zooplankton Net, DC: Drop Camera, BC: Box Core, GC-S: Gravity Core-Short (150 cm), GC-L: Gravity Core-Long (300 cm), SBP: Sub-bottom profiler.

Date	CTD	CTD-R	PN	ZN	DC	BC	GC-S	GC-L	SBP	Moorings	Notes
July 10									X		Mobilization of reduced scientific team
July 11	2	1	4	2		5(4)	4(2)	1(0)	X		
July 12	2	2	4	2	5	7(6)	1	2	X		
July 13	17	2	3	2	1	7		8	X		
July14	3	3	16(6)	3		6(4)	2	5(4)	X		
July15	3	3	5	3		12	2	6(4)	X	1	Recovering test mooring (ASL)
July 16	3	1	2	1	1	8		1	X	1	Deployment MO_in
July 17	11				1	3(1)	6(2)	2(1)	X	1	Deployment MO_edge
July18											Demobilization
Total attempted	41	12	34/24	13	8	48	15	25			Total attempted stations: 186
Total successful	41	12	24	13	8	42	9	20			Total successful stations: 169

EQUIPMENT AND PROCEDURES

CTD and CTD-Rosette

A stand-alone seabird 19plusV2 SeaCAT profiler CTD was used to collect water column profiles during the cruise. Deployment steps were as follow: 1) start archiving, 2) immerse the CTD just below the surface for 2 minutes, 3) descent at 1 m/second and stop at about 5 meters above the bottom, 4) wait 30 seconds, 5) ascend to the surface, 6) turn off the instrument, 7) rinse with freshwater. The data was downloaded at the end of each day. Location of CTD profiles are presented in Figure A3 and Table A3. Downcast measurements are presented in Appendix B (Figs. B1-B40).

The CTD-Rosette is 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), which continuously measures the conductivity, temperature and density, as well as a fluorescence sensor, a seabird dissolved oxygen sensor and a Photosynthetically Active Radiation (PAR) sensor were attached to the rosette. Deployment 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 1 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, turn the CTD off; 9) Stop archiving and close deck unit.

Location of CTD-R profiles are presented in Figure A4 and Table A4. Downcast measurements are presented in Appendix C (Figs. C1-C12).

Phytoplankton Net (PN)

The phytoplankton net is conical with a 30 cm diameter, 75 cm length, and 20 µm mesh net, with a 10 kg weight fixed at the base of the cod-end. The phytoplankton nets were deployed horizontally in the water column. The net was lowered to ~5 m below the surface and towed behind the boat at a speed of approximately 2-4 knots for a minimum of 15 minutes. Start/end times and positions were recorded. Once the net was back onboard, its sides were rinsed from top to bottom with a seawater hose. The excess water was then drained by gently rubbing the cup mesh.

The samples collected for UNB were transferred into 500 mL Nalgene jars, preserved with 10 mL of formalin (37%) and stored in a refrigerator (4°C).

The samples for MUN were filtered through a 150 µm mesh. A 40 mL subsample was fixed in formalin (0.5 mL of buffered formalin was used for every 10mL of sample). Three subsamples were also filtered, and the filters were stored at -20°C for later analysis. The details of all the phytoplankton net are available in Table A5 and Figure A5

Zooplankton Net (ZN)

The zooplankton net is conical with a 200 µm mesh net. The net was lowered slowly to allow the cod end to fill with seawater. The net was always towed vertically. It was lowered to about 5 m above the seafloor and lifted up at a speed of 10 m/minute. Start/end times and depth were recorded. Once the net was back onboard, its sides were rinsed from top to bottom with a seawater hose.

A subsample of ~40 mL was fixed with formalin (1 mL of buffered formalin was added to every 10 mL of sample) and stored in the refrigerator. The remaining sample was poured in a picking tray and organisms (krill, large copepods, pteropods, amphipods, small jellies) were collected in separate falcon tubes. The remaining sample was filtered through 500, 355 and 200 µm mesh sizes and each fraction was kept in separate tubes. The samples and filters were stored at -20°C for later analysis at MUN. Details of the zooplankton net are available in Table A6 and Figure A6.

Sediment coring

During the 2022William-Kennedy cruise, two types of sediment corers were used: 1) a box corer (BC) and 2) a gravity corer (Fig. 2). The gravity corer was configured with one (GC-S) or two barrels (GC-L), for a maximum length of 2.5 m. Following feedback from the 2021William-Kennedy cruise, the RV William-Kennedy increased their A-Frame capabilities by adding an extension to accommodate longer gravity cores.

Figure 2. A) The box corer; B) The gravity corer with 2 barrels (2.5m-long) and C) The gravity corer with one barrel of 90 cm long. Photographs by N. Van Nieuwenhove.

The box corer (Fig. 2A) was used to collect surface samples (0-1 cm) as it generally did not penetrate deep enough to recover undisturbed samples. Deployment speed was as fast as possible, which was approximately 100 m/min. The box corer allowed the collection of 42 surface sediment samples from 21 locations (Appendix A, Table A1 and Fig. A1, D1-D41), and 3 surface sediment samples were bagged each time for a series of microfossil, sedimentological, geochemical and biomarker analyses. Samples for palynological analysis were kept in the dark for future culture studies. Sample 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 (2gL^{-1} in ethanol = 0.790 g mL^{-1}) 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 2B-C) was deployed when previous surface sampling revealed the presence of fine-grained sediment on the seabed or where sub-bottom profiles suggested fine-grained sediment. Two gravity core heads were available, one provided by the William-Kennedy and one by the GSC. The one provided by the William-Kennedy had one 90 cm-long barrel whereas the one from GSC was operated with 2 barrels for a total length of 2.5 m. During deployment, the gravity corers were stabilized around 15 meters above the seafloor before accelerating descent speed to maximum. In both cases, six ballast weighs of 20 kg were used to facilitate penetration in the seabed. A total of 29 cores were successfully collected using the gravity corers (Table A2, Figures A2, E1-E21)

Sub-Bottom profiler (SBP) and navigation

A 3.5 kHz Knudsen Pinger sub-bottom profiler was pole-mounted to the port side of the vessel, and recorded data almost continuously during the cruise. It was used to acquire high-resolution subsurface data (sediment stratigraphy), to select core locations and identify features of interest on the seabed. The SBP was coupled with a Garmin GLO 2 bluetooth GPS/GLONASS receiver, which was also used for navigation purposes. Both the SBP and GPs performed well, generally tracking with the ship's navigation, even in typically challenging environments (steep-walled fjords).

The echocontrol acquisition software was consistently monitored for phase changes and depth ranging. Although there is automatic phase change in the software, manual phase changing was preferred for data quality purposes. Using the settings in Figure 3 provided good data quality upon data acquisition. In shallower waters (<50 m) the setting was changed on the dry box end from BATHY mode to SBP mode, which improved the penetration and resolution. During the cruise, the ping rate was not directly adjustable; the system automatically adjusted the ping rate based on the set water depth, the pulse width (Tx Pulse) and Tx power.

One issue was encountered with the computer supplied for logging the navigation data and running the SBP. After being unattended for several hours, it would go into sleep mode, which would stop the Pinger, creating gaps in the sub-bottom profiles. Nonetheless, the system performed well overall and achieved its objective of providing high-quality data in support of selecting coring locations.

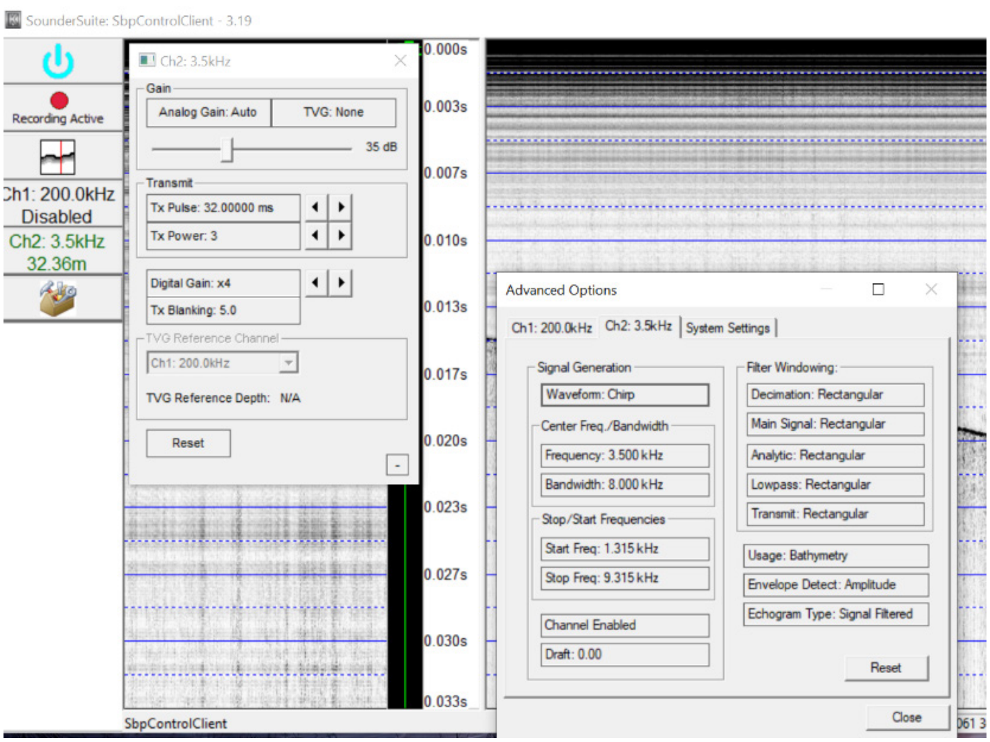

Figure 3. EchoControl screenshot of settings used during sub-bottom acquisition

Drop Camera

A drop camera 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 feet, 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 A7, Figure A7).

Moorings

Mooring instruments

Two moorings equipped with sediment traps, CTDs and an Acoustic Doppler Current Profiler (ADCP) were deployed during the cruise. 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. That information will then allow us to 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), 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. Seawater was collected offshore Halifax during the sea trials (King et al., 2022). To prepare the solution, seawater was filtered twice: i) first on a 3 µm, 142 mm diameter A/D glass fiber filter, ii) then on a 0.2 µm GTTP membrane filter. Approximately 10 L of formalin solution was prepared in advance at the Bedford Institute of Oceanography. Leftover solution was kept for later measurements of blank values for elemental analyses and chlorophyll measurements (CHN+ fluorimeter).

The sediment trap cups were labelled with the abbreviated cruise number (2022WK), the station ID (MO_edge or MO_in), the year of collection (2022 or 2023) and a unique ID for the cups (1-12).

Table 4. The two sediment traps were set up using the same configuration. Time and dates are given as Universal Time Coordinated (UTC). The sediment traps were programmed to rotate at intervals of 730 hours. First sampling started July 18 (2022), and the last trap bottle is set up to close July 16 (2023).

Bottles	Start date	Start time (UTC)	End date	End time (UTC)	Number of days
1	18-Jul	0:35	17-Aug	10:35	30.42
2	17-Aug	10:35	16-Sep	20:35	30.42
3	16-Sep	20:35	17-Oct	6:35	30.42
4	17-Oct	6:35	16-Nov	16:35	30.42
5	16-Nov	16:35	17-Dec	2:35	30.42
6	17-Dec	2:35	16-Jan	12:35	30.42
7	16-Jan	12:35	15-Feb	22:35	30.42
8	15-Feb	22:35	18-Mar	8:35	30.42
9	18-Mar	8:35	17-Apr	18:35	30.42
10	17-Apr	18:35	18-May	4:35	30.42
11	18-May	4:35	17-Jun	14:35	30.42
12	17-Jun	14:35	16-Jul	0:35	30.42

The inshore mooring (station 0160) was also equipped with an RBR duet T.D. (Temperature and Depth sensors), which is setup to record data continuously throughout the year (Table 5). A CT2X was placed at the same location on the mooring line, near the sediment trap, and records temperature and conductivity at an interval of 30 minutes.

Table 5. Instrument configuration on mooring station 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
Estimated duration	12 months	7 years	450 days

The sea-ice edge mooring (station 0181) was equipped with RBR Duet T.D., a CT2X, a Signature 500 ADCP and a CTD Concerto (Table 6). 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 (0160). 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 property every 10 minutes (Table 6).

Table 6. Instrument configuration on 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
Estimated duration	12 months	7 years	450 day	542 days	2.7 years

Mooring deployment

For the deployment of the moorings, the upper float and instruments were streamed off the back deck by hand, and the anchor (train wheel) was deployed last using the winch. The ship moved slowly towards the target site and the anchor was released when above target location. Once the moorings were released, they were monitored to their rest position using the WASSP system, and using a Teledyne deck unit connected to an element transducer. To accurately determine the mooring rest positions, the range of three positions away from the moorings were measured and the position of each mooring corresponds to the triangulated position of the acoustic release (Table 7, Figures 4-5).

Table 7: Deployment details of the mooring

Mooring ID	Mo_in (160)	Mo_edge (181)
Ship coordinates during deployment:	56.595016 -61.964566	56.509000 -61.009000
Coordinates of mooring on bottom (triangulation)	56.595063 -61.964052	56.509061 -61.008715
Depth deployment (m):	70	116
Date deployment:	16 July 2022	17 July 2022
Julian day	197	198
Time deployment:	18:26 UTC	16:04 UTC

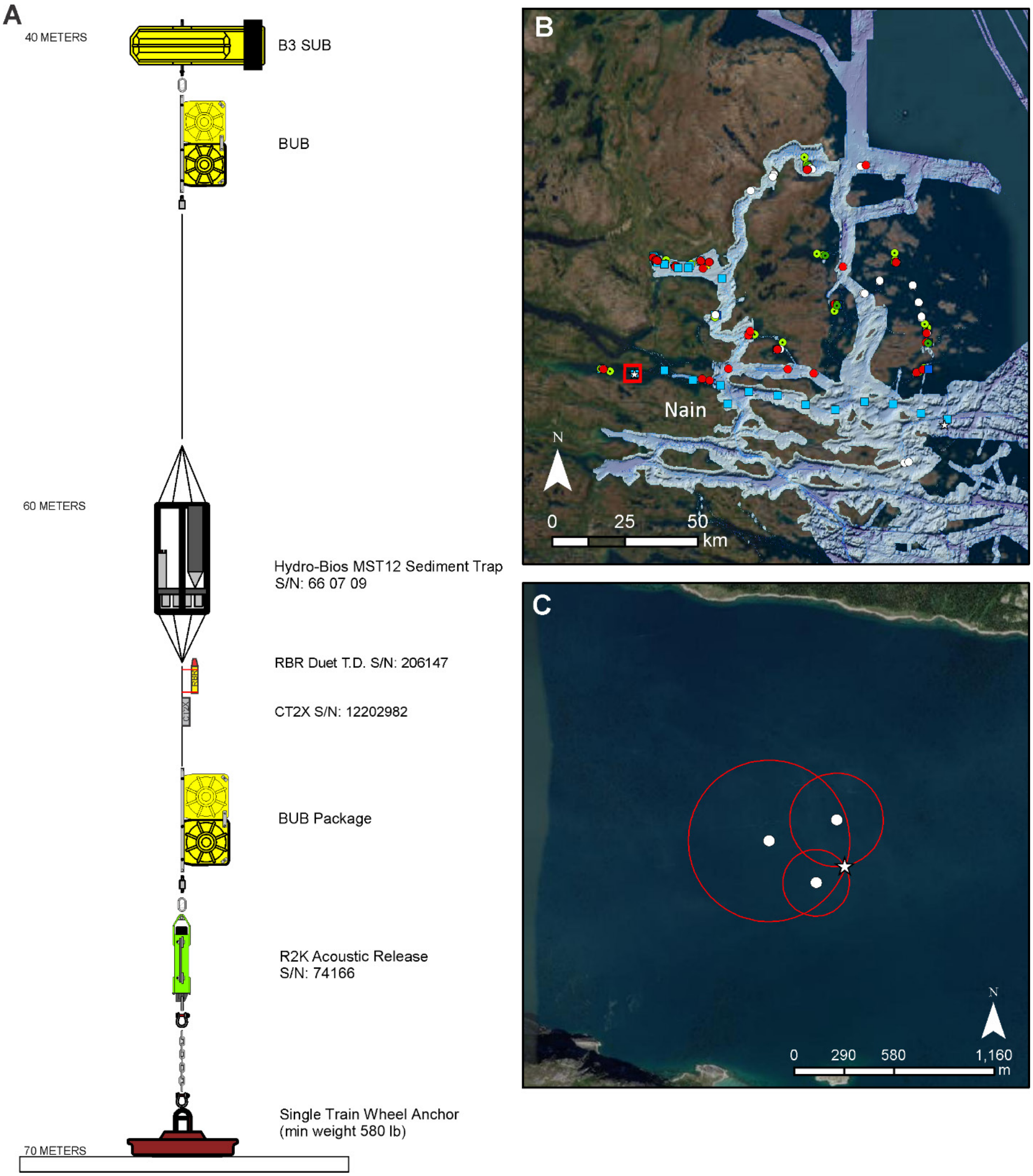

Figure 4. Configuration Mooring "MO_in" (Mooring #2219, station 0160). It consists of a sediment trap, and 1 RBR duet on the sediment trap. An acoustic release is placed 1m above the bottom. The mooring is 40 m. B) Overall geographic location of the mooring (red square). C) Triangulation from three points (white dots), which allowed positioning the mooring (white star).

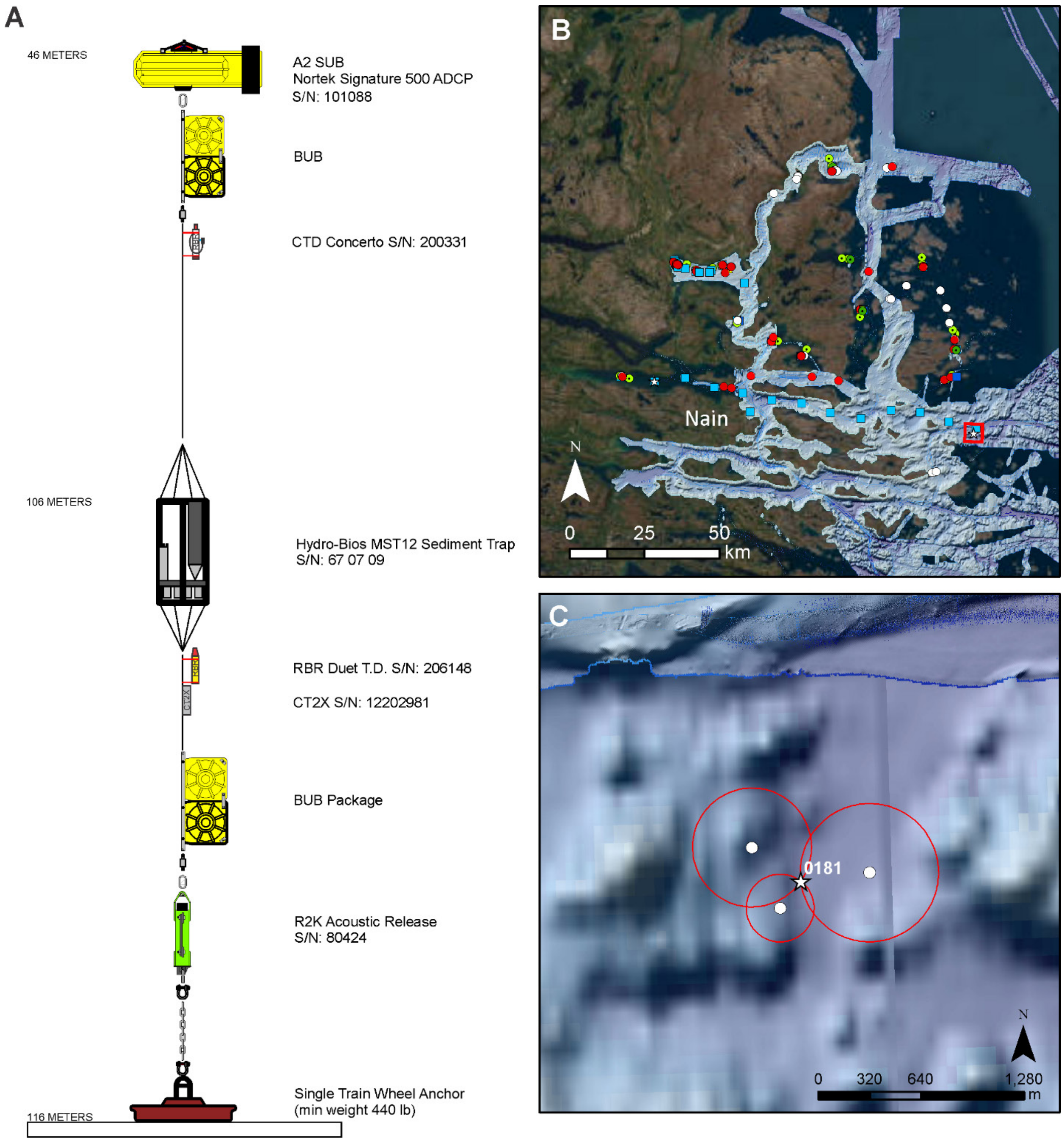

Figure 5. A) Configuration Mooring "MO_edge" (Mooring #2218, station 0181). It consists of an Acoustic Doppler Current Profiler (ADCP) and a sediment trap. One CTD Concerto and 1 RBR duet are placed on the sediment trap and the ADCP. An acoustic release is placed 1m above bottom. The mooring is 70 m long. B) Overall geographic location of the mooring (red square). C) Triangulation from three points (white dots), which allowed positioning the mooring (white star).

DAILY ACTIVITIES

This section provides a brief overview of the cruise narrative.

*All times in Atlantic Standard time

JD 191 – July 10, 2022

A reduced scientific team of five participants boarded the ship at 4:00pm. The rest of the team had their flight cancelled from Goose Bay because of foggy weather. By 5:45pm, the vessel had departed Nain for site 11 (See figure 1 for site locations). The sub-bottom profiler was turned on immediately. Familiarization and security procedures were explained by the chief mate at 6:45pm. Seas were calm. Sub-bottom profiler (SBP) troubleshooting was done. From 8:00pm, several lines of SBP were completed in the vicinity of sites 11, 12 and 13. Potential coring targets were identified for the next day.

JD192 – July 11, 2022

Station operations began at 07:00 at site 13, where a CTD, CTD-R, 2 horizontal PN, 1 vertical ZN and 2 BC were collected. No sediment core was collected. Although sediment was present, the coarser material and abundant shells prevented us from collecting a core. We then transited to site 12 where a CTD, CTD-R, 2 horizontal PN, 1 vertical ZN, 2 BC and 1 GC-S were collected. Several attempts to collect a longer core were unsuccessful. The sediment contained abundant shells, and the voids likely caused the water to wash out much of the sediment when the GC was lifted-up. At 5:05pm, operations at site 12 were completed and we started our transit towards site 11. At site 11, we collected 2 BC and 1 GC-S. During the transit from site 11 to Webb Bay, a uniform blanket of semi-transparent sediment of ~5 m thick was mapped throughout Webb Bay over the till and was interpreted to potentially represent Holocene deposition. Once in Webb Bay, several SBP lines were completed in the eastern and western sides.

JD193 – July 12, 2022

Station operations began at 07:00 at site 10, where a CTD-R, 2 horizontal PN, 1 vertical ZN, 1 CTD, 2BC, 1GC-S and 1 GC-L were collected. At 12:00, the zodiac was deployed to pick up the rest of the team in Nain. The operations continued at site 9 where a CTD, CTD-R, 2 horizontal PN, 1 vertical ZN, 1, 2BC and 1 GC-L (224 cm) were collected. Familiarization and security procedures were explained by the chief mate at 5:00pm to the new participants. The day and night scientific crew working-shifts were adjusted (day shift ended at 2:00am the next day) to ensure that a sufficiently large team could help with night operations. At 6:00pm we started our transit to western Webb Bay for drop camera transects in the region where mounds and depressions were identified through multibeam echosounder. A transect of CTDs was done away from the river-mouth toward the south-east over the mounds and depressions.

JD194 – July 13, 2022

Overnight, several GCs were collected. Two GC-L were collected for Emma Harisson in western Webb Bay. Three GC targeted the collapsed mounds. The first two showed good recovery, but a lot of sediment was lost out of the cutter/catcher. The third core hit frozen sediment at ~26.5 m depth. A short frozen core of ~30 cm was photographed and stored in the -80°C freezer. The ship then transited east to perform a drop camera transect and sediment coring on the DeGeer moraines.

Day station operations began at 07:00 at site 11, where a CTD-R, 1 CTD, 1 horizontal PN, 1 vertical ZN and 1 BC were collected. Sediment coring had been done on JD192. Very windy day (30kn). We sailed north through the narrow passage between mainland and South Aulatsivik Island. Opportunistic BCs were collected along the way; especially near the rattles. At 16:38, we started operations at site 8 and all sampling was done except for the sediment. We did two unsuccessful deployments of the gravity corer and decided to wait until the sub-bottom profiling could be performed before attempting more coring. Because of the strong winds, we decided to sail south to sites 6 and 5 – that were more protected from the swell– for the night shift.

JD195 – July 14, 2022

More SBP troubleshooting was needed overnight. The toggle on the box "BATHY" was switched since travelling in deeper waters. This improved the penetration and reduced the noise. Crew became seasick. Four SBP lines were performed in Kolotulik Bay, near site 6. Sediment sampling was completed at these stations overnight. Several attempts with the PN were unsuccessful due the conditions.

Day operations began at 8:20 at site 4, where a CTD, CTD-R, 2 horizontal PN, 1 vertical ZN, 2 BC and 2 GC-L were collected. In the meantime, the zodiac was used to identify the best trajectory to sites 3, 2 and 1, since this area was uncharted. We then transited to sites 5 to do a CTD- CTD-R, 2 horizontal PN and 1 vertical ZN. The same suite of sampling was done at site 6. We then sailed north back to sites 7 and 8 to perform SBP lines and collect sediment.

JD196 – July 15, 2022

During the night shift, because of a relatively rough sea, science personnel had retreated to cabin due to seasickness. Jordan was helped by Captain David and Matthew who stayed beyond their shift. A drop camera transect could not be completed at the Nain's Gate station. The William-Kennedy transited to site 3.

Daytime operations began at 09:45 at site 3, where a CTD, CTD-R, 1 vertical ZN, 2 horizontal PN were collected. John did a drop camera. We then moved to site 2 to do the same suite of sampling, with the exception that only 1 horizontal PN was completed. We transited to site 1 for a full station and steamed back to sites 2 and 3 to complete the sediment coring. We decided to improve the spatial coverage with box coring between sites 3-4 and 5 overnight.

JD197 – July 16, 2022

A drop camera transect was completed at Paul's Island for Katleen Robert. We then sailed back to Nain to pick up Tom Carson. Caroline disembarked the vessel. We transited to the mooring station MO_in. At 13:00, smoke in the galley triggered the fire alarm and all crew members gathered at the muster station. During the transit, the mooring was assembled, and the trap bottles were filled with the formalin solution and attached to the sediment trap carousel. At 13:59, the mooring was deployed; and identified with the WASSP system. The transducer was not able to communicate at first, until the code was entered correctly. Three different ranges were then taken with coordinates and distances for triangulation. We completed the last full site, site 14, where a CTD, CTD-R, 1 vertical ZN, 2 horizontal PN, 2 BC and 1GC were collected. We sailed back to Nain, doing CTDs along the way. Two sediment cores were also collected at landslide and moraine sites. John and Liz disembarked the vessel.

JD198 – July 17, 2022

At 7:00 we started a second drop camera transect at Paul's Island, for 20 minutes. We then transited to MO_edge, collected a BC during the transit, and completed several lines of SBP to identify the best location for the deployment of the mooring. At 13:05, the mooring was deployed. Three different ranges were taken with coordinates and distances for triangulation, and the mooring was identified with the WASSP system. We then made a transect of CTDs between the mooring location and Nain. The last CTD was completed at 19:30. The William Kennedy anchored in Nain.

JD199 – July 18, 2022

The lab was cleaned, and the material was demobilized to the Nunatsiavut Research Center. We were able to meet with Ron Webb to show the permafrost core collected during the cruise, and ask questions about the location of core ice that he remembered from several decades ago. He confirmed he would discuss with other members of his family and verify if they have pictures. Furthermore, he mentioned core ice also being present around Hebron Bay, which they used when hunting caribou. He talked positively about the community session that he found very informative. Later during the day, Henry Webb also came to the ship to discuss our findings.

Around 11:30am, it became clear that we would have to find an alternative solution to store the sedimentary material as the cold room of the research center had been converted into a freezer to store seasonal food resources for the community. After asking all potential stores or public spaces that may have had cold storage – with the help of Liz – a decision was made to buy two refrigerators. The refrigerators were bought and installed in the research center around 15h00. This also meant that all the sections of 1.5m had to be cut in two to fit in the refrigerator. Therefore, all the longer sections were cut in half using a new annotation system: A–A', B–B', B-C. We transported the cores to the research center at 18:30. By 19:00, demobilisation was completed. The scientific crew stayed on the ship overnight.

JD200-July 19, 2022

Flights were delayed by several hours due to foggy conditions. At 17:00 the scientific team flew out from Nain.

PRELIMINARY RESULTS

Water-column properties measured with the standalone CTD and CTD-R casts along an inshore-offshore transect starting in Nain Bay and ending offshore Dog Islands highlight strong mixing of the water column at the location of the recurrently forming rattle south of Hillsburry Island (Figure 6). Strong currents in this area appear to contribute to the vertical advection of warmer and fresher water masses down to the bottom of the water column.

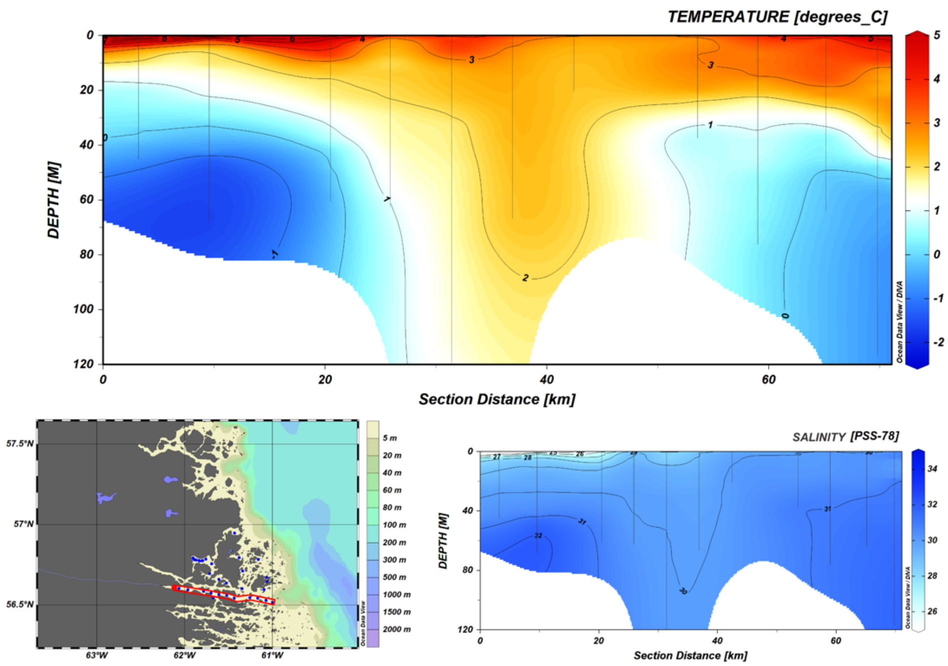

Figure 6. Water column profiles along an inshore-offshore transect from Nain bay to offshore Dog Islands. Water temperature and salinity profiles show clear mixing near Hillsburry Island (~40 km distance), with the influence of warmer, fresher waters down to the bottom of the water column.

In Webb Bay, the sampling of frozen sediment confirms the initial hypothesis that the mounds and depressions could represent subsea permafrost in a degrading state, similar to onshore thermokarst. At the time of sampling, waters <0°C appear to be a consistent feature at a depth greater than 22m in Webb Bay (Figure 7) over the mound and depression area (Figure 8). These cold-water masses likely play a key role in the preservation of subsea permafrost sampled with the gravity core.

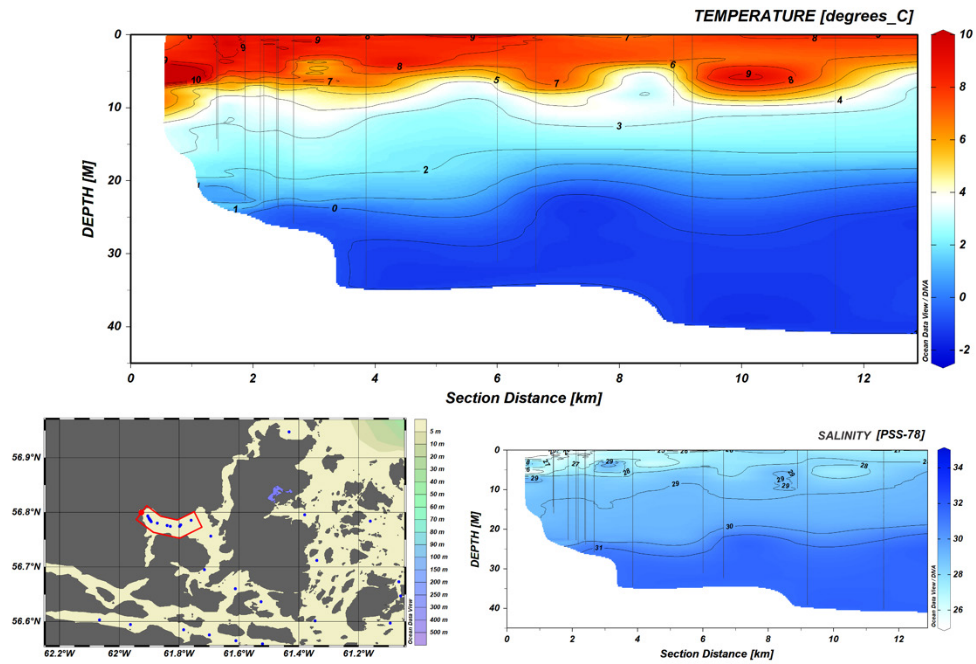

Figure 7. Water column profiles in Webb Bay. Bottom water temperatures < 0°C appear to be a consistent feature in the bay.

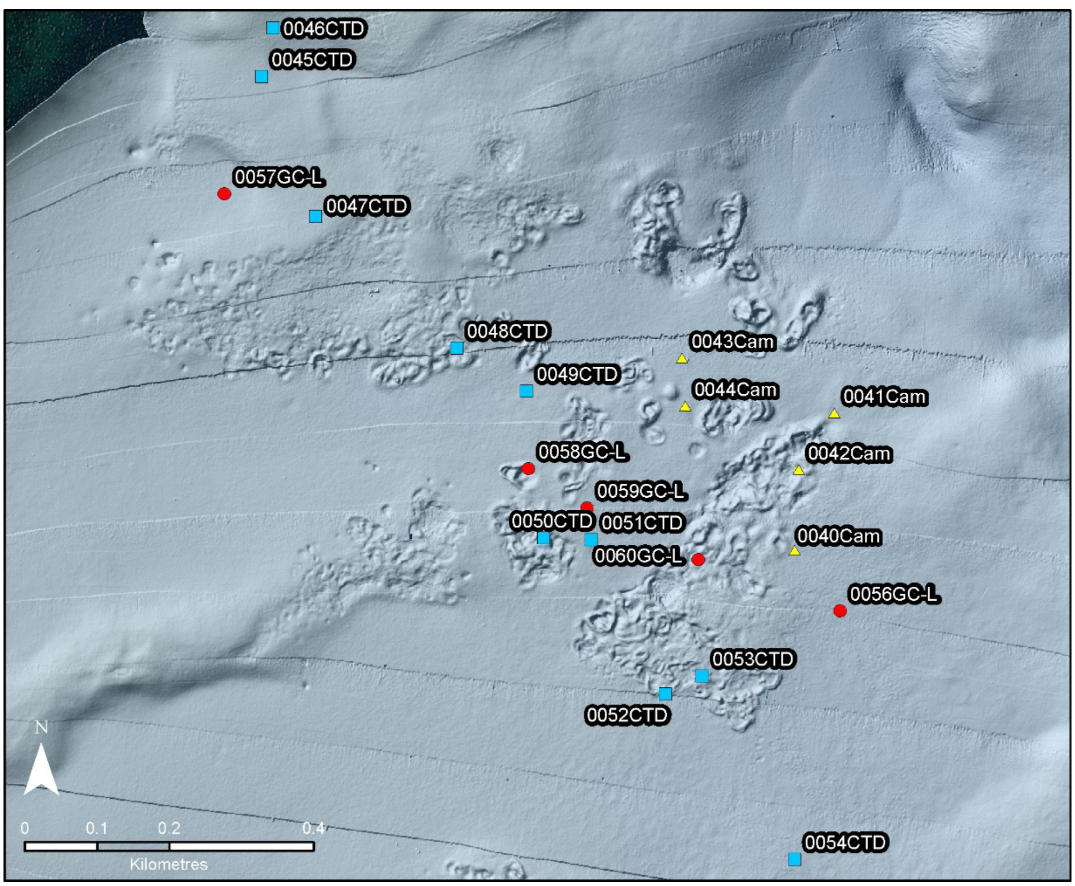

Figure 8. Stations completed on the mounds and depression area of Webb Bay.

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APPENDIX A: STATION SUMMARY

Table A 1: List of box core stations

Station No	Site	Type	Julian Date / Time (UTC)	Latitude	Longitude	Water depth (m)	Location	No Samples	Archived at	Comments
6	13	BC	192/1309	56.637033	-61.516816	28.6	Labrador Shelf - Nain	1	UNB	
7	13	BC	192/1455	56.63665	-61.5271	28.9	Labrador Shelf - Nain	1	GSC	
15	12	BC	192/1838	56.6611	-61.614816	33.3	Labrador Shelf - Nain			Box core failed to engage, two tries
16	12	BC	192/1847	56.660866	-61.614966	32.4	Labrador Shelf - Nain	1	UNB	
17	12	BC	192/1901	56.6609	-61.615716	33.7	Labrador Shelf -	1	GSC	
20	11	BC	192/2125	56.695483	-61.71605	38.7	Labrador Shelf - Nain	1	UNB	
21	11	BC	192/2134	56.695383	-61.71575	39.4	Labrador Shelf - Nain	1	GSC	
28	0	BC	193/1315	56.7767	-61.8405	34.4	Labrador Shelf - Webb Bay	1	UNB	
29	0	BC	193/1351	56.776616	-61.840783	34.7	Labrador Shelf - Webb Bay	1	GSC	First try did not trigger
37	0	BC	193/1858	56.786633	-61.762233	43.5	Labrador Shelf - Webb Bay	1	UNB	
38	0	BC	193/1954	56.7854	-61.761216	43.2	Labrador Shelf - Webb Bay	1	GSC	
73	0	BC	194/1308	56.695066	-61.715583	38.5	Labrador Shelf - South Webb Bay Crattle	3	UNB and GSC	
74	0	BC	194/1628	56.903533	-61.6081	23	Labrador Shelf - Narrow Passage NW Aulatsivik Island	1	UNB	
75	0	BC	194/1718	56.93275	-61.5356	11.1	Labrador Shelf - Narrow Passage NW Aulatsivik Island	1	GSC	
76	0	BC	194/1725	56.931016	-61.535816	20	Labrador Shelf - Narrow Passage NW Aulatsivik Island	1	UNB	
77	0	BC	194/1737	56.927233	-61.539166	23	Labrador Shelf - Narrow Passage NW Aulatsivik Island	1	UNB	
83	0	BC	194/2234	56.9421	-61.423117	75.8	Labrador Shelf - Port Manvers	1	UNB	
84	0	BC	194/2244	56.9406	-61.419	76.9	Labrador Shelf - Port Manvers	2	UNB and GSC	
85	6	BC	195/0428	56.796233	-61.3801	103	Labrador Shelf -	2(?)	UNB	Second attempt was successful

87	6	BC	195/0724	56.713233	-61.348767	89	Labrador Shelf -			
91	6	BC	195/0436	56.79615	-61.380283	103	Labrador Shelf -	1	GSC	0085B at UNB
105	0	BC	195/1349	56.78335	-61.160216	90.7	Labrador Shelf - South David Island	2	UNB	
106	0	BC	195/1359	56.78355	-61.1605	90.5	Labrador Shelf - South David Island	2	UNB/GSC	
119	7	BC	196/0202	56.9455	-61.269367	91.9	Labrador Shelf -	2	UNB/GSC	
120	7	BC	196/0210	56.94495	-61.270616	91.3	Labrador Shelf -	1	UNB	
137	1	BC	196/1809	56.597116	-61.096833	58	Labrador Shelf - South Dog Islands	2	UNB	
138	1	BC	196/1818	56.597083	-61.097933	57.7	Labrador Shelf - South Dog Islands	1	GSC	
141	2	BC	196/2011	56.647333	-61.0617	34.3	Labrador Shelf -	2	UNB	
142	2	BC	196/2017	56.647116	-61.061616	31.9	Labrador Shelf -	1	GSC	
145	3	BC	196/2137	56.6644	-61.066467	67.8	Labrador Shelf -	2	GSC+UNB	
146	3	BC	196/2146	56.663716	-61.0651	69.6	Labrador Shelf -	1	UNB	
148	0	BC	196/2255	56.690533	-61.08105	81.7	Labrador Shelf - Alagaia Hill	1	GSC	
149	0	BC	196/2300	56.691533	-61.081483	92.8	Labrador Shelf -	2	UNB	
150	0	BC	196/2326	56.71525	-61.090517	91.7	Labrador Shelf -	2	UNB + GSC	
151	0	BC	196/2332	56.71625	-61.091266	98.3	Labrador Shelf -	1	UNB	
152	0	BC	197/0000	56.74425	-61.1078	83.6	Labrador Shelf - North Carey Island	2	UNB + GSC	
153	0	BC	197/0005	56.744566	-61.1088	83.6	Labrador Shelf -	1	UNB	
154	0	BC	197/0059	56.751666	-61.21095	101	Labrador Shelf -	2	UNB +GSC	Cobble holding the gates open but still good recovery
155	0	BC	197/0104	56.7522	-61.210866	100	Labrador Shelf -	1	UNB	
156	0	BC	197/0200	56.7309	-61.260183	83.4	Labrador Shelf - Fermoy Island	2	UNB +GSC	
157	0	BC	197/0204	56.7309	-61.25765	85.7	Labrador Shelf - Fermoy Island	1	UNB	
166	0	BC	197/2206	56.603783	-62.063733	54.7	Labrador Shelf - Nain Bay	2	UNB + GSC	
167	0	BC	197/2214	56.603516	-62.061883	54.2	Labrador Shelf - Nain Bay	1	UNB	
178	0	BC	198/1053	56.443833	-61.133516	39.5	Labrador Shelf - Paul's Island			Both attempts failed
179	0	BC	198/1105	56.446083	-61.1216	50	Labrador Shelf - Paul's Island	3	UNB and GSC	

Figure A 1: Location of box core stations (surface samples).

Table A 2: List of gravity core stations. GC-S = Gravity corer with one barrel. GC-L = Gravity core with 2 barrels.

Station No	Site	Type	Julian date / Time (UTC)	Latitude	Longitude	Water Depth	Location	Corer length (cm)	App. Penetration (cm)	Core length (cm)	No. of Sections	Bagged	Archived at	Comments
8	13	GC-S	192/1510	56.637	-61.525466		Labrador Shelf - Nain	75	30		0			Failed to collect sediment
9	13	GC-L	192/1520	56.636716	-61.526133		Labrador Shelf - Nain	75	0		0			Failed to collect sediment
18	12	GC-S	192/1914	56.661	-61.614916	33.7	Labrador Shelf -	75	75	66	1	0	GSC	
19	12	GC-S	192/2002	56.667433	-61.609466	38.2	Labrador Shelf -	75	40		0			Nothing remained in liner
22	11	GC-S	192/2152	56.695483	-61.7158	38.3	Labrador Shelf - Nain	150	75	65	1	0	GSC	
30	0	GC-S	193/1404	56.777066	-61.838683	35.2	Labrador Shelf - Webb Bay	150	100	82	2	0	GSC	AB = 76cm, BC = 6cm
31	0	GC-L	193/1425	56.775516	-61.838833	34.9	Labrador Shelf - Webb Bay	300	312	225	2	1	GSC	AB = 150cm, BC = 75cm
39	0	GC-L	193/2017	56.78565	-61.761633	44.7	Labrador Shelf - Webb Bay	300	300	GSC	2	2	GSC	Cutter & catcher bagged. AB = 150cm, BC = 74cm
56	9	GC-L	194/0254	56.786133	-61.8926	28.3	Labrador Shelf - Webb Bay	300	264	264	2	1	GSC	Emma (Dalhousie) core - outer west Webb Bay. Catcher bagged, no cutter. AB = 150cm, BC = 114cm
57	9	GC-L	194/0347	56.79145	-61.906416	20.7	Labrador Shelf - Webb Bay	300	260	185	2	0	GSC	No cutter. AB = 150cm, BC = 34cm
58	9	GC-L	194/0422	56.787966	-61.899616	25.2	Labrador Shelf - Webb Bay	300	150	139	1	0	GSC	No cutter or catcher but some fell out.
59	9	GC-L	194/0442	56.787466	-61.8983	25.6	Labrador Shelf - Webb Bay	300	250	172	2	1	GSC	Catcher bagged. AB = 150cm, BC = 22cm
60	9	GC-L	194/0521	56.7868	-61.8958	26.5	Labrador Shelf - Webb Bay	300	150	frozen core of ~30cm	1	1	GSC	Cutter present and frozen. Length not preserved due to frozen sample and sediment condition. Around 30cm in length. Kept in -80C freezer.
65	10	GC-L	194/0838	56.783416	-61.736766	12.4	Labrador Shelf - Webb Bay	300	250	197	2	1	GSC	AB: 150 BC 47
66	10	GC-L	194/0908	56.783433	-61.735916	13.7	Labrador Shelf - Webb Bay	300	150	126	1	1	GSC	AB:126
67	10	GC-L	194/0933	56.7736	-61.753966	21	Labrador Shelf - Webb Bay	300	275	222	2	1	GSC	AB: 150 BC: 72
86	6	GC-L	195/0457	56.7958	-61.38005	103	Labrador Shelf -	300	320	165	2	1	GSC	AB: 150 BC: 15

88	6	GC-L	195/0745	56.71355	-61.34895	89	Labrador Shelf -	300	75	55.5	1	0	GSC	core was small and collapsed in on itself. Done again with a second core in the same spot
89	6	GC-S	195/0802	56.71365	-61.348516	89.3	Labrador Shelf -	90	90	60	1	0	GSC	Little drill hole at the bottom of the core. Covered with tape and wax to seal
90	0	GC-S	195/0915	56.776116	-61.324533	95.2	Labrador Shelf - Black Harbor	90	90	72	1	0	GSC	Landslide location
107	0	GC-L	195/1429	56.784133	-61.16155	88.6	Labrador Shelf - South David Island	300	250	236	2	0	GSC	Lost top of core
108	0	GC-L	195/1506	56.78325	-61.160583	89.3	Labrador Shelf - South David Island	300	250	220	2	3	GSC	3 bags core catcher and cutter
121	7	GC-S	196/0323	56.947059	-61.253521	78	Labrador Shelf -	90	90	69	1	1	GSC	5th overall attempt (3 at previous station) was successful. 1st attempt at this station was only ca 10cm, gravel, brittle stars, not really a core.
122	8	GC-S	196/0648	56.939666	-61.43355	66.5	Labrador Shelf -	90	90	57	1	1	GSC	
123	8	GC-L	196/0711	56.939233	-61.435333	64.2	Labrador Shelf -	300	300	164	2	0	GSC	
139	0	GC-L	196/1841	56.5978	-61.09755	60.2	Labrador Shelf - South Dog Islands				0	0		first and second attempt failed no sediment collected
140	0	GC-L	196/1909	56.601883	-61.078166	37	Labrador Shelf - South Dog Islands	300	260	241	2	0	GSC	
143	2	GC-L	196/2057	56.6485	-61.066783	55	Labrador Shelf -	300	300	265	2	1	GSC	AB: 150 BC: 115
147	0	GC-L	196/2202	56.664183	-61.06645	68.2	Labrador Shelf -	300	300	278	2	1	GSC	AB: 150 BC: 128
168	0	GC-L	197/2225	56.603266	-62.05965	55	Labrador Shelf - Nain Bay	300	300	212	2	1	GSC	AB: 150 BC: 72
171	0	GC-L	198/0132	56.58675	-61.75725	47.4	Labrador Shelf - Barth Island				0	0		No sediment collected
172	0	GC-L	198/0147	56.58455	-61.733466	53.6	Labrador Shelf - Barth Island	300	250	228	2	1	GSC	AB = 150cm, BC = 78cm
174	0	GC-S	198/0437	56.604133	-61.675633	56.3	Labrador Shelf - Marainel	90	90	45	1	1	GSC	Second attempt using a short GC instead of long
175	0	GC-S	198/0608	56.602783	-61.4927	49.8	Labrador Shelf -	90	20	38	1	1	GSC	first core unsuccessful
176	0	GC-S	198/0700	56.595616	-61.414033	18.6	Labrador Shelf -	90			0	0		All three attempts failed

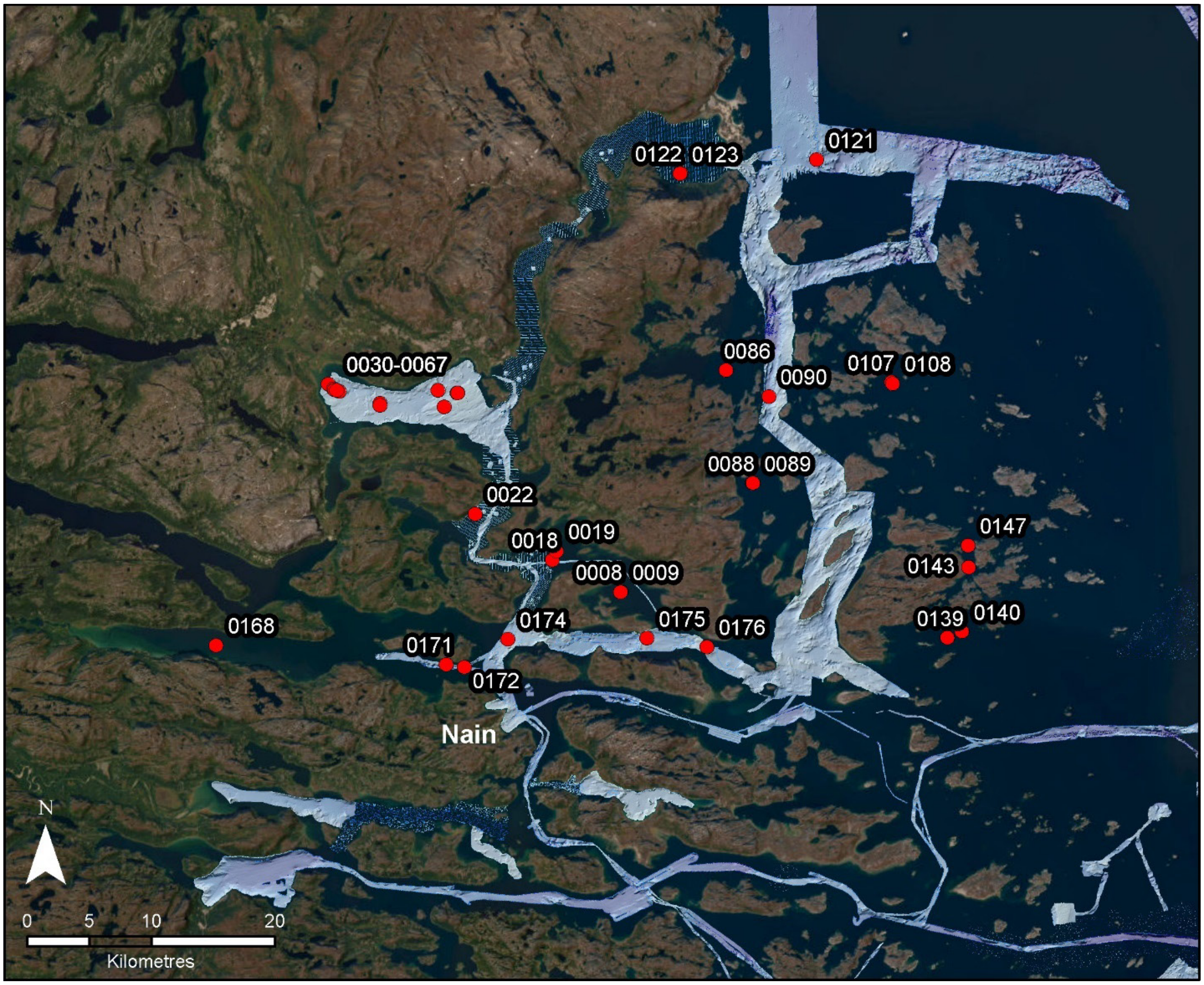

Figure A 2: Locations of gravity cores collected with the short and long gravity corers (GC).

Table A 3: List of CTD stations

Station No	Site	Cast no	Type	Julian Date / Time (UTC)	Latitude	Longitude	Water depth (m)	Location
1	13	3	CTD	192/1033	56.636783	-61.526517	30	Labrador Shelf - Nain
10	12	4	CTD	192/1640	56.660383	-61.612967	26.7	Labrador Shelf - Nain
27	10	5	CTD	193/1301	56.776133	-61.840466	34.4	Labrador Shelf - Webb Bay
32	9	6	CTD	193/1625	56.785566	-61.760366	42.3	Labrador Shelf - Webb Bay
45	0	7	CTD	194/0036	56.7929	-61.905533	19.6	Labrador Shelf - Webb Bay
46	0	8	CTD	194/0044	56.7935	-61.90525	17.4	Labrador Shelf - Webb Bay
47	0	9	CTD	194/0057	56.79115	-61.90435	21.6	Labrador Shelf - Webb Bay
48	0	10	CTD	194/0109	56.789483	-61.9012	26	Labrador Shelf - Webb Bay
49	0	11	CTD	194/0119	56.788933	-61.899633	27.3	Labrador Shelf - Webb Bay
50	0	12	CTD	194/0130	56.7871	-61.8993	26.5	Labrador Shelf - Webb Bay
51	0	13	CTD	194/0141	56.787067	-61.898217	27.4	Labrador Shelf - Webb Bay
52	0	14	CTD	194/0151	56.785133	-61.896583	26.4	Labrador Shelf - Webb Bay
53	0	15	CTD	194/0201	56.78535	-61.89575	26.7	Labrador Shelf - Webb Bay
54	0	16	CTD	194/0213	56.78305	-61.893717	28.8	Labrador Shelf - Webb Bay
55	0	17	CTD	194/0233	56.7802	-61.8733	37	Labrador Shelf - Webb Bay
61	9	18	CTD	194/0613	56.7745	-61.830483	37.5	Labrador Shelf -
62	10	19	CTD	194/0643	56.777117	-61.795667	44.2	Labrador Shelf - Webb Bay
63	10	20	CTD	194/0726	56.7745	-61.798783	13.9	Labrador Shelf - Webb Bay
68	0	21	CTD	194/1019	56.7566	-61.69515	44.7	Labrador Shelf - Webb Bay
69	11	22	CTD	194/1129	56.695167	-61.716517	37.1	Labrador Shelf - Narrow South of Webb Bay
78	8	23	CTD	194/1941	56.947267	-61.43345	38.1	Labrador Shelf - Port Manners
100	4	24	CTD	195/1132	56.78385	-61.161567	88.2	Labrador Shelf - South David Island
109	5	25	CTD	195/1716	56.712	-61.340283	89	Labrador Shelf -
114	6	26	CTD	195/2120	56.795633	-61.380783	105	Labrador Shelf -
124	3	27	CTD	196/1300	56.673167	-61.066333	27.7	Labrador Shelf -
129	2	28	CTD	196/1443	56.647067	-61.060267	21.6	Labrador Shelf -
132	1	29	CTD	196/1637	56.59715	-61.0953	53	Labrador Shelf - South Dog Islands
159	0	30	CTD	197/1759	56.594783	-61.963667	70.4	Labrador Shelf - Nain Bay
161	14	31	CTD	197/2003	56.603333	-62.066717	48.8	Labrador Shelf - Nain Bay
169	0	32	CTD	198/0007	56.60055	-61.8737	85.2	Labrador Shelf - Nain Barth Island
170	0	33	CTD	198/0105	56.585283	-61.785067	89	Labrador Shelf - Nain Barth Island
173	0	34	CTD	198/0210	56.575516	-61.69935	66.8	Labrador Shelf -
180	0	35	CTD	198/1408	56.51785	-61.001483	125	Labrador Shelf -
182	0	36	CTD	198/1717	56.528133	-61.082617	67.8	Labrador Shelf - E. Whale Island

183	0	37	CTD	198/1813	56.54355	-61.169033	80	Labrador Shelf - Nain
184	0	38	CTD	198/1907	56.547283	-61.25685	41.5	Labrador Shelf - Nain
185	0	39	CTD	198/2001	56.534383	-61.346783	55	Labrador Shelf - Nain
186	0	40	CTD	198/2050	56.543067	-61.437333	25.2	Labrador Shelf - Nain
187	0	41	CTD	198/2137	56.5588	-61.5242	70	Labrador Shelf - Nain
188	0	42	CTD	198/2233	56.56455	-61.613317	125	Labrador Shelf - Nain
189	0	43	CTD	198/2320	56.544517	-61.679233	24.9	Labrador Shelf - Nain wharf

Figure A 3: Location of CTD stations

Table A 4: List of CTD-R stations

Station No	Site	Type	Julian Date / Time (UTC)	Latitude	Longitude	Water depth (m)	Location	Comments
2	13	CTD-R	192/1050	56.6366	-61.525933	32	Labrador Shelf - Nain	8m (chlorophyll peak)
11	12	CTD-R	192/1658	56.660416	-61.614966	31.6	Labrador Shelf - Nain	
23	10	CTD-R	193/1112	56.775983	-61.83925	35.9	Labrador Shelf - Nain	Tair = 8.4C, sea state calm, no ice, salinity surface = 27.58, salinity bottom = 31.8, temp surface = 7.76C, temp bottom = -1.1C. Rosette was done before CTD while trouble shooting the CTD. Target depth 17m.
33	9	CTD-R	193/1645	56.7862	-61.76055	42.9	Labrador Shelf – Webb Bay	Tair = 7.98C, relatively calm sea state, no ice, surface salinity = 27.89, bottom salinity = 31.89, surface temp = 7.80C, bottom temp = -1.34C, target depth = 14m (chlorophyll max)
70	11	CTD-R	194/1148	56.694166	-61.710816	25.6	Labrador Shelf - Narrow South of Webb Bay	Tair = 6.6°C, sea state calm, No ice, target depths = 5m, salinity at surface = 26, salinity at bottom = 29.03, Temp at surface = 4.0°C, temp at bottom = 4.02°C.
79	8	CTD-R	194/1954	56.94785	-61.4351	44.6	Labrador Shelf - Port Manvers	Tair = 6.6C, rough sea state (winds 30kn), no ice, surface salinity = 30.05, bottom salinity = 30.55, surface temp = 3.11C, bottom temp = 2.18C, target depth: 7m.
101	4	CTD-R	195/1211	56.785116	-61.161016	90.7	Labrador Shelf - South David Island	sea state: calm, temp: 8.48 Celsius, target depth: 20m (chlorophyll peak), salinity surface: 30.54 bottom, 31.76, temperature surface: 4.48, bottom: -0.92
110	5	CTD-R	195/1735	56.7115	-61.339766	78	Labrador Shelf -	Tair = 9C, calm sea state, icebergs around, surface salinity = 30.17, bottom salinity = 31.91, surface temperature = 4.95C, bottom temperature = -1.17C, target depth = 22m (chlorophyll peak)
115	6	CTD-R	195/2151	56.79585	-61.381333	104	Labrador Shelf -	Tair = 6C, calm sea state, no ice, surface salinity = 30.05, bottom salinity = 32.65, surface temp = 5.10C, bottom temp = -1.67C, target depth = 17m.
125	3	CTD-R	196/1315	56.672483	-61.065933	21.4	Labrador Shelf -	Tair = 8.4C, calm sea state, icebergs around, surface salinity = 30.31, bottom salinity = 30.67, surface temp = 4.25C, bottom temp = 3.57C, target depth = 5m.
130	2	CTD-R	196/1459	56.64695	-61.0627	37	Labrador Shelf -	Tair = 8.7C, calm sea state, ice n/a, surface salinity = 30.10, bottom salinity = 30.90, surface temp = 4.88C, bottom temp = 1.60C, target depth = 20m.
133	1	CTD-R	196/1650	56.597266	-61.093833	50	Labrador Shelf - South Dog Islands	Tair = 9.1C, calm sea state, ice floes around, surface salinity = 30.27, bottom salinity = 31.13, surface temp = 3.60C, bottom

								temp = 0.31C, target depth = 20m.
162	14	CTD-R	197/2019	56.602633	-61.0608	51.6	Labrador Shelf -	Tair = 22.8C, mirror sea state, no ice, surface salinity = 24.73, bottom salinity = 30.71, surface temperature = 6.06C, bottom temperature = -0.80C. Target depth = 13m (first chlorophyll peak). Highest chlorophyll peak.

Figure A 4: Location of CTD-R stations.

Table A 5: List of Phytoplankton and zooplankton net stations

Station No.	Old station	Sample Type	J Day	UTC at Surface (down)	Lat Surface (down)	Long Surface (down)	UTC at Bottom	Lat Bottom	Long Bottom	UTC at Surf. (up)	Lat Surface (up)	Long Surface (up)	Location	Water Depth (m)	Net Depth (m)	Archived at	Comments
0003	13	PN	192	1125	56°38.223'N	61°31.585'W				1148	56°38.732'N	61°30.417'W		34-24	8	MUN	Horizontal / Speed ship: 2.6Kn
0004	13	PN	192	1212	56°38.874'N	61°30.539'W								24-34	8	UNB	Horizontal / Speed ship: 2.5kn
0005	13	ZN	192	1243	56°38.224'N	61°31.584'W	1256	56°38.245'N	61°31.587'W	1248	56°38.251'N	61°31.593'W		28.4	25	MUN	Vertical
0012	12	PN	192	2013	56°39.639'N	61°36.758'W				2033	56°39.651'N	61°35.412'W		33.3	27.3	UNB	
0013	12	PN	192	2052	56°39.674'N	61°35.699'W				2057	56°39.664'N	61°36.913'W		33.3	27.3	MUN	
0014	12	ZN	192	2113	56°39.670'N	61°36.876'W	2115	56°39.688'N	61°36.876'W	2017	56°39.703'N	61°36.885'W		33.7		MUN	
0024	10	PN	193	1135	56°46.695'N	61°50.490'W					56°47.298'N	61°51.421'W	Webb Bay	48.2	5	UNB	Horizontal tow
0025	10	PN	193	1213	56°47.250'N	61°52.016'W				1235	56°46.745'N	61°50.673'W	Webb Bay	45.3	5	MUN	Horizontal tow
0026	10	ZN	193	1244	56°46.548'N	61°50.399'W	1247	56°46.545'N	61°50.399'W	1251	56°44.552'N	61°50.408'W	Webb Bay	35		MUN	Vertical tow
0034	9	PN	193	1706	56°47.155'N	61°45.893'W				1723	56°46.855'N	61°47.390'W	Webb Bay	45.8	5	UNB	Horizontal tow, ship speed = 3.1 kn
0035	9	PN	193	1736	56°46.886'N	61°47.433'W				1757	56°47.119'N	61°46.012'W	Webb Bay	45.9	5	MUN	Horizontal tow, ship speed = 2.5 kn
0036	9	ZN	193	1810	56°47.173'N	61°45.617'W	1815	56°47.249'N	61°45.677'W	1817	56°47.271'N	61°45.702'W	Webb Bay	43.4	38	MUN	Vertical tow.
0071	11	PN	194	1205	56°41.464'N	61°43.043'W				1228	56°42.126'N	61°41.847'W	Narrow south of Webb Bay				Ship speed = 2.3 kn, horizontal tow
0072	11	ZN	194	1245	56°41.678'N	61°42.971'W	1250	56°41.616'N	61°43.052'W	1253	56°41.585'N	61°43.088'W	Narrow south of Webb Bay				Vertical tow
0080	8	PN	194	2012	56°56.897N	61°26.057'W				2033	56°57.795'N	61°26.141'W	Port Manners	44.3 - 75	5	MUN	horizontal tow, ship speed = 2.8 kn
0081	8	PN	194	2047	56°57.618N	61°26.542'W				2104	56°56.886'N	61°26.319'W	Port Manners	74-37.5	5	UNB	horizontal tow, ship speed 1.3kn
0082	8	ZN	194	2214	56°56.786N	61°25.869'W	2216	56°56.750'N	61°25.824'W	2222	56°56.672'N	61°25.699'W	Port Manners	34.9		MUN	Vertical
0102	4	PN	195	1230	56°47.266'N	61°09.756'W				1245	56°47.836'N	61°09.592'W	S David Island	82.3	5	UNB	Horizontal, ship speed: 2.6kn
0103	4	PN	195	1258	56°47.952'N	61°09.846'W				1318	56°47.164'N	61°09.855'W	S David Island	86.2	5	MUN	Horizontal, ship speed: 2.4kn
0104	4	ZN	195	1329	56°47.024'N	61°09.816'W	1333	56°47.032'N	61°09.827'W	1339	56°47.049'N	61°09.849'W	S David Island	60.2		MUN	Vertical tow
0111	5	PN	195	1757	56°42.719'N	61°20.437'W				1812	56°42.177'N	61°20.903'W		65	5	UNB	Horizontal tow, ship speed = 2.4kn
0112	5	PN	195	1822	56°42.055'N	61°20.946'W				1842	56°42.637'N	61°20.401'W		6.2	5	MUN	Horizontal tow, ship speed = 2.2kn
0113	5	ZN	195	1849	56°42.653'N	61°20.439'W	1851	56°42.636'N	61°20.454'W	1853	56°42.620'N	61°20.463'W		76.5		MUN	Vertical tow
0116	6	PN	195	2213	56°47.774'N	61°22.978'W				2228	56°47.876'N	61°24.096'W		104	5	UNB	Horizontal tow, ship speed = 2.1kn
0117	6	PN	195	2237	56°47.863'N	61°24.213'W				2258	56°47.743'N	61°22.630'W		101	5	MUN	Horizontal tow, ship speed = 2.6 kn
0118	6	ZN	195	2305	56°47.734'N	61°22.662'W	2309	56°47.756'N	61°22.707'W	2315	56°47.766'N	61°22.733'W		105		MUN	Vertical tow
0126	3	ZN	196	1326	56°40.374'N	61°03.881'W	1327	56°40.377'N	61°03.868'W	1331	56°40.383'N	61°03.851'W		30.4		MUN	Vertical tow
0127	3	PN	196	1338	56°40.378'N	61°03.834'W				1354	56°40.939'N	61°04.385'W		30 - 83	5	UNB	Horizontal tow, ship speed = 2.5kn
0128	3	PN	196	1401	56°40.787'N	61°04.267'W				1421	56°40.110'N	61°03.995'W		57.4 - 27.7	5	MUN	Horizontal tow, ship speed = 2.1 kn
144	2	ZN	196	1510	56°38.823'N	61°03.744'W	1512	56°38.822'N	61°03.737'W	1514	56°38.822'N	61°03.730'W		35.3		MUN	Vertical tow, old station 130B
0131	2	PN	196	1519	56°38.805'N	61°03.733'W				1536	56°38.238'N	61°03.485'W		12.1 - 3	5	MUN	Horizontal tow, ship speed 2kn
0134	1	ZN	196	1704	56°35.856'N	61°05.559'W	1707	56°35.861'N	61°05.541'W	1710	56°35.861'N	61°05.531'W	S Dog Island	57.3		MUN	Vertical tow
0135	1	PN	196	1716	56°35.878'N	61°05.469'W				1732	56°36.219'N	61°04.416'W	S Dog Island	61.9	5	UNB	Horizontal tow, ship speed = 2.4 kn
0136	1	PN	196	1742	56°36.320'N	61°04.486'W				1756	56°35.996'N	61°05.020'W	S Dog Island	26.5	5	MUN	Horizontal tow, ship speed = 2.0 kn
0163	14	ZN	197	2041	56°36.219'N	62°04.096'W	2043	56°36.221'N	62°04.061'W	2045	56°36.224'N	62°04.029'W	Nain Bay	50.9		MUN	Vertical
0164	14	PN	197	2113	56°36.226'N	62°04.119'W				2129	56°36.047'N	62°03.016'W	Nain Bay	50.9	5	UNB	Horizontal; speed 2.6km
0165	14	PN	197	2138	56°36.001'N	62°02.410'W				2159	56°36.249'N	62°03.545'W	Nain Bay	50.8	5	MUN	Horizontal; Speed2.4km

Figure A 5: Location of Phytoplankton net stations

Figure A 6: Location of zooplankton stations

Table A 6: List of camera stations

Station No	Site	Type	Julian Date / Time (UTC)	Latitude	Longitude	Water depth (m)	Location	Comments
40		Cam	193/2212	56.7869	-61.8936	29.9	Labrador Shelf - Webb Bay	Assumed unsuccessful, but took pictures after all.
41		Cam	193/2227	56.7886	-61.89265	32.4	Labrador Shelf - Webb Bay	Missed target / control data
42		Cam	193/2254	56.7879	-61.893483	28.6	Labrador Shelf - Webb Bay	
43		Cam	193/2336	56.789316	-61.896083	30.9	Labrador Shelf - Webb Bay	
44		Cam	193/2353	56.788716	-61.896033	30.2	Labrador Shelf - Webb Bay	
64	10	Cam	194/0802	56.779116	-61.7404	13	Labrador Shelf - Webb Bay	
158		Cam	197/0656	56.44505	-61.1287	31.9	Labrador Shelf – Paul’s Island	Depth changed from 31.9m to 36.8m, and down to 50 m in between
177		Cam	198/1004	56.4439	-61.1337	29.7	Labrador Shelf - Paul's Island	

Figure A 7: Location of camera stations.

APPENDIX B: CTD PROFILES

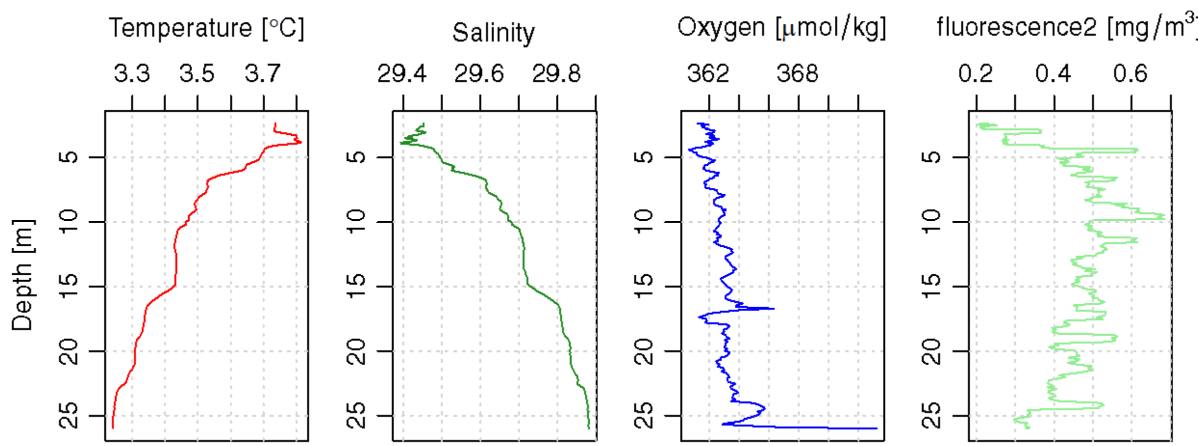

Figure B 1. Station CTD 0003

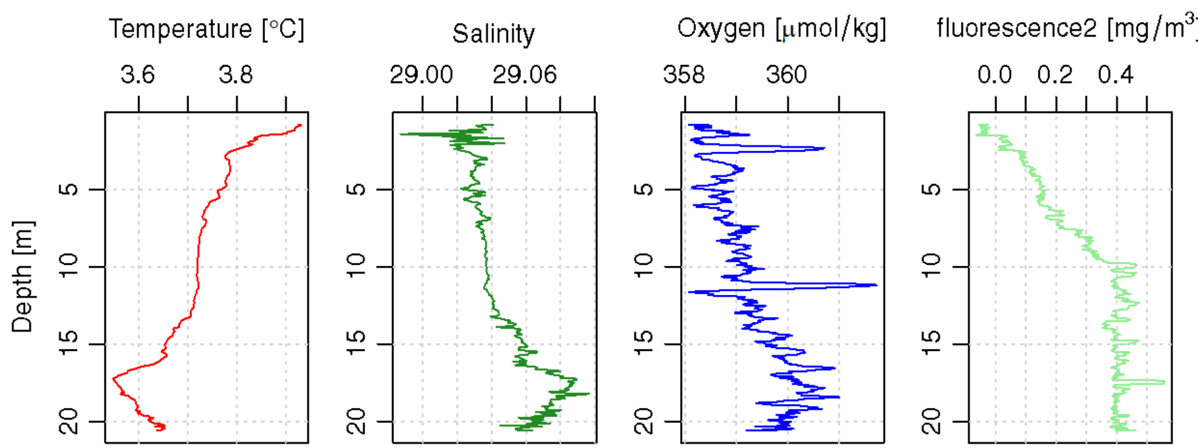

Figure B 2. station CTD 0010

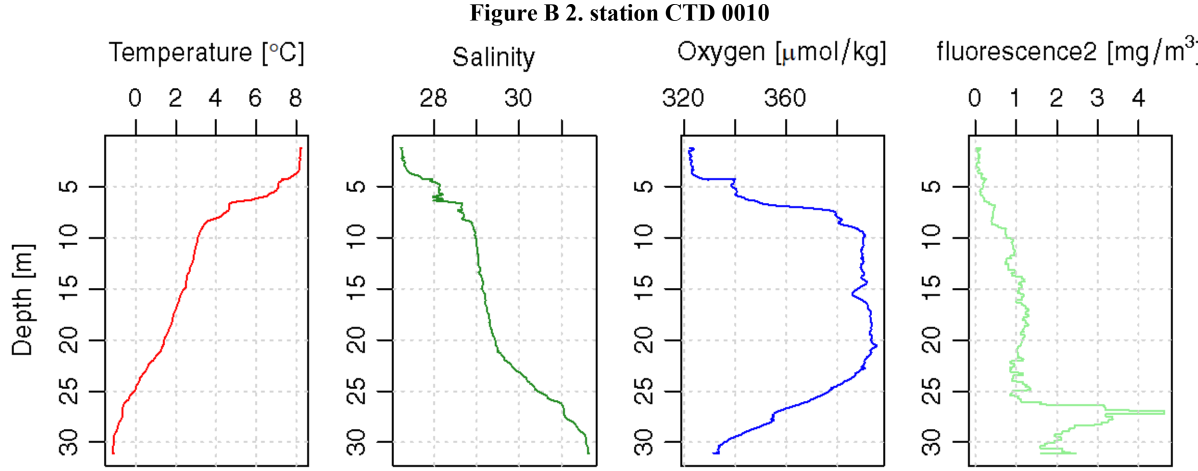

Figure B 3. station CTD 0027 (Webb Bay)

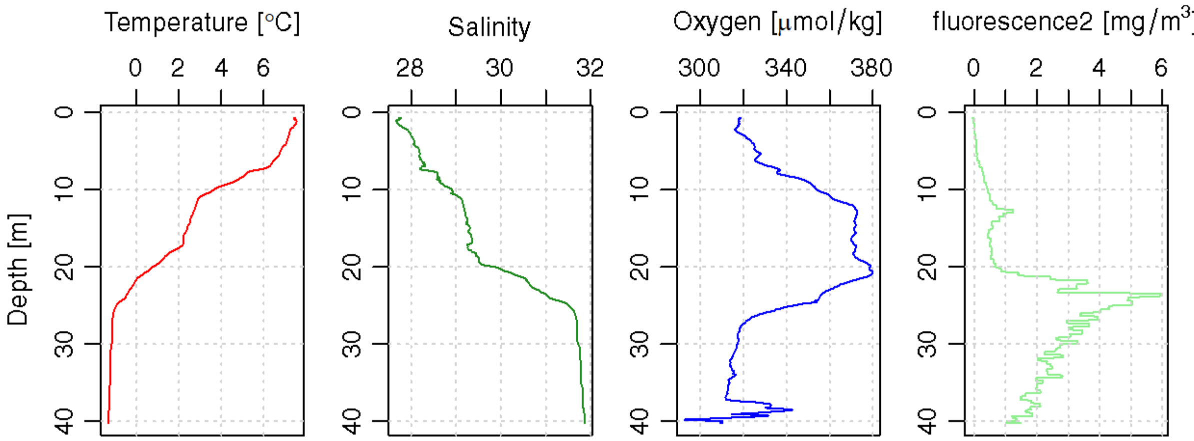

Figure B 4. station CTD 0032 (Webb Bay)

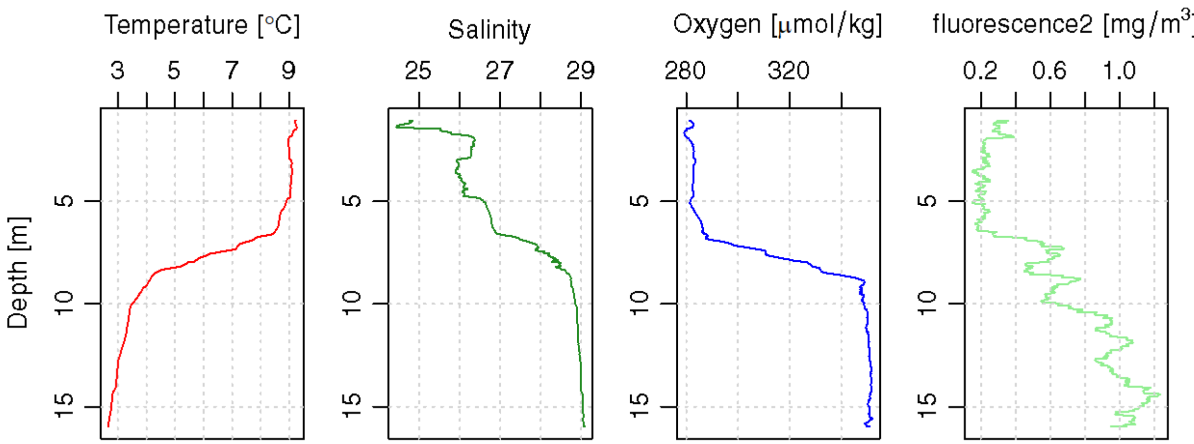

Figure B 5. station CTD 0045 (Webb Bay)

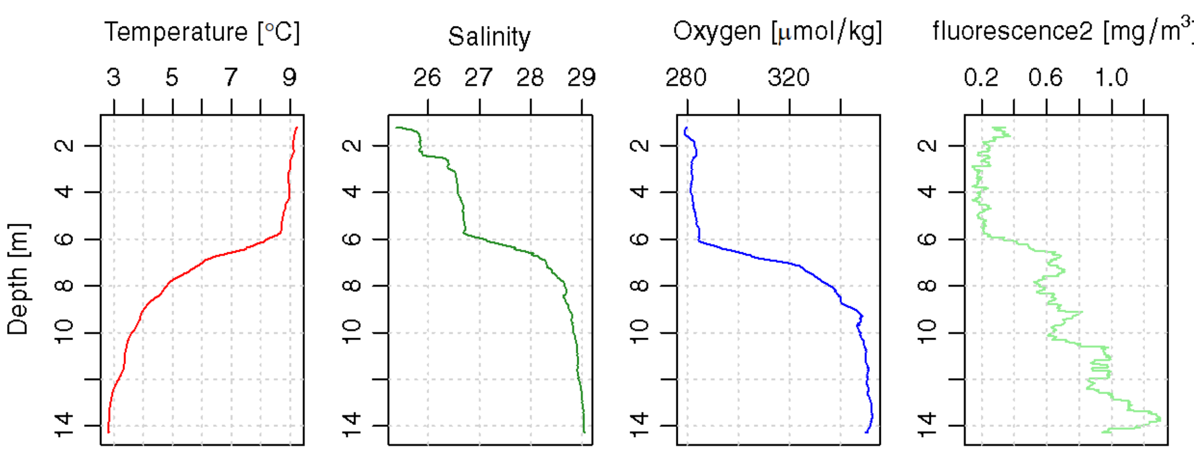

Figure B 6. station CTD 0046 (Webb Bay)

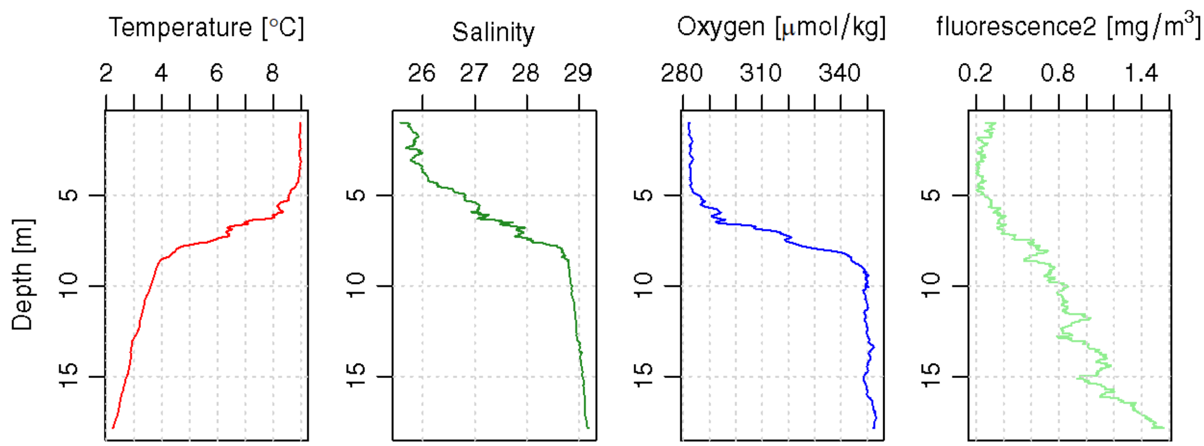

Figure B 7. station CTD 0047 (Webb Bay)

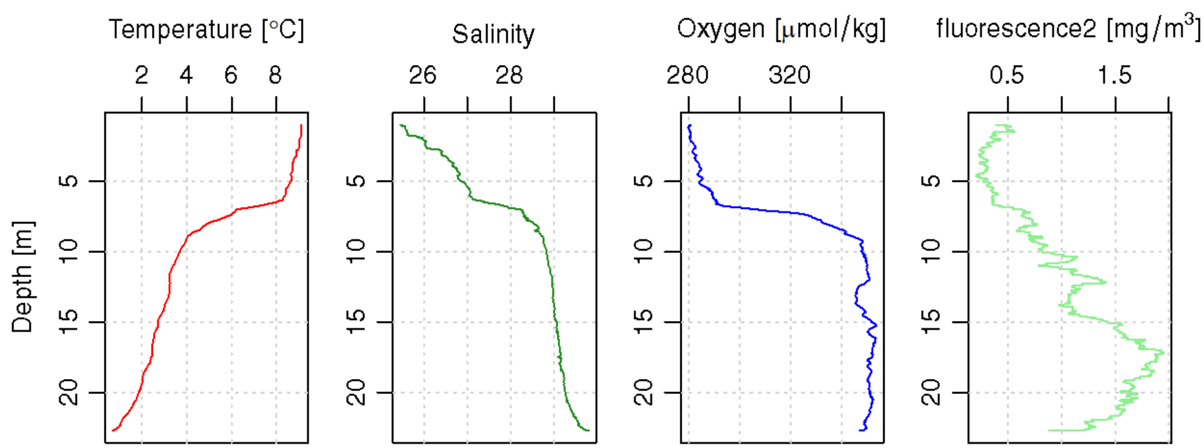

Figure B 8. station CTD 0048 (Webb Bay)

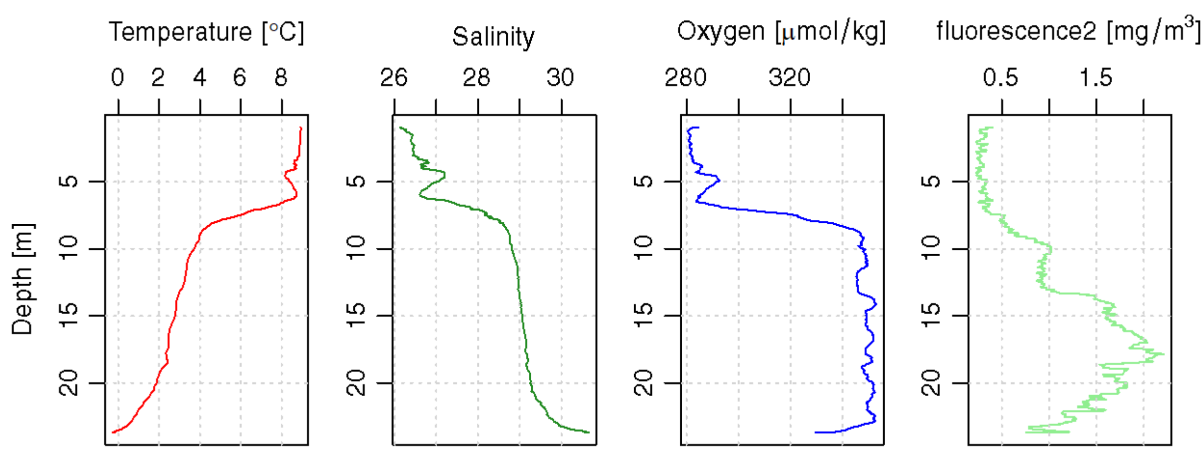

Figure B 9. station CTD 0049 (Webb Bay)

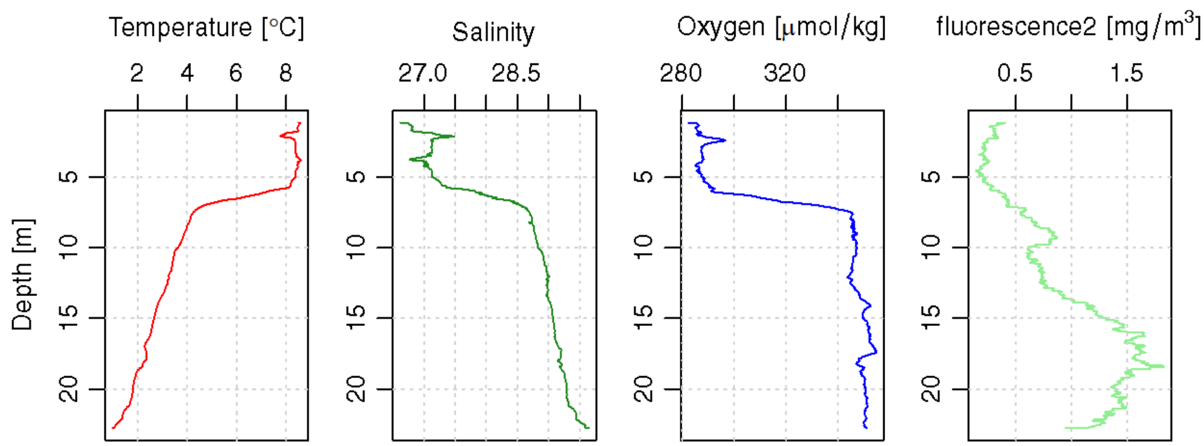

Figure B 10. station CTD 0050 (Webb Bay)

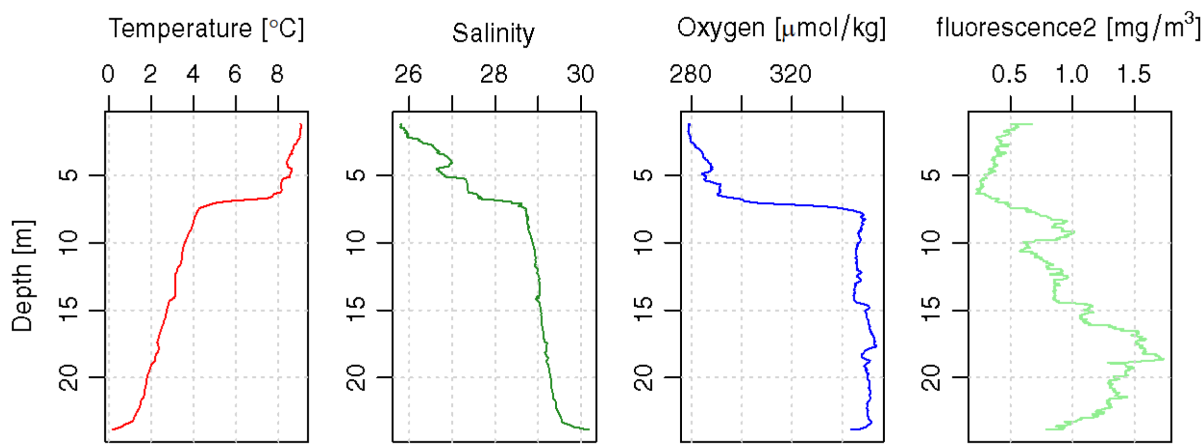

Figure B 11. station CTD 0051 (Webb Bay)

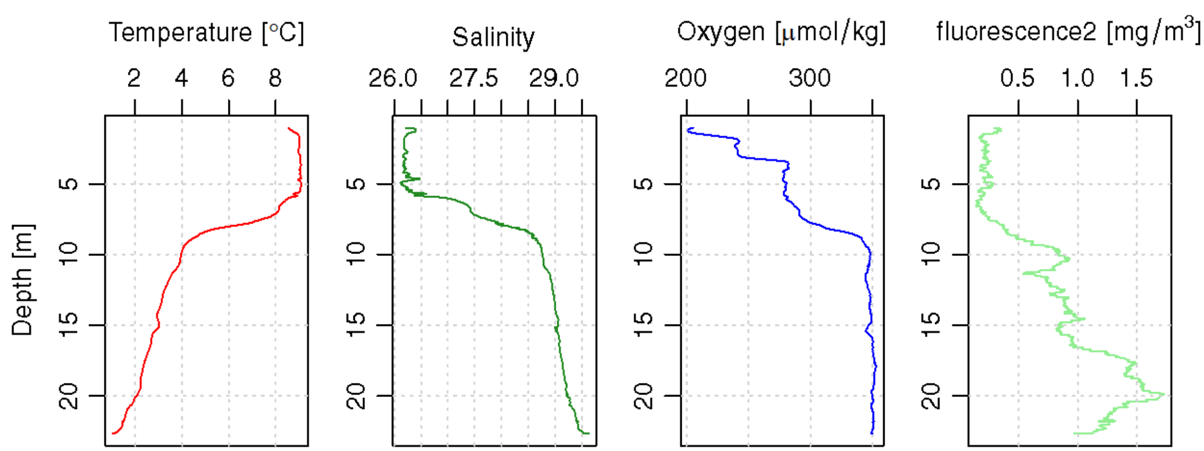

Figure B 12. station CTD 0052 (Webb Bay)

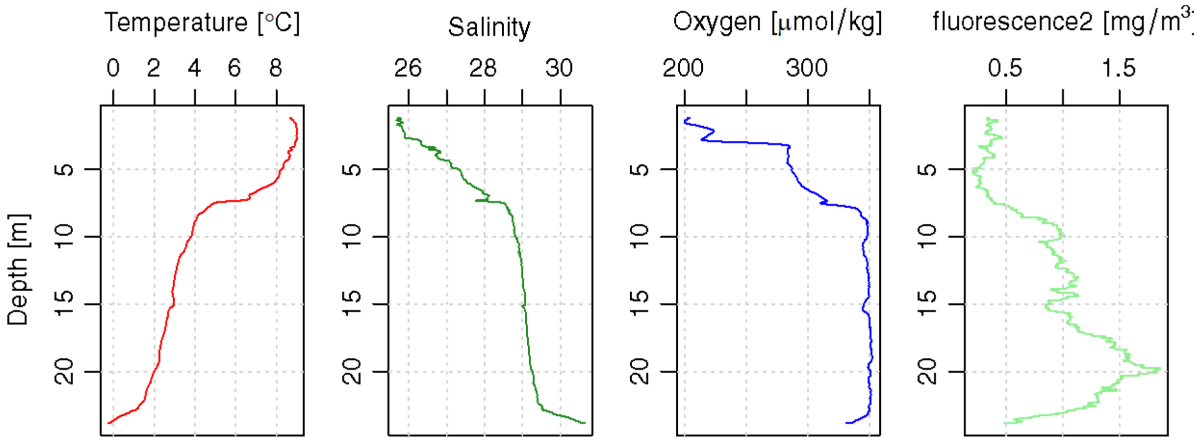

Figure B 13. station CTD 0053 (Webb Bay)

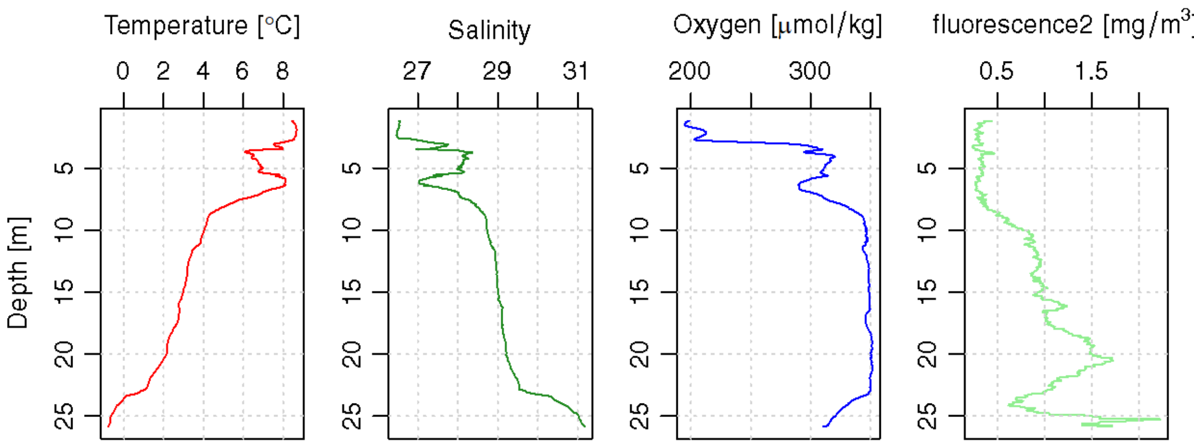

Figure B 14. station CTD 0054 (Webb Bay)

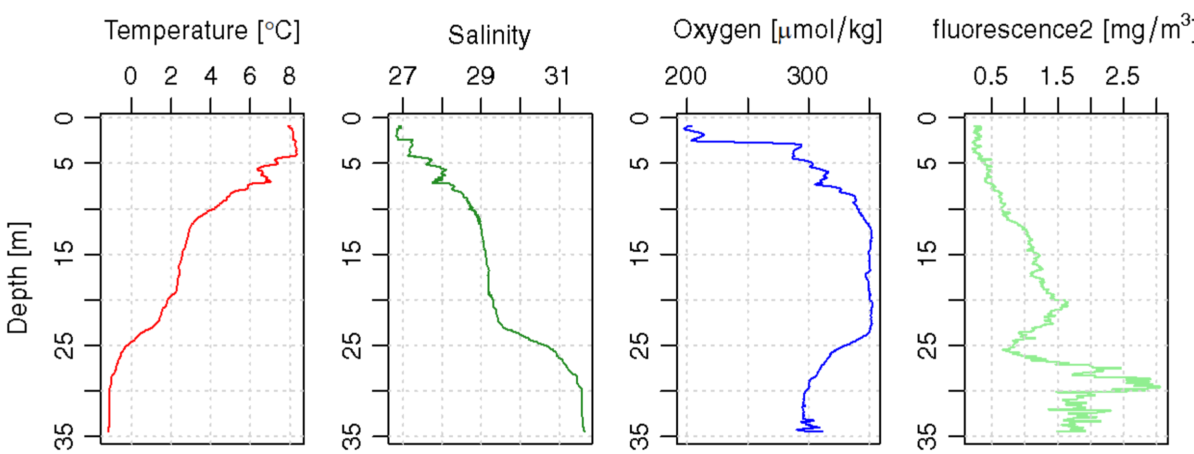

Figure B 15. station CTD 0055 (Webb Bay)

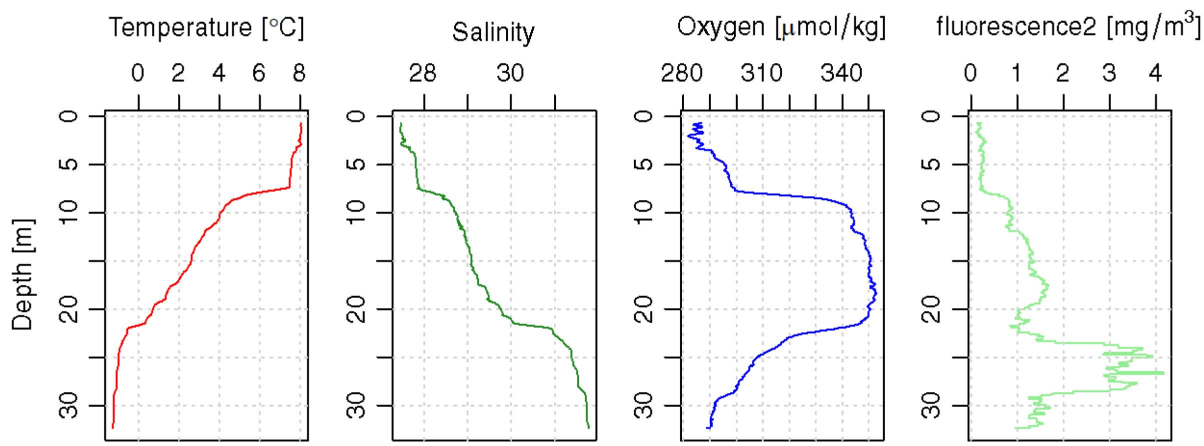

Figure B 16. station CTD 0061 (Webb Bay)

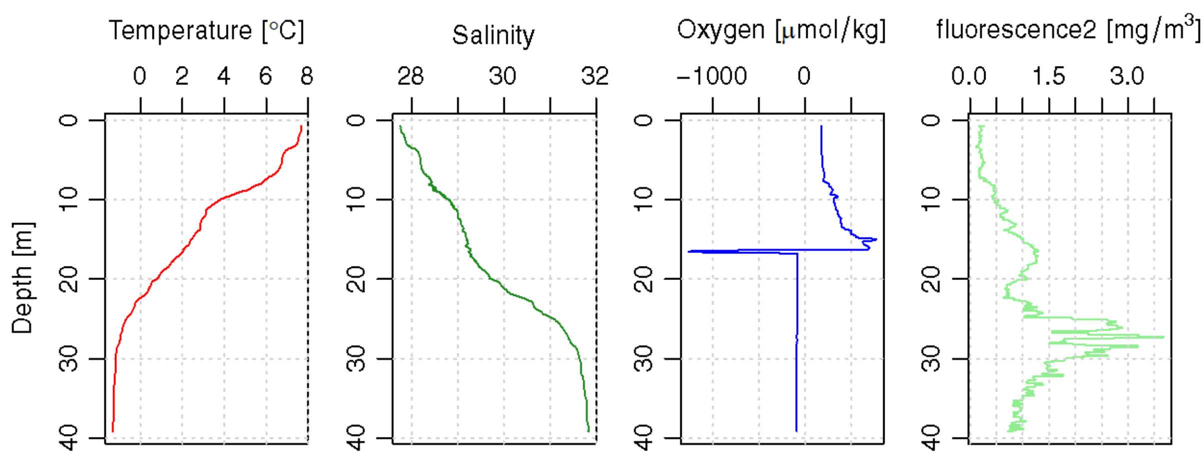

Figure B 17. station CTD 0062 (Webb Bay)

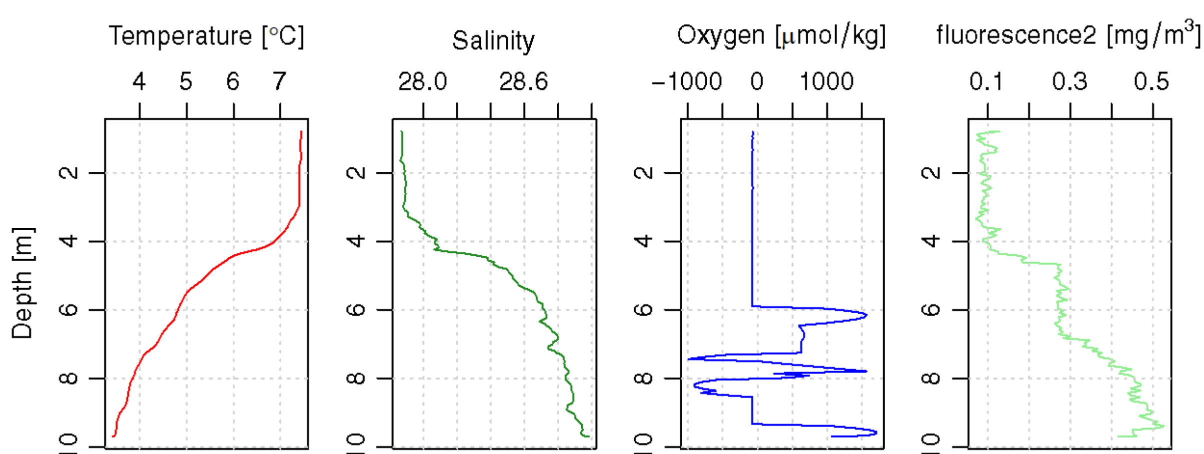

Figure B 18. station CTD 0063 (Webb Bay)

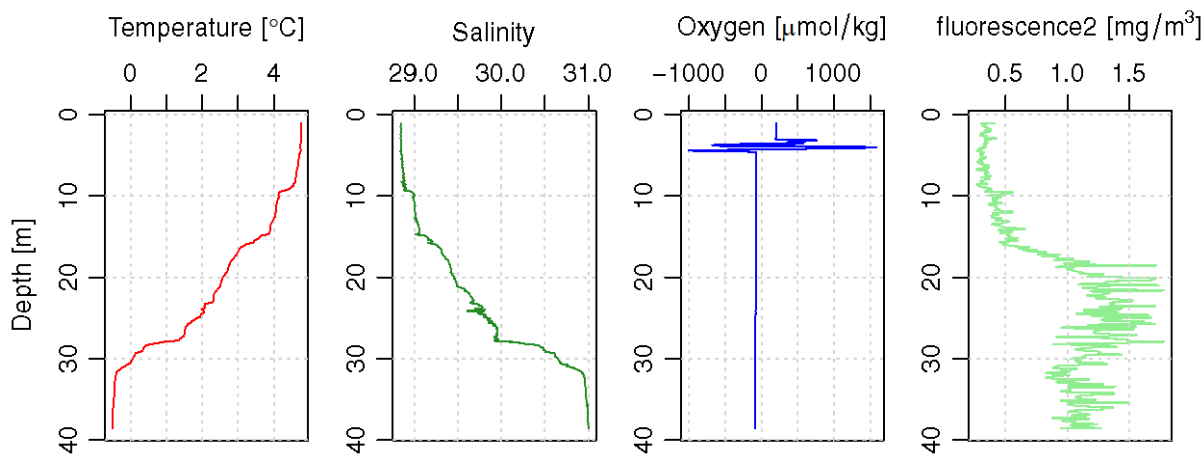

Figure B 19. station CTD 0068 (Webb Bay)

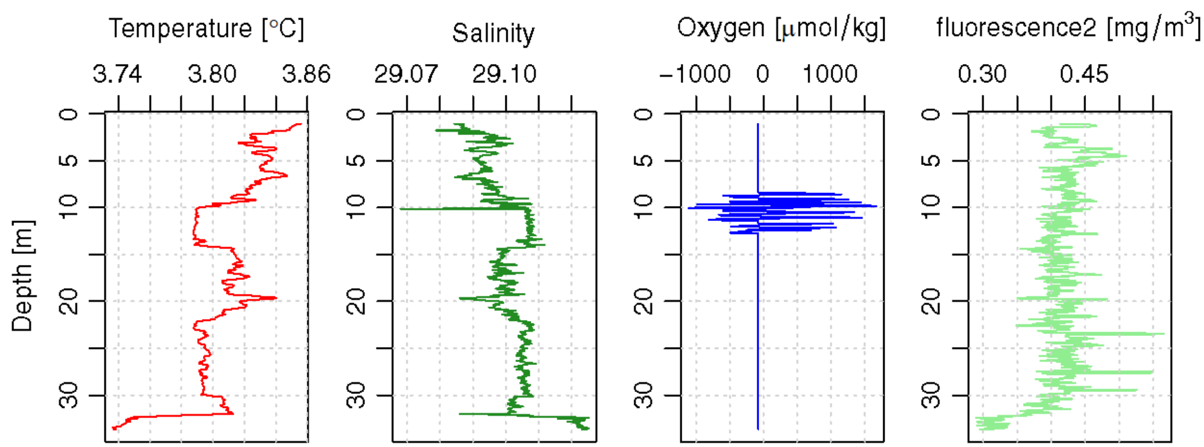

Figure B 20. station CTD 0069

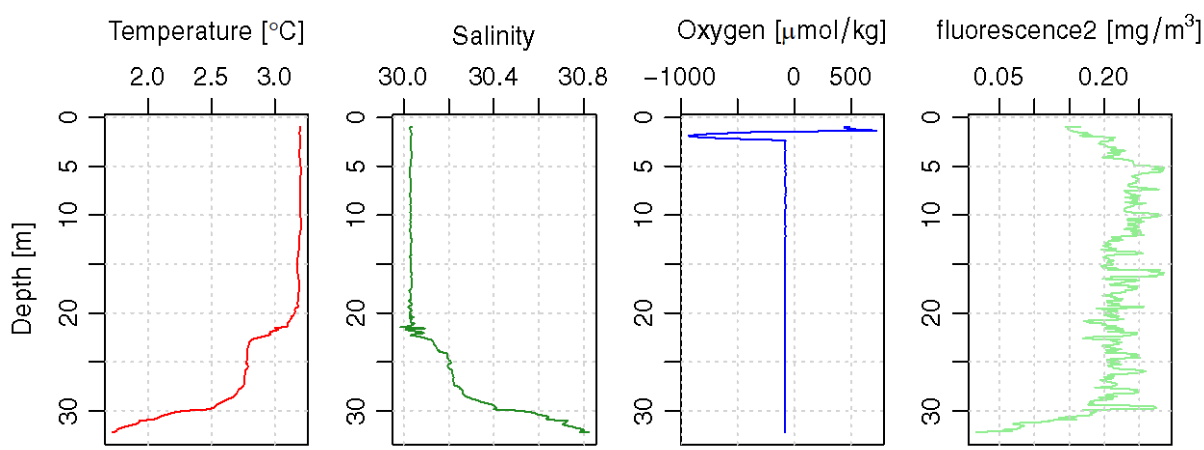

Figure B 21. station CTD 0078

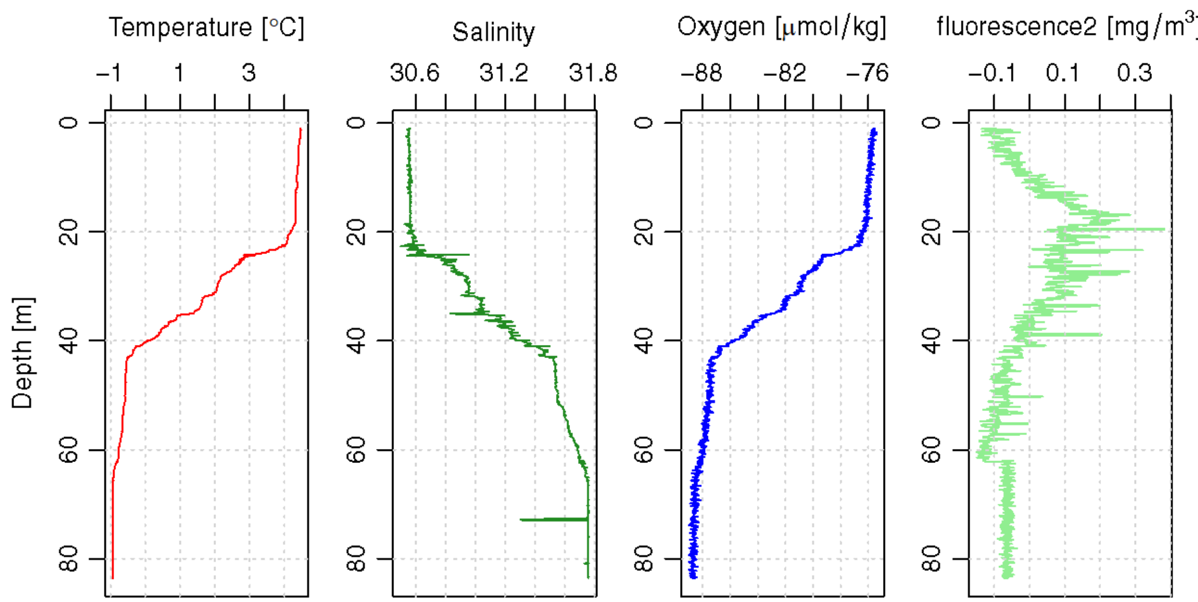

Figure B 22. station CTD 0100

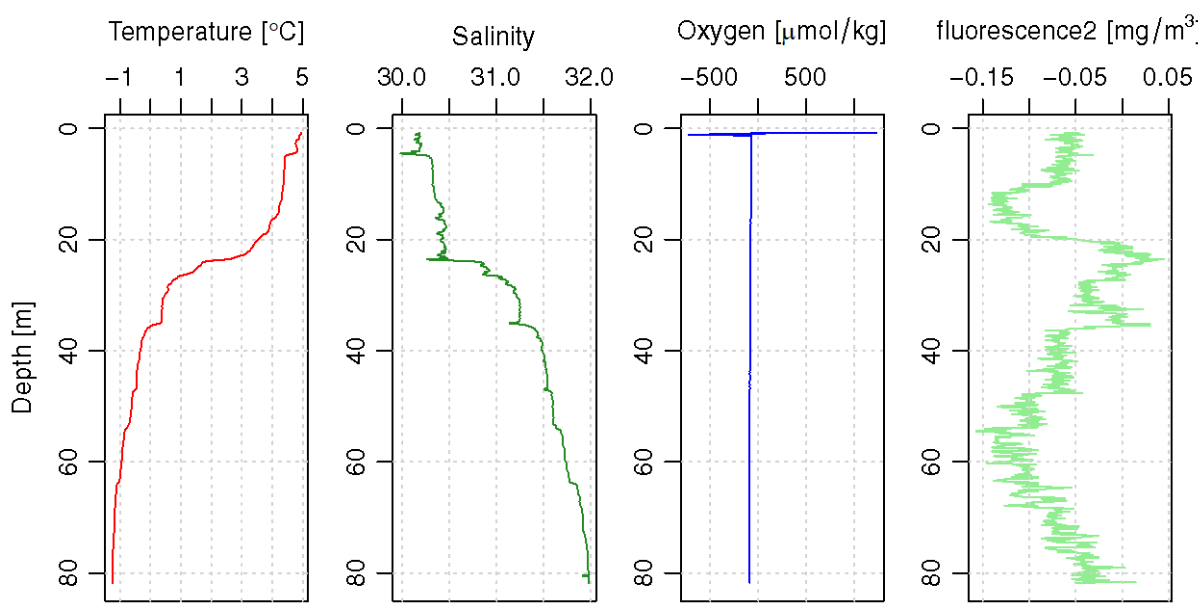

Figure B 23. station CTD 0109

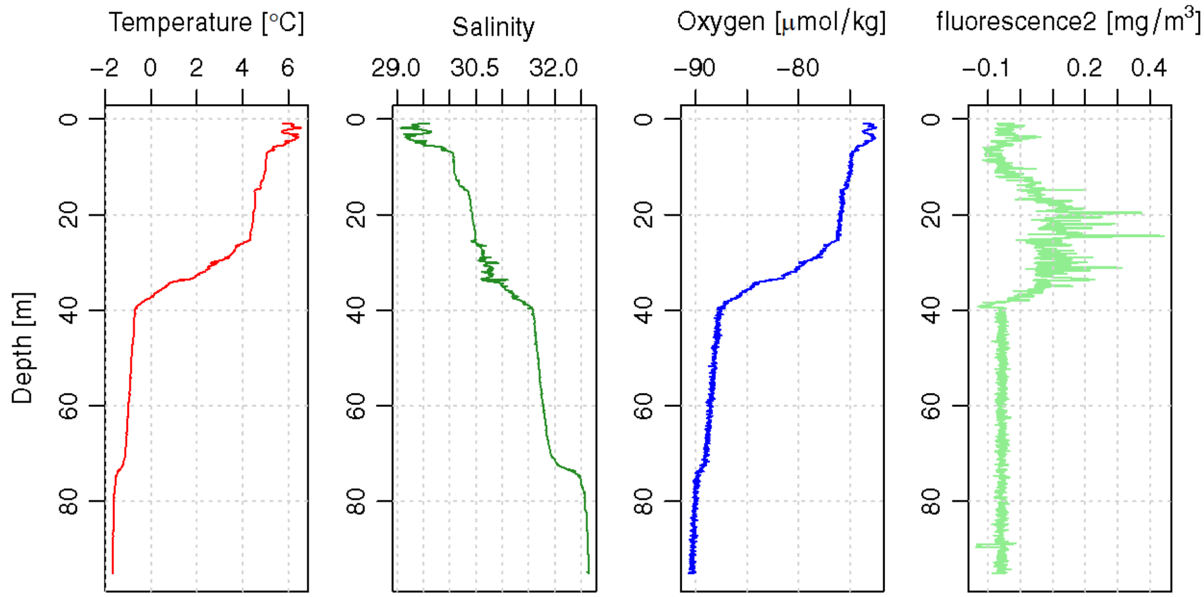

Figure B 24. station CTD 0114

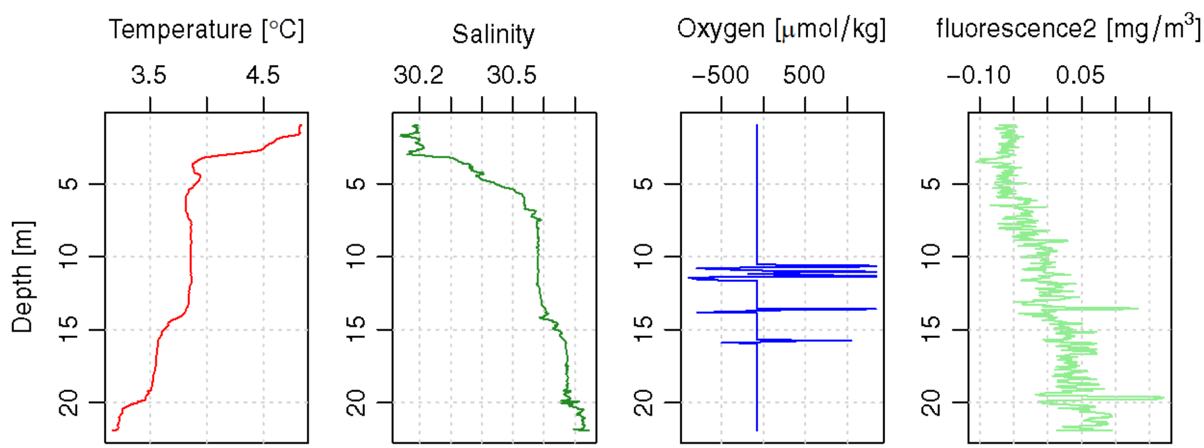

Figure B 25. station CTD 0124

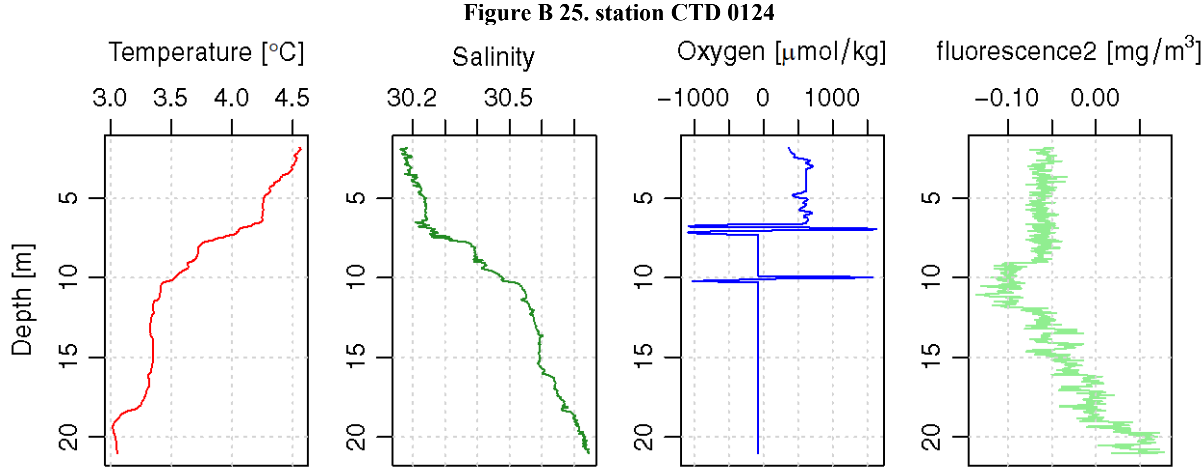

Figure B 26. station CTD 0129

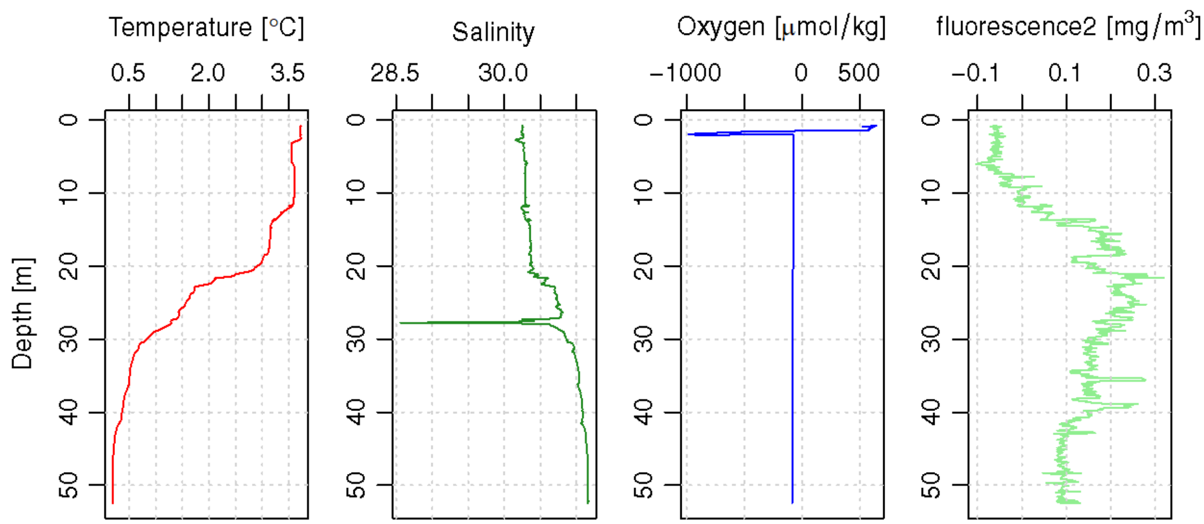

Figure B 27. station CTD 0132

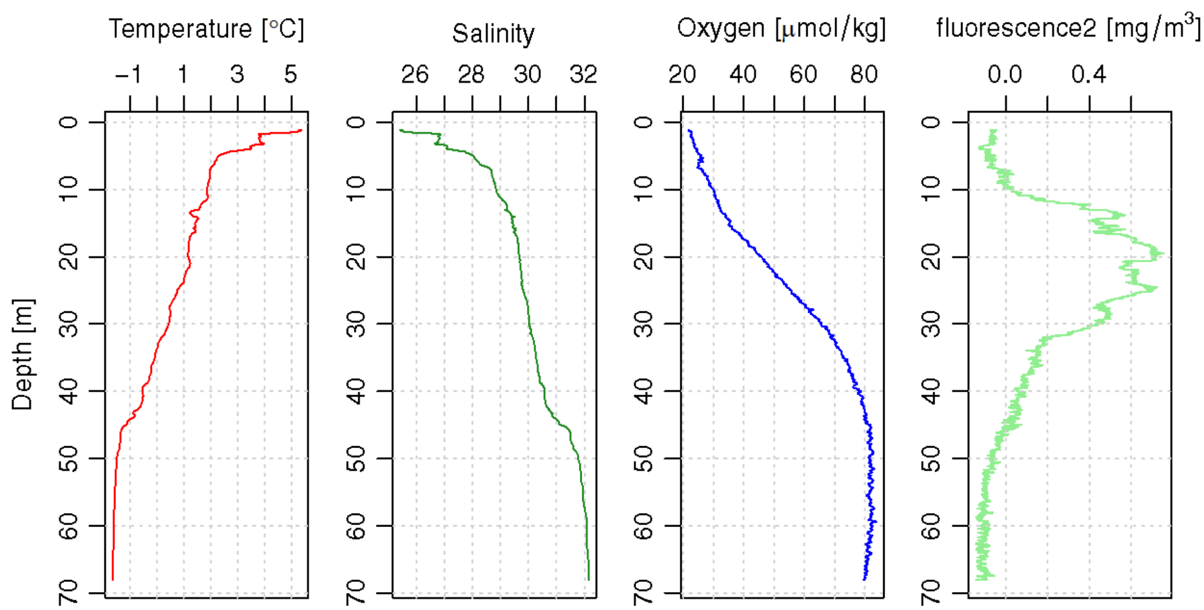

Figure B 28. station CTD 0159

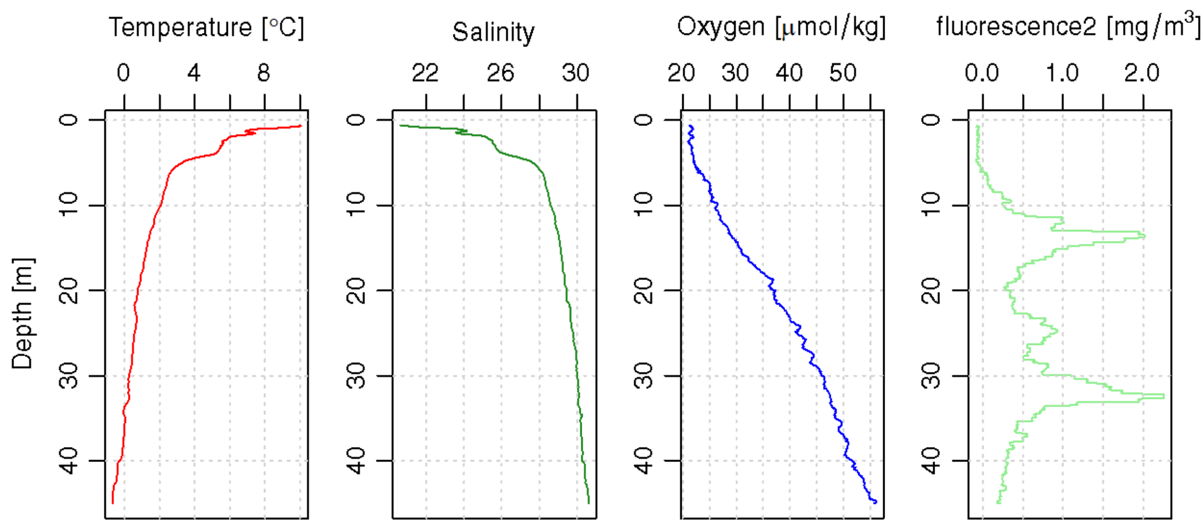

Figure B 29. station CTD 0161

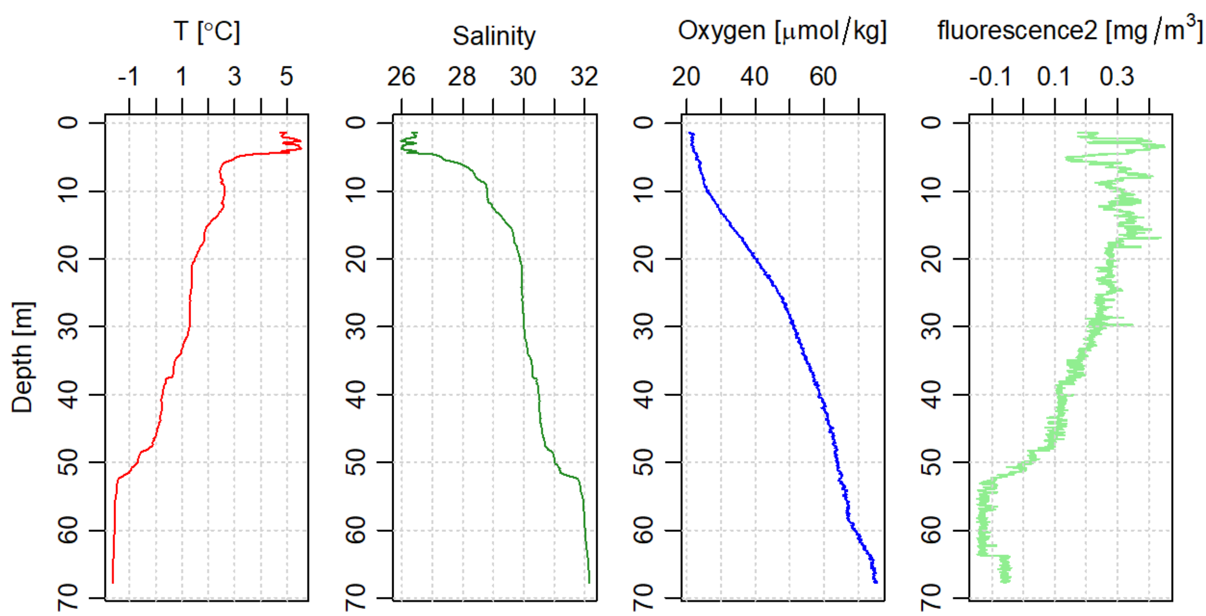

Figure B30. station CTD 0169

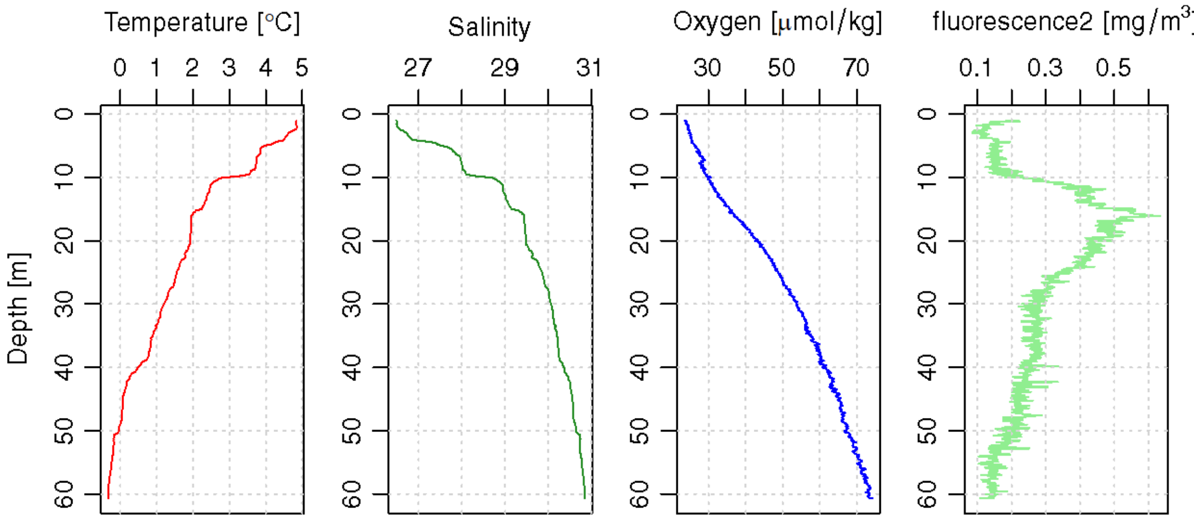

Figure B 30. station CTD 0170

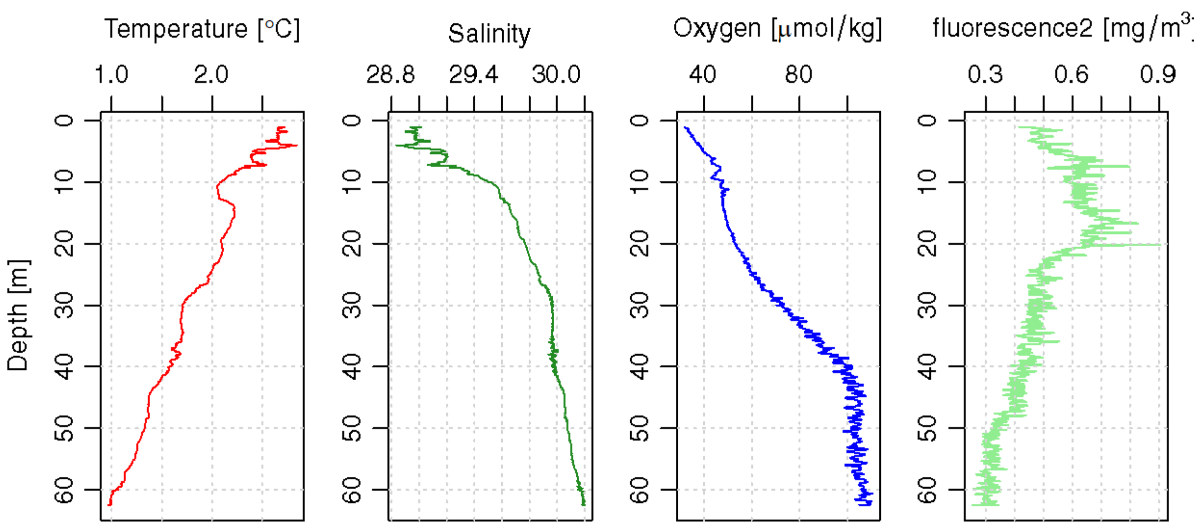

Figure B 31. station CTD 0173

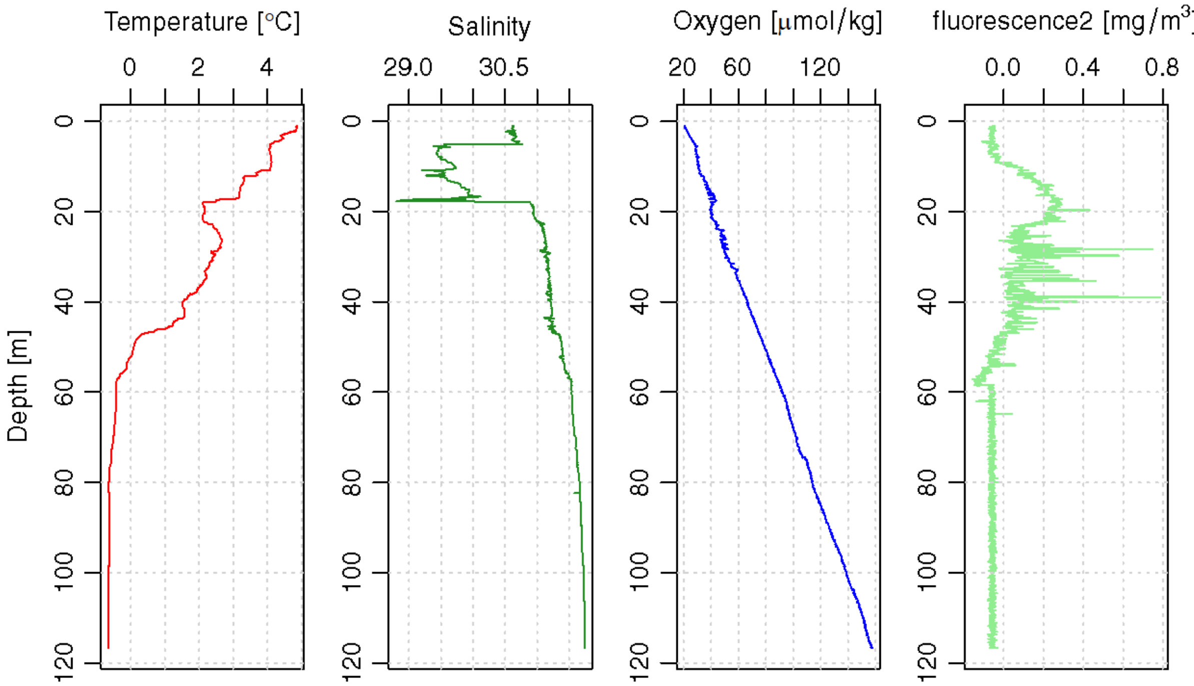

Figure B 32. station CTD 0180

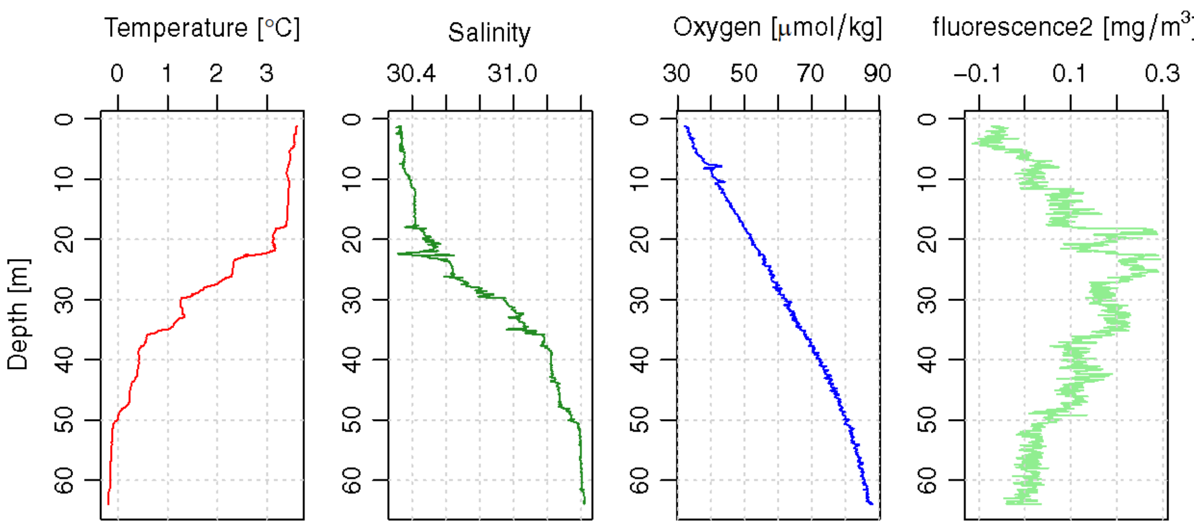

Figure B 33. station CTD 0182

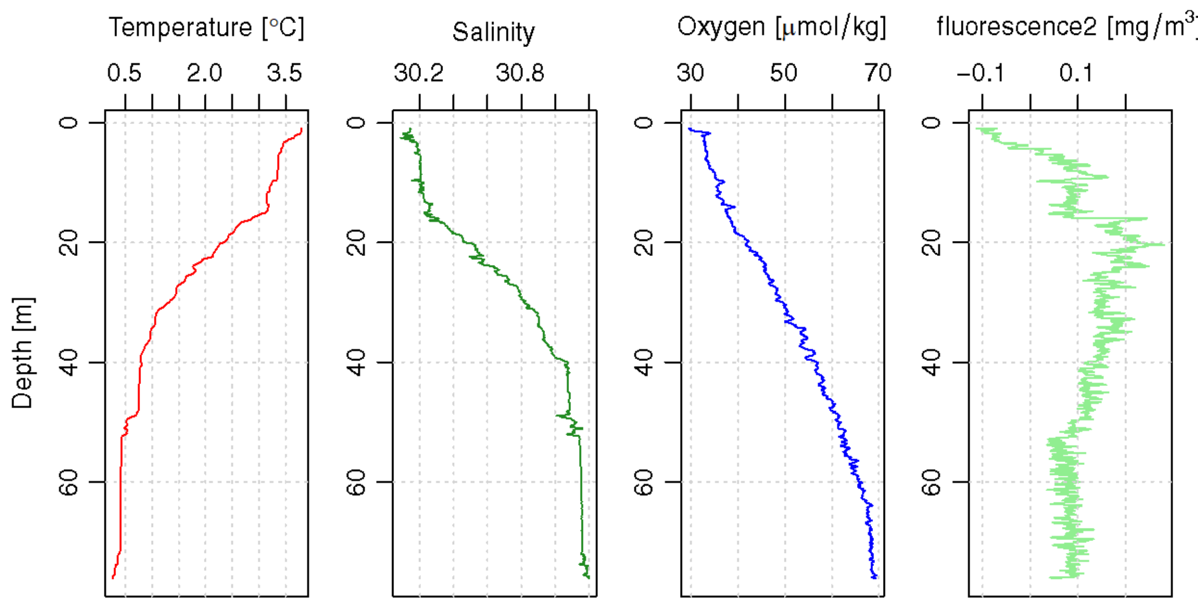

Figure B 34. station CTD 0183

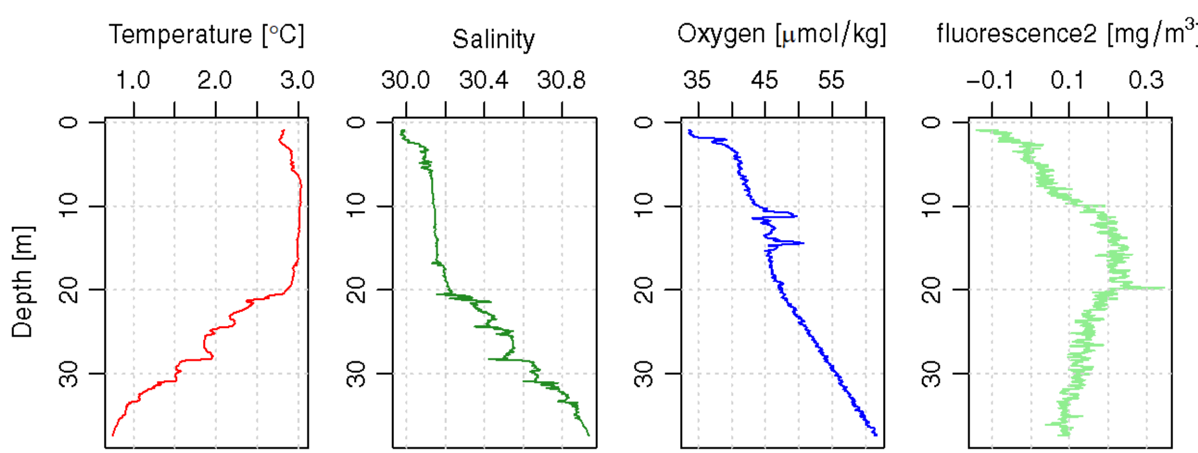

Figure B 35. station CTD 0184

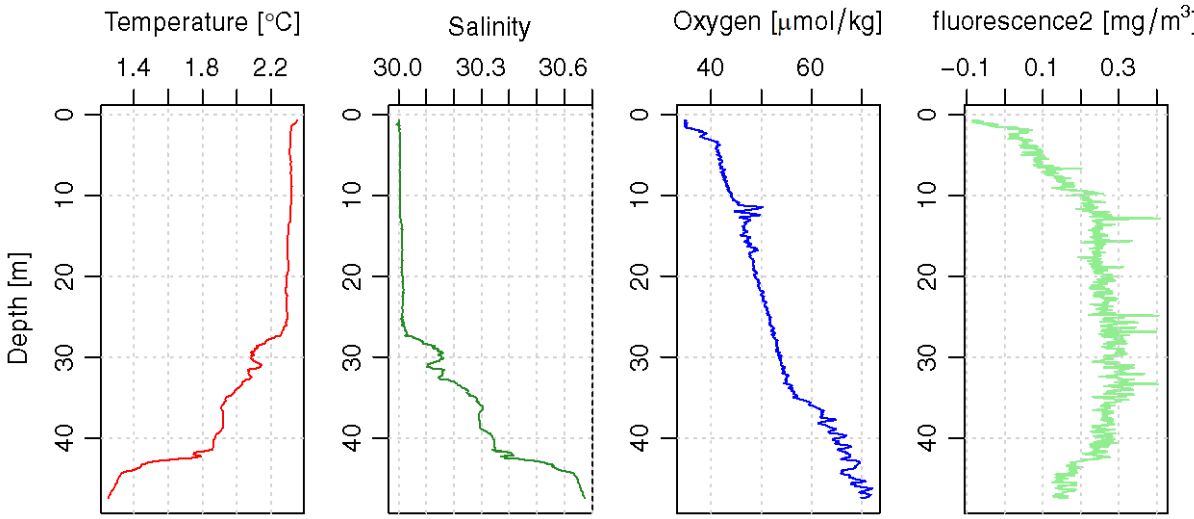

Figure B 36. station CTD 0185

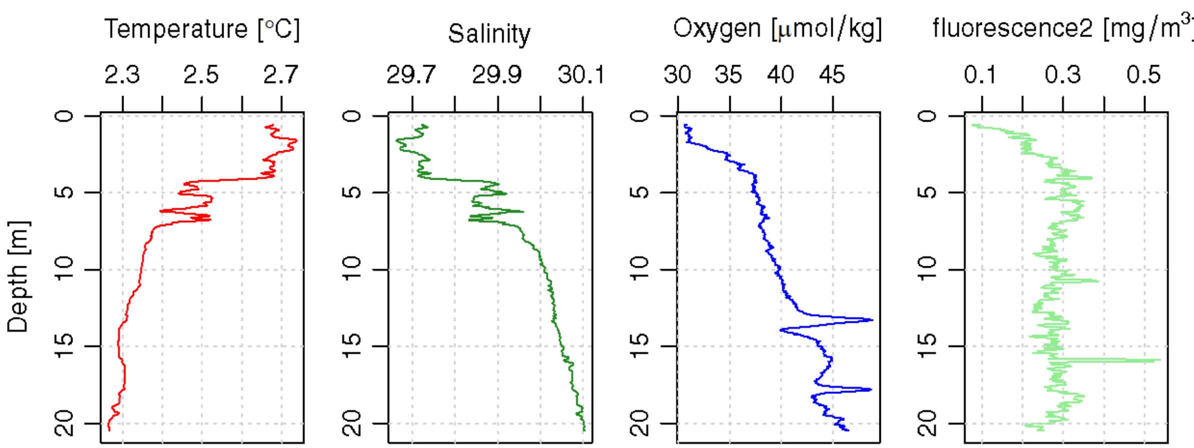

Figure B 37. station CTD 0186

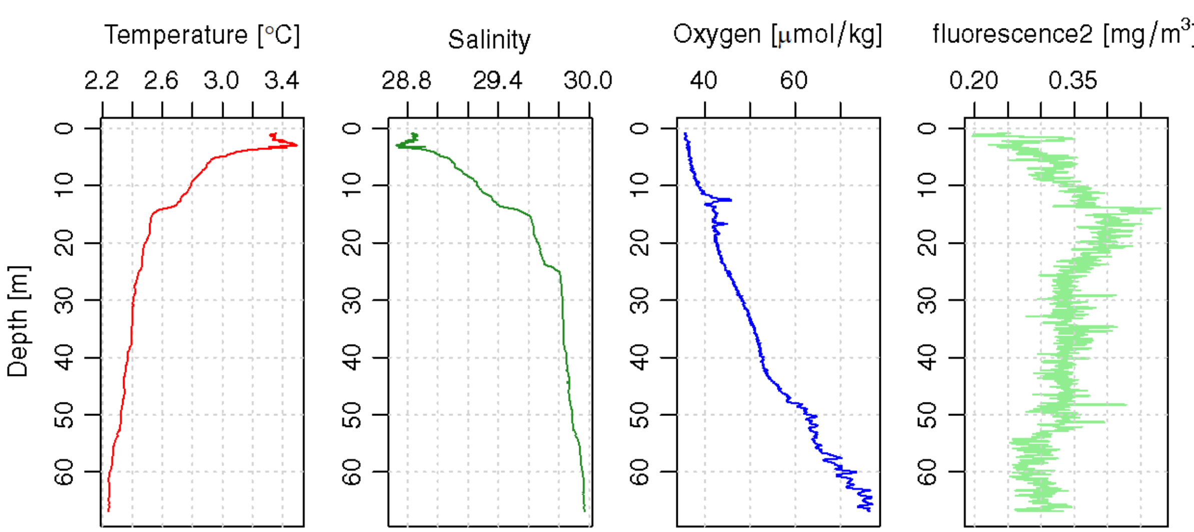

Figure B 38. station CTD 0187

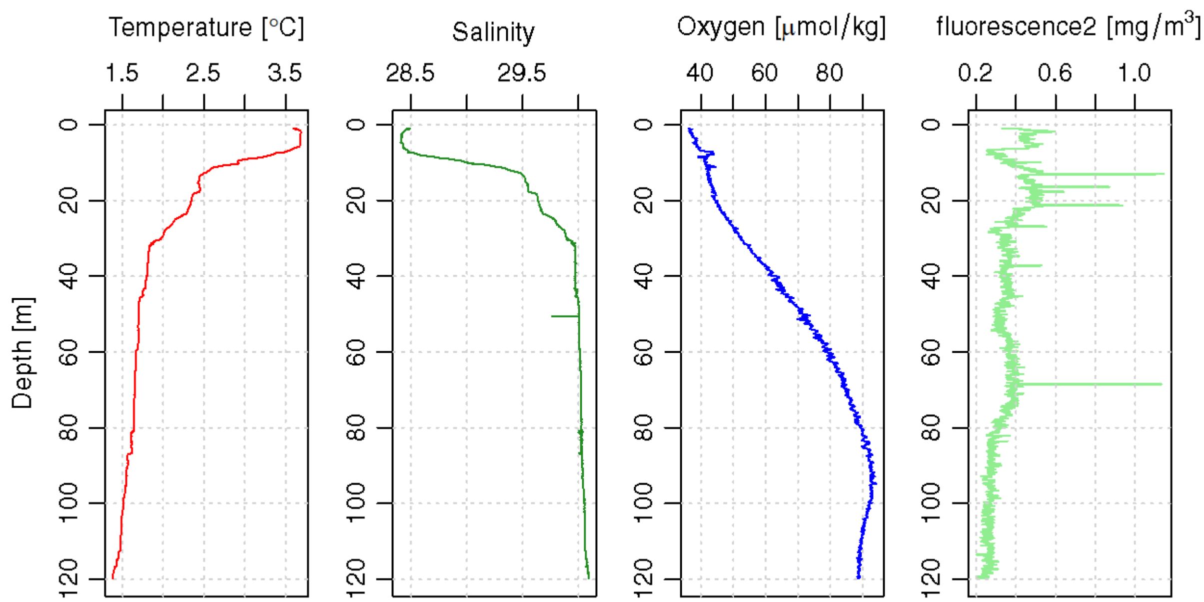

Figure B 39. station CTD 0188

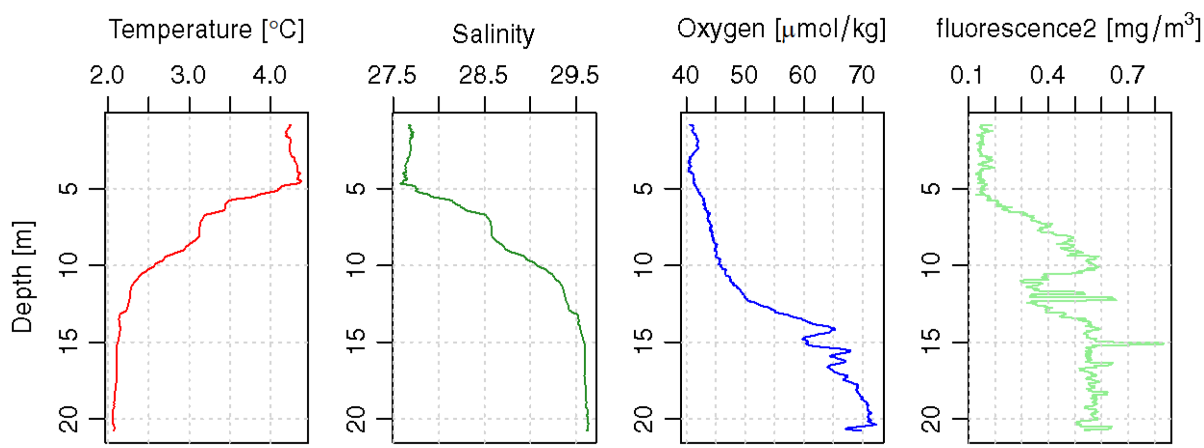

Figure B 40. station CTD 0189

APPENDIX C: CTD-R PROFILES

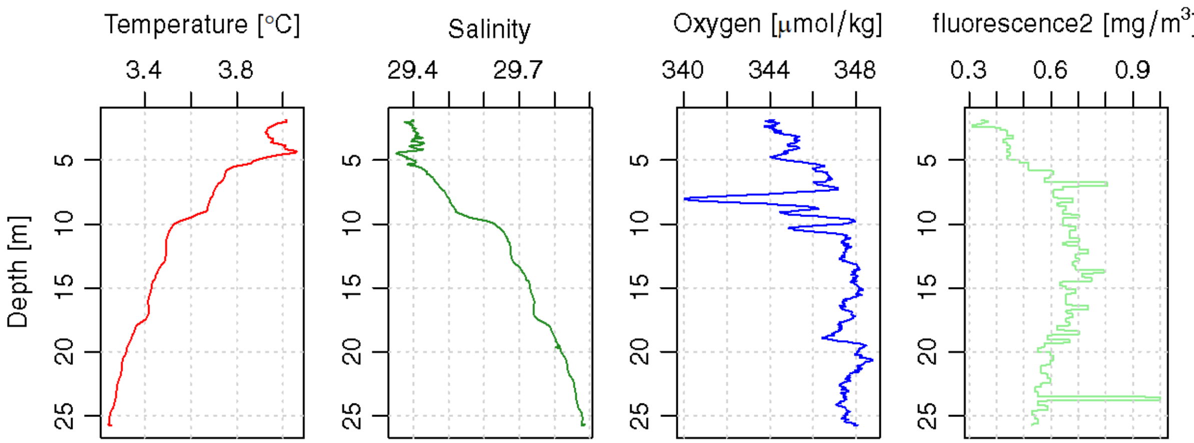

Figure C 1. station CTD-R 0002

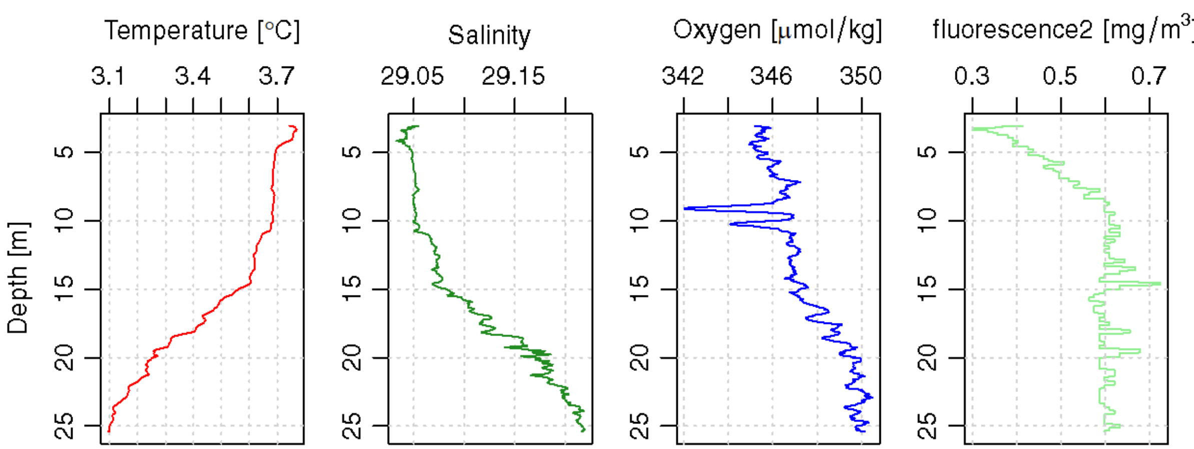

Figure C 2. station CTD-R 0011

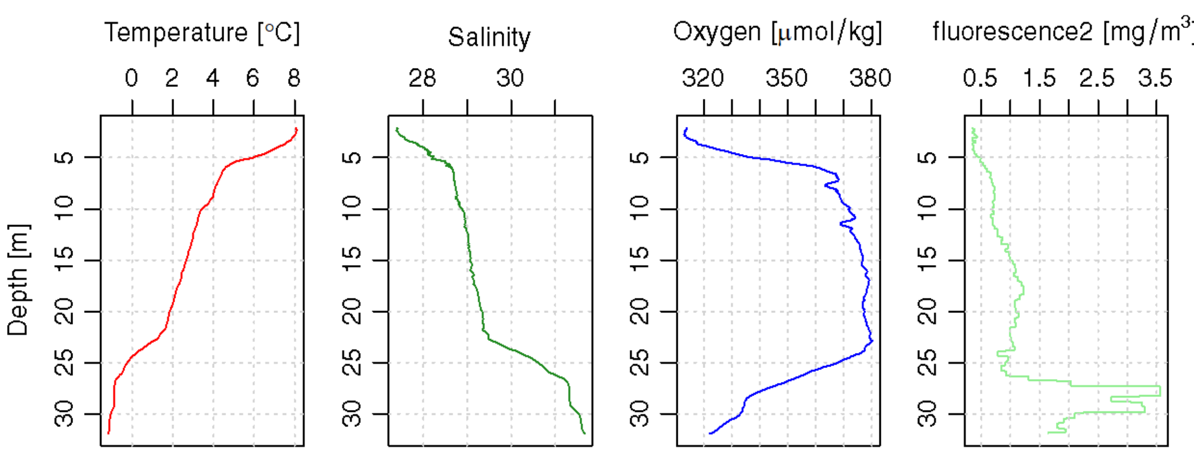

Figure C 3. station CTD-R 0023

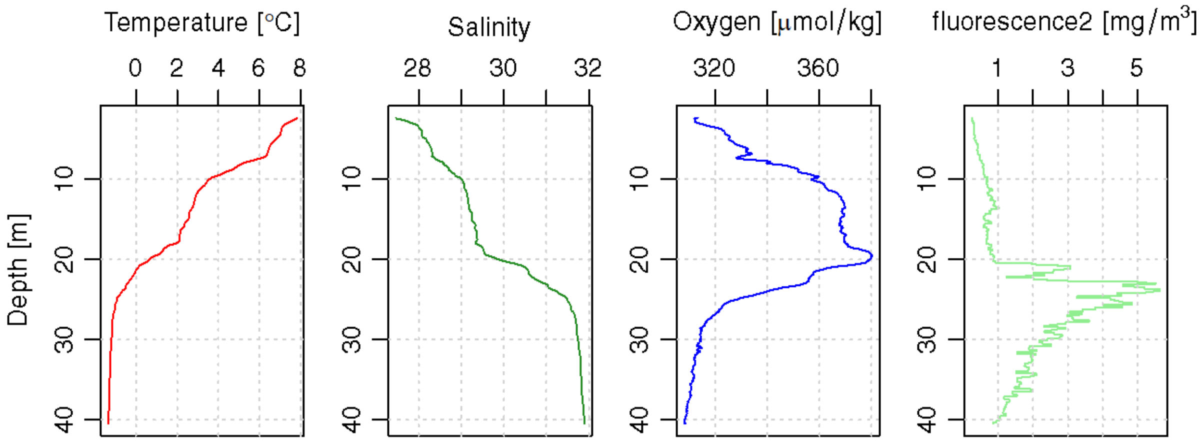

Figure C 4. station CTD-R 0033

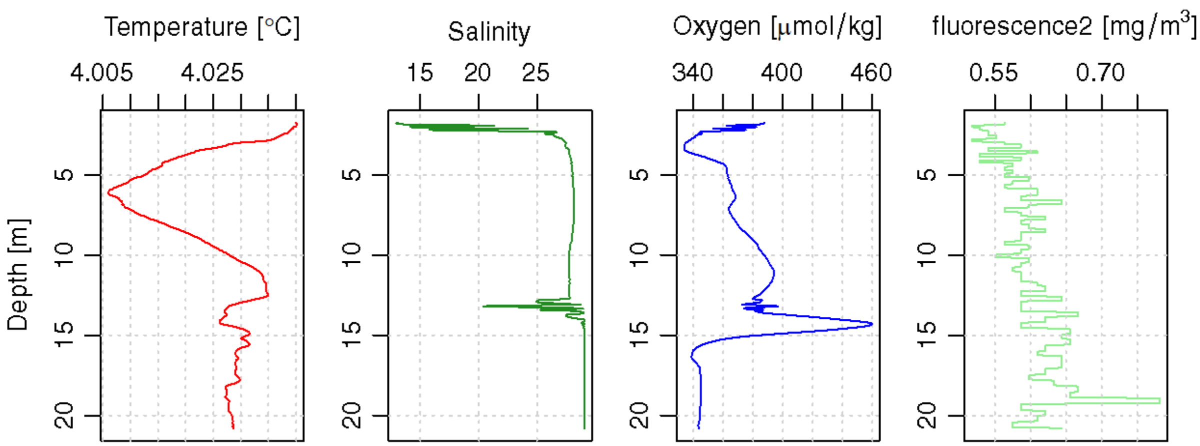

Figure C 5. station CTD-R 0070

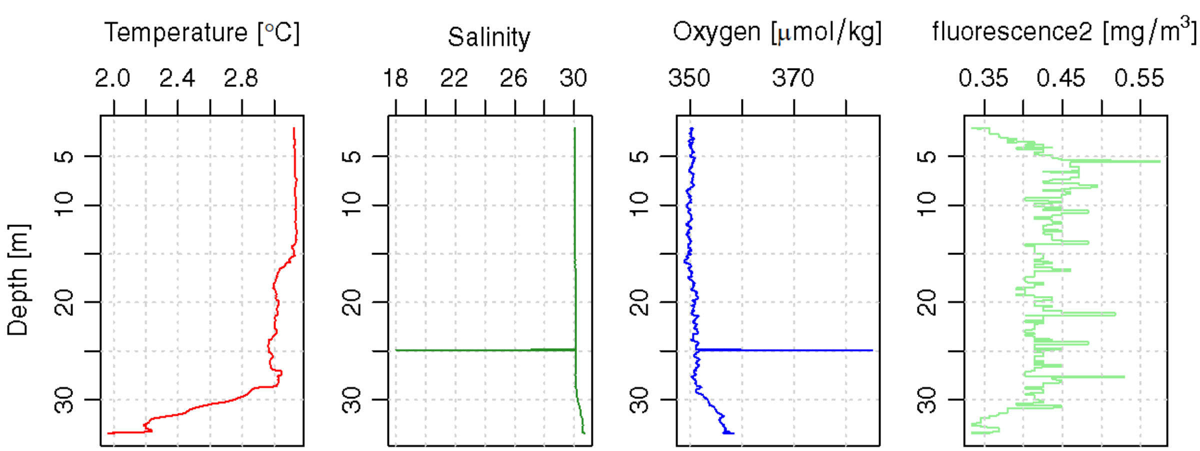

Figure C 6. station CTD-R 0079

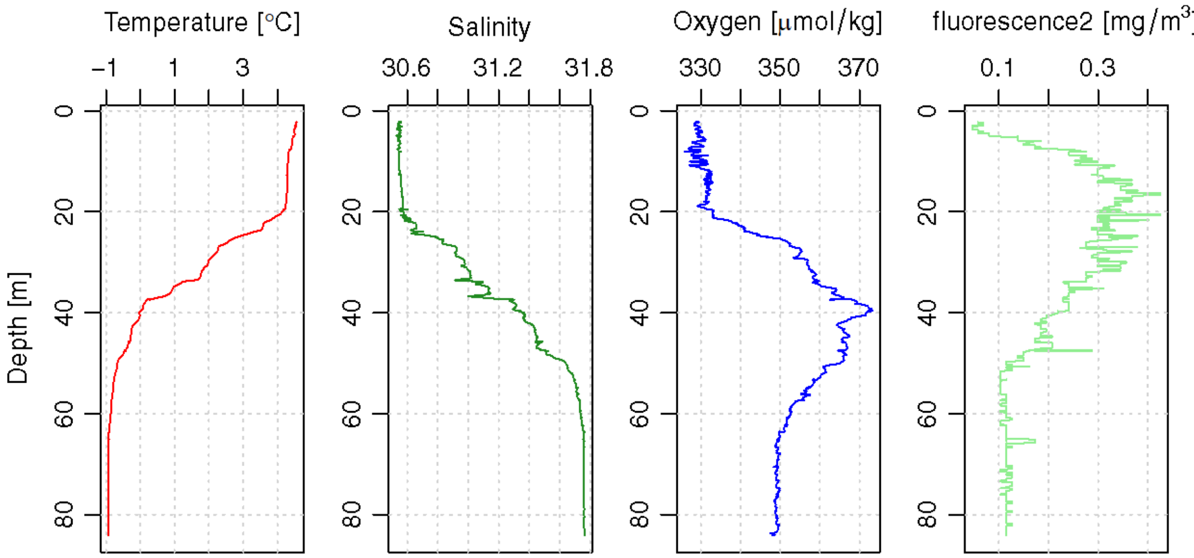

Figure C 7. station CTD-R 0101

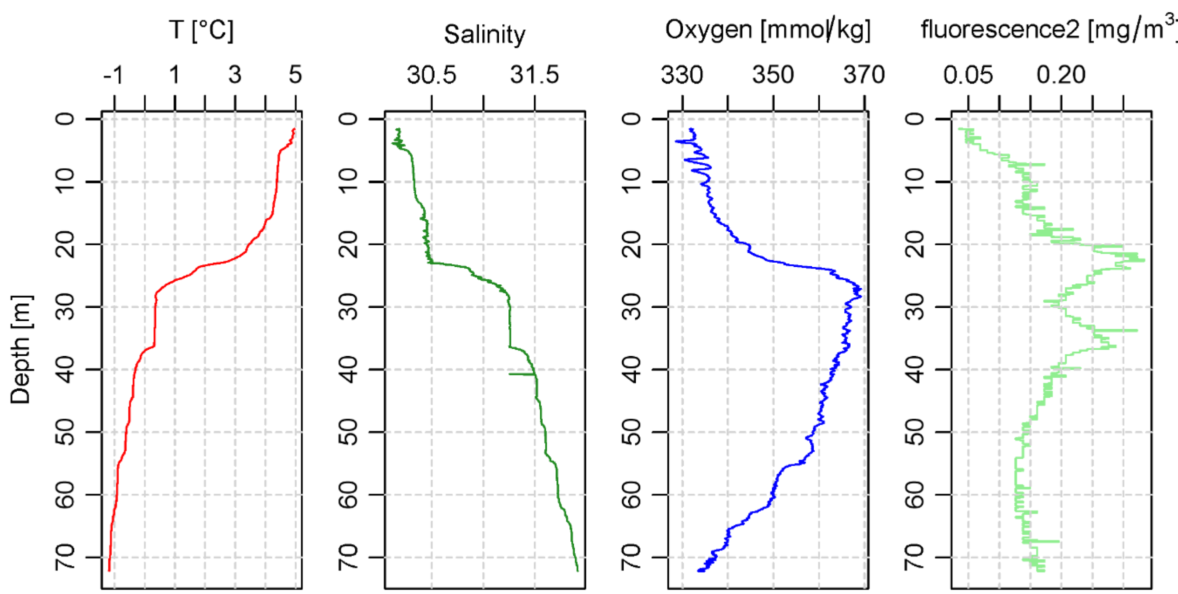

Figure C8. station CTD-R 0110

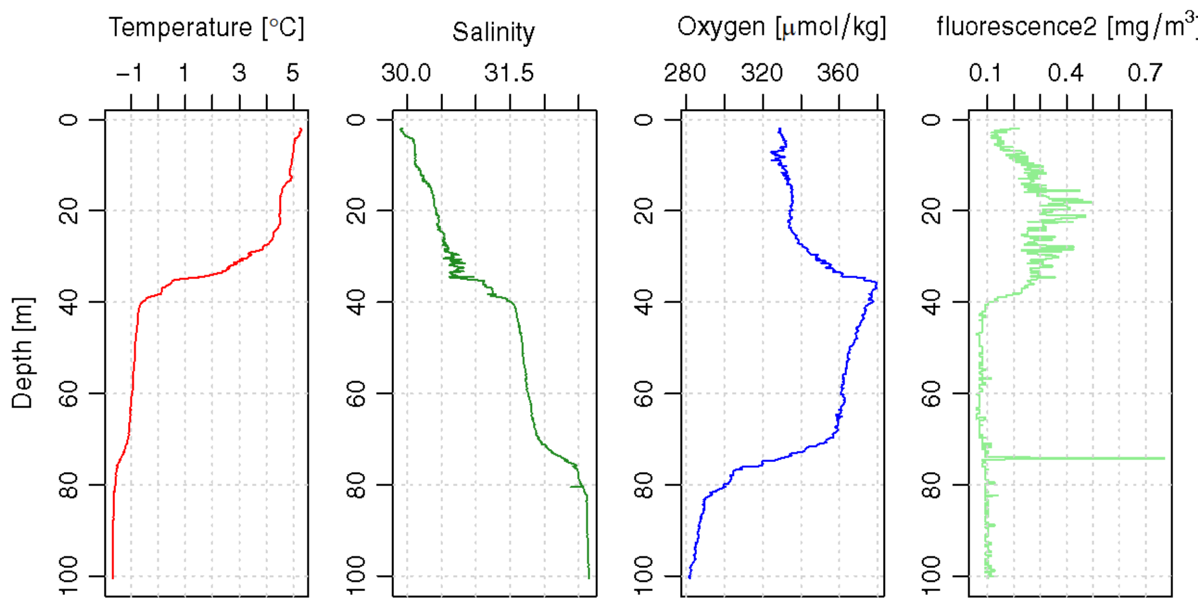

Figure C 8. station CTD-R 0115

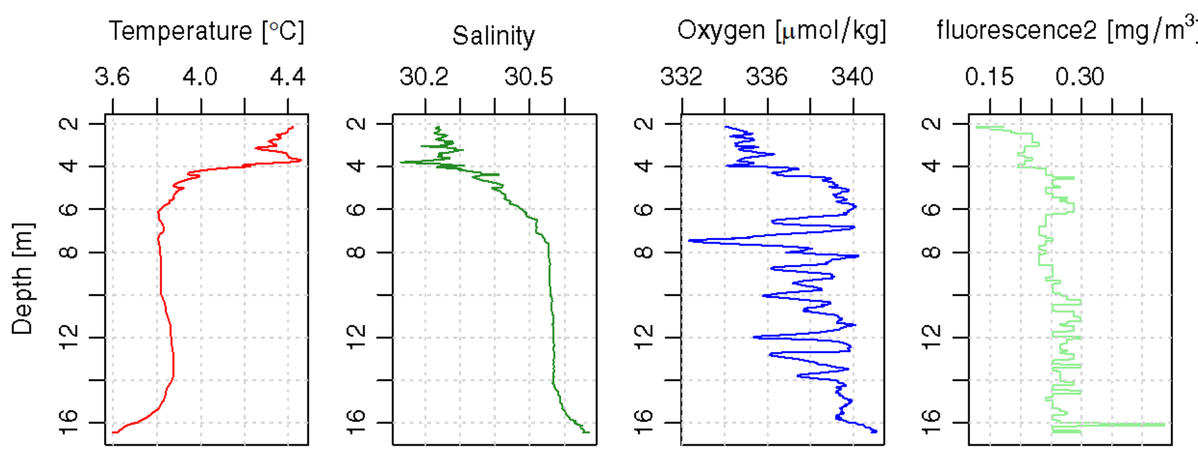

Figure C 9. station CTD-R 0125

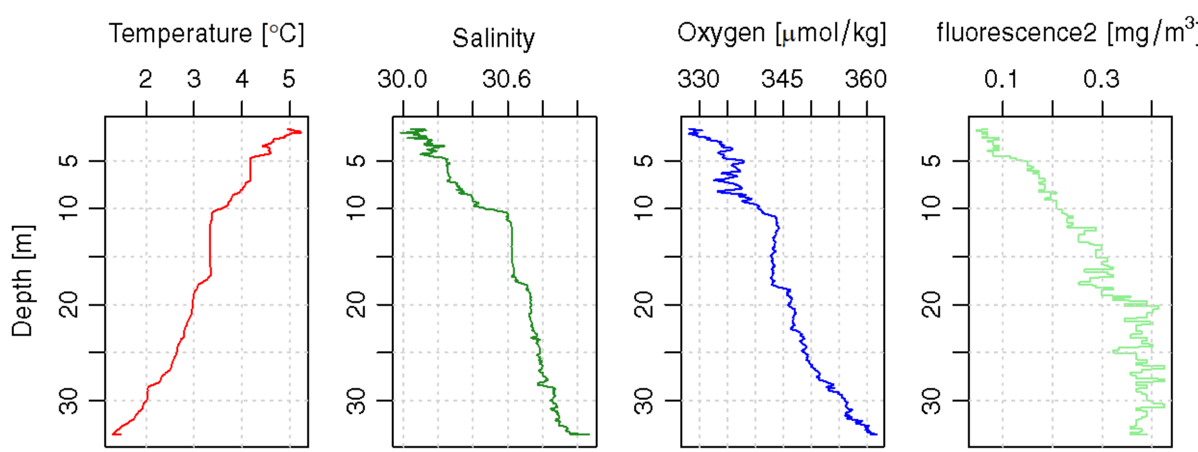

Figure C 10. station CTD-R 0130A

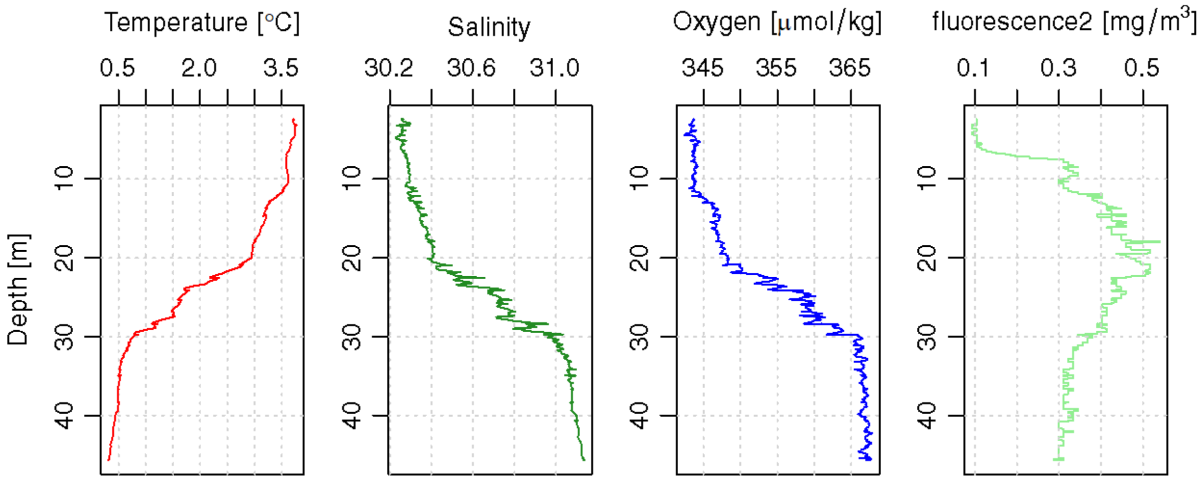

Figure C 11. station CTD-R 0133

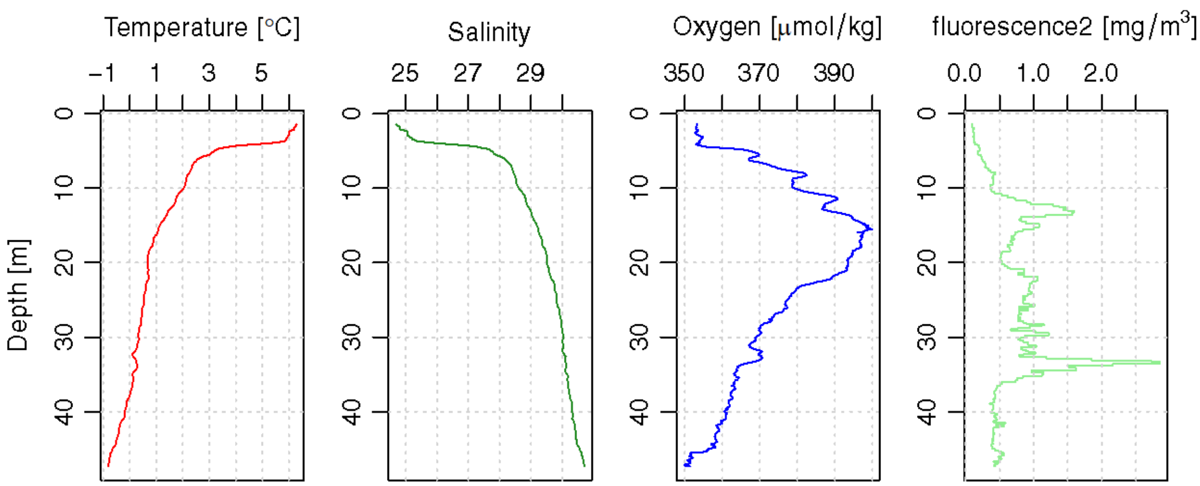

Figure C 12. station CTD-R 0162

APPENDIX D: PHOTOS BOX CORES

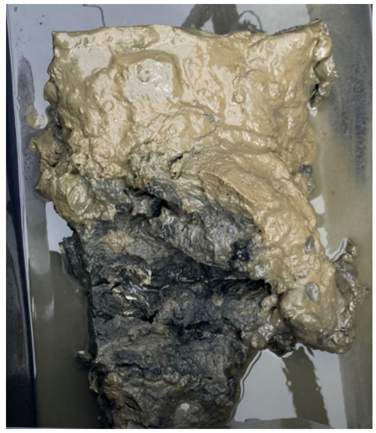

Figure D 1. Sediment sample collected at station 007BC

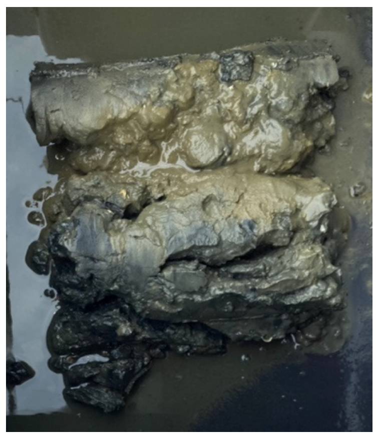

Figure D 2. Sediment sample collected at station 0016BC

Figure D 3. Sediment sample collected at station 0017BC


Figure D 4. Sediment sample collected at station 0020BC


Figure D 5. Sediment sample collected at station 0021BC


Figure D 6. Sediment sample collected at station 0028BC

Figure D 7. Sediment sample collected at station 0029BC

Figure D 8. Sediment sample collected at station 0037BC

Figure D 9. Sediment sample collected at station 0038BC

Figure D 10. Sediment sample collected at station 0073BC

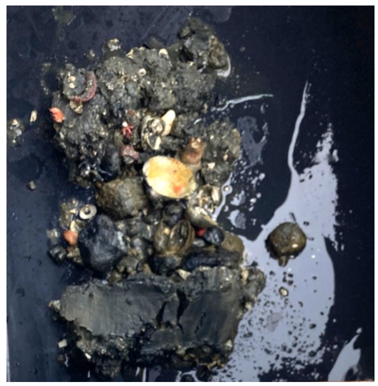

Figure D 11. Sediment sample collected at station 0074 BC

Figure D 12. Sediment sample collected at station 0075 BC

Figure D 13. Sediment sample collected at station 0076BC

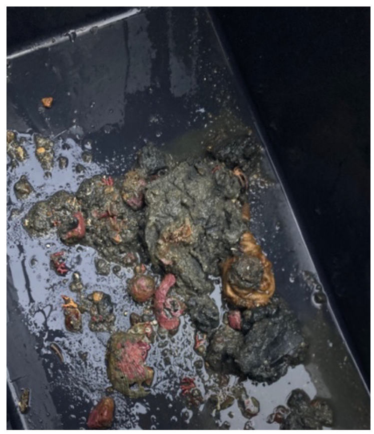

Figure D 14. Sediment sample collected at station 0077BC

Figure D 15. Sediment sample collected at station 0083BC

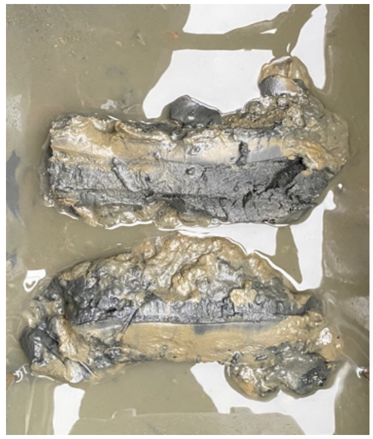
Figure D 16. Sediment sample collected at station 0084BC


Figure D 17. Sediment sample collected at station 0085BC


Figure D 18. Sediment sample collected at station 0085BBC

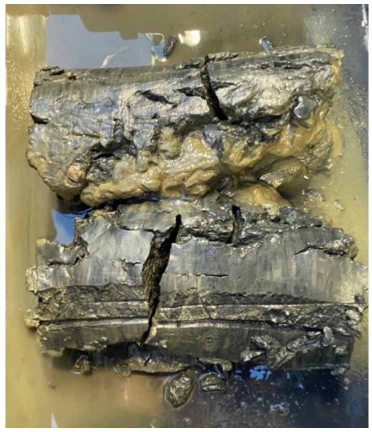

Figure D 19. Sediment sample collected at station 0087BC

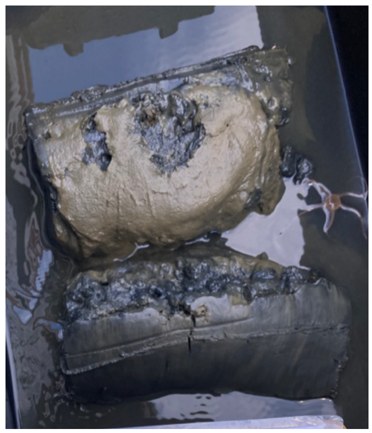

Figure D 20. Sediment sample collected at station 0105BC

Figure D 21. Sediment sample collected at station 0106 BC

Figure D 22. Sediment sample collected at station 0119 BC

Figure D 23. Sediment sample collected at station 0120BC

Figure D 24. Sediment sample collected at station 0137BC


Figure D 25. Sediment sample collected at station 0138BC

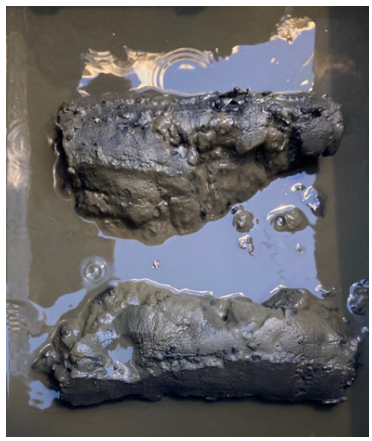
Figure D 26. Sediment sample collected at station 0141BC


Figure D 27. Sediment sample collected at station 0142BC

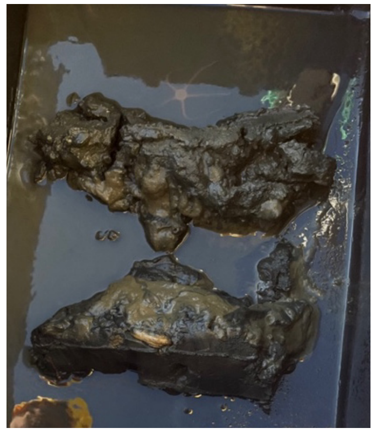

Figure D 28. Sediment sample collected at station 0145BC

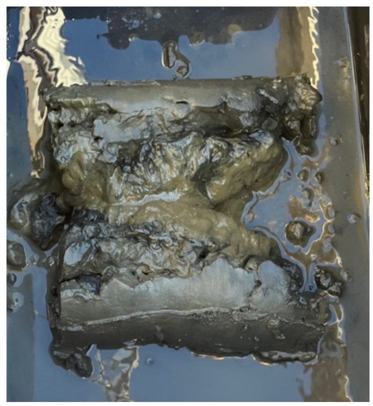

Figure D 29. Sediment sample collected at station 0146BC

Figure D 30. Sediment sample collected at station 0148BC

Figure D 31. Sediment sample collected at station 0149BC

Figure D 32. Sediment sample collected at station 0150BC

Figure D 33. Sediment sample collected at station 0151BC


Figure D 34. Sediment sample collected at station 0152BC


Figure D 35. Sediment sample collected at station 0153BC


Figure D 36. Sediment sample collected at station 0154BC

Figure D 37. Sediment sample collected at station 0155BC

Figure D 38. Sediment sample collected at station 0156BC

Figure D 39. Sediment sample collected at station 0157BC

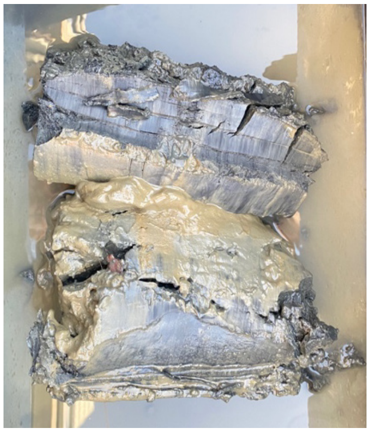
Figure D 40. Sediment sample collected at station 0166BC


Figure D 41. Sediment sample collected at station 00167BC

APPENDIX E: GRAVITY CORE STRATIGRAPHY

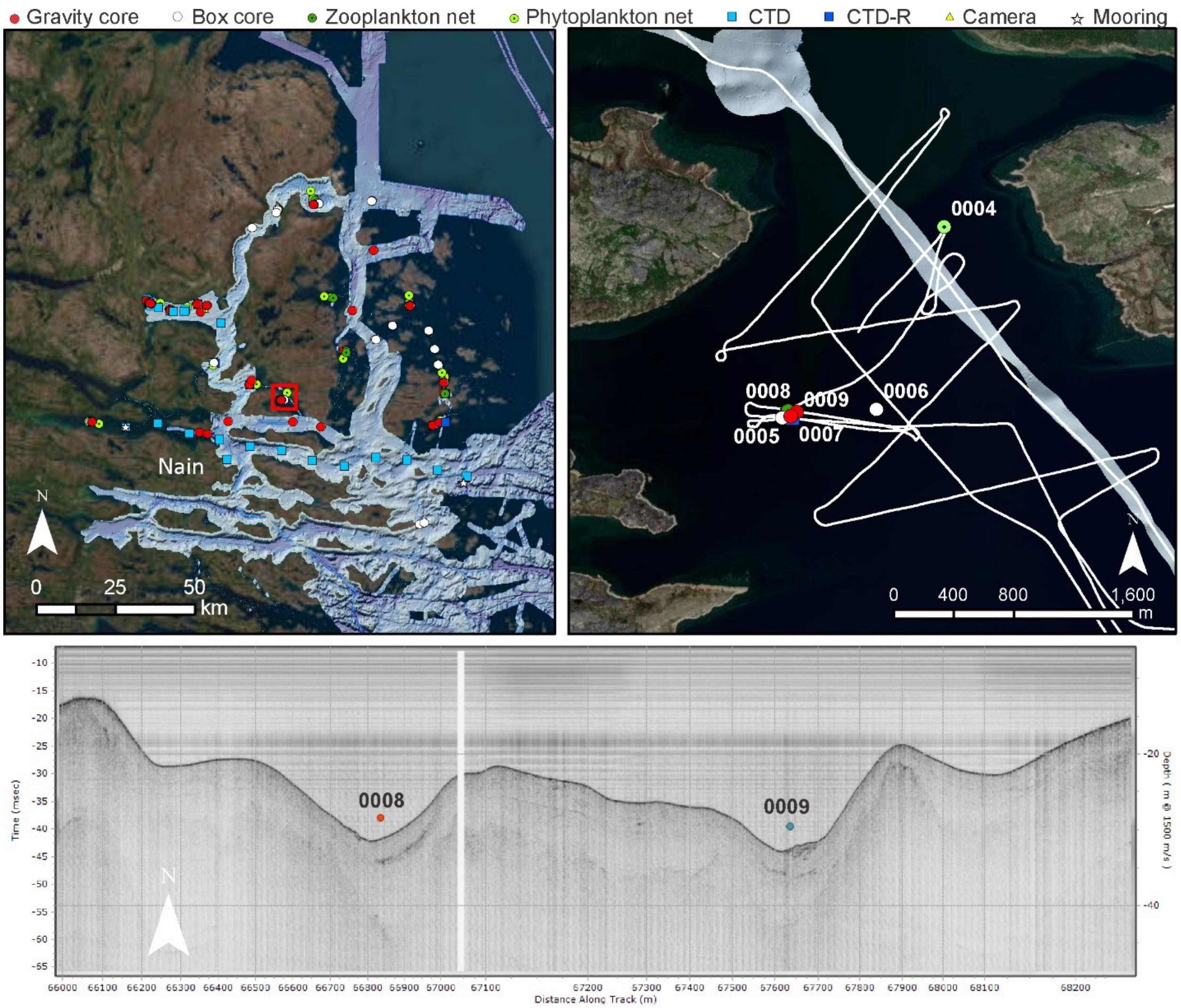

Figure E 1: Stratigraphic context of cores 0008 and 0009.

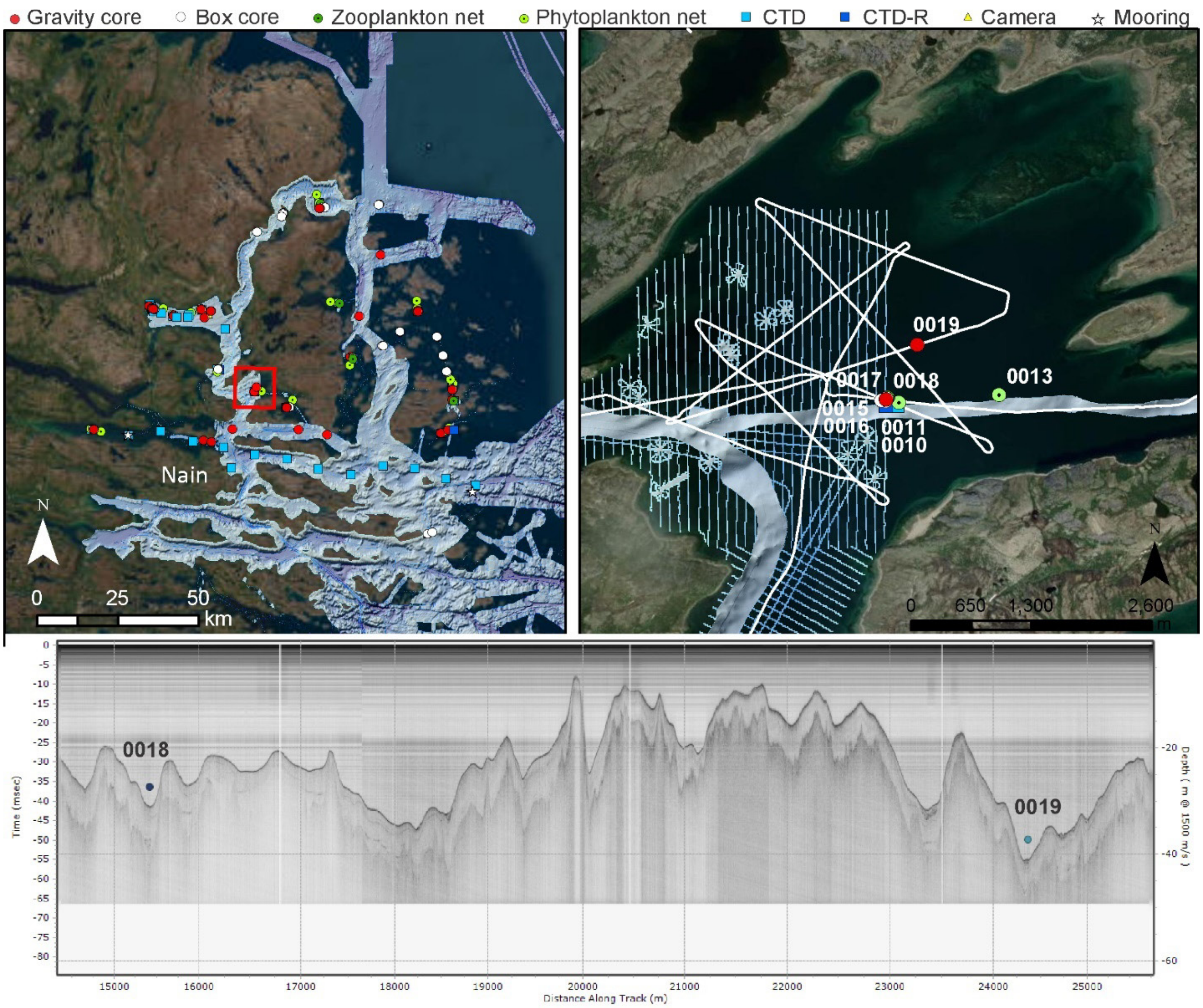

Figure E 2: Stratigraphic context of cores 0018 and 0019.

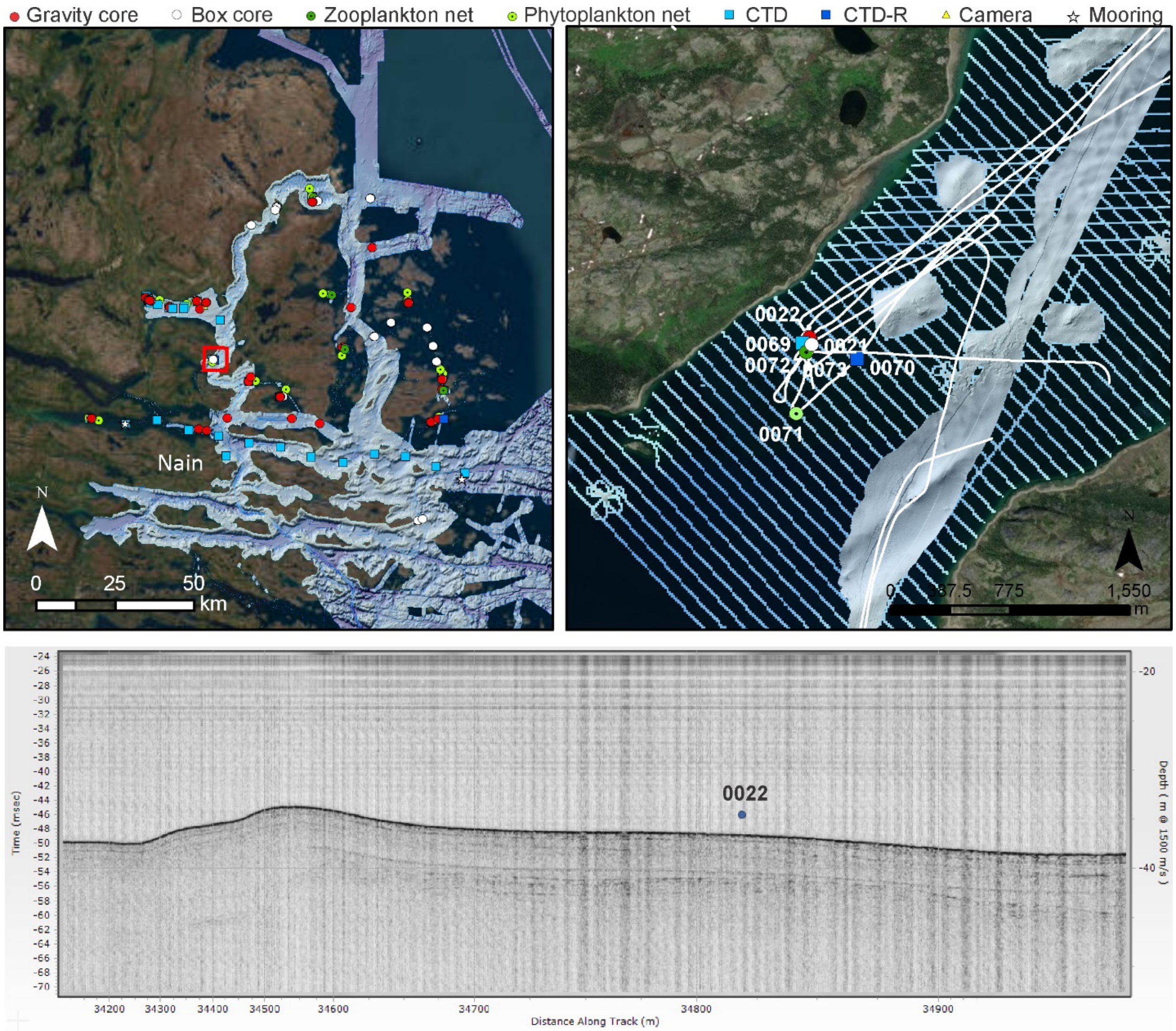

Figure E 3: Stratigraphic context of core 0022.

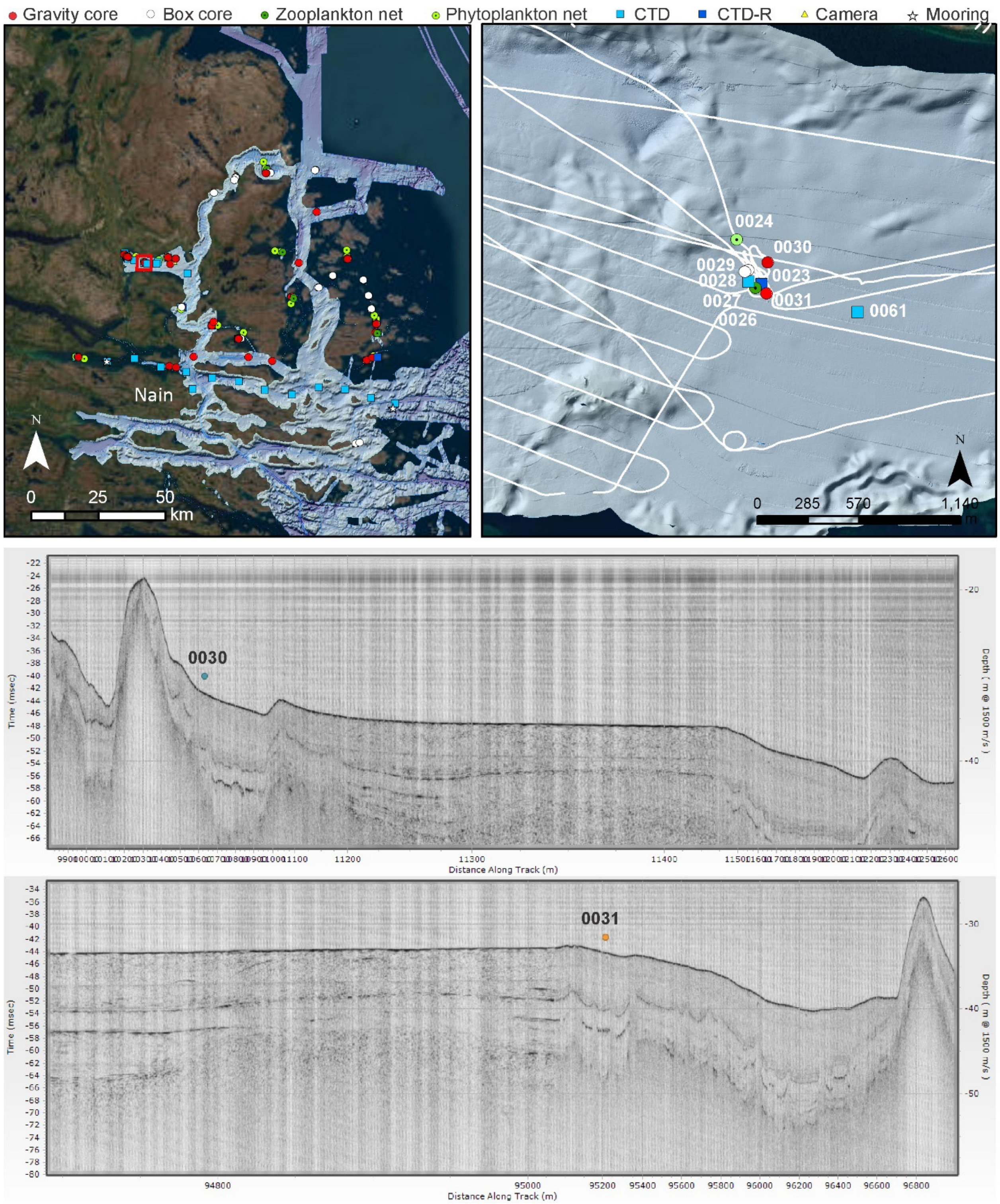

Figure E 4: Stratigraphic context of cores 0030 and 0031.

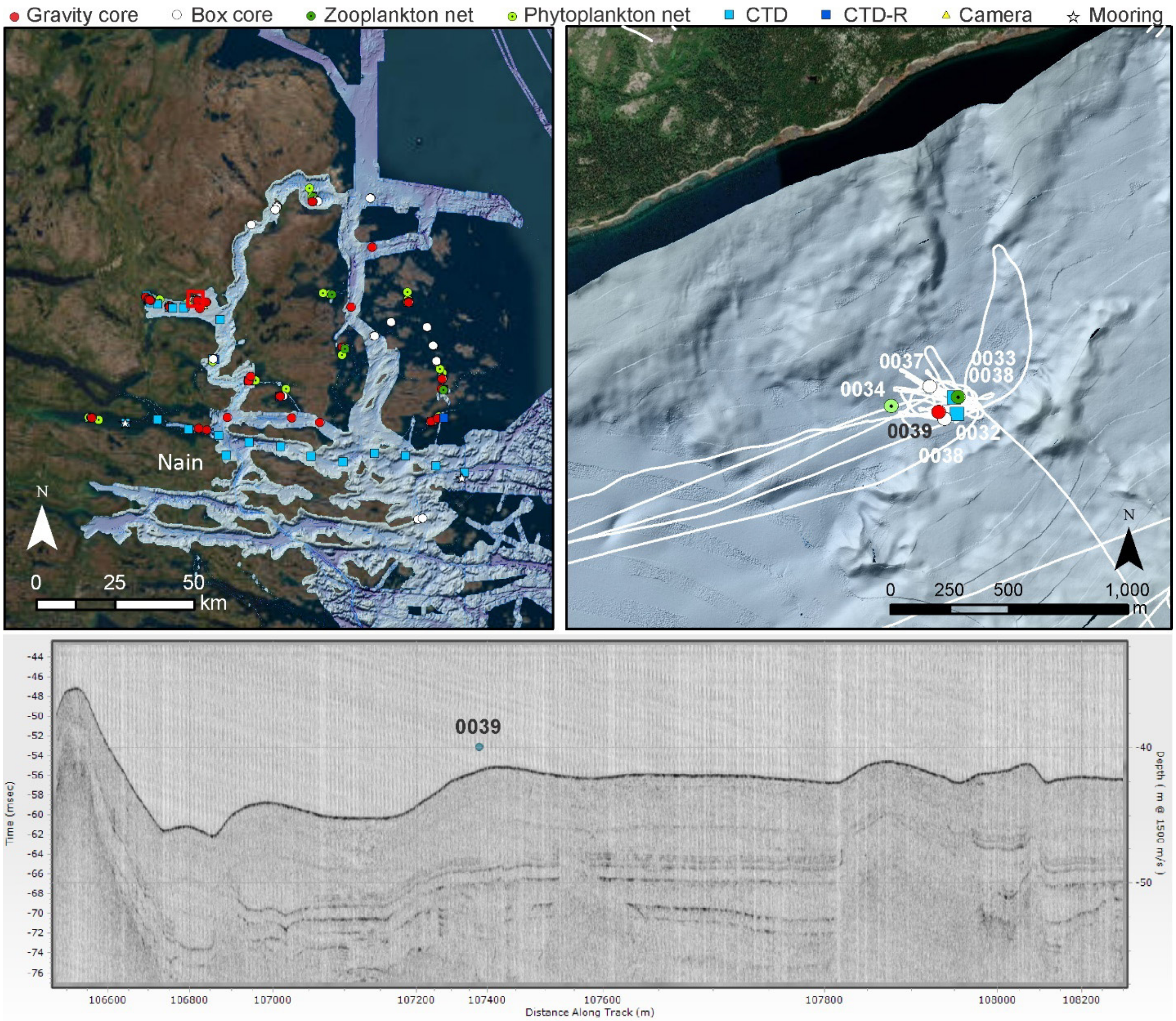

Figure E 5: Stratigraphic context of core 0039.

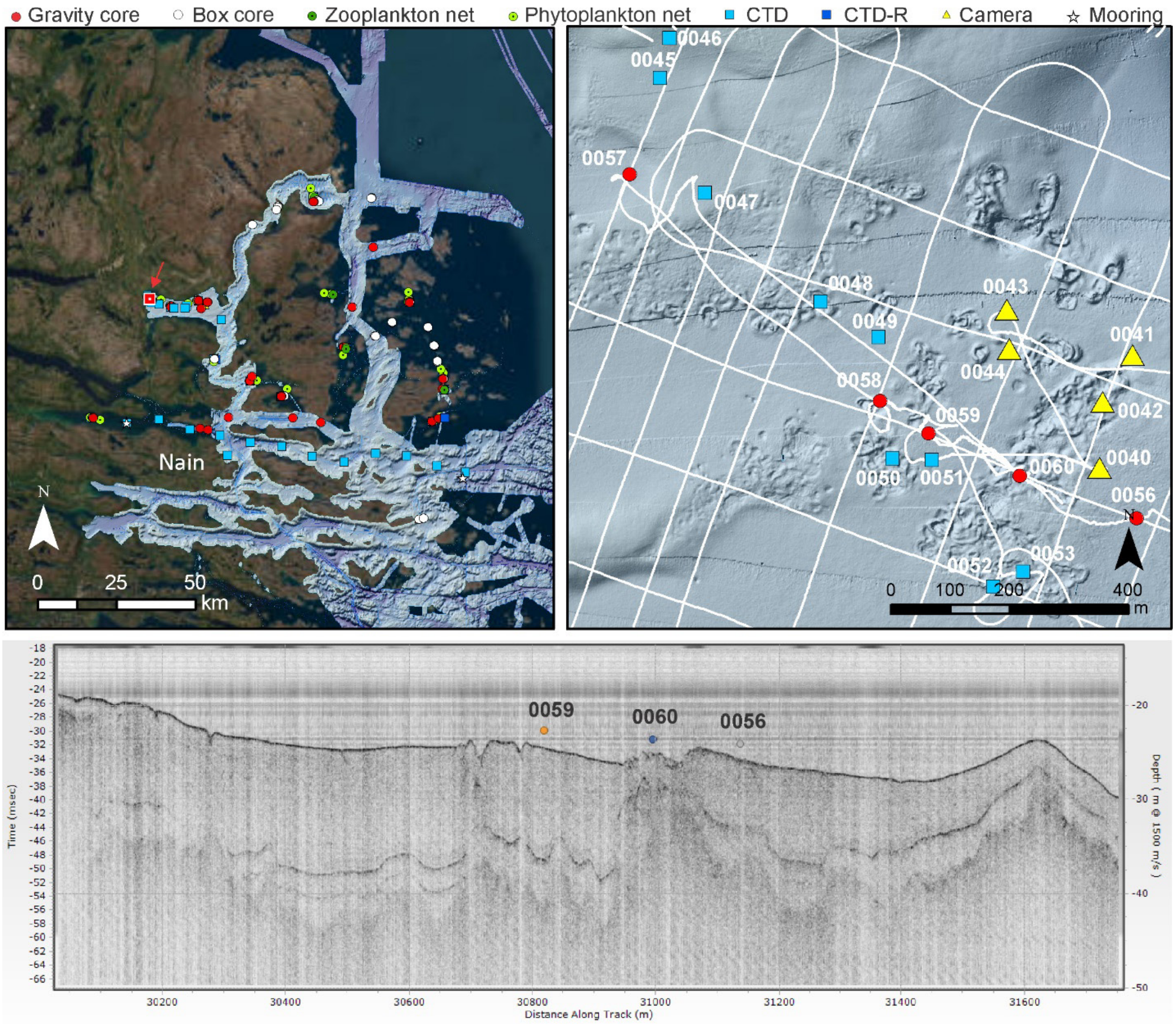

Figure E 6: Stratigraphic context of cores 0059, 0060 and 0056.

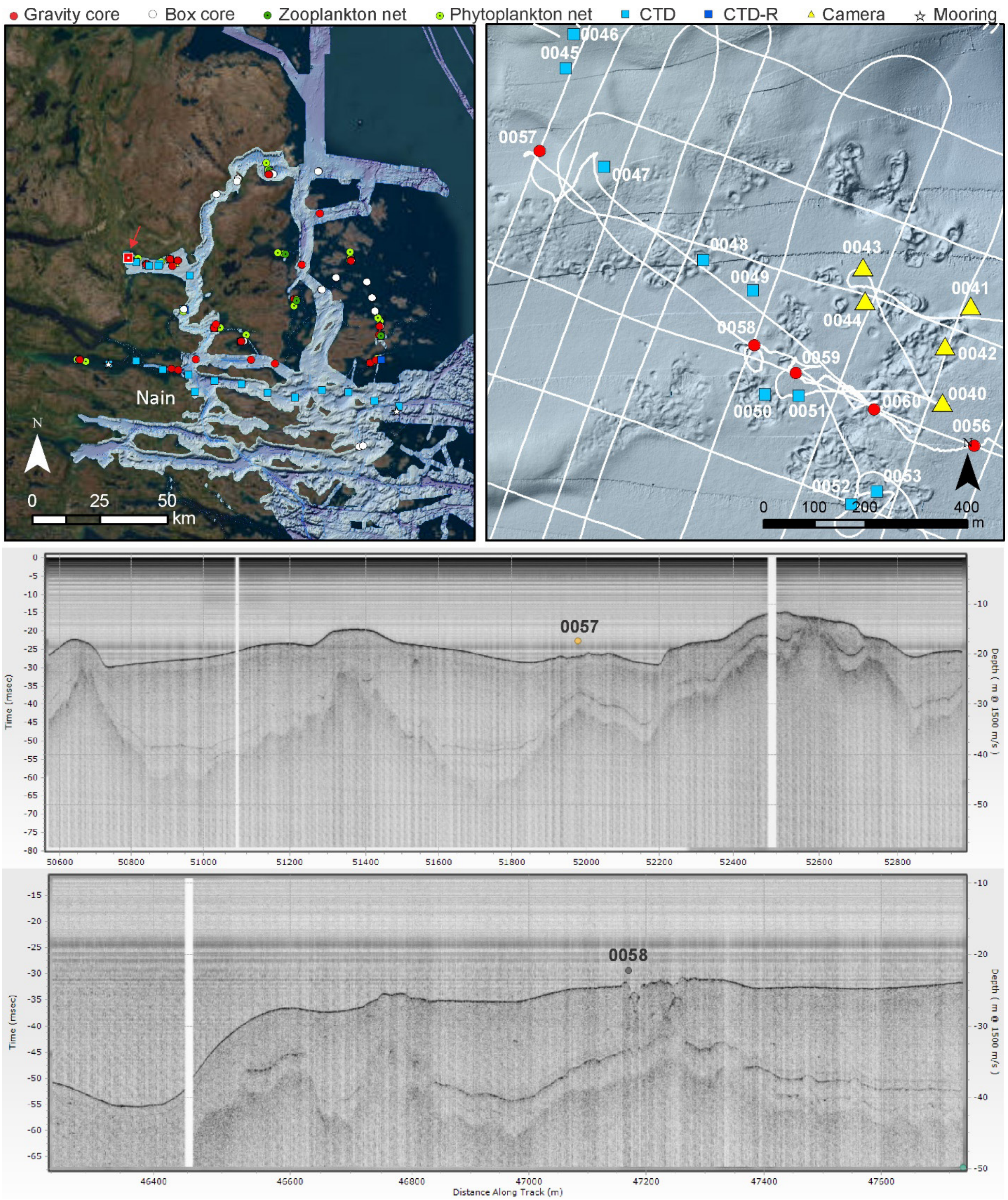

Figure E 7: Stratigraphic context of cores 0057 and 0058.

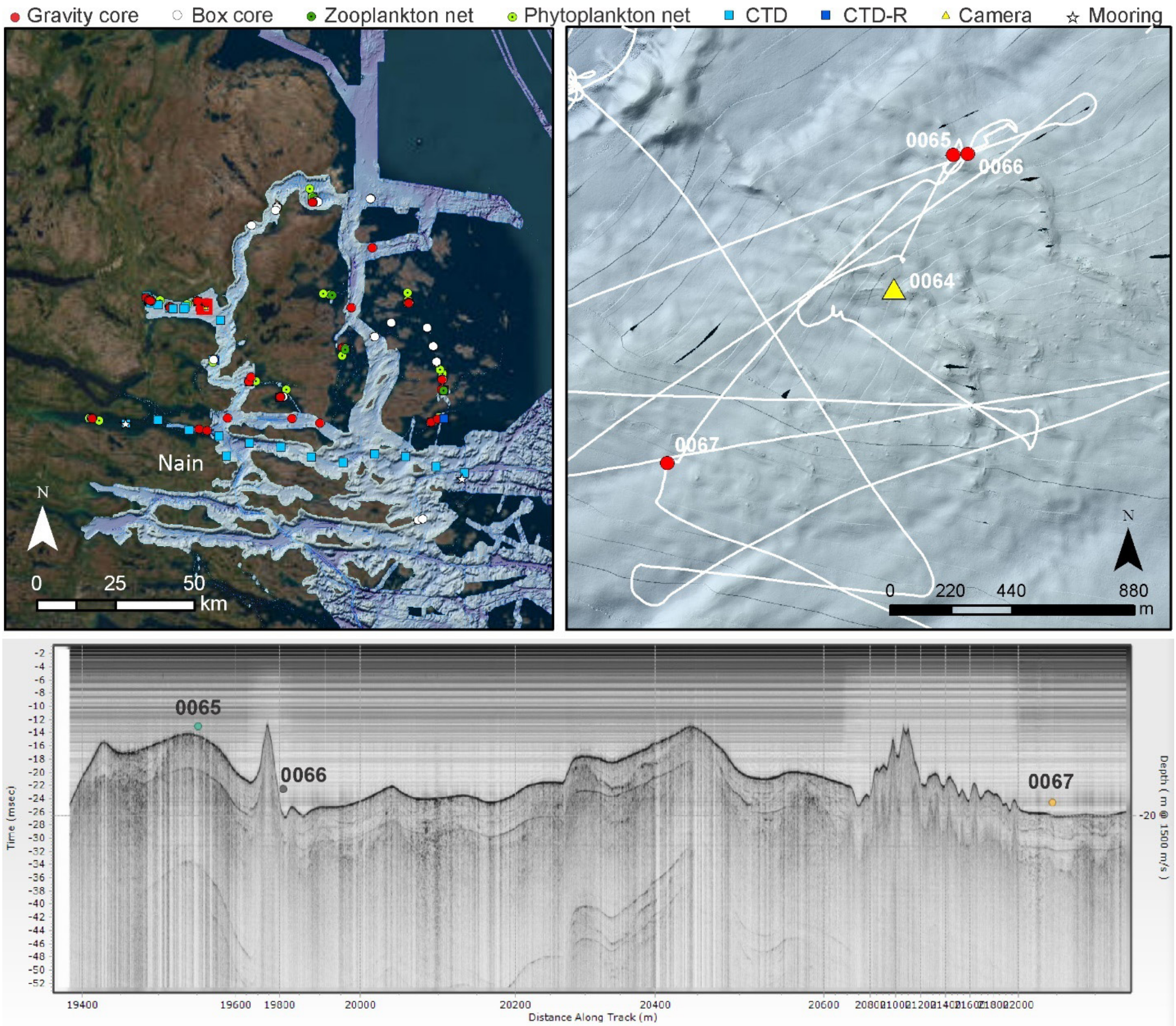

Figure E 8: Stratigraphic context of cores 0065, 0066 and 0067.

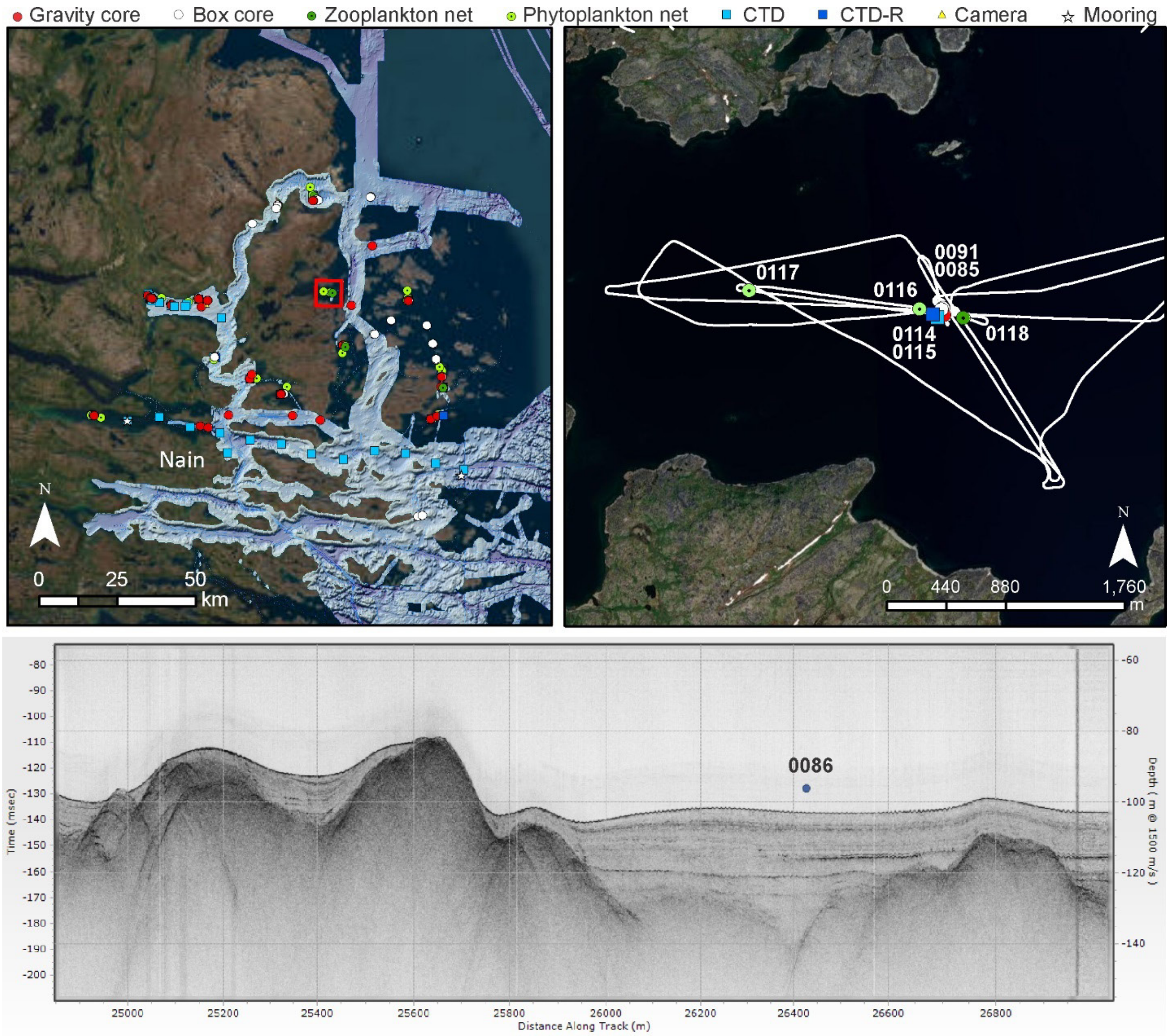

Figure E 9: Stratigraphic context of core 0086.

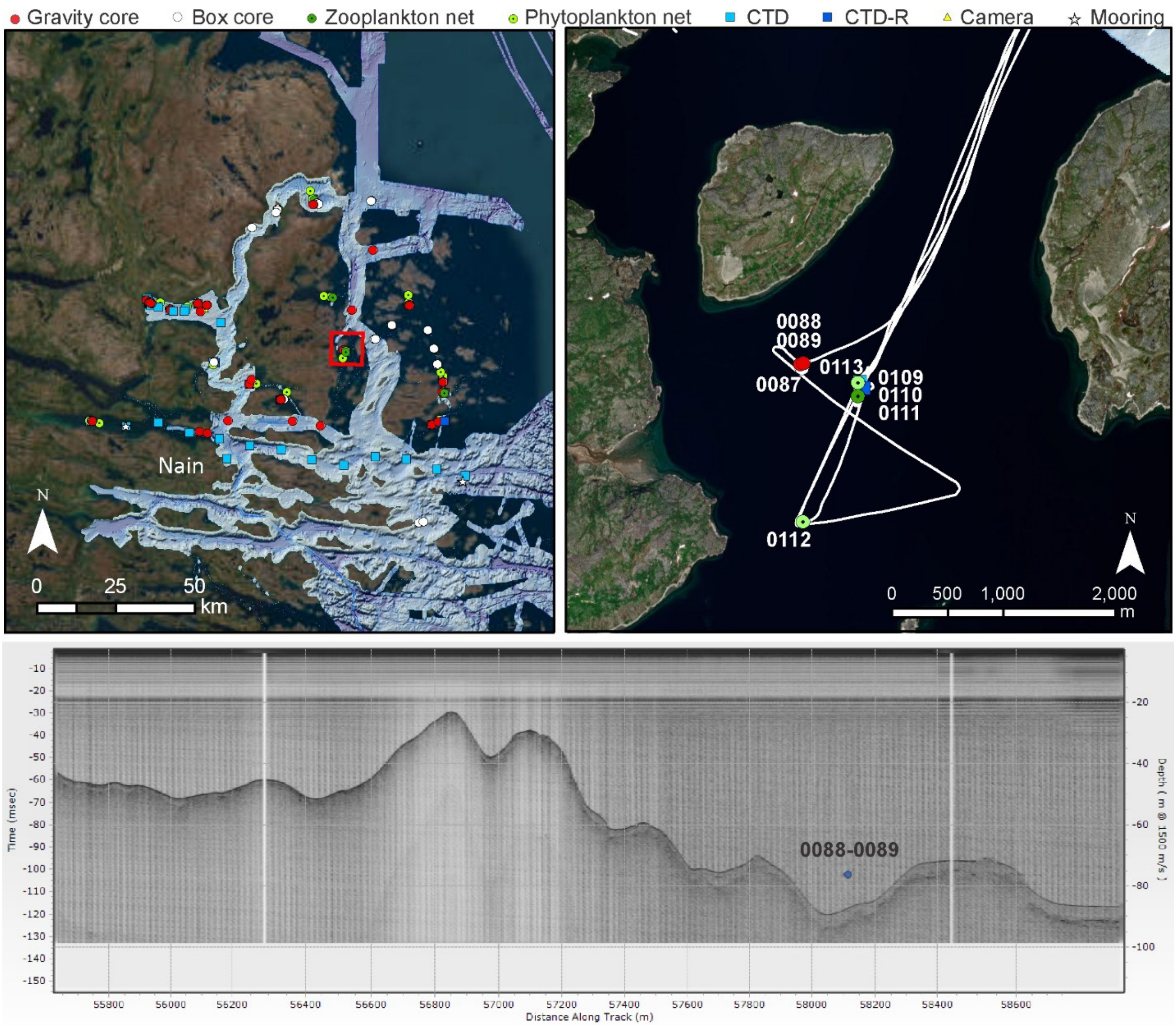

Figure E 10: Stratigraphic context of cores 0088 and 0089.

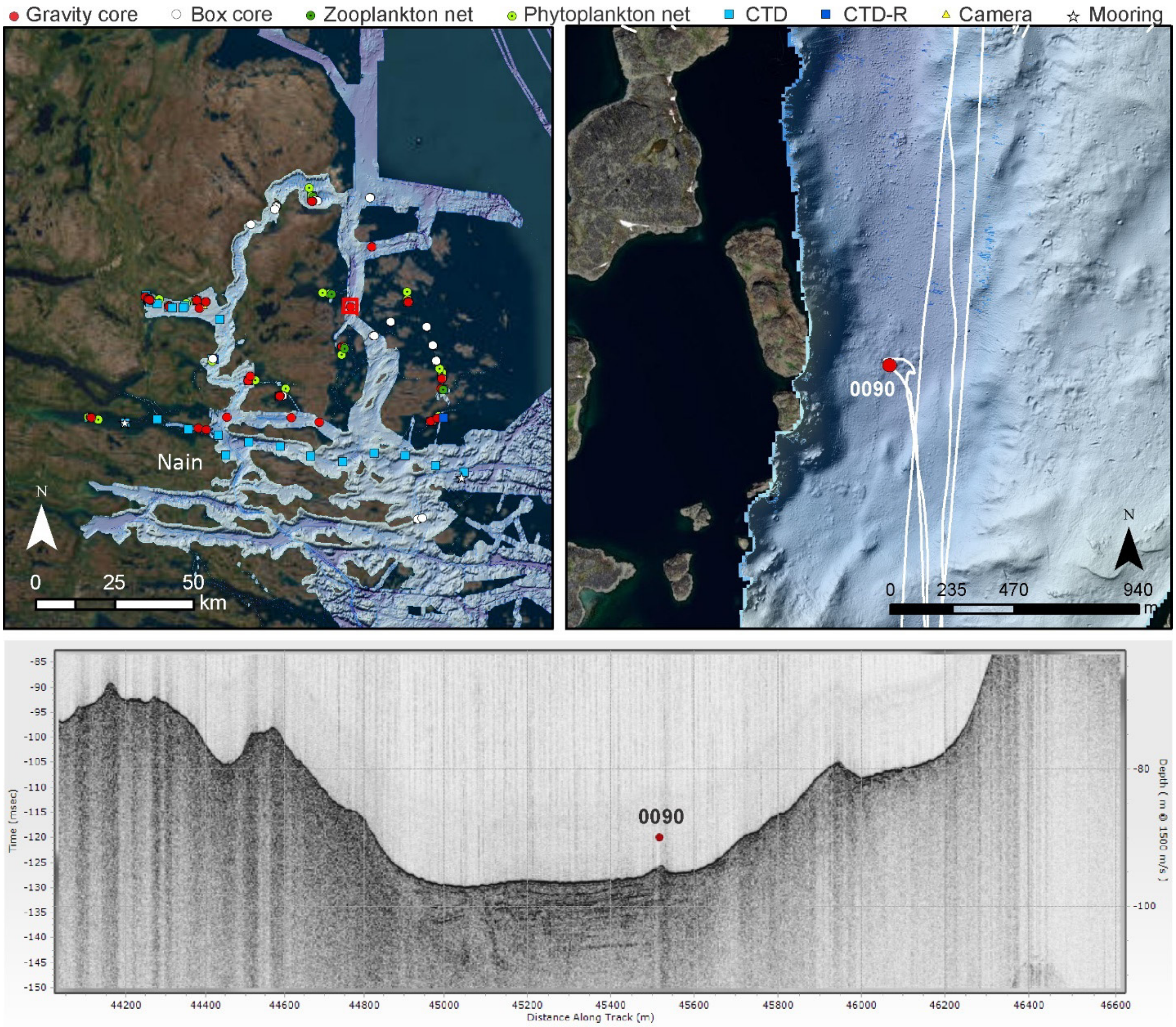

Figure E 11: Stratigraphic context of core 0090.

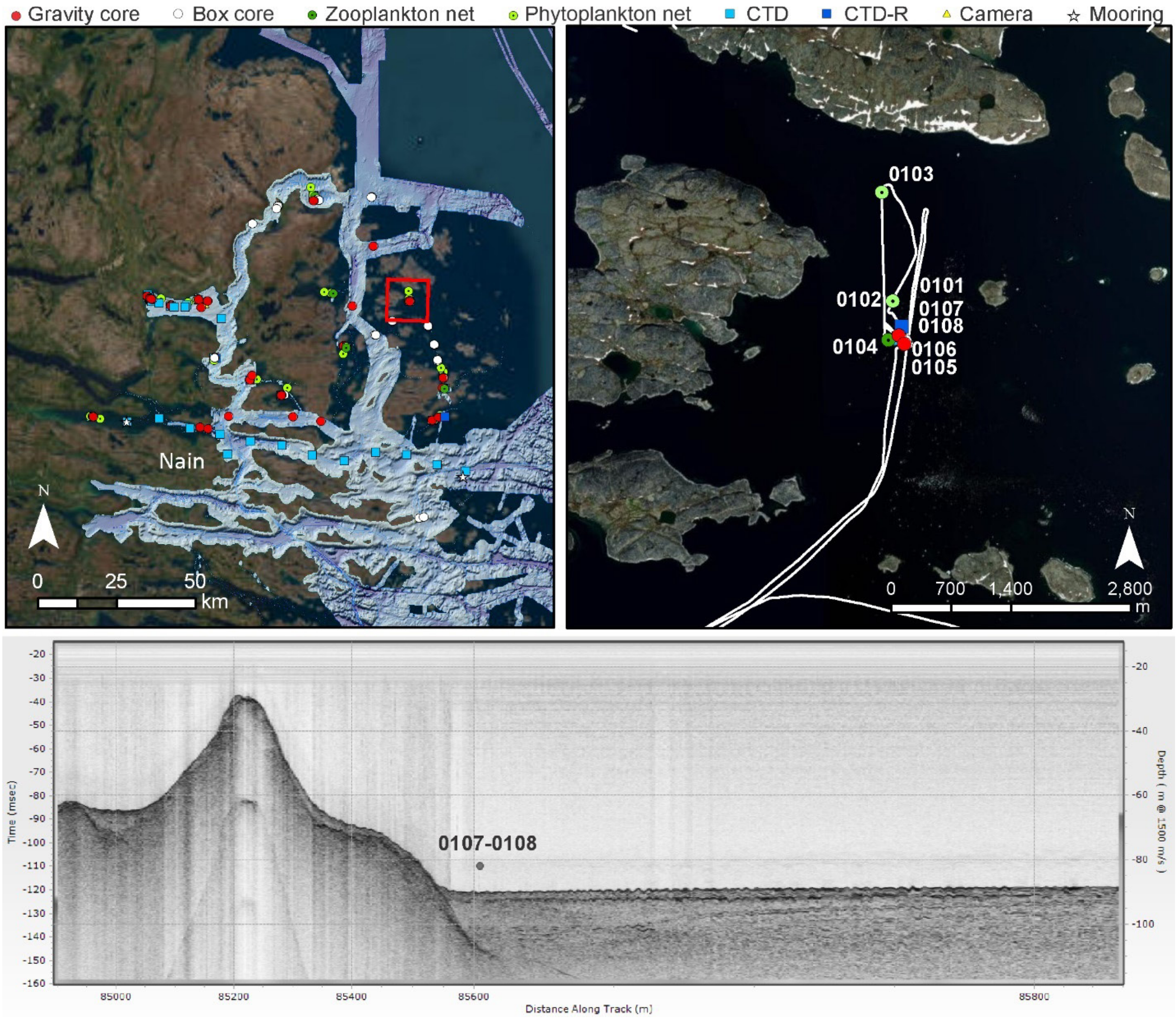

Figure E 12: Stratigraphic context of cores 0107 and 0108.

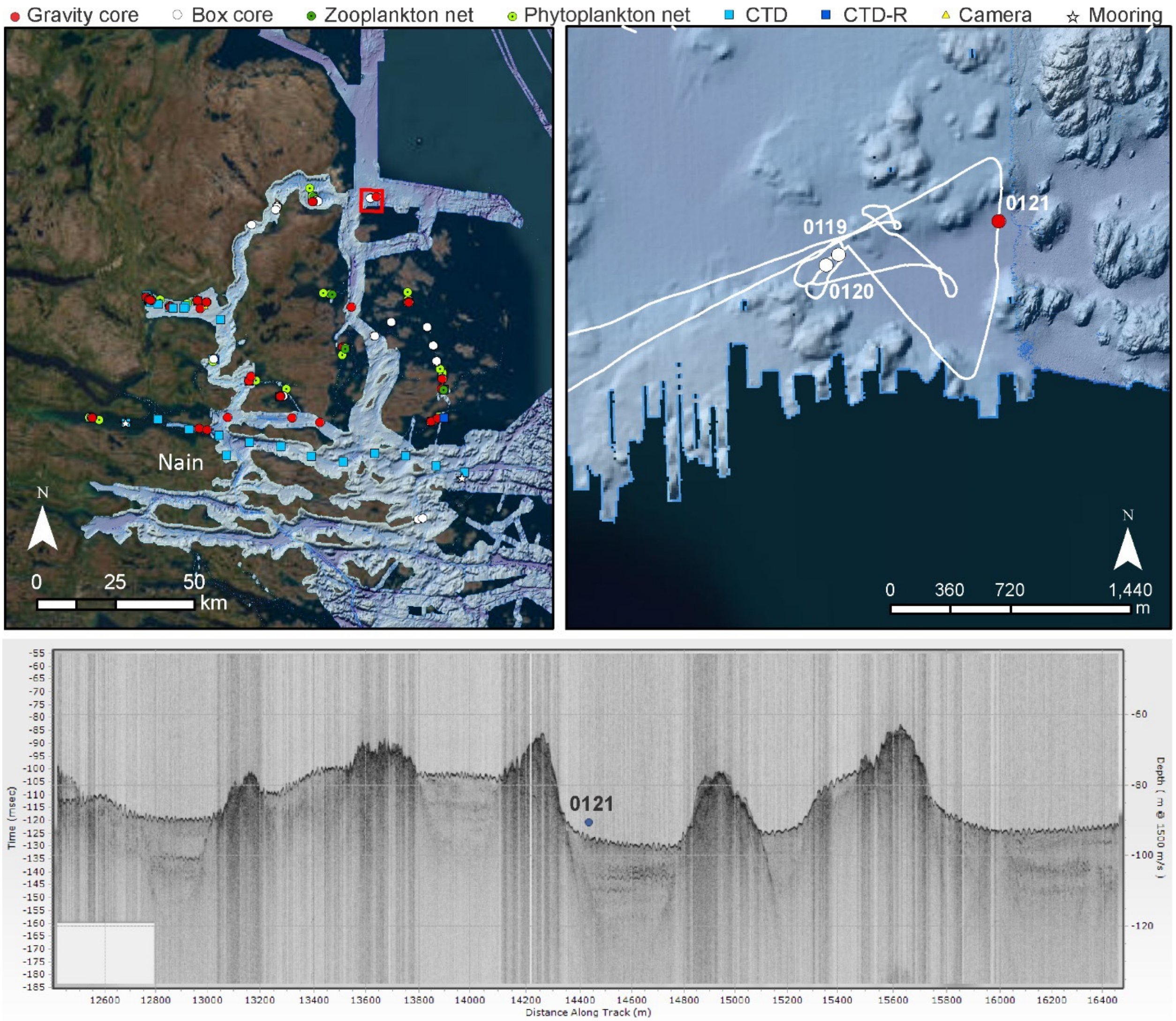

Figure E 13: Stratigraphic context of cores 0121.

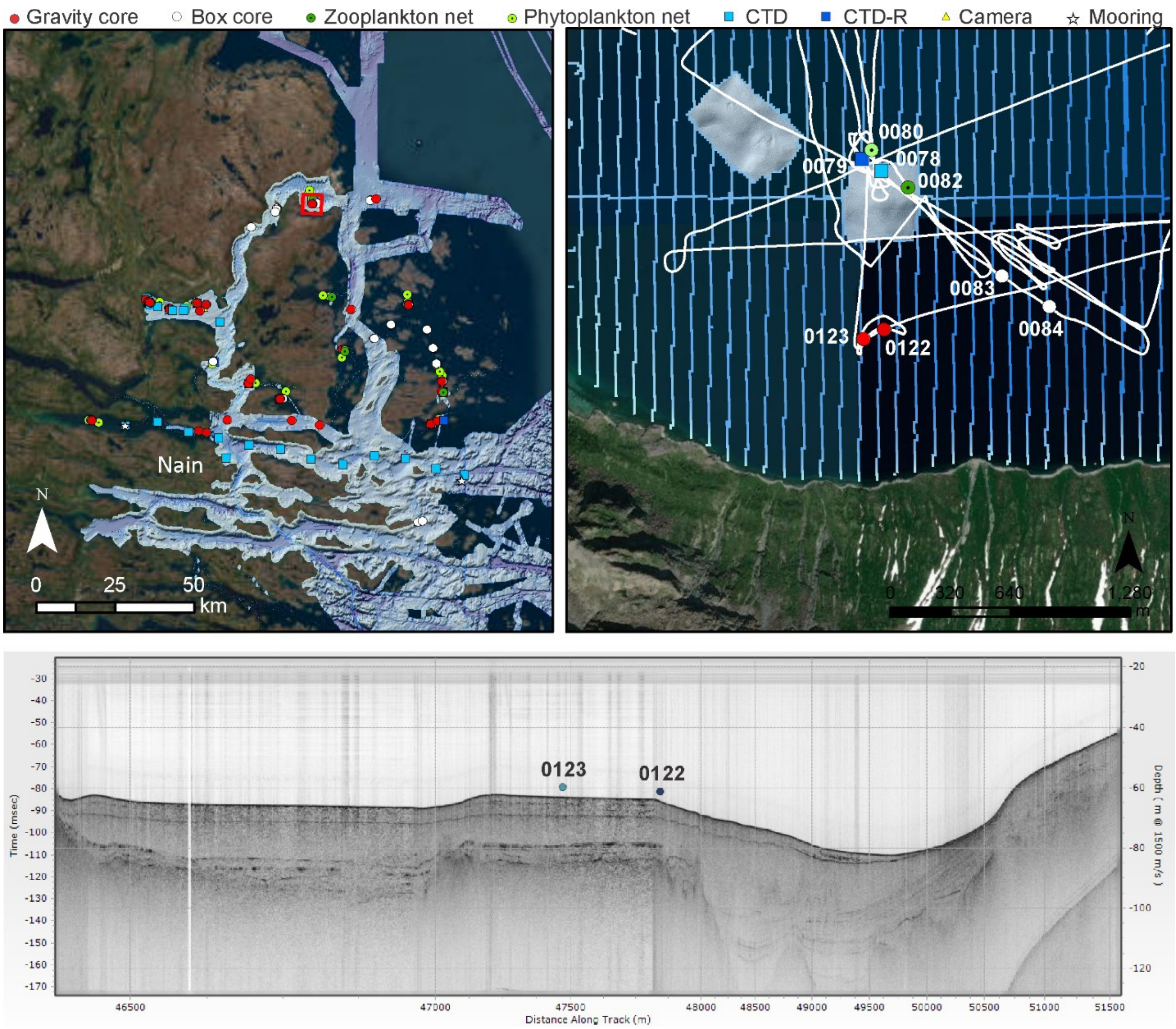

Figure E 14: Stratigraphic context of cores 0122 and 0123.

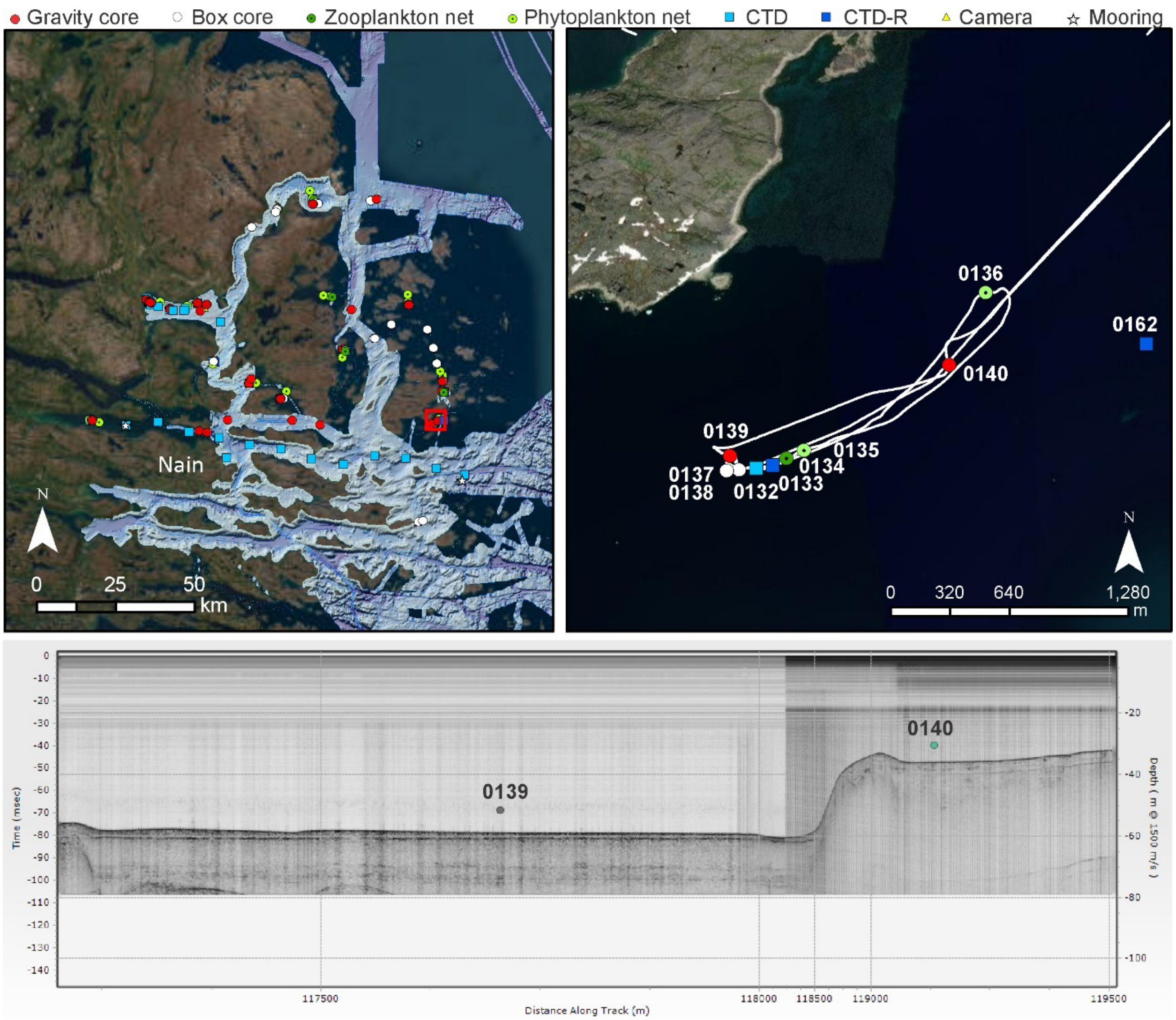

Figure E 15: Stratigraphic context of cores 0139 and 0140.

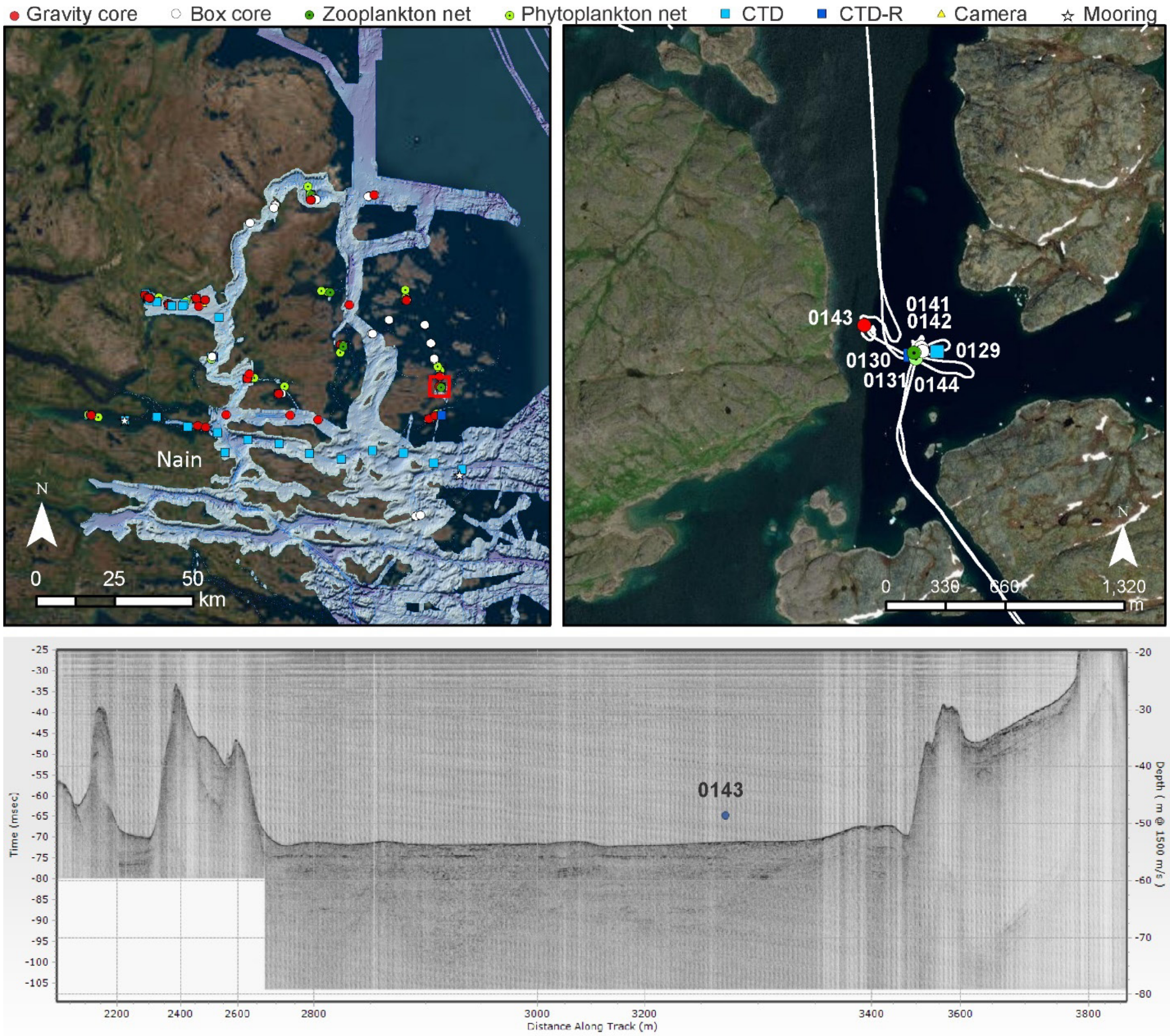

Figure E 16: Stratigraphic context of core 0143.

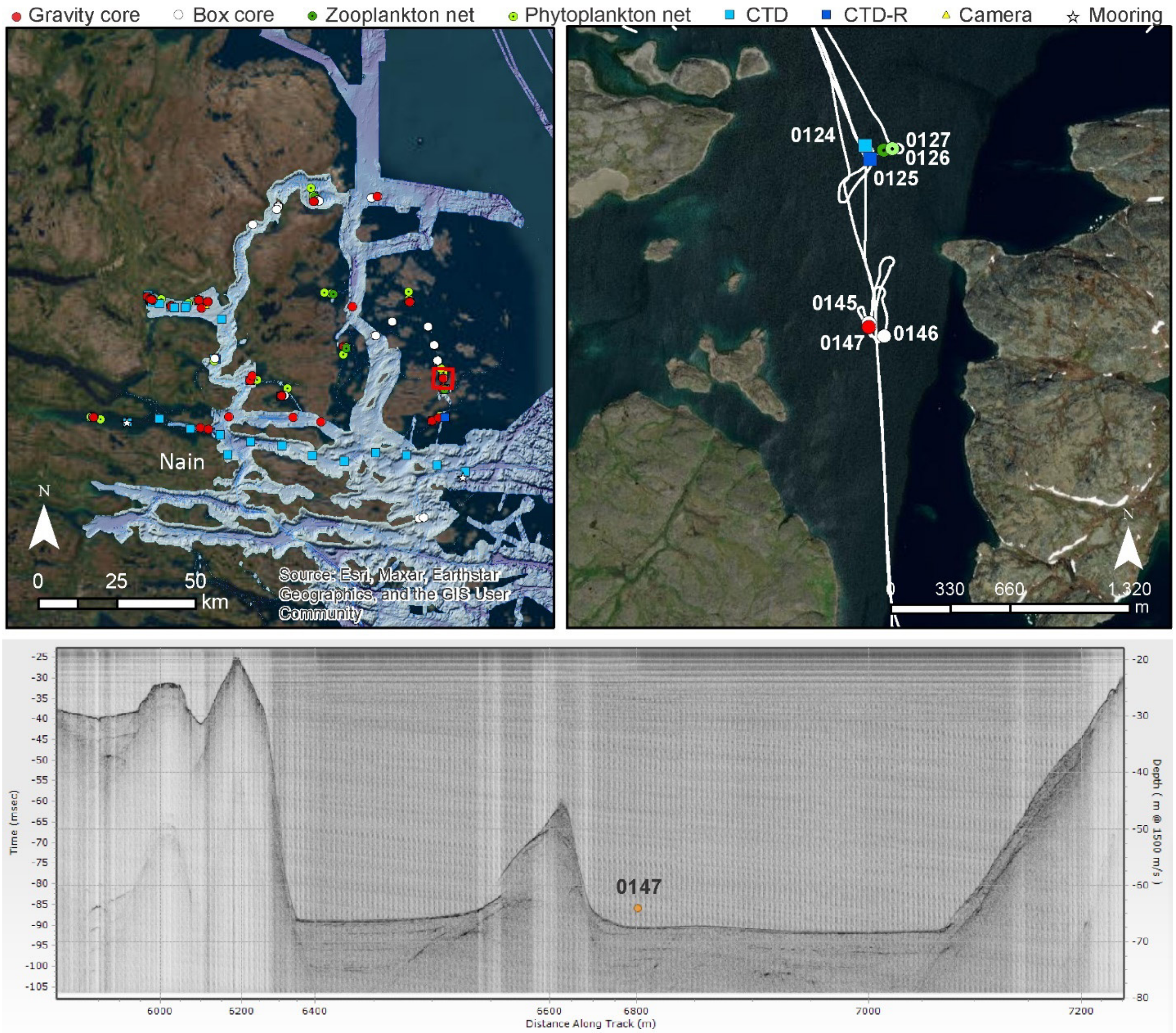

Figure E 17: Stratigraphic context of cores 0147.

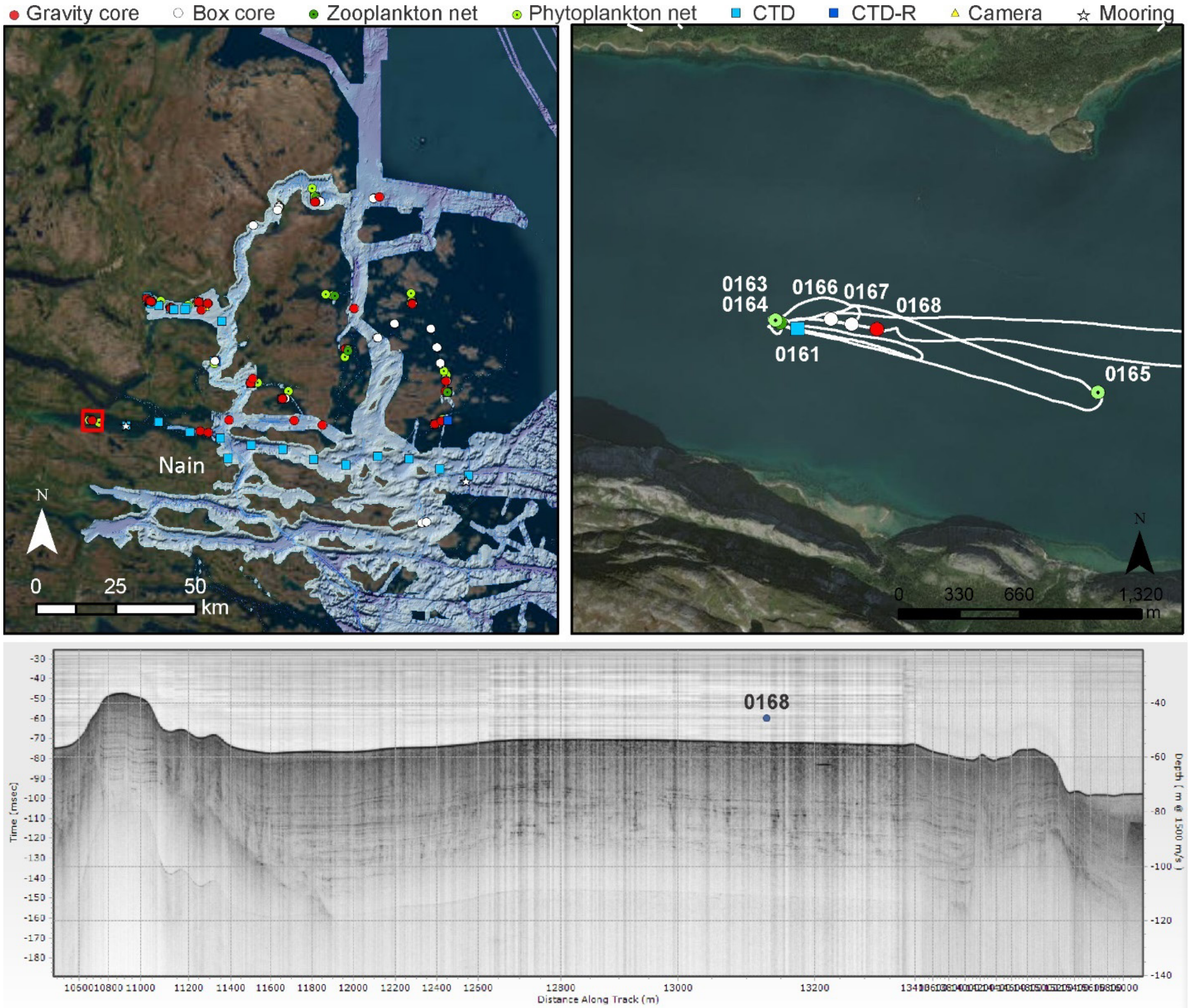

Figure E 18: Stratigraphic context of cores 0168.

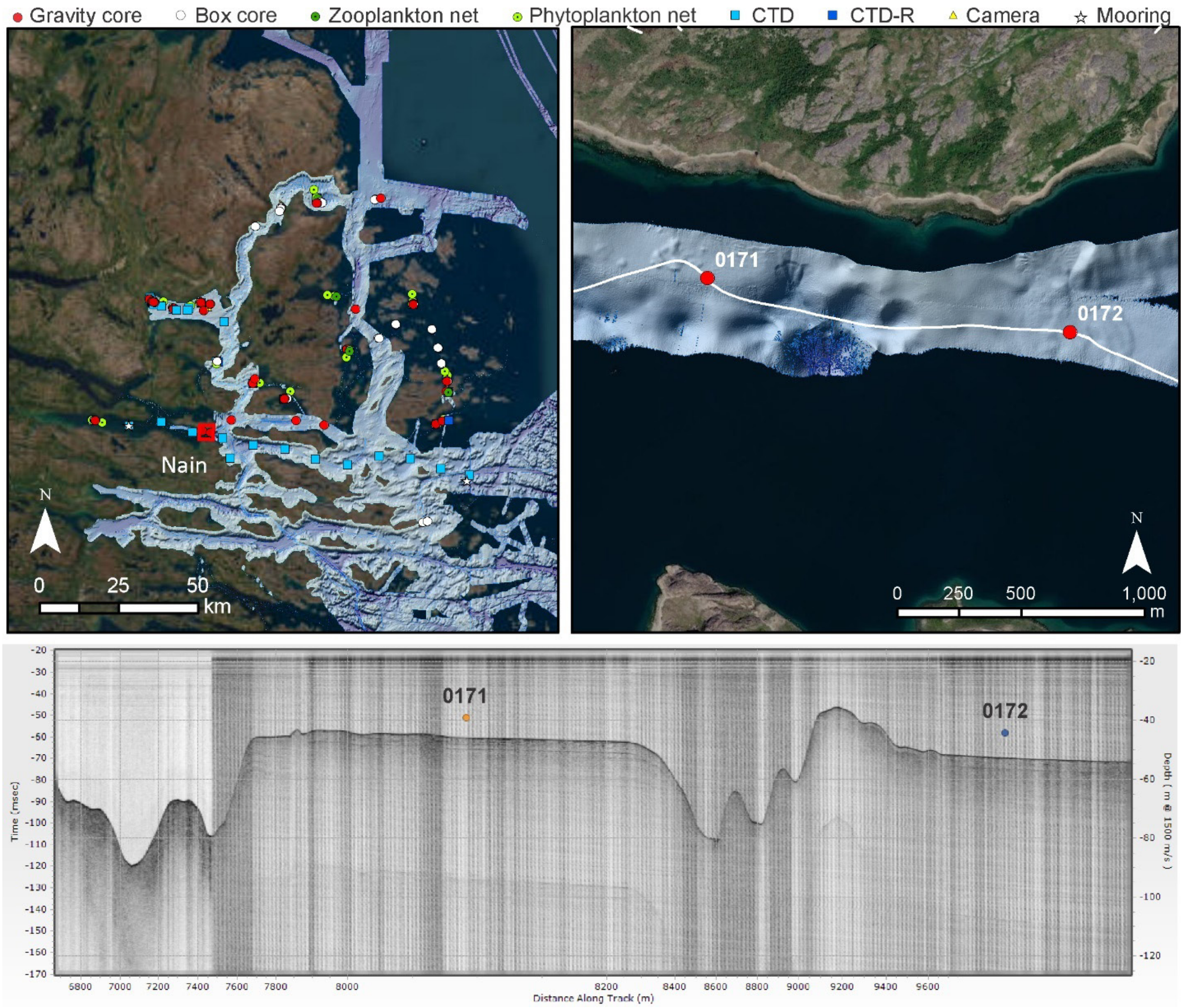

Figure E 19: Stratigraphic context of cores 0171 and 0172.

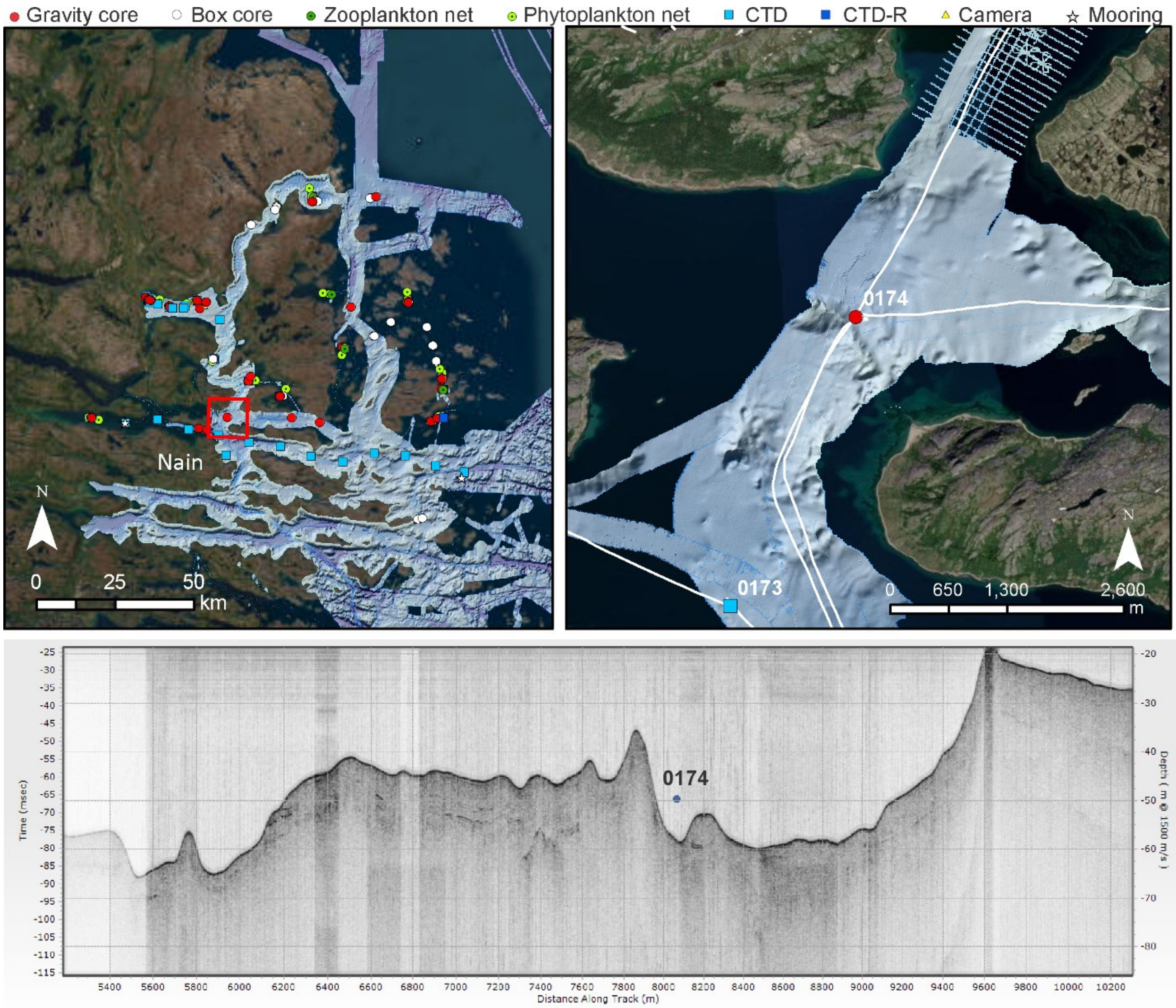

Figure E 20: Stratigraphic context of cores 0174.

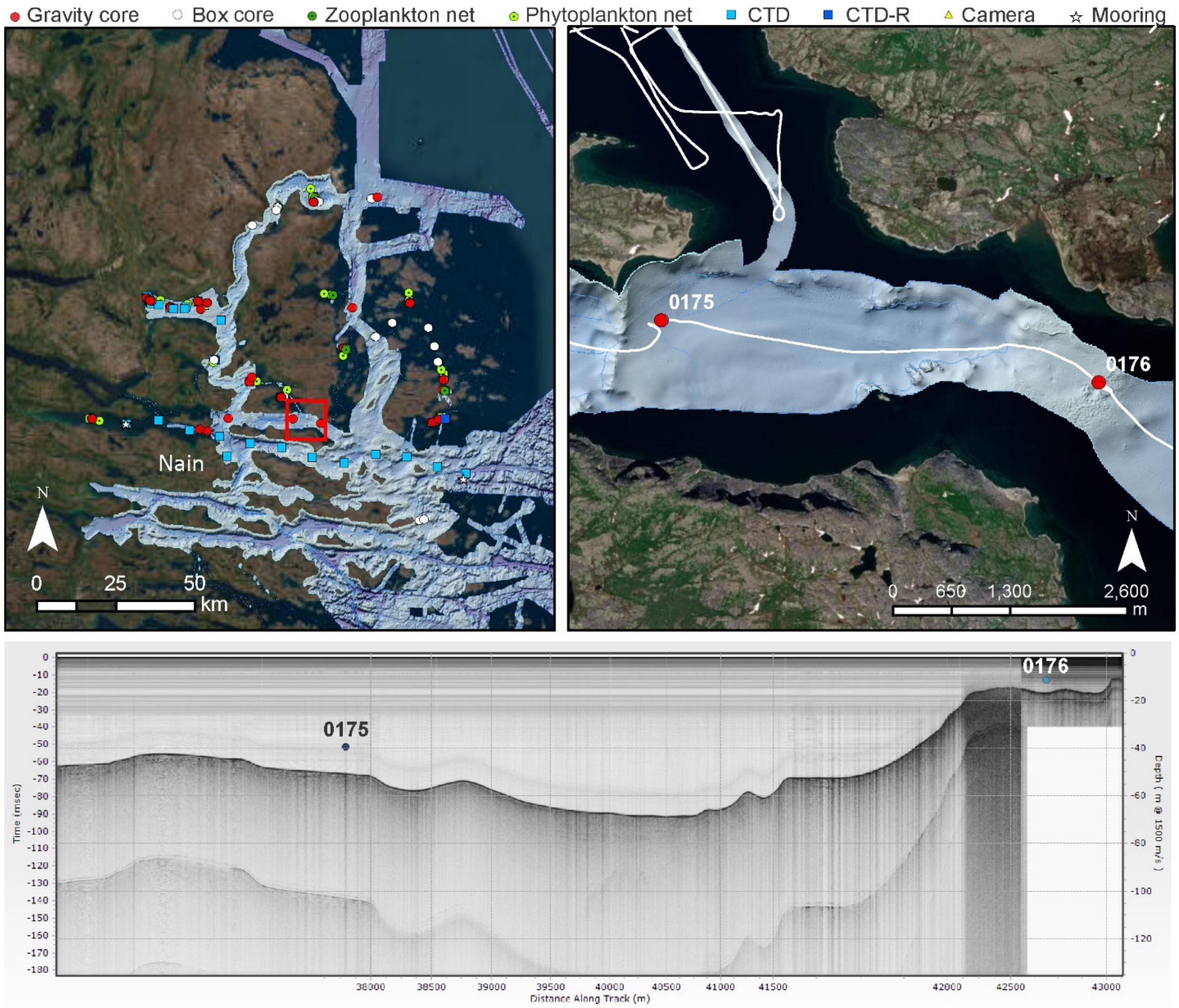

Figure E 21: Stratigraphic context of cores 0175 and 0176.